PART I

Introduction to Surveying

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What is Surveying?

- Surveying is the science and art of determining the relative positions above, on or below the surface of the Earth.
- This relative position can be determined by measuring horizontal distance, vertical distance (elevations), horizontal angles and vertical angles using various surveying instruments.
- The measurements are being taken in field and computations, plans and maps are being prepared in office.

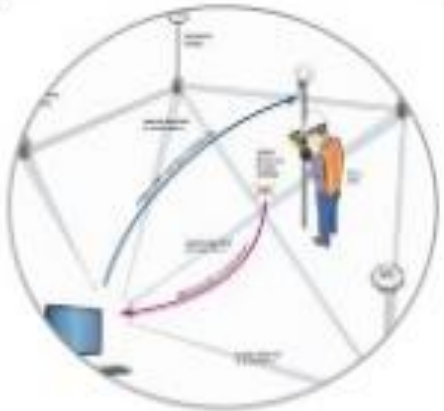
Why it is an art/science?

- Because only a surveyor who possesses through understanding of surveying techniques will be able to determine the most efficient methods required to obtain optimal results over a wide variety of surveying problems.
- Because the use of mathematical techniques to analyze field data, accuracy and reliability depends on understanding scientific principles underlying and affecting survey measurement.

OBJECTS OF SURVEYING

To Prepare a map or plan.

To show the relative position of the objects on the surface of the earth.



To establish the boundaries of the land.

To select a suitable site for an engineering project.

Uses of Surveying

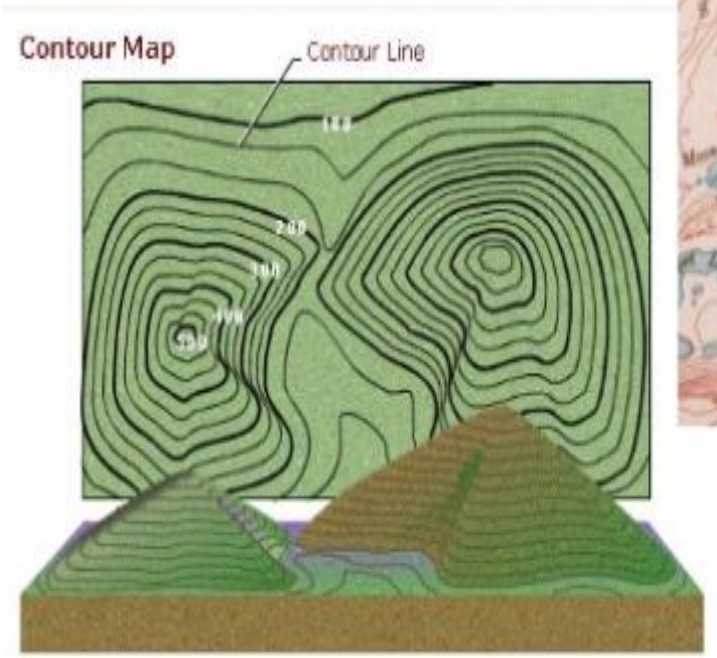
- Topographical map – hills, valley, forests, river etc.
- Cadastral map – boundaries of fields, plot houses etc.
- Engineering map – buildings, canals, roads, railways, dams etc.
- Contour map – to find suitable site for road, bridges, railways etc.
- Military maps
- Geological maps
- Archeological maps

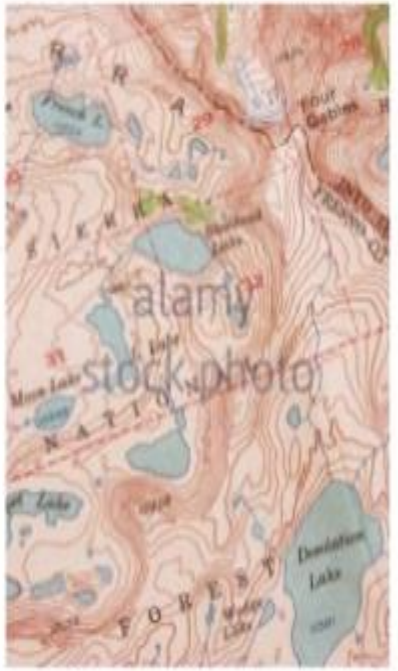
Topographical maps

Cadastral maps

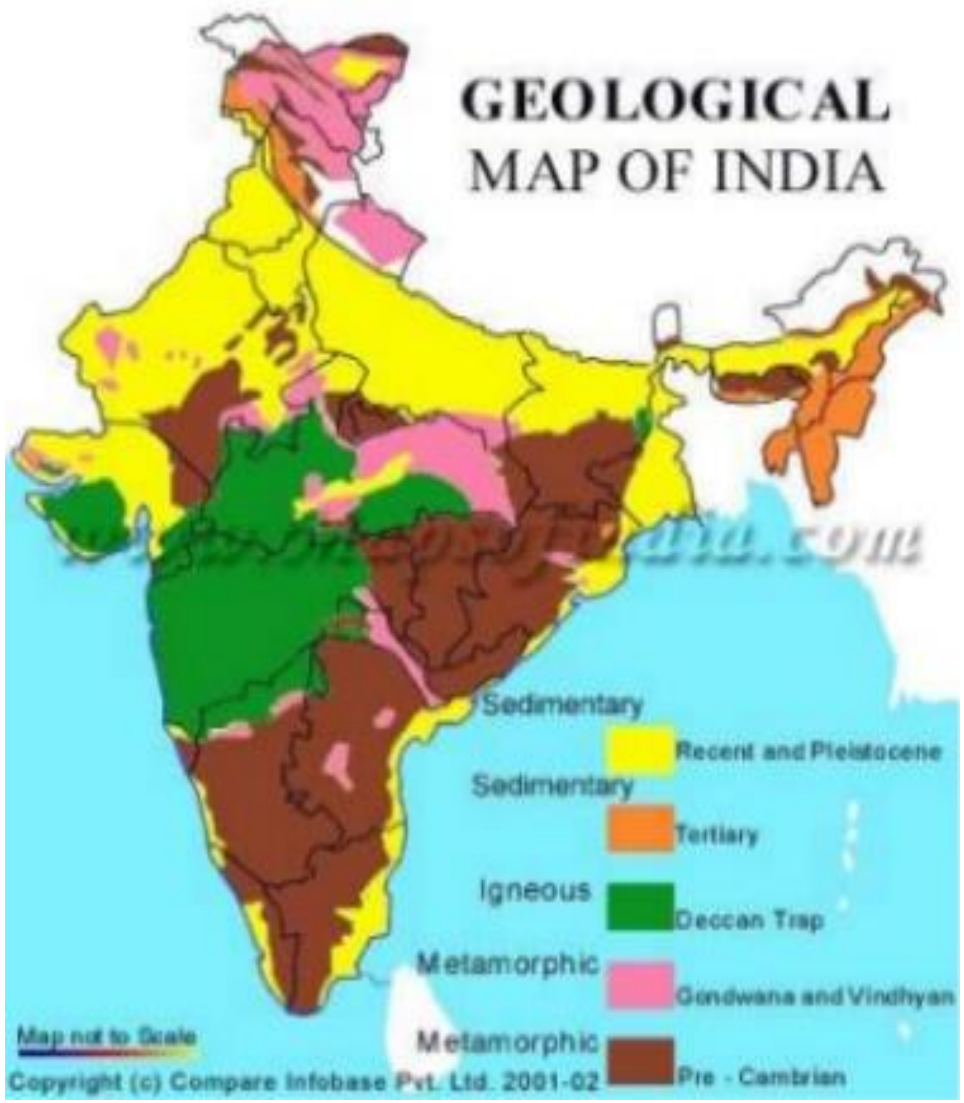
Engineering map

Contour map





Geological map



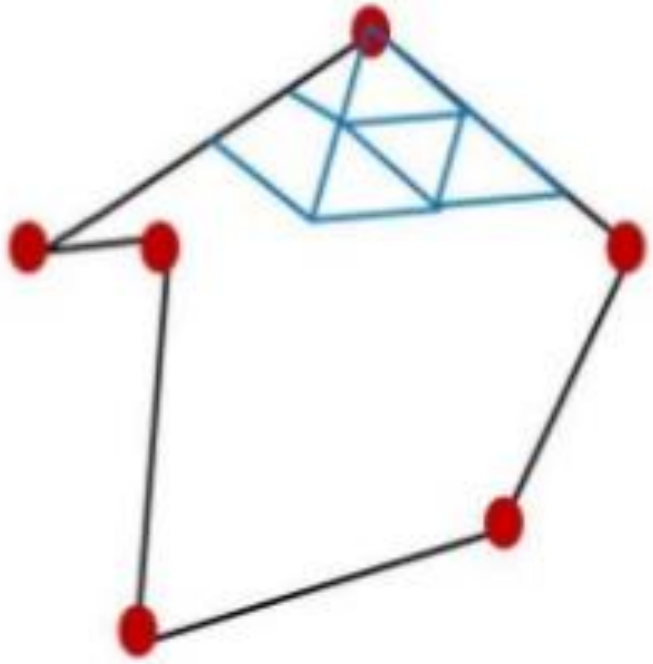
Archeological map

Fundamental Principles of Surveying

- Always work from Whole to Part
- Locate a point by atleast two measurements

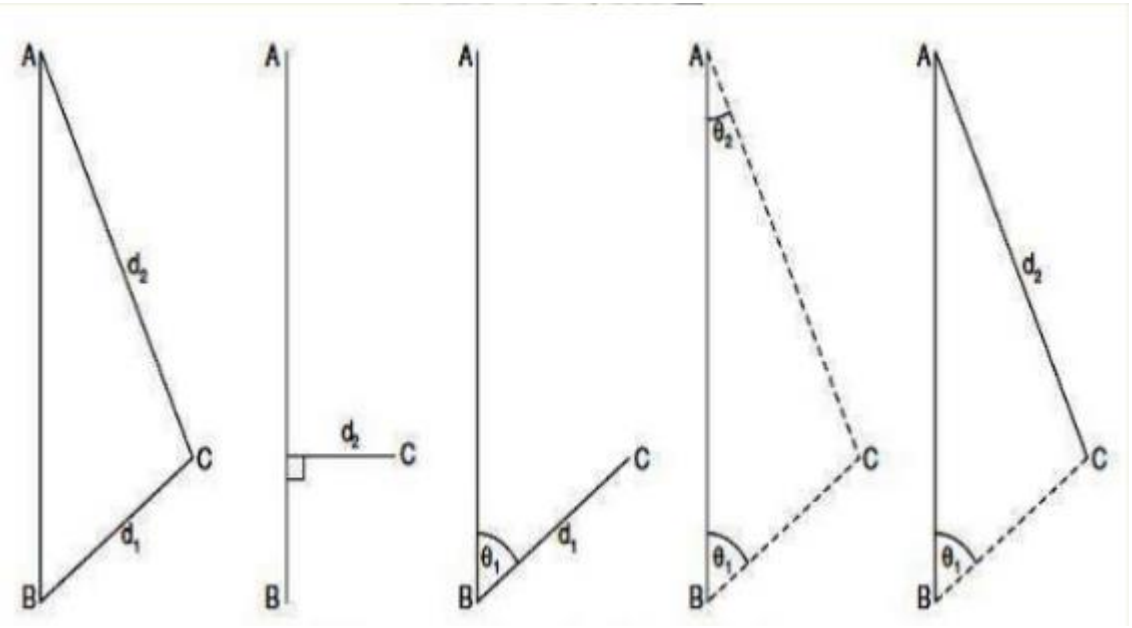
Whole to Part

- For large areas, a system of control points are identified and located with high precision.
- Then secondary control points are established with less precise methods.
- This helps in localizing the errors.

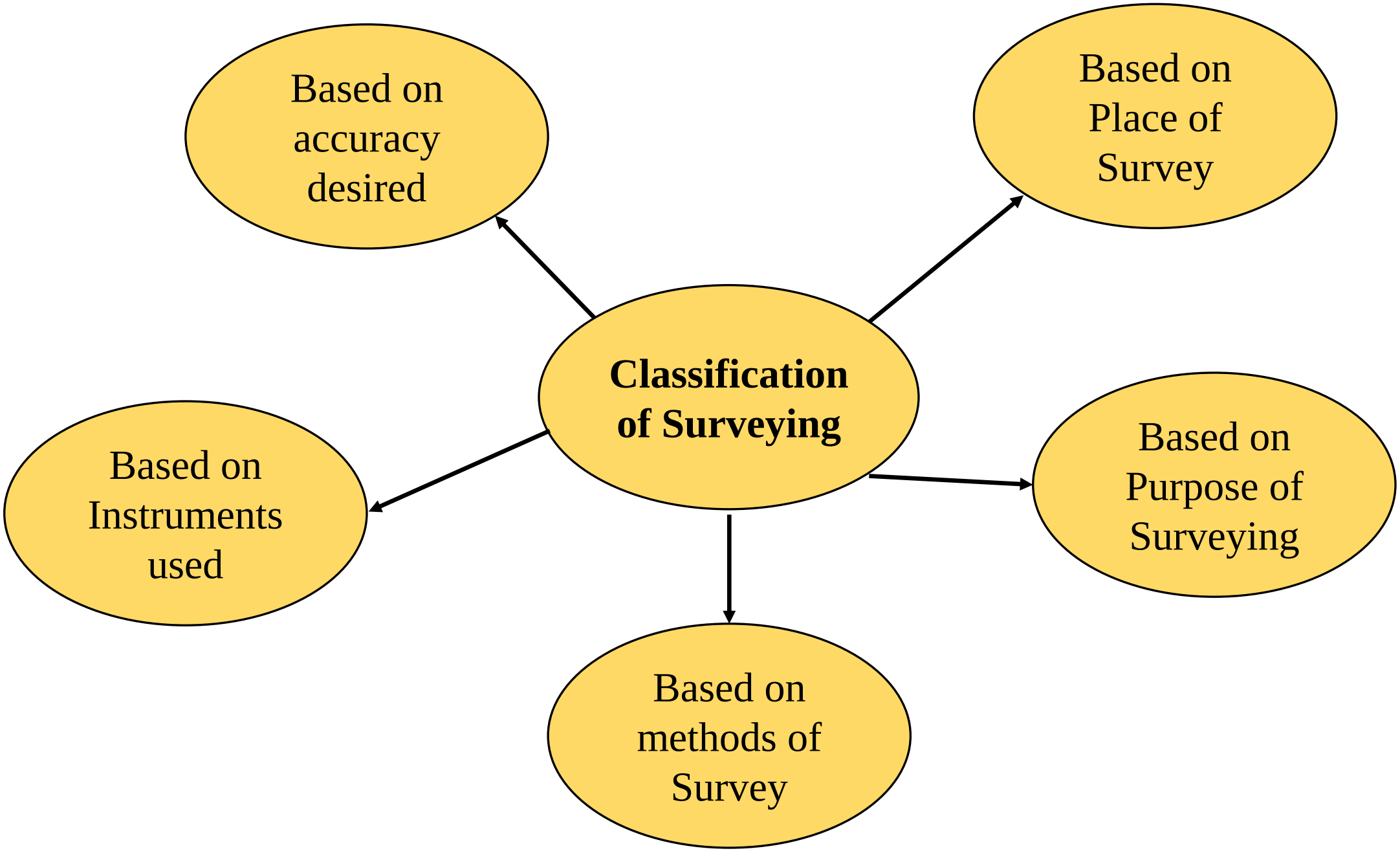


Principle 2

- Control point are selected in the area and distance between them is measured accurately.
- The line joining them is plotted on drawing sheet to the scale.
- New station is plotted by doing measurements from given control point.
- The new station is plotted by using linear/angular measurements or both.

