UNIT 3

# SURVEYING

"The best preparation for tomorrow is doing your best today."

H. Jackson Brown, Jr.

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## Learning Objectives

At the end of this lesson you shall be able to

- Know the Objectives, Classifications and Uses of surveying
- Understand the purpose of Chain surveying
- State the various instruments used in Chain surveying
- Explain levelling and list the instruments used in levelling
- Know the advancements in Surveying.

## 3.1 Introduction to Surveying

### 3.1.1 Definition

Surveying is an art of determining the relative positions of different points on, above or beneath the surface of the earth by means of direct or indirect measurements of distance, direction and elevation.

### 3.1.2 Divisions of Surveying

Surveying is broadly classified into two primary divisions.

a. Plane surveying

b. Geodetic surveying

#### a. Plane surveying

When the extent of area surveyed is comparatively small, then the effect of curvature is not considered as the surface of the earth is assumed to be flat or plane is called plane surveying.

#### b. Geodetic surveying

When the extent of area surveyed is large or degree of accuracy required is more, then the effect of curvature of earth is taken into consideration and the survey is called geodetic surveying. It is also known as trigonometrical survey. In our country it is carried out by the great trigonometrical department of India.

### 3.1.3 Classification of Surveying

The detailed classification of surveying is shown in the a flow chart below.

**Classification of surveying Based on**

**Nature of field**

1. Land
2. Marine (or) Navigation
3. Astronomical
4. Space

**Object of surveying**

1. Engineering
2. Archaeological
3. Geological
4. Military
5. Mine

**Method of surveying**

1. Triangulation
2. Traverse

**Instruments used**

1. Chain
2. Compass
3. Plane table
4. Level
5. Theodolite
6. Tacheometry
7. Aerial and photography

### 3.1.4 Uses of Surveying

Some of the uses of surveying from engineer's point of view are as follows

1. To know the relative position and shapes of the area to be surveyed (hills, valleys, lakes, rivers, etc.)
2. To establish boundary lines of property.
3. To find the areas of boundary, catchment, ayacut, etc.
4. To calculate the volumes of earthwork in cutting and embankment, capacity of reservoir, etc.
5. To select suitable alignment for engineering woks (roads, railway, canal, bridge, etc.) and to locate the same properly.
6. To determine the suitability of a site for any engineering work
7. To collect data for planning , analysis, design, cost estimation, etc.

8. To execute engineering works for proper management.

## 3.2 Chain Surveying

### 3.2.1 Definition

Chain surveying is the simplest process of measuring distances with a chain. It is also called chaining.

### 3.2.2 Purpose of Chain surveying

1. To secure data necessary for making a plan.
2. To secure data for exact description of boundary of land.
3. To determine the area of land.
4. To divide a piece of land into a number of units.

### 3.2.3 Operations in Chain surveying

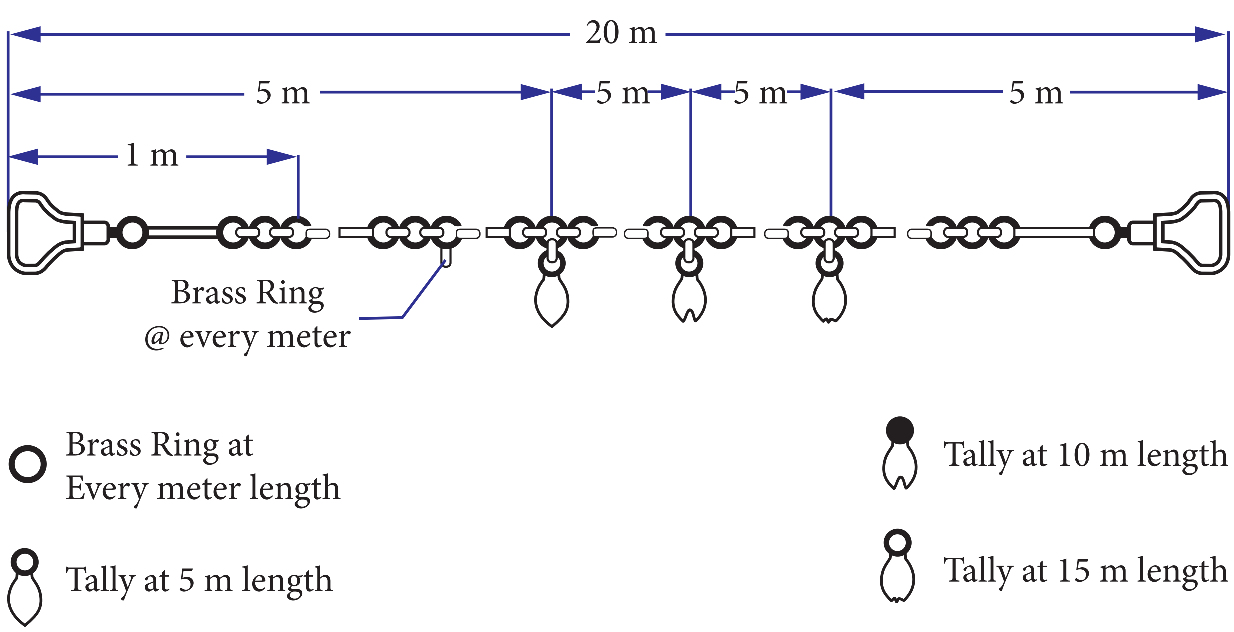
1. Ranging
2. Chaining
3. Offsetting

### 3.2.4 Instruments used in Chain surveying

1. Chain
2. Tape
3. Arrows
4. Pegs
5. Ranging rods
6. Offset rods
7. Plumb bob
8. Cross staff
9. Optical square
10. Field book

**1. Chain**

A chain may metric or non metric. Generally a chain is divided into 100 links or 150 links. The links are made by galvanized iron (or) steel wires of 4 mm to 6 mm diameter. The ends of the links are bent into a loop and connected to a circular or oval rings. The ends of the chain are provided with a swivel jointed brass handle as shown in figure.




Details of metric chain

### Types of chain

**a. Metric chain:** Metric chains of length 5 m, 10 m, 20 m, 30 m are in use. Every metre is divided into 5 links each of length 0.2 m.

The length of the link is the distance between the centre of the two consecutive middle links. Small brass rings are provided at every metre and tallies at every 5 m length.

**b. Non metric chain:** The following are the non – metric chain in which the unit of measurement is in foot.

i. **Engineer's chain:** Engineer's chain is 100 feet long and is divided into 100 links, each link is being one foot long.

ii. **Gunter's chain (or) surveyor's chain:**

Gunter chain is 66 feet long and is divided into 100 links, each link is being 0.66 feet long.

iii. **Revenue chain:** Revenue chain is 33 feet long and is divided into 16 links.

**Note:** The above non – metric chains are not in use nowadays. They have become obsolete.

**c. Steel bands:** It is a steel ribbon with a brass swivel handle at each end. It is 3 to 16 mm wide, 20 to 30 m long and 0.2 to 0.6 mm thick. It is light weight and easy to handle

### 2. Tapes

Tapes are made of different materials.

