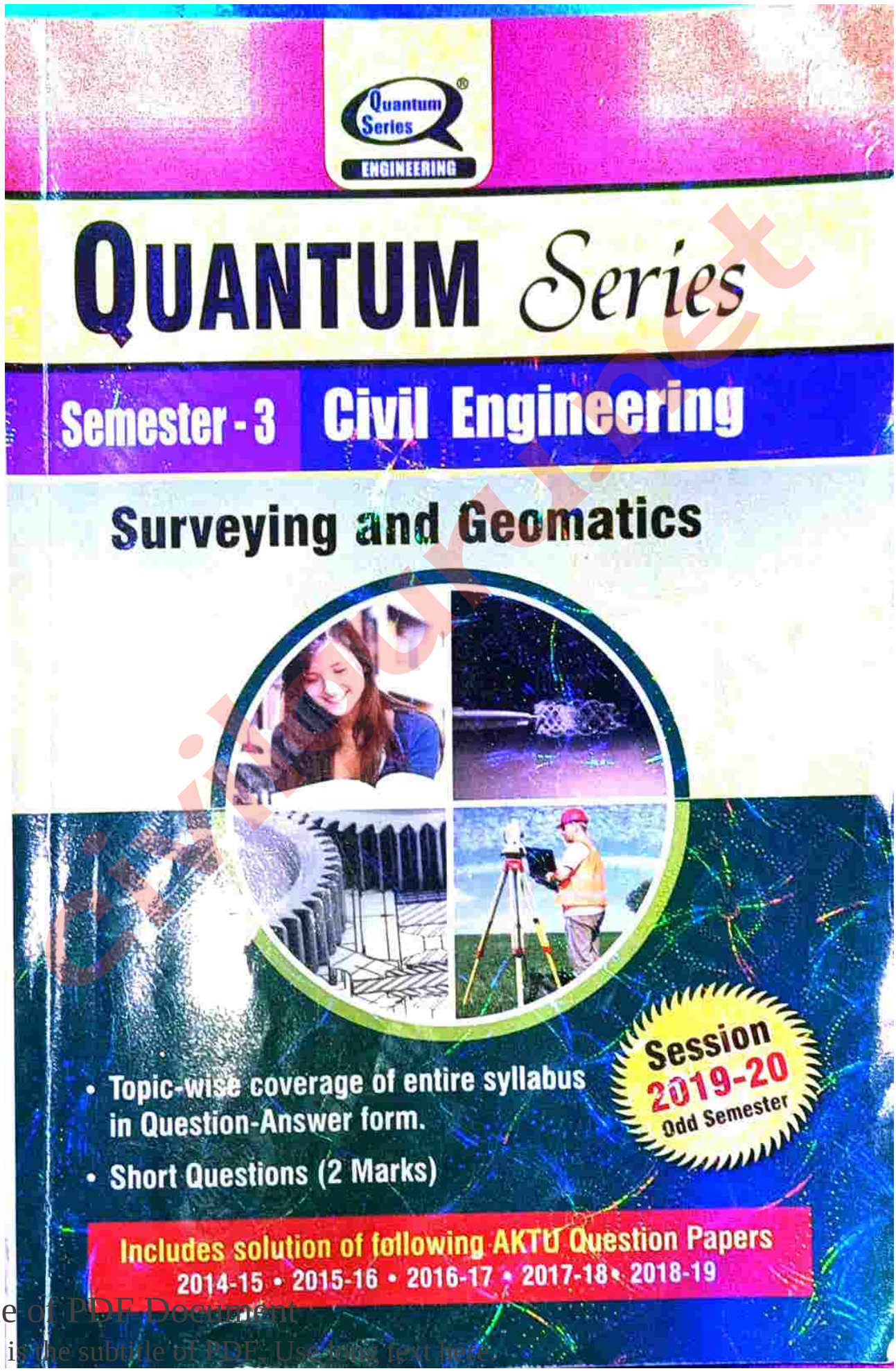
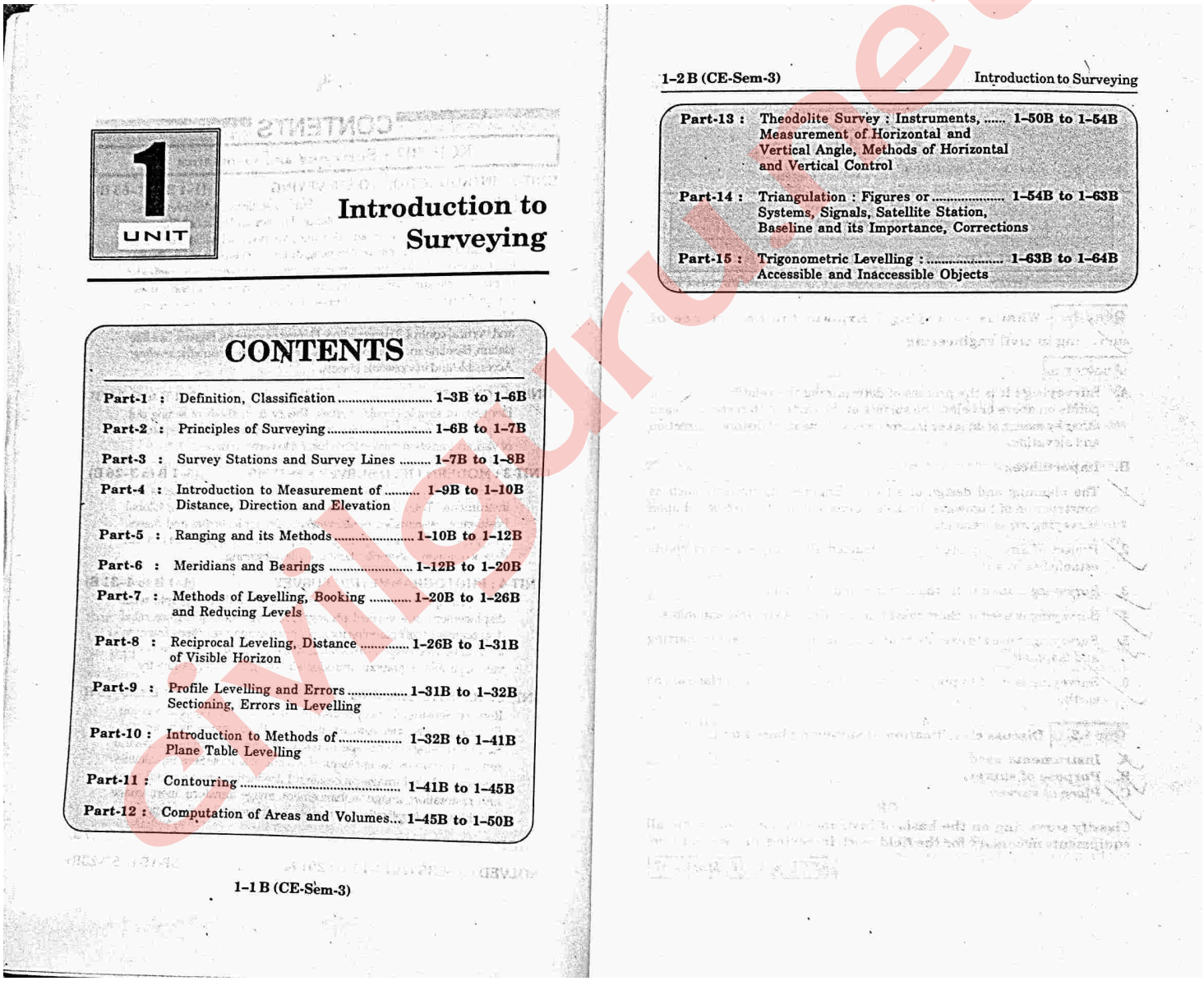

Quantum Series
ENGINEERING
QUANTUM Series
Semester - 3
Civil Engineering
Surveying and Geomatics
• Topic-wise coverage of entire syllabus in Question-Answer form.
• Short Questions (2 Marks)
Session 2019-20 Odd Semester
Includes solution of following AKTU Question Papers
2014-15 • 2015-16 • 2016-17 • 2017-18 • 2018-19



1 UNIT

Introduction to Surveying

CONTENTS

PART-1

Definition, Classification.

Questions-Answers

Long Answer Type and Medium Answer Type Questions

Que 1.1. What is surveying ? Explain the importance of surveying in civil engineering.

Answer

A. Surveying : It is the process of determining the relative position of points on above or below the surface of the earth with respect to each other by means of direct or indirect measurements of distance, direction and elevation.

B. Importance :

1. The planning and design of all Civil Engineering projects such as construction of highways, bridges, tunnels, dam etc., are based upon surveying measurements.
2. Project of any magnitude is constructed along the lines and points established by surveying.
3. Surveying is used to fix the national and state boundaries.
4. Surveying is used to chart coast lines, navigable streams and lakes.
5. Surveying is used to execute hydrographic and oceanographic charting and mapping.
6. Surveying is used to prepare topographic map of land surface of the earth.

Que 1.2. Discuss classification of surveying based on :

A. Instruments used.
B. Purpose of survey.
C. Place of survey.

OR

Classify surveying on the basis of instruments used and name all equipments necessary for the field work involving any one of them.

AKTU 2017-18, Marks 07

Answer

A. Based on Instrument Used :

1. **Chain Survey :** When a plan is to be made for a very small open field, the field work may consist of linear measurements only. All the measurements are done with a chain and tape.
2. **Levelling :** This is a method of surveying in which the relative vertical heights of the points are determined by employing a level and a graduated staff.
3. **Plane Tabling :** It is a graphical method of surveying in which field work and plotting are done simultaneously.
4. **Triangulation :** When the area to be surveyed is of considerable extent, triangulation is adopted. In this, the entire area is divided into a network to triangles.
5. **Electromagnetic Distance Measurement (EDM) Survey :** This is the electronic method of measuring distance using the propagation, reflection and subsequent reception of either light or radio waves.
6. **Total-station Survey :** The electronic theodolites combined with EDMs and electronic data collectors are called total stations.
7. **Satellite Based Survey :** Remote sensing and global positioning system (GPS) are the satellite-based surveys.

B. Based on Purpose of Survey :

1. **Engineering Survey :** Surveys which are done to provide sufficient data for the design of engineering projects such as highways, railways, water supply, sewage disposal, reservoirs, bridges, etc., are known as engineering surveys.
2. **Defence Survey :** Surveys have a very important and critical application in the military. They provide strategic information that can decide the course of a war.
3. **Geological Survey :** In this, both surface and subsurface surveying is required to determine the location, extent and reserves of different minerals and rock types.
4. **Geographical Survey :** Surveys conducted to provide sufficient data for the preparation of geographical maps are known as geographical surveys.

C. Based on Place of Survey :

1. **Land Survey :** This is used for determining the boundaries and areas to parcels of land. Topographical, city and cadastral surveys are some of the examples of land surveying.
2. **Hydrographic Survey :** It deals with the survey of water bodies like streams, lakes, coastal waters and consists in acquiring data to chart the shore lines of water bodies.

3. **Underground Survey :** This is referred to as the preparation of underground plans, fixing the position and directions of tunnels, shafts and drifts etc.
4. **Aerial Survey :** When the survey is carried out by taking photographs with a camera fitted in an aeroplane, it is called aerial or photogrammetric surveying.

Que 1.3. **Explain primary division of surveying *i.e.*, plane and geodetic surveying and also write down assumptions used in plane surveying.**

Answer

A. Plane Surveying :

1. The plane surveying is that type of surveying which does not take account the curvature of the earth, and the surface of the earth is treated as a plane surface.
2. If the area to be surveyed is more than 1000 km^2, the angles measured on the surface of the earth cannot be in a plane surface, but are in a curved surface, therefore, geodetic surveying must be employed to achieve precision for large areas.
3. Most ordinary surveys, such as location and construction surveys of highways, railways, canal and other civil engineering projects, fall in this category.
4. In plane surveys the direction of plumb lines are considered parallel, at different points, and all angles are plane angles.

B. Assumptions of Plane Surveying :

1. A level line is a straight line and a horizontal line.
2. Plumb lines *i.e.*, vertical lines are parallel to each other and perpendicular to the level line.
3. The triangle formed by joining three points of such a small area (250 km^2) form a plane triangle with each angle a plane angle.

C. Geodetic Surveying :

1. Geodetic survey is the survey in which the shape of the earth is taken into account.
2. Geodetic survey is carried out to locate widely distant points on the surface of the earth like to mark the boundaries of a state, country or a continent.
3. In geodetic survey a higher degree of precision is exercised in angular and linear measurements.

Que 1.4. **Discuss the difference between plane and geodetic surveying.**

Answer

Difference between Plane and Geodetic Surveying :

S. No.	Plane Survey	Geodetic Survey
1.	The curvature of earth is not taken into consideration in this survey.	The curvature of earth is taken into consideration in this survey.
2.	These surveys extend over small area.	These surveys extend over large area (more than 250 km^2).
3.	The degree of accuracy is comparatively low.	The degree of accuracy is high.

PART-2

Principles of Surveying.

Questions-Answers

Long Answer Type and Medium Answer Type Questions

Que 1.5. **Explain and describe the fundamental principles of surveying.**

Answer

Basic Principle of Surveying : Following are the basic principles of surveying :

1. To work from whole to part.
2. To locate a point by at least two measurement.

1. To Work from Whole to Part :

i. It is the main principle of surveying and a method violating the principle of working from whole to part should not be adopted until and unless there is no alternative.

ii. The main idea of working from whole to part is to localise the errors and prevent their accumulation.

iii. A part, say AC, of the whole distance AB to be measured is fixed by fixing a point C as C' by judgment or by process of ranging with respect to A and B, the end points.

iv. Then the other points D, E, F, etc., are fixed with respect to A and C' (part AC).

v. Now if point C is not in line with AB, all the points D, E, F, etc., established will be out of line with an increasing magnitude of error.

vi. The length measured will, therefore, be incorrect to a larger extent as compared to the direct method.

vii. This method may introduce serious error as the survey at the end becomes uncontrollable and hence working from part to whole is never recommended.

v. The plane table surveying, however, is an example of working from part to whole.

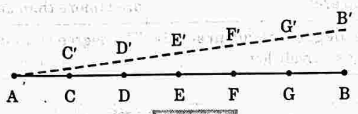


Fig. 1.5.1.

2. To Locate a Point by at Least Two Measurement :

i. The control points (any two important features) are selected in the area and the distance between them is measured accurately.

ii. The line joining the control points is plotted to the scale on drawing sheet.

iii. Now the desired point can be plotted by making two suitable measurements from the given control points.

Let A and B be the two control points, whose positions are already known on the plan. The position of C can be plotted by any of the following methods :

a. By measuring distance BC and angle α, as shown in Fig. 1.5.2(a).

b. By dropping a perpendicular from C on the line AB and measuring either AD and CD or BD and CD, as shown in Fig. 1.5.2(b).

c. By measuring the distances AC and BC, as shown in Fig. 1.5.2(c).

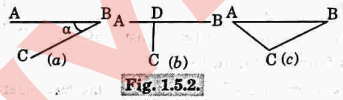


Fig. 1.5.2.

PART-3

Survey Stations and Survey Lines.

Questions-Answers

Long Answer Type and Medium Answer Type Questions

Que 1.6. Describe the different types of survey stations.

Answer

Survey Stations : Survey stations are the points at the beginning and the end of a chain line.

Following are the survey stations :

1. **Main Stations :**

i. Stations taken along the boundary of an area as controlling points are known as 'main stations'.

ii. The lines joining the main stations are called 'main survey lines'.

iii. The main stations are denoted by 'Δ' with letters A, B, C, D, etc.

2. **Subsidiary Stations :**

i. Stations which are on the main survey lines or any other survey lines are known as "subsidiary stations".

ii. These stations are taken to run subsidiary lines for dividing the area into triangles, for checking the accuracy of triangles and for locating interior details. These stations are denoted by '$\odot$' with letters S_1, S_2, S_3, etc.

3. **Tie Stations :**

i. These are also subsidiary stations taken on the main survey lines. Lines joining the tie stations are known as tie lines.

ii. Tie lines are mainly taken to fix the directions of adjacent sides of the chain survey map.

iii. Tie stations are denoted by '$\odot$' with letters T_1, T_2, T_3, etc.

Que 1.7. Describe the different types of survey lines.

Answer

Following are the types of survey lines :

1. **Main Survey Line :** The chain line joining two main survey stations is called main survey line.

2. **Base Line :** It is the longest main survey line on a fairly level ground and passing through the centre of the area. It is the most important line as the direction of all other survey lines are fixed with respect to this line.

3. **Check Line :** Check line or proof line is a line which is provided to check the accuracy of the field work. The measured length of the check line and the computed one (scaled off the plan) must be the same.

PART-4

Introduction to Measurement of Distance, Direction and Elevation.

Questions-Answers

Long Answer Type and Medium Answer Type Questions

Que 1.8. **Discuss the different methods of measuring horizontal distance.**

Answer

The horizontal distances can be measured by following three methods :

1. **Direct Method :**
   - i. Direct method is measuring distances between two points with the help of a chain or a measuring tape after proper ranging.
   - ii. Measuring distances with chains is not in practice now, however tapes are generally employed to measure distances. Measuring distances with the help of a tape is conventionally called "Taping".
2. **Indirect Method :**
   - i. In this method the surveying equipments are equipped with a stadia diaphragm.
   - ii. The horizontal distance is computed on the basis of stadia intercept and the vertical angle applying trigonometric relations.
   - iii. Using subtense bar horizontally is another indirect method of measuring horizontal distances.
3. **Electromagnetic Distance Measuring (EDM) :**
   - i. It is an electronic device which works on the principle of propagation of electromagnetic (EM) waves.
   - ii. One instrument is installed at the first point and the other or a reflector at the other end.
   - iii. A beam of EM energy is generated at the initial station, which is diverted towards the other station.
   - iv. It is percepted again at the initial station after reflection from the second station.
   - v. The total time elapsed between the generation and perception after reflection is recorded by the EDM.
   - vi. Distance between the two point = 1/2 × Time elapsed × Velocity of light.

Que 1.9. **Describe the measurement of directions.**

Answer

Measurement of Directions :

1. The directions of survey lines are measured with magnetic compass by free or loose-needle method.
2. The fore and back bearings of each line are measured independently by setting up compass at each successive station to avoid accumulation of errors.
3. If error between fore and back bearings of a line exceeds the limit of permissible error, *i.e.*, 15', the bearings of the line are observed again.
4. Even if, on checking, the error remains, it may be due to local attraction at one or both the stations of the line.
5. Before using the observed bearings in traverse plotting, they should be corrected for local attraction.
6. The following two methods are commonly used to measure the directions in compass surveying.

i. **Loose-needle Method :**

- a. In this method, the direction of the magnetic meridian is established at each station of the traverse, and the directions of the line are determined with reference to the magnetic meridian.
- b. As the magnetic bearings are read directly with a compass, the accuracy of the loose-needle method is that of the compass, and not that of theodolite.
- c. The loose-needle method is rarely used in a theodolite traverse.

ii. **Fast-needle Method :**

- a. In the fast-needle method, the magnetic meridian is established only at the starting station.
- b. The magnetic bearing of the first line is measured directly, and the magnetic bearings of the other lines are computed indirectly from the magnetic bearing of the first line and the included angles.
- c. The method is more accurate than the loose-needle method, and is generally preferred.

PART-5

Ranging and its Methods.

Questions-Answers

Long Answer Type and Medium Answer Type Questions

Que 1.10. Define the ranging. Describe the methods of ranging.

OR

Describe the method of ranging a line across a ridge, when terminal stations are not intervisible ?

Answer

Ranging : The process of establishing intermediate points on a straight line between two end points is known as ranging.

Following are the two method of ranging :

1. **Direct Ranging :** When intermediate ranging rods are fixed on a straight line by direct observation from end stations, the process in known as direct ranging. Direct ranging is possible when the end stations are intervisible.

The following procedure is adopted for direct ranging :

i. Assume that A and B are two end stations of a chain line, where two ranging rods are already fixed. Suppose it is required to fix a ranging rod at the intermediate point P on the chain line in such a way that the points A, P and B are in the same straight line.

ii. The surveyor stands about 2 m behind the ranging rod at A by looking towards the line AB.

iii. The assistant holds a ranging rod at P vertically and now the surveyor directs the assistant to move the ranging rod to the left or right until the three ranging rods come exactly in the same straight line.

iv. The ranging will be perfect, when the three ranging rods coincide and appear as a single rod.

v. When the surveyor is satisfied that the ranging is perfect, he signals the assistant to fix the ranging rod on the ground by waving both his hands up and down.

vi. Following the same procedure, the other ranging rods may be fixed on the line Fig. 1.10.1.

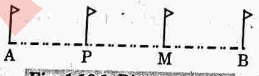


Fig. 1.10.1. Direct ranging.

2. **Indirect or Reciprocal Ranging :** When the end stations are not intervisible due to there being high ground between them, intermediate ranging rods are fixed on the line in an indirect way. This method is known, as indirect ranging or reciprocal ranging.

The following procedure is adopted for indirect ranging :

i. Suppose A and B are two end stations which are not intervisible due to high ground existing between them.

ii. Suppose it is required to fix intermediate points between A and B. Two chain men take up positions at R_1 and S_1 with ranging rods in their hands.

iii. The chainman at R_1 stands with his face towards B so that he can see the ranging rods at S_1 and B.

iv. Again, the chainman at S_1 stands with his face towards A, so that he can see the ranging rods at R_1 and A.

v. Then the chainmen proceed to range the line by directing each other alternately.

vi. The chainmen at R_1 direct the chainman at S_1 to come to the position S_2 so that R_1, S_2 and B are in the same straight line.

vii. Again, the chainman at S_2 directs the chainman at R_1 to move to the position at R_2 so that S_2, R_2 and A are in the same straight line.

viii. By directing each other alternately in this manner, they change their positions every time until they finally come to the positions R and S, which are in the straight line AB.

ix. This means the points A, R, S and B are in the same straight line as shown in Fig. 1.10.2.

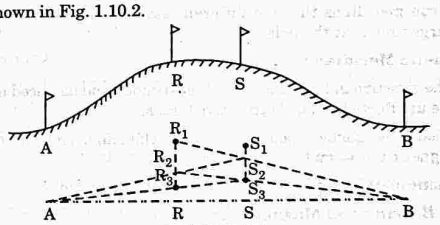


Fig. 1.10.2.

PART-6

Meridians and Bearings.

Questions-Answers

Long Answer Type and Medium Answer Type Questions

Que 1.11. **Write short notes on the following :**

A. Reference meridian and bearing.
B. True meridian and magnetic meridian.
C. True bearing and magnetic bearing.
D. Fore bearing and back bearing.
E. Azimuths.

Answer

A. Reference Meridian and Bearings :

1. **Reference Meridian :** It is the fixed direction in which the bearing of survey lines is expressed.
2. **Bearing :** It is the horizontal angle between the reference meridian and the survey line measured in clockwise or anticlockwise direction.

B. True Meridian and Magnetic Meridian :

1. **True Meridian :**
   i. True meridian is the line on earth surface joining true north pole, true south pole and the point on earth surface.
   ii. The direction of true meridian is always the same.
   iii. The true meridians through different stations are not parallel but converge (meet) at the poles.
2. **Magnetic Meridian :**
   i. It is the direction indicated by a freely suspended and balanced magnetic needle unaffected by local attractive forces.
   ii. Location of the magnetic poles is constantly changing, hence the direction of magnetic meridian keeps changing.
   iii. Magnetic meridian is usually employed in plane surveys.

C. True Bearing and Magnetic Bearing :

1. **True Bearing :** The horizontal angle measured clockwise between the true meridian and the line is called true bearing of the line.
2. **Magnetic Bearing :** The horizontal angle which a line makes with the magnetic meridian is called magnetic bearing. It varies with time.

D. Fore Bearing and Back Bearing :

1. **Fore Bearing :** It is the bearing of a line in the direction of progress of survey as shown in Fig. 1.11.1. α is the fore bearing of line AB.
2. **Back Bearing :** It is the bearing of a line in the backward direction of progress of survey as shown in Fig. 1.11.1. β is the back bearing of line AB.

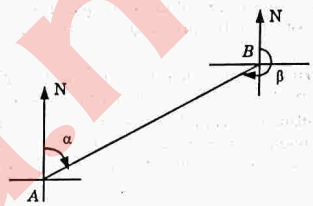


Fig. 1.11.1. Fore and back bearing of a line.

E. Azimuths :

1. The angle between a line and the meridian measured in clock-wise direction usually from the north branch of the meridian is the azimuth of the line.
2. Also, some surveyors reckon azimuths from the south branch of the meridian, and therefore, it becomes necessary to specify that the azimuth is from the north or from the south.

Que 1.12. **What is compass ? Describe the prismatic compass and surveyor's compass.**

Answer

A. Compass :

1. Compass is an instrument with the help of which horizontal angles can be deduced.
2. Compass being light and portable is best suited for reconnaissance.
3. It has a graduated circle, whose diameter determines its size.
4. **Uses :** Tubular compass is used to measure azimuth.

B. Prismatic Compass : The following are the essential parts of this compass.

1. **Compass Box :** The compass box is a circular metallic box (the metal should be non-magnetic) of diameter 8 to 10 cm.
2. **Magnetic Needle and Graduated Ring :** The magnetic needle is made of a broad, magnetised iron bar. The bar is pointed at both ends. The magnetic needle is attached to a graduated aluminium ring.
3. **Sight Vane and Prism :**
   i. The sight vane and the reflecting prism are fixed diametrically opposite to the box.
   ii. The sight vane is hinged with the metal box and consists of horsehair at the centre.

iii. The prism consists of a sighting slit at the top and two small circular holes, one at the bottom of the prism and the other at the side of the observer's eye.

4. **Adjustable Mirror :** A mirror is provided with the sight vane. The mirror can be lowered or raised, and can also be inclined.

5. **Lifting Pin :** A lifting pin is provided just below the sight vane. When the sight vane is folded, it presses the lifting pin. The lifting pin then lifts the magnetic needle out of the pivot point to prevent damage to the pivot head.

6. **Glass Cover :** A glass cover is provided on top of the box to protect the aluminium ring from dust shown in the Fig. 1.12.1.

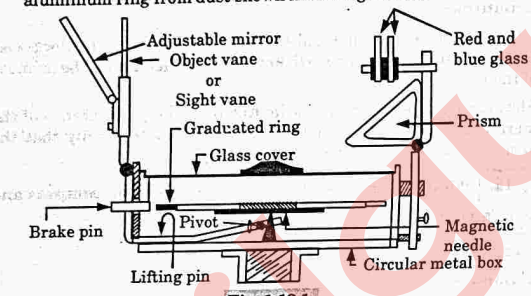


Fig. 1.12.1.

Uses : Following are the uses of prismatic compass :

i. It is used for rough surveys.
ii. It is used for ranging the survey line.
iii. It is used for measuring bearing of a survey line.

Advantages : Advantage of prismatic compass is that both sighting as well as taking the reading can be done simultaneously without changing the position of the surveyor.

C. **Surveyor's Compass :** The surveyor's compass is similar to the prismatic compass except for the following points :

i. There is no prism on it. Readings are taken with naked eye.
ii. It consists of an eye-vane (in place of prism) with a fine sight slit.
iii. The graduated aluminium ring is attached to the circular box. It is not fixed to the magnetic needle.
iv. The magnetic needle moves freely over the pivot. The needle shows the reading on the graduated ring.
v. The ring is graduated from 0° to 90° in four quadrants. 0° is marked at the north and south, and 90° at the east and west.
vi. No mirror is attached to the object vane.

Uses : It is used to measure horizontal angles.

Disadvantage : The surveyor has to shift his position while sighting and while taking the reading.

Que 1.13. Differentiate between prismatic compass and surveyor's compass. **AKTU 2014-15, Marks 3.5** **AKTU 2018-19, Marks 07**

OR

Explain clearly the difference between a prismatic compass and surveyor's compass. **AKTU 2015-16, Marks 10**

Answer

S. No.	Prismatic Compass	Surveyor's Compass
1.	It consists of prism.	It does not have prism.
2.	It gives whole circle bearing.	It gives quadrantal or reduced bearing.
3.	Graduations are marked from 0° to 360° in this type of compass.	It is divided into four quadrants and graduations are marked from 0° to 90° in each quadrant.
4.	Sighting and reading can be done simultaneously without changing the position of the eye.	Sighting and reading can not be done simultaneously without changing the position of the eye.
5.	It does not rotate with the line of sight.	It can rotate with the line of sight.

Que 1.14. Describe the temporary adjustment of a compass.

Answer

The adjustments required to be made every time the compass is set up are called its temporary adjustment and are as follows :

1. **Centring :**
i. A tripod is placed over the station with its legs spread well apart so that it is at a workable height.
ii. The compass is fixed on the tripod. It is then centred over the station, where the bearing is to be taken (*i.e.*, the centre of the compass, the pivot is brought exactly above the ground station.
iii. A plumb bob is hung from the centre of compass to ensure exact centring.

2. **Levelling :**
i. The compass is levelled by eye judgment. This is essential so that the graduated ring swings freely.

ii. Sometimes, in surveyor's compass, two plate levels at right angles are also provided to level the instrument.

iv. The levelling is achieved by a ball and socket arrangement which is adjusted till the bubbles become central in both the plate levels.

3. **Focusing the Prism :** This adjustment is done only in a prismatic compass. The prism is moved up or down till the figures and graduations are seen clearly.

Que 1.15. What does the term 'sensitiveness' mean in the context of a bubble ? How the sensitiveness of a bubble is determined ?

AKTU 2017-18, Marks 07

Answer

Sensitiveness of the Bubble :

1. The term sensitiveness in the context of a bubble means the effect caused by the deviation of the bubble per division of the graduation of the bubble tube.
2. Sensitiveness is expressed in terms of the radius of curvature of the upper surface of the tube or by an angle through which the axis is tilted for the deflection of one division of the graduation.

Determining Sensitiveness :

1. Consider Fig. 1.15.1 suppose the level was set up at O at a distance D from the staff at P.
2. The staff reading is taken with the bubble at the extreme right end (*i.e.*, at E). Say it is PA.
3. Another staff reading is taken with the bubble at the extreme left end (*i.e.*, at E_1). Let it be PB.

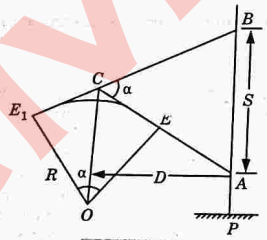


Fig. 1.15.1.

4. Let
D = Distance between the level and staff,
S = Intercept between the upper and lower sights,

n = Number of divisions through which the bubble is deflected.
R = Radius of curvature of the tube.
α = Angle subtended by arc EE_1.
d = Length of one division of the graduation, expressed in the same units as D and S.

5. Movement of centre of bubble = $EE_1 = nd$.

6. Triangle OEE_1 and ACB are similar.

Here $R\alpha$ = arc EE_1

$$\alpha = \frac{EE_1}{R} = \frac{nd}{R} \quad \text{...(1.15.1)}$$

(as arc EE_1 = chord EE_1)

7. Again $\frac{EE_1}{R} = \frac{S}{D}$ (height of ΔOEE_1 may be considered as R)

$$\frac{nd}{R} = \frac{S}{D} \quad \text{...(1.15.2)}$$

8. From eq. (1.15.1) and (1.15.2), we get

$$\alpha = \frac{nd}{R} = \frac{S}{D} \quad \text{...(1.15.3)}$$

$$R = \frac{nd \times D}{S}$$

9. Let α' = Angular value for one division in radians.

$$\alpha' = \frac{\alpha}{n} = \frac{S}{D} \times \frac{1}{n} \text{ radians}$$

or $$\alpha' = \frac{S}{Dn} \times 206,265 \text{ sec} \quad (\because 1 \text{ radian} = 206.265 \text{ sec})$$

Que 1.16. Following are the bearings observed while traversing with a compass, an area where local attraction was suspected. Find the correct bearing of the lines and also the true bearings, if the magnetic declination is 10° W.

AKTU 2015-16, Marks 15

Line	FB	BB
AB	59°00′	239°00′
BC	139°30′	317°00′
CD	215°15′	36°30′
DE	208°00′	29°00′
EA	318°30′	138°45′

Answer

A. To Calculations of Correct Bearings :

Station	Line	Readings	Correction	Final reading	Calculation
A	AB	59°00′	+ 00°00′	59°00′	
	BA	239°00′	+ 00°00′	239°00′	
B	BC	139°30′	↑ + 00°00′ ←	139°30′ ←	− 180°
	CB	317°00′	+ 2°30′ →	319°30′	
C	CD	215°15′	↑ + 2°30′ ←	217°45′ ←	+ 180°
	DC	36°30′	+ 1°15′ →	37°45′	
D	DE	208°00′	↑ + 1°15′ ←	209°15′ ←	+ 180°
	ED	29°00′	+ 00°15′ →	29°15′	
E	EA	318°30′	↑ + 00°15′	318°45′ ←	+ 180°
	AE	138°45′	+ 00° 00′ →	138°45′	

B. Rules :

1. Add or subtract in the reading when the angle is below 180° or greater than 180° respectively.
2. First we have to make sure that which readings have exactly difference 180°. It means that particular station is free from local attraction. Hence, correction for that reading is 00° 00′.
3. In the question, the difference of back bearing and fore bearing reading at station A is 180°. Hence, this station is free from local attraction.
4. We have solved the question from bottom to top by adding or subtracting the suitable corrections from readings.

C. Checks : The difference in back bearing and fore bearing readings of all the stations is 180°. Hence, solution of question is correct.

D. Calculation of the Bearing if MD is 10° W :

Line	FB	BB	MD	Corrected FB = FB-Declination	Corrected BB = BB-Declination
AB	59°	239°	10°	49°	229°
BC	139°30′	319°30′	10°	129°30′	309°30′
CD	217°45′	37°45′	10°	207°45′	27°45′
DE	209°15′	29°15′	10°	199°15′	19°15′
EA	318°45′	138°45′	10°	308°45′	128°45′

PART-7

Methods of Levelling, Booking and Reducing Levels.

Questions-Answers

Long Answer Type and Medium Answer Type Questions

Que 1.17. Mention and explain different methods of determining elevations.

Answer

Following are the different methods of determining elevation :

1. Direct Levelling :

i. Direct levelling is the process in which elevation of points is obtained by measuring vertical distances with respect to a horizontal surface of known elevation. It is also called spirit levelling.

ii. Instruments used for direct levelling are called levelling instruments, which are dumpy level, auto level etc.

2. Indirect Levelling :

i. In indirect levelling, elevation of points is calculated from observed vertical angles and measured horizontal distances.

ii. Indirect levelling is carried out with the help of a theodolite or a tacheometer.

iii. Surveying with a tacheometer is an optical method in which horizontal and vertical distances are calculated from observed readings and is modified form of trigonometric levelling.

3. Barometric Levelling :

i. Barometric levelling is based on the fact that atmospheric pressure is inversely proportional to elevation.

ii. It is not an accurate method because atmospheric pressure is also affected by weather conditions besides elevation.

iii. Two types of barometers are used for it :

a. Mercury barometer, and b. Aneroid barometer.

iv. Mercury barometer uses mercury for measurement of atmospheric pressure and is therefore bulky to transport.

v. Aneroid barometer is a dry and compact instrument. It is portable therefore convenient to use.

4. **Hypsometry :** Hypsometry is based on the fact that boiling point of water gets lowered on decrease of atmospheric pressure.

Que 1.18. Describe the height of instrument and rise and fall methods of computing the levels.

Answer

1. Collimation or Height of Instrument (HI) Method :

i. In this method height of instruments (HI) is calculated for each setting of the instrument by adding back sight to the elevation of the BM.

ii. The elevation of the change (or turning) point is then calculated by subtracting the fore sight (FS) from HI. For the next setting of the instrument, HI is obtained by adding the back sight taken on change (turning) point to its reducing level (RL).

iii. The process continues till RL of the last point is obtained.

iv. An arithmetical check is applied as below to ascertain correctness of the calculations.

$$\Sigma BS - \Sigma FS = \text{Last RL} - \text{First RL}$$

v. RL of inter sights is arrived at in the same way as for fore sights by deducting them from height of instrument.

2. Rise and Fall Method :

i. In this method, the difference of level between two consecutive points for each setting of the instrument is obtained by comparing their staff readings.

ii. The difference indicates a rise if the back sight is more than the fore sight, and a fall if it is less than the fore sight.

iii. The two consecutive points may have reading as BS and FS, BS and intermediate sight or IS.

iv. The rise or fall worked out for all the points, give the difference in level of each point relative to the preceding one.

v. Therefore, if the RL of the preceding point is known then the RL of the following point can be obtained by adding the rise or subtracting the fall as the case may be.

Que 1.19. Describe the comparison between collimation method and rise and fall method.

Answer

S. No.	Collimation Method	Rise and Fall Method
1.	Less tedious, more rapid and simple method.	The method is more tedious.
2.	Less numbers of calculations are required.	More calculations are required.
3.	Less accurate.	More accurate.
4.	There is no check on RL of intermediate points, hence possibilities of more mistakes in calculation.	There is a cross check on each RL of intermediate points and hence less chances of mistakes in calculation.
5.	The error in calculation of RL of any point is not carried forward.	The mistake made in calculation of RL of any point will be carried forward.
6.	Used for calculating the RL of profile levelling work, for preparation of contour maps.	Used for precise levelling, fly levelling and check levelling.

Que 1.20. The staff readings for a survey work were as follows :
1.810, 2.110, 1.225, 1.455, 0.905, 2.435, 2.810, 2.675 and 1.765.
The level was shifted after the 4th and 7th readings. The first reading was taken on a bench mark of RL 50.000 rule out a page of level book and enter the readings :

i. Work out the RLs of all stations.
ii. If the staff were held invert and readings on a ceiling from last instrument position was 3.500, Find the RL of the ceiling.
iii. Work out the staff readings on the top of 4 pegs at 20 m intervals from the last station to give an upgrade of 1 in 100.

AKTU 2017-18, Marks 07

Answer

Given : RL of bench mark = 50
Staff shifted after 4th and 7th readings, Inverted reading = 3.5 m
Pegs interval = 20 m, Gradient = 1 in 100
To Find : RL of all stations, ceiling and staff reading at pegs.

1. The reduced levels of the points are calculated by rise and fall method and tabulated in table 1.20.1.

Table 1.20.1.

Station	Readings			Rise	Fall	RL	Remark
	BS	IS	FS				
1	1.810					50.000	BM
2		2.110			0.300	49.700	
3		1.225		0.885		50.585	
4	0.905		1.455		0.230	50.355	CP1
5		2.435			1.53	48.825	
6	2.675		2.810		0.375	48.450	CP2
7			1.765	0.91		49.36	End point
Σ	5.39		6.03	1.795	2.435		

2. **Arithmetic check :**

$\Sigma BS - \Sigma FS = \Sigma Rise - \Sigma Fall = Last\ RL - First\ RL$

$= 5.39 - 6.03 = 1.795 - 2.435 = 49.36 - 50.00$

$= -0.64 = -0.64 = -0.64$

3. RL of floor = 49.36
   Staff reading on floor = 1.765
   Inverted staff reading = 3.500
   Height of ceiling above floor = 1.765 + 3.5 = 5.265
   RL of ceiling = 49.36 + 5.265 = 54.625 m
4. The first peg is at end point with staff reading 1.765, the staff reading of the subsequent pegs at 20 m interval will depend upon the rising gradient which is 1 in 100.
5. Difference in level between two consecutive readings = Distance/gradient = 20/100 = 0.2 m.
   The ground is rising by 0.2 m between the consecutive pegs.
6. Subsequent staff readings at pegs will be :
   Peg 1 = 1.765
   Peg 2 = 1.765 – 0.2 = 1.565 m
   Peg 3 = 1.565 – 0.2 = 1.365 m
   Peg 4 = 1.365 – 0.2 = 1.165 m

Que 1.21. **The following successive staff readings were taken with a level using 5 m leveling staff on a continuously sloping ground at an interval of 25 m :**
0.405, 1.035, 1.930, 2.895, 3.805, 4.760, 0.715, 2.060, 3.160, 4.415
The reduce level of the first point is known to be 62.980 m. Workout the staff reading by height of instrument method and find the gradient of the line joining the first and the last points.

AKTU 2018-19, Marks 07

Answer

Given : Staff interval = 25 m, RL of first point = 62.980 m
To Find : RL of various points and gradient of line joining the first and last point.

1. The reduce level of points are calculated by HI method and tabulated in table 1.21.1.

Table 1.21.1.

Station	Distance	Readings			HI	RL	Remarks
		BS	IS	FS			
A	0	0.405			63.385	62.98	
	25		1.035			62.35	
	50		1.930			61.455	
	75		2.895			60.49	
	100		3.805			59.58	
	125	0715		4.760	59.34	58.625	CP
	150		2.060			57.28	
	175		3.160			56.18	
B	200			4.415		54.925	

2. **Arithmetic Checks :**

$\Sigma BS - \Sigma FS = 1.12 - 9.175 = -8.055$ m

RL of last point – RL of first point = 54.925 – 62.98 = – 8.055 m

3. There is a full of 8.055 m in a distance of 200 m
4. Gradient = $\frac{8.055}{200}$ = 1 in 24.83

Que 1.22. **The consecutive readings taken with a levelling instrument at intervals of 20 m are 2.375, 1.730, 0.615, 3.450, 2.835, 2.070, 1.835, 0.985, 0.435, 1.630, 2.2255 and 3.630 m. The instrument was shifted after the fourth and eighth readings. The last reading was taken on BM of RL 110.200 m. Find the RL's of all the points.**

AKTU 2015-16, Marks 15

Answer

Given : RL of BM = 110.200 m, Staff reading at intervals = 20 m.
To Find : Reduce level of all points

1. By Using Rise and Fall Method :

Station	BS	IS	FS	Rise	Fall	RL
A	2.375			–	–	112.6205
		1.730		0.645		113.2655
		0.615		1.115		114.3805
(CP) B	2.835		3.450		2.835	111.5455
		2.070		0.765		112.3105
		1.835		0.235		112.5455
(CP) C	0.435		0.985	0.85		113.3955
		1.630			1.195	112.2005
		2.2255			0.5955	111.605
			3.630		1.405	110.200 (Given)
Σ	5.645		8.065	3.610	6.0305	

2. Checks : ΣBS – ΣFS = ΣRise – ΣFall
= Last point RL – First point RL = – 2.4205
where, CP = Change point of station.

Que 1.23. **Staff reading on the floor of a factory is 1.32 m and on a beam at the roof of truss when the bottom of the staff touching the beam is 3.705 m, RL of the beam is 475.00 m. What is the reduced level of the floor ?**

Answer

Given : Staff reading = 1.32 m, Inverted staff reading = 3.705 m
RL of beam = 475 m
To Find : RL of floor.

1. Height of instrument = 475 – 3.705 = 471.295 m
2. RL of the floor = 471.295 – 1.32 = 469.975 m

PART-8

Reciprocal Levelling, Distance of Visible Horizon.

Questions-Answers

Long Answer Type and Medium Answer Type Questions

Que 1.24. **What is reciprocal levelling ? When it is done ? Describe the method along with a sketch.**

AKTU 2015-16, Marks 10

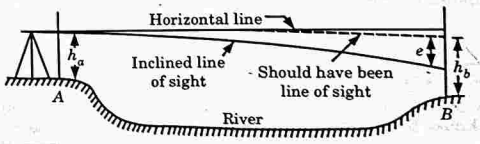
Answer

A. Reciprocal Levelling :

1. It is the operation of levelling in which the difference in elevation between two points is accurately determined by two sets of reciprocal observations.
2. This method is very useful when the instrument cannot be set up between the two points due to an obstruction such as a valley, river, etc., and if the sights are much longer than are ordinarily permissible.
3. For such long sights the errors of reading the staff, the curvature of earth, and the imperfect adjustments of the instrument become prominent.
4. Reciprocal levelling should be used to minimize these errors.

B. Method :

1. In it the instrument is once set very close to one point such that levelling staff can be observed at both the points and second time similarly very close to the second point.
2. Two points *A* and *B* are selected on either side of the depression as shown in Fig. 1.24.1. First let the instrument be set close to *A*.



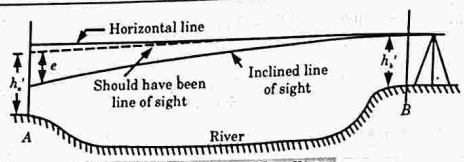


Fig. 1.24.1. Reciprocal levelling.

3. Let staff readings at stations A and B be h_a and h_b respectively.
4. Staff at A is very close to the instrument position, therefore, staff reading at $A(h_a)$ can be assumed to be free of errors, let the error in staff reading of station B due to line of collimation not being perpendicular to vertical axis be 'e'.
5. If sight is long it can be assumed to include error due to curvature and refraction also.
6. Observed staff reading at station, $B = h_b$
   Corrected reading at station, $B = h_b - e$.
   Difference in elevation between points A and B
   $$= h_a - (h_b - e) \quad ...(1.24.1)$$
7. Now shift the instrument to the other side and set it close to station B.
8. Let the staff readings at stations A and B be h'_a and h'_b respectively.
9. Staff of station B being close to the instrument can be assumed to be free of errors.
10. Because the distance between the two points A and B is same, error due to line of collimation not being perpendicular to vertical axis in staff reading of station A (h'_a) will be 'e' again.
11. Observed reading at station, $A = h'_a$
    Corrected reading at station, $A = h'_a - e$
    Difference in elevation between points A and B
    $$= (h'_a - e) - h'_b \quad ...(1.24.2)$$
12. Now adding eq. (1.24.1) and (1.24.2), we get
    2 × Difference in elevation between points A and B
    $$= [h_a - (h_b - e)] + [(h'_a - e) - h'_b]$$
    $$= (h_a - h_b) + (h'_a - h'_b)$$
    Difference in elevation between points A and B
    $$= \frac{1}{2}[(h_a - h_b) + (h'_a - h'_b)]$$

Que 1.25. Explain curvature and refraction correction in levelling. The eye of an observer is 7.5 m above sea level and he was able to see a light house 50 m high just above the horizontal. Find the distance between observer and lighthouse. **AKTU 2016-17, Marks 10**

Answer

A. Curvature Correction : The vertical distance between a horizontal line and the level line represent the effect of curvature of the earth.