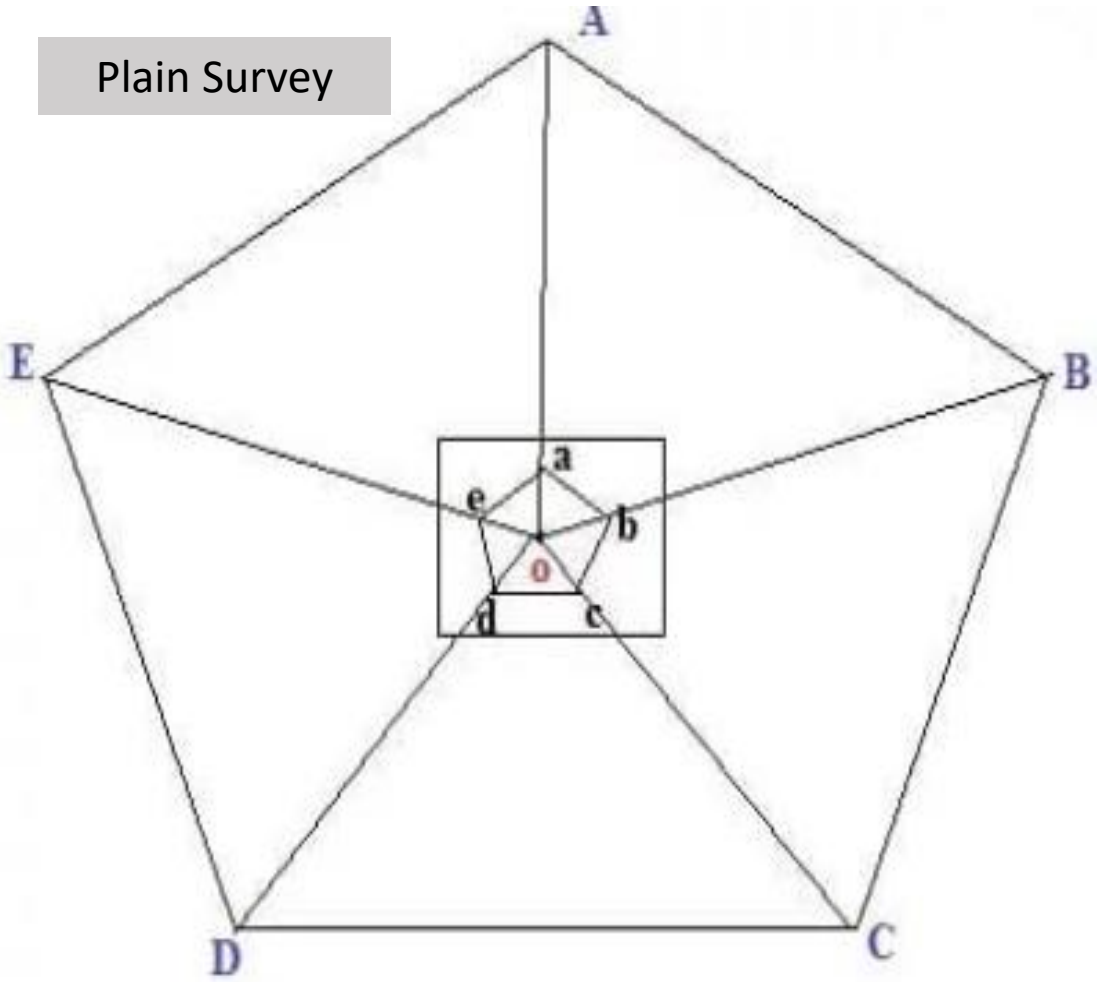


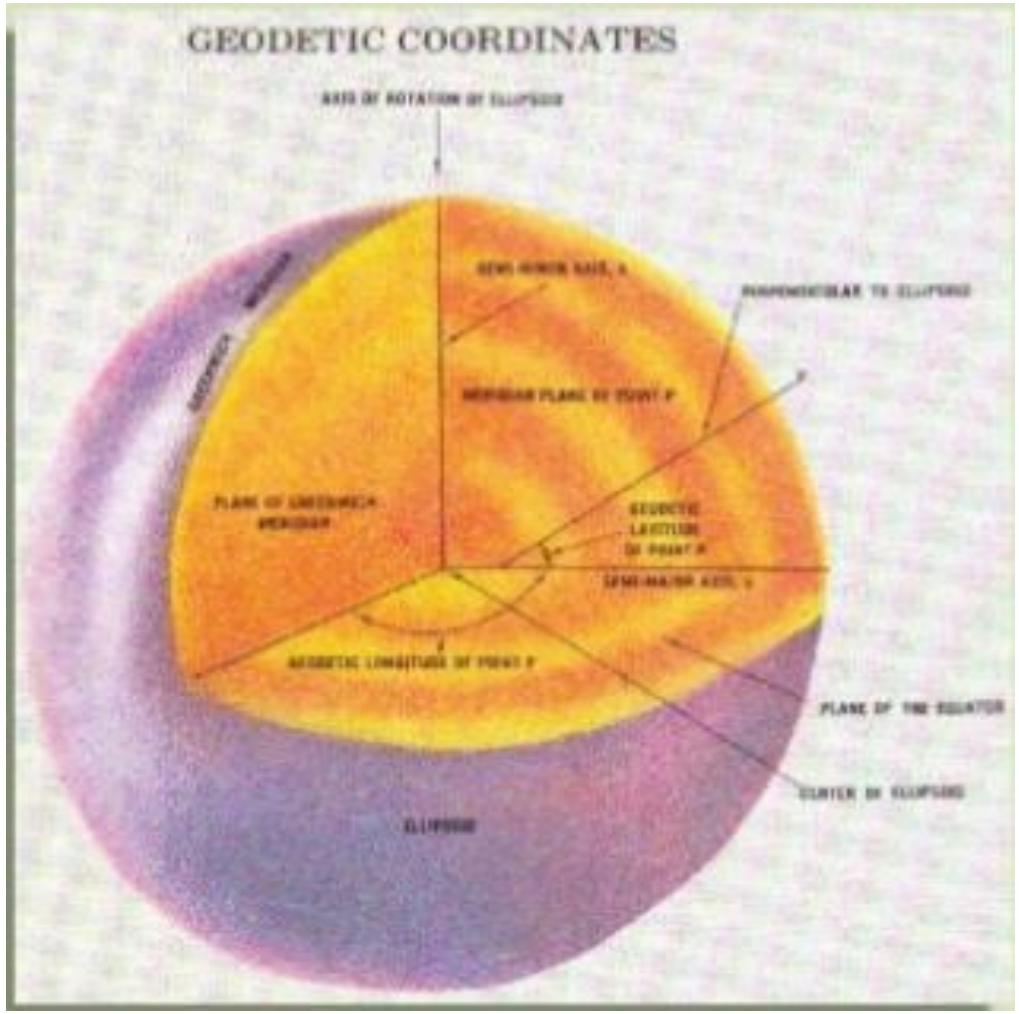
- Distance AB can be measured accurately and relative position can be plotted on sheet to some scale.
- Take linear measurement from A and B for C.
- Take linear measurement of perpendicular from D to C.
- Take one linear measurement from B and one angular measurement as /ABC.
- Take two angular measurements at A & B as /CAB and /ABC.
- Take one angle at B as /ABC and one linear measurement from A as AC.


Based on accuracy desired
Based on Place of Survey
Classification of Surveying
Based on Instruments used
Based on Purpose of Surveying
Based on methods of Survey

1. Based on Accuracy desired

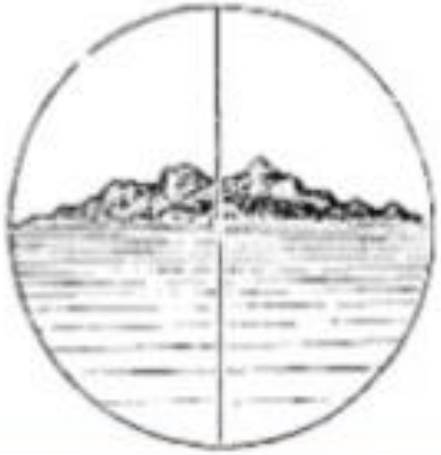
Plain Survey





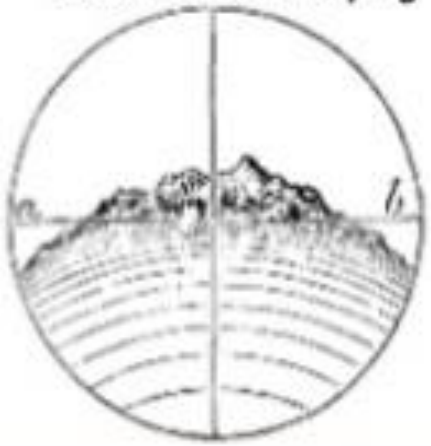
Difference between Plane and Geodetic Surveying ??

Plane Surveying



- Earth surface is considered as a plane surface.
- The curvature of the earth is ignored.
- The line joining any two stations is considered as a straight line.
- The triangle formed by any three points is considered as a plane.
- The angles of the triangle are considered to be plane angles.
- Carried out for a small area < 250km2 .

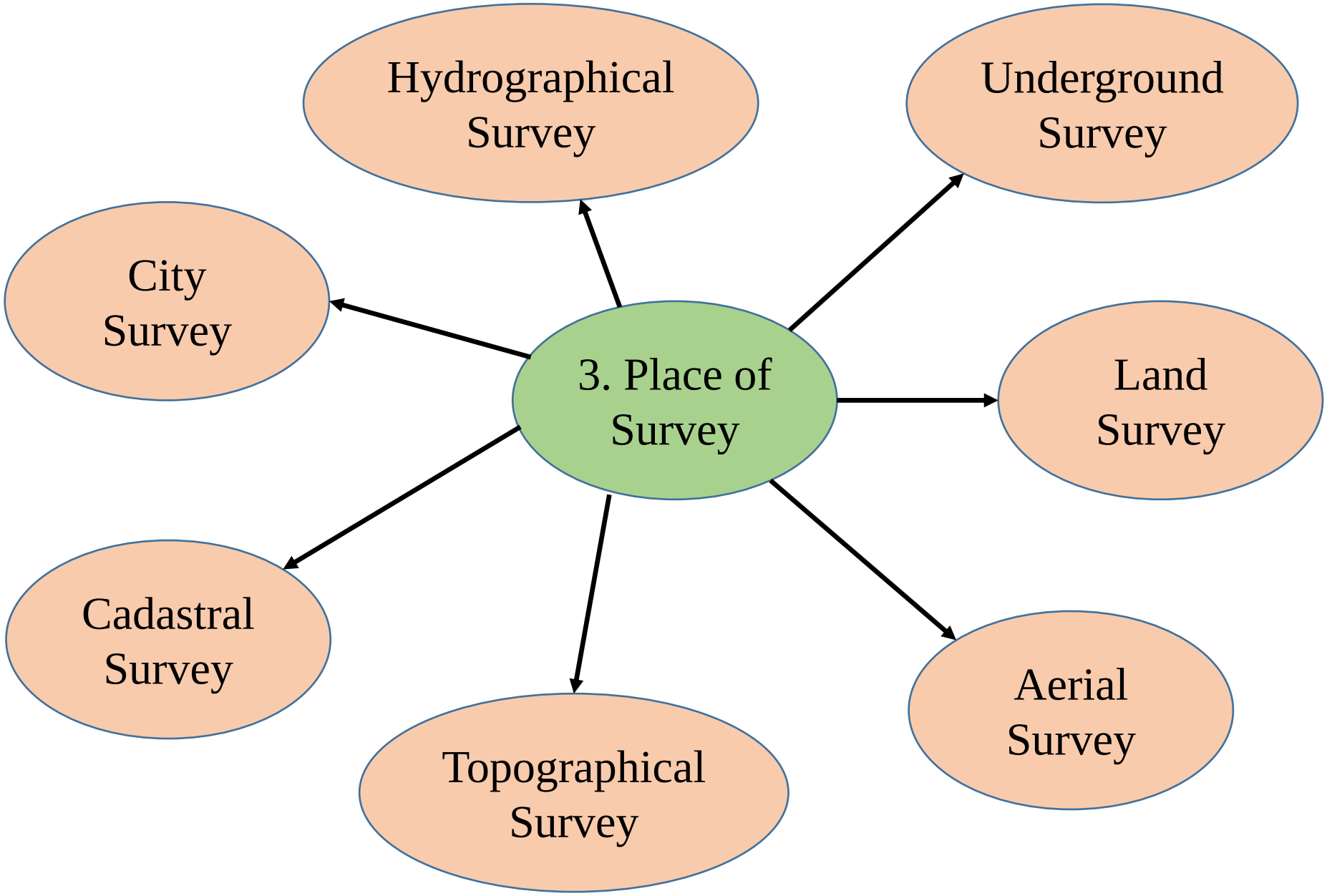
Geodetic Surveying



- Earth surface is considered as a curved surface.
- The curvature of the earth is taken into account.
- The line joining any two stations is considered as a curved line.
- The triangle formed by any three points is considered as spherical.
- The angles of the triangle are considered to be spherical.
- Carried out for a large area >250km2 .

2. Based on Instruments Used

- Chain Survey
- Compass Survey
- Plane Table Survey
- Total Station Survey
- Chain & Compass Survey
- Level Survey
- Theodolite Survey
- GPS Survey
- Unmanned Aerial Vehicle Survey
- Photogrammetry Survey
- Remote Sensing Survey
- Aerial Survey


Hydrographical Survey
Underground Survey
City Survey
3. Place of Survey
Land Survey
Cadastral Survey
Topographical Survey
Aerial Survey

4. BASED ON PURPOSE OF SURVEY

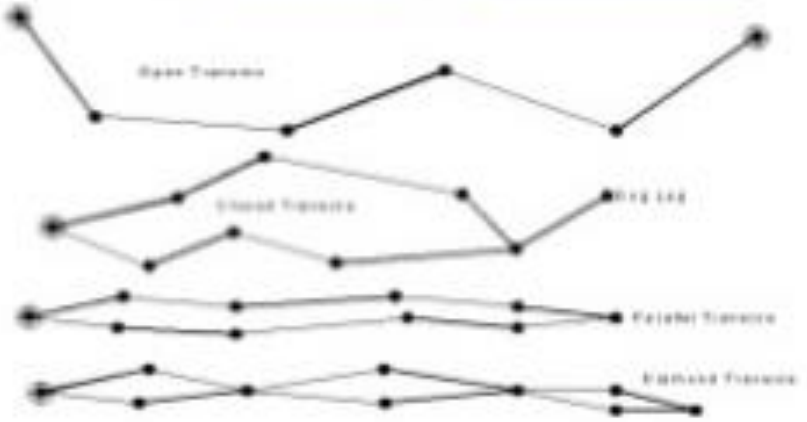
- ENGINEERING SURVEY
- DEFENCE SURVEY
- GEOLOGICAL SURVEY
- GEOGRAPHICAL SURVEY
- MINE SURVEY
- ARCHEOLOGICAL SURVEY
- ROUTE SURVEY
- RECONNAISSANCE SURVEY
- PRELIMINARY SURVEY
- CONTROL SURVEY
- LOCATION SURVEY

5. BASED ON METHODS OF SURVEY

TRIANGULATION

TRAVERSING

- OPEN
- CLOSED



Difference between Plan and Map?

Plan

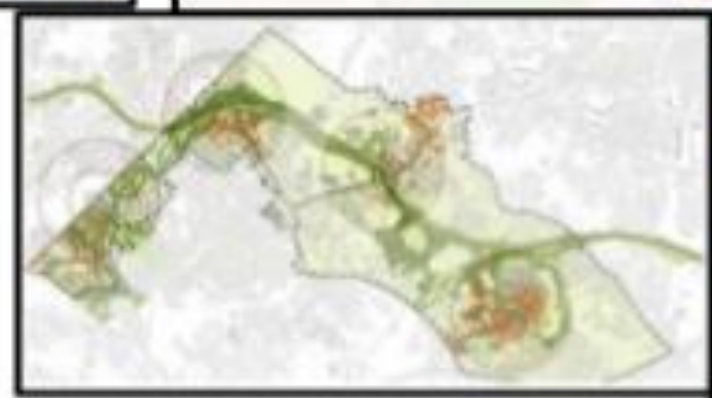
- A plan is a detail of drawing of small areas.
- Details are in the form of symbols.
- A plan can show length and breadth.

Map

- Study a part or whole of the earth with the help of a map.
- A map contains a lot of information.
- A map shows very important features of the area.

MAP

PLAN



Scale

- Is the ratio of the distance marked on the map to the corresponding distance on the ground.
- Selection of scale depends upon the purpose, size and precision required during plotting.
- Scales are generally classified as small, medium and large.
  - Large scale – 1 cm in map = 10 m or less than 10 m on ground
  - Medium scale – 1 cm in map = 10 m to 100 m
  - Small Scale – 1 cm in map = 100 m or more than 100 m.