The following are some of the tapes commonly used:

a. Linen (or) cloth tape
b. Glass fibre tape
c. Metallic tape
d. Steel tape
e. Invar tape

#### Glass fiber tape

It is made of glass fiber and PVC. It is flexible, strong and durable. It does not stretch or shrink due to change in temperature and dampness. It is available in varieties of lengths.

#### Steel tape

It is made of steel (or) stainless steel and used for accurate measurements. It is available in lengths of 5 m, 10 m, 20 m and 50 m.

**DO YOU KNOW?**

Stephen Crane is the Inventor of digital tape.

### 3. Arrows

These are made of hardened and tempered steel wires of 4 mm diameter and length of 400 mm. These are pointed at one end and other end is bent to a circle of diameter 50 mm.

Arrows are used to mark the points on the ground or end of chain lengths and to note the number of chains measured during the chaining process.

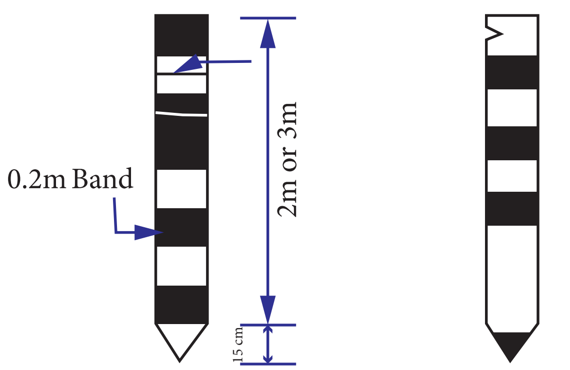
**4. Pegs**

Pegs are made of wood. These are 25 mm square and 150 mm long, tapered at one end. It is used to mark the survey stations by driving it into the ground. Iron or steel pegs of 12 mm diameter can also be used as pegs.

**5. Ranging Rods**

Ranging rods are made of well seasoned, straight grained timber or steel tubular rods.

These are circular (or) octagonal in cross section of 25 mm diameter and 2 m or 3 m long. The bottom end is tapered and fitted with a metal shoe to insert it into the ground. They are painted with alternate bands of red and white (0.2 m band length). A flag can also be attached to the top of the ranging rod.




Ranging rod offset rod

Ranging rod are used to locate the survey stations and to range the survey lines.

**6. Offset rods**

It is similar to ranging rod. It is provided with a recessed hook for pulling the chain through any obstruction.

It can be used for locating stations and ranging the lines.

**7. Plumb-bob**

It is made of steel in conical shape with a thread connected at the centre. Generally it is used for centering a station point.

While measuring distances on the sloping ground, it is used to transfer the point to the ground by suspending the plumb bob.

Plumb-bob

**8. Cross Staff**

Cross staff is used for

i. Establishing perpendicular offset from a given point to a line

ii. Setting out a right angle at a given point on a line

The two forms of cross staff commonly used are:

a. Open cross staff

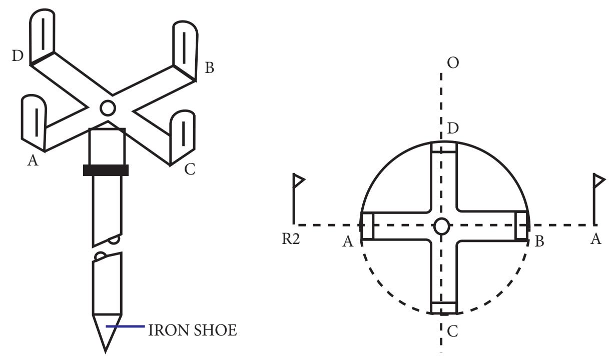
b. French cross staff

**a. Open cross staff**

It consists of two pairs of vertical slits providing two lines of sight mutually at right angles. Each pair consists of two vanes, one is eye vane and the other is objective vane.

**b. French cross staff**

It consists of an octagonal brass tube with slits on all eight sides. It has an alternate vertical slit and an opposite vertical window, with a vertical cross hair on each of the four sides. These are used for setting out right angles.




Open cross staff

French cross staff

## Activity 1

Collect pictures of various chain surveying instruments and prepare an album.

### 9. Optical Square

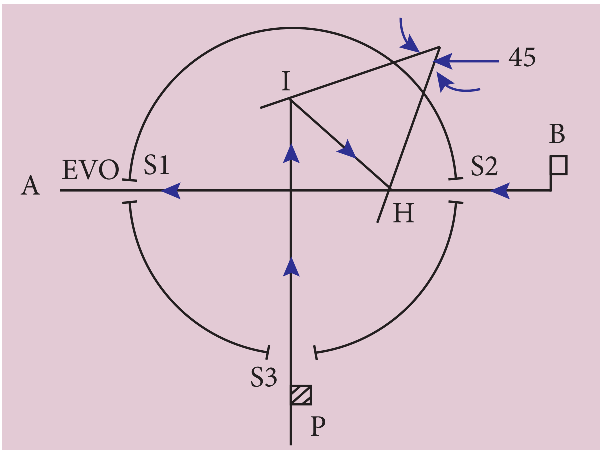
Optical square is an instrument used to construct perpendicular to a chain line.

It is circular in shape of 50 mm radius and 125 mm height. It has a sliding lid which cover the instrument when it is not in use.

As shown in figure, there are two reflecting mirrors H and I fixed at an angle of $45^0$ to each other. The mirror H is half silvered and the mirror I is completely silvered. The three slits in the instrument are $S_1$ for eye sight $S_2$ is horizontal sight for ranging the station and $S_3$ is the index sight perpendicular to slits $S_1$ and $S_2$

The image of the ranging rod fixed at 'p' falls in the mirror I and gets reflected to the silvered portion of mirror H and reaches eye of the observer.

The ranging rod B can be viewed by the observer directly through the unsilvered portion of the mirror H. The ranging rod at 'P' is adjusted until the images of these two ranging rods coincide. Now the perpendicular is set for the chain line.




Optical Square

## 3.2.5 Ranging

The process of establishing intermediate points on a straight line between terminal points is known as ranging.

If the line is short (or) end of the station is clearly visible, it is easy to put the chain in the true alignment. But, if it is long or the end station is not clearly visible, it is necessary to place intermediate ranging rods to maintain the direction. It may be done by eye (or) instrumentally by using a line ranger.