B. Refraction Correction : The average refraction correction can, however, be taken as $\frac{1}{7}$ th of the curvature correction.

C. Effect of Curvature :

1. The effect of curvature is to increase the staff readings. When the distance are small the error is negligible, but for greater distances error is considerable more.
2. In Fig. 1.25.1(a) Q is the instrument position. A levelling staff CP is held vertically at P.
3. PC is the reading of staff for the horizontal line of sight AC. [But the actual line of sight is slightly bent towards the earth due to refraction] level line is a curved line when we take curvature of earth into account, thus AB is the level line.

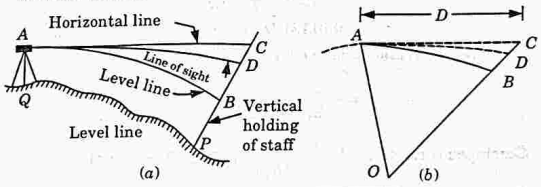


Fig. 1.25.1. Curvature and refraction.

4. Thus increase in staff reading due to curvature = $PC - PB = BC$.
5. Because staff reading is more therefore (i) level of point P will come out to be lower than the actual (ii) so the correction for curvature to be applied to the staff reading is, therefore to be negative and will be equal to BC.
6. Different positions of staff reading at P are reproduced in Fig. 1.25.1(b) where O is the centre of earth.
7. In right angled triangle OAC
   $OC^2 = OA^2 + AC^2$, $\angle CAO = 90°$
   $OA = OB = R$ (Radius of earth) and $AC = D$
   $(R + BC)^2 = R^2 + D^2$,
   $BC = C_c$ = Correction for curvature to be applied to staff reading.
   $(R + C_c)^2 = R^2 + D^2$
   $C_c(2R + C_c) = D^2$

$$C_c = \frac{D^2}{2R + C_c} = \frac{D^2}{2R}$$ (Neglecting C_c in comparison to $2R$)

$R = 6{,}370$ km

$C_c = 0.0785\, D^2$ meters (–ve)

where, D is in km.

D. Effect of Refraction :

1. Effect of refraction is to bend the line of sight towards the earth. As such the actual line is AD not AC.
2. So the correction for refraction to be applied to staff reading is positive and equal to DC as shown in Fig. 1.25.1(*b*).
3. For average conditions refraction curve is assumed to have a diameter about 7 times that of earth, so correction for refraction is $\frac{1}{7}$ of correction for curvature of earth.

$\therefore$ Correction for refraction, $C_r = \frac{1}{7} \times \frac{D^2}{2R}$ (+ ve)

$= 0.01121\, D^2$ meters, where D is in km.

Combined correction due to curvature and refraction

$$= -\frac{D^2}{2R} + \frac{1}{7}\left(\frac{D^2}{2R}\right)$$

4. Combined correction, $C = \frac{6}{7}\left(\frac{D^2}{2R}\right) = 0.06728 D^2$ m (–ve).

Numerical :

Given : Eye level of observer = 7.5 m, Height of light house = 50 m
To Find : Distance between observer and light house

Fig. 1.25.2.

1. Distance between observer and light house,

$D = D_1 + D_2$

$$= \sqrt{\frac{7.5}{0.0673}} + \sqrt{\frac{50}{0.0673}}$$

$= 10.55 + 27.25$

$D = 37.80$ km

2. Distance between observer and light house is 37.8 km.

Que 1.26. **What are the curvature and refraction errors in levelling ? An observer on the deck sees a light house which is 40 m above the sea level. The position of the observer's eye is 6.50 m above sea level. Determine the distance of the light house from the observer.** **AKTU 2018-19, Marks 07**

Answer

Curvature and Refraction Errors : Refer Q. 1.25, Page 1–27B, Unit-1.

Numerical :

Given : Eye level of observer = 6.5 m, Height of light house = 40 m
To Find : Distance between observer and light house

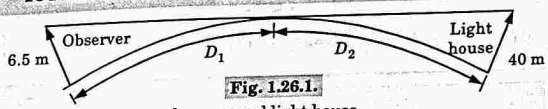


Fig. 1.26.1.

1. Distance between observer and light house,

$D = D_1 + D_2$

$$= \sqrt{\frac{6.5}{0.0673}} + \sqrt{\frac{40}{0.0673}}$$

$= 9.83 + 24.38$

$D = 34.21$ km

2. Distance between observer and light house is 37.8 km.

Que 1.27. **The following are observations in reciprocal levelling :**

Instrument Near	Staff Reading at A	Staff Reading at B	Remarks
A	1.825	2.750	Distance AB = 1020 m
B	0.930	1.615	RL of A = 126.325 m

Find true RL of B and combined correction for curvature and refraction. **AKTU 2014-15, Marks 06**

Answer

Given : Staff reading in table (Qus) RL of A = 126.325 m
Distance between A and B = 1020 m
To Find : True RL of B, Combined correction.

1. **When level at A :**
Staff reading on B = 2.750 m

Staff reading on A = 1.825 m
Apparent difference in level = 2.750 – 1.825 = 0.925 m

2. **When level at B :**
Staff reading on B = 1.615 m
Staff reading on A = 0.930 m
Difference in level = 1.615 – 0.930 = 0.685 m

3. True difference of level A and B = $\frac{0.925 + 0.685}{2}$ = 0.805 m

RL of B = 126.325 – 0.805 = 125.52 m

4. Combined correction for curvature and refraction
= 0.0673 D^2 (–ve)
Combined correction, C = 0.0673 × $(1.02)^2$ = 0.0700 m (–ve)

PART-9

Profile Levelling and Cross Sectioning, Errors in Levelling.

Questions-Answers

Long Answer Type and Medium Answer Type Questions

Que 1.28. Write a short note on :
A. Profile levelling.
B. Cross sectioning levelling.

Answer

A. Profile Levelling :

1. The operation of taking levels along the centre line of any alignment (road, railway, etc.) at regular intervals is known as longitudinal levelling.
2. In this operation, the backsight, intermediate sight and foresight readings are taken at regular intervals, at every set up of the instrument.
3. The chainages of the points are noted in the level book.
4. This operation in undertaken in order to determine the undulations of the ground surface along the profile line Fig. 1.28.1.

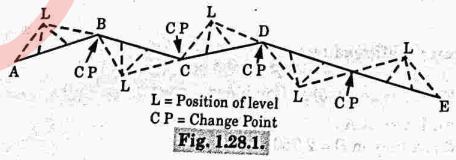


Fig. 1.28.1.

B. Cross-sectional Levelling :

1. The operation of taking levels transverse to the direction of longitudinal levelling, is known as cross-sectional levelling.
2. The cross-sections are taken at regular intervals (such as 20 m, 50 m, etc.) along the alignment.
3. Cross-sectional levelling is done in order to know the nature of the ground across the centre line of any alignment Fig. 1.28.2.

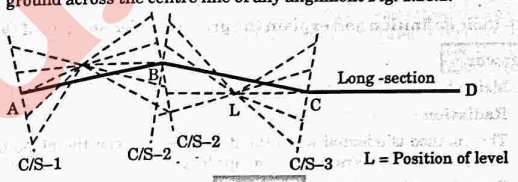


Fig. 1.28.2.

Que 1.29. What are the sources of error in levelling ?

Answer

The following are the different sources of error in levelling :

1. **Instrumental Errors :**
i. The permanent adjustment of the instrument may not be perfect. That is, the line of collimation may not be parallel to the axis of the bubble tube.
ii. The internal arrangement of the focusing tube is not perfect.
iii. The graduation of the levelling staff may not be perfect.

2. **Personal Errors :**
i. The instrument may not be levelling perfectly.
ii. The focusing of the eye-piece and object glass may not be perfect and the parallax may not be eliminated entirely.
iii. The position of the staff may be displaced at the change point at the time of taking FS and BS readings.
iv. A wrong entry may be made in the level book.
v. The staff may not be properly and fully extended.

3. **Errors Due to Natural Causes :**
i. When the distance of sight is long, the curvature of the earth may affect the staff reading.
ii. The effect of refraction may cause a wrong staff reading to be taken.
iii. The effect of high winds and a shining sun may result in a wrong staff reading.

PART-10

Introduction to Methods of Plane Table Levelling.

Questions-Answers

Long Answer Type and Medium Answer Type Questions

Que 1.30. **Which are the methods of plane tabling, enlist them with their definition and explain the procedure for any one of them.**

Answer

Methods of plane tabling are as follows :

1. **Radiation :**

i. This method is adopted when the distances between the plane table station and the objects is within a tape length.

ii. Once the table is set, the alidade is directed towards the object to be plotted with its straight (fiducial) edge touching the position of station on the sheet occupied by the plane table and a ray is drawn.

iii. Measure the distance of the object from the plane table station and plot it on the sheet to scale along the ray drawn.

Procedure of Radiation Method :

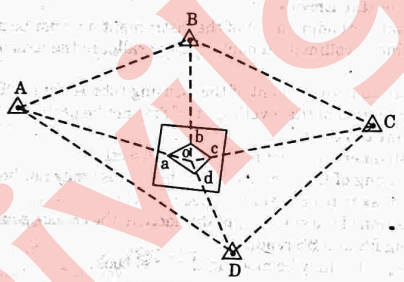


Fig. 1.30.1. Radiation with plane table.

i. Select a station *o* such that all the other stations *A*, *B*, *C* and *D* are accessible and visible from *o*.

ii. Plot the N–S direction. Setup a plane table at *o*.

iii. Place the alidade at *o* and successively sight stations *A*, *B*, *C* and *D*.

iv. Draw rays from *o* to the stations and cut the distances *oa*, *ab*, *oc* and *od* to the chosen scale.

5. Join *a*, *b*, *c* and *d*.

2. **Intersection :**

i. This method is adopted when the distances between the plane table station and the objects either too large or cannot be measured accurately due to some field conditions.

ii. For this method position of at least two stations should be available on the drawing sheet.

iii. The line joining the two stations is called base line.

iv. This method can also be used to locate other plane table stations but the point should be obtained by intersection of three or more rays.

3. **Traversing :**

i. Radiation method when used to plot the plane table stations of a closed or open traverse is termed as traversing.

ii. Diagonals are used as check lines.

iii. It is most suited when a narrow strip of terrain is to be surveyed.

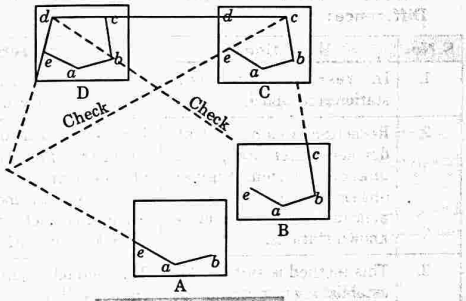


Fig. 1.30.2. Traversing.

4. **Resection :**

i. Resection is a method of orientation employed when the table occupies a station whose position is not yet available on drawing sheet.

ii. It is done by means of sights towards known points whose location on the sheet is available.

iii. The resection of two rays will be the point representing the station to be located, provided the orientation at the station to be plotted is correct, which is seldom achieved.

iv. This method is employed when during surveying the surveyor feeds that some important details can be plotted easily by choosing any station other than the triangulation stations.

v. This method is not preferred if one of the other two methods can be used due to the effect of local attraction on the accuracy of orientation.

vi. However, this method is generally used for rapid and approximate orientation before final orientation by other methods.

vii. This method is independent of magnetic compass and thus, not affected by local attraction. It is essential that the same edge of the alidade is used for drawing lines. It may be ensured that the back ray remains vertically above the ground position of the forward station.

Que 1.31. What is orientation in plane table surveying ? Distinguish between resection and intersection methods as applied to plane table surveying.

Answer

Orientation : It is the process of putting the plane table into such a position that a line representing a certain direction on the planes parallel to the direction on the ground or bringing the plane table parallel to the position it occupied at the previous station. Centering and orientation should be done simultaneously.

Difference :

S. No.	Resection	Intersection
1.	In resection unknown station is occupied.	In intersection the unknown station is observed.
2.	Resection uses measuring devices, which occupy the unknown station. Angular observations are then measured to three or more known stations.	Intersection approach on the contrary measures angular observations to the unknown station, with the measuring device occupying each of the three or more known stations.
3.	This method is suitable for establishing new stations at a place in order to locate missing details.	This method is suitable for locating inaccessible points by the intersection of the rays drawn from two instrument stations.

Que 1.32. What is orientation ? What are the methods of orientation ? Describe the methods with a sketch.

AKTU 2017-18, Marks 07

Answer

A. Orientation : Refer Q. 1.31, Page 1–35B, Unit-1.

B. Method of Orientation : Orientation can be done in three ways.

1. By Trough Compass :

i. With the help of trough compass or circular compass magnetic meridian is draw on sheet at the first station.

ii. When the table is shifted to the successive station, the trough compass or circular compass is placed along the drawn meridian.

iii. Then the board is turned until the zero of the needle points the meridian exactly.

iv. The board is then clamped in position.

v. This method is suitable for small scale plotting.

vi. This method is sufficiently accurate provided there is no local attraction.

2. By Back Sighting :

i. This is the most accurate method of orientation. The plane table is set on a new station and the alidade is placed against the line joining the new station with the preceding station.

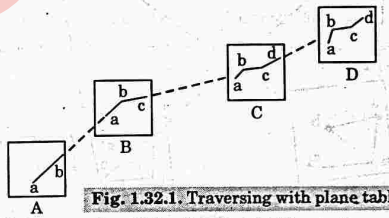


Fig. 1.32.1. Traversing with plane table.

ii. The table is rotated until the line of sight bisects the previous station.

iii. To achieve this, let the plane table be shifted from station *A* to *B*, and let the line *ab* has been plotted with the plane table at *A*.

iv. Set up the table on *B*, place the alidade along the plotted line *ba* and rotate the table until the line of sight bisects the station *A*. Clamp the board.

v. The line *ba* truly represents the line *BA* on the ground.

3. Resection : Refer Q. 1.30, Page 1–33B, Unit-1.

Que 1.33. Explain the two point problem of plane tabling with a neat sketch.

AKTU 2016-17, Marks 10

Answer

Resection after Orientation by Two Points :

The two-point problem consists of locating the position of a plane table station on the drawing sheet by observation of two well-defined points, whose positions have already been plotted on plan.

Procedure :

1. Let *A* and *B* be the two stations plotted as *a* and *b* on the drawing sheet Fig. 1.33.1. It is required to plot station *C*, where the plane tabling is to be done.

2. Choose an arbitrary station D such that CD is approximately parallel to AB. $\angle CAD$ and $\angle CBD$ should not be very acute, which is the necessary condition for good intersection of points.
3. Set up the plane table at D. Orient it approximately by eye judgment such that ab is parallel to AB. Clamp the table.
4. Pivot the alidade against a, sight A, and draw a back ray. Pivot the alidade against b, sight B, and draw a back ray. The two rays intersect at d_1.

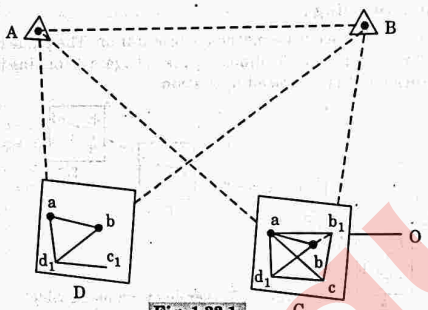


Fig. 1.33.1.

5. This will not be the correct position of D as the orientation at D is not exact.
6. Pivot the alidade against d_1 and sight C. Draw a ray d_1c and fix the position of c_1 by estimation.
7. Shift the table to station C. Set up the table and orient it by back sighting at station D.
8. Pivot alidade against a, sight A and draw a back ray resecting the line d_1c_1 in c.
9. Pivot the alidade at c and sight B. Draw a ray to B. If the ray passes through the plotted point b, the orientation of the table is correct and c is the correct position of C. Whereas, if this ray cuts the previously plotted line d_1b at some other point, say b_1, then the position c is not the correct position of C.
10. To eliminate this error the table must be rotated by the $\angle b_1ab$. To do this a ranging rod O is fixed, in line with ab_1 far away from the plane table. The alidade is kept along ab_1 and O is bisected.
11. The alidade is kept along ab and the table is rotated till the ranging rod at O is bisected. It is oriented now. The table is then clamped.
12. With alidade touching a sight A and draw a back ray to C. Then, with alidade touching b, sight B and draw a back ray to C. The resection of these two rays gives the position of C.

Que 1.34. What do you understand by three point problem, explain Lehmann's method and rules for solving it.

Answer

A. Three Point Problem :

1. The three-point problem consists in locating the position of a plane table station on the drawing sheet by means of observation of three well defined points, whose positions have already been plotted on plan.
2. In this type of problem, position of three ground stations A, B, C is available on the drawing sheet as a, b, c. Let P be the station occupied by the plane table whose position is to be located on the drawing sheet.

B. Lehmann's Method or Trial and Error Method :

1. Suppose A, B and C are three well-defined points which have been plotted as a, b, and c on the map. Now it is required to establish a station at P.
2. The table is set up at P and levelled. Orientation is done by eye estimation.
3. With the alidade, rays Aa, Bb and Cc are drawn. As the orientation is approximate, the rays may not intersect at a point, but may form a small triangle- the triangle of error.
4. To get the actual point, this triangle of error is to be eliminated. By repeatedly turning the table clockwise or anticlockwise, the triangle is eliminated in such a way that the rays Aa, Bb, and Cc finally meet at a point p. This is the required point on the map. This point is transferred to the ground by U-fork and plumb bob Fig. 1.34.1.

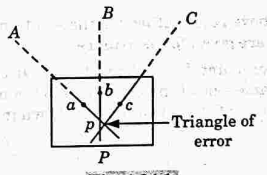


Fig. 1.34.1.

Lehmann's Rules :

i. The distance of the point p from each of the rays Aa, Bb and Cc is in proportion to the distance of A, B and C from P respectively.

ii. When looking in the direction of each of the distant points A, B and C, the point p will be found on the same side of the three rays Aa, Bb and Cc *i.e.*, it is either to the left or to the right of each of the three rays as shown in Fig. 1.34.2 and Fig. 1.34.3.

iii It follows from the above two rules that if the instrument station P lies outside the great triangle ABC, the triangle of error falls outside abc and the required point p is outside the triangle of error as shown in Fig 1.34.2 and Fig. 1.34.3.

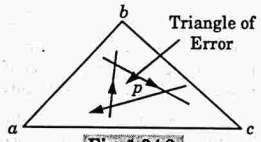


Fig. 1.34.2.

iv. Similarly if the station P lies within the great triangle ABC, the triangle of error falls inside the triangle abc and the point p must within the triangle of error as shown in Fig. 1.34.3.

Note : The triangle formed by joining the ground points the great triangle, while the circle passing through these points is known as the great circle.

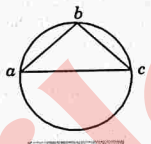


Fig. 1.34.3.

v. Although the above rules suffice for the solution of the problem, yet two more rules are given for assistance :

vi. When the station-point P is outside the great circle, the point p is always on the same side of the ray drawn to the most distant point as the intersection (e) of other two rays as shown in Fig. 1.34.4.

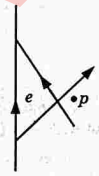


Fig. 1.34.4.

vii. When the station-point P is outside the great triangle ABC, but inside the great circle *i.e.*, within one of the three segments of the great circle, formed by the sides of the great triangle, the ray drawn towards the middle point lies between the point p and the intersection (e) of the order two rays.

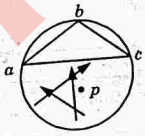


Fig. 1.34.5.

Que 1.35. State the three point problem, explain how it is solved by the graphical method ? **AKTU 2016-17, Marks 10**

Answer

A. Three Point Problem : Refer Q. 1.34, Page 1–38B, Unit-1.

B. The Graphical Method :

1. Suppose A, B and C are three well-defined points which have been plotted as a, b, and c. Now it is required to locate a station at P.
2. The table is placed at the required station P and levelled. The alidade is placed along the line ca and the point A is bisected. The table is clamped. With the alidade centred on C, the point B is bisected and ray is drawn as shown in Fig. 1.35.1(a).

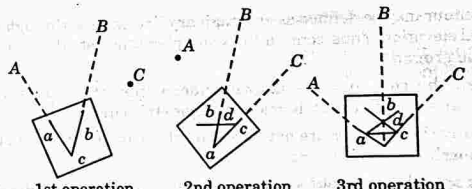


Fig. 1.35.1.

3. Again the alidade is placed along the line ac and the point C is bisected and the table is clamped. With the alidade touching a, the point B is bisected and a ray is drawn. Suppose this ray intersects the previous ray at a point d as shown in Fig. 1.35.1(b).

4. The alidade is placed along *db* and the point *B* is bisected. At this position the table is said to be perfectly oriented. Now the rays *Aa*, *Bb* and *Cc* are drawn.
5. These three rays must meet at a point *p* which is the required point on the map. This point is transferred to the ground by *U*-fork and plumb bob shown in Fig. 1.35.1(*c*).

PART-11
Contouring

Questions-Answers
Long Answer Type and Medium Answer Type Questions

Que 1.36. **Define contour and write the characteristics of contour.**

AKTU 2014-15, Marks 06
AKTU 2015-16, Marks 07
AKTU 2018-19, Marks 04

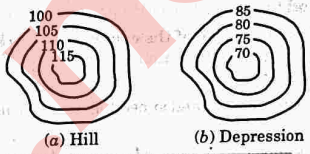
Answer

A. Contour :

1. A contour may be defined as an imaginary line passing through points of equal elevation. Thus, contour lines on a plan illustrate the conformation of the ground.
2. When the contours are drawn underwater, they are termed as submarine contours, fathoms or bathymetric curves.
3. Usually the contours are not visible on the grounds except in the case of shorelines.

B. Characteristics : Following are the characteristics of contour :

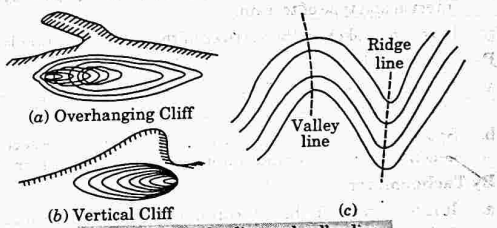
1. Contours are smooth curves.
2. No two contours intersect each other except in case of an overhanging cliff or a cave penetrating a hill side.
3. A contour line must close on to itself, not necessarily within the limits of a map.
4. Contours are perpendicular to the line of steepest slope because the perpendicular distance between contour lines is the shortest distance.



(*a*) Hill (*b*) Depression

Fig. 1.36.1. Hill and depression.

5. Close contour lines indicate steep slope.
6. Wide spaced contour lines indicate gentle slope.
7. Contour lines equally spaced indicate uniform slope.
8. A closed contour with higher ones within it represents a hill as shown in Fig. 1.36.1(*a*).
9. A closed contour with lower ones within it represents a pond, lake or a depression as shown in Fig. 1.36.1(*b*).



(*a*) Overhanging Cliff

(*b*) Vertical Cliff (*c*)

Fig. 1.36.2. Ridge line and valley line.

10. Ridges and valley (lines) are perpendicular to the contours where contours form somewhat U shape with concave side on higher side in case of ridges and concave side on lower side in case of valleys as shown in Fig. 1.36.2(*c*).

Que 1.37. **Discuss the method of contouring. What are the various methods of interpolating contour ? State the suitability of each one of them.**

AKTU 2016-17, Marks 10

OR

Explain the indirect method of contouring.

AKTU 2016-17, Marks 05

Answer

A. Methods : Following are the methods of surveying for contours :

1. **Direct Method :**

i. The points of the elevation of the contour are marked on the ground with a level and then their position surveyed by chain survey, compass survey or plane table survey.

ii. Their positions are plotted and joined together to complete the contour line.

iii. This method is slow and is adopted in accurate surveys.

2. **Indirect Method :** Levels of different ground points are taken plotted and contours drawn by interpolation. While interpolating, it is assumed that the slope between any two adjacent points is uniform.

Following are the methods used for indirect method of contour :

i. **By Squares or Rectangles :**

a. It is adopted when the area to be surveyed is small and ground not very much undulating.

b. Size of squares varies from 5 to 20 m depending upon the contour interval and type of terrain.

c. Levels are taken at the vertices of the squares/rectangles.

ii. **By Cross-Sections :**

a. In this method, cross sections are run from a line and levels taken at regular intervals along the cross section lines.

b. Spacing of cross section lines and that on the cross section lines depends upon the contour interval and the type of terrain.

iii. **By Tacheometer :**

a. It is best suited for hilly terrain. Staff is held vertical cautiously and stadia hair readings taken.

b. Let s = Difference of stadia hair readings. Then

Horizontal distance, $D = k\,s\cos^2\theta + C\cos\theta$ and

Vertical distance, $V = D\tan\theta$

where, k and C are multiplying and additive constants of the tacheometer respectively.

c. Radial lines are surveyed around a station with a tacheometer.

B. **Methods of Interpolating Contours :** Following are the methods of interpolating contours :

1. **By Estimation :**

i. This is very crude method and is usually adopted where the ground forms are quite regular, the scale of the map is small, and high accuracy is not required.

ii. The positions of the contour points between the ground points are estimated and contours are drawn through them.

iii. It is assumed that the slope between the ground points is uniform.

2. **By Arithmetic Calculations :**

i. This method is used when high accuracy is required and the scale of the map is of intermediate or large.

ii. In this method the distance between two points of known elevations are accurately measured.

iii. Then with the help of arithmetic calculations, the positions of the required elevation points are computed.

3. **By Graphical Method :**

i. When high accuracy is required and many interpolations are to be made, this method of plotting contours proves to be the most rapid and convenient.

ii. On tracing paper, parallel lines are drawn at some fixed interval, say 0.5 m. Every tenth line is made thicker.

Que 1.38. What are the applications of contour map ?

AKTU 2018-19, Marks 03

Answer

Uses of Contour Maps : Following are the important uses of contour map.

1. To draw sections along a line.
2. To determine intervisibility of triangulation stations.
3. To know location of route.
4. To mark water sheds and drainage lines.
5. To measure drainage area or catchment area of a river.
6. In the calculation of capacity of a reservoir.

Que 1.39. What are the advantages and disadvantages of indirect method of contouring ?

AKTU 2016-17, Marks 05

Answer

Advantages of Indirect Method :

1. It depicts slope and size of different landforms on map.
2. By reading contour interval it is easy to determine the different elevation of the landscape.
3. It provides the basis for coloring method.
4. It can be used in drawing cross section of the given features on the mapped area.

Disadvantages of Indirect Method :

1. Contour fails to show some of the heights due to limitation of vertical interval.
2. Some of the landforms cannot be shown by using contours for example coral reef, outcrop rock and craters.
3. Contour method is mostly not used to show relief on small scale map as it may obscure some details.

PART-12

Computation of Areas and Volumes.

Questions-Answers

Long Answer Type and Medium Answer Type Questions

Que 1.40. **State the trapezoidal rule and Simpson's rule. What is the limitation of Simpson's and trapezoidal rule ?**

Answer

1. **Trapezoidal Rule :** To the sum of the first and the last ordinate, twice the sum of intermediate ordinates is added. This total sum is multiplied by the common distance. Half of this product is the required area :

i. While applying the trapezoidal rule, boundaries between the ends of ordinates is assumed to be straight.

ii. Thus the areas enclosed between the base line and the irregular boundary line are considered as trapezoids.

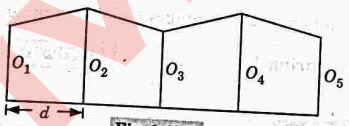


Fig. 1.40.1.

Let $O_1, O_2, ..., O_n$ = Ordinates at equal intervals.

d = Common distance.

$$\text{Total area} = \frac{d}{2}\{O_1 + 2O_1 + 2O_2 + ... + 2O_{n-1} + O_n\}$$

$$= \frac{\text{Common distance}}{2}$$

{(1st ordinate + last ordinate + 2 (sum of other ordinate))}

Limitation : There is no limitation for this rule. This rule can be applied for any number of ordinates.

2. **Simpson's Rule :** To the sum of the first and the last ordinate, four times the sum of even ordinates and twice the sum of the remaining odd ordinates are added. This total sum is multiplied by the common distance. One-third of this product is the required area :

i. In this rule, the boundaries between the ends of ordinates are assumed to form an arc of a parabola.

ii. Hence Simpson's rule is sometimes called the parabolic rule.

Let, O_1, O_2, O_3 = Three consecutive ordinates.

d = Common distance between the ordinates.

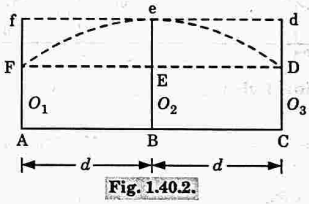


Fig. 1.40.2.

$$\therefore \text{Total area} = d/3(O_1 + 4O_2 + 2O_3 + 4O_4 + ... + O_n)$$

$$= d/3\{O_1 + O_n + 4(O_2 + O_4 + ...) + 2(O_3 + O_5 + ...)\}$$

$$= \frac{\text{Common distance}}{3}$$ [(1st ordinate + last ordinate) + 4 (sum of even ordinates)] + 2 (sum of remaining odd ordinates)

Limitation : This rule is applicable only when the number of divisions is even, *i.e.*, the number of ordinates is odd.

Que 1.41. **What are the difference between trapezoidal rule and Simpson's rule ?**

Answer

S. No.	Trapezoidal Rule	Simpson's Rule
1.	The boundary between the ordinates is considered to be straight.	The boundary between the ordinates is considered to be an arc of a parabola.
2.	There is no limitation. It can be applied for any number of ordinates.	To apply this rule, the number of ordinates must be odd. That is, the number of divisions must be even.
3.	It gives an approximate result.	It gives a more accurate result.

Que 1.42. **The following offsets were taken from a chain line to an irregular boundary line at an interval of 10 m :**
0, 2.50, 3.50, 5.00, 4.60, 3.20, 0 m
Compute the area between the chain line, the irregular boundary line and the end offsets by :
1. The trapezoidal rule.
2. Simpson's rule.

Answer

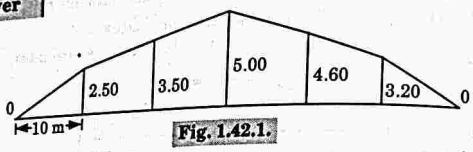


Fig. 1.42.1.

1. **By Trapezoidal Rule :**
Here $d = 10$

$$\text{Required area} = \frac{10}{2}\{0 + 0 + 2(2.50 + 3.50 + 5.00 + 4.60 + 3.20)\}$$
$$= 5 \times 37.60 = 188 \text{ m}^2$$

2. **By Simpson's Rule :**
$d = 10$

$$\text{Required area} = \frac{10}{3}\{0 + 0 + 4(2.50 + 5.00 + 3.20) + 2(3.50 + 4.60)\}$$
$$= \frac{10}{3}\{42.80 + 16.20\} = \frac{10}{3} \times 59.00$$
$$= \frac{10}{3} \times 59.00 = 196.66 \text{ m}^2$$

Que 1.43. **A page of the field book of a cross-staff survey is given in Fig. 1.43.1. Plot the required figure and calculate the relevant area.**

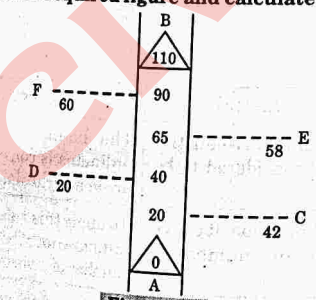


Fig. 1.43.1.

Answer

1. The figure is plotted as follows Fig. 1.43.1.

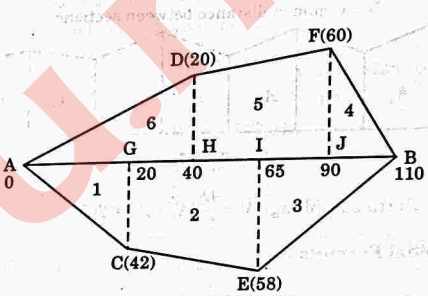


Fig. 1.43.2.

2. The calculation for area is given in the following table :

Sl No.	Figure	Chainage (m)	Base (m)	Offset (m)	Mean offset(m)	Area (m²) +ve	Area (m²) –ve	Remark
1	2	3	4	5	6	7	8	9
1	ΔACG	0 and 20	20	0 and 42	21	420	—	Area = Col (4) × Col (6)
2	Trap. GCEI	20 and 65	45	42 and 58	50	2,250	—	
3	ΔIEB	65 and 110	45	58 and 0	29	1,305	—	
4	ΔBFJ	90 and 110	20	0 and 60	30	600	—	
5	Trap. FJHD	40 and 90	50	60 and 20	40	2,000	—	
6	ΔDHA	0 and 40	40	20 and 0	10	400	—	
						6975		

3. Area of field = 6975 m²

Que 1.44. **Give the formulae for computation of volume and their limitations.**

Answer

A. Trapezoidal Rule (Average End Area Rule) :

D = Common distance between sections

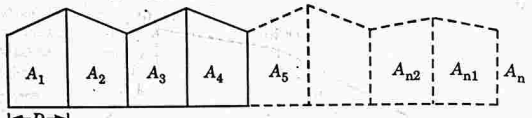


Fig. 1.44.1.

Volume (Cutting or filling), $V = \frac{D}{2}\{A_1 + A_n + 2(A_2 + A_3 + \ldots + A_{n-1})\}$

B. Prismoidal Formula :

Volume (Cutting or filling), $V = \frac{D}{3}\{A_1 + A_n + 4(A_2 + A_4 + A_{n-1}) + 2(A_3 + A_5 + \ldots + A_{n-2})\}$

Limitation : The prismoidal formula is applicable when there are an odd number of sections. If the number of section is even, the end strip is treated separately and the area is calculated according to the trapezoidal rule.

Que 1.45. **An embankment of width 10 m and side slopes $1\frac{1}{2}$: 1 is required to be made on a ground which is level in a direction transverse to the centre line. The central heights at 40 m intervals are as follows :**

0.90, 1.25, 2.15, 2.50, 1.85, 1.35, and 0.85

Calculate the volume of earth work according to :

i. The trapezoidal formula, and

ii. The prismoidal formula.

Answer

1. The cross-sectional areas are calculated by,

$\Delta = (b + Sh) \times h$

$\Delta_1 = (10 + 1.5 \times 0.90) \times 0.90 = 10.22 \text{ m}^2$

$\Delta_2 = (10 + 1.5 \times 1.25) \times 1.25 = 14.84 \text{ m}^2$

$\Delta_3 = (10 + 1.5 \times 2.15) \times 2.15 = 28.43 \text{ m}^2$

$\Delta_4 = (10 + 1.5 \times 2.50) \times 2.5 = 34.38 \text{ m}^2$

$\Delta_5 = (10 + 1.5 \times 1.85) \times 1.85 = 23.63 \text{ m}^2$

$\Delta_6 = (10 + 1.5 \times 1.35) \times 1.35 = 16.23 \text{ m}^2$

$\Delta_7 = (10 + 1.5 \times 0.85) \times 0.85 = 9.58 \text{ m}^2$

2. Volume according to trapezoidal formula :

$V = \frac{40}{2}\{10.22 + 9.58 + 2(14.84 + 28.43 + 34.38 + 23.63 + 16.23)\}$

$= 20\{19.80 + 235.02\} = 5,096.4 \text{ m}^3$

3. Volume calculated in prismoidal formula :

$V = \frac{40}{3}\{10.22 + 9.58 + 4(14.84 + 34.38 + 16.23) + 2(28.43 + 23.63)\}$

$= \frac{40}{3}(19.80 + 261.80 + 104.12) = 5,142.9 \text{ m}^3$

PART-13

Theodolite Survey : Instruments, Measurement of Horizontal and Vertical Angle, Methods of Horizontal and Vertical Control.

Questions-Answers

Long Answer Type and Medium Answer Type Questions

Que 1.46. **Explain the geometry of theodolite with figure.**

Answer

Following are the element of theodolite :

1. **Trivet or Base Plate :** It is a circular plate having a central, threaded hole for fixing the theodolite on the tripod stand by a wing nut.
2. **Foot Screws :** These are meant for levelling the instrument. The lower part of the foot screws are secured in the trivet by means of a ball-and-socket arrangement, and the upper threaded part passes through the threaded hole in the tribrach plate.
3. **Levelling Head :** The trivet, foot screws and the tribrach constitute a body which is known as the levelling head.
4. **Lower Plate :**

i. The lower plate is attached to the outer axis, and is also known as the scale plate.

ii. It is levelled and the scale is graduated from 0 to 360° in a clockwise direction.

5. **Upper Plate :** The upper plate contains the vernier scales *A* and *B*. It is attached to the inner axis. Its motion is controlled by the upper clamp screw and the upper tangent screw.

6. Plate Bubble :

i. Two plate bubbles are mounted at right angles to each other on the upper surface of the vernier plate.

ii. One bubble is kept parallel to the horizontal axis of the theodolite. Sometimes one plate bubble is provided on the vernier plate.

iii. The bubbles are meant for levelling the instrument at the time of measuring the horizontal angles.

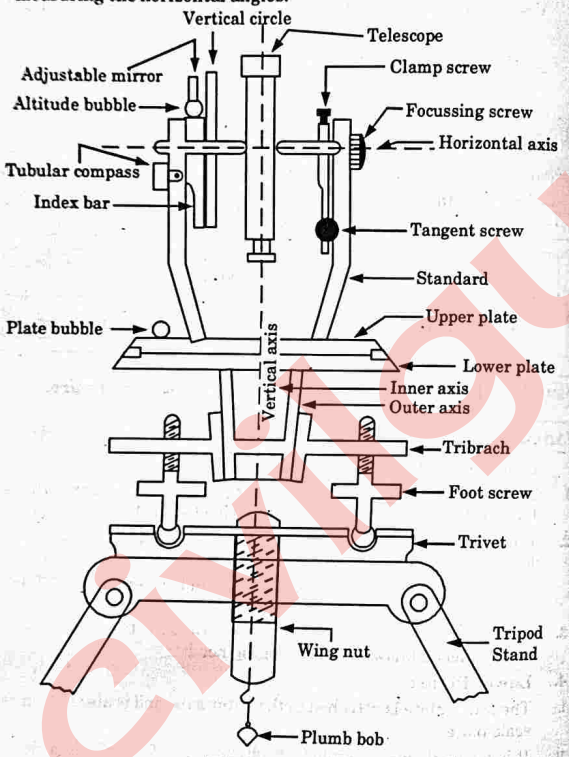


Fig. 1.46.1.

7. Standard or 'A' Frame : Two frames (shaped like the letter 'A') are provided on the upper plate to support the telescope, the vertical circle and the vernier scales. These frames are known as standards or A-frames.

8. Telescope :

i. The telescope is pivoted between the standards at right angles to the horizontal axis. It can be rotated about its horizontal axis in a vertical plane.

ii. The telescope is provided with a focusing screw, clamping screw and tangent screw.

9. Vertical Circle :

i. The vertical circle is rigidly fixed with the telescope and moves with it. It is divided into four quadrants.

ii. Each quadrant is graduated from 0 to 90° in opposite directions, with the 'zero' mark at the ends of the horizontal diameter of the vertical circle.

10. Altitude Bubble :

i. A long sensitive bubble tube is provided on the top of index bar.

ii. The bubble it contains is brought to the centre by the clip screw at the time of measuring the vertical angle.

11. Compass :

i. Sometimes a circular box compass is mounted on the vernier scale between the standards.

ii. In modern theodolites, an adjustable trough compass or tubular compass can be fitted with a screw to the standard for taking the magnetic bearing of a line.

Que 1.47. What are the fundamental lines and their desired relations in a theodolite ? **AKTU 2014-15, Marks 3.5**

Answer

A. Fundamental Lines or Axis : The fundamental axis of a theodolite are :

1. The vertical axis.
2. The trunnion axis or horizontal axis.
3. The line of collimation or line of sight.
4. Axis of plate levels.
5. Axis of altitude level.
6. Axis of striding level, if provided.

B. Relation between different Fundamental Axis of a Theodolite :

The relationships are as under :

1. Axis of plate levels must be perpendicular to the vertical axis.
2. The vertical cross hair of the diaphragm must be truly vertical.
3. The line of sight must be perpendicular to the horizontal axis.

4. The horizontal axis must be perpendicular to the vertical axis.
5. The line of collimation, the horizontal axis and the vertical axis must intersect at a point.
6. The line of collimation must be parallel to axis of altitude level.
7. The vertical circle must read zero when the line of collimation is horizontal.

Que 1.48. **Describe the process of repetition and reiteration in theodolite survey.** **AKTU 2015-16, Marks 10**

OR

Explain the process of repetition and reiteration in theodolite survey. **AKTU 2018-19, Marks 07**

Answer

A. Measuring Horizontal Angle by Repetition Method :

1. To measure an angle, say *ABC*, by the method of repetition, set up the instrument at *B* and level it. The telescope should be in normal position.
2. Loosen the upper clamp and turn the upper plate until the index (the arrow) of the vernier *A* coincides with the zero (or 360°) of the horizontal circle.
3. Clamp both the plates with the upper clamp. Turn the upper slow motion (tangent) screw so as to make the two zeros exactly coincident.
4. Tighten the lower clamp and bisect station *A* exactly by the lower tangent screw. Read both the verniers.
5. Unclamp the upper plate and swing the telescope clockwise. Bisect station *C* by the upper clamp and tangent screw.
6. Read both the verniers. Take the average to get angle *ABC*.
7. Unclamp the lower plate and swing the telescope clockwise and bisect station *A* accurately by using the lower clamp and lower tangent screw.
8. Read both the verniers. Check the vernier reading. It should be the same (unchanged) as that obtained in step 6.
9. Release the upper plate by using the upper clamp and tangent screw and bisect station *C* accurately (the telescope is turned clockwise). The vernier will read twice the angle *ABC*.
10. Repeat the process for required number of times, say three times, and find out the value of angle *ABC*.
11. Repeat the above procedure with the face changed and calculate the angle *ABC*.
12. The average of the two values of angle *ABC* thus obtained with face left and face right gives a precise value of the horizontal angle.

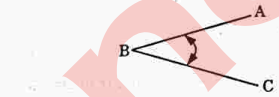


Fig. 1.48.1. Horizontal angle by repetition.

B. Measuring Horizontal Angle by Reiteration Method :

1. This method is adopted when several angles are to be measured at a station (say angles *POQ*, *QOR*, *ROS* and *SOP*) are to be measured. Finally the horizon is closed.
2. The step wise procedure is as follows :

i. Set the instrument at station *O* and level it.

ii. Carry out the steps of measuring horizontal angle process for angle *QOR*.

iii. Loosen the upper clamp.

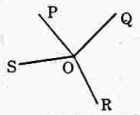


Fig. 1.48.2.

iv. Similarly measure angles *ROS*, *SOP*, *POQ*.

v. Finally close the horizon. The vernier readings should be the same as these were at the start. If not, distribute the discrepancy equally amongst all the angles.

vi. Change face and measure all the angles again with changed face.

vii. Average of face left and face right observations gives the measure of each angle.

PART-14

Triangulation : Figures or Systems, Signals, Satellite Station, Baseline and its Importance, Corrections.

Questions-Answers

Long Answer Type and Medium Answer Type Questions

Que 1.49. **What is triangulation and what are the various methods for it ?**

Answer

A. Triangulation :

1. The method of measuring the chain angle of a framework of triangle being formed by making the station on the surface of the earth is called as triangulation.
2. In triangulation the length of one line called "base line" is measured very precisely. This is generally the most central and longest line of the network.
3. All the angles are measured very precisely.
4. The process is continued till whole of the sides of the framework have been computed applying sine rule $\frac{\sin A}{a} = \frac{\sin B}{b} = \frac{\sin C}{c}$.

B. Methods : There are two methods :

1. Grid iron system. 2. Centered system.

1. Grid iron System :

i. Grid iron system primary triangulation is laid in series of chains of triangles usually run roughly along the meridians (north-south) and along the perpendiculars to the meridians (east-west) throughout the country distance between two chains may vary from 150 km to 250 km

ii. Area between the parallel and perpendicular series of primary triangulation is covered by the secondary and tertiary triangulation systems. Adopted in India, Austria, Spain and France

2. Centered System : Centered system whole area of the survey is covered by a net work of primary triangulation extending outwards in all directions from the initial base line, base line is generally laid at the centre of the country used for the survey of an area of moderate extent adopted in United Kingdom.

Que 1.50. Describe the various triangulation figures.

Answer

Following are the triangulation figure :

1. Single Chain of Triangles :

i. Single chain of triangles is suitable where a narrow strip of terrain. *e.g.*, road, railway, canal is to be surveyed.

ii. The survey of this figure is rapid and economical.

iii. Only check available is sum property of angles of a triangle. It is necessary to have sufficient number of "check bases" as a check on the work done.

iv. Therefore a single chain of triangles is never adopted for high order triangulation.

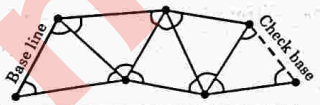


Fig. 1.50.1. Single chain of triangles.