Representation of Scale

Representative fraction

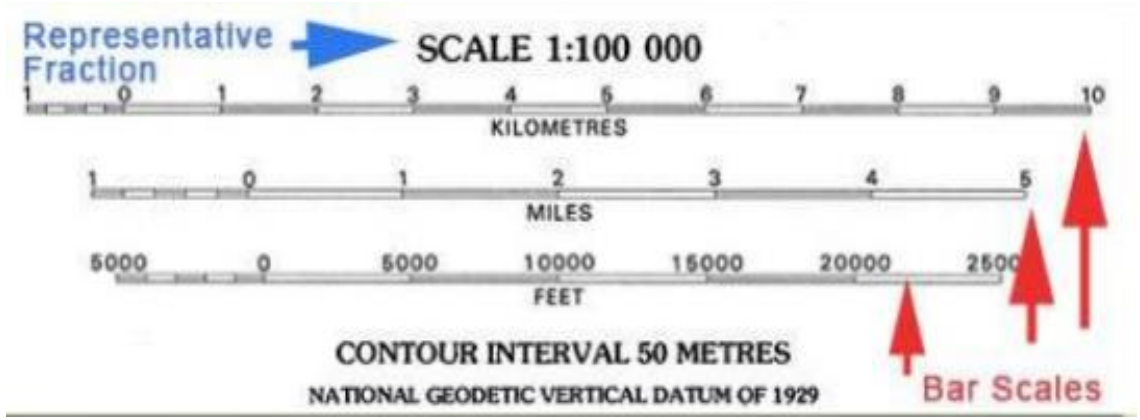
- Indicated by a ratio.
- $R.F. = \frac{distance\ on\ map}{distance\ on\ ground}$
- Both the distance should be in same unit.
- E.g. R.F. = 1/5000 or 1:5000

Engineer's scale

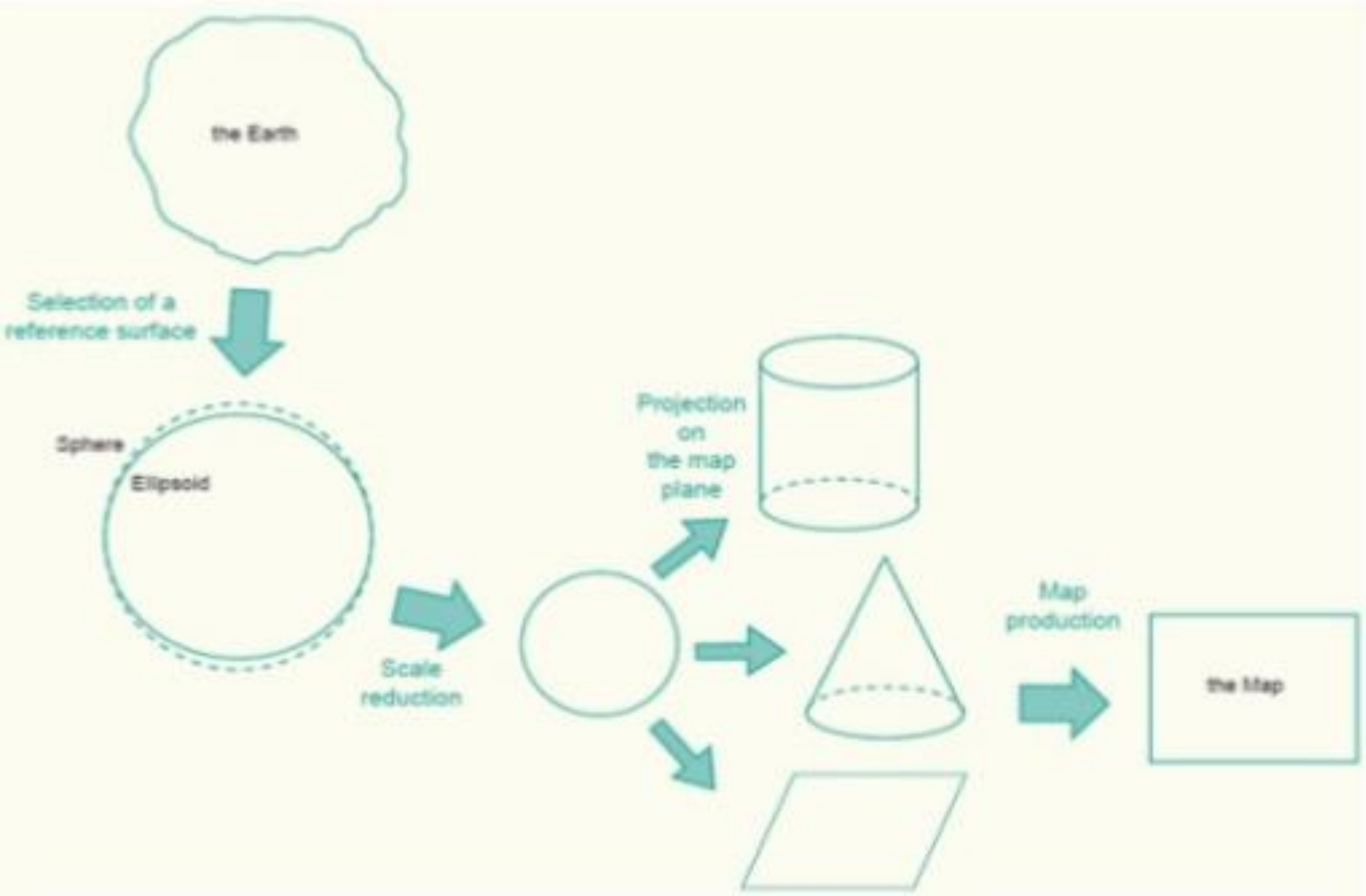
e.g. 1 cm = 50 m

Graphical Scale

- Represented by a line drawn on the map.



Coordinate System



Coordinate System

- Coordinate system is a reference system used to represent the locations of geographic features, imagery and observations within a common geographic framework.
- This system is required to project a point from space on a planimetric map.
- Coordinates are a conventional method of recording position in space.
- These are used to locate position from three dimensions to two dimensions.
- A reference system is used to measure horizontal and vertical distances on a planimetric map.

Types of Coordinate System

Geographic CS

- Latitudes and longitudes
- It includes angular unit of measure, a prime meridian and a datum.

Projected CS

- Universal Transverse Mercator (UTM)
  - Northing and Easting

Geographic Coordinate System

Positions on Globe: Lines of Reference

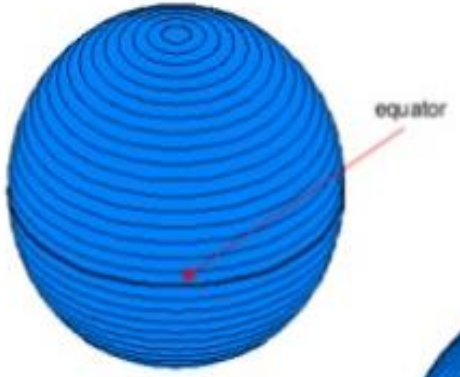
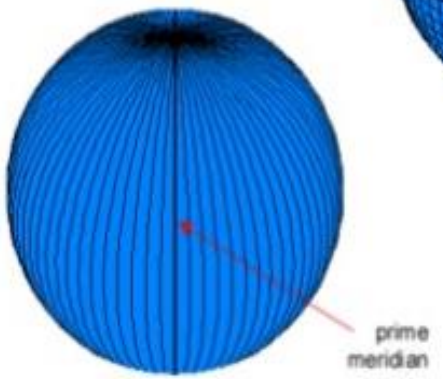


Figure: 1



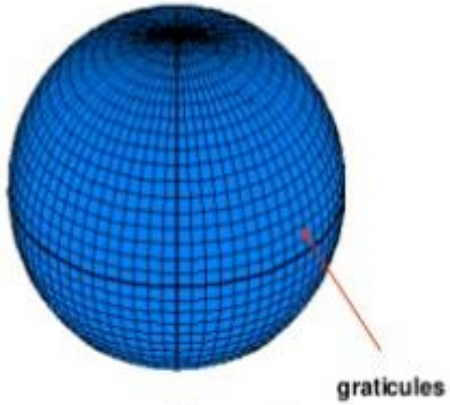
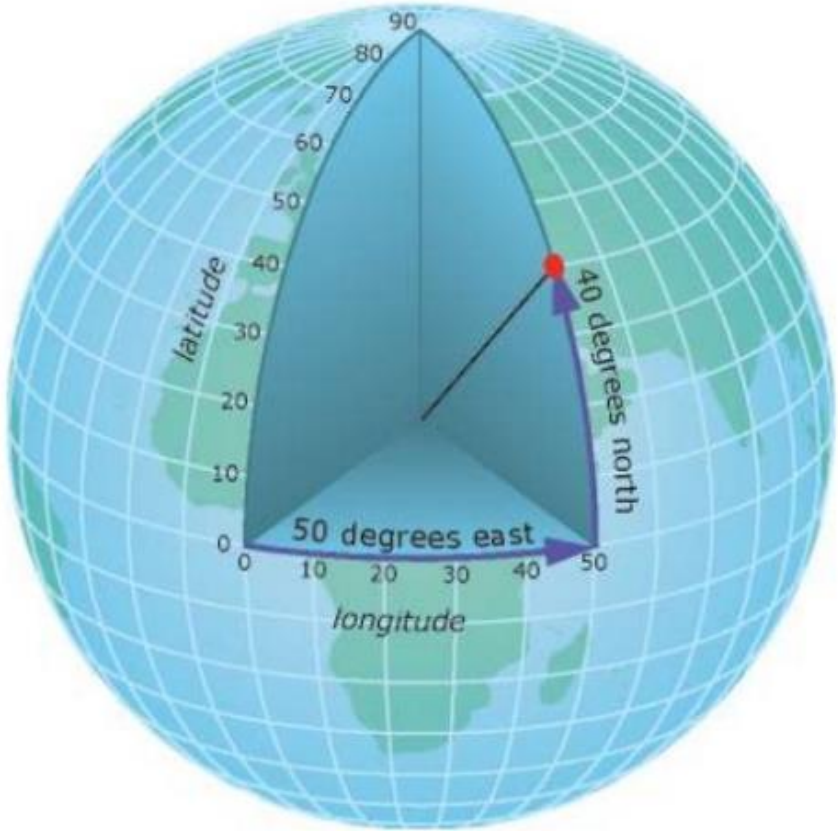


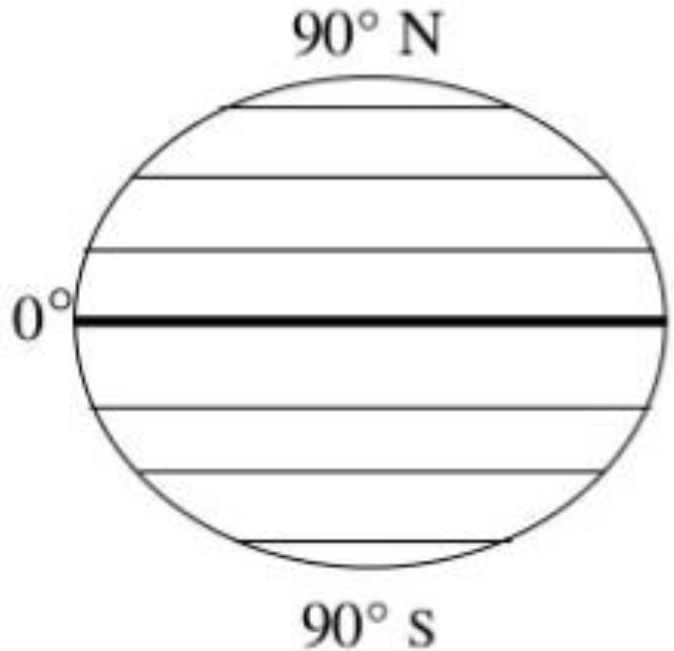
Figure: 3



Latitude

"Latitude is the angular distance of any point on Earth measured north or south of the Equator in degrees, minutes and seconds"

- ***At poles*** (North and South Poles) latitudes are ***90° North*** and ***90° South***
- At ***equator*** latitude is ***0°***
- The equator divides the globe into ***Northern*** and ***Southern Hemispheres***
- ***Each degree*** of latitude is approximately ***69 miles (111 km)*** (variation because Earth is not a perfect sphere)



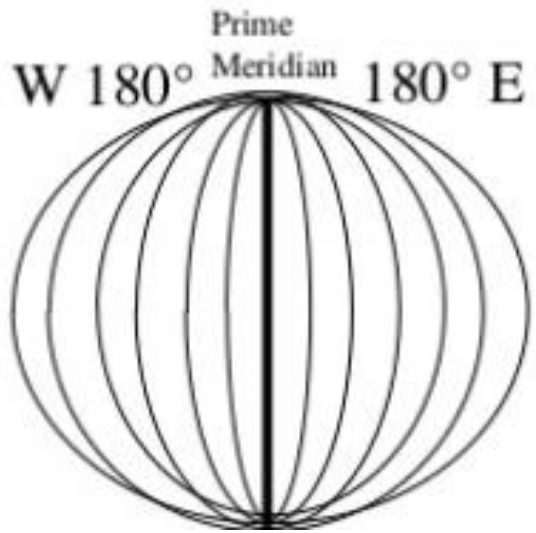
Some Important Small Circles

- **Tropic of Cancer**
  - At 23.5°N of Equator and runs through Mexico, Egypt, Saudi Arabia, India and southern China.
- **Tropic of Capricorn**
  - At 23.5°S of Equator and runs through Chile, Southern Brazil, South Africa and Australia.
- **Arctic and Antarctic Circles**
  - At 66° 33′ 39″ N and 66° 33′ 39″ S respectively

Longitude

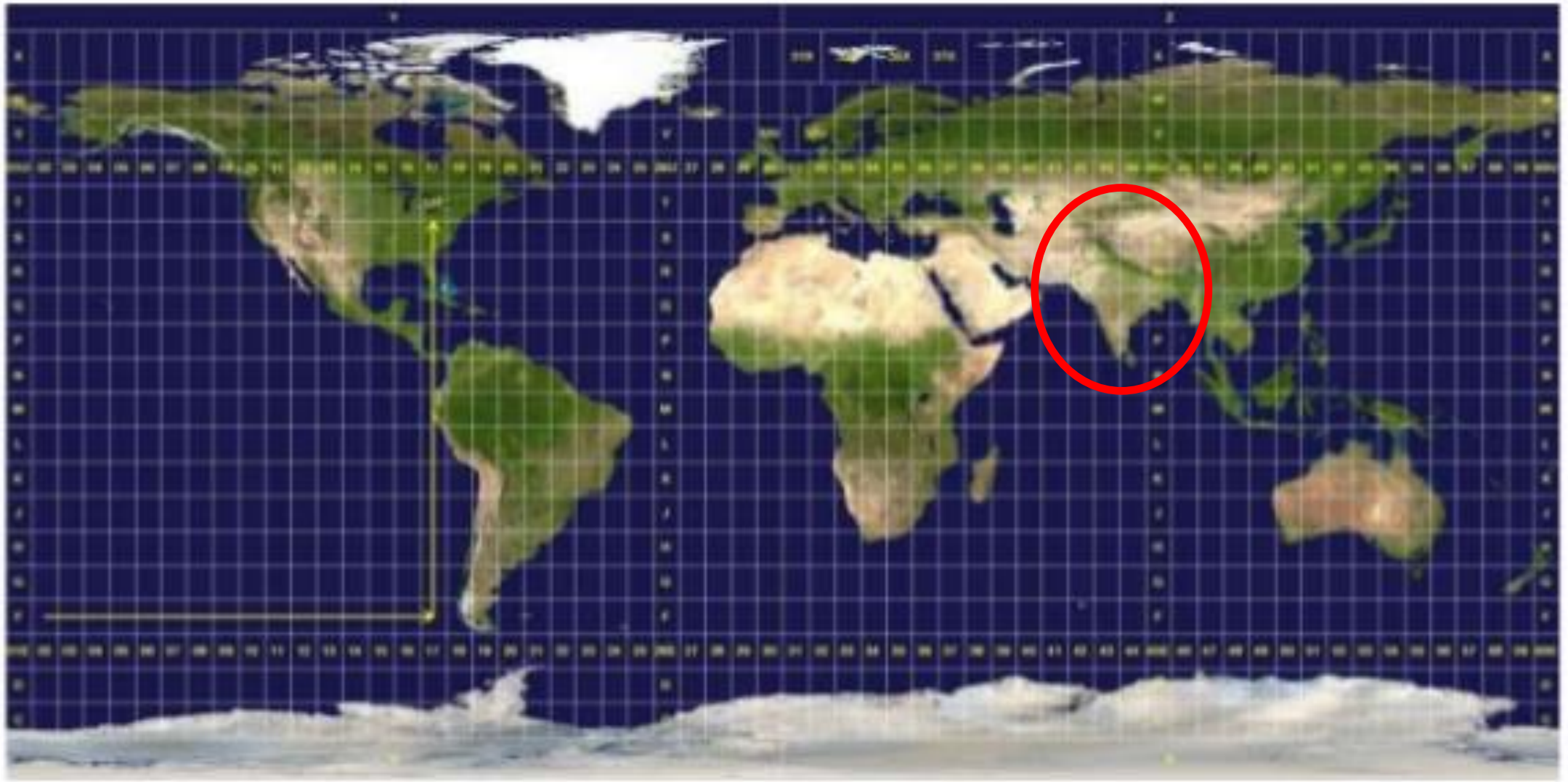
"Longitude is the angular distance of any point on Earth measured east or west of the prime meridian in degrees, minutes and seconds"