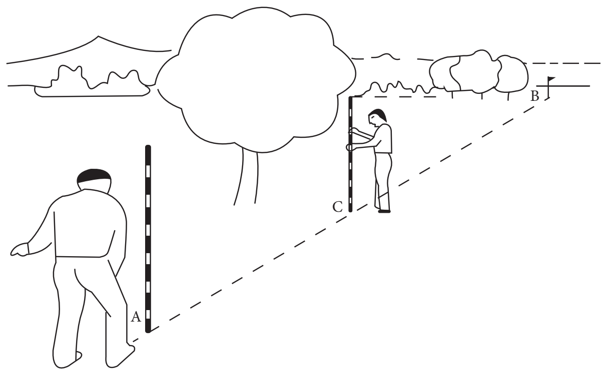
## Types of ranging

Ranging is of two types namely,

1. Direct ranging
2. Indirect ranging

### 1. Direct ranging:

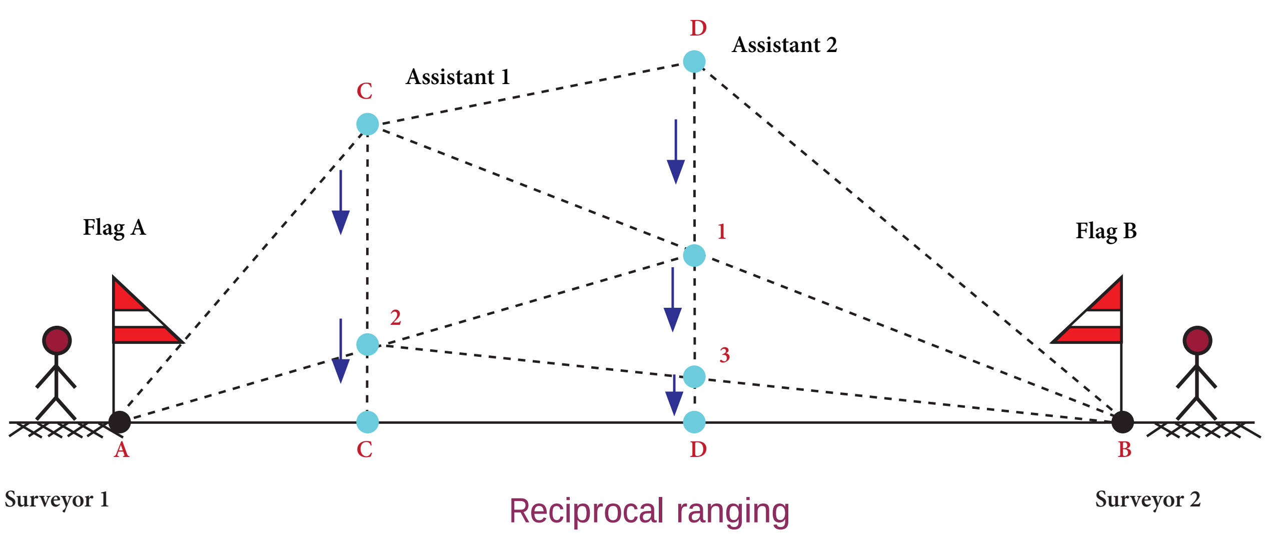
When the intermediate ranging rods are placed in line by direct observation then it is called Direct ranging. It is possible only when the end stations are mutually intervisible.




Direct ranging

### 2. Indirect ranging

When the end stations of survey line are not mutually intervisible then it is called indirect ranging. It may be due to an intervening hill or a valley or an obstacle such as tall building or a thick wooded forest, etc. It is also called as Reciporcal ranging.




Reciprocal ranging

**DO YOU KNOW?**

### Microwave Instruments - Distance measurer

These instruments make use of high frequency radio waves. These instruments were invented as early as 1950 in South Africa by Dr. T. L. Wadley. The range of these instruments is up to 100 km and can be used both during day and night. It is used in surveying to measure the distances. E.g. Tellurometer

### 3.2.6 Obstacles in chain surveying

Obstacles prevent direct measurement of distances between the points and pose problems. Hence the distances are to be found by indirect measurement.

There are three types of obstacles

1. Obstacles to ranging
2. Obstacles to chaining
3. Obstacles to both ranging and chaining

**1. Obstacles to ranging**

This type of obstacle in which the ends are not intervisible, but the distance between the points can be measured.

Example: rising ground, hill, wooded forest.

**2. Obstacles to chaining**

In this method chaining is obstructed but the two end points are intervisible. Obstacles to chaining are pond, river, lake and plantations.

There are two cases of this obstacle.

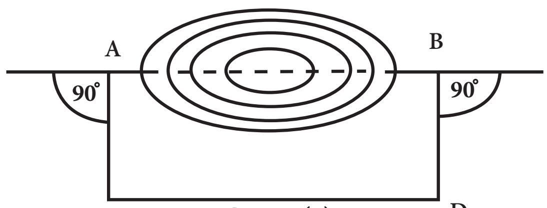
i. When it is possible to chain round the obstacle.

ii. When it is not possible to chain round the obstacle.

**Case (i) When it is possible to chain round the obstacle.**

In obstacles to chaining like lake, pond, hedge, etc.

1. Select two points in A & B on either side of the obstacle.
2. Erect two perpendiculars AC and BD from stations A and B. ie., AC = BD.
3. Join C and D and measure the distance between them.
4. The distance CD is equal to AB.

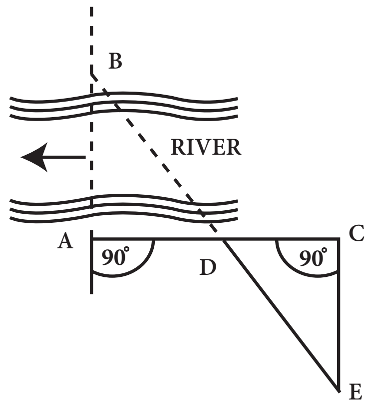



Case (i)

**Case (ii) Impossible to chain round the obstacle**

In obstacles to chaining like river, stream etc.

1. Select two points A and B on either side of the obstacle.
2. Erect perpendicular AC and bisect it at D.
3. Erect perpendicular CE at C and range E in line with BD.
4. Measure CE That is equal to AB (CE=AB)

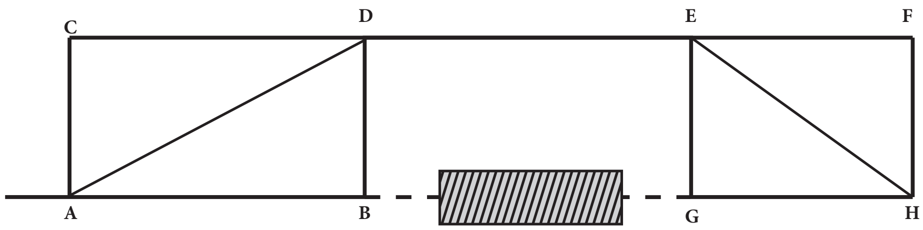



Case (ii)

**3. Obstacles to both chaining and ranging**

In this case, the following procedure is adopted to determine the obstructed distance. A tall building is a typical example.

1. Choose A and B on one side of the obstacle.
2. Erect perpendiculars AC and BD of equal length.
3. Join CD and prolong it to pass through the obstacle.
4. Choose E and F on CD erect the EG and FH equal to that of AC and BD. Join GH and prolong it.