2. Double Chain of Triangles : A double chain of triangles cover a wider area and are preferred.

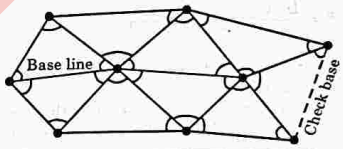


Fig. 1.50.2. Double chain of triangles.

3. Quadrilaterals :

i. Quadrilaterals with four sides and two diagonals form eight angles within it and measuring all the eight angles is the most accurate system because of more number of checks available.

ii. There is no station at the intersection of diagonals.

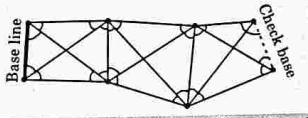


Fig. 1.50.3. Quadrilaterals with two diagonals and eight angles.

4. Polygons with or without a Station Inside :

i. In it polygonal figures e.g. quadrilaterals, pentagons, hexagons (with or without a station inside) are used, though basically these all consist of triangles.

ii. It is a slow process because of more settings of the instrument but give accurate results.

iii. It is suitable for wide areas. Stations inside polygons need not be at intersection of diagonals.

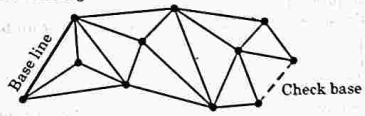


Fig. 1.50.4. Polygons with central points.

Que 1.51. **What is strength of figure ? How is it determined ?**

Answer

1. The strength of figure is a factor to be considered in establishing a triangulation system to maintain the computations within a desired degree of precision.
2. It plays also an important role in deciding the layout of triangulation system.

$$R = \frac{D-C}{D}\Sigma(\delta_A^2 + \delta_A\delta_B + \delta_B^2) \qquad ...(1.51.1)$$

where,

D = Number of directions observed excluding the known side of the figure.

$\delta_A, \delta_B, \delta_C$ = Difference per second in the sixth place of logarithm of the sine of the distance angles A, B and C, respectively. (Distance angle is the angle in a triangle opposite to a side).

C = Number of geometric conditions for side and angle to be satisfied in each figure. It is given by,

$C = (n' - S' + 1) + (n - 2S + 3)$

n = Total number of lines including the known side in a figure.

n' = Number of lines observed in both directions including the known side.

S = Total number of stations.

S' = Number of stations occupied.

3. In any triangulation system more than one route are possible for various station.
5. The strength of figure decided by the factor R alone determines the most appropriate route to adopt the best shaped triangulation network.
6. If the computed value of R is less, the strength of figure is more and vice versa.

Que 1.52. **Determine the value of $(D - C)/D$ for the triangulation figures (D and C is related with strength of triangulation figure) if all the stations have been occupied and all the line have been observed in both directions :**

A. A braced quadrilateral.

B. A four sided central point figure without diagonals.

Answer

A. Braced Quadrilateral Figure :

1. In the triangulation system, the braced quadrilateral figure is more suited and hence it should be adopted whenever it is feasible and possible.

2. When the quadrilateral is near about square or if the triangle is near about equilateral, then it gives the maximum strength with a minimum of essential geometric conditions.

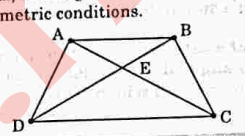


Fig. 1.52.1. Braced quadrilateral.

3. We know that, $C = (n' - S' + 1) + (n - 2S + 3)$

where,

n = Total number of lines (including known side) = 6,

S = Total number of stations = 4

S' = Number of station occupied = 4

n' = Number of lines observed in both direction including known side = 6

4. $C = (6 - 4 + 1) + (6 - 2 \times 4 + 3) = 4$

D = number of direction observed (forward and backward) excluding those along known side $= 5 \times 2 = 10$

$$\therefore \quad \frac{D-C}{D} = \frac{10-4}{10} = 0.6$$

B. Four-Sided Central Point Figure without Diagonals :

1. Fig. 1.52.2 shows four sided central point figure without diagonals.
2. This type of figure is probably used when both the diagonal are obstructed.

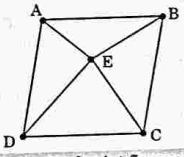


Fig. 1.52.2. Four-sided central point figure without diagonal.

3. From Fig. 1.52.2, excluding one known side we get, number of forward directions = $AB + BC + CD + CE + BE + AE + DE = 7$, (provided that side AD is known)
4. Number of backward direction $= BA + CB + DC + EC + EB + EA + ED = 7$
5. $D = 7 + 7 = 14$
6. $n = 8, n' = 8, S = 5, S' = 5$

$C = (n' - S' + 1) + (n - 2S + 3)$

$C = (8 - 5 + 1) + (8 - 2 \times 5 + 3) = 5$

$$\therefore \quad \frac{D-C}{D} = \frac{14-5}{14} = 0.64$$

Que 1.53. **What is satellite station ? Why is it required ? Define reduction to centre and explain the procedure of reduction to centre ?**

OR

What is the purpose of a satellite station in triangulation ? Derive an equation to obtain angle at triangulation station with the help of satellite station observation which is inside the triangle.

AKTU 2014-15, Marks 06

OR

What do you mean by satellite station and reduction to center ? Derive expression for reducing the angles measured at the satellite stations to center.

AKTU 2018-19, Marks 07

Answer

A. Satellite Station :

1. Satellite station is also called 'False' or 'Eccentric' station.
2. To have intervisibility (and to achieve well conditioned triangles) sometimes high objects like church spire, towers etc, are selected as triangulation station but it is impossible to set up the instrument at such stations. In such cases a station nearby called "satellite station" is fixed and all the observations are made from it.

B. Purpose : Following are the various purposes of satellite station in triangulation :

i. To make well conditioned triangle.
ii. To have the intervisibility of the station.

C. Reduction to Center : The measured angle are corrected and reduced to the values they would have if the true station was occupied. This is known as reduction to centres.

D. Derivation :

1. In Fig. 1.53.1, S is the satellite station and B the actual station, $AC = (b)$ is the known side or the base line.
   α and β are corrections to the observed angle θ.
2. In ΔABC $\quad \frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C}$

   so, $\quad a = b\frac{\sin A}{\sin B}$ and $c = b\frac{\sin C}{\sin B}$
3. In ΔASB and ΔCSB

   $$\frac{d}{\sin\alpha} = \frac{c}{\sin(\theta+\gamma)} \text{ and } \frac{d}{\sin\beta} = \frac{a}{\sin\gamma}$$

   so, $\quad \sin\alpha = \frac{d\sin(\theta+\gamma)}{c}$ and $\sin\beta = \frac{d\sin\gamma}{a}$
4. Since α and β are very small, therefore $\sin\alpha = \alpha$ and $\sin\beta = \beta$ in radians

   $$\alpha = \sin\alpha = d\frac{\sin(\theta+\gamma)}{c} \text{ in radians} = d\frac{\sin(\theta+\gamma)}{c} \times 206265 \text{ seconds}$$

$$\beta = \sin\beta = d\frac{\sin\gamma}{a} \text{ in radians} = d\frac{\sin\gamma}{a} \times 206265 \text{ seconds}$$

5. Exterior angle $\angle AOC$ of $\Delta AOS = \angle\alpha + \angle\theta$
   Exterior angle $\angle AOC$ of $\Delta BOC = \angle ABC + \angle\beta$

   $\angle\alpha + \angle\theta = \angle ABC + \angle\beta$

   or, $\quad \angle ABC = \angle\alpha + \angle\theta - \angle\beta$

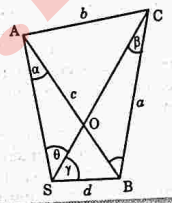


Fig. 1.53.1. Reduction to centre (satellite station).

Que 1.54. **Define the baseline. What are the importance of baseline ?**

Answer

Baseline and its Importance :

1. A line which is generally longest of all the survey lines and upon which the entire frame work is built up is known as a base line.
2. It generally runs in the centre of the area to be surveyed and should be laid off on the level ground.
3. It is very important line and since the entire accuracy of the survey work depends upon its accuracy and straightness, therefore, it should be measured accurately twice or thrice by independent methods and its straightness should also be ensured.
4. In large surveys or where convenient, two base lines should be run in the form of a cross (×) through the centre of the area.

Que 1.55. **State the correction to be applied in base line measurement.**

Answer

1. **Correction for Absolute Length :** If the absolute length (or actual length) of the tape or wire is not / equal to its nominal or designated length, a correction will have to be applied to the measured length of the line. If the absolute length of the tape is lesser than the nominal or designated length, the measured distance will be too great and the correction will be subtractive.

   Thus, $\quad C_a = \frac{Lc}{l}$

where, C_a = correction for absolute length.
L = measured length of the line.
c = correction per tape length.
l = designated length of the tape C_a will be of thesame sign as that of c.

2. **Correction for Temperature :**

i. If the temperature in the field is more than the temperature at which the tape was standardised, the length of the tape increases, measured distance becomes less, and the correction is therefore, additive.

ii. Similarly, if the temperature is less, the length of the tape decreases, measured distance becomes more and the correction is negative. The temperature correction is given by

$$C_t = \alpha(T_m - T_0)L$$

where, α = Coefficient of thermal expansion.
T_m = Mean temperature in the field during measurement.
T_0 = Temperature during standardisation of the tape.
L = Measured length.

3. **Correction for Pull or Tension :**

i. If the pull applied during measurement is more than the pull at which the tape was standardised, the length of the tape increases, measured distance becomes less, and the correction is positive.

ii. Similarly, if the pull is less, the length of the tape decreases, measured distance becomes more and the correction is negative.

If C_p is the correction for pull, we have

$$C_p = \frac{(P - P_0)L}{AE}$$

where, P = Pull applied during measurement (N).
P_0 = Standard pull (N).
L = Measured length (m).
A = Cross-sectional area of the tape (cm²).
E = Young's Modulus of Elasticity (N / cm²).

4. **Correction for Sag :** When the tape is stretched on supports between two points, it takes the form of a horizontal catenary. The horizontal distance will be less than the distance along the curve. The difference between horizontal distance and the measured length along catenary is called the Sag Correction.

$$C_s = \frac{lW^2}{24n^2P^2}$$

where, C_s = Tape correction per tap length.
l = Total length of the tape.
W = Total weight of the tape.
n = Number of equal spans.
P = Pull applied.

5. **Normal Tension :** Normal tension is the pull which, when applied to the tape, equalises the correction due to pull and the correction due to sag. Thus, at normal tension or pull, the effects of pull and sag are neutralized and no correction is necessary.

$$P_n = \frac{0.204\, W_1 \sqrt{AE}}{\sqrt{P_n - P_0}}$$

The value of P_n is to be determined by trial and error with the help of the above equation.

Que 1.56. **A 30 m long tape was standardized at 20 °C and under a pull of 100 N. The tape was used to measure the distance AB when the temperature was 45 °C and the pull was 150 N. The tape was supported at the ends only. Find the corrections per tape length if the cross section of the tape was 4 mm², the unit weight of the tape material is 0.0786 N/mm³, and the coefficient of thermal expansion of the tape material is 11.5 × 10⁻⁶ / °C. E = 2,000,000 kN/m².**

AKTU 2018-19, Marks 07

Answer

Given : Length of tape = 30 m, Standard temperature = 20 °C, Standard pull = 100 N, Operate temperature = 45 °C, Operate pull = 150 N
Cross section of tape = 4 mm², Weight of tape = 0.0786 N/mm³
Coefficients of thermal expansion = 11.5 × 10⁻⁶/°C
To Find : Correction per tape length

1. **Correction for Temperature :**

$$C_T = \alpha(T_m - T_0)L = 11.5 \times 10^{-6}(45° - 20°) \times 30$$
$$= 8.625 \times 10^{-3}\text{ m (+ ve)}$$

2. **Correction for Pull :** $C_p = \frac{P - P_0}{AE} \times L$

$$= \frac{150 - 100}{0.04 \times 2 \times 10^6 \times 10^3 / 10^4} \times 30 = 0.1875\text{ m (+ ve)}$$

3. **Correction for Sag :**

i. In this question weight of tape is more, so we assume weight of tape = 0.00786 N/mm³.

ii. Weight of tape per meter length = Unit weight × Cross sectional area of tape

$$= \frac{0.00786 \times 4}{10^{-3}} = 31.44\text{ N/m}$$

iii. Sag correction is given by, $C_s = \frac{LW^2}{24P^2}$

$$C_s = \frac{30 \times 31.44^2}{24 \times 150^2} = 0.0549\text{ mm (– ve)}$$

4. Total correction = $8.625 \times 10^{-3} + 0.1875 - 0.0549 = 0.1407$ m (Too long)

PART-15

Trigonometric Levelling : Accessible and Inaccessible Objects.

Questions-Answers

Long Answer Type and Medium Answer Type Questions

Que 1.57. **Write a short note on trigonometric levelling.**

Answer

1. Trigonometrical levelling is the process of determining the differences of elevations of stations from observed vertical angles and known distances, which are assumed to be either horizontal or geodetic lengths at mean sea level.
2. The vertical angles may be measured by means of an accurate theodolite and the horizontal distances may either be measured (in the case of plane surveying) or computed (in the case of geodetic observations).
3. Triagnometric levelling discuss under two heads :

i. Observation for height and distances.

ii. Geodetical observation :

Observation for Height and Distance :

a. In this case, the principles of the plane surveying will be used.

b. It is assumed that the distances between the points observed are not large so that either the effect of curvature and refraction may be neglected or proper correction may be applied linearly to the calculated difference in elevation.

c. Under this head fall the various methods of angular levelling for determining the elevations of particular points such as the top of chimney, or church spire etc.

Geodetical Observation :

a. In the geodetical observations of trigonometrical levelling, the distance between the points measured is geodetic and is large.

b. The ordinary principles of plane surveying are not applicable.

c. The corrections for curvature and refraction are applied in angular measure directly to the observed angles.

Que 1.58. **An instrument was set up at a point 200 m away from a transmission tower. The angle of elevation to the top of the tower was 30°42′, whereas the angle of depression to the bottom was 2°30′. Calculate the total height of the transmission tower.**

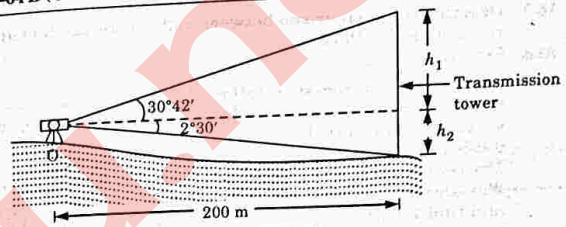


Fig. 1.58.1.

Answer

Given : Angle of elevation, $\theta_1 = 30°42'$, Angle of depression, $\theta_2 = 2°30'$
Distance of tower from instrument = 200 m
To Find : Total height of transmission tower.

1. Let the height of the tower be h.
2. $h = h_1 + h_2$
3. $h_1 = 200 \tan 30°42' = 118.75$ m
4. $h_2 = 200 \tan 2°30' = 8.732$ m

$h = 118.75 + 8.732 = 127.482$ m

VERY IMPORTANT QUESTIONS

Following questions are very important. These questions may be asked in your SESSIONALS as well as UNIVERSITY EXAMINATION.

Q. 1. What is surveying ? Explain the importance of surveying in civil engineering.

Ans. Refer Q. 1.1, Unit-1.

Q. 2. Classify surveying on the basis of instruments used and name all equipments necessary for the field work involving any one of them.

Ans. Refer Q. 1.2, Unit-1.

Q. 3. Explain and describe the fundamental principles of surveying.

Ans. Refer Q. 1.5, Unit-1.

Q. 4. Explain clearly the difference between a prismatic compass and surveyor's compass.

Ans. Refer Q. 1.13, Unit-1.

Q. 5. Describe the comparison between collimation method and rise and fall method.

Ans. Refer Q. 1.19, Unit-1.

Q. 6. The following successive staff readings were taken with a level using 5 m leveling staff on a continuously sloping ground at an interval of 25 m :
0.405, 1.035, 1.930, 2.895, 3.805, 4.760, 0.715, 2.060, 3.160, 4.415
The reduce level of the first point is known to be 62.980 m. Workout the staff reading by height of instrument method and find the gradient of the line joining the first and the last points.

Ans. Refer Q. 1.21, Unit-1.

Q. 7. Explain curvature and refraction correction in levelling. The eye of an observer is 7.5 m above sea level and he was able to see a light house 50 m high just above the horizontal. Find the distance between observer and lighthouse.

Ans. Refer Q. 1.25, Unit-1.

Q. 8. Which are the methods of plane tabling, enlist them with their definition and explain the procedure for any one of them.

Ans. Refer Q. 1.30, Unit-1.

Q. 9. What is orientation in plane table surveying ? Distinguish between resection and intersection methods as applied to plane table surveying.

Ans. Refer Q. 1.31, Unit-1.

Q. 10. Define contour and write the characteristics of contour.

Ans. Refer Q. 1.36, Unit-1.

Q. 11. Discuss the method of contouring. What are the various method of interpolating contour ? State the suitability of each one of them.

Ans. Refer Q. 1.37, Unit-1.

Q. 12. What are the applications of contour map ?

Ans. Refer Q. 1.38, Unit-1.

Q. 13. What are the fundamental lines and their desired relations in a theodolite ?

Ans. Refer Q. 1.47, Unit-1.

Q. 14. Explain the process of repetition and reiteration in theodolite survey.

Ans. Refer Q. 1.48, Unit-1.

Q. 15. What do you mean by satellite station and reduction to center ? Derive expression for reducing the angles measured at the satellite stations to center.

Ans. Refer Q. 1.53, Unit-1.

☺☺☺

2 UNIT

Curves

CONTENTS

PART-1

Element of Simple Circular Curves.

Questions-Answers

Long Answer Type and Medium Answer Type Questions

Que 2.1. **What is curve ? Why these are needed and also give a classification of curves ?**

OR

Explain the various types of circular curves.

AKTU 2018-19, Marks 03

OR

Why is a curve provided ?

AKTU 2017-18, Marks 03

Answer

A. **Curves :** These are defined as arcs, with some finite radius, provided between intersecting straights to gradually negotiate a change in direction.

B. **Necessity :** These are necessary due to following reasons :

1. Gradual change in gradient or direction or orientation in the alignment can be made by providing the curves.
2. Curves are provided so as to get comfort to the passengers.
3. Curves are provided so as to get easy turning in case of road and track.

C. **Classification of Curves :**

1. **Horizontal Curves :** These are the curves provided to negotiate a change in direction. These can be further classified as :

i. **Simple Circular Curve :** A simple circular curve consists of a single arc of a circle. It is tangential to both the straight lines of the route as shown in Fig. 2.1.1.

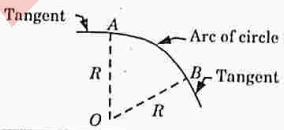


Fig. 2.1.1. Simple circular curve.

ii. **Compound Curve :** Compound curves are the curves composed of two or more simple circular curves of different radii meeting at a common tangent point T as shown in Fig. 2.1.2.

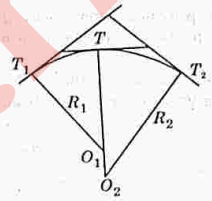


Fig. 2.1.2. Compound curve.

iii. **Reverse Curve :** Two simple circular curves of equal or different radii having opposite direction of curvature joining together to form a S-or reverse curve are called reverse curves as shown in Fig. 2.1.3.

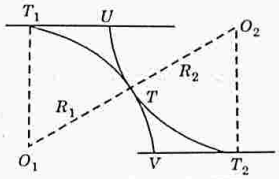


Fig. 2.1.3. Reverse curve.

2. **Transition Curve :** It is a curve provided in between a simple circular curve and the straight, whose radius changes from infinite to finite (equal to radius of simple circular curve) or vice-versa.

3. **Combined Curve :** A combination of circular curve and transition curve is called a combined curve as shown in Fig. 2.1.4.

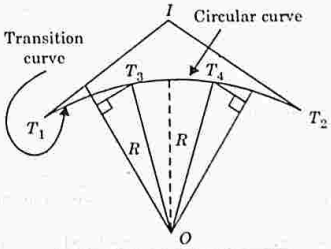


Fig. 2.1.4. Combined curve.

LAL – TCRA

4. **Vertical Curve :** These are the curves provided to smoothly change one gradient (longitudinal slope) to another. Vertical curves are further of two types :

i. **Summit Curve :** It is provided when a rising gradient meets a falling gradient *i.e.*, when the two straights form a summit as shown in Fig. 2.1.5(*a*).

ii. **Sag or Valley Curve :** Sag curve is the curve provided when a falling gradient meets a rising gradient or the two straights form a valley or sag.

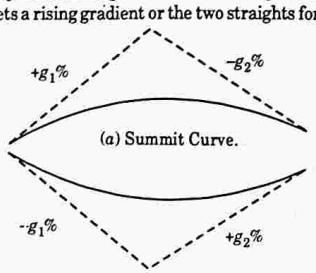


Fig. 2.1.5. Vertical curves.

Que 2.2. **Explain the various elements of simple circular curve with its figure.**

Answer

Fig. 2.2.1 shows a simple circular curve of radius R with its centre at O. A curve has the following element :

1. **Back Tangent :** The tangent AT_1 at the point of commencement T_1 of the curve is the back tangent.
2. **Forward Tangent :** The tangent T_2B at the end point T_2 of the curve is the forward tangent.
3. **Point of Intersection (PI) :** The point I where the back tangent when produced forward and forward tangent when produced backward meet, is called the point of intersection.
4. **Intersection Angle :** The angle ϕ between the back tangent AT_1 and the forward tangent T_2B at I, is called the intersection angle.
5. **Deflection Angle of the Curve :** The angle Δ through which the forward tangent deflects, is called deflection angle of the curve. It may be either to the left or the right.
6. **Point of Commencement (PC) :** The point T_1 where the curve commences is called the point of commencement of the curve. It is also called point of the curve.
7. **Point of Tangency (PT) :** The point T_2 where the curve joins the forward tangent, is called point of tangency.

8. **Deflection Angle to any Point on the Curve :** The deflection angle δ to any point a on the curve is the angle at PC between the back tangent and the chord T_1a from PC to the point.

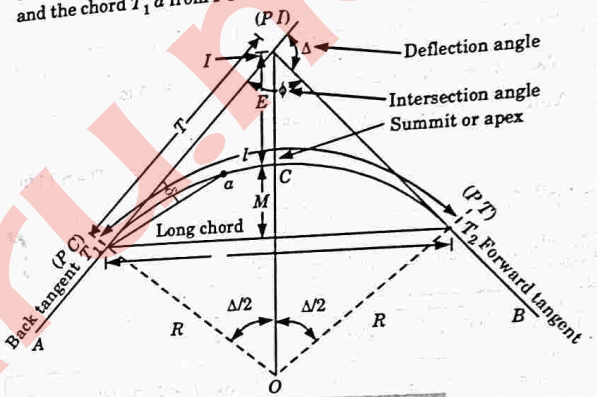


Fig. 2.2.1. Element of a circular curve.

9. **Tangent Distance (T) :** It is the distances from PC to PI (or PI to PT)
10. **External Distance (E) :** It is the distance from the midpoint C of the curve to PI. It is also known as the apex distance.
11. **Length of Curve (l) :** It is the total length of the curve from PC to PT.
12. **Long Chord (L) :** It is the chord joining PC and PT.
13. **Mid-ordinate (M) :** It is the ordinate from the midpoint of the long chord to the midpoint of the curve. It is also called the versine of the curve.
14. **Normal Chord (C) :** A chord between two successive regular pegs on the curve is called a normal chord.
15. **Sub-Chord (c) :** When the chord is shorter than the normal chord, it is called a sub-chord. These generally occur at the beginning and end of the curve. These will be designated by c_f and c_l, respectively.
16. **Right-hand Curve :** If the curve deflects to the right of the direction of the progress of survey it is called the right-hand curve.
17. **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.

Que 2.3. **Two tangents intersect at a chainage of 1320.5 m, the deflection being 24°. Calculate the tangent length, and versed sine of curve, for setting out a curve of 275 m radius.**

AKTU 2015-16, Marks 10

Answer

Given : Chainage length = 1320.5 m, Deflection angle, $\Delta = 24°$
Radius, $R = 275$ m
To Find : Tangents length, Versed sine of curve.

1. Tangent length $= R \tan \frac{\Delta}{2} = 275 \times \tan 12° = 58.45$ m
2. Versed sine of curve (Apex distance)

$$= R\left(\sec \frac{\Delta}{2} - 1\right) = 275 (\sec 12° - 1) = 6.14 \text{ m}$$

PART-2

Theory and Methods of Setting Out Simple Circular Curves.

Questions-Answers

Long Answer Type and Medium Answer Type Questions

Que 2.4. **Give in detail different linear methods of setting out simple circular curves.**

OR

Explain the various types of circular curves. Derive the expression for setting out simple circular curve by offsets from the long chord.

AKTU 2018-19, Marks 07

Answer

A. Circular Curve : Refer Q. 2.1, Page 2–2B, Unit-2.

B. Linear Methods : Following are the different linear method :

1. Perpendicular offsets from long chord method.
2. Offsets from chords produced.
3. Perpendicular offsets from tangents.
4. Radial offsets from tangents.
5. Successive bisection of arcs.

1. Perpendicular Offsets from Long Chord Method :

i. Refer Fig. 2.4.1, T_1I and T_2I are two straights intersecting at I at deflection angle Δ.

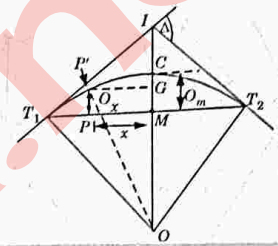


Fig. 2.4.1. Offsets from long chord method.

ii. T_1T_2 is the long chord, M is its mid point, C is the apex of the curve.

iii. P is a point on the long chord at a distance 'x' from its mid point M and PP' perpendicular offset from it, meeting the circular curve at P' and $PP' = O_x$. Join OP.

iv. Drop perpendicular $P'G$ from P' on line OI.

$$PP' = O_x = OG - OM$$
$$= OG - (OC - CM)$$

v. In right angled triangle $OP'G$

$$OG = \sqrt{(OP')^2 - (P'G)^2} = \sqrt{R^2 - x^2}$$
$$PP' = O_x = OG - OM$$
$$= \sqrt{R^2 - x^2} - (R - CM) \quad ...(2.4.1)$$
$$O_x = R\left[1 - \frac{x^2}{R^2}\right]^{1/2} - (R - O_m) = R\left[1 - \frac{x^2}{2R^2} + ...\right] - R + O_m$$
$$O_x = O_m - \frac{x^2}{2R} \quad ...(2.4.2)$$

vi. Perpendicular offsets at different distances along the long chord are calculated by Eq. 2.4.2.

vii. Two halves of the curve are laid out from mid point of long chord on either side in the same manner.

2. Offsets from Chords Produced : This is the best method for setting out a long curve by linear method and is usually employed for highway curves when a theodolite is not available.

i. T_1 is the PC along the tangent T_1I as shown in Fig. 2.4.2. T_1a is the first subchord, C_1. From the PC, a length equal to first subchord C_1 (T_1a') is taken.

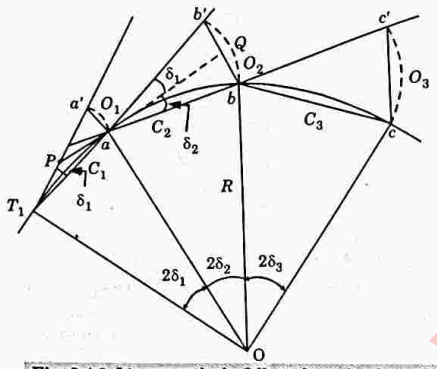


Fig. 2.4.2. Linear method : Offsets from chords produced.

ii. The perpendicular offset (O_1) aa' is set out, thereby getting point a.

iii. T_1a is joined and produced by distance C_2 (full chord length).

iv. The second offset O_2 (bb') is set out to get point b. Points a and b are joined and produced further by distance C_3 (full chord length).

v. The third offset O_3 (cc') is set out to get point c.

vi. The procedure is repeated till the curve is completed.

vii. $\angle a' T_1 a = \delta_1$ = Deflection angle of the first chord.

$$O_1 = a'a = T_1 a\delta = C_1 \delta_1 \quad ...(2.4.3)$$

$$\angle T_1 Oa = 2 \times \angle aT_1a' = 2\delta_1$$

i.e., $$\delta_1 = \frac{C_1}{2R}$$

Putting this value of δ_1 in eq. (2.4.3), we get

$$O_1 = C_1 \times \frac{C_1}{2R} = \frac{C_1^2}{2R} \quad ...(2.4.4)$$

viii. To compute O_2, draw tangent PQ to the curve at a.

Now, $$ab' = ab = C_2$$

$$O_2 = b'b = b'Q + bQ$$

From $\Delta b'\, a\, Q$ and $\Delta\, Q\, ab$

$$= C_2\delta_1 + C_2\delta_2 = C_2\frac{C_1}{2R} + C_2\frac{C_2}{2R}$$

$$= \frac{C_1C_2 + C_2^2}{2R} = \frac{C_2}{2R}(C_1 + C_2) \quad ...(2.4.5)$$

ix. Similarly 3rd offset $O_3 = c'c = \frac{C_3}{2R}(C_2 + C_3)$ ...(2.4.6)

x. But normally $C_3 = C_4 = C_{n-1} = C$

The last offset is given by, $= O_n = \frac{C_n}{2R}(C_{n-1} + C_n)$ ...(2.4.7)

Field Procedure :

i. Locate the tangent points (T_1 and T_2) and find out their chainage. Calculate the first and last sub chord and length of curve.

ii. Calculate offsets from O_1 to O_n.

iii. Put the zero mark of the chain at T_1, take length T_1a' and swing the chain so that $a'a = O_1$.

iv. Pull the chain along T_1ab' with zero at a and $ab' = C_2$ (normal chord). Swing the chain so that $bb' = O_2$.

v. Continue likewise till last point of the curve is obtained.

Que 2.5. Describe in detail different angular methods of setting out simple circular curves.

OR

Explain Rankine's method of setting out of a circular curve.

AKTU 2014-15, Marks 06

OR

Write a short note on two theodolite method of setting out curve.

Answer

Angular methods of setting out a simple circular curve are as follows :

A. Two theodolite method.

B. Rankine's method of deflection angle.

C. Tacheometric method.

A. Two Theodolite Method : It is suitable for undulating ground where linear measurements are not possible.

Principle : Angle subtended by a chord in the opposite segment is equal to the angle subtended between the chord and the tangent.

Field Procedure :

1. Set one theodolite at T_1 and other at T_2. Set vernier A of both the theodolites to zero.
2. Direct the theodolite at T_1 towards I, and the theodolite at T_2 towards T_1.
3. Set angles δ_1 in both the theodolites so as to direct the line of sights towards T_1a and T_2a. Point a is established at the intersection is the first point on the curve.
4. Similarly establish other point on the curve and complete the curve.

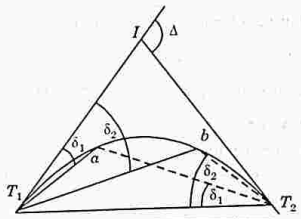


Fig. 2.5.1. Two theodolite method.

B. Rankine's Method of Deflection Angle :

1. This method is suitable for large radius curves or curves of long length.
2. Deflection angle to any point on the curve is the angle at PC between the tangent and the chord from PC to that point.
3. From the property of a circle, deflection angle is half the angle subtended by the chord at the centre of the circle.
4. In Fig. 2.5.2. T_1, is the PC a, b, c etc, are the points on the curve, $\delta_1, \delta_2, \delta_3$ etc, are the respective deflection angles between the chord and the respective tangent at T_1, a, b, etc. $\Delta_1, \Delta_2, \Delta_3$, etc are the total deflection angles to the points, a, b, c, etc.
5. In $\Delta T_1 aO$, $\angle T_1 Oa = 2 \times \angle IT_1 a = 2\delta_1$

$$R \times 2\delta_1 = T_1 a = C_1$$

or $$\delta_1 = \frac{C_1}{2R} \text{ radians} = \frac{C_1}{2R} \times \frac{180}{\pi} \times 60 \text{ minutes}$$

$$= \frac{1718.9 C_1}{R} \text{ minutes}$$

6. Similarly, $$\delta_2 = \frac{1718.9 C_2}{R} \text{ minutes}$$

$$\delta_3 = \frac{1718.9 C_3}{R} \text{ minutes}$$

.....

.....

$$\therefore \quad \delta_n = \frac{1718.9 C_n}{R} \text{ minutes}$$

7. The deflection angle for first chord $T_1 a$, $\Delta_1 = \delta_1$ (Tangential angle).
8. Let the tangential angle for chord $ab = \delta_2$ *i.e.*, the angle between the tangent at a and chord ab. The angle subtended by the chord ab at T_1 is $\angle a T_1 b = \delta_2$.

Deflection angle at point b, $\Delta_2 = \angle IT_1 b = \angle IT_1 a + \angle a T_1 b = \delta_1 + \delta_2$

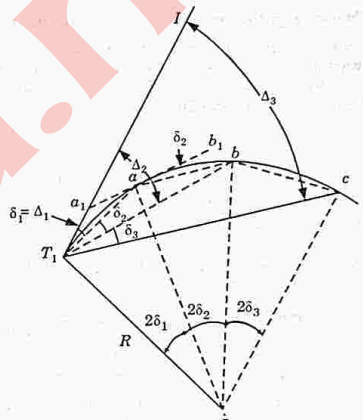


Fig. 2.5.2. Rankine's method of deflection angle.

9. Similarly, $$\Delta_3 = \angle IT_1 c = \angle IT_1 b + \angle b T_1 c$$

$$\delta_n = \delta_1 + \delta_2 + \delta_3 = \Delta_2 + \delta_3$$

10. $$\Delta_n = \Delta_{n-1} + \delta_n = \angle IT_1 T_2 = \Delta/2$$
11. Sum of all the individual tangential angles should be equal to half the deflection angle of the circular.
12. Field procedure of laying the curve is as follows :

i. Set up the theodolite at T_1. Make the scale plate read zero. Release the lower clamp. Sight point of intersection I. Tighten the lower clamp.

ii. Loosen the upper clamp. Rotate the telescope till the angle on the scale plate is equal to Δ_1. Now the telescope is oriented in the direction $T_1 a$. Tighten the upper clamp.

iii. Hold zero of the tape at T_1 and measure $T_1 a = C_1$, a is the point on the curve. Loosen the upper clamp.

iv. Rotate the telescope till the scale plate reads angle equal to Δ_2. Tighten the upper clamp. The telescope is aligned in the direction $T_1 b$.

v. Hold zero of the tape at a and measure ab equal to C_2 such that b lies on the line $T_1 b$. 'b' is another point on the curve.

vi. Proceed likewise till whole of the curve is laid.

Que 2.6. **Two straight *AI* and *BI* meet at a chainage of 3450 m. A right handed simple circular curve of 250 m radius joins them. The deflection angle between the two straights is 50°. Tabulate the necessary data to layout the curve by Rankine's method of deflection angles. Take the chord interval 20 m.**

Answer

Given : Radius of curve, $R = 250$ m, Deflection angle, $\Delta = 50°$
Chord interval = 20 m, Chainage of meeting point = 3450 m
To Find : Layout of curve.

1. Tangent length $= R \tan \frac{\Delta}{2} = 250 \times \tan 25° = 116.58$ m

2. Length of the curve, $L = R \times \Delta \times \frac{\pi}{180°} = 250 \times 50° \times \frac{\pi}{180°}$
$= 218.166 \approx 218.17$ m

3. Chainage of starting point, $T_1 = 3450 - 116.58 = 3333.42$ m
Chainage of the end point, $T_2 = 3333.42 + 218.17 = 3551.59$ m

4. Length of the chords : There will be 12 chords altogether.
First subchord, $C_1 = 3340 - 3333.42 = 6.58$ m
Last subchord, C_{12} = Chainage of $T_2 - 3540$
$= 3551.59 - 3540 = 11.59$ m
C_2 to $C_{11} = 20 \times 10 = 200$ m
$\delta_1 = 1719 \times C_1/R = 1719 \times 6.58/250 = 45'15'' = \Delta_1$
$\delta_2 = 1719 \times C_2/R = 1719 \times 20/250 = 2°17'31''$
Hence, $\Delta_2 = \delta_2 + \Delta_1 = 2°17'31'' + 45'15'' = 3°2'46''$
Similarly,
$\Delta_3 = \delta_3 + \Delta_2 = 2°17'31'' + 3°2'46'' = 5°20'17''$
$\Delta_4 = \delta_4 + \Delta_3 = 2°17'31'' + 5°20'17'' = 7°37'48''$
$\Delta_5 = \delta_5 + \Delta_4 = 2°17'31'' + 7°37'48'' = 9°55'19''$
$\Delta_6 = \delta_6 + \Delta_5 = 2°17'31'' + 9°55'19'' = 12°12'50''$
$\Delta_7 = \delta_7 + \Delta_6 = 2°17'31'' + 12°12'50'' = 14°30'21''$
$\Delta_8 = \delta_8 + \Delta_7 = 2°17'31'' + 14°30'21'' = 16°47'52''$
$\Delta_9 = \delta_9 + \Delta_8 = 2°17'31'' + 16°47'52'' = 19°5'23''$
$\Delta_{10} = \delta_{10} + \Delta_9 = 2°17'31'' + 19°5'23'' = 21°22'54''$
$\Delta_{11} = \delta_{11} + \Delta_{10} = 2°17'31'' + 21°22'54'' = 23°40'25''$
$\delta_{12} = 1719 \times 11.59/250 = 1°19'42''$
$\Delta_{12} = \delta_{12} + \Delta_{11} = 1°19'42'' + 23°40'25'' = 25°0'7'' = 25°$

5. **Check :** $\Delta_{12} = \frac{\Delta}{2} = \frac{50°}{2} = 25°$

Que 2.7. **Two tangents intersect at a chainage of 1320.5 m, the deflection being 24°. Calculate the tangent length, and versed sine of curve, for setting out a curve of 275 m radius.**
AKTU 2015-16, Marks 10

Answer

Given : Chainage length = 1320.5 m, Deflection angle, $\Delta = 24°$
Radius, $R = 275$ m
To Find : Tangents length, Versed sine of curve.

1. Tangent length $= R \tan \frac{\Delta}{2} = 275 \times \tan 12° = 58.45$ m
2. Versed sine of curve (Apex distance)
$= R \left(\sec \frac{\Delta}{2} - 1\right) = 275 (\sec 12° - 1) = 6.14$ m

Que 2.8. **The apex distance of a 3° circular curve is 82.45 m. Determine the deflection angle, tangent length and length of long chord.**
AKTU 2016-17, Marks 10

Answer

Given : Degree of curve = 3°, Apex distance = 82.45 m
To Find : Deflection angle, Tangent length, Length of long chord

1. Radius of curve, $R = \frac{1719}{D} = \frac{1719}{3} = 573$ m
2. Apex distance $= R \left(\sec \frac{\Delta}{2} - 1\right)$
$82.45 = 573 \left(\sec \frac{\Delta}{2} - 1\right)$
$\sec \frac{\Delta}{2} = 1.143$
Deflection angle, $\Delta = 57.93°$
3. Tangent length,
$T = R \tan \frac{\Delta}{2}$
$= 573 \tan \left(\frac{57.93°}{2}\right)$
$T = 317.16$ m

4. Length of long chord,

$$L = 2R \sin \frac{\Delta}{2} = 2 \times 573 \times \sin \frac{57.93°}{2} = 554.98 \text{ m}$$

Que 2.9. **Two straight lines *AC* and *CB* to be connected by a 3° at *C* intersect at a chainage of 2760 m. The WCB of *AC* and *CB* are 45° 30' and 75° 30' respectively. Calculate radius, tangent length, curve length, length of long chord, chainage of point of commencement and tangency.** **AKTU 2014-15, Marks 06**

Answer

Given : Degree of curve, $D = 3°$, Chainage at point $C = 2760$ m, Bearing of line AC and $CB = 45° 30'$ and $75° 30'$ respectively.
To Find : Radius of curve, Tangent length, Curve length, Length of long chord, Chainage at point commencement and tangency.

1. For 30 m chord length radius of curve,

$$R = \frac{1719}{D} = \frac{1719}{3°} = 573 \text{ m}$$

2. Angle of intersection of both lines,

$$= 180° - (75°30' - 45° 30')$$
$$= 225° 30' - 75° 30' = 150°$$

3. Deflection angle,

$$\Delta = 180° - 150° = 30°$$

4. Length of curve,

$$l = R \times \Delta \times \frac{\pi}{180°} = 573 \times 30° \times \frac{\pi}{180°}$$
$$l = 300.0 \text{ m}$$

5. Tangent length, $T = R \tan \left(\frac{\Delta}{2}\right) = 573 \times \tan \frac{30°}{2}$

$$T = 153.53 \text{ m}$$

6. Long chord length, $L = 2R \sin (\Delta/2)$

$$L = 2 \times 573 \times \sin \left(\frac{30°}{2}\right)$$
$$L = 296.6 \text{ m}$$

7. Chainage of point of commencement =
Chainage of point C – Tangent length = 2760 – 153.53 = 2606.47 m

8. Chainage of tangency = Change of point of commencement + Curve length = 2606.47 + 300.0 = 2906.47 m

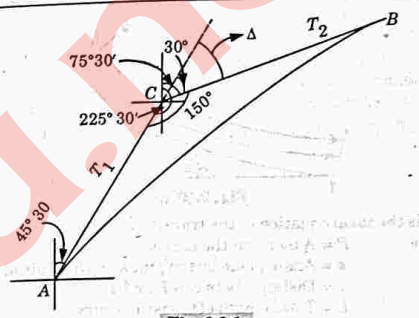


Fig. 2.9.1.

PART-3

Transition Curves : Types, Characteristics and Equations of Various Transition Curves.

Questions-Answers

Long Answer Type and Medium Answer Type Questions

Que 2.10. **Define the transition curve. What are the different types of transition curves ?**

Answer

Transition Curve : It is a curve of varying radius and varying curvature introduced between a simple circular curve and a straight or between two branches of a compound curve or reverse curve to provide a transition.

Types of Transition Curves : Following are the different types of transition curves :

1. **Euler's Spiral :**

i. Euler's spiral curve is shown in Fig. 2.10.1. The equation of this curve,

$$\phi = \frac{l^2}{2RL}$$

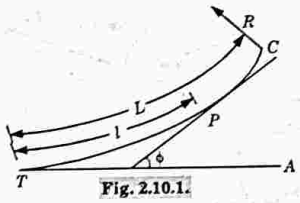


Fig. 2.10.1.

ii. This is the ideal equation of the transition curve,

where, P = A point on the curve.
ϕ = Angle made by tangent at P with initial tangent TA.
l = Distance between P and T.
L = Total length of transition curve.
R = Radius of circular curve.

2. Cubical Spiral :

Fig. 2.10.2 shows a cubical spiral. The equation of this curve is given by,

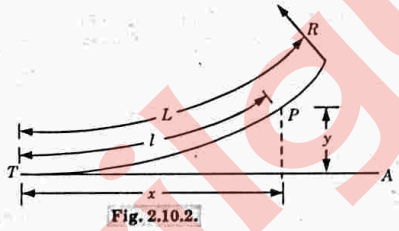


Fig. 2.10.2.

$$y = \frac{l^3}{6RL}$$

where, y = Perpendicular offset to any point from TA.
l = Distance of the point from T.
L = Total length of transition curve.
R = Radius of circular curve.

3. Cubic Parabola : Fig. 2.10.3 shows a cubic parabola. The equation of this curve is

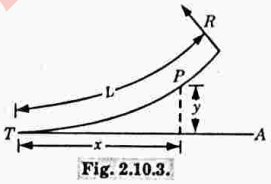


Fig. 2.10.3.

$$y = \frac{x^3}{6RL}$$

where, x = Horizontal distance between P and T.
y = Perpendicular distance between P and TA line.

ii. Such curves are the most convenient for railway tracks.

4. Lemniscate Curve : Such a curve is shown in Fig. 2.10.4. The equation of this curve is given by,

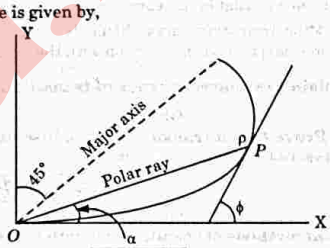


Fig. 2.10.4.

i. $$R = \frac{P}{3\sin 2\alpha}$$

where, R = Radius of curvature at any point.
P = Polar ray at any point.
α = Polar deflection angle.

ii. These curves are provided in roads.

Que 2.11. What are the advantages of providing a transition curve ?

OR

Explain the requirements of a transition curve.

AKTU 2016-17, 2017-18, 2018-19; Marks 03

Answer

A. Advantages of a Transition Curve :

1. The chances of overturning of the vehicles and the derailment of trains are reduced considerably.
2. It provides comfort to the passengers while vehicles negotiating a curve.
3. The superelevation is introduced gradually in proportion to the rate of change of curvature.
4. It permits higher speeds at curves.
5. It reduces the wear on the running gears.

B. Requirements of a Transition Curve : A transition curve introduced between tangent and the circular curve should fulfill the following conditions :

1. It should be tangential to the straight.
2. It should meet the circular curve tangentially.
3. Its curvature should be zero ($R = \infty$) at the origin on tangent.
4. Its curvature should be equal to that of the circular curve at the junction with the circular curve.
5. The rate of change of curvature from zero to that of the circular curve should be the same as that of increase of cant or superelevation.
6. The length of the transition curve should be such that full cant or superelevation is attained at the junction with the circular curve.

Que 2.12. Explain the characteristics of transition curve.