- Measured from ***0° to 180° east*** and ***180° west*** (or -180°)
- The ***meridian at 0°*** is called ***Prime Meridian*** located at Greenwich, UK
- Both 180-degree longitudes (east and west) share the same line, in the middle of the Pacific Ocean where they form the ***International Date Line***
- 1 degree of Longitude=
  - **69.17 mi at Equator**
  - **48.99 mi at 45N/S**
  - **0.0 mi at 90N/S**



Map of the World

Universal Transverse Mercator (UTM)



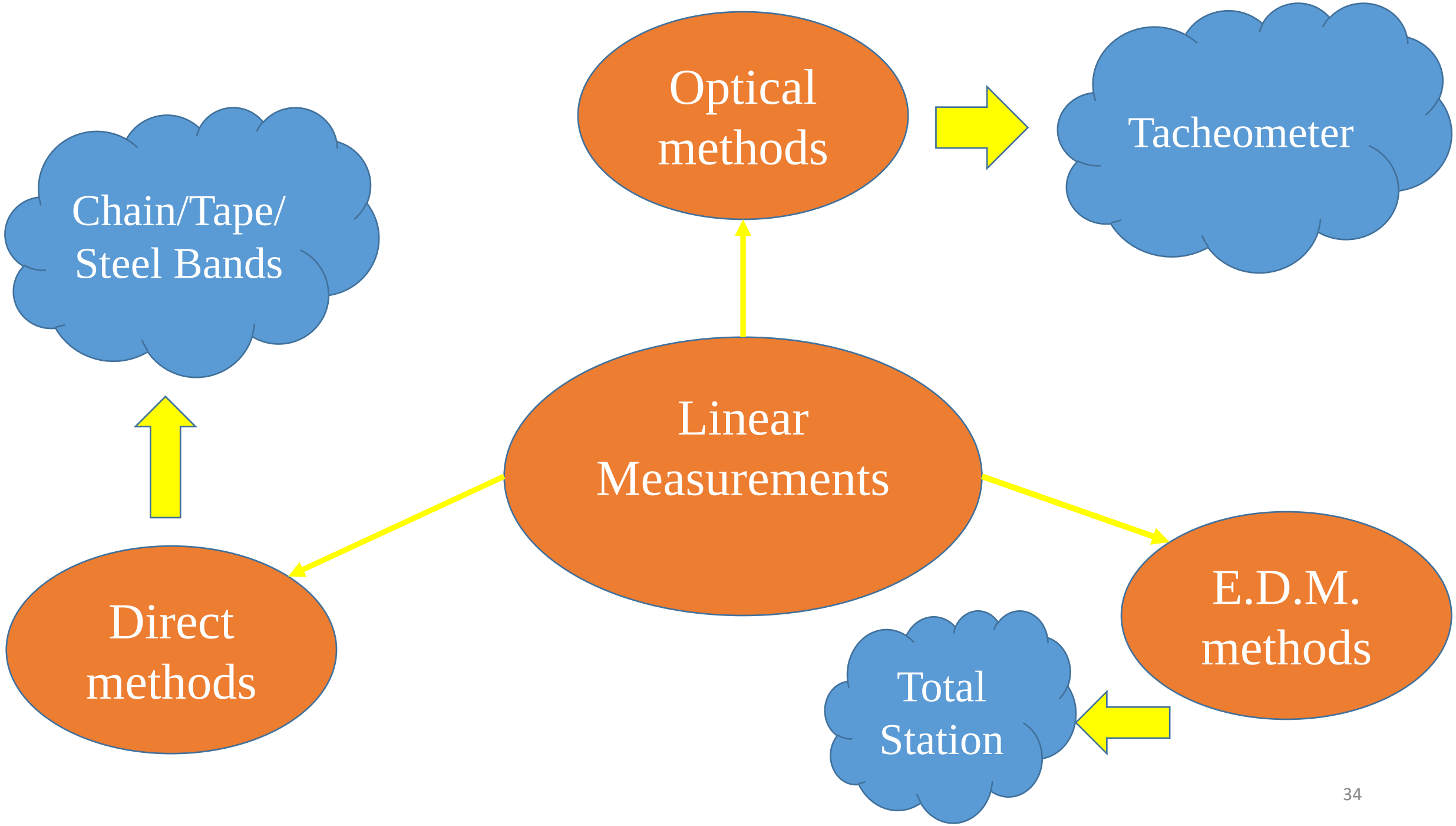
Instruments used for different measurements

- **Horizontal distances** – Chains, Tapes, Tacheometers, Electronic Distance Measurement (EDM) etc.
- **Vertical distances** – Levelling Instruments, Tacheometers etc.
- **Horizontal angles** – Magnetic Compass, Theodolite, sextants etc.
- **Vertical angles** – Theodolites, clinometers, sextants etc.

PART II

Linear Measurements

Horizontal Distance


Optical methods
Tacheometer
Chain/Tape/ Steel Bands
Linear Measurements
Direct methods
E.D.M. methods
Total Station

Chain Surveying (linear measurements)

- The whole area to be surveyed is divided into framework of triangles of suitable sizes.
- Triangles are selected because of its simplicity to be plotted with the measurements of its sides only.
- The triangles should be well-conditioned whose sides should be of same length and forming angles between 30˚ to 120˚ (preferably 60˚).
- This method is preferred when area is small and it is flat and open.

Types of Chain

- **Metric chains**
  - 20m and 30m
  - Tallies @every five-meter length brass rings @ every meter length
- **Gunter's chain or surveyors chain**
  - Length = 66 ft (22 yards), No of links = 100, Each link = .66'
  - Used for measuring distances in miles or furlongs (220 yards), acres (Area).
- **Engineers chain**
  - Length = 100 ft , No of links = 100, Each link = 1'
  - Used in all Engineering Surveys.
- **Revenue chain**
- Length = 33ft, No of links = 16
- Commonly used for measuring fields in cadastral Survey

Survey Stations

These are important point fixed on ground indicating the starting point and the end point of the survey line. These are also the basic control points of the survey. There can be two types of survey stations.

Main Station

Main stations are control points at the ends of the chain lines commanding the boundaries of survey.

Subsidiary or Tie Station

These are stations selected on the main survey lines for running auxiliary lines drawn to locate, measure and plot interior details.

Lines

Base Lines

- It is main and longest line, which passes approximately through the center of the field. Detailing work carryout with respect of this line.

Check Line

- Or Proof line is a line joining the apex of a triangle to some fixed points on any two sides of a triangle. To check the accuracy of the framework.
- The length of a check line, as measured on the ground should agree with its length on the plan.

Survey Lines

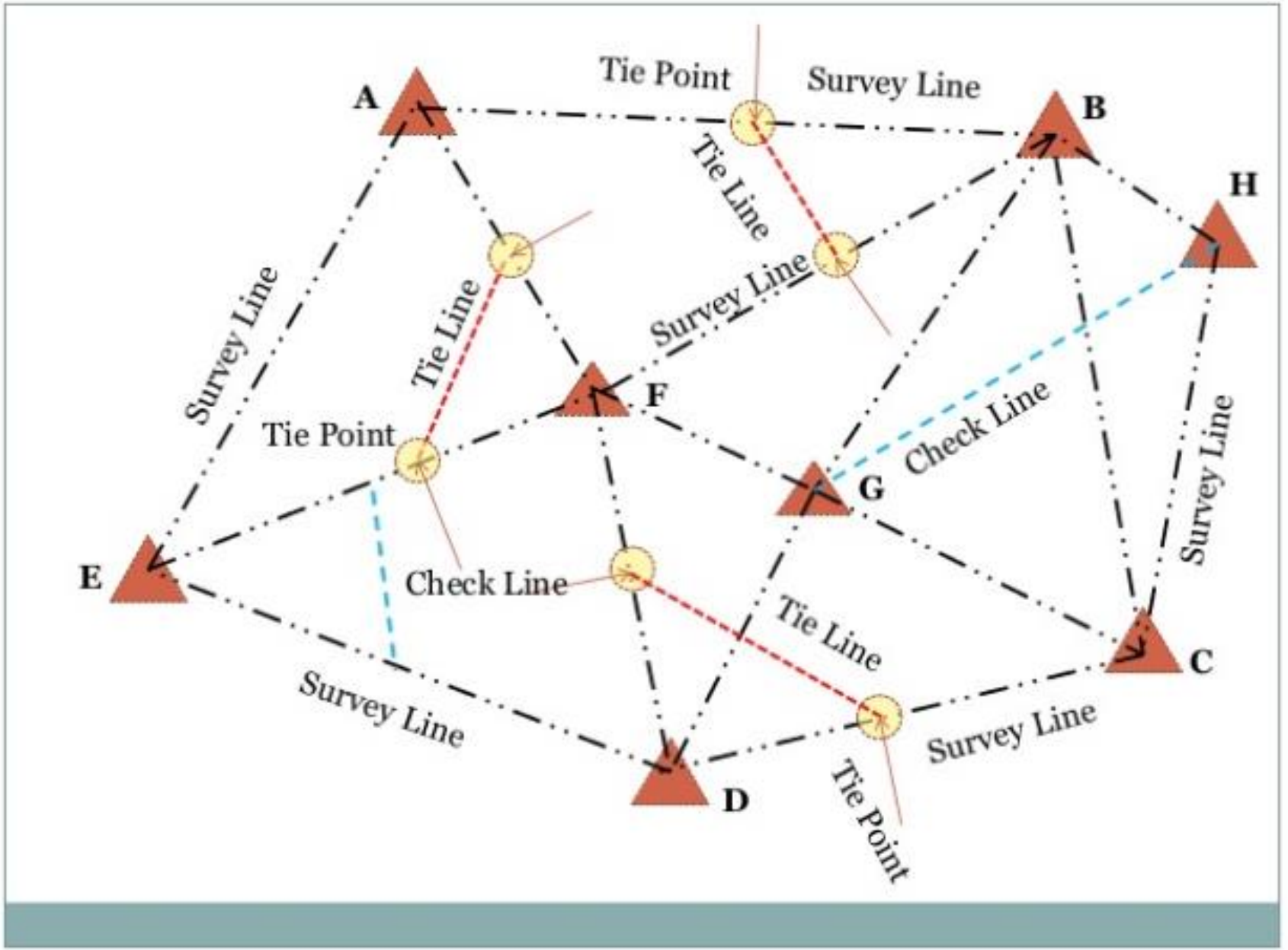
The lines joining survey stations are the survey lines. The survey lines between main stations are thus called main survey lines or chain lines. The longest of the main survey line is normally called Base Line (Line BE in Figure 1) running primarily through the middle of the area to be surveyed.

The framework of triangles shall have one or two base lines since the entire survey is built around base line. It shall be measured with higher care and accuracy. The survey line joining the subsidiary or tie stations on main line is termed Tie Line

The shape of triangle in which any error in angular measurements, has a minimum effect upon the lengths of a computed angles, is known as Well conditioned triangle

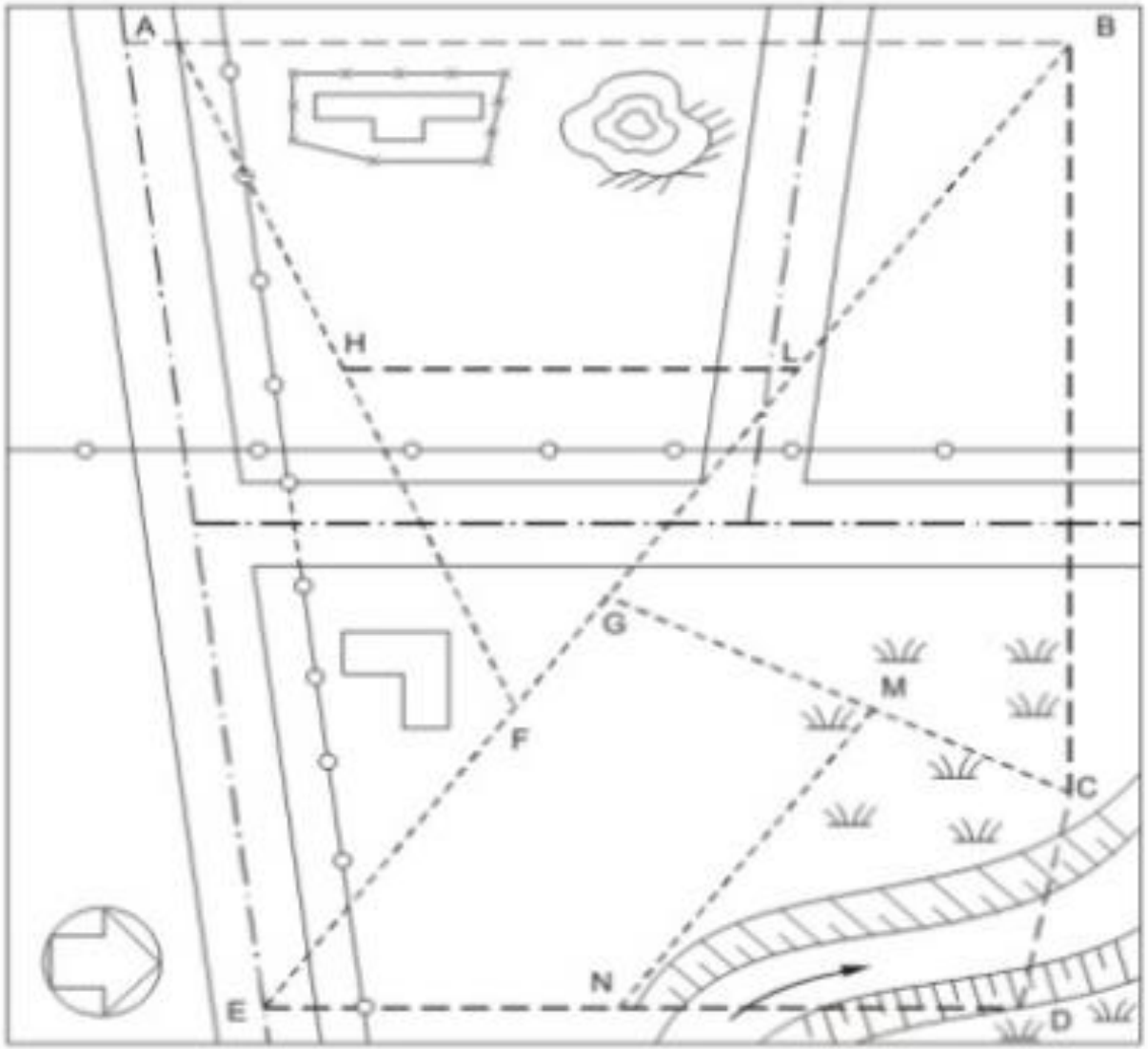
Equilateral triangle may be treated as well conditioned triangle.

Triangles, less than 30˚or more than 120˚, should be avoided



Important Note

The survey stations are suitably selected with care so that at least main survey stations are mutually visible and survey lines run through as flat ground as possible and are as close to the boundaries as possible.