(b)

Obstacles to both chaining and ranging

5. Measure DE. That is the obstructed distance between BG. (DE=BG)

### 3.2.7 Errors in chaining

The common types of errors are:

1. Mistakes
2. Compensating errors (or) accidental errors (or) random errors
3. Cumulative errors (or) systematic errors

1. **Mistakes**

Mistakes occur due to displacement of arrow, miscounting the number of chains, misreading the chain length, erroneous recording, etc.

2. **Compensating errors**

They are liable to occur in either direction and hence tend to compensate. They do not affect results much.

These errors are caused by the following reasons

i. Incorrect holding of the chain
ii. If the fractional part of the chain may not be correct
iii. Tape is not calibrated uniformly throughout its length.

3. **Cumulative errors**

These are the errors which are liable to occur in the same direction and tend to accumulate. Cumulative errors occurred due to

1. Bends in links, knots in links, removal of rings during adjustment of chain.
2. Slope correction is not applied when measuring along sloping ground.
3. Sag correction is not applied when chain is suspended in air
4. Measurements are made along the incorrectly aligned line.

## 3.3 Levelling

### 3.3.1 Definition

Levelling is the art of determining the relative vertical heights of different points on the surface of earth. Hence, in levelling, the measurements are taken only in the vertical plane.

### 3.3.2 Basic terms used in levelling

1. **Level surface**

It is defined as curved surface which is parallel to the mean spheroidal surface of the earth.

2. **Level line**

It is a line lying in the level surface. All points on the level line are at the same elevation.

3. **Horizontal line**

It is a straight line lying in the horizontal plane. It is tangential to the level line and perpendicular to the vertical line at that point.

4. **Horizontal plane**

It is a plane perpendicular to the direction of gravity. It is tangential to the level surface at that point.

5. **Vertical line**

It is a line indicated by a freely suspended plumb bob. It is a line along the direction of gravity.

6. **Vertical plane**

It is a plane containing a vertical line at a point.

7. **Datum surface**

It is any level surface taken as a reference for the determination of elevation of various points. The datum commonly used is Mean Sea Level (MSL).

8. **Mean Sea Level (MSL)**

It is a level surface which represents the average sea water level.

9. **Reduced level**

The vertical distance above (or) below the datum is known as elevation. It's level is called reduced level.

### 3.3.3 Benchmark and its types

Benchmark is defined as a fixed reference point of known elevation. It is denoted by BM

The types of benchmarks are:

1. Great Trignometrical Survey Benchmark (GTS)
2. Permanent Benchmark
3. Temporary Benchmark
4. Arbitrary Benchmark

### 3.3.4 Instruments used in leveling

The instruments used in leveling are

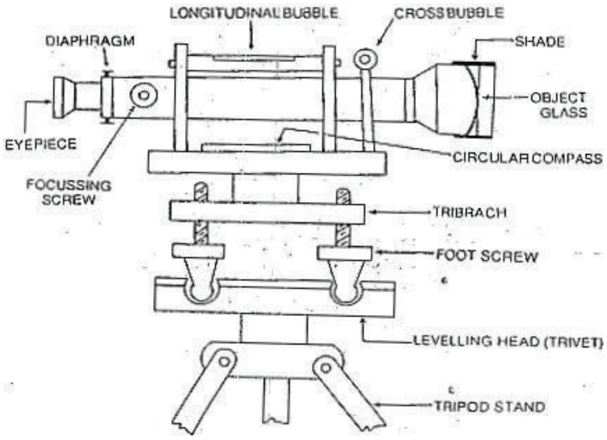
i. Level
ii. Leveling staff

### 3.3.5 Different types of levels

The following are the various types of levels

1. Dumpy level
2. Tilting level
3. Quick setting level
4. Wye or Y level
5. Reversible level
6. Automatic level
7. Laser level

### 3.3.6 Setting up instrument




DUMPY LEVEL

### (i) Adjusting of a level

The types of adjustments to be done in a level are

1. Temporary adjustment
2. Permanent adjustment

1. **Temporary adjustment**

The operations involved in temporary adjustments are

a. Setting up the level
b. Levelling up
c. Elimination of parallax

a. **Setting up the level**

   i. Fixing the instruments on to the tripod.
   ii. Approximately leveling the instrument by leg adjustment.

b. **Levelling up**

The purpose of leveling up is to make the vertical axis truly vertical.

It is done with the help of three foot screws.

1. The bubble tube is kept parallel to any two foot screws. The foot screws are turned both inwards or outwards until the bubble is central.
2. Now the telescope is rotated to 90° so that it lies over the third foot screw.
3. The third screw is turned until the bubble is central.
4. Now, the telescope is rotated back to its old position. The procedure in steps1 to 3 is repeated till the bubble remains central in all position.
5. The bubble should remain central if the instrument is in proper adjustment.

**c. Elimination of parallax**

It is the process of making the image of an object to exactly fall on the plane of crosshairs (diaphragm). Unless parallax is eliminated, accurate sighting is impossible. It consists of focusing the eyepiece and objective of level.

**i. Focusing the eyepiece**

The operation is done to make the crosshairs to appear distinct and clearly visible. The steps involved in this operation are:

1. The telescope is directed towards sky (or) a sheet of white paper is held in front of the objective.
2. The eyepiece is moved in or out till the crosshairs appear distinct.

**ii. Focusing the objective**

The operation is done to bring the image of the object in the plane of cross hairs. The steps involved in this operation are.

i. The telescope is directed towards the staff

ii. The focusing screw is turned until the image appears clear and sharp.

**2. Permanent Adjustment**

These are the adjustments which are made to establish fixed relationships between the fundamental parts or fundamental lines of a leveling instrument.

The fundamental lines of a leveling instrument are:

- Axis of bubble tube
- Axis of telescope
- Line of collimation
- Vertical axis

Permanent adjustments once done may keep the instrument in perfect condition for a long time.

**Activity 2**

Prepare a report about different types of levelling instruments.

### 3.3.7 Levelling staff

Levelling staff is a graduated rod of rectangular cross section. It is used for the measurement of vertical distance between the line of sight and the point on which the staff is held. It is also known as level rod.

The levelling staff is usually made of best quality seasoned teak wood or aluminium channel. The length of levelling staff in common use are 2 m, 3 m, 4 m and 5 m.

Graduations of the staff give the distances from the bottom of the cap. Each meter is divided into 20 divisions. The thickness of each division is 5 mm.

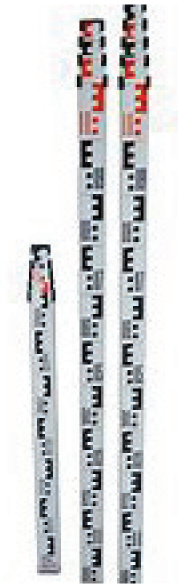
### *(i) Types of levelling staff*

Based on the method of taking reading, the levelling staffs are divided into two types

1. Self reading staff (or) direct reading staff
2. Target staff

**1. Self reading staff**

In this type of staff the observer takes the reading directly on the staff by looking through the telescope.