OR

What is Shift ? Prove that a transition curve bisects the shift and that the shift bisects the transition curve.

AKTU 2017-18, Marks 07

OR

State the different methods of calculating length of transition curve.

AKTU 2014-15, 2017-18; Marks 06

Answer

Shift : When a transition curve is introduced in circular curve, then the circular curve is found to be shifted by some distance towards the centre. This distance is known as the shift of the curve.

Characteristics of Transition Curve : Following are the characteristics of transition curve :

1. **Length :** The required length of a transition curve may be worked out in the following ways :

i. **By Adopting a Definite Rate of Superelevation :** The definite rate of superelevation is adopted as 1 in n, the value of n varying from 300 to 1,000.

Length of transition curve,

$$L = \frac{nh}{100} \text{ m}$$

where, h = Amount of superelevation in centimetres.

ii. **By Considering Arbitrary Time Rate of Superelevation :**

Length of transition curve,

$$L = \frac{h \times v}{x}$$

where, h = Amount of superelevation.

v = Speed in metres per second.

x = Time rate in centimetres per second, it varies from 2.5 to 5 (cm/sec).

iii. **By Considering Rate of Change of Radial Acceleration :**

a. Radial acceleration on circular curve.

$$= \frac{v^2}{R} \quad \text{...(2.12.1)}$$

b. Time taken by vehicle to cover transition curve

$$= \frac{L}{v} \text{ sec} \quad \text{...(2.12.2)}$$

c. Again, if k m/sec^3 be the change of radial acceleration, Time taken to attain maximum radial acceleration

$$= \frac{v^2}{k \times R} \text{ sec} \quad \text{...(2.12.3)}$$

d. From Eq. (2.12.2) and eq. (2.12.3), we get

$$\frac{L}{v} = \frac{v^3}{k \times R}$$

$$L = \frac{v^3}{k \times R} \quad \text{...(2.12.4)}$$

2. **Spiral Angle :** From the intrinsic equation of the ideal transition curve.

$$\phi_1 = \frac{l^2}{2RL} \text{ radians}$$

when $\phi_1 = \phi$ and $l = L$

$$\phi = \frac{L^2}{2RL} = \frac{L}{2R} \text{ radians}$$

This angle ϕ is known as the spiral angle.

3. **Deflection Angle :** In Fig. 2.12.1

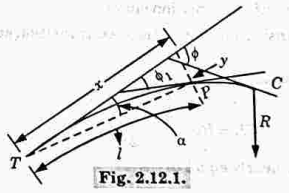


Fig. 2.12.1.

P = Any point on transition curve.

C = Point of junction between transition curve and circular curve.

ϕ = Spiral angle.

ϕ_1 = Angle between tangent at P and initial tangent.

α = Deflection angle at P.

x = Abscissa of point P.
y = Ordinate of point P.
R = Radius of circular curve.
l = Length of transition curve between T and P.

i. $$\tan\alpha = \frac{y}{x} \qquad ...(2.12.5)$$

ii. From the equation of the cubical spiral,

$$y = \frac{x^3}{6\,RL} = \frac{l^3}{6\,RL} \qquad [x = l \text{ (approx)}] \quad ...(2.12.6)$$

iii. when α is small, $\tan\alpha = \alpha$.
From Eq. (2.12.5) and Eq. (2.12.6), we get

$$\alpha = \frac{1}{x} \times \frac{x^3}{6\,RL} = \frac{x^2}{6\,RL} = \frac{l^2}{6\,RL} \text{ radians} = \frac{573 l^2}{RL} \text{ mins}$$

4. **Shift :** In Fig. 2.12.2.
TB = Initial tangent.
T = Tangent point of combined curve.
T_1 = Tangent point at simple circular curve.
T_1E = Shift (S)
C = Junction point of transition curve with circular curve.
DC = Common tangent.
ϕ = Spiral angle.
N = Intersection point of shift and transition curve.
R = Radius of circular curve.
L = Length of transition curve.

i. From the intrinsic equation of the ideal transition curve, we know that

Spiral angle, $\phi = \frac{L}{2R}$

ii. Now, $$CE = R\phi = R \times \frac{L}{2R} = \frac{L}{2}$$

iii. But CN is very nearly equal to CE.

$$\therefore \quad CN = \frac{L}{2}$$

Hence $$TN = \frac{L}{2}$$

So, the shift T_1E bisects the transition curve at N.

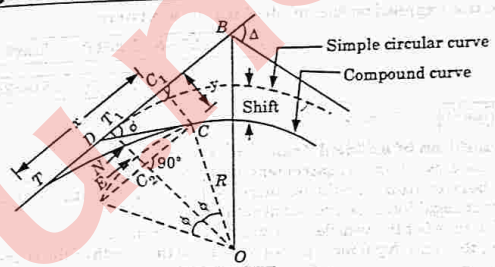


Fig. 2.12.2.

iv. Again, CC_2 is drawn perpendicular to OT_1, and CC_1 is drawn perpendicular to TB.

v. Now, $S = C_2T_1 - C_2E$ (C_2E = versed sine of curve with central angle 2ϕ)

$$S = CC_1 - R(1 - \cos\phi) = y - R(1 - \cos\phi)$$

$$\therefore \quad S = y - R \times 2\sin^2\phi/2$$

vi. But we know that,

$$y = \frac{x^3}{6\,RL} = \frac{L^3}{6\,RL} = \frac{L^2}{6\,R} \qquad [x = L \text{ (approx)}]$$

vii. When ϕ is small, $\sin\phi = \phi$.

$$\therefore \quad S = \frac{L^2}{6R} - R \times 2\left(\frac{\phi}{2}\right)^2 = \frac{L^2}{6R} - 2R \times \frac{\phi^2}{4}$$

$$= \frac{L^2}{6R} - 2R \times \frac{1}{4} \times \left(\frac{L}{2R}\right)^2 = \frac{L^2}{6R} - \frac{L^2}{8R} = \frac{L^2}{24R}$$

$$\therefore \quad \text{Shift} = \frac{L^2}{24R}$$

viii. Again, $$T_1N = \frac{TN^3}{6\,RL} = \frac{(L/2)^3}{6\,RL} = \frac{L^2}{48\,R} \qquad \left(TT_1 = TN = \frac{L}{2}\right)$$

ix. Now, $$\frac{\text{Shift}}{T_1N} = \frac{L^2}{24\,R} \times \frac{48R}{L^2} = 2$$

So, $$T_1N = \frac{\text{shift}}{2} = \frac{T_1E}{2}$$

That means the transition curve bisects the shift.

Que 2.13. **Explain the condition of an ideal transition curve and derive the equation for ideal transition curve.**

OR

Derive the expression for an ideal transition curve.

AKTU 2016-17, 2017-18; Marks 06

AKTU 2018-19, Marks 04

Answer

A. Condition of an Ideal Transition Curve :

1. According to the requirement of an ideal transition curve, the superelevation should be increased uniformly with increase of centrifugal force, at a constant rate.
2. The speed of the vehicle is assumed to be constant.

i. So, the centrifugal force is proportional to the length of the transition curve, *i.e.*, $P \propto L$

or $\frac{W v^2}{gR} \propto L$

where, P = Centrifugal force.
L = Length of transition curve.

Here, W, v and g are constant.

$\therefore \quad \frac{1}{R} \propto L \quad$ or $\quad LR = a$ constant

ii. Again, the superelevation (h) is also proportional to the length of the transition curve (L), *i.e.*,

$$h \propto L \propto \frac{Wv^2}{gR}$$

Hence, we get $L \propto \frac{1}{R}$ or $LR =$ a constant

3. Thus it is seen that the fundamental condition for a curve to be a transition curve is that a radius of curvature should be inversely proportional to the length.
4. Such a curve is also known as a clothoid or true spiral.

B. Intrinsic Equation of Ideal Transition Curve : In Fig. 2.13.1.

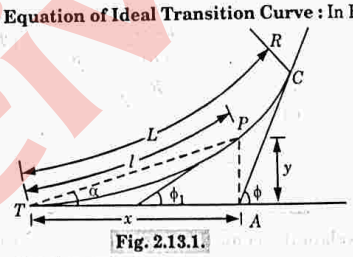


Fig. 2.13.1.

TA = Rear tangent.

T = Starting point of transition curve.

C = Point of junction between transition curve and circular curve.

P = Any point on transition curve.

r = Radius of curve at P.

R = Radius of circular curve.

ϕ = Spiral angle (angle between tangent TA and tangent at C).

ϕ_1 = Angle between tangent at P and tangent TA.

l = Distance between point P and T.

L = Total length of transition curve.

x = Abscissa of point P.

y = Ordinate of point P.

α = Deflection angle at point P.

2. The fundamental requirement of a spiral curve is that the radius of curvature at any point be inversely proportional to its length. So considering the point P,

$$r \propto \frac{1}{l} \quad \text{or} \quad \frac{1}{r} \propto l$$

or $\frac{1}{r} = ml$ ...(2.13.1)

where m = Constant of proportionality.

3. Again, for any curve,

$$\frac{d\phi_1}{dl} = \frac{1}{r} \quad \text{or} \quad d\phi_1 = \frac{1}{r} \times dl$$

or $d\phi_1 = ml \times dl$

4. Integrating the above equation

$$\phi_1 = \frac{ml^2}{2} + C$$

5. when $l = 0$ and $\phi_1 = 0$
then $C = 0$

So, $\phi_1 = \frac{ml^2}{2}$ ...(2.13.2)

6. At point C, $l = L$, $r = R$ and $\phi_1 = \phi$
From eq. (2.13.1),

$$\frac{1}{R} = mL \quad \text{or} \quad m = \frac{1}{RL}$$

From eq. (2.13.2), $\phi_1 = \frac{l^2}{2RL}$ radian

7. $\therefore$ Spiral angle, $\phi = \frac{L^2}{2RL} = \frac{L}{2R}$ (as $l = L$) ...(2.13.3)

This is the intrinsic equation of the ideal transition curve.

Que 2.14. Two straight intersect at angle of 122°. The maximum allowable speed of the vehicle on the curve is 80 km/hr, centrifugal ratio is ¼ and the rate of change of radial acceleration is 30 cm/sec². Calculate the radius of the circular curve and the length of the transition curve. **AKTU 2017-18, Marks 10**

Answer

Given : Intersect angle = 122°, Speed, V = 80 kmph,
Centrifugal ratio = 1/4
Rate of change of radial acceleration, $C = 30$ cm/sec²
To Find : Radius of circular curve and length of transition curve.

1. The deflection angle, $\Delta = 180° - 122° = 58°$
2. Speed of vehicle, $v = \frac{80 \times 1000}{3600}$ m/sec = 22.222 m/sec
3. The centrifugal ratio = $\frac{\text{Centrifugal force}}{\text{Weight of the vehicle}} = \frac{F}{W} = \frac{W v^2}{gR} \times \frac{1}{W} = \frac{v^2}{gR}$

$$\therefore \quad \frac{v^2}{gR} = \frac{1}{4}$$

$$\frac{22.222^2}{9.81 \times R} = \frac{1}{4}$$

Radius of curve,

$$R = \frac{22.222^2 \times 4}{9.81} = 201.35 \text{ m}$$

4. Length of the transition curve,

$$L = \frac{v^3}{CR}$$

$$\therefore \quad L = \frac{22.222^3}{0.3 \times 201.35} = 181.67 \text{ m}$$

PART-4

Introduction to Vertical Curves.

Questions-Answers

Long Answer Type and Medium Answer Type Questions

Que 2.15. What is vertical curve and its type ?

Answer

A. Vertical Curves :

1. When two different gradients intersect at a point, then they are connected by a curve in a vertical plane termed as vertical curve
2. The parabolic curves are preferred as it is easy to work out the minimum sight distance.

B. Types of Vertical Curves : Following are two types of vertical curve :

1. Summit or convex Curve :

i. If a vertical curve has its convexity upward, it is called a summit curve.

ii. Depending upon the field condition a summit curve may be formed :

a. Upgrade followed by a downgrade ($+g_1\%, -g_2\%$).

b. Steeper upgrade is followed by a milder upgrade $[+g_1\%, +g_2\% (g_1 > g_2)]$.

c. Milder downgrade followed by a steeper downgrade $[-g_1\%, -g_2\% (g_2 > g_1)]$.

2. Valley Sag or Concave Curve :

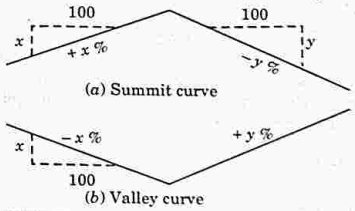
i. The vertical curve having its convexity downwards or when it is concave upward it is called a sag or valley curve.

ii. A sag curve may be formed :

a. Downgrade followed by an upgrade ($-g_1\%, +g_2\%$).

b. Steeper downgrade is followed by a milder downgrade $[-g_1\%, -g_2\% (g_1 > g_2)]$.

c. Milder upgrade is followed by a steeper upgrade $[+g_1\%, +g_2\% (g_2 > g_1)]$.



(a) Summit curve

(b) Valley curve

Fig. 2.15.1. Representation of gradients on straights.

Que 2.16. **Find the length of the vertical curve connecting two uniform grades – 0.5% and +1% respectively. The rate of change of grade is 0.05% per 30 m.**

Answer

Given : Grades of curves = – 0.5 % and + 1%
Rate of change of grade = 0.05 % per 30 m
To Find : Length of vertical curve.

$$\text{Length of vertical curve} = \frac{\text{Change of gradient}}{\text{Rate of change of gradient}}$$

$$= \frac{-0.5\% - (+1\%)}{0.05\%} \times 30 \text{ m} = \frac{-1.5\%}{0.05\%} \times 30 \text{ m}$$

L = 900 m.

Que 2.17. **A vertical curve lies between two gradients of + 0.60 % and – 0. 9 %. Rate of change of gradients is to be 0.075 % per 30 m. If the elevation and chainage of point of intersection is 1430 m and 985.5 m respectively. Find the chainage of the tangent points and apex of the curve.**

Answer

Given : grades g_1 and g_2 = + 0.60 % and – 0.9 %,
Rate of change of gradient = 0.075% / 30 m, Elevation = 1430 m,
Chainage = 985.5 m
To Find : Chainage of the tangent points, Apex of curve

1. Length of curve $= \frac{\text{Change of gradient}}{\text{rate of change of gradient}}$

$$L = \frac{0.60 - (-0.90)}{0.075} \times 30 = 600 \text{ m}$$

2. The curve midpoint will be the apex of the curve. Chainage of apex of the curve is the chainage of point of intersection *i.e.*, 1430 m.
3. Chainage of the two tangent points will be (985.50 – 300) and (985.50 + 300) = 685.5 m and 1285.5 m.
4. 1st tangent point = $1430 - \frac{0.6}{100} \times 300 = 1430 - 1.8 = 1428.2$ m
5. 2nd tangent point = $1430 + \frac{0.9}{100} \times 300 = 1430 + 2.70 = 1432.70$ m

Que 2.18. **Write a short note on superelevation or cant.**

Answer

A. Superelevation or Cant :

1. Superelevation is the raising of an outer edge of a road or rail passage on a curve to counter the effect of the centrifugal force.
2. When a vehicle moves on a curved path, a force known as the centrifugal force P, as shown in Fig. 2.18.1 acts upon it horizontally through the centre of gravity G of the vehicle in a direction away from the centre of the curve.
3. This force is in addition to the weight W of the vehicle.
4. The force P tends to push the vehicle off the road or track.
5. In order to balance this force, the outer edge of the road or outer rail on railways is raised above the inner one.
6. The difference h in the top levels of outer and inner edges or rails is called superelevation or cant.
7. The amount of raising depends upon the radius of the curve, and the average speed of the vehicles.

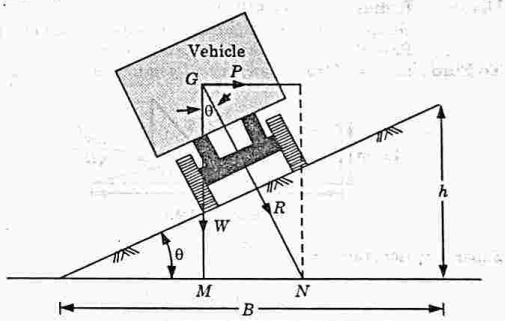


Fig. 2.18.1. Superelevation.

8. From mechanics, centrifugal force P is given by,

$$P = \frac{W v^2}{gR} \quad \ldots(2.18.1)$$

where, v = Speed of the vehicle (m/sec)
R = Radius of the curve (m)
g = Acceleration due to gravity (9.81 m/sec²)

From Eq. (2.18.1), we have

$$\frac{P}{W} = \frac{v^2}{gR}$$

Now, $\tan\theta = \frac{h}{B}$, or $= \frac{MN}{MG}$, or $= \frac{P}{W} = \frac{v^2}{gR}$

or $\frac{h}{B} = \frac{v^2}{gR}$

or $h = \frac{Bv^2}{gR}$ ...(2.18.2)

In Eq. (2.18.2), B is the horizontal distance between the two edges of highway or the gauge of the railway track.

Que 2.19. **A transition curve is required for a circular curve of 410 m radius, the gauge being 1.5 m between rail centers and maximum superelevation restricted to 12 cm. The transition is to be designed for a velocity such that no lateral pressure is imposed on the rails and the rate of radial accelerations 30 cm/sec³. Calculate the required length of transition curve and the design speed.**

Answer

Given : Radius of curve = 410 m
Guage of rail = 1.5 m, Maximum superelevation = 12 cm,
Rate of radial accelerations = 30 cm/sec³
To Find : Length of transition curve, Design speed.

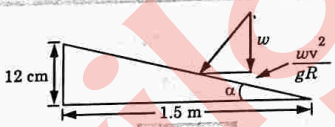


Fig. 2.19.2.

1. Superelevation, $\tan\alpha = \frac{12}{150} = \frac{v^2}{gR}$

$$v^2 = \frac{12 \times 9.81 \times 410}{150}$$

Design speed, $v = 17.94$ m/sec

2. Rate of radial acceleration is given by,

$$\alpha' = \left(\frac{30}{100}\right) = \frac{v^3}{LR}$$

Length of transition curve,

$$L = \frac{(17.94)^3}{0.3 \times 410} = 46.94 \text{ m}$$

Que 2.20. **A road 8 m wide is to deflect through an angle of 60° with the centre line radius of 300 m, the chainage of intersection points being 3605.0 m. A transition curve is to be used at each end of circular curve of such a length that rate of gain of radial acceleration is 0.5 m/sec³. When speed is 50 kmph. Find out :**
1. **Length of transition curve.**
2. **Superelevation.**
3. **Chainage of all junction points.** **AKTU 2016-17, Marks 10**

Answer

Given : Radius, $R = 300$ m
Radial acceleration, $\alpha = 0.5$ m/sec³
Speed, $v = 50$ km/hr $= 50 \times 5/18 = 13.88$ m/seo
Deflection angle, $\theta = 60°$
Chainage of intersection point = 3605 m
To Find : Length of transition curve, Superelevation, Chainage of all junction point.

1. Length of transition curve,

$$L = \frac{v^3}{\alpha R} = \frac{(13.88)^3}{0.5 \times 300} = 17.82 \text{ m}$$

2. Superelevation,

$$\tan\theta = \frac{0.4v^2}{gR} = \frac{0.4 \times (13.88)^2}{9.81 \times 300} = 0.026$$

3. Chainage of all junction points

i. Shift, $S = \frac{L^2}{24R} = \frac{(17.82)^2}{24 \times 300}$

$S = 0.044$ m

ii. Total tangent length,

$$T_t = (R + S)\tan\frac{\theta}{2} + \frac{L}{2}$$

$$= (300 + 0.044)\tan\frac{60°}{2} + \frac{17.82}{2}$$

$T_t = 173.23 + 8.91 = 182.14$ m

iii. Chainage at the beginning at the transition
$= 3605 - 182.14 = 3422.86$ m

iv. Chainage at the junction of the transition curve with the circular curve
$= 3422.86 + 17.82 = 3440.68$ m

Que 2.21. **Two straight lines AC and CB intersect at C, at a chainage of 86.22 chains at a deflection angle of 62°. These lines are to be smoothly connected by a simple curve of radius 12 chains.**

Find the tangent length, length of the curve and the chainages of the starting and end points of the curve. Find also the length of the long chord. **AKTU 2018-19, Marks 07**

Answer

Given : Deflection angle, $\Delta = 62°$, Radius, $R = 12$ chain
To Find : Tangent length, length of curve, chainage at be starting and end points, length of long chord.

1. Tangent length $= R \tan \frac{\Delta}{2} = 12 \times \tan \frac{62°}{2} = 7.21$ chains
2. Chainage at starting $= 86.22 - 7.21 = 79.01$ chains
3. Length of curve $= \frac{\pi R \Delta}{180°} = \frac{\pi \times 12 \times 62°}{180°} = 12.985$ chains
4. Chainage at end of curve $= 79.01 + 12.985 = 91.995 = 92$ chains
5. Length of long chord $= 2R \sin \frac{\Delta}{2} = 2 \times 12 \times \sin \frac{62°}{2} = 12.36$ chains

VERY IMPORTANT QUESTIONS

Following questions are very important. These questions may be asked in your SESSIONALS as well as UNIVERSITY EXAMINATION.

Q. 1. What is curve ? Why these are needed and also give a classification of curves ?
Ans. Refer Q. 2.1, Unit-2.

Q. 2. Give in detail different linear methods of setting out simple circular curves.
Ans. Refer Q. 2.4, Unit-2.

Q. 3. Describe in detail different angular methods of setting out simple circular curves.
Ans. Refer Q. 2.5, Unit-2.

Q. 4. The apex distance of a 3° circular curve is 82.45 m. Determine the deflection angle, tangent length and length of long chord.
Ans. Refer Q. 2.8, Unit-2.

Q. 5. Explain the requirements of a transition curve.
Ans. Refer Q. 2.11, Unit-2.

Q. 6. State the different methods of calculating length of transition curve.
Ans. Refer Q. 2.12, Unit-2.

Q. 7. Explain the condition of an ideal transition curve and derive the equation for ideal transition curve.
Ans. Refer Q. 2.13, Unit-2.

Q. 8. What is vertical curve and its type ?
Ans. Refer Q. 2.15, Unit-2.

Q. 9. Two straight lines AC and CB intersect at C, at a chainage of 86.22 chains at a deflection angle of 62°. These lines are to be smoothly connected by a simple curve of radius 12 chains. Find the tangent length, length of the curve and the chainages of the starting and end points of the curve. Find also the length of the long chord.
Ans. Refer Q. 2.21, Unit-2.

☺☺☺

3 UNIT

Modern Field Survey Systems

CONTENTS

PART-1

Principle and Types of Electronic Distance Measurement Systems and Instrument.

Questions-Answers

Long Answer Type and Medium Answer Type Questions

Que 3.1. **Define the EDM. Discuss briefly the method of measuring distance between two points.**

Answer

A. **EDM :**

1. Electronic distance measuring instrument is a surveying instrument for measuring distance electronically between two points through electromagnetic waves.
2. Electronic distance measurement (EDM) is a method of determining the length between two points, using phase changes, that occur as electromagnetic energy waves travels from one end of the line to the other end.

B. **Measuring Method :** Following are three methods of measuring distance between two points :

1. **DDM or Direct Distance Measurement :** This is mainly done by chaining or taping.
2. **ODM or Optical Distance Measurement :** This measurement is conducted by tacheometry, horizontal subtense method or telemetric method. These are carried out with the help of optical wedge attachments.
3. **EDM or Electromagnetic Distance Measurement :** The method of direct distance measurement cannot be implemented in difficult terrains. When large amount of inconsistency in the terrain or large obstructions exist, this method is avoided.

Que 3.2. **Discuss the types of electronic distance measurement systems.**

Answer

Types of EDM Instruments : Depending upon the type of carrier wave employed, EDM instruments can be classified under the following heads :

1. Microwave Instruments :

i. These instruments come under the category of long range instruments, where in the carrier frequencies of the range of 3 to 30 GHz ($1\ GHz = 10^9$) enable distance measurements upto 100 km range. Tellurometer comes under this category.

ii. Phase comparison technique is used for distance measurement.

iii. This instrument, known as remote instrument is identical to the master instrument placed at the measuring end.

2. Visible Light Instruments :

i. These instruments use visible light as carrier wave, with a higher frequency, of the order of 5×10^{14} Hz.

ii. Since the transmitting power of carrier wave of such high frequency falls off rapidly with the distance, the range of such EDM instruments is lesser than those of microwave units.

iii. A geodimeter comes under this category of EDM instruments.

iv. The carrier, transmitted as light beam, is concentrated on a signal using lens or mirror system, so that signal loss does not take place.

3. Infrared Instruments :

i. The EDM instruments in this group use near infrared radiation band of wavelength about 0.9 μm as carrier wave which is easily obtained from gallum arsenide (Ga As) infrared emitting diode.

ii. These diodes can be very easily directly amplitude modulated at high frequencies. This, modulated carrier wave is obtained by an inexpensive method.

iii. Due to the reason, there is predominance of infrared instruments in EDM.

iv. Wild Distomats fall under this category of EDM instruments.

Que 3.3. Describe the working of EDM.

Answer

1. Principle of Working of the Instrument : The basic principle of EDM instrument is the determination of time required for electro-magnetic waves to travel between two stations. Here the velocity of electro-magnetic wave is the basis for computations of the distance.

2. Working of Electro - Optical EDM Instrument :

i. An Electro-optical EDM instrument, set up on one station, emits a continuous-wave carrier beam of light.

ii. It is generated in the transmitter and modulated by an electronic shutter before entering the aiming optics.

iii. The modulator chops the beam into wavelengths that are proportional to the modulating frequency, where the wavelength is given by,

$$\lambda = v/f$$

where, λ = Wavelength.

v = Velocity of light through the atmosphere, m/sec.

f = Modulating frequency, Hz (cycles per second).

iv. The modulated light is transmitted to the reflector, placed at the other end of the line.

v. The reflector, acting as a mirror, reflects the light beam back to the receiver, where the incoming light is converted to an electrical signal.

vi. A phase comparison is made between the projected and reflected pulses.

vii. Then the amount by which the transmitted and received signals are out of phase get measured electronically and registered in a meter by getting converted to an equivalent distance.

viii. In using an Electro-optical EDM, a clear line of sight is required and thus required inter-visibility between the stations.

PART-2

Total Station–Its Advantages and Applications.

Questions-Answers

Long Answer Type and Medium Answer Type Questions

Que 3.4. Define the total station and also give the working principle of total station.

Answer

Total Station : A total station, also known as electronic tachcometer, is an optical instrument. It is a combination of an electronic theodolite for measuring horizontal and vertical angles, an electromagnetic distance measurement (EDM) device for measurement of slope distance and on board software to convert the raw observed data to three dimensional co-ordinates.

Working Principle of Total Station :

1. These instruments are measuring the distances of prism poles mounted with prisms with the help of Laser beam or Infrared rays.
2. These signals are emitted by the instrument EDM and reflected back to instruments by the prism mounted on the prism poles.
3. The time interval between emission and reception helps to calculate the distance as the speed of these signals is precisely known.

$D = (t/2) \times v$

where, D = Distance, t = Total time taken, v = Velocity

Que 3.5. **What are the advantages and disadvantages of total station ?**

Answer

Advantage of Total Station :

1. Relatively quick collection of information.
2. Multiple surveys can be performed at one set-up location.
3. Easy to perform distance and horizontal measurements with simultaneous calculation of project co-ordinates (Northings, Eastings, and Elevations).
4. Layout of construction site quickly and efficiently.
5. Digital design data from CAD programs can be uploaded to data collector.
6. Greater accuracy in area computation.

Disadvantage of Total Station :

1. Vertical elevation accuracy not as accurate as using conventional survey level and rod technique.
2. It may be difficult for the surveyor to look area and check the work while surveying.
3. The instrument is costly and skilled personnel are required.

Que 3.6. **Write down the uses of total station.**

Answer

Uses : Following are the uses of total station :

1. It is mainly used by land surveyors and civil engineers, either to record features as in topographic surveying or to set out features (such as roads, houses or boundaries).
2. It is the primary survey instrument used in mining surveying.
3. It is used to record the absolute location of the tunnel walls, ceilings (backs), and floors as the drifts of an underground mine are driven.
4. Meteorologists also use total stations to track weather balloons for determining upper-level winds.
5. It is used to track ceiling balloons to determine the height of cloud layers.

PART-3

Global Positioning System–Segments, Working Principle, Errors and Bioses.

Questions-Answers

Long Answer Type and Medium Answer Type Questions

Que 3.7. **What do you understand by GPS ? Describe various types of GPS.**

OR

Describe differential GPS and its advantages and functioning. **AKTU 2014-15, Marks 10**

OR

Describe the principle of differential GPS. **AKTU 2015-16, Marks 03** **AKTU 2017-18, Marks 05**

OR

Explain the kinematics GPS. **AKTU 2015-16, Marks 04**

Answer

A. GPS :

1. The GPS is a space-based all weather radio navigation system that provides quickly, accurately and inexpensively the time, position, and velocity of the object anywhere on the globe at any time.
2. The current GPS is based on accurate ephemeris data on the real-time location of each satellite and on a precisely kept time.
3. It uses the satellite signals, accurate time, and sophisticated algorithms to generate distances in order to triangulate positions anywhere on earth.
4. The system provides accurate, continuous, worldwide, three-dimensional position and velocity information to users with the appropriate receiving equipment.
5. The global positioning system is comprised of three segments :

i. Satellite constellation called space segment.
ii. Ground control/monitoring network called operational control segment.
iii. User receiving equipment called user equipment segment.

B. Types : Following are two types of GPS system :

1. Differential GPS :

i. It is a system in which differences between observed and computed co-ordinates or ranges called differential corrections, at a particular known point called the reference station, are transmitted to users to improve the accuracy of the user's receiver position. In fact, DGPS is a way to make GPS even more accurate.

ii. DGPS is mainly a navigation method in which there is a fixed reference station and co-ordinates of moving platform or rover are determined in real time.

Principle of DGPS :

i. It is based on the concept that bias error in position of the location is similar to those for all locations in a given local area (say within 100 km).

ii. Unfortunately, a user can not just figure out the error once and use it to correct all the measurements made for the rest of the day, because the satellite errors are continuously changing.

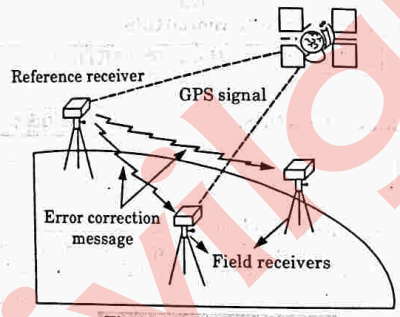


Fig. 3.7.1. Differential GPS.

iii. A user needs to have two receivers working simultaneously to do the job. The reference receiver stays put and continuously monitors the errors and then transmits or records corrections for those errors so that the second receiver (the one that is out roving around doing positioning work) can apply these corrections to its measurements, either as it is making them or some time later.

iv. Thus, by having a reference receiver at a fixed location, the user can tune up the accuracy of a roving receiver, or for a whole fleet of roving receivers as shown in Fig. 3.7.1.

Advantages of DGPS :

i. It improves accuracy.

ii. DGPS works by cancelling out most of the natural and man-made errors that keep into normal GPS measurements.

2. Kinematic GPS :

i. It is known as Real Time Kinematic (RTK). RTK satellite navigation is a technique used to enhance the precision of position data derived from satellite based positioning systems being unable in conjunction with GPS, GLONASS and/or Galileo.

ii. It used the measurements of the phase signals carrier wave rather than the information content of the signal and relies as a single reference station to provide the real-time corrections, providing upto centimeter level accuracy.

iii. With reference to GPS this system is commonly known as carrier phase enhancement or CPGPS. It has a lot of applications in land survey and hydrographic survey.

iv. The Virtual Reference Station (VRS) method, has extended the use of RTK, to a whole area of a reference station network operational reliability and accuracy, depends upon the density and capabilities of the reference station network.

Que 3.8. Describe the principle of global positioning system.

OR

Explain the principle which helps GPS to determine the position of place. **AKTU 2017-18, Marks 07**

OR

What is the basic principle of position determination with GPS ? Describe with a suitable sketch.

Answer

Principle of Global Positioning System :

1. The GPS satellites act as reference points from which receivers on the ground reset their positions.
2. The fundamental navigation principle is based on the measurements of pseudo ranges between the user and four satellites as shown in Fig. 3.8.1.
3. By measuring the travel time of signals transmitted from the satellites (orbiting at an altitude of 20200 km above the earth), four distances between satellites and receiver are calculated which in turn yield accurate position, direction and speed.
4. The GPS technique overcomes the numerous limitations of the terrestrial surveying methods, like the requirement of intervisibility of survey stations, dependability on weather, difficulties in observations, etc.

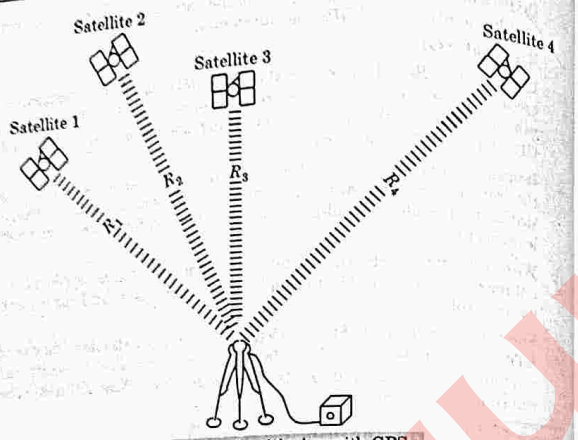


Fig. 3.8.1. Principle of positioning with GPS.

5. The GPS technology has applications in providing geodetic control and survey control for photogrammetric control surveys and mapping, finding out location of offshore drilling, pipeline and power line survey, navigation of civilian ships and aircrafts, crustal movement studies, geophysical positioning, mineral exploration and mining, determination of precise geoid, estimation of gravity anomalies, etc.

Que 3.9. **Discuss about the following terms :**

A. GLONASS.

B. GALILEO. **AKTU 2015-16, Marks 10**

Answer

A. GLONASS :

1. It is a satellite navigation system, providing real time position and velocity determination for military and civilian users.
2. The satellites are located in middle circular orbit at 19,100 km altitude with a 64.8 degree inclination and a period of 11 hours and 15 minutes.
3. GLONASS orbit makes it especially suited for usage in high latitudes (north or south), where getting a GPS signal can be problematic.
4. The constellation operates in three orbital planes, with 8 evenly spaced satellites on each.

5. A fully operational constellation with global coverage consists of 24 satellites, while 18 satellites are necessary for covering the territory of Russia.
6. To get a position fix the receiver must be in the range of at least four satellites.

B. GALILEO :

1. The aim of Galileo is to provide a high-precision positioning system.
2. It is intended to provide horizontal and vertical positions measurements within 1 m precision, and better positioning at high altitudes than GPS and GLONASS systems.
3. When completed, Galileo will comprise 30 satellites located in Medium Earth Orbit (MEO). The constellation has an inclination of 56° relative to the equatorial plane. The Galileo orbit inclination was selected to ensure good performance at polar latitudes and in particular northern European Latitudes.
4. This system will provide a signal to the users, informing them that their situation has been detected and help is on way.

Que 3.10. **Explain the various segments of GPS.**

AKTU 2016-17, Marks 15

OR

Explain the functional segment of GPS.

AKTU 2017-18, Marks 05

Answer

Segments of GPS : Following are three types of GPS segments :

1. GPS Satellite Constellation or Space Segment :

i. The satellite constellation consists of the nominal 24-satellite constellation.

ii. They transmit signals (at 1575.42 MHz) that can be detected by receivers on the ground.

iii. The satellites are positioned in six earth-centred orbital planes with four satellites in each plane.

iv. This means that signals from six of them can be received 100 percent of the time at any point on earth.

v. The nominal orbital period of a GPS satellite is one half of a sidereal day or 11 h 58 min.

vi. The orbits are nearly circular and equally spaced about the equator at a 60° separation with an inclination relative to the equator of nominally 55°.

vii. The orbital radius is approximately 26,600 km (*i.e.*, distance from satellite to centre of mass of the earth).

Fig. 3.10.1. GPS satellite constellation.

2. **Operational Control Segment (OCS) :**

i. The OCS has responsibility for maintaining the satellites and their proper functioning.

ii. This includes maintaining the satellites in their proper orbital positions (called station keeping) and monitoring satellite subsystem health and status.

iii. The OCS also monitors the satellite solar arrays, battery power levels, and propellant levels used for maneuvers and activate spare satellites.

iv. The overall structure of the operational ground/control segment is comprised of three different physical components :

a. The master control station (MCS),

b. The monitor stations (MS), and

c. Ground antennas.

3. **User Equipment Segment :**

i. The user receiving equipment, referred to as a GPS receiver, receives and processes the L-band signals transmitted from the satellites to determine user position, velocity and time (PVT).

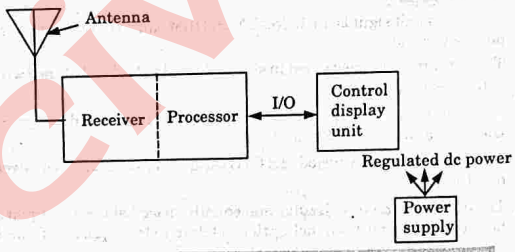


Fig. 3.10.2. A schematic representation of the GPS receiver.

ii. Almost all GPS receivers have essentially the same basic components- an antenna, an RF (radio frequency) section, a microprocessor, a control and display unit (CDU), a recording device and a power supply.

Block diagram of the GPS receiving set is shown in Fig. 3.10.2.

a. **Antenna and Preamplifier :**

i. The task is to receive the electromagnetic radiation coming from the satellites and amplify them for further processing. Microstrip antenna is one of the widely used systems.

b. **Radio Frequency Section and Computer Processor :**

i. The RF section of a GPS receiver converts the incoming signal after preamplification to an intermediate frequency (IF) for further processing.

ii. The modulated signal extracted from the carrier is processed by a powerful microprocessor.

c. **Input/Output Device :** This enables operators to interact with the microprocessor, and the measured data is stored/displayed. It will also have a standard interface to transfer to digital data outside.

d. **Power Supply :** Since transportable and handheld GPS are very common, internal battery packs form a part of the receiver.

Que 3.11. Differentiate between kinematic and differential GPS.

AKTU 2016-17, Marks 05

Answer

Following are difference between differential GPS and kinematic GPS :

S. No.	Differential GPS	Kinematic GPS
1.	Differential GPS uses only pseudorange to compute its position.	Kinematic GPS uses not only pseudorange for computing position, but also for carrier phase and Doppler measurements.
2.	Accuracy for this technique is in the order of sub-meter.	This technique has centimeter accuracy.
3.	Differential GPS systems are inexpensive.	Kinematic GPS systems are expensive.

Que 3.12. What are the sources of errors in GPS ? List and explain in brief how the errors can be minimized with the help of differential GPS.

Answer

A. **Sources of Errors :** Following are the sources of error :

1. **Atmospheric Conditions Error :**
   i. Speed of GPS signal is affected by ionosphere and troposphere.
   ii. It causes a deviation of 0 to 30 m from the actual position of receiver.
2. **Ephemeris Error :**
   i. The predicted changes in the orbit of a satellite.
   i. It causes a deviation of 0 to 5 m from the actual position of receiver.
3. **Clock Drift Error :**
   i. Due to different code generations in satellite and receiver simultaneously.
   ii. It causes a deviation of 0 to 1.5 m from the actual position of receiver.
4. **Multipath Error :**
   i. Bouncing of GPS signal due to a reflecting surface before reaching to receiver antenna.
   ii. It causes a deviation of 0 to 1 m from the actual position of receiver.

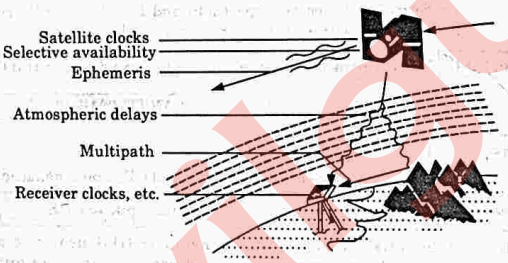


Fig. 3.12.1. Sources of error.

B. Error Minimization :

1. GPS errors common to an area can be minimized with the use of a differential GPS reference station. The errors correctable with differential GPS are the satellite ephemeris errors, satellite clock errors, and atmospheric errors (ionosphere and troposphere errors).
2. **Minimize of Multipath Error :**
   i. A variety of techniques, most notably narrow correlator spacing, have been developed to mitigate multipath errors.
   ii. For long delay multipath, the receiver itself can recognize the wayward signal and discard it.
   iii. To address shorter delay multipath from the signal reflecting off the ground, specialized antennas (e.g., a choke ring antenna) may be used to reduce the signal power as received by the antenna.

3. **Minimize of Ephemeris and Clock Errors :** For very precise positioning (e.g., in geodesy), these effects can be eliminated by differential GPS: the simultaneous use of two or more receivers at several survey points.

Que 3.13. Explain various applications of GPS. Explain clearly use of GPS in land use classification.

OR

How has GPS revolutionized our life ? Explain.

AKTU 2016-17, Marks 15

Answer

Application : Following are the various applications of GPS :

1. **Navigation :**
   i. Marine and air navigation are perhaps the two most obvious applications of GPS. Both military and civilians wish to know their spatial locations as precisely as possible.
   ii. The regional applications of GPS include exploration, transportation management, structural monitoring, and various types of automation.
   iii. As a local application, GPS can aid in berthing and docking of large vessels.
2. **Surveying :**
   i. The combination of real-time positioning, mobile data communications, and on-board data processing and applications software, all contribute to a new era in surveying.
   ii. GPS techniques permit the collection of data on specified profile, cross section, and boundary locations, contours may be readily plotted from the collected data.
   iii. Local use of GPS include local property and site survey, to perform topographic survey, to use GPS kinematic surveying to determine the co-ordinates of the photocentre during aerial mapping flights.
3. **Mapping :**
   i. A major early implementation of GPS was in the provision of ground truthing, or orientation of aerial photogrammetry.
   ii. Index marks are often surveyed on ground to provide reference locations on these photographs, which can be used in determining their scale and orientation. GPS can be used to survey these references.
   iii. The generation of roads map, or any other kind of feature map, is now extremely easy achieved simply by recording a series of positions as a receiver is moved over the area to be mapped.

4. **Remote Sensing :**
   i. It is also possible to integrate GPS positioning into remote-sensing method such as photogrammetry and aerial scanning, magnetometry, and video technology.
5. **Military and Space :**
   i. GPS was conceived and constructed for the use of military. The use of GPS in spacecraft has been widespread.
   ii. GPS has flown on several shuttle missions, and has been useful in providing better orbital positioning in much shorter time than has been previously possible.
6. **Agriculture :**
   i. GPS is opening a new era of precision farming in the advance countries.
   ii. A farmer can analyze the soil condition of every region of his farm and compile a fertilizer demand map. This map is digitized and stored in the GPS system computer.
   iii. As the chemical spreader moves through his fields, its GPS-measured position is correlated with the stored demand map to determine the exact amount of fertilizer or pesticide to be applied at every point.
7. **GPS in Land Use :**
   i. The land use/land cover pattern of a region is an outcome of natural and socio-economic factors and their utilization by man in time and space. Land is becoming a scarce resource due to immense agricultural and demographic pressure. Hence, information on land use / land cover and possibilities for their optimal use is essential for the selection, planning and implementation of land use schemes to meet the increasing demands for basic human needs and welfare.
   ii. This information also assists in monitoring the dynamics of land use resulting out of changing demands of increasing population.
   iii. Over the past years, data from earth sensing satellites has become vital in mapping the earth's features and infrastructures, managing natural resources and studying environmental change.

PART-4

Geographic Information System : Concepts and Data Types Data Models, Data Acquisition.

Questions-Answers

Long Answer Type and Medium Answer Type Questions

Que 3.14. Discuss GIS and all its components in detail.

AKTU 2016-17, Marks 05 **AKTU 2017-18, Marks 07**

OR

Define GIS and its components. **AKTU 2014-15, Marks 10**

Answer

A. GIS :

1. GIS stands for Geographical Information System. It consists of three disciplines, (geography + information + system) :
   i. **Geography** is about earth's various surface features (physical, biological and cultural).
   ii. **Information** amongst them spatially referenced *i.e.*, denoted by a co-ordinate system, latitudes, longitudes.
   iii. **System** implies that a GIS is made up of several inter-related and mutually linked components with different functions.
2. These parts operate individually and interact with one another as per procedures.
3. It can be considered to be made up of input, processing and output sub-systems.

B. Definitions of GIS : Several definitions of GIS have been given by different agencies, of which two are as follows :

1. **According to Rhind (1989) :** GIS is a system of hardware, software, and procedures designed to support the capture management, manipulation, analysis, modeling and display of spatially referenced data for solving complex planning and management problems.
2. **According to United State Geological Survey (1997) :** GIS is a computer based system capable of assembling, sorting, manipulating and displaying geographically referenced information *i.e.*, data identified according to their location. In simplest form, GIS is a computer aided system for storing, managing, manipulating geographical data to solve spatial problems of real world.

C. Components : The GIS is composed of five key components :

1. **Hardware :**
   i. It is computer hardware on which GIS software runs.
   ii. It consists :
      a. Input devices e.g., digitizer, scanner and GPS.
      b. Storage devices e.g., magnetic tapes, CD, DVD, CD ROMs.
      c. CPU : depending on the data processing power of CPU, computers are classified as super computers, main frame, mini computers, work sections, micro computers and personal computers.
      d. Output devices e.g., display devices, printers, plotters.