Main Survey Stations : A, B, C, D, E
Main Diagonal (Base Line) : BE
Subsidiary or Tie Lines : AF, GC

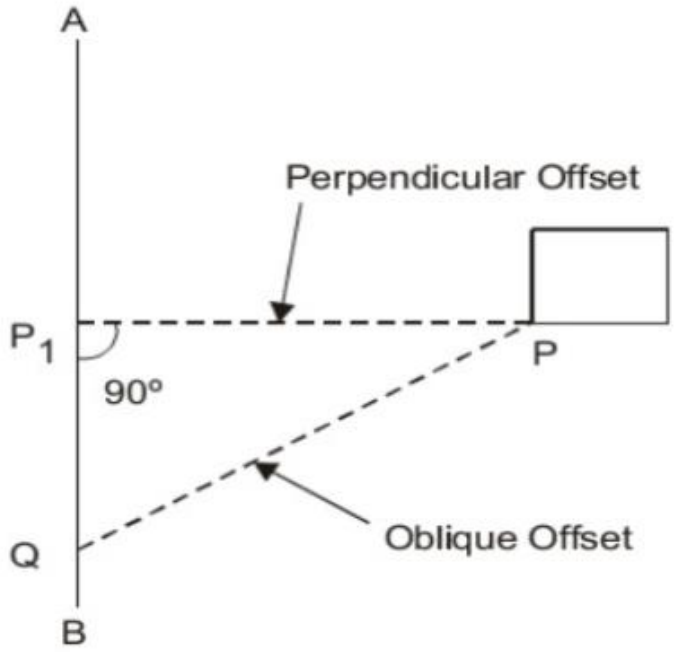
Subsidiary Stations : F, G, H, L
Main Survey Lines : AB, BC, CD, DE, EA
Check Lines : HL, MN

Offsets

The details on ground such as fences, buildings and towers, etc. are to be located with reference to main chain lines by means of lateral measurements. These lateral measurements with reference to the chain line are referred to as offsets.

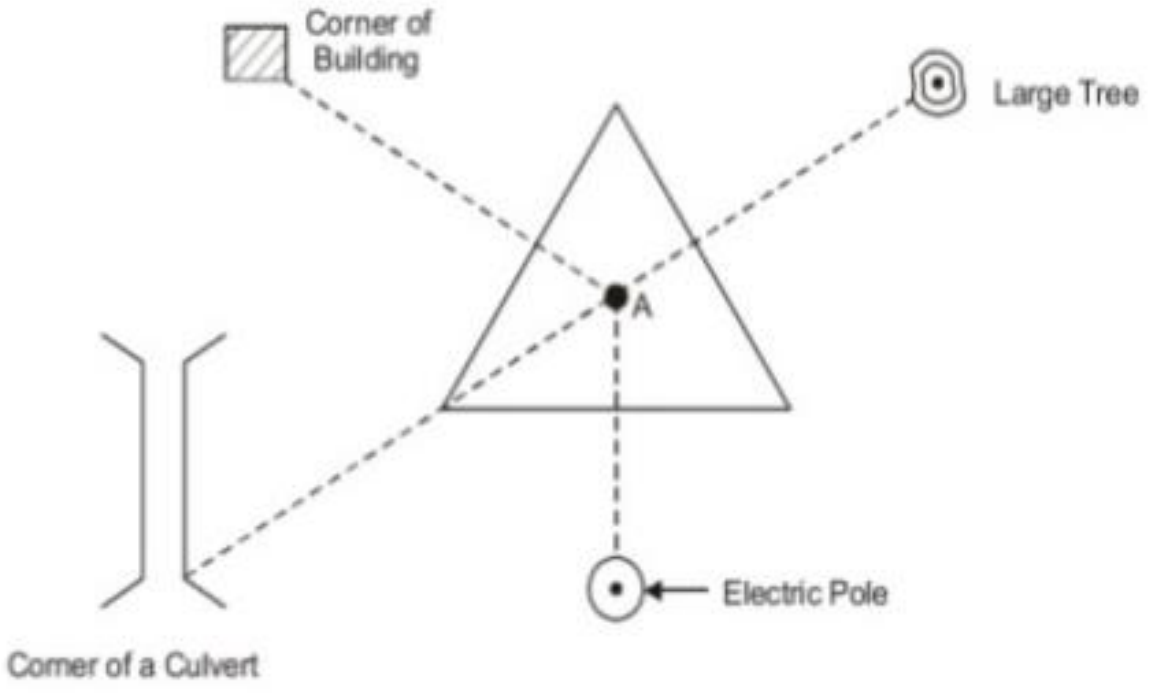
Type of Offsets

- Perpendicular offset/right angle offset
- Oblique offset



Marking the Stations

- The stations should be mutually inter-visible and quasi-permanently fixed during surveying process.
- The position of stations should be such that base survey line and other main survey lines are aligned to some permanent ground features either natural or manmade.
- This helps in locating the position of stations unambiguously and accurately at any time in future.



It can be noted that the distance of station A must be measured from at least three permanent ground features, e.g. large tree, electric pole, building or culvert etc. existing in the vicinity of the station.

- The stations are marked temporarily on ground by fixing the ranging rod at their location.
- A wooden peg is driven in the ground such that it is projecting atleast 40 mm above the ground to provide some permanency.
- For permanent marking, a stone or concrete block can be embedded in ground.

Ranging in Surveying

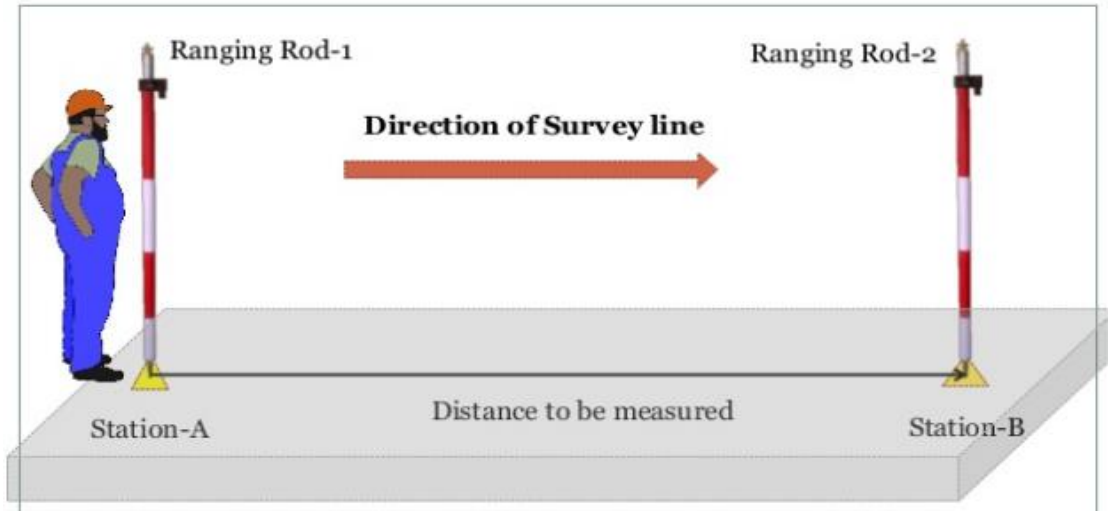
- To align intermediate points on chain line so that the measurements are along the line
- Process of locating intermediate points on survey line is known as ranging

Methods of ranging

1. Direct Ranging
2. Reciprocal Ranging

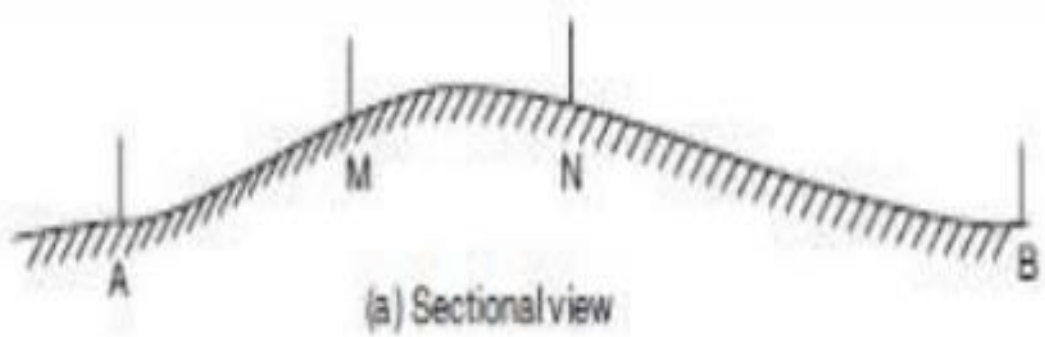
Direct Ranging

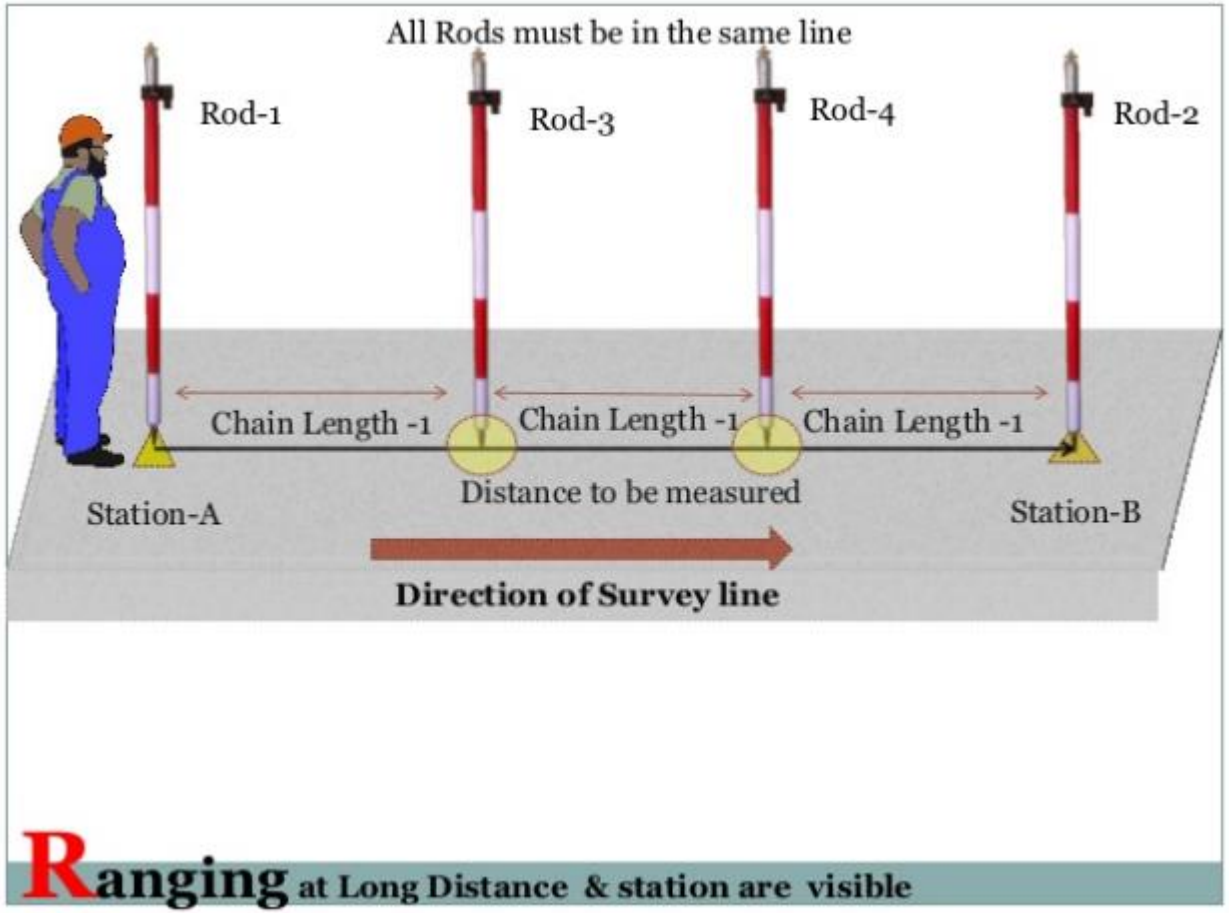
- Used when the stations are intervisible
- Done by eye-judgement
- Ranging rods are erected vertically beyond each end of survey line
- The surveyor stands 2m beyond the ranging rod while the assistant folds the ranging rod vertically in the intermediate stations.
- The surveyor directs the assistant to move the rod to the left or right until the three ranging rods appear to be in a straight line.

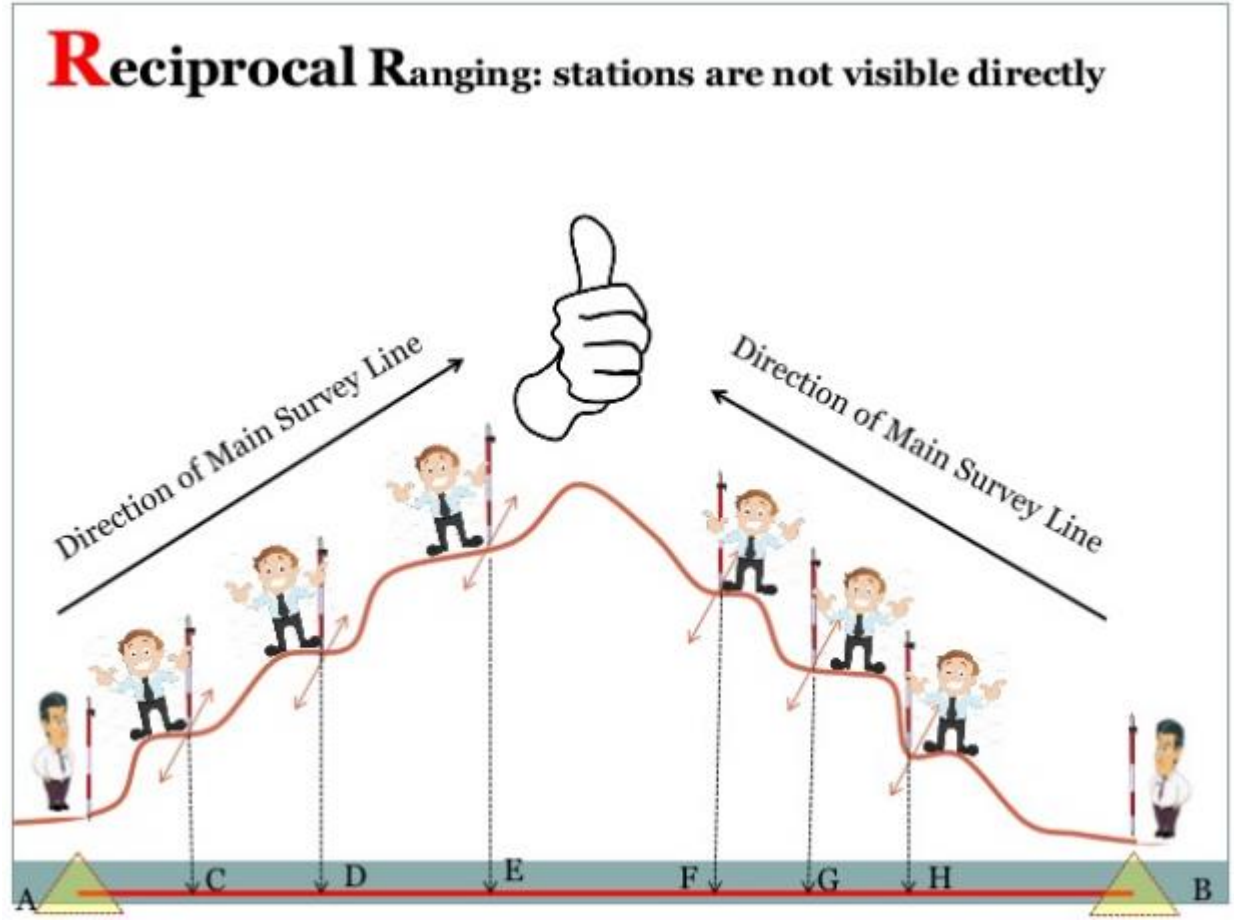


Indirect Ranging/ Reciprocal Ranging

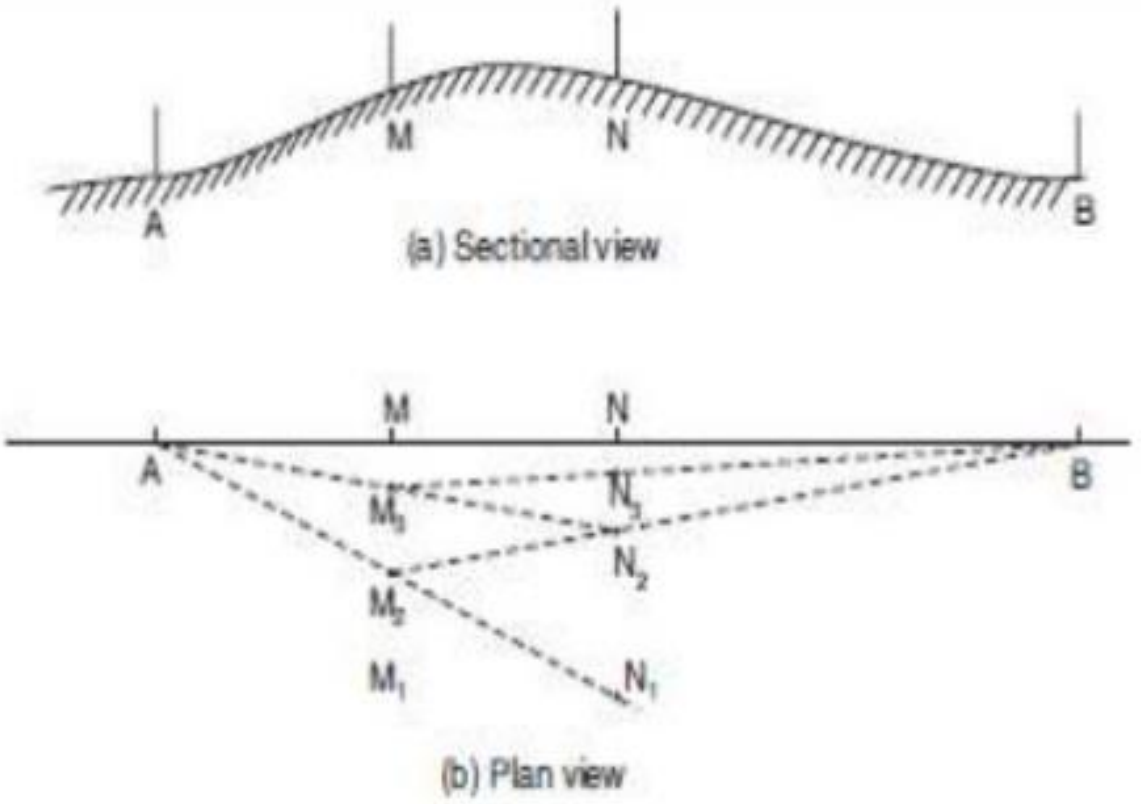
- when ends of a line are not inter-visible due hill ground or stations are not clearly inter-visible
- needs two assistants one at point M and another at point N, where from those points both station A and station B are visible