Self reading staff

Based on the method of construction self reading staffs are further divided into 4 types.

- Solid staff
- Folding staff
- Telescopic staff
- Invar precession staff

**2. Target staff**

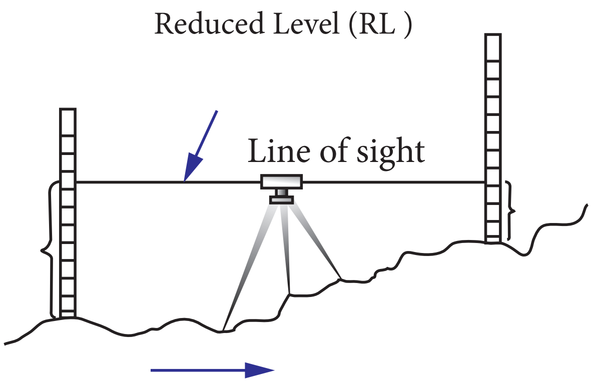
In this type of staff the observer sights the target and directs the staffman to move the target upward (or) downward until it bisects the line of sight exactly.

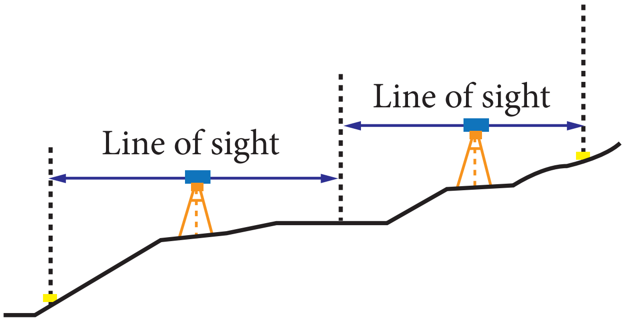
Target levelling staff

### 3.3.8 Reduction of Levels

Reduction of level means reducing the elevation of a point from the observed staff reading. It can be done by two methods

a. Height of collimation method
b. Rise and fall method



**a. Height of collimation method**

**Procedure:**

1. In this method, height of collimation (HC) is calculated for each setting of instrument

   Height of collimation (HC)=RL of BM +Back sight

2. The reduced levels of intermediate points (IS) and foresight sight points (FS) are calculated by using the formula.

   RL = HC – IS (or)

   HC – FS

3. When the instrument is shifted to a new position(C.P), a new height of collimation level is setup and the steps (1) and (2) are repeated

   Note:

   HC=Height of collimation level

   BS = Back sight reading

   IS = Intermediate sight reading

   FS = Foresight reading

   RL=Reduced Level

   BM = Bench mark

   C.P= Change Point

**b. Rise and fall method**

**Procedure:**

1. In this method the difference of level between consecutive points is found by comparing staff readings Rise indicates (+) and fall indicates (-).

   i.e., BS – IS (Or) IS – IS (or) I.S – F.S

2. RL of any point = (RL of preceding point) + Rise (or) - fall

DO YOU KNOW?

**Digital Level**

- They are not popular instead auto levels are more extensively used.
- The Trimble DiNi Digital level: Determine accurate height information 60% faster than with automatic levelling.
- Eliminate errors and reduce rework with digital readings.
- Transfer data to the office easily.
- Measure to a field of just 30 cm.

**Example 1:**

The page of a level book is given below. Calculate the RL of all the points by any one of the methods. Apply usual checks. Assume the RL of BM as 25.000m.

| Station | BS | IS | FS | Remarks |
|---|---|---|---|---|
| A | 1.120 | | | BM |
| B | | 1.650 | | |
| C | | 1.750 | | |
| D | 1.200 | | 2.900 | CP1 |
| E | | 1.660 | | |
| F | | 2.520 | | |
| G | 0.900 | | 3.250 | CP2 |
| H | 1560 | | 2.100 | |
| I | | | 2.200 | |

**Solution**

**Type (I) Height of collimation method**

The observation are tabulated and reduced levels are obtained as follows.

| Station | BS | IS | FS | HC or HI | RL | Remarks |
|---|---|---|---|---|---|---|
| A | 1.120 | | | 26.120 | 25.000 | BM |
| B | | 1.650 | | | 24.470 | |
| C | | 1.750 | | | 24.370 | |
| D | 1.200 | | 2.900 | 24.420 | 23.220 | CP1 |
| E | | 1.660 | | | 22.760 | |
| F | | 2.520 | | | 21.900 | |
| G | 0.900 | | 3.250 | 22.070 | 21.170 | CP2 |
| H | 1.560 | | 2.100 | 21.530 | 19.970 | |
| I | | | 2.200 | | 19.330 | |
| Total | 4.780 | | 10.450 | | | |

**Calculations**

HC for I set up = RL of A + BS of A = 25.000 + 1.120 = 26.120

RL of B = HC for I set up – IS of B = 26.120 - 1.650 = 24.470

RL of C = HC for I set up – IS of C = 26.120 - 1.750 = 24.370

RL of D = HC for I set up – IS of D = 26.120 - 2.900 = 23.220

HC for II set up = RL of D + BS of D = 23.220 + 1.200 = 24.420

RL of E = HC for II set up – IS of E = 24.420 - 1.660 = 22.760

RL of F = HC for II set up – IS of F = 24.420 - 2.520 = 21.900

RL of G = HC for II set up – IS of G = 24.420 - 3.250 = 21.170

HC for III set up = RL of G + BS of G = 21.170 + 0.900 = 22.070
RL of H = HC for III set up – IS of H = 22.070 - 2.100 = 19.970
HC for IV set up = RL of H + BS of H = 19.970 + 1.560 = 21.530
RL of I = HC for IV set up – IS of I = 21.530 - 2.200 = 19.330

**Arithmetic check**

Σ BS ~ Σ FS = first RL ~ last RL
4.780 ~ 10.450 = 25.000 ~ 19.330
5.670 = 5.670

**Hence checked**

**Type (II)Rise and fall method**

| Station | BS | IS | FS | Rise (+) | Fall (–) | RL | Remarks |
|---|---|---|---|---|---|---|---|
| A | 1.120 | | | | | 25.000 | BM |
| B | | 1.650 | | | 0.530 | 24.470 | |
| C | | 1.750 | | | 0.100 | 24.370 | |
| D | 1.200 | | 2.900 | | 1.150 | 23.220 | CP1 |
| E | | 1.660 | | | 0.460 | 22.760 | |
| F | | 2.520 | | | 0.860 | 21.900 | |
| G | 0.900 | | 3.250 | | 0.730 | 21.170 | CP2 |
| H | 1.560 | | 2.100 | | 1.200 | 19.970 | |
| I | | | 2.200 | | 0.640 | 19.330 | |
| Total | 4.780 | | 10.450 | | 5.670 | | |