2. **Software :**
   i. These are programmes which run on the computers.
   ii. These programmes provide functions and tools to store, analyze and display geographic information.
3. **Data :**
   i. Data in GIS is geospatial data. The sources of spatial data are digitized maps, satellite images, aerial photographs, statistical tables etc.
   ii. Geographical and related attribute data can also be collected by surveying.
   iii. Digital map forms are basic data input for GIS to which is attached tabular (attribute) data.
   iv. Database is the foundation of a GIS, and is as good as the data it uses.
   v. GIS integrates spatial and attribute data.
4. **Procedure :**
   i. Procedures designed to support the data capture, storage, processing, analysis, modeling and display of geospatial data is important for a GIS.
   ii. The interest and willingness of the organization setup and decision makers is important for using the results for planning and implementations.
5. **Users :** The roles of users are to select pertinent (useful) information to set necessary standards, to design cost efficient updating schemes to analyze GIS outputs for relevant purposes and plan the implementation. No GIS exists in isolation of the user.

Que 3.15. **What things can be represented by point, line and polygon ? Explain topological data model to represent area.**

AKTU 2015-16, Marks 10

Answer

A. **Point :**
1. Depiction by point depends on scale of the map. It is used to denote survey control points, a well are generally represented as point, which have negligible dimension.
2. A building, village, a city can be represented as point depend on scale of map.

B. **Line :** These are used to depict features which are primarily linear e.g. a roadway, railway, a river, a canal, pipe lines, village boundary etc.

C. **Polygon :** These is used to depict an area e.g. a forest, cultivable land, fellow land, water body etc.

D. **Topological Data Model :**
Topological data model is described the relations what exist in area features which are as follows :
1. **Adjacency :** These are areas which have a common boundary.
2. **Containment :** These are area features which may be wholly contained within another e.g., an island within a lake, district of a state.
3. **Connectivity :** It is used to describe linkage between linear features e.g., network of railways/roads.

Que 3.16. **List important functions of GIS and explain any one in detail.**

OR

Explain the functions of GIS. **AKTU 2017-18, Marks 04**

AKTU 2015-16, Marks 05

Answer

Function : Following are the various functions of GIS :
1. Buffering.
2. Reclassification.
3. Overlay analysis.
4. Proximity analysis.
5. Filtering.

I. **Buffering :**
   i. It is the creation of a zone of interest around an entity.
   ii. It is possible both in vector and raster data format.
   iii. In vectors case, the result is a new set of objects.
   iv. Buffers are very useful for analyzing landscapes, highway alignments water supply networks and drainage studies.
   v. Buffering is very simple but involves complex computational operation.
   vi. If a point is buffered, a circular zone is created. Buffering lines and areas creates new areas.
   vii. Creating buffer zones around point features is the easiest operation; a circle of required radius is simply drawn around each point.
   viii. Some GIS do this by placing a circle of required radius at one end of the line or area boundary to be buffered. This circle is then moved along the length of the segment.
   ix. Sometimes there may be a need for another buffer around a buffer. This is called doughnut buffer.

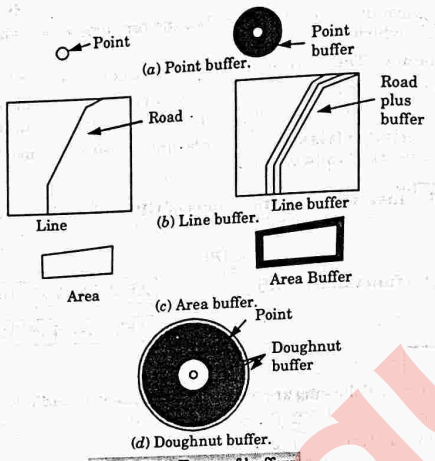


Fig. 3.16.1. Types of buffers.

Que 3.17. What are the limitations of GIS ?

AKTU 2015-16, Marks 05

Answer

Limitations : Following are the limitations of GIS :

1. Data for some area may lack spatial or temporal continuity.
2. Collecting data may be time consuming.
3. GIS may be subjected to misuse of misinterpretation.
4. GIS shows only spatial relationship but does not explain them which may be the requirement of the user.
5. GIS has its origin in earth science and computer science, therefore, may not be appropriate for humanities science or research.
6. GIS integrates several subjects which demand proper knowledge of all of them.
7. GIS needs computer equipment and software.

Que 3.18. What is a data model ? Explain the data models used in GIS. Differentiate between the object and field data models.

Answer

A. Data Model :

1. The ways of representing data are known as data models. The data model represents the linkages between the real-world domain of geographical data and the computer (or GIS representation of the features).
2. The process of linkages involves :

i. Identifying the spatial features from the real world in the context to an application and representing them in a conceptual model.

ii. Use raster or vector approach to represent conceptual model.

iii. Selecting an appropriate spatial data structure to store the model within the computer.

B. Types of Data Model : Following are two types of data model :

1. Object-based Model :

i. In object-based model, the geographic space is to be filled by discrete and identifiable objects.

ii. An object having spatial feature, identifiable boundaries, relevance to some intended application, and can be described by one or more characteristic knows as attributes.

2. Field-based Model :

i. In field-based model, geographic space is populated by one or more spatial phenomena of real-world with no obvious or specific extent.

ii. Data for spatial phenomena structured can be acquired either directly or indirectly by aerial photography, remote sensing, map scanning.

C. Difference : Following are the differences between object and field data model :

S. No.	Object Data Model	Field Data Model
1.	It deals with object oriented blue print of the system.	It deals with spatial phenomena of real-world.
2.	It defines how the application interacts with the information recieved from an external source.	It defines how table and fields store each individual piece of data.
3.	A vector data structure is an object based implementation.	A raster data structure is a field based implementation.

Que 3.19. Explain raster data model and vector data model. **AKTU 2017-18, Marks 07**

Answer

A. Raster Data Model :

1. The raster data model (raster image) divides the geographic space into a regular grid of cells in specific sequence (row-column structure).
2. In traditional raster image, the X-axis is the column indicator and the Y-axis is the row indicator.
3. Geographic as well as pictorial data can be represented and stored in a computer as raster.
4. Raster images representing geographically referenced spatial data are named as georaster by some people.
5. For example, a digital photograph of one's pet; this is not a geographic or geospatial data but a raster.
6. The cells which make a raster can be compared with the pixels. Each cell in the raster contains a single value. This value can be a reference to another value, but the idea is that each cell has just a single value, and it is assumed that the value is distributed evenly throughout the cell.
7. The raster cell size is an important factor. Smaller cell improve data quality because they can provide more detail. As cell size increases, data definition decreases or blurs.
8. Conceptually, raster models are the simplest of available spatial data models. We can create a raster of elevation values by encoding each cell with a value that represents the elevation which best represents the elevation in that cell's area.

B. Vector Data Model :

1. In the vector data model, the objects are represented as points, lines, or areas.
2. In a vector model, the positions of points, lines, and areas are precisely specified.
3. The position of each object is defined by a (series of) coordinate pairs.
4. A point is described by a single $x-y$ co-ordinate pair and by its name or label. A line is described by a set of co-ordinate-pairs and by its name or label.
5. In reality, a line is described by an infinite number of points. In practice, this is not a feasible way of storing a line.
6. Therefore, a line is built up by its starting and ending co-ordinate pairs. An area, also called a polygon, is described by a set cf co-ordinate pairs and by its name or label.

7. Vector data model are classified on the basis of :
   i. Object-based vector model.
   ii. Field-based vector model.

Que 3.20. Describe the general topological vector data model. How does it differ from the spaghetti model ?

OR

Explain topological model of vector data. **AKTU 2015-16, Marks 10**

Answer

1. Topology handles characteristics of geometry that unchanged under certain transformation e.g. stretching or bonding. The connections and relationships between objects are described independent of their co-ordinates.
2. Topology refers to how spatial objects/geographic features are related to each other. It describes the relationships like connectivity, adjacency, containment etc.
3. The topological relationships are normally listed in tables and stored within a database in GIS.
4. Following are the three basic topological percept that are necessary to understand topological data model :

i. Connectivity :
   a. This geometric property is used to define the linkages between the features.
   b. It identifies which chains are connected at which nodes (points) e.g., if networks of roads, where these are connected to each other, a network of drain gullies.

ii. Adjacency :
   a. It describes geometric relationship between area features like common boundaries.
   b. For example-district boundaries in state, boundaries of different states.

iii. Containment : It describes area features which may be wholly contained within another e.g., an islands within a lake.

5. Topology is mathematical method to define spatial relationship. These relationships are entered in forms of nodes, chains and polygons.
6. Nodes are the beginnings and endings of chains. Chains are lines and strings used to delineate boundaries. Polygons are areas defined by a series of connected lines.

Difference :

1. Topology is a set of rules that model the relationships between neighboring points, lines, and polygons and determines how they share geometry.

2. For example, consider two adjacent polygons. In the spaghetti model, the shared boundary of two neighbouring polygons is defined as two separate, identical lines.
3. The inclusion of topology into the data model allows for a single line to represent this shared boundary with an explicit reference to denote which side of the line belongs with which polygon.

Que 3.21. Describe advantages and disadvantages of vector data structure and raster data structure. **AKTU 2014-15, Marks 10**

Answer

A. Raster Data Structure :

1. Advantages : Following are advantages of raster data structure :

i. Simple data structure.
ii. Easy and efficient overlaying.
iii. Compatible with remote sensing imagery.
iv. High spatial variability is efficiently represented.
v. Efficient to represent continuous data.

2. Disadvantages : Following are disadvantages of raster data structure :

i. Larger file size.
ii. All the objects are series of pixels, no identity for discrete objects other than points / pixels.
iii. Difficult to build topological relationship.
iv. Inefficient projection transformations
v. Loss of information when using large cells.
vi. Difficult to edit.

B. Vector Data Structure :

1. Advantages : Following are the advantages of vector data structure :

i. Simple file size.
ii. Individual identity for discrete objects like line, polygon, etc.
iii. Efficient for topological relationship.
iv. Efficient projection transformation.
v. Accurate map output.
vi. Easy to edit.

2. Disadvantages : Following are the disadvantages of vector data structure :

i. Complex data structure.
ii. Difficult overlay operations.
iii. High spatial variability is inefficiently represented.
iv. Not compatible with remote sensing imagery.
v. Not appropriate to represent continuous data.

Que 3.22. Write a note on data acquisition. What are the various sources from which data can be derived to be used in GIS ?

Answer

A. Data acquisition :

1. Data acquisition is collecting spatial data from available resources e.g., maps, photographic images and converting it into digital form.
2. Data which is already in digital form can be recorded directly.
3. The method for acquisition of data depends on factors such as location, size of area of interest, the purpose of terrain modeling and the technical resources available.

B. Sources : Data can be acquired from any of the following sources :

1. Data from satellites remote sensing.
2. Digital data by GPS.
3. Data from internet (World Wide Web).
4. Data by aerial photography.
5. Data from existing maps.
6. Data by surveying in field.

Que 3.23. Explain the concept of object-oriented data model applied in GIS. **AKTU 2015-16, Marks 05**

Answer

1. The object oriented data model in GIS uses object class concept to organize spatial data.
2. In it all phenomenon are treated as distinct objects that have properties such as co-ordinate system and other attributes.
3. This model can perform operations on request such as zoom, pan, query etc.
4. For example a road is stored as an object with attributes like its name, its types (*i.e.*, a road), its quality (*i.e.*, a highway) and a sequence of co-ordinates that represent its path which the road follows.
5. Each geographic object belongs to some class of object. The object approach to GIS has many advantages.
6. It extends method of handling data of object and can define a relationship between different classes of objects.
7. For example roads and highways are two classes as they are maintained by two different agencies but the relationship between them is are used for transportation.

PART-5

GIS Applications in Civil Engineering.

Questions-Answers

Long Answer Type and Medium Answer Type Questions

Que 3.24. **What are the applications of GIS ?**

AKTU 2017-18, Marks 03

Answer

Application : Major application areas of GIS as follows :

Academic :	i. Research in engineering, science and humanities.
	ii. Primary and secondary schools : Schools district delineation, facilities, management, bus routing, spatial digital libraries.
Industry :	i. Engineering : Surveying and mapping, site and landscape development, pavement management.
	ii. Transportation : Route selection for goods delivery, public transit, vehicle tracking.
	iii. Utilities and communications : Electricity and gas distribution, pipelines telecommunication networks.
Business :	i. Banking and insurance.
	ii. Real estate.
	iii. Retail and market analysis.
	iv. Delivery of goods and services.
Government :	i. National topographic mapping, resource and environmental management, weather services, public land management, population census, election, and voting.
Military :	i. Training.
	ii. Command and control.
	iii. Intelligence gathering.

VERY IMPORTANT QUESTIONS

Following questions are very important. These questions may be asked in your SESSIONALS as well as UNIVERSITY EXAMINATION.

Q. 1. **Describe the principle of differential GPS.**
Ans: Refer Q. 3.7, Unit-3.

Q. 2. **Explain the principle which helps GPS to determine the position of place.**
Ans: Refer Q. 3.8, Unit-3.

Q. 3. **Discuss about the following terms :**
A. GLONASS.
B. GALILEO.
Ans: Refer Q. 3.9, Unit-3.

Q. 4. **Explain the functional segment of GPS.**
Ans: Refer Q. 3.10, Unit-3.

Q. 5. **How has GPS revolutionized our life ? Explain.**
Ans: Refer Q. 3.13, Unit-3.

Q. 6. **Discuss GIS and all its components in detail.**
Ans: Refer Q. 3.14, Unit-3.

Q. 7. **Explain the functions of GIS.**
Ans: Refer Q. 3.16, Unit-3.

Q. 8. **Explain raster data model and vector data model.**
Ans: Refer Q. 3.19, Unit-3.

Q. 9. **Describe advantages and disadvantages of vector data structure and raster data structure.**
Ans: Refer Q. 3.21, Unit-3.

Q. 10. **What are the applications of GIS ?**
Ans: Refer Q. 3.24, Unit-3.

☺☺☺

4 UNIT

Photogrammetric Survey

CONTENTS

PART-1

Basic Principles, Aerial Camera, Scale of a Vertical.

Questions-Answers

Long Answer Type and Medium Answer Type Questions

Que 4.1. **What is the principle of photogrammatic survey ? Describe the types of photogrammetric survey.**

Answer

1. It is the science and art of obtaining accurate measurements by use of photographs, for various purposes such as the construction of planimetric and topographic maps, classification of soils, interpretation of geology, acquisition of military intelligence and the preparation of composite pictures of the ground.
2. The photographs are taken either from the air or from station on the ground.
3. Following are the two types of photogrammetry :

i. **Terrestrial Photogrammetry :** It is that branch of photogrammetry wherein photographs are taken from a fixed position on or near the ground.

ii. **Aerial Photogrammetry :** It is that branch of photogrammetry wherein the photographs are taken by a camera mounted in an aircraft flying over the area.

4. Mapping from aerial photographs is the best mapping procedure developed for large project and is invaluable for military intelligence.

Que 4.2. **Mention the different type of aerial photographs and explain each one of them.**

Answer

Following are the different types of aerial photographs :

A. **Terrestrial Photograph :**

1. It is the photograph taken from ground station.
2. The instrument used is phototheodolite which is a theodolite mounted on a camera with its axis horizontal or nearly horizontal.
3. The line of collimation of the telescope and the optical axis of the camera are parallel to each other.

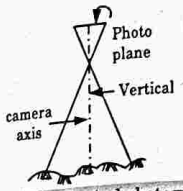


Fig. 4.2.1. Vertical photograph.

B. Aerial Photograph :

1. These are the photographs taken from overhead position with a camera board on an aeroplane, an artificial or natural satellite or a planet.
2. It can further be divided depending upon the angle between the axis of camera and the vertical axis as follows :

i. **Vertical Photograph :** It is a one, in which the optical axis of the camera is vertical or nearly vertical. A truly vertical photograph resembles a map, through a vertical photograph can be rarely obtained.

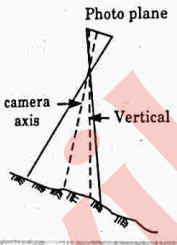


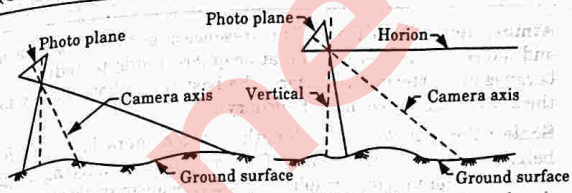
Fig. 4.2.2. Tilted photograph.

ii. **Tilted Photograph :** When the optical axis of the camera is unintentionally inclined to the vertical by not more than 3°, then the photograph taken is called "tilted photograph".

iii. **Oblique Photograph :** It is the photograph taken when the optical axis is intentionally inclined to the vertical at a greater angle. This is done to obtain a more familiar view of the terrain. Oblique photographs may further be divided into two categories :

a. **Low Oblique Photographs :** Photographs which do not show the horizon.

b. **High Oblique Photographs :** Photographs which show the horizon.



(a) Low-oblique photograph (b) High-oblique photograph

Fig. 4.2.3.

iv. **Convergent Photographs :**

a. These are low oblique photographs taken with two cameras exposed simultaneously at successive exposure stations.

b. The camera axes are tilted at a fixed inclination from the vertical in the direction of flight, so that forward exposure of the first station forms a stereopair with backward exposure of the next station.

v. **Trimetrogen Photographs :** These type of photographs are combination of vertical and low oblique photographs exposed simultaneously from the air station with two cameras.

Que 4.3. What is aerial photogrammetry ? Write advantages and disadvantages of aerial photogrammetry.

OR

What do you understand by the term 'Aerial photography' ? Also write a short note on the factors that influence aerial photography.

AKTU 2017-18, Marks 07

Answer

A. Aerial Photogrammetry : It is that branch of photogrammetry wherein the photographs are taken by a camera mounted in an aircraft flying over the area.

B. Advantages : Following are the advantages of aerial photogrammetry :

1. Suitable for inaccessible areas.
2. Suitable for mountainous region with less vegetation.
3. Suitable for mapping large areas, faster and economical.

C. Disadvantages : Following are the disadvantages of aerial photogrammetry :

1. Not suitable for dense forests and flat sands due to difficulty of identifying objects upon the photographs.
2. Not economical for survey of small areas.

Factors : Following are the factors that influence aerial photography :

1. **Atmospheric Conditions :** The presence of particles (smoke or dust) and molecules of gases in the atmosphere tends to reduce contrast because of scattering, therefore, the best time photography is when the sky is clear (November-February).
2. **Scale :** Ratio of *f*/*h* (*f*-focal length of the camera lens and *h*-flying height above the mean terrain). Due to variations in flying height, the scales of different photographs may vary. Scale may also vary because of the effects of tilt and relief displacements.
3. **Camera/Film/Filter Combination :** To ensure good image quality, modern distortion free cameras are used. Depending upon the requirements different lens/focal length/film/filter combinations can be used.
4. **Flight Direction :** Aerial photography is flown in strips to cover the designated area. It is advisable to keep the number of strips to minimum. The flight direction of strips is therefore kept along the length of the area.
5. **Time/ Season of Photography :** Aerial photography should be flown when the sun's elevation is 30 degrees above the horizon or three hours before and after the local noon time.

Que 4.4. **Differentiate between 'Aerial photography' and 'Aerial photogrammetry'.** **AKTU 2017-18, Marks 07**

Answer

S. No.	Aerial Photography	Aerial Photogrammetry
1.	Aerial photography is the art of taking and processing photographs.	Aerial photogrammetry is the science of making measurements from photographs.
2.	The fundamental principle used by photography is line of sight.	The fundamental principle used by photogrammetry is triangulation.

Que 4.5. **Describe aerial camera with the help of its neat sketch.**

Answer

Aerial camera consists of following three basic components :

1. **Magazine :**
   i. It holds the roll of unexposed film, advances the film between exposures, holds the film in place and winds up the exposed film.
   ii. The film is moved continuously past a small slit called format opening in the focal plane.

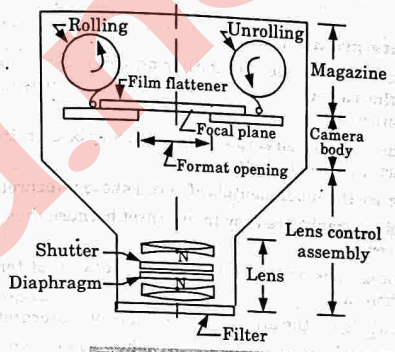


Fig. 4.5.1. Aerial camera.

2. **Camera Body :**
   i. The camera body is the part of the camera provided at the top of the cone.
   ii. Sometimes, it forms the integral part of the cone in which case they act as an integral part of preserve the interior orientation once the camera is calibrated.
3. **Lens Cone Assembly :** It has following components :
   i. **Lenses :** Lenses are the most important part of an aerial camera. Lenses used in aerial cameras are compound lenses of very high quality. Lenses gather light from objects and focus on the focal plane.
   ii. **Filter :** It is provided in front of the lens. It reduces effects of atmospheric haze, protects lens from dust and provides uniform light distribution over the format.
   iii. **Shutter :** It controls the exposure time depending upon aircraft speed so that sharp images are obtained.
   iv. **Diaphragm :** It controls the amount of light to pass through the lens by varying the size of aperture. It is normally placed in the air space between the lens elements.

Que 4.6. **Explain in detail about the characteristics of photographic images.** **AKTU 2015-16, Marks 7.5**

OR

Illustrate the fundamentals of aerial photo-interpretation. **AKTU 2015-16, Marks 10**

Answer

A. Photo Interpretation :

1. The process of studying and gathering the information required to identify the various cultural and natural features is called photo interpretation.
2. The information from an aerial photograph may be extracted by studying the characteristics of a photograph.
3. Following are the fundamentals of aerial photo interpretation :

i. Oblique photographs are easy to interpret because they depict a more familiar view.

ii. Color photographs are easy to interpret because of tonal variations present their in.

iii. Local knowledge of the area helps a lot in photo interpretation.

iv. Photo interpretation can also be arrived at by inspections or by association with familiar objects.

v. Knowledge, skill, training and experience of the interpreter coupled with imagination are very vital for interpretation.

vi. Stereopair photographs viewed stereoscopically greatly help in interpretation.

vii. Selective keys and elimination keys also greatly help in photo interpretation.

C. Characteristics of Photograph :

Following characteristics help the interpreter in identifying and recognizing the objects whose images appear in the aerial photographs.

1. Shape :

i. This refers to the general form, configuration, or outline of individual objects.

ii. In the case of stereographic photographs, the height of the object also defines its shape.

iii. Therefore, to facilitate easy recognition objects in profile, the interpreter must use stereographic photographs under stereoscope.

iv. The top view of the objects in vertical photography is quite unfamiliar and difficult to interpret, and one requires special training to acquire expertise in studying top views.

2. Size :

i. It is one of the most important and useful clues to identify the objects.

ii. By measuring an unknown object interpreter can arrive at more accurate identification.

iii. The size of objects on photographs must be considered in the context of the scale.

iv. For example, an irrigation ditch and antitank ditch images look alike but differ in size.

3. Shadows :

i. These are important for two opposing reasons :
   a. The shape or outline of a shadow affords the profile view of the objects which aids the interpretation; and
   b. Objects within shadows reflect little light and difficult to discern on photographs. This hinders interpretation.

ii. As an example for the first, shadows cast by towers, bridges, and certain species of trees can aid interpretation.

4. Pattern :

i. This relates to the spatial arrangement of objects.

ii. The repetition of certain general forms is characteristics of many natural and man-made objects.

iii. This is what constitutes a pattern that aids recognition.

iv. For example, the ordered spatial arrangement of trees in an orchard is distinctly different from that of groups of trees in a forest.

5. Tone (or Hue) :

i. This refers to the relative brightness or colour of objects on photographs.

ii. In aerial photographs which are generally in black and white, the objects are observed in tones of grey.

iii. The tones of photographic images are influenced by many factors.

iv. It may be clearly understood by the interpreter that a body of water may appear on a photograph in tone ranging from white to black.

v. Lighter-toned areas are topographically higher and drier while darker toned areas are lower and wetter.

6. Texture :

i. The texture in aerial photograph is created by tonal repetitions in group of objects too small to be discerned.

ii. As the scale of the photograph is reduced, the texture of the object or area becomes progressively finer.

iii. An example would be the smooth texture of green grass as contrasted with the rough texture of green tree crowns on medium scale aerial photographs.

7. **Site :** This refers to topographic or geographic locations and is particularly valuable in the identification of types of vegetation.

8. **Association :** This refers to the occurrence of certain features in relation to others. For example, a Ferris wheel, which might be difficult to identify if standing in a field near a barn, would be easily identified if it is in an amusement park.

Que 4.7. How will you determine the scale of an aerial photograph ? What do you understand by the terms 'datum scale' and 'average scale' ?

OR

Derive an expression for the scale of vertical photograph.

AKTU 2016-17, Marks 05

Answer

A. Scale of Aerial Photograph :

1. Scale of a vertical photograph = $\frac{\text{Distance on photo}}{\text{Corresponding distance on ground}}$

2. In the case of a map, the scale is uniform for the entire map because a map is an orthographic projection, whereas in case of a photograph the scale varies due to variation in elevation of a terrain because a photograph is a perspective projection.

i. **Flat Terrain :** The Fig. 4.7.1 shows a flat terrain AB height h above datum.

$$\text{Scale, } S = \frac{ab}{AB}$$

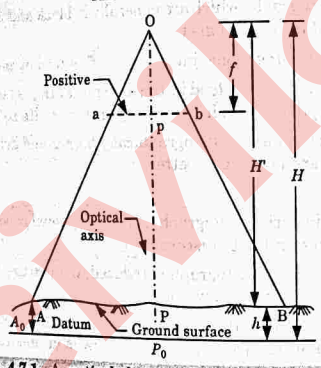


Fig. 4.7.1. A vertical photograph taken over flat terrian.

From similar triangles Oap and OAP,

$$\frac{ab/2}{AB/2} = \frac{Op}{OP}$$

$$\frac{ab}{AB} = \frac{Op}{OP} = \frac{f}{H'} = \frac{f}{H-h}$$

$$S = \frac{f}{H-h}$$

ii. **Variable Terrain :** Fig. 4.6.2 shows the vertical photograph of a terrain, in which the elevation is not constant. As per formula $S = \frac{f}{H-h}$, the scale increases with increase in elevation. Consider two points A and B, h_A and h_B above datum respectively.

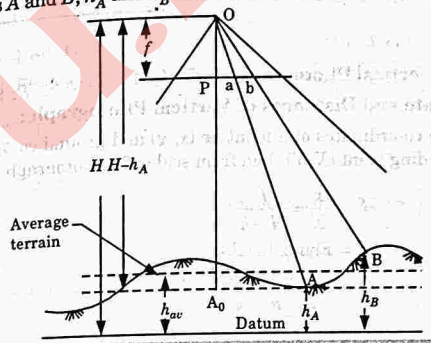


Fig. 4.7.2. Vertical photograph taken over variable terrain.

$$S_A = \frac{f}{H-h_A}$$

and,

$$S_B = \frac{f}{H-h_B}$$

B. Average Scale :

1. For a variable terrain it is often convenient to express average scale of the photograph. If elevation of points A, B, C, D..... is h_A, h_B, h_C, h_D ....

then

$$h_{av} = \frac{1}{n}(h_A + h_B + h_C + h_D + ...)$$

$$S_{av} = \frac{f}{H-h_{av}}$$

2. Average scale of a terrain can also be obtained by determining scale of different points and taking their average.

$$S_{av} = \frac{1}{n}(S_A + S_B + S_C + S_D + ...)$$

C. Datum Scale (S_D) :

1. The datum scale of a vertical photograph is the scale that would be, if all the ground points were projected downwards on the datum.

2. From Fig. 4.7.1, $S_D = \frac{ap}{A_0P_0} = \frac{f}{H}$

Que 4.8. **Discuss the method of determination of ground co-ordinates and distance between two points on ground.**

OR

Derive an expression for the scale of a vertical photograph. Explain how the ground coordinates and the distances can be obtained from a vertical photograph. **AKTU 2016-17, Marks 05**

Answer

A. Scale of Vertical Photograph : Refer Q. 4.7, Page 4–9B, Unit-4.

B. Coordinate and Distances of Vertical Photograph :

1. Let photo co-ordinates of a point be (x, y) and ground co-ordinates of corresponding point (X, Y) then from scale of a photograph

$$S = \frac{x}{X} = \frac{f}{H-h}$$

where, H = Flying height
h = Elevation of the point.

Then, $$X = x\frac{H-h}{f} = \frac{x}{S}$$

2. If there are two points A and B on the ground with elevations h_A and h_B then their ground co-ordinates are :

$$X_A = x_A\frac{H-h_A}{f} = \frac{x_A}{S_A} \text{ and } Y_A = y_A\frac{H-h_A}{f} = \frac{y_A}{S_A}$$

$$X_B = x_B\frac{H-h_B}{f} = \frac{x_B}{S_B} \text{ and } Y_B = y_B\frac{H-h_B}{f} = \frac{y_B}{S_B}$$

3. Distance between two points by co-ordinate geometry,

$$D = \sqrt{(X_A - X_B)^2 + (Y_A - Y_B)^2}$$

PART-2

Relief displacement of a Vertical Photograph, Height of Object from Relief Displacement.

Questions-Answers

Long Answer Type and Medium Answer Type Questions

Que 4.9. **Explain relief displacement on a vertical photograph. Derive an expression for its determination. Also derive an expression for determining scale of a vertical photograph.**

OR

Explain, what is relief displacement and how is it calculated ? **AKTU 2014-15, Marks 05**

OR

Define relief. Derive an expression for the displacement due to ground relief. **AKTU 2016-17, Marks 10**

Answer

A. Relief Displacement :

i. Relief displacement occurs when the point being photographed is not at an elevation of the mean datum.

ii. The distance on a photograph, from the image of any ground point to its fictitious image projected to a datum plane is the image displacement caused by topographic relief and is known as relief displacement.

B. Derivation :

1. Fig. 4.9.1 shows a vertical photograph taken from a height H above datum.
2. The image of ground point A_0, whose elevation is h_1, is 'a' on the photograph and that of its projection on the datum plane A_1 is a_1, thus aa_1 is the relief displacement of point A due to its elevation h_1. Similarly the relief displacement of point A_2 is aa_2 on the photograph.
3. Let, r_0 = Radial distance of 'a' from principal point 'p'
   r_1 = Radial distance of 'a_1' from principal point 'p'
   r_2 = Radial distance of 'a_2' from principal point 'p'
   R = Ground distance A_0P_0.
4. From similar triangles a_1pO and A_1P_1O,

$$\frac{f}{H} = \frac{r_1}{R}$$
$$fR = r_1H = a_1 \quad \text{...(4.9.1)}$$

5. From similar triangles apO and A_0P_0O,

$$\frac{f}{H-h_1} = \frac{r_0}{R}$$
$$fR = r_0(H-h_1) \quad \text{...(4.9.2)}$$

6. From eq. (4.9.1) and eq. (4.9.2), we get

$$r_1 H = r_0 (H - h_1) \quad ...(4.9.3)$$

or
$$r_0 = r_1 \frac{H}{H - h_1} \quad ...(4.9.4)$$

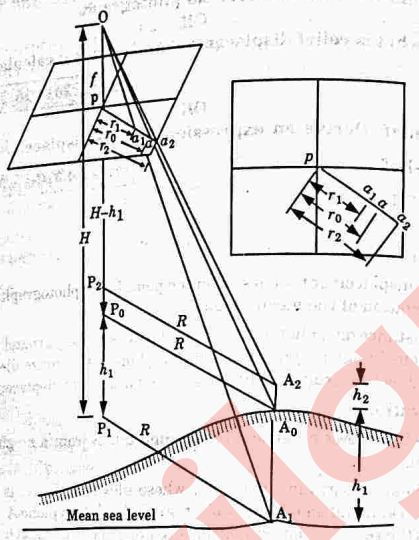


Fig. 4.9.1. Topographic relief displacement.

7. Relief displacement of ground point A_0,

$$d = aa_1$$
$$d = pa_0 - pa_1 = r_0 - r_1$$
$$= r_1\left(\frac{H}{H-h_1}\right) - r_1 = r_1\left[\frac{H}{H-h_1} - 1\right] = \frac{r_1 h_1}{H-h_1} \quad ...(4.9.5)$$

8. From similar triangles a_2pO and A_2P_2O,

$$\frac{f}{H-h_1-h_2} = \frac{r_2}{R}$$
$$fR = r_2(H-h_1-h_2) \quad ...(4.9.6)$$

9. From eq. (4.9.2) and eq. (4.9.6), we get

$$fR = r_0(H-h_1) = r_2(H-h_1-h_2)$$

$$r_0 = r_2 \frac{H-h_1-h_2}{H-h_1} \quad ...(4.9.7)$$

10. Relief displacement of point A_2,

$$d = r_2 - r_0 = r_2 - r_2 \frac{H-h_1-h_2}{H-h_1}$$
$$= r_2\left[1 - \frac{H-h_1-h_2}{H-h_1}\right] = \frac{r_2 h_2}{H-h_1} \quad ...(4.9.8)$$

Que 4.10. How do you determine the height of object from relief displacement ?

Answer

1. If the scale of the photograph is known, the height of any object, such as a tower TB shown in Fig. 4.10.1 can be determined by following equation :

$$d = \frac{rh}{H} \quad ...(4.10.1)$$

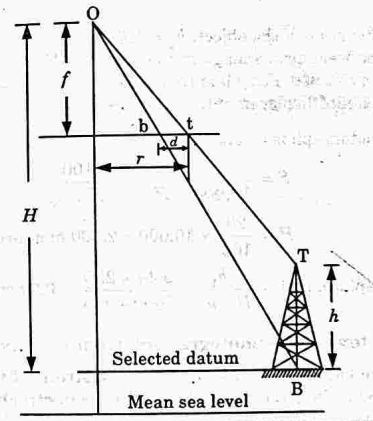


Fig. 4.10.1. Height of a tower from relief displacement.

2. Let h be the height of the tower above its exposure station above the selected datum passing through the base of the tower.
3. Let t and b be the top and bottom positions of the tower on the photograph.
4. The radial distance r and the relief displacement can very easily be measured.
5. If the scale S of the photograph is known, the height H can be calculated from the relation

$$S = \frac{f}{H} \quad \text{...(4.10.2)}$$

6. Knowing H, and measuring d and r, the height h is calculated from eq. (4.10.1). Thus,

$$h = \frac{dH}{r} \quad \text{...(4.10.3)}$$

where h is the height of the tower above the selected datum with reference to which H has been computed.

7. Incidentally, if the elevation of the bottom of the tower is known, the height of flight above mean sea level can be known.

Que 4.11. **The distance from the principal point to an image on a photograph is 6.44 cm and the elevation of the object above datum is 250 m, what is the relief displacement of the point is datum is 1/10000 and focal length is 20 cm.** **AKTU 2014-15, Marks 05**

Answer

Given : Elevation of the object, $h_1 = 250$ m
Distance between principal point to image on photograph, $r_1 = 6.44$ cm
Scale, $S = 1 : 10{,}000$, Focal length, $f = 20$ cm
To Find : Relief displacement.

1. Scale of photograph is given by,

$$S = \frac{1}{10{,}000} = \frac{f}{H} = \frac{20/100}{H}$$

or $$H = \frac{20}{100} \times 10{,}000 = 2{,}000 \text{ m above datum.}$$

2. Relief displacement $= \frac{r_1 h_1}{H - h_1} = \frac{6.44 \times 250}{2000 - 250} = 0.92$ cm

Que 4.12. **A tower was photographed from an elevation of 800 m above msl. The radial distance of top and bottom of the tower from the principal point is 121.3 mm and 90.7 mm respectively. If the bottom of tower has elevation of 280 m determine the height of the tower above its bottom.**

Answer

Given : $H = 800$ m, $r_2 = 121.3$ mm, $r_0 = 90.7$ mm, $h_1 = 280$ m
To Find : Height of the tower above its bottom, h_2.

1. Relief displacement, $d = r_2 - r_0 = 121.3 - 90.7 = 30.6$ mm

2. Relief displacement is given by,

$$d = \frac{r_2 h_2}{H - h_1}$$

$$30.6 = \frac{121.3 \times h_2}{800 - 280} = \frac{121.3 \times h_2}{520}$$

Height of tower above its bottom,

$$h_2 = \frac{30.6 \times 520}{121.3} = 131.179 \text{ m.}$$

PART-3

Flight Planning for Aerial Photography, Selection of Altitude, Interval between Exposures, Crab and Drift.

Questions-Answers

Long Answer Type and Medium Answer Type Questions

Que 4.13. **Explain briefly the aspects of flight planning for an aerial survey and obtain an expression for the number of photographs required for a given area of length and width for such a survey.**

Answer

A. Flight Planning :

1. Flight planning consists of the following information :
   - i. The area to be surveyed.
   - ii. Focal length of the camera.
   - iii. Scale of the photograph.
   - iv. Longitudinal and side overlap.
   - v. Approximate ground speed of the aircraft in stable air.
2. The above information is required to find the altitude of the aircraft above datum, time interval between the exposures, the area covered by each photograph, number of photographs, number of strips and air base.
3. To cover the entire terrain to be surveyed, the sufficient photographs with suitable overlap should be taken.

B. Expression :

1. Let, Ground length to be surveyed = L
   Ground width to be surveyed = W
   Length of photograph = l

Width of photograph = w
Scale of photograph = S
End or longitudinal overlap = l_e
Side overlap = l_s

2. Net ground length covered by each photograph = $lS(1-l_e)$
3. Net ground width covered by each photograph = $wS(1-l_s)$
4. Number of exposures per flight line $(N_1) = \dfrac{L}{lS(1-l_e)} + 1$
5. Number of flight lines $(N_2) = \dfrac{W}{wS(1-l_s)} + 1.$
6. Number of photographs required = $N_1 \times N_2$
7. Required number of photographs can also be worked out on the basis of net area covered by each photograph and area to be surveyed.

Area to be surveyed = LW

8. Net area covered by each photograph = $lS(1-l_e) \times wS(1-l_s)$
$= lwS^2(1-l_e)(1-l_s)$
9. Number of photographs required = $\dfrac{WL}{wlS^2(1-l_e)(1-l_s)}$
10. Number of photographs required on area basis will be lesser than that required on the basis of number of exposures per flight line × number of flight lines.

Que 4.14. Write a short note on :

i. Interval between exposures.
ii. Selection of flying altitude.

Answer

i. Interval Between Exposures :

1. The time interval between the exposures can be calculated if the ground speed of the airplane and the ground distance along the direction of flight between exposures are known.
2. Let V = Ground speed of the airplane (km/hour).

Ground distance covered by each photograph in the direction of flight in km,

$L = (1-le)\,Sl$

Time interval between the exposures, $T = \dfrac{3600L}{V}$

3. The exposures are regulated by measuring the time required for the image of a ground point to pass between two lines on a ground-glass plate of the view-finder.

4. Usually, however, the interval is not calculated, but the camera is tripped automatically by synchronizing the speed of a moving grid in the view-finder with the speed of the passage of images across a screen.

ii. Selection of Flying Altitude :

1. The selection of height above ground depends upon the accuracy of the process to be used and the contour interval desired.
2. Several inter-related factors which affect the selection of flying height, such as desired scale, relief displacement, and tilt.
3. Since vertical accuracy in a topographic map is the limiting factor in the photogrammetric process, the flying height is often related to the contour interval of the finished map.
4. The process is rated by its *C*-factor which is the number by which the contour interval is multiplied to obtain the maximum height about the ground.

Thus, Flying height = (Contour interval) × (*C* factor)

5. *C*-factor for various processors varies from 500 to 1500, and depends upon the conditions surrounding the entire map-compilation operation.

Que 4.15. Explain with reference to aerial photographs, what is meant by end overlap and side overlap and why they are provided ?

OR

Why overlapping is required in aerial photography ? Also explain crab and drift.

OR

Why overlapping is necessary ? **AKTU 2014-15, Marks 05**

Answer

A. Overlap : To ensure a complete coverage of the area to be surveyed, there should be some overlap of the area covered by each aerial photograph. Following are the two types of overlap :

1. **End or Longitudinal or Forward Overlap :** It is the overlap in photographs in the direction of flight. It is kept 55 % to 65 %.
2. **Side Overlap :**

i. It is the overlap in photograph in a direction perpendicular to the line of flight. It is kept 25 % to 35 %.

ii. It is the overlap between photographs of two adjacent flight strips. It is also called "lateral overlap".

B. Requirements of Overlapping :

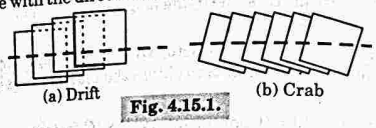
1. It is required to orient prints so as to form a continuous flight strip.
2. The central portion of the print is always less distorted than the outer edges. Since, due to the overlap, the same area is photographed twice or

thrice, the highly distorted outer portion of the photograph can therefore be discarded.

3. For a stereoscopic vision only the overlapped portion is useful.
4. If a proper side overlap is provided, there will be no possibility of gaps left because of the deviation of the aircraft from the flight line.

C. **Drift :** It is shifting of aircraft from its planned flight lines often caused due to strong winds (while taking photographs).

D. **Crab :** When the camera mounted abroad an aircraft is not square with the direction of flight at the time of exposure, the photograph taken will be oblique with the direction of flight.



(a) Drift (b) Crab

Fig. 4.15.1.

Que 4.16. **An area 30 km in the north south direction and 24 km in the east west direction is to be photographed with a lens having 30 cm focal length. The photograph size is 20 cm × 20 cm. The average scale is 1 : 12000 effective at an elevation of 400 m above datum. Longitudinal and side lap are 60 % and 30 % respectively. The two other flight lines are to coincide with east and west boundaries of the area. Determine flying altitude, number of flights lines, number of photographs per flight line and total number of photographs required.**

Answer

Given : Photograph size = 20 cm × 20 cm, Scale = 1 : 12000
Elevation = 400 m, Longitudinal lap, = 60 %, Side lap, = 30 %
Focal length, $f = 30$ cm
To Find : Flying altitude, number of flights lines, number of photographs per flight lines, total number of photographs.

1. Flying altitude, $\frac{H}{f} = \frac{1}{S}$

$$H = 12000 \times 0.30 = 3600 \text{ m}$$

2. Theoretical ground spacing of flight lines,

$$W = (1 - l_s)\, Sw$$
$$= (1 - 0.30) \times 12000 \times 0.20 = 1680 \text{ m}$$

3. Number of flight lines required,

$$N_2 = \frac{L_2}{W} + 1 = \frac{24 \times 10^3}{1680} + 1 = 15.28 \approx 16$$

4. Actual spacing of flight lines,

$$= \frac{24 \times 10^3}{16} = 1500 \text{ m}$$

5. Ground distance between exposure,

$$L = (1 - l_e)\, Sl$$
$$= (1 - 0.60) \times 12000 \times 0.20 = 960 \text{ m}$$

6. Number of photographs per flight line,

$$N_1 = \frac{30 \times 10^3}{960} + 1 = 32.25 \approx 33$$

7. Total number of photographs required

$$= N_1 \times N_2 = 33 \times 16 = 528$$

Que 4.17. **The scale of an aerial photograph is 1 cm = 160 m and the size of photography is 20 cm × 20 cm. If the longitudinal lap is 65 % and side lap is 35 %, determine the number of photographs, required to cover an area 348 sq km.** **AKTU 2014-15, Marks 15**

Answer

Given : Size of photograph, $l \times w = 20$ cm × 20 cm
Longitudinal overlap, $le = 65$ %, Side overlap, $ls = 35$ %
Total area covered, $A = 348$ km^2
To find : Number of photograph.

1. Scale of photograph, $S = \frac{160 \times 100}{1} = 16000 : 1$
2. Number of photographs per flight lines,

$$N_1 = \frac{L}{l \times S(1 - l_e)} + 1$$
$$L = \sqrt{348} = 18.65 \text{ km}$$
$$N_1 = \frac{18.65 \times 10^3}{0.20 \times 16000 \times (1 - 0.65)} + 1$$
$$= 17.65 \approx 18$$

3. Number of flight lines, $N_2 = \frac{W}{wS(1 - l_s)} + 1$

$$= \frac{18.65 \times 10^3}{0.20 \times 16000 \times (1 - 0.35)} + 1$$
$$N_2 = 9.96 \approx 10$$

4. Total number of photograph required $= N_1 \times N_2 = 18 \times 10 = 180$

Que 4.18. **A line PQ appears to be 10.16 cm on a photograph for which the focal length is 16 cm. The corresponding line measure 2.54 cm on a map which to be a scale 1/50,000. The terrain has an**

average elevation of 200 m above msl. Calculate the flying altitude of the aircraft above mean sea level.

Answer

Given : Length of line PQ on photograph = 10.16 cm
Length of line PQ on map = 2.54 cm, Focal length, f = 16 cm
Scale of map, S_m = 1/50000, Average elevation of terrain, h_1 = 200 m
To Find : Flying altitude.

1. $$\frac{\text{Photo scale}}{\text{Map scale}} = \frac{\text{Photo distance of line } PQ}{\text{Map distance of line } PQ}$$

i.e., $$\frac{S_p}{\frac{1}{50000}} = \frac{10.16}{2.54}$$

$$S_p = \frac{1}{12500} \quad \ldots(4.18.1)$$

2. $$\text{Photo scale} = \frac{f}{H - h_1} = \frac{0.16}{H - 200} \quad \ldots(4.18.2)$$

3. From equations (4.18.1) and (4.18.2), we get

$$\frac{0.16}{H - 200} = \frac{1}{12500}$$

Flying altitude, H = 2200 m

Que 4.19. **Two consecutive photographs were taken with a camera of focal length 37.5 cm, at a height of 7200 m. The overlap was exactly half and the prints were 22.5 cm × 22.5 cm. The height was same for both the exposures and the aircraft flew on even peel with no drift. The ground was flat at approx 2500 m above msl. Determine the scale of the photograph and the length of the airbase.**

AKTU 2016-17, Marks 05

Answer

Given : Focal length of camera, f = 37.5 cm
Height of aircraft, H = 7200 m
Height of the ground above mean sea level, = 2500 m
Size of print = 22.5 cm × 22.5 cm
To Find : Scale of photograph and length of airbase.