All Rods must be in the same line
Rod-1
Rod-3
Rod-4
Rod-2
Chain Length -1
Chain Length -1
Chain Length -1
Distance to be measured
Station-A
Station-B
Direction of Survey line
Ranging at Long Distance & station are visible


Reciprocal Ranging: stations are not visible directly
Direction of Main Survey Line
Direction of Main Survey Line
A
C
D
E
F
G
H
B

- It needs two assistants, one at point M and another at point N, where from those points both station A and B are visible.
- It needs one surveyor at A and another at B.
- To start with, M and N are approximately selected, say M1 and N1.
- The surveyor near end A ranges person near M to position M2 such that AM2N1 are in a line.
- The surveyor at B directs person at N, to move to N2 such that BN2M2 are in a line.
- The process is repeated till AMNB are in a line.

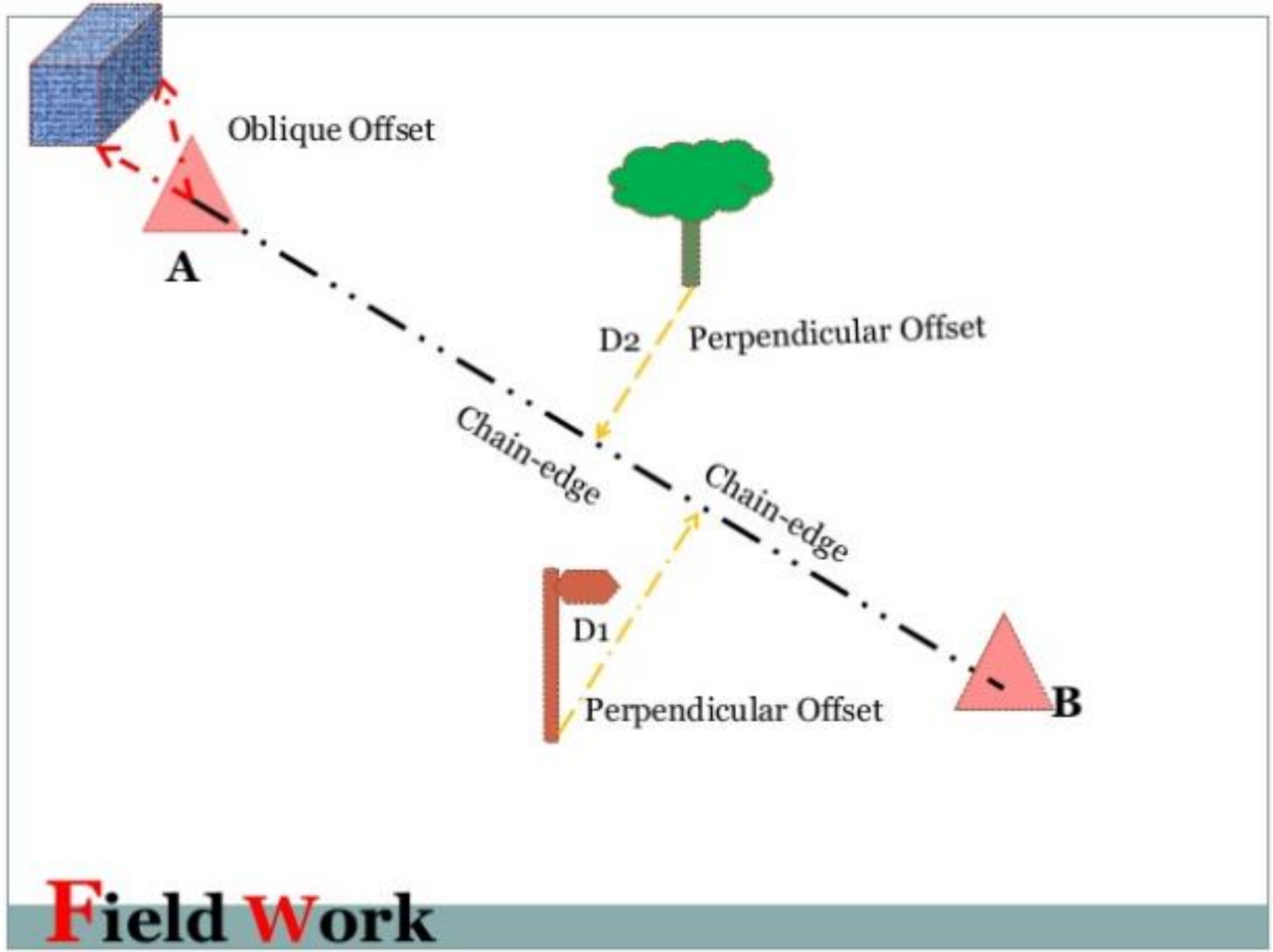


Procedure in chain survey

- Reconnaissance: preliminary inspection
- Marking Station: fixes up the required no stations at places with maximum visibility
- Methods used for marking are:

1. Fixing ranging poles
2. Driving pegs
3. Marking a cross if ground is hard
4. Digging and fixing a stone.

- Selects main survey line
- Fix ranging roads on the stations
- Start chaining and Make ranging if required
- Field book Entry


Oblique Offset
A
D2
Perpendicular Offset
Chain-edge
Chain-edge
D1
Perpendicular Offset
B
Field Work

Field Work

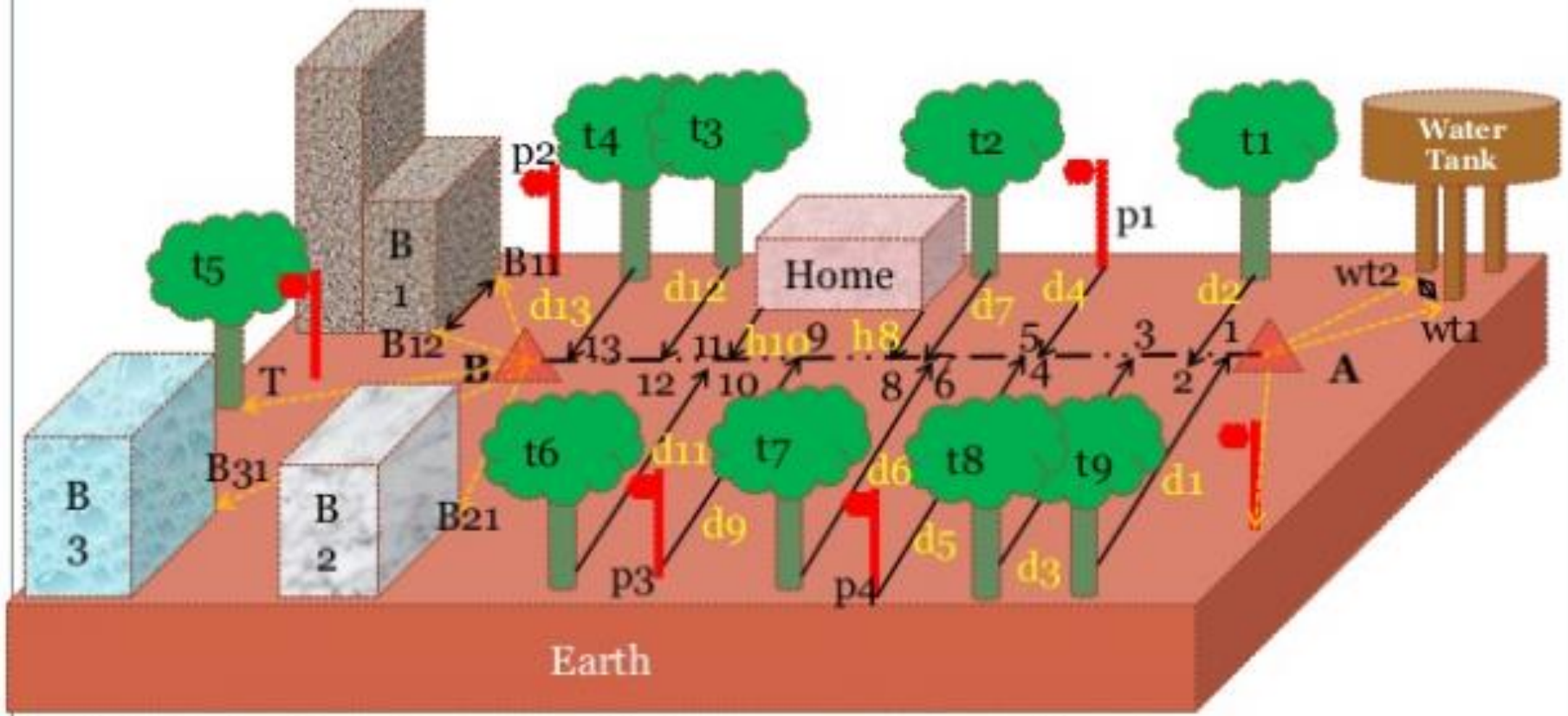
Here;

1,2,3,.....,12,13 are the chain-edge(Where offset meets perpendicular to chain)

d1,d2,d3,.....,d12,d13 are the offset distances

wt1, wt2, B11, B12, B31 and B21 are the references/ oblique offset from permanent structure i.e. Water Tank, Buildings, electric towers

T refers to offset taken at tree(shouldn't consider reference, however it is oblique offset)



B1, B2 & B3: Buildings, t1,t2..... used for tree, p1,p2,p3.....used for poles

h8 h11 offsets for home

Office Work

Legends or Coding

1,2,3,.....,12,13 are the chain-edge(Where offset meets perpendicular to chain)

d1,d2,d3,.....,d12,d13 are the offset distances

wt1, wt2, B11, B12, B31 and B21 are the references/ oblique offset from permanent structure i.e. Water Tank, Buildings, electric towers

T refers to offset taken at tree(shouldn't consider reference, however it is oblique offset)

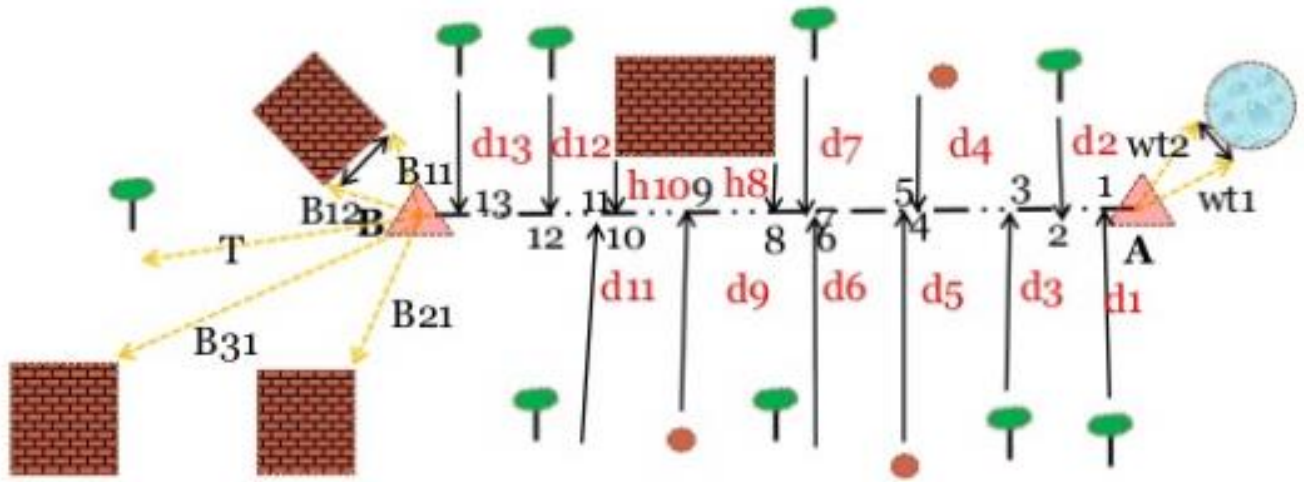
Legends:

Pole

Tree

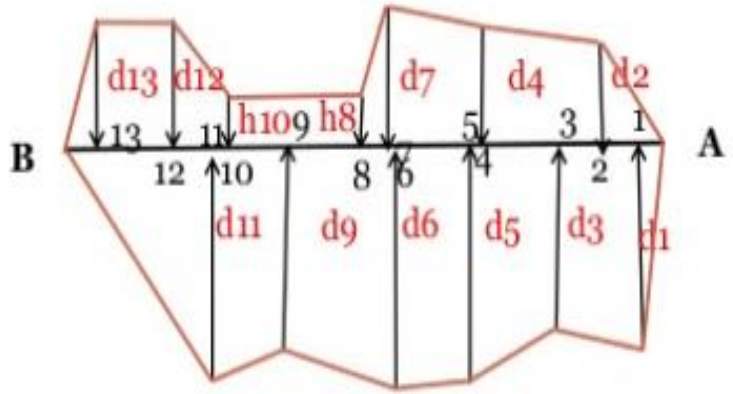
Building/Home

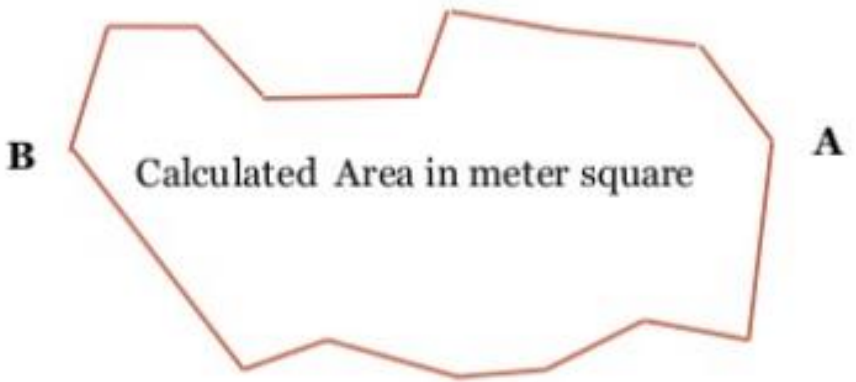
Water Tank



B1, B2 & B3: Buildings, t1,t2..... used for tree, p1,p2,p3.....used for poles

h8 h11 offsets for home



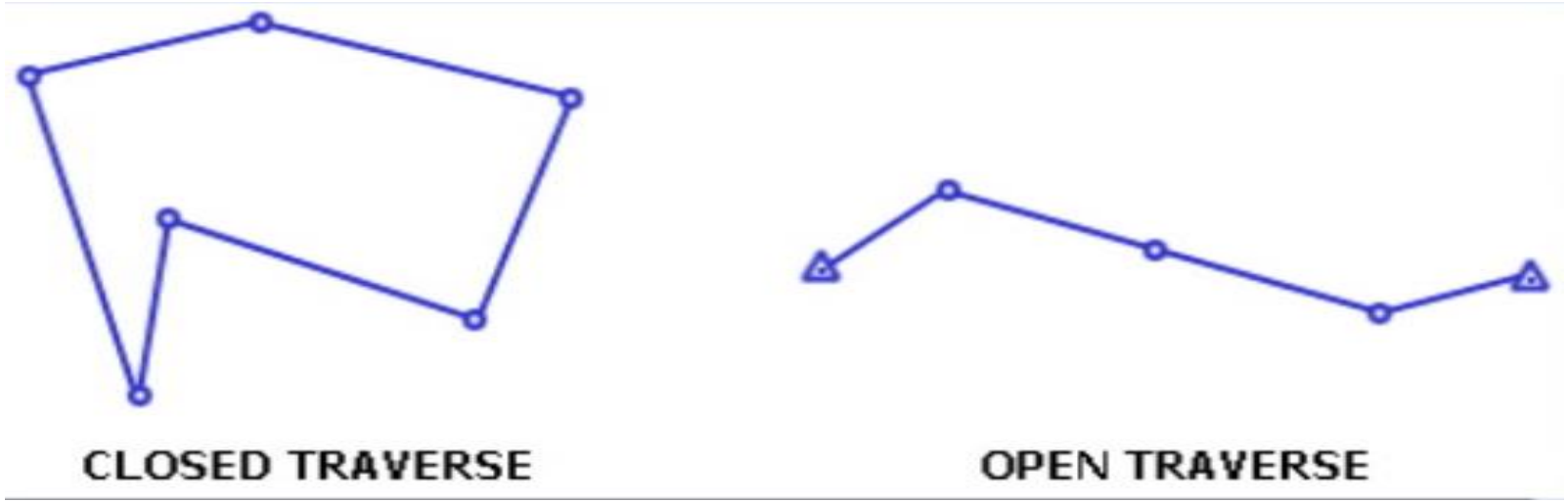


COMPASS SURVEYING

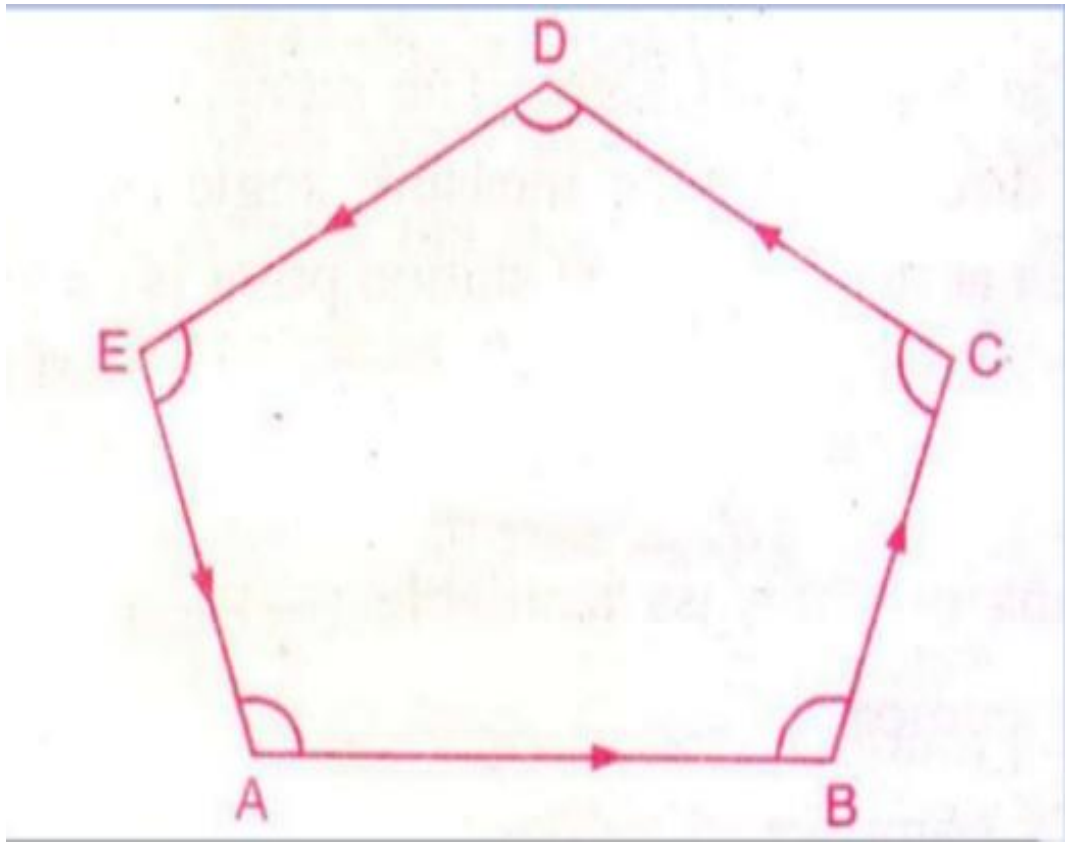
HORIZONTAL ANGLES

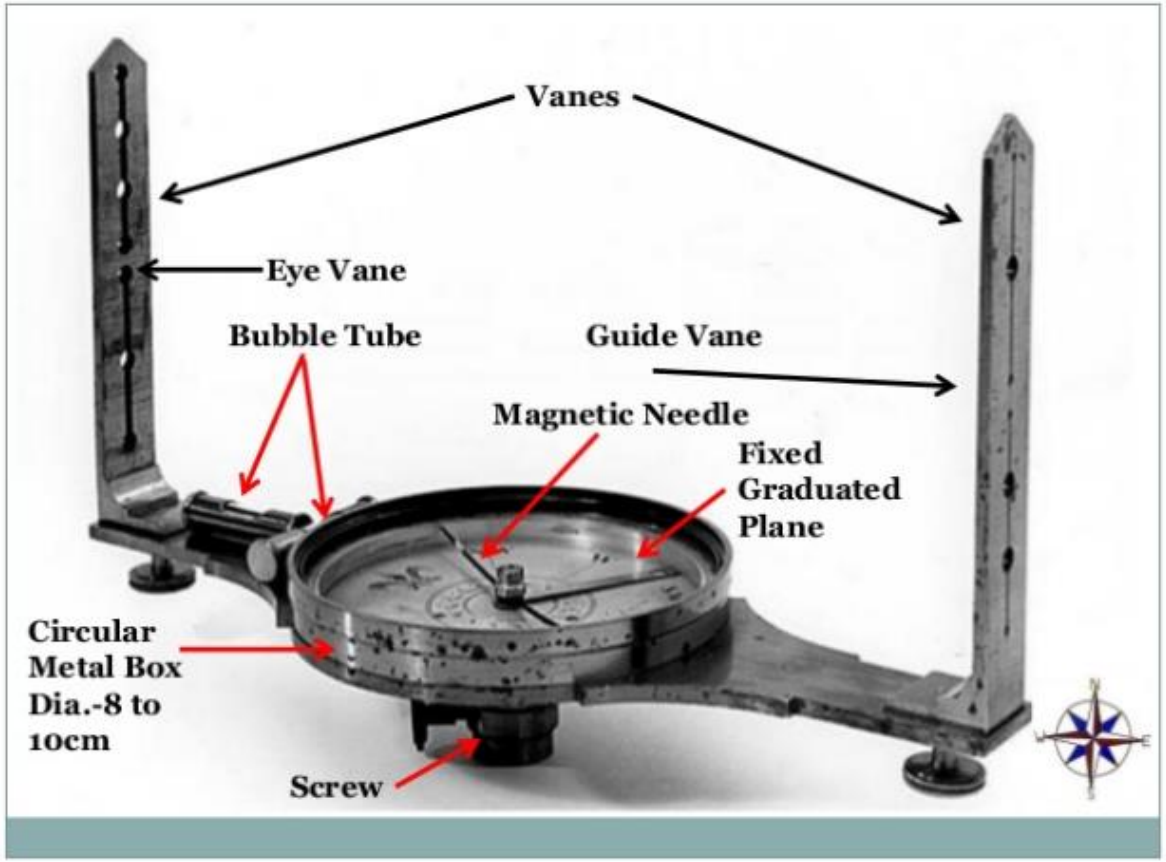
Compass Surveying

- When the area is large, undulated and crowded with many details then chain surveying is not used.
- Compass surveying is a traversing method (length are measured by chain/tapes and direction is measured by compass).



- Compass surveying is not recommended in areas where local attraction is suspected due to presence of magnetic substances in compass.
- This survey involves measurement of magnetic bearing of the lines.





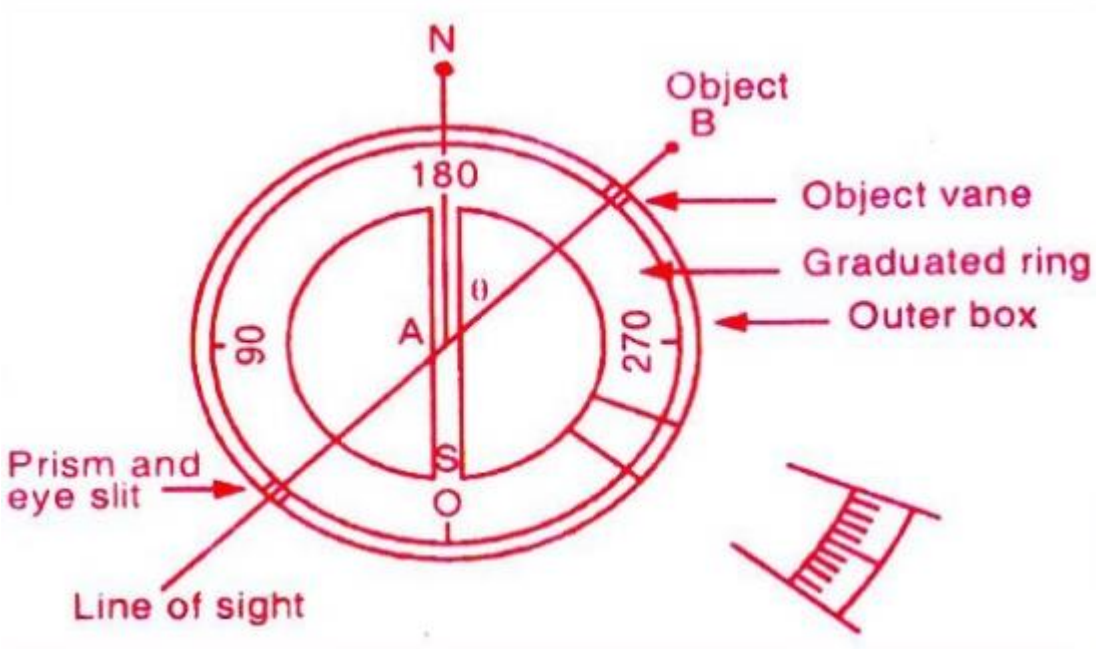
Sr. No.	Base Of Comparison	Prismatic Compass	Surveyor Compass
1	First look	Prism at one end and slit on other	No prism only Slit at both end
2	Use of Tripod Stand	May or may not use along, Steady hold in hand also give good results	Use of Tripod stand is necessary
3	Observation/ Readings	Taken with help of prism provided by eye slit	Directly read from top of compass
4	Magnetic Needle	Does not act as index	Act as index
5	Graduation	WCB system	QB system
6	Graduation marking	Appear inverted from top, Zero at south & 180 degrees at north	Mark directly Zero at North and 90 degree at East
7	Graduated circle	Attached with needle, Does not rotate with line of sight	Permanently attached with box, rotates with line of sight

Comparison between

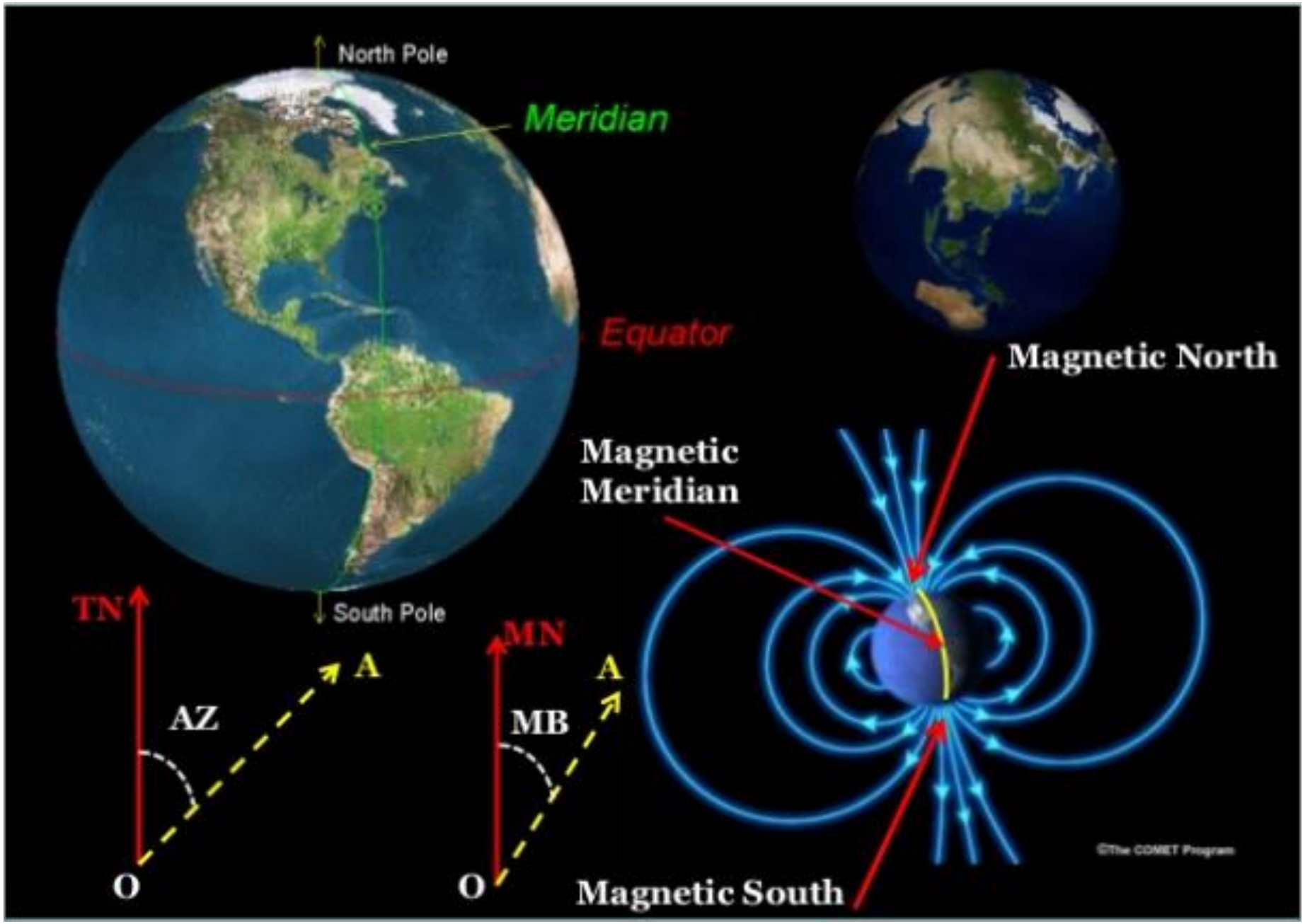
Prismatic Compass and Surveyor Compass

- **Compass:** A compass is a small instrument essentially Consisting of magnetic needle, a graduated circle, and a line of sight. The compass can not measure angle between two lines directly but can measure angle of a line with reference to magnetic meridian at the instrument station point is called magnetic bearing of a line. The angle between two lines is then calculated by getting bearing of these two lines.

When needle of a compass is suspended freely, it always point towards north. Therefore, all angles measured with compass are with respect to north (magnetic meridian).