**Calculation**

1. Level difference between points A and B = 1.120 - 1.650 = -0.530
2. Level difference between points B and C = 1.650 - 1.750 = -0.100
3. Level difference between points C and D = 1.750 – 2.900 = -0.150
4. Level difference between points D and E = 1.200 - 1.660 = -0.460
5. Level difference between points E and F = 1.660 – 2.520 = -0.860
6. Level difference between points F and G = 2.520 – 3.250 = -0.730
7. Level difference between points G and H = 0.900 – 2.100 = -1.200
8. Level difference between points H and I = 1.560 – 2.200 = -0.640

**Arithmetic check**

Σ BS ~ Σ FS = Σ Rise ~ Σ Fall = first RL ~ last RL
4.780 ~ 10.450 = 0 ~ 5.670 =25.000 ~ 19.330
5.670 = 5.670 = 5.670

**Hence checked**

**Example 2:**

The following staff readings were observed successively with a level. The instrument having been moved after the second, fifth and eighth readings.

0.675, 1.230, 0.750, 2.565, 2.225, 1.935, 1.835, 3.220, 3.115 and 2.875. The RL of BM is 100.000 m

Obtain the reduced levels of each point and apply usual check.

Brief explanation for tabulating the readings.

1. The readings are tabulated in their respective method of tabulation.
2. In every setting up of instrument the first reading taken as BS. Last reading taken as FS, and other between readings as IS
3. The instrument is shifted (or) moved after the 2nd , 5th , 8th readings. They are the F. S readings.
4. Therefore 1,3,6.9 are BS readings and the others are IS reading (4,7)
5. Final reading is a FS reading. (10)
6. In two settings with a change point, first set's last reading being FS and second set's first reading being BS. They are entered in a same line for continuity of leveling process.

**Solution**

**(i) Height of collimation method**

| Station | BS | IS | FS | HC or HI | RL | Remarks |
|---|---|---|---|---|---|---|
| A | 0.675 | | | 100.675 | 100.000 | BM |
| B | 0.750 | | 1.230 | 100.195 | 99.445 | $CP_1$ |
| C | | 2.565 | | | 97.630 | |
| D | 1.935 | | 2.225 | 99.905 | 97.970 | $CP_2$ |
| E | | 1.835 | | | 98.070 | |
| F | 3.115 | | 3.220 | 99.880 | 96.685 | $CP_3$ |
| G | | | 2.875 | | 96.925 | |
| Total | 6.475 | | 9.550 | | | |

**Calculations:**

HC for I set up = RL of A + BS of A 100.000 + 0.675 = 100.675

RL of B = HC for I set up – FS of B = 99.445

HC for II set up = RL of B + BS of B = 100.195

RL of C = HC for II set up – FS of C = 97.630

RL of D = HC for II set up - FS of D = 97.970

HC for III set up = RL of D + BS of D = 99.905

RL of E = HC for III set up – FS of E = 98.070

RL of F = HC for III set up – FS of F = 96.685

HC for IV set up = RL of F + BS of F = 99.880

RL of G = HC for IV set up – FS of G = 96.925

**Arithmetic check**

Σ BS ~ Σ FS = first RL ~ last RL

6.475 ~ 9.550 = 100.000 ~ 96.925

3.075 = 3.075

**Hence checked**

**(II) Rise and fall method**

| Station | BS | IS | FS | Rise (+) | Fall (-) | RL | Remarks |
|---|---|---|---|---|---|---|---|
| A | 0.675 | | | | | 100.000 | BM |
| B | 0.750 | | 1.230 | | 0.555 | 99.445 | $CP_1$ |
| C | | 2.565 | | | 1.815 | 97.630 | |
| D | 1.935 | | 2.225 | 0.340 | | 97.970 | $CP_2$ |
| E | | 1.835 | | 0.100 | | 98.070 | |
| F | 3.115 | | 3.220 | | 1.385 | 96.685 | $CP_3$ |
| G | | | 2.875 | 0.240 | | 96.925 | |
| Total | 6.475 | | 9.550 | 0.680 | 3.755 | | |

**Calculation**

**Level difference of station**

Level difference between the stations A and B = 0.675 – 1.230 = - 0.555

Level difference between the stations B and C = 0.750 – 2.565 = - 1.815

Level difference between the stations C and D = 2.565 – 2.225 = - 1.960

Level difference between the stations D and E = 1.935 – 1.835 = + 0.100

Level difference between the stations E and F = 1.835 – 3.220 = - 1.285

Level difference between the stations F and G = 3.115 – 2.875 = + 0.240

**RL of station**

RL of B = RL of A ± level difference of B = 100.00 – 0.555 = 99.445

RL of C = RL of B ± level difference of C = 99.445 – 1.815 = 97.630

RL of D = RL of C ± level difference of D = 97.630 +0.340 = 97.970

RL of E = RL of D ± level difference of E = 97.970 + 0.100 = 98.070

RL of F = RL of E ± level difference of F = 98.070 – 1.385 = 96.685

RL of G = RL of F ± level difference of G = 96.685 + 0.240 = 96.925

**Arithmetic check**

Σ BS ~ Σ FS = Σ Rise ~ Σ fall = first RL ~ last RL

6.475 ~ 9.550 = 0.680 ~ 3.755 = 100.000 ~ 96.925

3.075 = 3.075 = 3.075

**Hence checked**

**Example 3:**

Record the observations in the form of levelling field book and obtain reduced level of each point. Apply usual check.

Reading of inverted staff on a point 'A' whose reduced level 15.995 m is 3.220. Reading of staff on a point 'B' on ground is 0.805. Change the instrument and the reading of staff on point 'B' is again 1.280. Inverted Reading of staff on point C is 3.695.

**Type I: Height of Collimation method**

**Solution:**

The observation are tabulated and reduced levels are calculated as follows.

| Station | BS | IS | FS | HC | RL | Remarks |
|---|---|---|---|---|---|---|
| A | –3.220 | | | 12.775 | 15.995 | BM – 1 |
| B | 1.280 | | 0.805 | 13.250 | 11.970 | CP |
| C | | | –3.695 | | 16.945 | BM – 2 |
| Total | –1.940 | | –2.890 | | | |

(Negative sign indicates inverted staff reading)

**Calculations**

HC for I set up = RL of A + BS of A = 15.995 + (-3.220) = 12.775

RL of B = HC for I set up – FS of B = 12.775 - 0.805 = 11.970

HC for II set up = RL of B + BS of B = 11.970 - 1.280 = 13.250

RL of C = HC for II set up – FS of C = 13.250 – (-3.695) = 16.945

**Arithmetic check**

$\Sigma$ BS ~ $\Sigma$ FS = first RL ~ last RL

1.940 ~ 2.890 = 16.945 ~ 15.995

0.950 = 0.950

**Hence checked**

**Type II Rise and fall method**

| Station | BS | IS | FS | Rise (+) | Fall (–) | RL | RL |
|---|---|---|---|---|---|---|---|
| A | –3.220 | | | | | 15.995 | BM – 1 |
| B | 1.280 | | 0.805 | | 4.025 | 11.970 | CP |
| C | | | –3.695 | 4.975 | | 16.945 | BM – 2 |
| Total | –1.940 | | –2.890 | 4.975 | 4.025 | | |