1. Scale of photograph, $S = \frac{f}{H - h} = \frac{37.5 \text{ cm}}{(7200 - 2500)\text{m}} = \frac{1}{125.33}$

Thus, the scale of the photographs is 1 cm = 125.33 m

2. The actual ground length covered by each photograph,

$$L = (1 - l_o) \times S \times l$$
$$= (1 - 0.5) \times 125.33 \times 22.5 = 1410 \text{ m}$$

Hence length of airbase, L = 1410 m

Que 4.20. **A flooded area is covered by 140 dots on a 25 dot/cm² grid on a 1:25000 vertical aerial photography. Find the ground area flooded.**

AKTU 2017-18, Marks 07

Answer

Given : Number of dots covered for flooded area = 140 dots
Number of dots per cm² = 25 dots
Scale of photograph = 1 : 25000
To Find : Ground area of flood.

1. Ground area shows by one dot

$$= \frac{1 \text{ cm}^2}{25 \text{ dots}} \times 25000^2 = 25{,}000{,}000 \text{ cm}^2 = 0.25 \text{ ha/dot}$$

2. Total ground area = 140 dots × 0.25 ha/dot = 35 ha

PART-4

Stereoscope and Stereoscope Views.

Questions-Answers

Long Answer Type and Medium Answer Type Questions

Que 4.21. **Describe the stereoscope with its functions and types.**

OR

Describe the mirror stereoscope with neat sketch.

AKTU 2014-15, Marks 05

Answer

A. **Stereoscope :** It is an instrument used for viewing stereopair in photogrammetric surveying or aerial surveying is called as stereoscope.

B. **Function of Stereoscope :**

1. A stereoscope is used to accommodate the wide separation of the individual photograph of the stereopair to the fixed length of the eye base.
2. It is also used to magnify the depth of perception.

C. Types of Stereoscope :

Following are the types of stereoscope which are generally used into practice of aerial surveying :

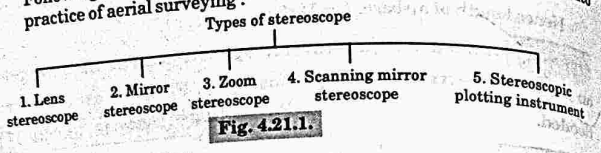


Fig. 4.21.1.

1. **Lens Stereoscope :**

i. This type of stereoscope consists of magnifying lens at a place of mirror for each eye.

ii. In case of lense stereoscope, the two lenses are mounted on an assembly in such way that distance between them is equal to the average eye base or interpupillary distance of the human eyes. However minor adjustment is done for the separation of these two lenses according to the user.

iii. The distance between the nodal points of the lens and the photograph is always proportionate to the focal length of the lens being used in the stereoscope.

iv. Lense stereoscope causes more strain to the eyes but lense stereoscope is small in size and compact and hence can be conveniently handled and used in the field of aerial survey.

v. Since lenses have the magnifying effect, the heights of an object can be seen larger than the actual height of an object.

2. **Mirror Stereoscope :**

i. This type of stereoscope consists of four mirrors, two mirror say m_1 and m_2 are small eye piece mirror and other two say M_1 and M_2 are larger wing mirror as shown in Fig. 4.21.2. These four mirrors are situated at an orientation of 45° with the plane of the photographs.

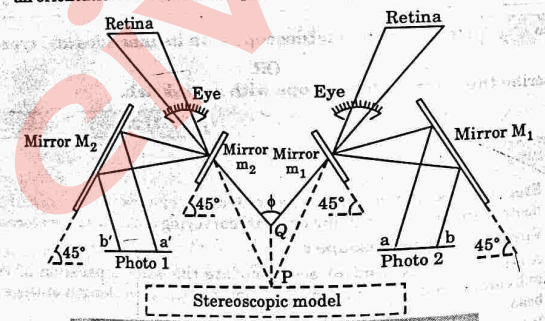


Fig. 4.21.2. Optical diagram of mirror stereoscope.

ii. The photographs to be viewed are placed at a certain distance from the wing mirror M_1 and M_2 and light reaches to the eyes exactly as it would come from the actual terrain.

iii. Mirror stereoscope completely separate the photographs for viewing and the whole overlap area can be seen stereoscopically without any slip of photographs, is the greatest advantages of mirror stereoscope.

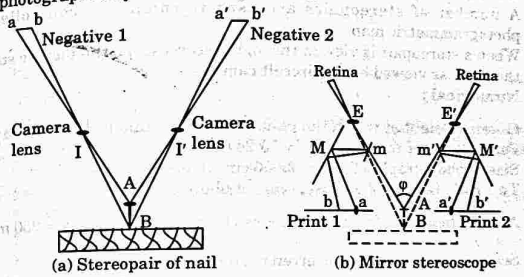
iv. It is not handy and portable due to its large size.

Que 4.22. Explain the working of mirror stereoscope.

Answer

1. The mirror stereoscope, shown diagrammatically in Fig. 4.22.1(b), consists of a pair of small eye-piece mirrors m and m', and a pair of larger wing mirrors, M and M', each of which is oriented at 45° with the plane of the photographs.

2. Fig. 4.22.1(a) shows a nail mounted on a block of timber, and is being photographed by two camera positions.



(a) Stereopair of nail (b) Mirror stereoscope

Fig. 4.22.1. Principle of mirror stereoscope.

3. The camera lens is placed first in the position of left eye and then in the position of right eye and separate photograph is taken in each position.
4. It will be noted that the head of the nail is to the left in the left film and to the right in the right film. ab and $a'b'$ are the images of the nail AB in the two films.
5. Contact prints from these negatives are placed in the mirror stereoscope as shown in Fig. 4.22.1(b), where only images of the nail are drawn.
6. The four mirrors transfer the light to the eyes exactly (except for accommodation) as if it had come from nail as shown by dotted line.
7. The convergence and retinal disparity are sufficient for the observer to see the nail in three dimensions.
8. The total distance $b\,M\,m\,E$ or $b'\,M'\,m'\,E'$, from the eye to the plane of the photographs varies 30 cm to 45 cm, in order that the unaided eye may comfortably view the photographs.

9. The angle φ is determined by the separation of photographs that gives the most eye comfort, and is compatible with the distance $bMmE$.
10. If this distance is to be reduced, a pair of magnifying lense is placed at E and E'. Each magnifier has a focal length slightly smaller than the distance $bMmE$.

Que 4.23. **What do you understand by stereopairs ? Vertical photographs were taken from height of 3048 m, the focal length of the camera lens being 15.24 cm. If prints were 22.86 × 22.86 cm and the overlap is 60 %, what is the length of airbase and what is the scale of photographs ?**

Answer

A. Stereopairs :

1. The two consecutive overlapping photographs taken from adjacent positions during a flight are called stereopair and these can only be viewed through a stereoscope.
2. A number of stereopairs are used to compile a controlled or photogrammetric map.
3. When a stereopair is viewed through a stereoscope the picture seen is the same as viewed by an aircraft camera.

B. Numerical :

Given : Height at which the photograph were taken, H = 3048 m
Focal length of the camera, f = 15.24 cm
Size of photograph = 22.86 × 22.86 cm, Overlap = 60 %
To Find : Length of airbase, scale of photographs.

1. Assume height of the ground above the mean sea level, h = 250 m
2. Scale of the photograph is given by, $S = \frac{f}{H - h}$

$$S = \frac{15.24}{3048 - 250} = \frac{1}{183.60} \text{ or } 1 \text{ cm} = 183.60 \text{ m}$$

3. The actual ground length covered by each photograph or air base,

$$L = (1 - l_p)\, Sl = (1 - 0.6) \times 183.60 \times 22.86$$

Length of airbase, L = 1678.83 m

PART-5

Parallax Equations.

Questions-Answers

Long Answer Type and Medium Answer Type Questions

Que 4.24. **Describe the construction and working of a parallax bar with the help of a neat sketch.**

OR

Describe the parallax bar with neat sketch.

AKTU 2014-15, Marks 05

Answer

A. Construction of Parallax Bar :

1. It is used to measure the parallax difference between two points. The difference in parallax of two points is called parallax difference.

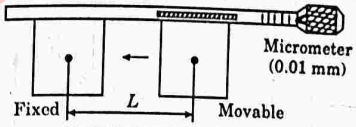


Fig. 4.24.1. Parallax bar.

2. Parallax is the displacement in the image of an object caused by a shift in the point of observation *i.e.*, successive exposures during a flight. It is also called stereoscopic parallax or x-parallax.
3. The instrument as shown in Fig. 4.24.1 consists of two plates of transparent materials attached to a bar.
4. The left plate is fixed and the right one movable with the help of a micrometer screw.
5. The total movement possible being 25 mm, which can be read nearest to 0.01 mm. Each plot contains a tiny dot in the centre.
6. The stereopair is viewed under a stereoscope and the parallax bar is placed on the photographs.

B. Working :

1. Let it be required to measure the parallax difference between two points A and C whose image appear on both the photographs at (a, c) and (a', c') respectively.
2. The left mark of the parallax bar is placed over a and the parallax bar is so oriented that it is parallel to the flight line.
3. Move the right mark and make the fused dot to touch the ground point. Take the micrometer reading.
4. Shift the bar bodily, put the left mark over the image c and move the right mark so that the fused marks again rests on the ground.
5. Note the micrometer reading. The difference between the two readings gives the value Δp.

6. Thus in Fig. 4.24.2 when point a is fused, the separation of the marks is lesser and the point is higher as is clear from the two intersecting rays OaA and $O'a'A$ in the lower part of the diagram.

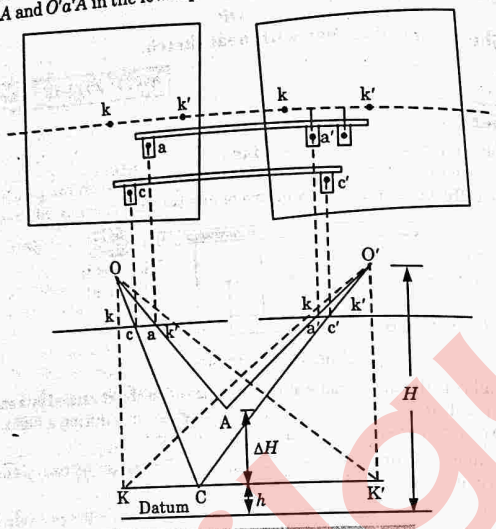


Fig. 4.24.2. Principle of a parallax bar.

7. Similarly, when c is fused, the separation of the marks is increased, and the point of lower as is clear from the two intersecting rays OcC and $O'c'C$.
8. The difference in elevation is then found by,

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

where, b_m is the mean principal base.

Que 4.25. Derive the parallax equation for determining the evaluation of a point.

OR

Establish parallel equation for determining elevation of a point from a stereopair.

Answer

1. Fig. 4.25.1 shows the two images of a point A as a when the aircraft is at position O_1 and as a' when the aircraft is at O_2.

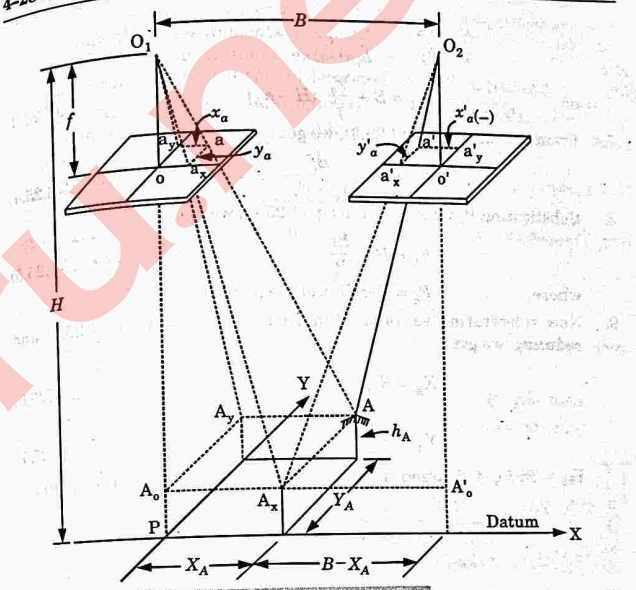


Fig. 4.25.1. Parallax relationship.

2. There is obviously a shift in the image because the image a is to the right of principal point whereas the image a' is to the left of principal point.
3. Co-ordinates of the point image a are (x_a, y_a) and that of a' are (x'_a, y'_a), while that of ground point A these are (X_A, Y_A).
4. From similar triangles O_1oa_y and $O_1A_oA_y$, we get

$$\text{or} \quad \frac{Y_A}{H-h_A} = \frac{y_a}{f}$$

$$Y_A = \frac{y_a}{f}(H-h_A) \qquad \ldots(4.25.1)$$

5. From the similar triangles O_1oa_x and $O_1A_oA_x$, yield

$$\frac{X_A}{H-h_A} = \frac{x_a}{f}$$

$$\text{or} \quad X_A = \frac{x_a}{f}(H-h_A) \qquad \ldots(4.25.2)$$

6. Also, from similar triangles $O_2o'a'_x$ and $O_2A'_oA_x$,

$$\frac{B - X_A}{H - h_A} = \frac{-x_a}{f}$$

or
$$X_A = B + \frac{x'_a}{f}(H - h_A) \quad \ldots(4.25.3)$$

7. From eq. (4.25.2) and (4.25.3), we get
$$h_A = H - \frac{Bf}{x_a - x'_a} \quad \ldots(4.25.4)$$

8. Substituting P_a for $x - x'_a$ into eq. (4.25.4), we get
$$h_A = H - \frac{Bf}{P_a} \quad \ldots(4.25.5)$$
where, P_a = Parallax of the point A.

9. Now substituting eq. (4.25.5) into eq. (4.25.2) and eq. (4.25.1) and reducing, we get
$$X_A = B\frac{x_a}{P_a} \quad \ldots(4.25.6)$$
$$Y_A = B\frac{y_a}{P_a} \quad \ldots(4.25.7)$$

Eq. (4.25.5), (4.25.6) and (4.25.7) are commonly called parallax equations.

PART-6

Introduction to Digital Photogrammetry.

Questions-Answers

Long Answer Type and Medium Answer Type Questions

Que 4.26. Describe the digital photogrammetry. What are the uses of digital photogrammetry ?

Answer

A. Digital Photogrammetry :

1. The digital or soft extension of the conventional hard copy photogrammetry is called as digital photogrammetry.
2. In case of digital photogrammetry, there is use of digital images without using the conventional photographic images. Digital images can be obtained by using the satellite images or by scanning aerial photos of high resolution.

3. In general, digital photogrammetry is the art of using computers so as to obtain the measurements of objects in a photograph. It consists of analyzing one or more existing photographs or videos with photogrammetric software to determine spatial relationships.
4. Some of the projects require only 2D *i.e.*, two dimensional measurements such as the height of a building or width of a river and these measurements can be taken from a single photographs.
5. For 3D *i.e.*, three dimension measurements, the process involves a 3D models from two or more photographs.

B. Uses of Digital Photogrammetry : Following are the various of digital photogrammetry :

1. It is used in digital terrain modeling.
2. It gives appropriate display and measurements.
3. It is used for two-dimensional and three-dimensional flood plain mapping.
4. It can also be used for stream mapping.
5. It can produce superior quality planimetric and topographic data.
6. It can also be used for highway mapping and data compilation.

VERY IMPORTANT QUESTIONS

Following questions are very important. These questions may be asked in your SESSIONALS as well as UNIVERSITY EXAMINATION.

Q. 1. What do you understand by the term 'Aerial photography' ? Also write a short note on the factors that influence aerial photography.
Ans. Refer Q. 4.3, Unit-4.

Q. 2. Differentiate between 'Aerial photography' and 'Aerial photogrammetry'.
Ans. Refer Q. 4.4, Unit-4.

Q. 3. Derive an expression for the scale of vertical photograph.
Ans. Refer Q. 4.7, Unit-4.

Q. 4. Derive an expression for the scale of a vertical photograph. Explain how the ground coordinates and the distances can be obtained from a vertical photograph.
Ans. Refer Q. 4.8, Unit-4.

Q. 5. Define relief. Derive an expression for the displacement due to ground relief.

Ans: Refer Q. 4.9, Unit-4.

Q. 6. The distance from the principal point to an image on a photograph is 6.44 cm and the elevation of the object above datum is 250 m, what is the relief displacement of the point is datum is 1/10000 and focal length is 20 cm.

Ans: Refer Q. 4.11, Unit-4.

Q. 7. Why overlapping is necessary ?

Ans: Refer Q. 4.15, Unit-4.

Q. 8. The scale of an aerial photograph is 1 cm = 160 m and the size of photography is 20 cm × 20 cm. If the longitudinal lap is 65 % and side lap is 35 %, determine the number of photographs, required to cover an area 348 sq km.

Ans: Refer Q. 4.17, Unit-4.

Q. 9. Two consecutive photographs were taken with a camera of focal length 37.5 cm, at a height of 7200 m. The overlap was exactly half and the prints were 22.5 cm × 22.5 cm. The height was same for both the exposures and the aircraft flew on even peel with no drift. The ground was flat at approx 2500 m above msl. Determine the scale of the photograph and the length of the airbase.

Ans: Refer Q. 4.19, Unit-4.

Q. 10. Describe the mirror stereoscope with neat sketch.

Ans: Refer Q. 4.21, Unit-4.

Q. 11. Describe the parallax bar with neat sketch.

Ans: Refer Q. 4.24, Unit-4.

Q. 12. Explain in detail about the characteristics of photographic images.

Ans: Refer Q. 4.6, Unit-4.

☺☺☺

UNIT 5

Remote Sensing and Digital Image Processing

CONTENTS

PART-1

Concepts and Physical Basis of Remote Sensing.

Questions-Answers

Long Answer Type and Medium Answer Type Questions

Que 5.1. **What do you understand by the term "Remote sensing"? Discuss its advantages and limitations.** **AKTU 2017-18, Marks 05**

Answer

A. Remote Sensing :

1. Remote sensing is, taking the pictures of any area, by a camera, without touching it *i.e.*, taking the pictures remotely.
2. The first remote sensing technique is the aerial photography. These photographs are taken from the air, by using aeroplanes.
3. The aerial photography has many applications e.g., for military purpose, for geological surveys, urban planning; disaster management like floods, landslides, forest fires, exploration of oil or minerals etc.

B. Advantages of Remote Sensing : Following are the advantages of remote sensing :

1. It gives a synoptic overview of the earth surface.
2. The data generated by remote sensing technique, is multi-spectral and have repetitive coverage.
3. It can collect the images and explain the intensity of the disaster and it aerial expansion.
4. This technique can help to collect the information in a little period of time.
5. The data generated by it can be used by multi-disciplines e.g., land use planning, forest development, geological surveys, urban planning, disaster management etc.

C. Limitations of Remote Sensing Techniques :

1. The aerial photographs and the satellite images do not have the facilities to correlate an aerial photograph with the ground.
2. It needs a skilled person to collect to analyse and to map the data.

3. It also includes data processing to extract information for the direct input to Geographic Information System (GIS).

Que 5.2. **Explain the general process involved in electromagnetic remote sensing. Differentiate between active and passive remote sensing systems, under what condition each is preferable ?** **AKTU 2014-15, Marks 10**

Answer

A. Remote Sensing Process : A remote sensing imaging system may be considered to be comprised of following elements as shown in Fig. 5.2.1.

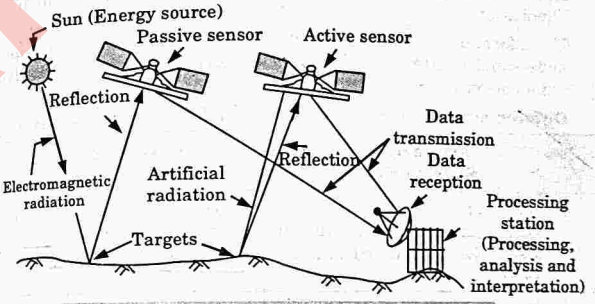


Fig. 5.2.1. Electromagnetic remote sensing process.

1. **Energy Source or Illumination :** An energy source that provides illumination or electromagnetic energy to the object of interest.
2. **Radiation and the Atmosphere :**
   i. As the energy propagates from the source to the object, it will come in contact with the atmosphere it passes, and will interact with the atmosphere.
   ii. The interaction will again take place while travelling back from object to the sensor.
   iii. The atmospheric effects are caused through the mechanism of scattering and absorption.
3. **Interaction with Earth Surface Features :**
   i. The energy will interact with the object depending upon the properties of the object and the radiation.
   ii. The effects of the interaction of the incident energy with earth surface features may cause the energy to be reflected, transmitted, scattered, absorbed, and emitted.

4. **Recording of Energy by the Sensor :**
   i. The scattered or emitted energy from the object is received, collected and recorded by the sensor.
   ii. These are mounted on platforms, which are at a considerable height from the earth surface.
   iii. The sensors may be passive or active.
5. **Processing :** The energy recorded by the sensor is transmitted in electronic form to a receiving and processing station where the data is processed into an image.
6. **Interpretation and Analysis :**
   i. The processed image is interpreted visually and/ or digitally or electronically to extract information about the object which was illuminated.
   ii. The information about the object extracted from the image helps to understand it better, reveal some new information, or assist in solving some new problem.

B. Diffefence between Active and Passive Remote Sensing System:

S. No.	Active Remote Sensing System	Passive Remote Sensing System
1.	A system which utilizes manmade sources of energy for data collection is called an active system.	A system that uses an existing source of energy (e.g. sun ray) is called passive system.
2.	In this, system waves are propagated near the sensor and are bounced on the earth's surface to be recorded on their return.	It simple emitted and reflected radiation from ground surface when the energy source is independent of the recording instrument.
3.	In this system image of landscapes, derived from SLR or SLAR resemble aerial photographs with low angle solar illumination.	In this system without illumination from the sun, no photograph can be taken with a camera.

Que 5.3. What are the characteristics of ideal remote sensing systems ? How do the real remote sensing systems differ from the ideal requirements ? **AKTU 2013-14, Marks 10**

Answer

A. Characteristics : Following are the main characteristics of ideal remote sensing system :

1. It has uniform energy source.
2. It contains non-interfering atmosphere.
3. It uses distinct and unique spectral response patterns for every feature.
4. It includes super-sensor.
5. It has real time data acquisition.
6. It includes multiple users.

B. Difference : Following are the difference between ideal and real remote sensing system :

S. No.	Aspect	Ideal Remote Sensing System	Real Remote Sensing System
1.	Energy source	It has uniform energy source, irrespective of time and place.	Energy varies with time, place and objects in ways that cannot be fully predicted.
2.	Atmosphere	It has noninterfering atmosphere that would neither absorb nor scatter electromagnetic energy.	It varies according to latitude, season, time of day, local weather etc.
3.	Spectral response	Each object would have a unique and known spectral response every where on earth surface.	In practical, these may change and cannot always be distinguished.
4.	Sensing system	Sensing system that would be highly sensitive through all wavelength of interest.	No existing sensing system can operate in all wavelength of interest.

Que 5.4. Explain with the help of a neat sketch an idealized remote sensing system. **AKTU 2017-18, Marks 02**

Answer

The ideal remote sensing system comprises of the following :

1. **A Uniform EM Energy Source :** It should provide energy of all wavelengths with uniform intensity at known high level of output irrespective of time and place.
2. **A Non-interfering Atmosphere :** EM energy should propagate through the atmosphere without loss on its way to or back from the target so that the energy does not get modified in the atmosphere. Ideally, it should hold irrespective of wavelength, time, place and sensing altitude.

3. **A Series of Unique Energy (Matter Interactions at the Earth's Surface) :** These interactions generate reflected and emitted signals that are selective with respect to wavelength, invariant and unique to each and every earth surface features type and sub-type of interest.

4. **A Super Sensor :**

i. The sensor (air borne or space borne) should be highly sensitive to all wavelengths and yield spatially detailed data on the absolute brightness (radiance) of the target as a function of wavelength.

ii. The super sensor would be simple, reliable, require virtually no power or space and be accurate and economical to operate.

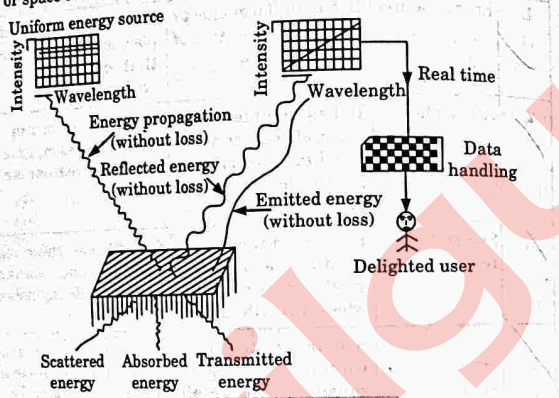


Fig. 5.4.1. Idealized remote sensing system.

5. **A Real Time Data Handling System :** The return signal from the target reaching a sensor is recorded and processed in real time (nearly instantaneously) by the data recorder. The data is then processed into a format useful for interpretation.

6. **Multiple Data Users :**

i. These people would have knowledge of great depth both of their respective disciplines and of remote sensing data acquisition and analysis techniques.

ii. The same set of data would become various forms of information for different users.

7. **Linear Sensor :** A sensor which responds linearly to EM energy of all wavelength.

PART-2

Electromagnetic Spectrum, Atmospheric Effects, Image Characteristics.

Questions-Answers

Long Answer Type and Medium Answer Type Questions

Que 5.5. **What do you understand by electromagnetic spectrum ? State the wavelength regions along with their uses for remote sensing applications.**

Answer

A. Electromagnetic Spectrum :

1. Visible light is the most obvious manifestation of EM radiation, other forms also exist.
2. EM radiation can be produced at a range of wavelengths and can be categorized according to its position into discrete region which is generally referred to electromagnetic spectrum.
3. Thus the electromagnetic spectrum is the continuum of energy that ranges from meters to nano-meters in wavelength travels at the speed of light and propagates through a vacuum like the outer space.
4. All matter radiates a range of electromagnetic energy, with the peak intensity shifting toward progressively shorter wavelength at an increasing temperature of the matter.

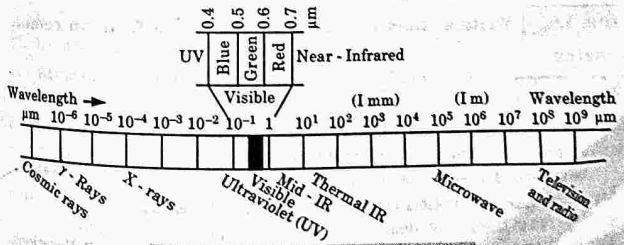


Fig. 5.5.1. Electromagnetic spectrum.

B. Wavelength Regions and their Applications in Remote Sensing:

Table. 5.5.1.

S. No.	Region	Wavelength (μm)	Principal Applications
A.	**Visible Region**		
1.	Blue	0.45 – 0.52	Coastal morphology and sedimentation study, soil and vegetation differentiation, conifers and deciduous vegetation discrimination.
2.	Green	0.52 – 0.60	Vigor assessment of vegetation, rock and soil discrimination, turbidity and bathymetry studies.
3.	Red	0.63 – 0.69	Plant species differentiation.
B.	**Infrared Region**		
4.	Near infrared	0.70 – 1.75	Vegetation, biomass, delineation of water features, landforms/geomorphic studies.
5.	Mid-infrared	1.55 – 1.75	Vegetation, moisture content, soil moisture content, snow and cloud differentiation.
6.	Mid-infrared	2.08 – 2.35	Differentiation of geological materials and soils.
7.	Thermal IR	3.0 – 5.0	For hot targets, *i.e.*, fire and volcanoes.
8.	Thermal IR	10.4 – 12.5	Thermal sensing, vegetation discrimination, volcanic studies.

Que 5.6. Write a short note on atmospheric effects on remote sensing.

Answer

Effects of Atmosphere on Remote Sensing :

i. When electromagnetic radiation travels through the atmosphere, it may be absorbed or scattered by the constituent particles of the atmosphere.

ii. *Molecular* absorption converts the radiation energy into excitation energy of the molecules.

iii. *Scattering* redistributes the energy of the incident beam to all directions.

iv. *The overall effect* is the removal of energy from the incident radiation.

The various effects of absorption and scattering are outlined as follows :

1. **Effects of Atmospheric Absorption on Remote Sensing Images.**

i. Atmospheric absorption affects mainly the visible and infrared bands. Optical remote sensing depends on solar radiation as the source of illumination.

ii. Absorption reduces the solar radiance within the absorption bands of the atmospheric gases.

iii. The reflected radiance is also attenuated after passing through the atmosphere.

iv. This attenuation is wavelength dependent. Hence, atmospheric absorption will alter the apparent spectral signature of the target being observed.

2. **Effects of Atmospheric Scattering on Remote Sensing Images :**

i. Atmospheric scattering is important only in the visible and near infrared regions.

ii. Scattering of radiation by the constituent gases and aerosols in the atmosphere causes degradation of the remotely sensed images.

iii. Most noticeably, the solar radiation scattered by the atmosphere towards the sensor without first reaching the ground produces a hazy appearance of the image.

iv. This effect is particularly severe in the blue end of the visible spectrum due to the stronger Rayleigh scattering for shorter wavelength radiation.

Que 5.7. Explain various interactions of incident EM energy with the atmosphere and earth surface.

Answer

A **Energy Interaction with Atmosphere :** The atmospheric effects are principally caused through the mechanism of atmospheric scattering and absorption.

1. **Scattering :**

i. Atmospheric scattering is the unpredictable diffusion of radiation caused by the molecules of the gases, dust and smoke in the atmosphere.

ii. Scattering is basically classified as selective and non-selective, depending upon the size of particles with which the electromagnetic radiation interacts.

a. **Non-selective Scattering :** The non-selective scattering occurs when the diameter of particles with which electromagnetic radiation interacts, is several times (about 10 times) the wavelength. Water droplets, pollen grains, ice and snow crystals, cause non-selective scatter.

b. **Selective Scattering :** The selective scatter is classified as Rayleigh scatter and Mie scatter. The effect of Rayleigh scatter is inversely proportional to the fourth power of the wavelength. Mie scatter tends to influence the longer wavelengths.

2. **Absorption :**

i. A part of electromagnetic radiation is absorbed by the molecules of ozone, carbon dioxide and water vapours.

ii. The absorption of radiation occurs in specific wavelength intervals called absorption band and governs the regions of the spectrum to be used in remote sensing.

iii. Wavelengths shorter than 0.3 μm are completely absorbed by the ozone layer in the upper atmosphere which allows life on earth, a prolonged exposure to the intense energy of these wavelengths destroys living tissue.

iv. The aerosol-sized particles of liquid water in clouds absorb and scatter electromagnetic radiation at wavelengths less than about 0.3 μm.

v. Only radiations of microwave and longer wavelengths are capable of penetrating clouds without being scattered, reflected, or absorbed.

B. Energy Interaction with Earth Surface :

1. EM energy that strikes or encounters matter (object) is called incident radiation.

2. The EM radiation striking the surface may be (i) Reflected/Scattered, (ii) Absorbed, and/or (iii) Transmitted.

3. These processes are not mutually exclusive — EM radiations may be partially absorbed. Which processes actually occur depends on the following factors : (i) Wavelength of radiation, (ii) Angle of incidence, (iii) Surface roughness, and (iv) Condition and composition of surface material.

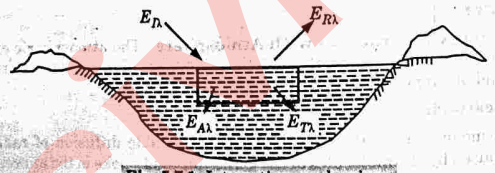


Fig. 5.7.1. Interaction mechanism.

4. Interaction with matter can change the following properties of incident radiation :

i. *Intensity.*
ii. *Direction.*
iii. *Wavelength.*
iv. *Polarization.*
v. *Phase.*

PART-3

Remote Sensing Systems, Spectral Signatures and Characteristics Spectral Reflectance Curves.

Questions-Answers

Long Answer Type and Medium Answer Type Questions

Que 5.8. Write a short note on spectral signature.

Answer

Spectral Signature :

1. It is the variation of reflectance or emittance of a material with respect to wavelengths.
2. The spectral signature of stars indicates the composition of the stellar atmosphere.
3. The spectral signature of an object is a function of the incidental EM wavelength and material interaction with that section of the electromagnetic spectrum.
4. The measurements can be made with various instruments, including a task specific spectrometer, although the most common method is separation of the red, green, blue and near infrared portion of the EM spectrum as acquired by digital cameras.
5. Calibrating spectral signatures under specific illumination are collected in order to apply a correction to airborne or satellite imagery digital images.

Que 5.9. Describe the EMR interaction with water, soil and vegetation.

OR

Discuss on the spectral reflectance characteristics of water and vegetation in spectral band. **AKTU 2015-16, Marks 15**

Answer

The EMR interaction with vegetation, soil and water is as follows :

A. Reflectance for Water :

1. Water has low reflectance at the most 10 % while vegetation may reflect up to 50 % and soil 30 – 40 %.
2. Water reflects in the visible and near IR range. Beyond 1.2 μm all energy is absorbed.
3. Turbid (silt laden) water has high reflectance.
4. Water containing plants with chlorophyll have peak reflectance in green wavelength.
5. Longer wave-lengths of visible and near IR radiation is absorbed by water than shorter wavelengths therefore due to reflection of shorter wavelengths, water looks blue or blue green if viewed in visible band and darker if viewed in IR wavelengths due to no reflection.

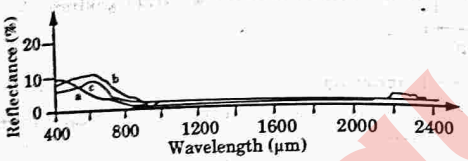


Fig. 5.9.1. Spectral reflectance curve of water.

6. Factors affecting variability of reflectance are depth of water, materials within water and surface roughness of water.

B. Reflectance in Bare Soils : Factors affecting reflectance in soils are (1) moisture content, (2) particle size, (3) organic matter content, and (4) iron oxide content.

1. Moisture Content :

i. Soils have different proportions of sand, silt and clay (particle size 0.05 to 2.0 mm ϕ, 0.002 to 0.005 mm ϕ respectively). Large numbers of particles are present in clay compared to sand.

ii. When moisture is there in clay, each particle will be covered by a very thin layer of water, millions of such particles will hold a large amount of water. Thus particle size and moisture holding capacity of the soils are interrelated.

iii. Fig. 5.9.2 shows typical reflectance curves of study soils with different levels of moisture content. It shows that there are no absorption bands for dry sandy soils.

iv. Moist soils have less reflectance than dry soils (reflectance decreases with presence of water).

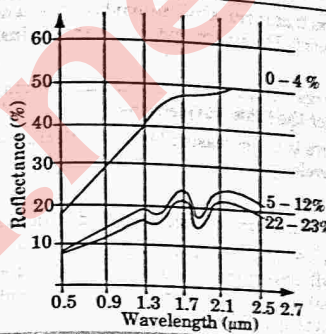


Fig. 5.9.2. Reflectance curves for a sandy soil at different levels.

2. Particle Size :

i. If particle size decreases, soil surface becomes smoother, more of the smoother energy is reflected.

ii. As particle size increases from 0.22 to 2.6 mm increase in absorption is 14 %.

3. Organic Matter :

i. It is an indication of amount and form of nitrogen in the soil organic content varies from 0.5 to 5 %.

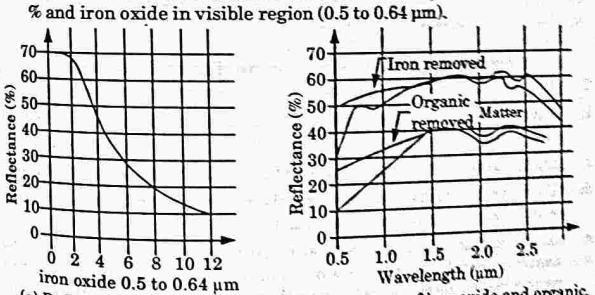
ii. A soil with 5 % organic matter appears dark brown or black in colour and with lower organic content light brown or light grey.

iii. Though this colour depiction with organic matter content changes with climatic and drainage conditions of the soil, which should also be considered.

4. Iron Oxide Content :

i. It can cause significant decrease in reflectance in the visible spectrum.

ii. Fig. 5.9.3 shows an excellent inverse relationship between reflectance % and iron oxide in visible region (0.5 to 0.64 μm).



(a) Reflectance of iron oxide (b) Influence of iron oxide and organic.

Fig. 5.9.3.

iii. Fig. 5.9.3 shows that removal of iron oxide causes a marked increase in reflectance from 0.5 to 1.1 μm and reflectance is insignificant beyond 1.1 μm.

iv. Removal of organic matter causes a similar marked increase in reflectance over the same wavelengths.

v. In general there is an increasing level of reflectance of dry soils with increase in wavelength.

C. Vegetation :

1. Spectral reflectance curve of vegetation is distinctive.
2. Reflectance is low in blue and red regions of visible spectrum due to two chlorophyll absorption bands centered at 0.4 and 0.65 μm with reflectance peak at 0.5 μm. Chlorophyll absorbs radiation in red and blue wavelengths by reflection.
3. In near infrared region the reflectance is much increased beyond 0.7 μm to 1.3 μm wavelength region and is of the order of 40 – 50 % (absorption 5 %) with reflectance peaks in between.
4. The reflectance from multi-leaf layers is high compared to single leaf layer. With decrease in moisture content of the leaf, the reflectance increases.
5. In middle IR portion, there are water absorption bands at 1.4, 1.9 and 2.7 μm with reflectance peaks at 1.6 and 2.2 μm.

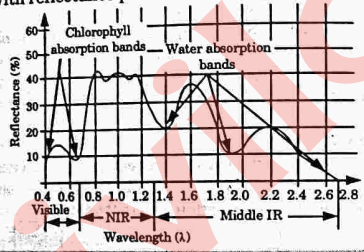


Fig. 5.9.4. Spectral reflectance curve of green vegetation.

6. Thus distinct spectral characteristics of green vegetation are :

i. There are distinct differences in the reflectance amongst visible, near IR and middle IR regions.

ii. In the visible portion pigmentation of leaves is the dominant absorbent.

iii. The internal leaf structure controls the reflectance in the near infrared where half is reflected and half transmitted.

iv. In the middle infrared, the total moisture content in the vegetation controls the reflectance where much of the incident energy is absorbed by the leaves. Green wavelengths leaves appear greenest to us in the summer when chlorophyll content is at its maximum.

v. In autumn, there is less chlorophyll in the leaves so there is less absorption and proportionality more reflection of red wavelengths making the leaves appear red or yellow.

Que 5.10. What do you mean by preprocessing of remote sensing data ? Explain in detail.

Answer

A. Preprocessing :

1. Geometric and radiometric correction in image rectification and restoration is called pre-processing.
2. These are the preliminary to produce a corrected image as close as possible to the original scene.
3. Geometric corrections are required to correct the distortions caused by variation in sensor-earth geometry to make the geometric representation of the image close to accurate representation of the earth.
4. It involves relating the spatial co-ordinates of the image *i.e.*, the column and row co-ordinates of a pixel to the corresponding spatial co-ordinates of the earth *i.e.*, latitude and longitude.

B. Types of Preprocessing : Following are various types of preprocessing :

1. Geometric Correction :

i. It is the process of rectification of geometric errors introduced in the image during the process of acquisition.

ii. The aim is to transform the remotely sensed image to have the scale and projection properties of a map.

iii. The main source of geometric error in satellite data is satellite path orientation (non-polar).

iv. The distortions may be systematic distortions—the effects that are constant, can be predicted in advance, or non-systematic—caused due to various in spacecraft variables, and atmospheric scatter.

2. Radiometric Correction :

i. When the image data contains errors in the measured brightness values of the pixels, it limits the ability of the analyst to visually interpret or quantitatively process and analyse the images.

ii. The potential sources of errors are : periodic drift or malfunctioning of a detector; electronic interference between sensor components; and intermittent disruptions in data transmission and recording.

3. **Noise Removal :** The unwanted disturbance in image data due to limitations in the sensing, signal digitization or data recording process also required correction in remote sensing.

4. **Georeferencing :** It is the process of assigning real world co-ordinates to each pixel of the raster. It may be applied to any kind of object or structure that can be related to a geographical location.

Que 5.11. Explain the following :

A. Atmospheric window.

B. Multi-spectral scanner. **AKTU 2017-18, Marks 04**

OR

Write short notes on (*a*) Multi spectral scanner (*b*) Along and across track scanner.

Answer

A. Atmospheric Windows :

1. The atmosphere transmits its energy through the certain wavelength regions (bands) throughout the entire electromagnetic spectrum.
2. These spectral bands, through which the atmosphere is relatively transparent and has least absorption by water vapour, carbon dioxide and other gases is known as the "Atmospheric window".
3. The atmospheric windows are used for recording the reflected or emitted energy. They are present in the visible spectrum *i.e.*, form 0.4 mm to 0.76 mm of EMR. They are also present in IR and in the microwave regions.
5. Wavelengths less than 0.3 μm are not available for remote sensing because these radiations do not reach the earth and are used or absorbed in upper atmosphere only wavelengths 0.3 μm to 30 cm have atmospheric windows as under :

Ultravoilet	0.3 – 0.4 μm
Visible Near IR	0.4 – 0.7 μm
	1.2 – 1.3 μm
Middle IR	1.5 – 1.8 μm
	2.0 – 2.5 μm
Thermal IR	3.0 – 5.0 μm
	8.0 – 14.0 μm
Microwave	10 mm – 100 mm

B. Multi-spectral Scanner :

1. A multispectral scanner (MSS) simultaneously acquires images in multiple bands of the EMR spectrum. It is the most commonly used scanning system in remote sensing.
2. For example the MSS onboard the first five landsat missions were operational in 4 bands : 0.5-0.6, 0.6-0.7, 0.7-0.8, 0.8-1.1 mm.

3. Similarly, IRS LISS-III sensors operate in four bands (0.52-0.59, 0.62-0.68, 0.77-0.86, 1.55-1.70 mm) three in the visible and NIR regions and one in the MIR region of the EMR spectrum.
4. Airborne or space-borne MSS systems generate two-dimensional image of the terrain beneath the aircraft.
5. Two different approaches are adopted for this : Across-track (whiskbroom) scanning and Along-track (push broom) scanning.

i. **Across-track Scanning :**

a. Across-track scanner is also known as whisk-broom scanner. In across track scanner, rotating or oscillating mirrors are used to scan the terrain in a series of lines, called scan lines, which are at right angles to the flight line.

b. As the aircraft or the platform moves forward, successive lines are scanned giving a series of continuous narrow strips.

ii. **Along-track Scanner :**

a. Along-track scanner is also known push-broom scanner.

b. Along-track scanners also use the forward motion of the platform to record successive scan lines and build up a two-dimensional image, perpendicular to the flight direction.

c. However, along-track scanner does not use any scanning mirrors, instead a linear array of detectors is used to simultaneously record the energy received from multiple ground resolution cells along the scan line.

d. This linear array typically consists of numerous charged coupled devices (CCDs). A single array may contain more than 10,000 individual detectors.

PART-4

Salient Features of Some of Remote Sensing Satellites Missions.

Questions-Answers

Long Answer Type and Medium Answer Type Questions

Que 5.12. Write characteristics of any one satellite with its sensor, band, swath, resolution, altitude and repeativity.

Answer

IRS P6/Resourcesat-1 and Resourcesat-2 :

1. The IRS (Indian Remote Sensing) satellites form a large family of Earth observation satellites operated by the Indian space agency.
2. IRS P6/Resourcesat-1 and Resourcesat-2 ensure continuity of medium and high resolution data supply provided by the twin satellites IRS-1C and IRS-1D. These two, launched in 1995 and 1997 respectively, have completed their missions after more than 10 years of service.
3. Like their predecessors, Resourcesat satellites carry a LISS-III sensor as well as a wide field AWiFS sensor, but the high resolution (5.8 m) LISS-4 sensor replaces the panchromatic sensor.
4. The high resolution data are useful for applications such as urban planning and mapping, while the average resolution is used for vegetation discrimination, land mapping, and natural resources management.

i. **Altitude :** 816-818 km
ii. **Inclination :** 98.6 degrees
iii. **Orbit:** Sun-synchronous polar
iv. **Orbit Period (Repeativity) :** 101 minutes
v. **Revisit Time (LISS-4 et AWiFS) :** 5 days
vi. **Swath Width :** 23.9 km – 70.3 km (LISS-IV) ; 140 km (LISS-III); 740 km (AWiFS)
vii. **Satellites :** IRS-P6/Resourcesat-1 (17/10/2003 – operational)
Resourcesat-2 (20/04/2011– operational)

LISS-III Sensor :

1. The LISS-III (Linear Imaging Self Scanning Sensor) sensor is an optical sensor working in four spectral bands (green, red, near infrared and short wave infrared). It covers a 141 km-wide swath with a resolution of 23 metres in all spectral bands.

Band	Spectral Band	Resolution
2	0.52 - 0.59 μm	23 × 23 m
3	0.62 - 0.68 μm	23 × 23 m
4	0.77 - 0.86 μm	23 × 23 m
5	1.55 - 1.70 μm	23 × 23 m

LISS-IV Sensor :

1. LISS-IV can work either in panchromatic or in multispectral mode with the same bands as LISS-III (except SWIR). However, the resolution is much better (5.8 m).

2. For Resourcesat-1, the swath width varies from 23.9 km in multispectral mode to 70.3 km in panchromatic mode.
3. For Resourcesat-2, the multispectral swath is enhanced to 70 km. The linear array sensor can be steered up to 26 degrees across-track, enabling stereoscopic imaging.

Mode	Spectral Band	Resolution
Panchromatic	0.50 - 0.75 μm	5.8 × 5.8 m

Mode	Band	Spectral Band	Resolution
Multispectral	2	0.52 - 0.59 μm	5.8 × 5.8 m
	3	0.62 - 0.68 μm	5.8 × 5.8 m
	4	0.77 - 0.86 μm	5.8 × 5.8 m

AWiFS Sensor :

AWiFS (Advanced Wide Field Sensor) is an optical sensor with intermediate spatial resolution.

Band	Spectral Band	Resolution
1	0.52 - 0.59 μm	56 × 56 m
2	0.62 - 0.68 μm	56 × 56 m
3	0.77 - 0.86 μm	56 × 56 m
4	1.55 - 1.70 μm	56 × 56 m

Que 5.13. Describe multi-concept in remote sensing. Explain how remote sensing helps in flood related studies.

AKTU 2014-15, Marks 05

AKTU 2017-18, Marks 07

Answer

A. **Multi Concept :** Multi concept means taking multi images with respect to a particular parameter. The multi concept of remote sensing data consists of the following :

1. **Multi Station Images :** These are successive overlapping pictures along a flight path of an air craft or a space craft for better perception of three dimensional features and improved signal to noise ratio.
2. **Multi Band Images :** When images taken in different wavelength bands are suitably combined, it is possible to unambiguously identify specific terrestrial features.

3. **Multi Date Images :** Comparative study of images taken on series of different dates can help to identify features since many features exhibit dynamic characteristics.
4. **Multi Stage Images :**
   i. It is obtaining more detailed information from successively smaller sub-samples of the area.
   ii. A three step process involving observations from space, aircraft and ground is normally used.
5. **Multi Polarization Images :**
   i. It enables distinguishing objects based on the polarization of the reflected radiation.
   ii. Some features like water body may reflect strongly polarized radiation while others like vegetation or fractured rock may reflect weakly polarized radiation.
6. **Multi Enhancement Images :** These are the composite images generated by combining multi band, multi date and multi polarization images to suitably generate composite images.
7. **Multi Disciplinary Analysis :** It is analyzing the data by two or more analyst from different disciplines to obtain a more accurate and complete information about the total earth resource of an area. Such multi disciplinary information is usually presented in a set of multi themes.

B. Remote Sensing helps in Flood Related Studies : Following are the areas where remote sensing helps in flood related studies :

1. **Planning :**
   i. GIS is useful in helping with forward planning.
   ii. It provides the framework for planners and disaster managers to view spatial data by way of computer based maps.
2. **Mitigation :**
   i. Representation of high risk areas.
   ii. Facilitates the implementation of necessary mechanism to lessen the impact.
3. **Preparedness :**
   i. Identification of emergency areas.
   ii. Positions of related departments, agencies, and human resources.
   iii. Make it easier for security and shelters to plan the strategies.
4. **Response :**
   i. Provide accurate information on exact location of an emergency situation.
   ii. Time saving during the determination of trouble areas (quick response).
   iii. Used as floor guide for evacuation routes.

Que 5.14. What are the difference between Geostationary and sun-synchronous satellites ? **AKTU 2014-15, Marks 05**

Answer

S.No.	Geostationary Satellites	Sun-synchronous Satellites
1.	It is an earth orbiting satellite, placed at an altitude of approximately 35,800 km directly over the equator.	It is a satellite that moving around the earth and always gets its power from the sun.
2.	It remains in geosynchronous orbit, where the object orbits once per day.	It remains in sun-synchronous orbit where the movement of satellite always looks the same when viewed from the sun.
3.	They rotate from west to east.	They rotate from the north pole to south pole and cross all latitudes at the same time.

PART-5

Digital Image Processing : Introduction, Image Rectification, and Restoration.

Questions-Answers

Long Answer Type and Medium Answer Type Questions

Que 5.15. What do you mean by digital image processing ?

Answer

Digital Image Processing :

1. The digital image processing is the task of processing and analyzing the digital data using some image processing algorithm.
2. The analysis relies solely upon multispectral characteristic of the feature represented in the form of tone and colour.

Purpose : Digital image processing is done to obtain images close to original geometry of the earth and the brightness values close to radiance from the respective feature.

Operations : The digital image processing has the following broad operations :

1. Image rectification and restoration.
2. Image enhancement.
3. Image classification.
4. Data merging and GIS integration.

Que 5.16. What is image rectification ? Explain the various types of image rectifications. **AKTU 2017-18, Marks 07**

OR

Describe the image rectification and restoration.

OR

Describe in brief the radiometric and geometric corrections which are required for rectification of satellite image. **AKTU 2014-15, Marks 10**

Answer

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

Uses :

1. It is used in computer stereo vision to simplify the problem of finding matching points between images (*i.e.*, the correspondence problem).
2. It is used in geographic information systems to merge images taken from multiple perspectives into a common map coordinate system.

Types : Following are the types of image rectification :

1. Plane Rectification :

i. Rectification requires a projective transformation or homograph of the image plane.

ii. This homograph is associated with the circular points, a pair of Euclidean invariant points imaged on the vanishing line of the plane.

iii. It can be computed from scene constraints. Specifically, we use parallel lines, lines at known orientations, pairs of unknown orientations and known ratios of line lengths

2. Cylindrical Rectification :

i. It is guarantees that the rectified images are bounded for all possible camera motions and minimizes the loss of pixel information along epipolar line.

ii. The processes (e.g., stereo matching, etc.) subsequently applied to the rectified images are thus more accurate and general since they can accommodate any camera geometry.

3. Polar Rectification :

i. It presents a simple algorithm for rectification which can deal with all possible camera geometries. Only the oriented fundamental matrix is required. All transformations are done in the images.

ii. The image size is as small as can be achieved without compressing parts of the images.

iii. This is achieved by preserving the length of the epipolar lines and by determining the width independently for every half epipolar line.

B. Image Restoration :

1. It is the operation of taking a corrupt/noisy image and estimating the clean, original image. Corruption may come in many forms such as motion blur, noise and camera miss-focus.
2. Image restoration is performed by reversing the process that blurred the image and such is performed by imaging a point source and use the point source image, which is called the Point Spread Function (PSF) to restore the image information lost to the blurring process.

C. Radiometric Corrections :

1. Radiometric corrections may be due to variations in scene illumination and viewing geometry, atmospheric conditions, and sensor noise and response.
2. Each of these will vary depending on the types of sensor and platform used to acquire the data, and the environmental conditions during data acquisition.
3. Sometimes, it may be desirable to convert and/or calibrate the data to known (absolute) radiation or reflectance units to facilitate comparison between different dates.

D. Geometric Corrections : All remote sensing imageries are inherently subject to geometric distortions. These distortions may be due to several factors such as :

1. The perspective of the sensor optics.
2. The motion of the scanning system.
3. The motion of the platform.
4. The platform altitude, attitude, and velocity.
5. The terrain relief.
6. The curvature and rotation of the earth.

Que 5.17. What is a satellite image ? Write short note on characteristics and formats of satellite image. **AKTU 2016-17, Marks 05**

OR

Enumerate and explain the various digital image data formats. **AKTU 2017-18, Marks 05**

Answer

A. Satellite Image :

1. A satellite image is an image of the whole or part of the earth taken using artificial satellites.
2. These images have a variety of uses, including cartography, military intelligence and meteorology.
3. Satellite images can either be visible light images, water vapour images or infrared images.

B. Characteristics : Following are the satellite image characteristics :

1. Spatial Resolution :

i. It is the size of a pixel in ground dimensions.

ii. A 30 m size represents a square ground dimension of 30 m × 30 m.

iii. It also means number of pixel per inch length of the image.

2. Spectral Bands :

i. Bands mean which wavelengths (colours) images have been captured and bandwidth means the "range of colours" imaged.

ii. Number of bands determines how many colours are imaged. Two most likely colour modes are RGB (Red, green and blue) colour for colour images and grey scale for black and white (B/W) images.

3. Radiometric Resolution :

i. The number of shades of one colour in which the data has been imaged.

ii. A bit is a single binary digit and represents only one of the two numbers.

iii. A one bit image can show only two shades.

4. File Format : There are several file formats in which the data can be stored. These are :

TIFF : Tagged Image File Format.

JPEG : Joint Photographic Expects Group.

GIF : Graphic Interchange Format.

PDF : Portable Document File.

EPS : Encapsulated Post Script.

5. File Size :

i. It depends upon number of pixels in the image, spectral bands, radiometric resolution and the file formats and is measured in bytes (8 bits), kilobytes (1024 bytes), mega bytes (1024 kilo bytes).

ii. File size of a 1200 × 1500 pixel image in 8 bits or 1 byte would be 18,00,000 bytes.

C. Formats : Digital remotely sensed data of a multispectral image is organized in following three data file interleaving formats :

1. Band Interleaved by Pixel (BIP) :

i. In this format, the data for same one pixel is organized one after the other for different spectral bands in the same line.

ii. The data is written for first pixel band 1, first pixel band 2, first pixel band 3 and so on, in one line as adjacent numbers followed by second pixel for all bands in the same pattern, second pixel for all bands and so on.

iii. This format provides information how the reflectance of the same pixel varies in different spectral bands.

2. Band Interleaved by Line (BIL) :

i. In this format, data of different pixels in sequence for the spectral band is arranged in one row, for the same pixels for another spectral band in second row, for the third band in third row and so on.

ii. This form facilitates observance of difference between radiance properties of adjacent pixels in different bands.

3. Band Sequential (BS) :

i. Data for each pixel sequentially for first spectral band is arranged together in different lines one after the other. Then for second band below it for each pixel in same sequence and so on.

ii. This format provides information how a scene looks like in a particular spectral band and can be used to generate colour image output bandwise.

iii. Fig. 5.17.1 is shows the data acquired for nine pixels in multi (four) bands along with how this data will be arranged under different formats.

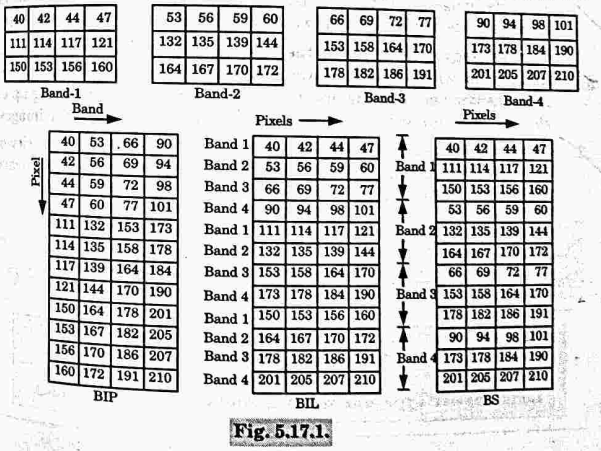


Fig. 5.17.1.

4. Other popular formats are Geo TIFF (Geo Tag Image File Format), Hierarchical Data Formats (HDF) which is used to store digital images and formats.

Que 5.18. **Elaborate the relative advantages of using aerial photos and satellite images over products of conventional survey.**

AKTU 2015-16, Marks 10

Answer

A. Advantages of Aerial Photos :

1. Aerial photos provide a current pictorial view of the ground that a map cannot.
2. It is more readily obtained. The photograph may be in the hands of the user within a few hours after it is taken; a map may take months to prepare.
3. It may be made for places that are inaccessible to ground soldiers.
4. It shows military features that do not appear on maps.
5. It can provide a day-to-day comparison of selected areas, permitting evaluations to be made of enemy activity.
6. It provides a permanent and objective record of the day-to-day changes with the area.

B. Advantages of Satellite Images :

1. Satellite images show the intensity, speed and direction of storms or more accurate details about the weather conditions in any given location.
2. By observing a satellite image, the forecaster can see what changes are taking place within the storm system over a period of time. If the storm is intensifying or breaking apart, changing directions, speeding up or slowing down, this will all become apparent in real time satellite images.
3. A satellite image can also help forecasters to determine the severity of the approaching storm. They can forecast heavy showers or snow storms, or light rain or flurries.

PART-6

Image Enhancement, Image Transformation, Image Classification.

Questions-Answers

Long Answer Type and Medium Answer Type Questions

Que 5.19. **What do you understand by image enhancement ? List any four changing operations. Describe linear contrast enhancement process.**

AKTU 2016-17, Marks 05

OR

An image from satellite is obtained which have the DN values in a narrow range. How would the quality of this image be enhanced ? Explain the methods.

Answer

A. Image Enhancement :

1. After geometric and radiometric corrections, the image is still not fit for visual interpretation.
2. Image enhancement is improving the appearance of the image to make its interpretation and easier understanding.
3. After restoration (geometric and radiometric corrections) the remotely sensed data is processed to enhance the features of special interest. For it the original digital values are changed.
4. The advantage of digital imagery is that it allows manipulating the digital values of a pixel in the image on a computer.

Methods : Following are the methods of contrast enhancement :

1. Linear contrast enhancement method—Min-max stretch.
2. Linear contrast enhancement method—Percentile stretching.
3. Non-linear contrast enhancement—Histogram equalization method.
4. Spatial filtering.

1. Linear Contrast Enhancement (Min-Max Stretch) :

i. In this method, lower value of the original histogram is assigned zero bright level and the upper value a brightness level of 255.

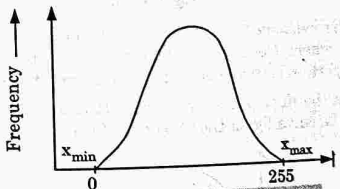


Fig. 5.19.1. Original histogram.

ii. Intermediate brightness levels are assigned new values by linear interpolation as under :

$$x_{new} = \frac{x_{in} - x_{min}}{x_{max} - x_{min}} x_r$$

Where, x_r = Range of brightness scale (0 – 255 for 8 bits data),
x_{in} = Original brightness value of the pixel, and
x_{min} and x_{max} = Minimum and maximum value of the original data.

iii. It produces a good contrast in the image but there is loss of contrast at the lowest and highest brightness values.

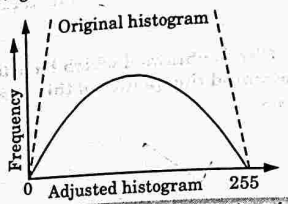


Fig. 5.19.2. Linear contrast enhancement—min-max stretch.

iv. The lower value areas become lighter and higher value areas become darker which leads to loss of information in these areas.

2. Linear Contrast Enhancement (Percentile Stretching) :

i. If the start and end of a histogram have very low frequency of the pixels as shown in Fig. 5.19.3, there is little improvement in the image under min-max stretching.

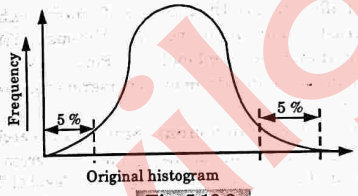


Fig. 5.19.3.

ii. Under such conditions 2 %, 5 %, ... of the data at the two ends of the histogram, where frequency of pixels is low, are curtailed and the remaining portion is stretched as min-max stretching.

iii. It decreases the slope of the histogram. It is not necessary that same percentage be curtailed at the two ends of the histogram.

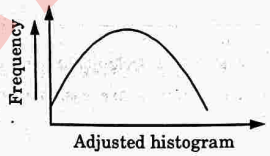


Fig. 5.19.4. Linear contrast enhancement-percentile stretching.

Que 5.20. Differentiate between restoration and enhancement of remote sensing image. **AKTU 2014-15, Marks 05**

Answer

S.No.	Restoration	Enhancement
1.	It is an objective process.	It is a subjective analysis.
2.	It involves the process to manipulate the image in order to take the psychophysical advantage of human being.	It involves modeling of degradation in image and applies some mechanism to get image back.
3.	Removing of blurring from an image by applying deblurring filter is an image restoration process.	Contrast stretching is an image enhancement technique.

Que 5.21. Describe image transformation.

Answer

1. Image transformation generates new images from two or more sources which tend to highlight particular features or properties of interest, better than the original input images.
2. Basic image transformations use simple arithmetic operations such as addition, subtraction, division and multiplication to the image data.
3. In image subtraction, two geometrically registered images acquired at two different dates are subtracted pixel by pixel to yield a new image called as the difference image.
4. In these new images, areas where there has been little or no change are represented in mid-grey tones, while those areas where significant change has taken place, and are shown brighter or darker tones depending on the direction of change in reflectance between the two images.
5. This type of image transformation can be useful for mapping growth of cities, deforestation, crop acreage, etc. Hence image subtraction is also known as change detection.
6. Image addition is basically an averaging operation, in order to reduce the overall effect of noise. It is very commonly used in spatial filtering to enhance features the overall effect of noise. It is very commonly used in spatial filtering to enhance features.
7. Image multiplication of two real images is rarely performed in remote sensing.

8. Image division or spectral ratioing is one of the most common transforms applied to image data.
9. It serves to highlight subtle variations in the spectral responses of various surface covers. By ratioing the data from two different spectral bands, yields useful information regarding the objects.
10. Healthy and green vegetation reflects strongly in the near-infrared portion of the spectrum while absorbs strongly in the visible red. Other types of surface, such as soil and water, show near equal reflectance in both the near-infrared and red portions.

Que 5.22. **Explain in detail land use/land cover classification system.** **AKTU 2014-15, Marks 10**

OR

What do you understand by Land use/Land Cover classification ? Explain. **AKTU 2016-17, Marks 07**

Answer

Land Cover :

1. This is the physical condition of ground surface – forest, grassland, water bodies, mountains, rocks, barren land, ice, snow, tundra etc.
2. These features may be natural, manmade or combination of the two. These are directly observable by remote sensing.

Land Use :

1. This is the human employment of land e.g., industrial area, residential area, agricultural fields, commercial, recreation, rural, urban, oil extraction or a combination of many activities.
2. Inferences about land use can often be made from land cover on the basis of ancillary (auxiliary) data and prior knowledge.

Land Cover/Land Use Classification System :

1. It is important to identify land use/land cover as per a classification scheme such as USGS (United States Geological Survey).
2. Anderson's classification is one of the best and most widely applied systems.
3. The classification system is in three levels. Level I divide total land use and land cover types into nine types. Level II divides level I division into its sup-types. Level II is further divided into its types at level III. Each level is assigned a number.
4. The nine level-I divisions are as under :

i. Urban or built-up (100) e.g., villages, towns, cities, highways and similar structures.

ii. Agriculture (200) e.g., crops, orchards, pastures.

iii. Range lands (300) *i.e.*, land covered by natural grasses, shrubs and forbs (non-woody plants such as weeds and flowers). These support native or domesticated grazing animals.

iv. Forest lands (400) : Forest produce timber and other wood products. These are also essential for balanced environmental conditions.

v. Water (500) : This includes natural and manmade water bodies which support aquatic life.

vi. Wet lands (600) : Wet lands are areas where water table is at near or above the land surface for a significant part of the year e.g. marshes, tidal flats, mud flats.

vii. Barren land (700) : These are surface with thin soil, sand or rock.

viii. Tundra (800) : These are treeless regions due to presence of permafrost and subfreezing temperatures most of the year.

ix. Perennial snow or ice (900) : There are the areas where snow and ice persists throughout the year e.g., snow fields and glaciers.

5. Level - II classification for urban and built-up are : 110-Residential, 120-Commercial, 130-Industrial, 140-Transportation, 150-Communication and utilities, 160-Institutional, 170-Recreational, 180-Mixed, 190-Open land and other.
6. Level III classifications of 170-Recreational are : 171-Golf courses, 172-Parks and Zoos, 173-Marinas, 174-Stadiums, fairgrounds and race-tracks.

Necessity :

1. Land cover and land use monitoring is necessary to have a consistent view of the stock and state of our natural and built resources for their management, development, planning sustainable development protection of natural resources.
2. It also helps to get an idea of change in land use pattern, intensity of change, developing strategies to balance conservation.

Que 5.23. **Write a note on image classification. Discuss supervised and unsupervised classification.** **AKTU 2014-15, Marks 05**

OR

What do you understand by image classification ? Differentiate between supervised and unsupervised classification. **AKTU 2017-18, Marks 07**

Answer

A. Image Classification :

1. The objective of image classification is to categorize all pixels in an image into land cover classes or themes.

7. Image classification is sorting pixel into finite number of individual classes based on their DN values in a spectral band.
8. Each homogeneous group belongs to a particular land cover type or feature e.g., water coniferous trees, deciduous forests, corn, wheat etc., and is essentially a thematic map of the original image.

B. Classification Procedures : Common classification procedures are :

1. Supervised Classification :

i. First the information class is specified on the image. The selection of information classes is based on the analyst familiarity with the geographical area and knowledge of the actual surface, cover types present in the image as if the analyst is supervising the categorization of a set of information classes.

ii. Information classes are termed as "training areas". The DN values of all spectral bands comprising the information class is used to train the computer to recognize spectrally similar areas for each class.

iii. The computer uses algorithms to determine the "class signatures" of each "training area".

iv. Now the computer compares each pixel in the image to these spectral signatures and labeled to the class it closely resembles digitally.

2. Unsupervised Classification :

i. Broadly speaking it reverses the supervised classification process. Spectral classes are grouped first based on DN values and then matched to information classes.

ii. In it the algorithm examines the pixels and aggregates them into number of spectral classes (clustering algorithm).

iii. Number of groups or clusters to be looked in the data is decided by the analyst.

iv. The analyst may also specify parameters related to the separation distance amongst the clusters and the variation within each cluster.

v. Finally the analyst may decide to combine some clusters or breakdown others.

vi. Unsupervised classification does not start with a predetermined set of classes as in supervised classification.

Que 5.24. What are temporal images ? Why these are used in remote sensing ? Explain with a suitable example, which cannot be carried out without the use of temporal images.

Answer

Temporal Image : Temporal means related to time. Therefore temporal images are images of the scene acquired at a particular time.

Uses of Temporal Images in Remote Sensing :

1. Remote sensing data provides essential information that helps in monitoring various applications such as image fusion, change detection and land cover classification.
2. Remote sensing is a key technique used to obtain information related to the earth's resources and environment. As we know temporal images are images of the scene acquired at a particular time. The time to take one image is dependent on the actual applications. If the application is to develop a soil map, the image should be taken in the off-growing season.
3. Similarly, mapping crop residue for conservation practices also uses imagery acquired in off-season. On the other hand, if the purpose is for crop monitoring, the remote sensing imagery should be obtained from the growing season. Hence temporal image is generally used in remote sensing for change detection.

Example :

1. For crop monitoring the remote sensing imagery should be obtained from the growing season. It is helpful for proper yield estimation and management if the temporal relationship between image and yield could be identified. Since the variation of crop spectral reflectance during the growing season can be used to relate to yield, it could help growers to estimate yield during the growing season.
2. Furthermore in-seasonal image data acquisition might need to occur many times to better understand the growth pattern and in-field variability.

Que 5.25. What are the essential differences between a raw, standard and geo-coded imagery ? Which are most suitable in terms of geometric quality ?

Answer

1. **Raw Data :** The data received from a sensor has certain flaws and discrepancies due to variation in sensor-earth geometry, platform altitude, altitude and velocity, earth curvature and rotation and atmospheric effects, is raw data.
2. **Standard Data :** When this data is corrected for distortions by establishing between image co-ordinates and map co-ordinates and by correcting the bright value of each pixel as close as possible to the original reflectance of the feature it becomes standard data.
3. **Geo-coded Data :** When the data is derived from conventional (non digital) map or image or the original data is in analog form and it is converted to digital form suitable for use by a computer is geo-coded data.

Suitability : Standard data and geo-coded data are most suitable in terms of geometric quality.

PART-7

Application of Remote Sensing to Civil Engineering.

Questions-Answers

Long Answer Type and Medium Answer Type Questions

Que 5.26. Explain the various applications of remote sensing.

AKTU 2014-15, Marks 05

Answer

Following are the applications of remote sensing :

1. **Agriculture :**
   i. Early season estimation of total cropped area.
   ii. Monitoring crop condition using crop growth profile.
   iii. Identification of crops and their coverage estimation in multi-cropped regions.
   iv. Crop yield modeling.
   v. Cropping system/crop rotation studies.
   vi. Command area management.
   vii. Detection of moisture stress in crops and quantification of its effect on crop yield.
2. **Forestry :**
   i. Improved forest type mapping.
   ii. Monitoring large scale deforestation, forest fire.
   iii. Monitoring urban forestry.
   iv. Forest stock mapping.
   v. Wild life habitat assessment.
3. **Land Use and Soils :**
   i. Mapping land use/cover (level III) at 1 : 25000 scale or better.
   ii. Change detection.
   iii. Identification of degraded lands/erosion prone areas.
   iv. Soil categorization.

4. **Geology :**
   i. Lithological and structural mapping.
   ii. Geo morphological mapping.
   iii. Ground water exploration.
   iv. Drainage analysis.
   v. Mineral exploration.
   vi. Coal fire mapping.
   vii. Oil field detection.
5. **Urban Land use :**
   i. Urban land use level IV mapping.
   ii. Updating of urban transport network.
   iii. Identification of unauthorised structures.
6. **Water Resources :**
   i. Monitoring surface water bodies frequently and estimation of their spatial extent.
   ii. Snow-cloud discrimination leading to better delineation of snow area.
7. **Coastal Environment :**
   i. More detailed inventory of coastal land use on 1:25000 scale.
   ii. Discrimination of coastal vegetation types.
   iii. Monitoring sediment dynamics.
8. **Ocean Resources :**
   i. Wealth of oceans / explorations / productivity.
   ii. Potential fishing zone.
   iii. Coral reef mapping.
9. **Environment :**
   i. Impact assessment on vegetation, water bodies.
   ii. Loss of biological diversity / biosphere reserves / ecological hot spot areas / wet land environment.
10. **Natural Resources Based Applications :**
    i. Management of wild and scenic rivers, recreation resources, flood plains, wet lands, agricultural lands, aquifers, forest, wild life etc.
    ii. Environmental Impact Analysis (EIA).
    iii. View shed analysis.
    iv. Hazardous or toxic facility siting.
    v. Ground water modeling and contamination tracking.
    vi. Wild life analysis, migration routes planning.
11. **Disasters :**
    i. Mapping flood inundated area, damage assessment.
    ii. Disaster warning mitigation.

VERY IMPORTANT QUESTIONS

Following questions are very important. These questions may be asked in your SESSIONALS as well as UNIVERSITY EXAMINATION.

Q. 1. Write short notes on (*a*) Multi spectral scanner (*b*) Along and across track scanner.
Ans: Refer Q. 5.11, Unit-5.

Q. 2. Describe multi-concept in remote sensing. Explain how remote sensing helps in flood related studies.
Ans: Refer Q. 5.13, Unit-5.

Q. 3. What are the difference between Geostationary and sun-synchronous satellites ?
Ans: Refer Q. 5.14, Unit-5.

Q. 4. What is image rectification ? Explain the various types of image rectifications.
Ans: Refer Q. 5.16, Unit-5.

Q. 5. What is a satellite image ? Write short note on characteristics and formats of satellite image.
Ans: Refer Q. 5.17, Unit-5.

Q. 6. What do you understand by image enhancement ? List any four changing operations. Describe linear contrast enhancement process.
Ans: Refer Q. 5.19, Unit-5.

Q. 7. Differentiate between restoration and enhancement of remote sensing image.
Ans: Refer Q. 5.20, Unit-5.

Q. 8. Explain in detail land use/land cover classification system.
Ans: Refer Q. 5.22, Unit-5.

Q. 9. Write a note on image classification. Discuss supervised and unsupervised classification.
Ans: Refer Q. 5.23, Unit-5.

Q. 10. Explain the various applications of remote sensing.
Ans: Refer Q. 5.26, Unit-5.

☺☺☺

UNIT 1

Introduction to Surveying (2 Marks Questions)

1.1. What are the assumptions made in plain survey ?
Ans: Following are the main assumptions used in plain survey :
i. A level line is considered a straight line and thus the plumb line at a point is parallel to the plumb line at any other point.
ii. The angle between two such lines that intersect is a plane angle and not a spherical angle.
iii. The meridians through any two points are parallel.

1.2. What are the basic principles of surveying ?
Ans: Following are the two basic principles of surveying :
i. To work form whole to part.
ii. To locate a point by at least two measurement.

1.3. What are the basic sources of error in survey ? Give detail.
Ans: Following are the different sources of error in survey :
i. Instrument errors. ii. Personal errors.
iii. Natural errors.

1.4. What are the different types of errors in surveying ?
Ans: Following are the errors occurring in surveying :
i. Mistake errors. ii. Systematic errors.
iii. Accidental errors.

1.5. Define the following terms :
Level line, mean sea level, datum, bench mark.
Ans:
i. **Level Line :** It is a line lying on level surface. It is normal to the plumb line at all the point.
ii. **Mean Sea Level :** The average elevation of sea water at Mumbai port is taken as mean sea level and all elevations in India are connected to it.
iii. **Datum :** It is a level surface with respect to which the levels of points are measured or referred to.
iv. **Bench Marks :** It is a fixed reference point of known elevation.

1.6. Enlist various methods for classification of survey based on different criteria.
Ans: Following are the different criteria for classification of survey :
i. Accuracy desired. ii. Purpose of survey.

iii. Place of survey. iv. Instrument used.

1.7. What do you mean by working from whole to part ?

AKTU 2016-17, Marks 02

Ans:
i. It implies that first of all, a traverse along the boundary of the area to be surveyed should be laid and precisely surveyed.
ii. After that the area should be divided in several parts consisting of smaller traverses and each part surveyed separately and so on.
iii. This way the error in the survey work will be localized.

1.8. Give the broad classification of surveying ?

Ans: Following are the classification of surveying :
i. Geodetic surveying. ii. Plane surveying.

1.9. Describe the ranging.

Ans: Ranging is establishing intermediate stations on a survey line to facilitate correct linear measurement of the survey lin . Ranging is done in two ways :
i. Direct ranging. ii. Indirect ranging.

1.10. How many ranging rods are required to range a line ?

AKTU 2015-16, Marks 02

Ans: At least three ranging rods are required for direct ranging and at least four for indirect ranging.

1.11. Define local attraction. How will you detect local attraction at a station ?

AKTU 2018-19, Marks 02

OR

How would you detect the presence of local attraction in an area ?

AKTU 2015-16, Marks 02

Ans: **Local Attraction :** Local attraction is any influence on the magnetic needle due to presence of magnetic substances such as iron pipes, steel structures, iron lamps, posts, rails, cables, chain arrows etc; in the vicinity which prevent the needle from pointing to the magnetic north.
Detection : When the difference of back bearing and fore bearing is not exactly 180°, then the particular station is affected by local attraction.

1.12. What is declination and its variations ?

OR

What is magnetic declination ?

AKTU 2016-17, Marks 02

Ans: **Declination :** The horizontal angle between true north and magnetic north at the time of observation is defined as magnetic declination.

True bearing = Magnetic bearing ± Magnetic declination (E/W)
Variations : The declination at any place keeps on changing from time to time. These variations may be classified as follows :
i. Secular variation. ii. Annual variation.
iii. Diurnal variation. iv. Irregular variation.

1.13. Write relationship between level line and horizontal line.

AKTU 2016-17, Marks 02

Ans: Horizontal line is a line in the horizontal plane and it is straight line tangential to the level line.

1.14. The magnetic bearing of a line as observed is 269°. If the local attraction at this point is known to be 5° E and the declination is 15° W. What is the true bearing of the line ?

AKTU 2014-15, Marks 3.5

Ans: True bearing of line = Observed bearing + East local attraction – West declination
= 269° + 5° – 15° = 259°

1.15. What is the necessity of providing tallies in a chain ?

AKTU 2015-16, Marks 02

Ans: Tallies in a chain ensure accuracy in measurement and facilitate the recollection of the distances to objects on the line.

1.16. What do you mean by positive RL and negative RL ?

AKTU 2015-16, Marks 02

Ans: When the sighted point is above the reference point then it is positive RL and when the sighted point is below the reference point, then it is known as negative RL.

1.17. How will you distinguish between a valley line and ridge line ?

AKTU 2015-16, Marks 02

Ans:

S. No.	Ridge Line	Valley Line
i.	For ridge line, the higher elevation contours are inside the loop or band.	Valley line is indicated by higher elevation contours outside the loop.
ii.	Ridge lines indicate mountains, steep hills, etc.	Valley lines indicate streams or rivers.

1.18. Write down the condition to check the computation process in height of instrument method.

Ans: Σ Back sight – Σ Fore sight = Last RL – First RL

1.19. Enlist various causes of errors in levelling.

Ans. Following are the causes of errors in levelling :

i. Errors due to sluggish bubble.
ii. Errors due to faulty focusing tube.
iii. Errors due to earth curvature and atmospheric refraction.
iv. Error due to temperature and wind vibration.
v. Error due to mistake in reading and recording.
vi. Error in sighting.

1.20. Correction due to refraction is given by

i. $0.0112\,D^2$ ii. $0.0673\,D^2$
iii. $0.785\,D^2$ iv. $0.0012\,D^2$ **AKTU 2016-17, Marks 02**

Ans. $0.0112\,D^2$

1.21. What is levelling and why it is important in survey work ? **AKTU 2016-17, Marks 02**

Ans. **Levelling :** It is the operation of determining the difference of elevation of points with respect to each other (on, above or below the earth surface)

Importance : Levelling is necessary for various purposes such as : calculation of the depth of cutting and filling, setting out grades for sewers, roads, railway track and pipe lines and the estimation of reservoir capacities.

1.22. What is the difference between triangulation and trilateration ?

Ans.

S. No.	Triangulation	Trilateration
i.	All the angles are measured very precisely	The three sides of triangles are measured precisely using the EDM, there is no need to measure angle.
ii.	It is more accurate and economical.	It is less accurate and economical.

1.23. What is triangulation ? **AKTU 2016-17, Marks 02**

Ans. The method of measuring the chain angles of a framework of triangle being formed by making the station on the surface of the earth is called as triangulation.

1.24. What is resection ? **AKTU 2016-17, Marks 02**

Ans. Resection is a method of orientation employed when the table occupies a station whose position is not yet available on drawing sheet.

1.25. What is an azimuth ? **AKTU 2017-18, Marks 02**

Ans. The angle between a line and the meridian measured in clock-wise direction usually from the north branch of the meridian is the azimuth of the line.

1.26. How are centering and leveling done in plane table ? **AKTU 2015-16, Marks 02**

Ans. **Procedure of Centering :** Place the pointed end of the upper leg of the fork coinciding with the point on the paper and suspend a plumb bob exactly over the centre of the station peg.

Procedure of Levelling :

i. The table or board is levelled by means of bubble tube or spirit level by placing them on the table or board in two positions at right angles.
ii. Board is adjusted by the tripod legs till the bubble come in centre and remains in centre in both the directions.

1.27. What is index sketch ? **AKTU 2017-18, Marks 02**

Ans. During reconnaissance survey, a neat hand sketch is prepared showing the framework of the survey. This sketch is known as the index sketch.

1.28. What is a 12 cm compass ? **AKTU 2017-18, Marks 02**

Ans. The size of a compass is designated by its diameter. Therefore, a 12 cm compass is a compass of diameter 12 cm.

1.29. In a map, it is found that two consecutive contours cross each other. What would you comment. **AKTU 2017-18, Marks 02**

Ans. In general, contour lines cannot cross each other, except in the case of an overhanging cliff. Therefore, the area represented in the map includes an overhanging cliff. But the contour line should be dotted line at the point of crossing to indicate that one location is below the other.

1.30. How will you identify a ridge line and a valley line in a contour map ? **AKTU 2018-19, Marks 02**

Ans. When the lower values are inside the loop, it indicates a valley line. When the higher values are inside the loop, it indicates a ridge line.

1.31. What is the difference between accuracy and precision ? **AKTU 2018-19, Marks 02**

Ans.

S. No.	Accuracy	Precision
1.	Accuracy is the degree of perfection obtained in any work.	Precision is referred to as the degree of fineness and care with which any physical measurement is made.
2.	It is considered to be an overall estimate of the errors, including systematic errors, present in measurement.	It represents the repeatability of a measurement and is concerned with only random errors.

1.32. Define a well-conditioned triangle.

AKTU 2018-19, Marks 02

Ans. A triangle is said to be well conditioned when no angle in it is less than 30° or greater than 120°.

1.33. What are the various types of meridians ?

AKTU 2018-19, Marks 02

Ans. Following are the various types of meridians :
i. True meridian. ii. Grid meridian.
iii. Magnetic meridian. iv. Arbitrary meridian.

1.34. Explain under which conditions tacheometric surveying is advantageous.

AKTU 2018-19, Marks 02

Ans. Following are the conditions in which tacheometric surveying adopted :
i. It is adopted in rough and difficult terrain where direct levelling and chaining are either not possible or very tedious.
ii. It is also used in location survey for railways, roads, reservoirs etc.

1.35. What do you mean by the terms 'telescope normal' and 'telescope inverted' ?

AKTU 2015-16, Marks 02

Ans. **Telescope Normal :** The position of telescope with the face left is known as telescope normal.
Telescope Inverted : The position of telescope with the face right is known as telescope inverted.

1.36. What is the principle of tacheometry ?

AKTU 2015-16, Marks 02

Ans. The principle of tacheometry is to enable horizontal and vertical distances to be computed from readings upon a stadia rod, and thus eliminate chaining operation.

☺☺☺

2 UNIT
Curves (2 Marks Questions)

2.1. What is degree of curve ?

AKTU 2015-16, Marks 02

Ans. The angle subtended at the centre by a standard chain of 30 m length is called as degree of the curve.

2.2. What do you mean by horizontal curves ?

Ans. The curves which are provided at turning points so as to get gradual change in the direction of alignment of a road or a track are termed as horizontal curves.

2.3. Define the term compound curve.

Ans. A compound curve is a combination of two or more simple circular curve with different radii.

2.4. Which transition curve is an ideal transition curve ?

Ans. Cubic spiral or clothoid is known as an ideal transition curve. In it, the radius of curvature is inversely proportional to its distance from the beginning of the curve, *i.e.*, $l \propto \frac{1}{r}$

2.5. Define superelevation.

Ans. It is defined as the raising of the outer end of a road or the outer rail over the inner one.
Superelevation, $h = Wv^2/gR$

2.6. Write down the functions of curve in road and track alignment.

OR

What is the basic importance of provision of curves in highway ?

AKTU 2016-17, Marks 02

Ans. Following are the functions of curves in the alignment of road :
i. Curves are provided so as to get comfort to the passengers.
ii. Curves are provided so as to get an easy turning in case of road and track.

2.7. Explain the elements of simple curve, with neat sketch.

AKTU 2016-17, Marks 02

Ans.

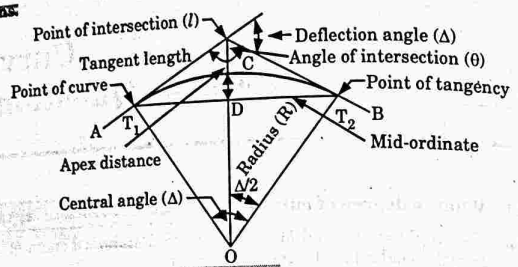


Fig. 2.6.1.

Elements of Simple Curve : Refer Q. 2.2, Page 2–4B, Unit 2.

2.8. Discuss the uses of transition curve.

Ans. Transition curves are commonly used in railway tracks between the circular curve and a tangent so as to provide easy and gradual change in direction.

2.9. Which type of transition curve is used in highway alignment?

Ans. Spiral curves are generally used in highway alignment.

2.10. What is the requirement of transition curve ?

Ans. Fundamental requirement of transition curve is that the radius of curvature at any point should be inversely proportional to the distance 'l' from the beginning of the curve.

☺☺☺

UNIT 3

Modern Field Survey Systems (2 Marks Questions)

3.1. Define EDM.

Ans. EDM is a surveying instrument for measuring distance electronically between two points through electromagnetic waves.

3.2. Write down the types of EDM instruments.

Ans. Following are the types of EDM instruments :

i. Microwave instruments.
ii. Visible light instruments.
iii. Infrared instrument.

3.3. Define the total station.

Ans. A total station is a combination of an electronic theodolite and an electronic distance meter (EDM).

3.4. What are the advantages of total station ?

Ans. Following are the advantages of total station :

i. Relatively quick collection of information.
ii. Multiple surveys can be performed at one set-up location.
iii. Layout of construction site quickly and efficiently.

3.5. Write short notes on orbital calendar and spatial resolution.

AKTU 2015-16, Marks 02

Ans. **Orbital Calendar :** A satellite covers different areas on different dates during the orbit. An orbital calendar gives the information on which a calendar date will cover that particular area.

Spatial Resolution : It is the size of a pixel in ground dimensions. A 30 m size represents a square ground dimension of 30 m × 30 m. It also means number of pixel per inch length of the image.

3.6. Describe the satellite navigation system.

Ans. It comprised of a system of satellites that transmits radio signals. Appropriately equipped aircraft receiving these transmitted signals can derive their three-dimensional position, velocity and time.

3.7. What is GPS ? **AKTU 2017-18, Marks 02**

Ans: Global Positioning System (GPS) is a space-based satellite navigation system that provides location and time information in all weather conditions, anywhere on or near the earth where there is an unobstructed line of sight to four or more GPS satellites.

3.8. Define image histogram. **AKTU 2015-16, Marks 02**

Ans: It is a graphical representation of brightness values of an image. The brightness values are plotted on X-axis and frequency of occurrence of each value in the image on Y-axis.

3.9. Identify the three segments of GPS.

Ans: Following are the segment of GPS :
i. GPS satellite constellation or space segments.
ii. Operational control segments (OCS).
iii. User equipment segments.

3.10. Classify the sources of errors.

Ans: Following are the sources of errors :
i. Satellite related errors.
ii. Propagation medium related errors.
iii. Receiver related errors.

3.11. Write the advantages of DGPS.

Ans: Following are the advantages of DGPS :
i. Improved accuracy.
ii. DGPS works by cancelling out most of the natural and man-made errors that creep into normal GPS measurements.

3.12. Compare kinematic and differential GPS systems.

Ans:

S. No.	Differential GPS	Kinematic GPS
i.	Inexpensive.	Expensive.
ii.	Accuracy of this technique is in the order of sub-meter.	This technique has centimeter accuracy.
iii.	DGPS uses only GPS pseudo ranges to compute its position.	It uses pseudo ranges as well as Doppler measurements and carrier phase also.

3.13. What are the different uses of GPS ?

Ans: Following are the uses of GPS :
i. For navigation purpose.
ii. For surveying.

iii. In remote sensing.
iv. In mapping.
v. In military and space.
vi. In agriculture, etc.

3.14. Write the use of GPS in remote sensing.

Ans: It is also possible to integrate GPS positioning into remote sensing method such as photogrammetry and aerial scanning, magnetometry, and video technology.

3.16. Give the functions of GPS satellite signals. **AKTU 2015-16, Marks 02**

Ans: A GPS satellite signal shows the three dimensional position of the user with the time at that moment.

3.16. Define GIS. **AKTU 2017-18, Marks 02**

Ans: GIS is a system of hardware, software, and procedures designed to support the capture management, manipulation, analysis, modeling and display of spatially referenced data for solving complex planning and management problems.

3.17. Discuss the advantages of GIS.

Ans: Following are the advantages of GIS :
i. GIS can handle spatially referenced, multilayered, heterogeneous huge data.
ii. GIS can process the data with high speed and produce output almost in no time and can answer allied queries related to the topic.

3.18. What are the components of GIS ?

Ans: Following are the components of GIS :
i. Hardware.
ii. Software.
iii. Procedure.
iv. Data.
v. Users.

3.19. What do you understand by spatial data model ? **AKTU 2015-16, Marks 02**

Ans: It is a geographical representation of earth features interconnected by a coordinate system. Spatial data available on maps, photographs is not in digital form, is spatially located in digital format while integrating it in a GIS.

3.20. What is data acquisition ?

Ans: Data acquisition is collecting spatial data from available resources e.g., maps, photographic images and converting it into digital form.

3.21. How can you classify raster data ?

AKTU 2015-16, Marks 02

Ans: In the raster data structure, everything is represented by grid cells, a point is represented by a single cell, a line by a string of cells and an area by a group of cells.

3.22. What are the hardware components of a GIS ?

Ans: Following are the hardware components of GIS :

i. **CPU :** Central processing unit is linked to disk drive, which provides space for storing data and programs.

ii. **Digitizer :** It is a device used to convert data from maps and documents into digital form (Raster to vector).

iii. **Plotter :** Plotter is used to present the result of the data processing on a paper.

iv. **Tape Drive :** It is used to store data or programs on magnetic tape for communicating with other system.

v. **VDU :** (Visual Display Unit) It is used to control the computer and the other peripherals. It is otherwise known as terminal or workstation.

3.23. What are the different uses of GIS ?

Ans: The area of GIS applications are unlimited as it can be used for management and planning that may be required in any field, e.g., urban planning, forestry, environmental management, flood control, natural disaster management, etc.

☺☺☺

4 UNIT Photogrammetric Survey (2 Marks Questions)

4.1. What is photogrammetric survey ?

AKTU 2017-18, Marks 02

Ans: It is the science and art of obtaining accurate measurements by use of photographs, for various purposes such as the construction of planimetric and topographic maps, classification of soils, interpretation of geology, acquisition of military intelligence and the preparation of composite pictures of the ground.