(Negative sign indicates inverted staff reading)

**Calculations**

Level difference between the stations A and B = –3.220 – 0.805 = –4.025

Level difference between the stations B and C = 1.280 – (-3.695) = 4.975

**Arithmetic check**

Σ BS ~ Σ FS = Σ Rise ~ Σ fall = first RL ~ last RL

1.940 ~ 2.890 = 4.975 ~ 4.025 = 16.945 ~ 15.995

0.950 = 0.950 = 0.950

**Hence checked**

**Problems to solve**

1. The following is the page of field book. Complete the RL of all the points by any one method. Apply usual check.

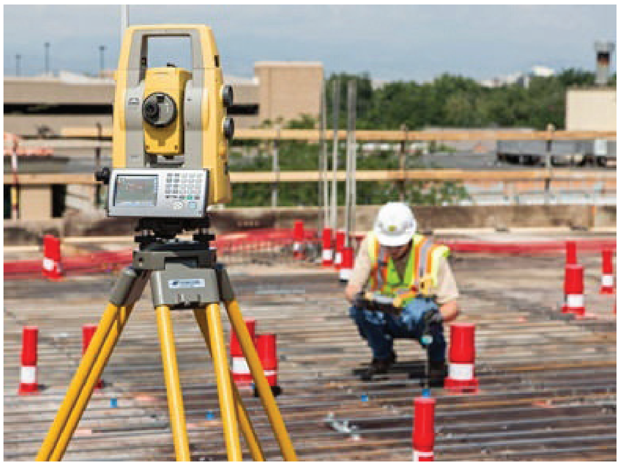
| Station | BS | IS | FS | RL | Remarks |
|---|---|---|---|---|---|
| 1 | 0.250 | | | 105.750 | BM |
| 2 | | 0.465 | | | |
| 3 | 1.750 | | 0.765 | | $CP_1$ |
| 4 | | 1.985 | | | |
| 5 | | 2.530 | | | |
| 6 | | 1.980 | | | |
| 7 | 0.680 | | 0.865 | | $CP_2$ |
| 8 | | | 2.535 | | |

2. Complete in all respects the following page of a field book and apply usual check. Determine the RL of all points by any one method.

| Station | BS | IS | FS | RL | Remarks |
|---|---|---|---|---|---|
| 1 | 3.920 | | | 116.750 | BM |
| 2 | 1.460 | | 7.780 | | $CP_1$ |
| 3 | 7.050 | | 3.270 | | $CP_2$ |
| 4 | | 2.360 | | | |
| 5 | 4.810 | | 0.850 | | $CP_3$ |
| 6 | 8.630 | | 2.970 | | $CP_4$ |
| 7 | 7.020 | | 3.910 | | $CP_5$ |
| 8 | | | 4.280 | | |

3. The following staff readings were observed successively with a level 0.875, 1.235, 2.310, 1.385, 2.930, 3.125, 4.125, 0.120, 1.875, 2.030 m.

The first reading taken on BM is 132.135 m. The instrument has been moved after 2nd , 5th and 8th reading. Enter the readings in a field book form and reduce the RLs. Apply usual checks.



Total Station

## 3.4 Advancements in Surveying

### 3.4.1 Introduction

With advancements in technology, new surveying equipments and techniques are developing. Current advancements are making the science of surveying more valuable, accurate and comprehensive than ever.

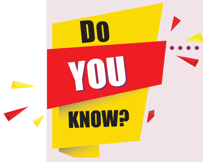
Few advancements in surveying instruments are discussed below

a. Total station
b. Global Positioning system
c. Geographical Information system

### 3.4.2 Total Station (TS)

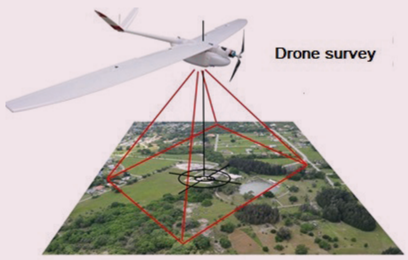
It is used for surveying and building construction. It is an electronic transit instrument integrated with electronic distance measurement(EDM) to measure both vertical and horizontal distance and the slope distance from the instrument to a particular point.

Robotic total stations allow the operator to control the instrument from a distance via remote control. This eliminates the need of an assistant staff member as the operator holds the retro-reflector and control the total station from observed point.




**Drone survey**

Drone surveys are a faster, safer and more cost-efficient way to survey at height. Sometimes referred to as aerial surveys; UAS (Unmanned Aerial System) surveys, or UAV (Unmanned Aerial Vehicle) surveys, drone surveys are more popular method of surveying.



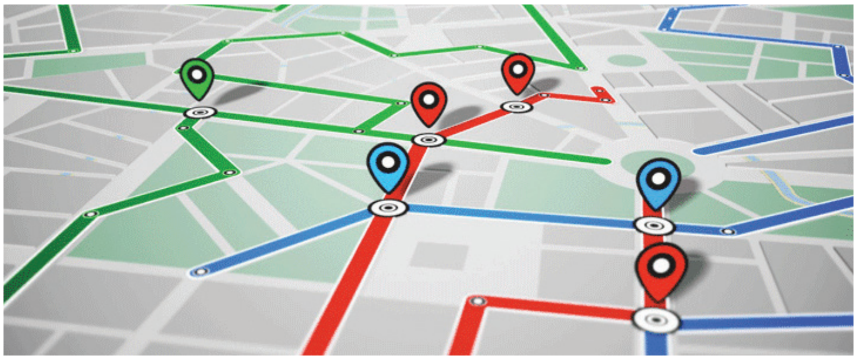
> **Activity 3**
>
> Differentiate total station from other levelling instruments and submit a report.

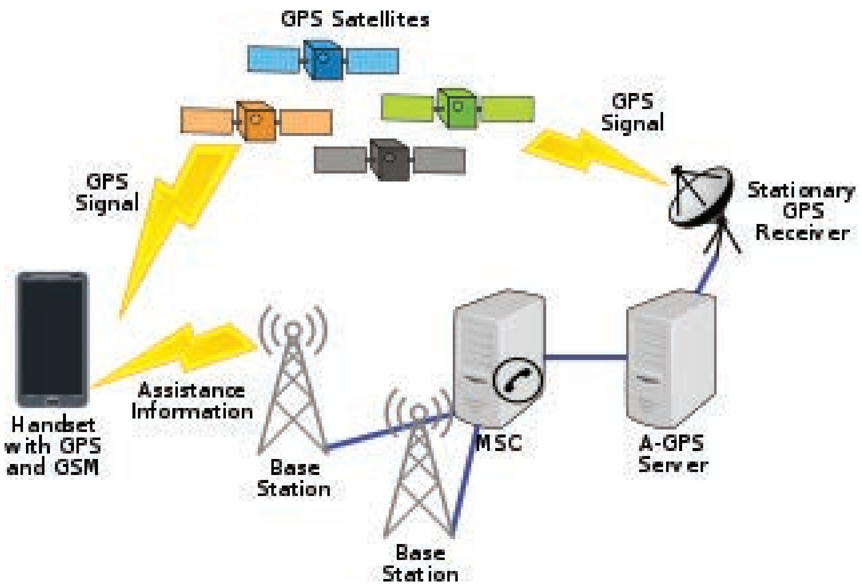
### 3.4.3 Global Positioning System (GPS)

The Global Positioning System (GPS) is a satellite based navigation and surveying system. It is adopted for the determination of precise position and time using radio signals from satellites.

GPS is a U.S space based radio navigation system freely available to all civilian user in all weather conditions, day and night anywhere in the world.

Now a days, GPS is finding its way into cars, boats, planes, construction equipments, farm machinery, cell phones and even in laptop computers.






### Fundamentals of GPS

GPS basically comprised of 3 segments

1. **Control segment:** Control segment consist of one master control station located at Colorado (USA) and five monitor stations located throughout the world.
2. **Space segment:** It consist of group of 24 satellites in 6 orbital planes. 4 satellites in each plane 20.200 km altitude and 55° inclination.
3. **User segment:** It consist of antennas, receiver, processor, display and a regulated DC power supply.

The GPS provides full coverage with minimum of 4 satellites at any place all over the globe. These 4 GPS satellite broadcast signals simultaneously from the space that are picked up and identified by GPS receivers. Each GPS receiver then provides three dimensional location (latitude, longitude and altitude) plus time.

### Uses of GPS

a. **Location** – Determining a basic position

b. **Navigation** – Getting from one location to another

c. **Tracking** – Monitoring the movement of people and things

d. **Mapping** – Creating maps

e. **Timing** – Provides precise timing

### Application of GPS

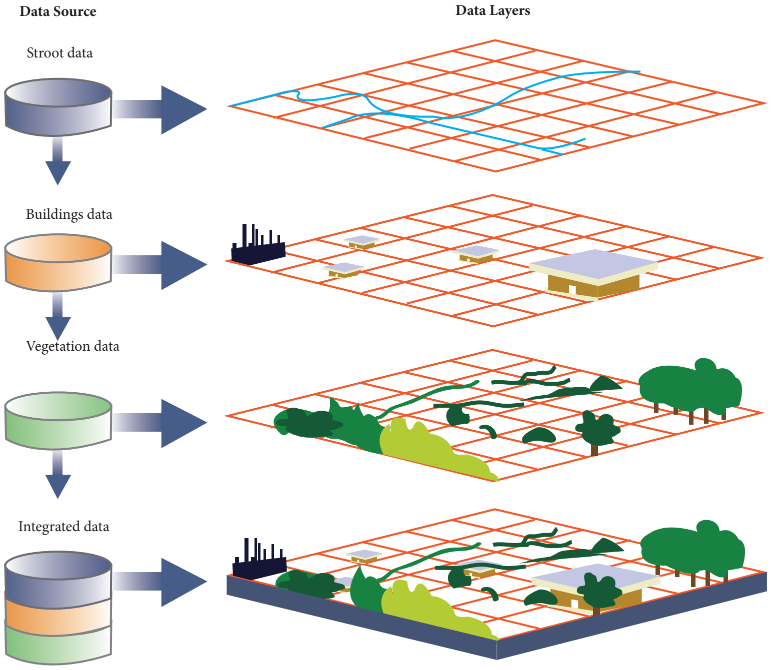
1. Land applications
2. Air applications
3. Marine applications
4. Space applications
5. Military applications

## 3.4.4 Geographic Information system (GIS)

GIS is a system designed to capture, store, manipulate, analyze, manage and present geographic data.

GIS applications are tools that allow users to analyze geographical information, edit data in maps, and present the results of all these operation.

GIS updates geographical data without wasting time to visit the field and update a database manually.




Geographical Information System

# MODEL QUESTIONS

5653PY

## Part - I

**Choose the correct answer** (1 Mark)

1. The determination of the relative positions of the object on the surface by making linear and angular measurement is called ___________.
   a. Measurement
   b. Surveying
   c. Traversing
   d. Levelling
2. The primary object of surveying is to prepare ___________.
   a. data
   b. Longitudinal section
   c. Map
   d. Cross section
3. The geodetic surveying is called _______.
   a. Plane surveying
   b. Trignometrical surveying
   c. Mine surveying
   d. Military surveying
4. The process of measuring distances with a chain is called ___________.
   a. Levelling survey
   b. chain survey
   c. compass survey
   d. plane table survey
5. The distance between the centers of the two consecutive middle links of a metric chain is called ___________.
   a. length of link
   b. length of chain
   c. distance of link
   d. distance of chain
6. The abbreviation of GPS is _________.
   a. Global positioning system
   b. Guide positioning system
   c. Global precise system
   d. Global positioning section
7. The user receiving equipment in a GPS system is called ___________.
   a. GPS receiver
   b. control segment
   c. space segment
   d. user segment

## Part – II

**Answer in one or two sentences** (3 Marks)

1. Define surveying.
2. What do you mean by chaining?
3. Define levelling.
4. Define Mean sea level.
5. Differentiate between level surface and horizontal surface.
6. State the fundamentals of GPS.

## Part – III

**Answer in brief** (5 Marks)

1. Differentiate between geodetic surveying and plane surveying.
2. Describe the different types obstacle in chain surveying.
3. What is a bench mark? List the different types of benchmark.
4. Briefly discuss about total station.

## Part –IV

**Answer in detail** **(10 Marks)**

1. State the main divisions and general classification of surveying.
2. What do you mean by ranging? Explain the types of ranging.
3. Explain with a neat diagram the construction and working of an optical square.
4. Explain the temporary adjustments of a dumpy level.
5. The level readings taken are listed as follows:

   1.430, 2.015, 1.005, 0.400, 3.370, 2.975, 1.415, 0.695

   The instrument is shifted after the 4th and 8th readings. The RL of Ist point is 100.000 m. Enter the reading in a field book form and reduce the RL by HC Method. Apply usual check.
6. The level readings taken are listed below:

   4.390, 7.620, 6.520, 3.910, 5.390, 4.730, 6.290, 3.520, 4.330, 2.990.

   The RL of First point is 200.000 m. The instrument is shifted after 3rd and 8th points. Enter the reading in a field book form and reduce RL by Rise and fall method. Apply usual check.

Answers:

1) b 2) c 3) b 4) b 5) a 6) a 7) a