4.2. Define aerial survey.

Ans: Aerial photography is taking photographs in air and producing maps or acquiring required information from these maps. It is also called aerial photogrammetry or aerial survey.

4.3. Mention the different types of aerial survey.

Ans: Following are the types of aerial survey :

i. Terrestrial photography. ii. Aerial photography.

4.4. Explain stereoscopy. **AKTU 2016-17, Marks 02**

Ans: It is a technique for creating or enhancing the illusion at depth in an image by means of stereoscope for binocular vision.

4.5. How is an aerial photography taken ?

AKTU 2015-16, Marks 02

Ans: An aerial photograph is taken with the help of camera mounted on aircraft, flying along predetermined lines called flight lines and at predetermined height generally at regular interval.

4.6. Explain flight planning ? **AKTU 2016-17, Marks 02**

Ans: It is the process of producing a flight plan to describe a proposed aircraft flight.

4.7. Give any three advantages that aerial photography offers over ground based observations.

AKTU 2015-16, Marks 02

Ans: Following are the advantages of aerial photography :
i. Inaccessible areas.
ii. Mountainous region with less vegetation.
iii. Mapping large areas is faster and economical.

4.8. Explain the disadvantages of aerial photograph.

Ans: Following are the disadvantages of aerial photograph :
i. Not economical for survey of small areas.
ii. Not suitable for dense forests and flat sands due to difficulty of identifying objects upon the photograph.

4.9. Explain relief displacement. **AKTU 2016-17, Marks 02**

Ans: The displacement on a photograph between the image of any ground point and its image, if the point is projected to a datum plane is the displacement caused by the topographic relief or elevation and is called relief displacement.

4.10. What is drift in aerial survey ?

Ans: It is shifting of aircraft from its planned flight lines often caused due to strong winds while taking photographs.

4.11. Explain parallax. **AKTU 2016-17, Marks 02**

Ans: Parallax is the displacement in the image of an object caused by a shift in the point of observation *i.e.*, successive exposures during a flight.

4.12. What is the use of parallax bar ?

Ans: It is used to measure the parallax difference between two points. The difference in parallax of two points is called parallax difference.

1.13. List the characteristics of photographic image.

Ans: Characteristics of photographic image can be divided into two categories :
i. **Qualitative Characteristics :** These include shape, size, tone, texture and pattern of photographic image.
ii. **Quantitative Characteristics :** These include areas, distances, slopes and heights of photographic images.

4.14. Explain advantages of digital photogrammetry.

Ans: Following are the advantages of digital photogrammetry :
i. It facilitates direct production of digital maps.
ii. It can handle inputs from other non-traditional sources such as LIDAR, digital camera output, etc.
iii. It does not require any periodic maintenance except in two types of instruments.

☺☺☺

5 UNIT

Remote Sensing and Digital Image Processing (2 Marks Questions)

5.1. What do you understand by remote sensing ? **AKTU 2015-16, Marks 02**

OR

Define remote sensing. **AKTU 2017-18, Marks 02**

Ans: Remote sensing is acquiring information about an object, area or phenomenon without coming in contact of it. Aerial photography is also called remote sensing.

5.2. Which type of energy is used in remote sensing ?

Ans: Electromagnetic energy, *i.e.*, light energy is used for remote sensing.

5.3. What is spectral signature ?

Ans: The patterns are averaged to get general reflectance characteristics of the object over different wavelength intervals. Representation of such averaged reflectance is called spectral signature.

5.4. Explain resolution. **AKTU 2016-17, Marks 02**

OR

What is resolution of a sensor ? **AKTU 2015-16, Marks 02**

Ans: Resolution is the ability of remote sensing system to record information of the smallest clearly separable quantity in terms of size (spatial), wavelength band of electromagnetic radiation (spectral), radiation strength, and time.

5.5. What are the characteristics of ideal remote sensing system ?

Ans: Following are the characteristics of ideal remote sensing system :
i. Uniform electromagnetic energy source.

ii. Series of unique energy.
iii. Non-interfering atmosphere.
iv. Super sensor, etc.

5.6. What is atmospheric windows ?

Ans: Wavelength of electromagnetic radiation which have high transmission through the atmosphere are called atmospheric windows.

5.7. Explain geosynchronous satellites.

AKTU 2016-17, Marks 02

Ans: A geostationary satellite is an earth-orbiting satellite, placed at an altitude of approximately 35,800 km directly over the equator that revolves in the same direction the earth rotates. At this altitude, one orbit take 24 hr, the same length of time as the earth requires to rotate once on its axis. The term geostationary comes from the fact that such a satellite appears nearly stationary in the sky as seen by a ground based observer.

5.8. Explain sun-synchronous satellite.

AKTU 2016-17, Marks 02

Ans: These are low altitude (300-1000 km) satellite. Satellites placed in near polar orbit such that pass over the same area of the earth at same local solar time every day.

5.9. Give the applications of Indian Remote Sensing (IRS).

Ans: **Application :** Imagery taken by Indian Remote Sensing (IRS) satellite has found application in diverse fields ranging from agriculture to urban planning.
Example : Crop health monitoring, Crop yield estimation and drought assessment.

5.10. Define spectral reflectance curve and what are its utilities in remote sensing.

AKTU 2015-16, Marks 02

OR

Explain spectral reflectance curve.

AKTU 2016-17, Marks 02

Ans: **Spectral Reflectance Curve :** It is a graph between spectral reflectance of an object versus wavelength.
Utilities : Spectral reflectance curves are used to compare the aerial photograph taken with them to assess what feature exists at any location in an aerial photograph.

5.11. Differentiate active and passive remote sensing system.

OR

Explain active and passive remote sensing.

AKTU 2016-17, Marks 02

Ans:

S. No.	Active RSS	Passive RSS
i.	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.
ii.	These systems operate in the microwave region of the electromagnetic spectrum.	They operate in the visible and infrared region of the electromagnetic spectrum.
iii.	Their wavelengths are longer than one mm.	Their wavelengths range from 0.4 to 10 μm.
iv.	**Example :** Synthetic aperture radar.	**Example :** Any electromagnetic remote sensing system (Camera without flash light).

5.12. Describe attribute data.

AKTU 2017-18, Marks 02

Ans: Attribute data is data that have a quality characteristic (or attribute) that meets or does not meet product specification. These characteristics can be categorized and counted.
Examples of attribute data include sorting and counting the number of blemishes in a particular product (defects), and the number of nonconforming pieces (defectives).

5.13. What do you mean by digital image processing ?

AKTU 2017-18, Marks 02

Ans: The digital image processing is the task of processing and analyzing the digital data using some image processing algorithm.
Digital image processing is done to obtain images close to original geometry of the earth and the brightness values close to radiance from the respective feature.

☺☺☺

B.Tech.
(SEM. III) ODD SEMESTER THEORY EXAMINATION, 2014-15
SURVEYING

Time : 2 Hours **Max. Marks : 50**

Note : Attempt all questions.

1. Attempt any four parts of the following : (4 × 3.5 = 14)

a. **Find the hypotenusal allowance per chain of 30 m length if the angle of slope is 12° 30'.**

Ans. This question is out of syllabus from session 2019-20.

b. **The magnetic bearing of a line as observed is 269°. If the local attraction at this point is known to be 5° E and the declination is 15° W. What is the true bearing of the line ?**

Ans. This question is out of syllabus from session 2019-20.

c. **What are the fundamental lines and their desired relations in a theodolite ?**

Ans. Refer Q. 1.47, Page 1–52B, Unit-1.

d. **Give brief description of total station.**

Ans. Refer Q. 3.4, Page 3–4B, Unit-3.

e. **Differentiate between prismatic compass and surveyor's compass.**

Ans. Refer Q. 1.13, Page 1–16B, Unit-1.

f. **A steel tape was exactly 30 m long at 20 °C when supported throughout under a pull of 10 kg. A line was measured with this tape under a pull of 15 kg and at a temperature of 32 °C and found to be 780 m long. The cross-sectional area of the tape = 0.03 cm², total weight of tape = 0.693 kg. α for steel = 11 × 10⁻⁶ per °C. *E* for steel = 2.1 × 10⁶ kg/cm². Compute true length of line if tape is supported at every 30 m.**

Ans. This question is out of syllabus from session 2019-20.

2. Attempt any two parts of the following : (2 × 6 = 12)

a. **A tacheometer provided with anallatic lens and having multiplying constant 100 is employed to find the gradient of line *PQ* from the following observations.**

Staff Station	Bearing	Top Hair Reading	Middle Hair Reading	Bottom Hair Reading	Vertical Angle
P	345°	0.900	1.772	2.544	+ 15°
Q	75°	0.750	2.205	3.660	+ 10°

Ans. This question is out of syllabus from session 2019-20.

b. **The following are observations in reciprocal leveling.**

Instrument Near	Staff Reading at *A*	Staff Reading at *B*	Remarks
A	1.825	2.750	Distance *AB* = 1020 m
B	0.930	1.615	RL of *A* = 126.325 m

Find true RL of *B* and combined correction for curvature and refraction.

Ans. Refer Q. 1.27, Page 1–30B, Unit-1.

c. **Define contour and write characteristics of contour.**

Ans. Refer Q. 1.36, Page 1–41B, Unit-1.

3. Attempt any two parts of the following : (2 × 6 = 12)

a. **Two straight lines *AC* and *CB* to be connected by a 3° C intersect at a chainage of 2760 m. The WCB of *AC* and CB are 45° 30' and 75° 30' respectively. Calculate radius, tangent length, curve length, length of long chord, chainage of point of commencement and tangency.**

Ans. Refer Q. 2.9, Page 2–14B, Unit-2.

b. **State the different methods of calculating length of transition curve.**

Ans. Refer Q. 2.12, Page 2–18B, Unit-2.

c. **Explain Rankine's method of setting out of a circular curve.**

Ans. Refer Q. 2.5, Page 2–9B, Unit-2.

4. Attempt any two parts of the following : (2 × 6 = 12)

a. **Discuss various methods of theodolite traversing.**

Ans. This question is out of syllabus from session 2019-20.

b. **Describe various rules to adjust closing error occurring in a closed traverse.**

Ans. This question is out of syllabus from session 2019-20.

c. **What is the purpose of a satellite station in triangulation ? Derive an equation to obtain angle at triangulation station with the help of satellite station observation which is inside the triangle.**

Ans. Refer Q. 1.53, Page 1–59B, Unit-1.

☺☺☺

B.Tech.
(SEM. III) ODD SEMESTER THEORY EXAMINATION, 2015-16
SURVEYING

Time : 3 Hours **Max. Marks : 100**

Section-A

1. Attempt all questions. (10 × 2 = 20)

a. How many ranging rods are required to range a line ?
Ans. Refer Q. 1.10, 2 Marks Questions, Page SQ–2B, Unit-1.

b. What is the necessity of providing tallies in a chain ?
Ans. Refer Q. 1.15, 2 Marks Questions, Page SQ–3B, Unit-1.

c. How would you detect the presence of local attraction in an area ?
Ans. Refer Q. 1.11, 2 Marks Questions, Page SQ–2B, Unit-1.

d. How are centering and levelling done in plane table ?
Ans. Refer Q. 1.26, 2 Marks Questions, Page SQ–5B, Unit-1.

e. What do you mean by positive RL and negative RL ?
Ans. Refer Q. 1.16, 2 Marks Questions, Page SQ–3B, Unit-1.

f. How will you distinguish between a valley line and ridge line ?
Ans. Refer Q. 1.17, 2 Marks Questions, Page SQ–3B, Unit-1.

g. What do the terms 'telescope normal' and 'telescope inverted' mean ?
Ans. Refer Q. 1.36, 2 Marks Questions, Page SQ–6B, Unit-1.

h. What are the sign conventions of latitude and departure ?
Ans. This question is out of syllabus from session 2019-20.

i. What is the degree of a curve ?
Ans. Refer Q. 2.1, 2 Marks Questions, Page SQ–7B, Unit-2.

j. What is the principle of tacheometry ?
Ans. Refer Q. 1.37, 2 Marks Questions, Page SQ–6B, Unit-1.

Section-B

Attempt any five questions from this section. (5 × 10 = 50)

2. The distance between two stations was 1200 m when measured with a 20 m chain. The same distance when measured with a 30 m chain was found to be 1195 m. If the 20 m chain was 0.05 m too long, what was the error in the 30 m chain ?
Ans. This question is out of syllabus from session 2019-20.

3. Explain clearly the difference between a prismatic compass and surveyor's compass.
Ans. Refer Q. 1.13, Page 1–16B, Unit-1.

4. What is orientation ? What are the methods of orientation ? Describe the methods with a sketch.
Ans. **Orientation :** Refer Q. 1.31, Page 1–35B, Unit-1.
Methods : Refer Q. 1.32, Page 1–35B, Unit-1.

5. What is reciprocal levelling ? When it is done ? Describe the method along with a sketch.
Ans. Refer Q. 1.24, Page 1–26B, Unit-1.

6. What are the characteristics of contour lines ? State the uses of contour maps.
Ans. **Characteristics :** Refer Q. 1.36, Page 1–41B, Unit-1.
Uses of Contour Maps : Refer Q. 1.38, Page 1–44B, Unit-1.

7. Describe the process of repetition and reiteration in theodolite survey.
Ans. Refer Q. 1.48, Page 1–53B, Unit-1.

8. Two tangents intersect at a chainage of 1320.5 m, the deflection being 24°. Calculate the tangent length, and versed sine of curve, for setting out a curve of 275 m radius.
Ans. Refer Q. 2.7, Page 2–13B, Unit-2.

9. 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 Angle	Hair Readings (m)	Remarks
C	BM	50°20′	1.50, 1.80, 2.45	RL of BM = 750.50 m
C	*D*	8°12′	0.75, 1.50, 2.25	

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

Ans: This question is out of syllabus from session 2019-20.

Section-C

Attempt any two questions from this section. (2 × 15 = 30)

10. Following are the bearings observed while traversing with a compass, an area where local attraction was suspected. Find the correct bearing of the lines and also the true bearings, if the magnetic declination is 10° W.

Line	FB	BB
AB	59°00′	239°00′
BC	139°30′	317°00′
CD	215°15′	36°30′
DE	208°00′	29°00′
EA	318°30′	138°45′

Ans: Refer Q. 1.16, Page 1–18B, Unit-1.

11. The consecutive readings taken with a levelling instrument at intervals of 20 m are 2.375, 1.730, 0.615, 3.450, 2.835, 2.070, 1.835, 0.985, 0.435, 1.630, 2.2255 and 3.630 m. The instrument was shifted after the fourth and eighth readings. The last reading was taken on BM of RL 110.200 m. Find the RL's of all the points.

Ans: Refer Q. 1.22, Page 1–25B, Unit-1.

12. The traverse data containing lengths and interior angles of a traverse are given below. The bearing of line *PQ* was observed and recorded as S 36° 12′ 30″E. Check the traverse for angles and closing errors, if any. Find the correct latitudes and departures by transit method.

Line	Length	Station	Included Angle
PQ	102.8	*P*	131°14′30″
QR	98.4	*Q*	84°19′25″
RS	110.8	*R*	116°35′25″
ST	82.8	*S*	119°58′05″
TP	113.29	*T*	87°54′0.5″

Ans: This question is out of syllabus from session 2019-20.

☺☺☺

B. Tech.
(SEM. III) ODD SEMESTER THEORY EXAMINATION, 2016-17
SURVEYING

Time : 3 Hours **Max. Marks : 100**

Section-A

Attempt all parts. Each part carries equal marks : (10 × 2 = 20)

1. Correction due to refraction is given by :
a. $0.0112\,D^2$ b. $0.0673\,D^2$
c. $0.785\,D^2$ d. $0.0012\,D^2$

Ans: Refer Q. 1.20, 2 Marks Questions, Page SQ–4B, Unit-1.

2. What do you mean by working from whole to part ?

Ans: Refer Q. 1.7, 2 Marks Questions, Page SQ–2B, Unit-1.

3. What is levelling and why it is important in survey work ?

Ans: Refer Q. 1.21, 2 Marks Questions, Page SQ–4B, Unit-1.

4. Write relationship between level line and horizontal line.

Ans: Refer Q. 1.13, 2 Marks Questions, Page SQ–3B, Unit-1.

5. For an open traverse, which is correct
a. Σ latitude = 0 b. Σ departure = 0
c. Both (a) and (b) d. None of the above

Ans: This question is out of syllabus from session 2019-20.

6. What is magnetic declination ?

Ans: Refer Q. 1.12, 2 Marks Questions, Page SQ–2B, Unit-1.

7. What is the basic importance of provision of curves in highway ?

Ans: Refer Q. 2.6, 2 Marks Questions, Page SQ–7B, Unit-2.

8. Explain the elements of simple curve, with neat sketch.

Ans: Refer Q. 2.7, 2 Marks Questions, Page SQ–8B, Unit-2.

9. What is triangulation ?

Ans: Refer Q. 1.23, 2 Marks Questions, Page SQ–4B, Unit-1.

10. **What is resection ?**

Ans. Refer Q. 1.24, 2 Marks Questions, Page SQ–4B, Unit-1.

Section-B

Attempt any three questions : (3 × 10 = 30)

1. **The distance measured between two points on a sloping ground is 450 m. Find the correction to be applied and horizontal distance if :**
   a. **The angle of slope is 10°.**
   b. **The slope is 1 in 5.**
   c. **The difference in elevation between two points is 45 m.**

Ans. This question is out of syllabus from session 2019-20.

2. **A closed traverse has the following lengths and bearings :**

Line	Length (m)	Bearing
AB	200.0	ROUGHLY EAST
BC	98.0	178°
CD	NOT REQUIRED	270°
DA	86.4	1°

The length *CD* could not be measured due to some obstruction to chaining. The bearing of *AB* could not be taken, as station *A* is badly affected by local attraction, find the exact bearing of the side *AB* and calculate length *C*.

Ans. This question is out of syllabus from session 2019-20.

3. **Explain the two point problem of plane tabling with a neat sketch.**

Ans. Refer Q. 1.33, Page 1–36B, Unit-1.

4. **A road 8 m wide is to deflect through an angle of 60° with the centre line radius of 300 m, the chainage of intersection points being 3605.0 m. A transition curve is to be used at each end of circular curve of such a length that rate of gain of radial acceleration is 0.5 m/sec^3. When speed is 50 kmph. Find out :**
   a. **Length of transition curve.**
   b. **Superelevation.**
   c. **Chainage of all junction points.**

Ans. Refer Q. 2.20, Page 2–29B, Unit-2.

5. **A 30 m long steel tape is supported at the ends. Find the normal tension for the tape with the following details : Cross section of the tape = 4 mm^2, unit weight of the tape material = 78600 N/m^3, $E = 2 \times 10^{11}$ N/m^2, the pull at which the tape is standardized is 100 N.**

Ans. This question is out of syllabus from session 2019-20.

Section-C

Attempt any five questions : (5 × 10 = 50)

1. **Explain curvature and refraction correction in levelling. The eye of an observer is 7.5 m above sea level and he was able to see a light house 50 m high just above the horizontal. Find the distance between observer and lighthouse.**

Ans. Refer Q. 1.25, Page 1–27B, Unit-1.

2. **Define a contour. Discuss the method of contouring. What are the various methods of interpolating contour ? State the suitability of each one of them.**

Ans. **Contour :** Refer Q. 1.36, Page 1–41B, Unit-1.
Method of Contouring and Method of Interpolating Contour and Suitability : Refer Q. 1.37, Page 1–42B, Unit-1.

3. **What are the different check in closed traverse and open traverse ?**

Ans. This question is out of syllabus from session 2019-20.

4. **State the three point problem, explain how it is solved by the graphical method ?**

Ans. **Three Point Problem :** Refer Q. 1.34, Page 1–38B, Unit-1.
Graphical Method : Refer Q. 1.35, Page 1–40B, Unit-1.

5. **What are the essential requirements of a transition curve ? Derive an expression for an ideal transition curve.**

Ans. **Requirements of Transition Curve :** Refer Q. 2.11, Page 2–17B, Unit-2.
Expression : Refer Q. 2.13, Page 2–21B, Unit-2.

6. **The apex distance of a 3° circular curve is 82.45 m. Determine the deflection angle, tangent length and length of long chord.**

Ans. Refer Q. 2.8, Page 2–13B, Unit-2.

7. **Explain the indirect method of contouring. What are the advantages and disadvantages of these methods ?**

Ans. **Indirect Method :** Refer Q. 1.37, Page 1–42B, Unit-1.
Advantages and Disadvantages of Indirect Method : Refer Q. 1.39, Page 1–44B, Unit-1.

☺☺☺

B.Tech.
(SEM. III) ODD SEMESTER THEORY EXAMINATION, 2017-18
SURVEYING

Time : 3 Hours **Max. Marks : 70**

Note : Attempt **all** sections. If required any missing data; then choose suitably.

SECTION – A

1. Attempt **all** questions in brief. **(2 × 7 = 14)**

a. What are the initial and final sub-cords ?
Ans. This question is out of syllabus from session 2019-20.

b. What is a 12 cm compass ?
Ans. Refer Q. 1.28, 2 Marks Questions, Page SQ–5B, Unit-1.

c. In a map, it is found that two consecutive contours cross each other. What would you comment.
Ans. Refer Q. 1.29, 2 Marks Questions, Page SQ–5B, Unit-1.

d. How is a chain folded and unfolded ?
Ans. This question is out of syllabus from session 2019-20.

e. What do you mean by normal tension ?
Ans. This question is out of syllabus from session 2019-20.

f. What is index sketch ?
Ans. Refer Q. 1.27, 2 Marks Questions, Page SQ–5B, Unit-1.

g. What is an azimuth ?
Ans. Refer Q. 1.25, 2 Marks Questions, Page SQ–5B, Unit-1.

SECTION-B

2. Attempt any **three** of the following : **(7 × 3 = 21)**

a. Classify surveying on the basis of instruments used and name all equipments necessary for the field work involving any one of them.
Ans. Refer Q. 1.2, Page 1–3B, Unit-1.

b. Explain how details can be surveyed by offset from survey lines. Discuss the relative merits of different types of offsets. Why are short offsets preferred to long ones ?
Ans. This question is out of syllabus from session 2019-20.

c. The staff readings for a survey work were as follows : 1.810, 2.110, 1.225, 1.455, 0.905, 2.435, 2.810, 2.675 and 1.765. The level was shifted after the 4th and 7th readings. The first reading was taken on a bench mark of RL 50.000 rule out a page of level book and enter the readings :
i. work out the RLs of all stations.
ii. If the staff were held invert and readings on a ceiling from last instrument position was 3.500, Find the RL of the ceiling.
iii. Work out the staff readings on the top of 4 pegs at 20 m intervals from the last station to give an upgrade of 1 in 100.
Ans. Refer Q. 1.20, Page 1–22B, Unit-1.

d. What is Shift ? Prove that a transition curve bisects the shift and that the shift bisects the transition curve.
Ans. Refer Q. 2.12, Page 2–18B, Unit-2.

e. Why is a curve provided ? Derive an expression for an ideal transition curve.
Ans. **Necessity :** Refer Q. 2.1, Page 2–2B, Unit-2.
Derivation : Refer Q. 2.13, Page 2–21B, Unit-2.

SECTION-C

3. Attempt any **one** part of the following : **(7 × 1 = 10)**

a. A steel tape was exactly 30 m long at 20 °C when supported throughout its length under a pull of 10 kg. A line measured with this tape under a pull of 15 kg and at a mean temperature of 32 °C and found to be 780 m long. Cross-section area of the tape = 0.03 cm², and its total weight = 0.693 kg. α for steel = 11 × 10⁻⁶ per °C and *E* for the steel = 2.1 × 10⁶ kg/cm².
Ans. This question is out of syllabus from session 2019-20.

b. What are the sources of error in chaining ? What precautions would you take to guard against them ?
Ans. This question is out of syllabus from session 2019-20.

4. Attempt any **one** part of the following : **(7 × 1 = 7)**

a. The following are the observed fore and back bearings of lines of a closed traverse. Correct them where necessary for local attraction.

Line	FB	BB
AB	292° 15′	11°45′
BC	221°45′	41°45′
CD	90°05′	270°00′
DE	80°35′	261°40′
EA	37°00′	216°30′

Ans. This question is out of syllabus from session 2019-20.

b. What do you understand by balancing the traverse ? Describe any three methods of adjusting traverse.

Ans. This question is out of syllabus from session 2019-20.

5. Attempt any one part of the following : (7 × 1 = 7)

a. What is orientation ? What are the methods of orientation ? Describe the methods with sketch.

Ans. **Orientation :** Refer Q. 1.31, Page 1–35B, Unit-1.
Methods : Refer Q. 1.32, Page 1–35B, Unit-1.

b. What do you mean by contour ? Describe the characteristics of contour. State the uses of contour map and contours.

Ans. **Contour and Characteristics :** Refer Q. 1.36, Page 1–41B, Unit-1.
Uses : Refer Q. 1.38, Page 1–44B, Unit-1.

6. Attempt any one part of the following : (7 × 1 = 10)

a. What does the term 'sensitiveness' mean in the context of a bubble ? How the sensitiveness of a bubble is determined ?

Ans. Refer Q. 1.15, Page 1–17B, Unit-1.

b. What do you mean by traversing ? Describe various methods of traversing.

Ans. This question is out of syllabus from session 2019-20.

7. Attempt any one part of the following : (7 × 1 = 10)

a. Two straight intersect at angle of 122°. The maximum allowable speed of the vehicle on the curve is 80 km/hr, centrifugal ratio is ¼ and the rate of change of radial acceleration is 30 cm/sec². Calculate the radius of the circular curve and the length of the transition curve.

Ans. Refer Q. 2.14, Page 2–24B, Unit-2.

b. What is the necessity of transition curve ? Describe the different method of finding out its length.

Ans. **Necessity :** Refer Q. 2.11, Page 2–17B, Unit-2.
Method : Refer Q. 2.12, Page 2–18B, Unit-2.

☺☺☺

B. Tech.
(SEM. III) ODD SEMESTER THEORY EXAMINATION, 2018-19
SURVEYING

Time : 3 Hours **Max. Marks : 70**

Note : Attempt all sections. If require any missing data; then choose suitably.

SECTION-A

1. Attempt all parts. Each part carries equal marks : (7 × 2 = 14)

a. How will you identify a ridge line and a valley line in a contour map ?

Ans. Refer Q. 1.30, 2 Marks Questions, Page SQ–5B, Unit-1.

b. Define local attraction. How will you detect local attraction at a station ?

Ans. Refer Q. 1.11, 2 Marks Questions, Page SQ–2B, Unit-1.

c. What is the difference between accuracy and precision ?

Ans. Refer Q. 1.31, 2 Marks Questions, Page SQ–5B, Unit-1.

d. Define a well-conditioned triangle.

Ans. Refer Q. 1.32, 2 Marks Questions, Page SQ–6B, Unit-1.

e. What are the principles of surveying ? Explain each in brief.

Ans. Refer Q. 1.5, Page 1–6B, Unit-1.

f. What are the various types of meridians ?

Ans. Refer Q. 1.33, 2 Marks Questions, Page SQ–6B, Unit-1.

g. Explain under which conditions tacheometric surveying is advantageous.

Ans. Refer Q. 1.34, 2 Marks Questions, Page SQ–6B, Unit-1.

SECTION-B

2. Attempt any three questions : (7 × 3 = 21)

a. The tacheometer is set up at an intermediate point on a traverse line PQ and the following observations are made on a vertically held staff :

Staff Station	Vertical Angle	Staff Intercept (m)	Axial Hair Readings (m)
P	+8° 36′	2.350	2.105
Q	+6° 6′	2.055	1.895

The instrument is fitted with an analytical lens and the constant is 100. Compute the length of PQ and reduce level of Q. The reduce level of P is 321.50 m.

Ans. This question is out of syllabus from session 2019-20.

b. A 30 m long tape was standardized at 20 °C and under a pull of 100 N. The tape was used to measure the distance AB when the temperature was 45 °C and the pull was 150 N. The tape was supported at the ends only. Find the corrections per tape length if the cross section of the tape was 4 mm^2, the unit weight of the tape material is 0.0786 N/mm^3, and the coefficient of thermal expansion of the tape material is 11.5×10^{-6} / °C. $E = 2{,}000{,}000$ kN/m^2.

Ans. Refer Q. 1.56, Page 1–62B, Unit-1.

c. The following data refer to a closed traverse ABCDE. Find the lengths of the side DE and EA.

Line	Length (m)	Bearing
AB	778.50	77° 30′
BC	649.00	337°30′
CD	660.50	284°48′
DE	?	231°06′
EA	?	135°40′

Ans. This question is out of syllabus from session 2019-20.

d. The following successive staff readings were taken with a level using 5 m levelling staff on a continuously sloping ground at an interval of 25 m :
0.405, 1.035, 1.930, 2.895, 3.805, 4.760, 0.715, 2.060, 3.160, 4.415
The reduce level of the first point is known to be 62.980 m. Workout the staff reading by height of instrument method and find the gradient of the line joining the first and the last points.

Ans. Refer Q. 1.21, Page 1–24B, Unit-1.

e. Two straight lines AC and CB intersect at C, at a chainage of 86.22 chains at a deflection angle of 62°. These lines are

to be smoothly connected by a simple curve of radius 12 chains. Find the tangent length, length of the curve and the chainages of the starting and end points of the curve. Find also the length of the long chord.

Ans. Refer Q. 2.21, Page 2–29B, Unit-2.

SECTION-C

3. Attempt any one of the following : (7 × 1 = 7)

a. Explain the process of repetition and reiteration in theodolite survey.

Ans. Refer Q. 1.48, Page 1–53B, Unit-1.

b. Differentiate between prismatic and surveyors compass.

Ans. Refer Q. 1.13, Page 1–16B, Unit-1.

4. Attempt any one of the following : (7 × 1 = 7)

a. What is the principle of stadia method ? Derive the distance and elevation formula when the staff is held vertically and is inclined to the line of sight.

Ans. This question is out of syllabus from session 2019-20.

b. What do you understand by balancing the traverse ? Describe any three methods of adjusting a traverse.

Ans. This question is out of syllabus from session 2019-20.

5. Attempt any one of the following : (7 × 1 = 7)

a. Explain the characteristics of contours. What are the various applications of a contour map ?

Ans. **Characteristics :** Refer Q. 1.36, Page 1–41B, Unit-1.
Application : Refer Q. 1.38, Page 1–44B, Unit-1.

b. What are the curvature and refraction errors in levelling ? An observer on the deck sees a light house which is 40 m above the sea level. The position of the observer's eye is 6.50 m above sea level. Determine the distance of the light house from the observer.

Ans. Refer Q. 1.26, Page 1–30B, Unit-1.

6. Attempt any one of the following : (7 × 1 = 7)

a. What are the various checks for a closed traverse ? Explain the various methods of traversing.

Ans. This question is out of syllabus from session 2019-20.

b. What do you mean by satellite station and reduction to center ? Derive expression for reducing the angles measured at the satellite stations to center.

Ans. Refer Q. 1.53, Page 1–59B, Unit-1.

7. Attempt any one of the following : **(7 × 1 = 7)**

a. Explain the various types of circular curves. Derive the expression for setting out simple circular curve by offsets from the long chord.

Ans. **Types :** Refer Q. 2.1, Page 2–2B, Unit-2.
Expression : Refer Q. 2.4, Page 2–6B, Unit-2.

b. Explain the requirements of a transition curve. Derive the expression for an ideal transition curve.

Ans. **Requirements :** Refer Q. 2.11, Page 2–17B, Unit-2.
Expression : Refer Q. 2.13, Page 2–21B, Unit-2.

☺☺☺

B. Tech.
(SEM. III) ODD SEMESTER THEORY EXAMINATION, 2019-20
SURVEYING AND GEOMATICS

Time : 3 Hours **Max. Marks : 100**

Note : 1. Attempt **all** sections. If require any missing data; then choose suitably.

Section-A

1. Attempt all questions in brief : **(2 × 10 = 20)**

a. Define surveying and list its principles.

Ans. **Surveying :** Refer Q. 1.1, Page 1–3B, Unit-1.
Principle : Refer Q. 1.2, 2 Marks Questions, Page SQ–1B, Unit-1.

b. Differentiate between WCB and QB system of bearings.

Ans.

S. No.	Whole Circle Bearing	Reduced Bearing
1.	In this system, the magnetic bearing of line is measured clockwise from the north point upto the line.	In this system, the bearing is measured clockwise or anticlockwise from the north or south towards the east or west.
2.	The values of WCB may lie between 0° and 360°.	The values of RB may lie between 0° and 90°.
3.	**For example :** WCB of line OA = 210°.	**For example :** RB of line OA = S 30° W.

c. Calculate the true bearing of a line for which magnetic bearing is 46° 34' and declination is 5° 38' East.

Ans.

Given : Magnetic bearing = 46°34', Declination = 5°38' E
To Find : True bearing.

We know that,
True bearing = Magnetic bearing ± Declination
= 46°34' + 5°38' = 52°12'

d. What do you understand by term degree of a curve ?

Ans. Refer Q. 2.1, 2 Marks Questions, Page SQ–7B, Unit-2.

e. Differentiate between almanac and ephemeris data.

Ans:

S. No.	Almanac Data	Ephemeris Data
1.	It contains orbital information and status of visible satellites.	It contains the precise orbital information of its own.
2.	Almanac data are not very precise and are considered valid for upto several hours.	Ephemeris data are very precise.
3.	The almanac data is periodically updated with the new information as the satellites moves around.	Ephemeris data are updated to the satellites in every two hours for GPS.

f. How many minimum numbers of satellites are required to obtain a position of a point on earth ?

Ans: Four satellites required to obtain a position of a point on earth.

g. What do you understand by the term photogrammetry ?

Ans: Photogrammetric surveying or photogrammetry is the science and art of obtaining accurate measurements by use of photographs.

h. Differentiate between principal point and nadir point.

Ans:

Principal Point	Nadir Point
It is a point on the photo where a perpendicular from the front nodal point of the camera lens strikes the photographic plane. On photo it is called 'photo principal point' (p). It is considered to be the origin of photo co-ordinate system.	The point, where the plumb line *i.e.*, line of gravity from the optical centre of the camera strikes the photograph, is called the photo nadir point (v) and where it strikes the ground, the ground nadir point (V).

i. What do you understand by image classification ?

Ans: Image classification is sorting pixel into finite number of individual classes based on their DN (Digital Number) values in a spectral band.

j. Differentiate between active and passive sensor.

Ans:

S. No.	Active Sensors	Passive Sensors
i.	Sensors which produce their own electromagnetic energy of specific wavelength.	Sensors which do not produce their own electromagnetic energy but sense natural radiations are passive sensors.
ii.	**Example :** Flash photography, radar, etc.	**Example :** Available light photography sensing during bright sunlight.

Section-B

2. Attempt any three of the following : (10 × 3 = 30)

a. The following bearings were observed while traversing with a compass.

Line	FB	BB
PQ	45°45′	226°10′
QR	96°55′	277°5′
RS	29°45′	209°10′
ST	324°48′	144°48′

Determine the corrected bearings.

Ans:

Given : Fore bearing and back bearing of lines give in table.
To Find : Corrected bearings.

1. On inspection we find that the fore and back bearings of line *ST* differ exactly by 180°. Hence, station *S* and *T* are free from local attraction. Hence, back bearing of *RS* is accepted to be correct.
2. **Correction in Bearings :**

BB of *RS* = 209° 10′
Subtract = 180°

Corrected FB of *RS* = 29° 10′
But observed FB of *RS* = 29° 45′

Difference = 0° 35′, the error at *R*

As the observed FB of *RS* is more than the corrected one therefore, the error at *R* is +ve and the correction is –ve.

Observed BB of QR = 277° 5′
Correction at *R* = – 0° 35′

Corrected BB of QR = 276° 30′
Subtract = 180°

Corrected FB of QR = 96° 30′
But observed FB of QR = 96° 55′

Difference = 0° 35′, the error at Q

The error is + ve, therefore correction at Q must be –ve

Observed BB of QR = 226° 10′
Correction at Q = – 0° 25

Corrected BB of PQ = 225° 45′
Subtract = 180°

Corrected FB of PQ = 45° 45′
Observed FB of PQ = 45° 45′

So, P is free from local attraction.

3. **Corrected Bearings :**

Line	FB	BB
PQ	45°45′	225°45′
QR	96°30′	276° 30′
RS	29°10′	209°10′
ST	324°48′	144°48′

b. Define the term vertical curve and explain its various types with help of neat sketch.

Ans: Refer Q. 2.15, Page 2–25B, Unit-2.

c. What are object and field based models ? Differentiate between vector and raster data formats.

Ans: **Object and Field Based Models :** Refer Q. 3.18, Page 3–20B, Unit-3.
Difference : Refer Q. 3.19, Page 3–21B, Unit-3.

d. Describe the function of different parts of an aerial camera with the help of a neat sketch. Also differentiate between angle of tilt and angle of swing.

Ans: **Function :** Refer Q. 4.5, Page 4–5B, Unit-4
Difference :

Angle of Tilt	Angle of Swing
It is a vertical angle obtained by the intersection of the optical axis with the plumb line at the exposure station. It lies in the principal plane.	It is the horizontal angle measured clockwise in the plane of the photograph from the positive direction of Y-axis to the photo nadir point.

e. What is an idealized remote sensing system ? Discuss the role of EM energy involved in it.

Ans: **Idealized Remote Sensing System :** Refer Q. 5.4, Page 5–5B, Unit-5.
Role of EM Energy :

1. The carrier of information in remote sensing is electromagnetic energy.
2. It is a form of energy which moves with the velocity of light (3×10^8 m/s) in a harmonic pattern consisting of sinusoidal waves.
3. Visible light is a particular range of electromagnetic radiation. Some of the other familiar forms are radio waves, ultraviolet rays, X-rays and heat.
4. Remote sensing makes use of electromagnetic radiation which is not visible to the human eye; it can supply information during night also.
5. This radiation can be detected only when it interacts with matter whereby a change in the electromagnetic energy takes place, which is detected by remote sensing.
6. The data obtained is used for the determination of the characteristics of the objects.

Section-C

3. Attempt any **one** of the following : **(10 × 1 = 10)**

a. Describe the process of contouring and state the characteristics and methods of locating the contours.

Ans: **Process :**

1. The process of finding the elevation and tracing contour lines is called contouring.
2. The paper on which the contour lines are drawn are called contour maps. Thus, a contour map of an area gives an idea of altitudes or reduced levels of the ground surface and their relative positions in plan.
3. Besides, the general idea of surface elevation of a plot of land, it is necessary to conduct levelling first on the plot of land, at different points.
4. Reduced levels of the points are plotted, and then joined with the point of equal reduced levels or elevations by lines to get the contour lines.
5. Thus, contouring are very important and are always associated in any construction projects.

Characteristics : Refer Q. 1.36, Page 1–41B, Unit-1.
Methods : Refer Q. 1.37, Page 1–42B, Unit-1.

b. The top (B) of a tower was sighted from two stations A and C at different levels, the station A and B being in line with top of tower. The angle of elevation from A to the top of tower is 48°31′ and that from C to the top of tower was 31°28′.

The angle of elevation from C to a vane 2 m above the foot of staff held at A was 25°21′. The heights of the instrument at A and C were 2.87 m and 2.64 m respectively. The horizontal distance between A and C were 2.87 m and 2.64 m respectively. The horizontal distance between A and C was 137 m and the reduced level of C was 122.78 m. Calculate the RL of the top of the tower and the horizontal distance from A to the tower.

Ans.

Given : Horizontal distance = 137 m, RL of station C = 122.78 m, Height of instrument at A and C = 2.87 m and 2.64 m, Angle of elevation from A = 48°31′. Angle of elevation from C = 31°28′, Height of vane = 2 m, Angle of elevation of vane = 25°21′
To Find : RL of the top of the tower and horizontal distance between A and tower.

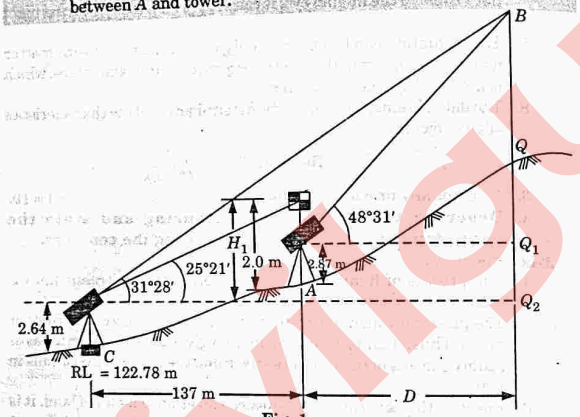


Fig. 1.

1. RL of C = 122.78 m
2. RL of A = RL of C + 2.64 + H_1 – 2
   H_1 = 137 × tan 25°21′ = 64.906 m
3. RL of A = 122.78 + 2.64 + 64.906 – 2.0 = 188.326 m
4. RL of instrument axis at A = 188.326 + 2.87 = 191.196 m
5. RL of instrument axis at C = 122.78 + 2.64 = 125.42 m
6. Difference in level Q_1 and Q_2 between the two instrument axes,
   Q_1Q_2 = 191.196 – 125.42 = 65.776 m
7. Now, $BQ_1 = D \times \tan 48°31'$
   and $BQ_2 = (137 + D) \times \tan 31°28'$
8. But, $Q_1Q_2 = BQ_2 - BQ_1$
   $65.776 = (137 + D) \times \tan 31°28' - D \times \tan 48°31'$

$$D = \frac{137 \times \tan 31°28' - 65.776}{\tan 48°31' - \tan 31°28'} = 34.82 \text{ m}$$

9. Thus, $BQ_1 = 34.82 \times \tan 48°31' = 39.38$
   RL of B = Height of instrument axis at $A + BQ_1$
   = 191.196 + 39.38 m = 230.576 m

4. Attempt any **one** of the following : **(10 × 1 = 10)**

a. Enlist various linear methods of setting out simple circular curve and describe any one of them in detail.

Ans. Refer Q. 2.4, Page 2–6B, Unit-2.

b. Explain the necessity of transition curve and derive the intrinsic equation for ideal transition curve.

Ans. **Necessity :** Refer Q. 2.11, Page 2–17B, Unit-2.
Intrinsic Equation : Refer Q. 2.13, Page 2–21B, Unit-2.

5. Attempt any **one** of the following : **(10 × 1 = 10)**

a. Describe the different methods of measuring distance and state the various types of EDM instruments.

Ans. **Methods :** Refer Q. 3.1, Page 3–2B, Unit-3.
Types of EDM : Refer Q. 3.2, Page 3–2B, Unit-3.

b. What is a GPS ? Explain the different sources of errors in GPS.

Ans. **GPS :** Refer Q. 3.7, Page 3–6B, Unit-3.
Sources of Errors : Refer Q. 3.12, Page 3–12B, Unit-3.

6. Attempt any **one** of the following : **(10 × 1 = 10)**

a. Derive an expression to obtain scale of a vertical photograph. A vertical photograph was taken at an altitude of 1000 m above MSL. Determine the scale of photograph for terrain lying at an elevation of 100 m if the focal length of the lens is 20 cm.

Ans. **Expression :** Refer Q. 4.7, Page 4–9B, Unit-4.
Numerical :

Given : Altitude, H = 1000 m, Elevation of terrain, h = 100 m, Focal length, f = 20 cm
To Find : Scale of photograph, S

Scale of photograph is given by,

$$S = \frac{f}{H-h} = \frac{20 \times 10^{-2}}{1000 - 100} = \frac{0.2}{900} = \frac{1}{4500}$$

b. Derive parallax equations for determining elevation and ground coordinates of a point.

Ans: Refer Q. 4.25, Page 4–27B, Unit-4.

7. Attempt any **one** of the following : **(10 × 1 = 10)**

a. Explain different spectral classes. Discuss the process of supervised and unsupervised classification.

Ans: **Spectral Classes :**

1. Spectral classes are groups of pixels that are uniform (or near-similar) with respect to their brightness values in the different spectral channels of the data.
2. Following are the types of spectral classification :

i. **Supervised Classification :** In supervised classification, we first start with specifying an information class on the image. An algorithm is then used to summarize multi-spectral information from the specified areas on the image to form class signatures. This process is called supervised classification.

ii. **Unsupervised Classification :** In the unsupervised case, an algorithm is first applied to the image and some spectral classes (also called clusters) are formed. This process is known as unsupervised classification.

Process : Refer Q. 5.23, Page 5–31B, Unit-5.

b. Explain the process of image enhancement linear and non linear contrast enhancement process.

Ans: **Image Enhancement and Linear Contrast Enhancement Process :** Refer Q. 5.19, Page 5–27B, Unit-5.

Non-Linear Enhancement Process : When the original histogram does not show a uniform distribution, linear contrast enhancement is not appropriate instead non-linear contrast enhancement works better. Histogram equalization method is the most commonly used method in non-linear contrast enhancement.

1. Histogram Equalization Method :

i. In this method, a histogram of any shape is changed to a histogram which has almost equal number of pixels (frequency) along the whole range of DN.

ii. The analyst can also change the number of brightness levels from 8 bit to 7 bit data or vice-versa. Thus in this method, all pixel values will be redistributed.

iii. Contrast will be increased in most populated range (peaks) of the histogram while it will be reduced in less populated (low frequency) range of the histogram.

2. Histogram Normalization or Gaussian Stretch :

i. There is one more method under non-linear contrast enhancement known as histogram normalization or gaussian stretch. In histograms, the frequency of the DN values at their ends is low.

ii. This type of stretch improves the contrast in these ranges of the image while it gets suppressed in the middle grey range of the image.

☺☺☺