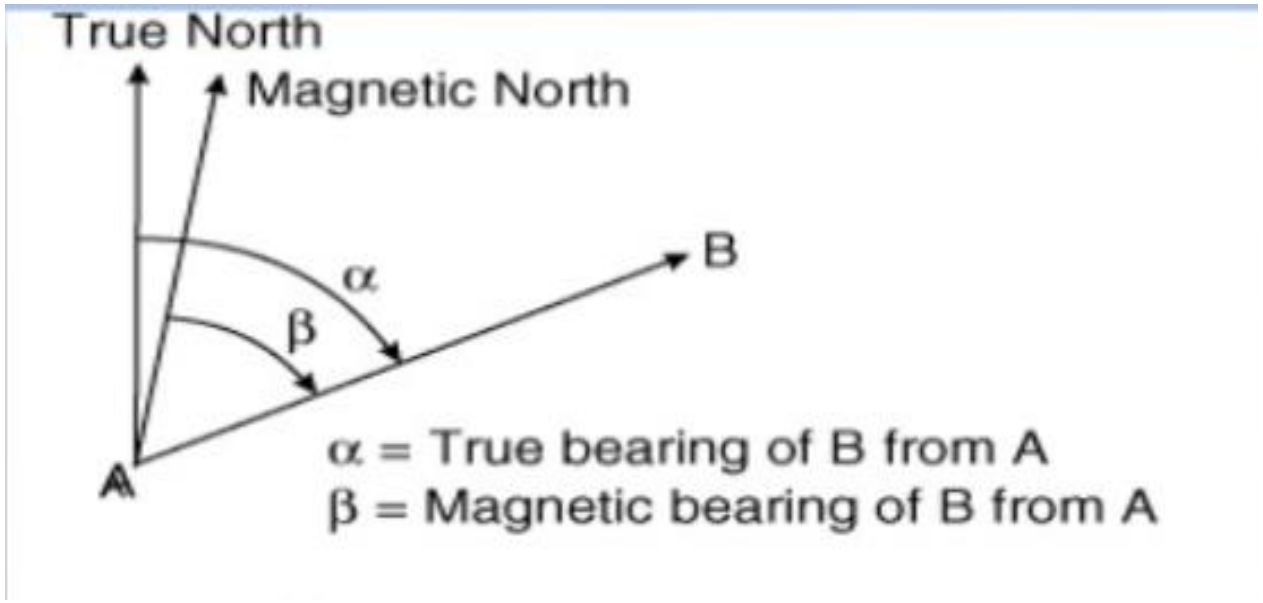


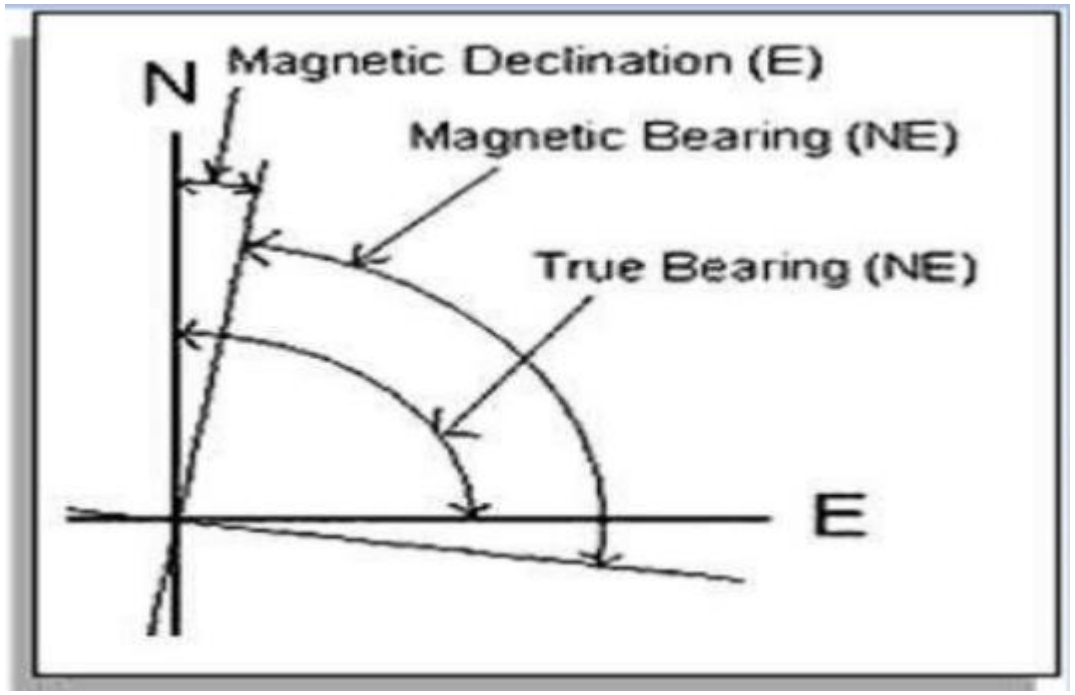
The horizontal angle made by a survey line with meridian in clockwise direction is called a bearing of a line.


North Pole
Meridian
Equator
South Pole
Magnetic North
Magnetic
Meridian
TN
A
AZ
O
MN
A
MB
O
Magnetic South
©The COMET Program

Bearing

- True Bearing
- Magnetic Bearing
- Grid Bearing
- Arbitrary Bearing





Designation of Bearing

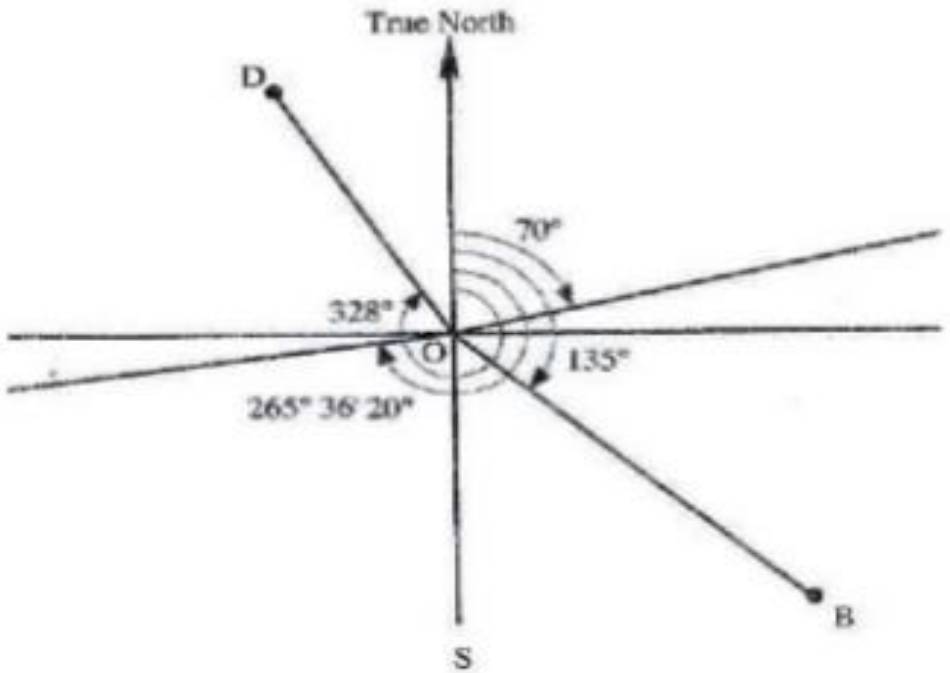
- Whole Circle Bearing System
- Quadrantal Bearing System

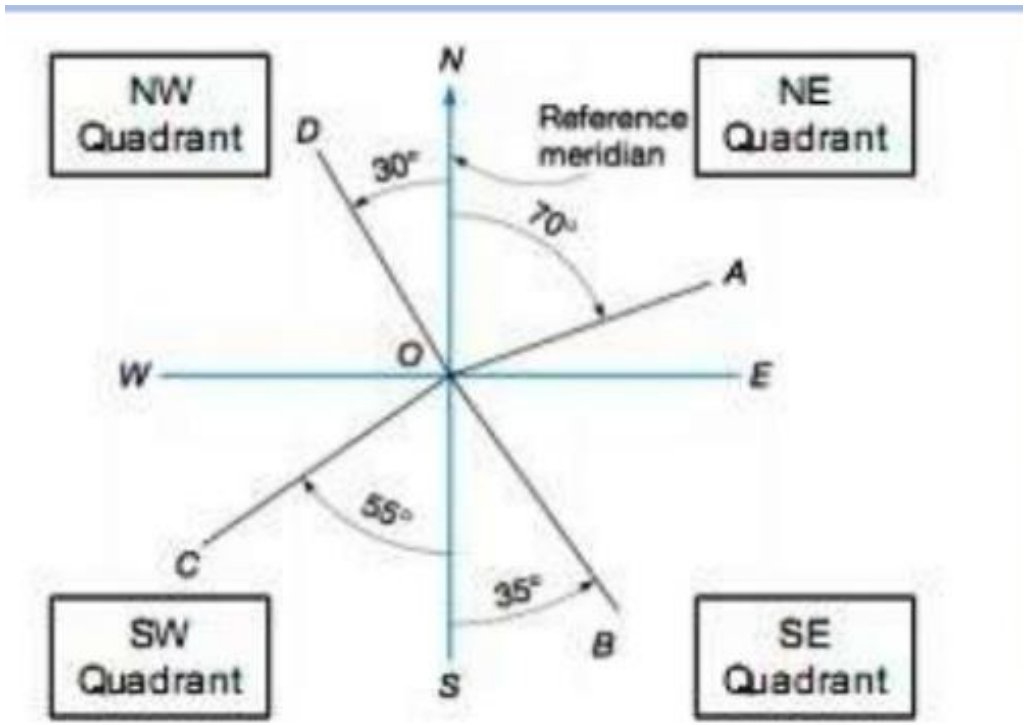
- The bearing of a line measured with respect to magnetic meridian in clockwise direction is called magnetic bearing and its value varies between 0^0 to 360^0.

- In this system, the bearing of survey lines are measured with respect to north line or south line which ever is the nearest to the given survey line and either in clockwise direction or in anticlockwise direction.

- The Quadrants start from North and Progress in a clockwise direction as the first quadrant is 0^0 to 90^0 in clockwise direction, 2^{nd} 90^0 to 180^0, 3^{rd} 180^0 to 270^0, and up to 360^0 is 4^{th} one.

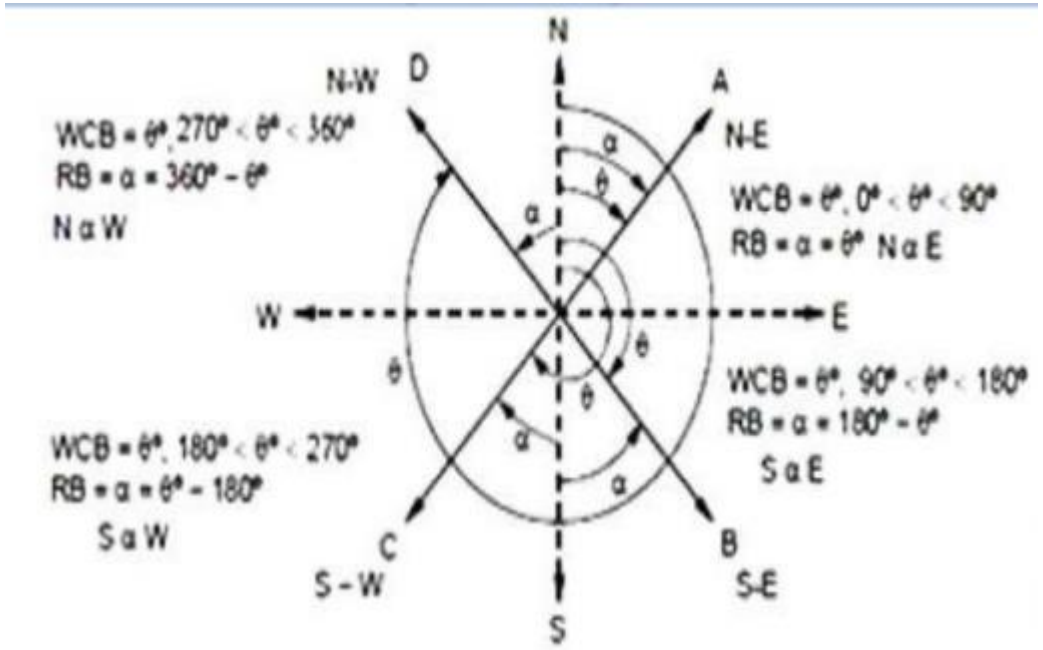
- The bearing of lines which fall in I^{st} and IV^{th} Quadrant are measured with respect to north line is nearer than south line, and bearing of lines fall in II^{nd} and III^{rd} quadrants are measured from south line as south is the nearer line. The surveyor's compass measures the bearing of lines in the quadrant system.

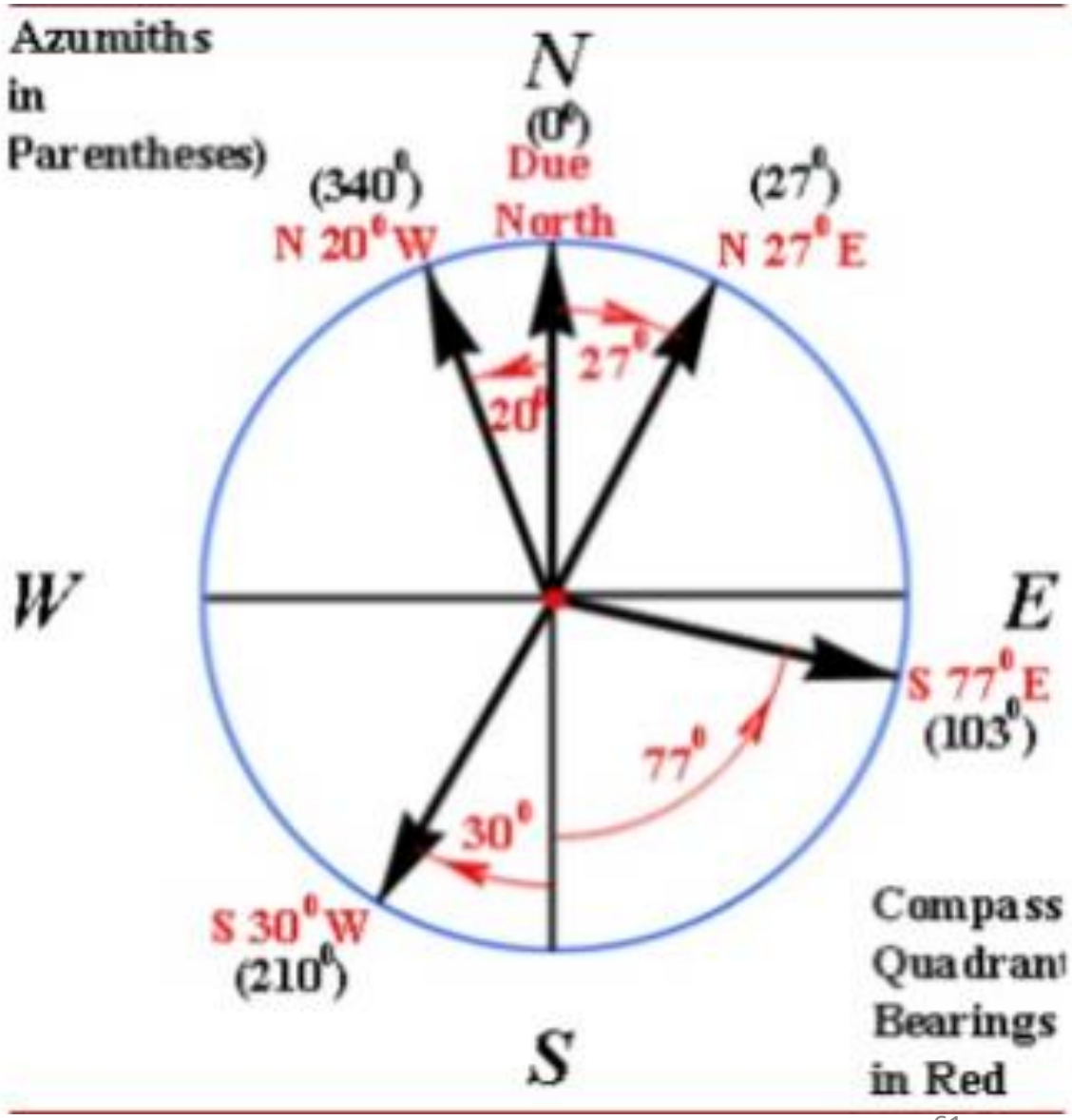




Reduced Bearing (RB)

- When the whole circle bearing of a line is converted into quadrantal bearing it is termed as 'Reduced Bearing'. Thus, the reduced bearing is similar to the quadrantal bearing. It's value lies between 0 ^{0} to 90 ^{0}, but the quadrants should be mentioned for proper designation.





WCB to RB

Case	WCB between	R.B.	QUADRANT
1	0^0 TO90^0	WCB	N-E
2	90^0 TO -180^0	180-WCB	S-E
3	180^0 TO -270^0	WCB-180^0	S-W
4	270^0 TO 360^0	360-WCB	N-W

RB to WCB

Case	R.B in quadrant	Rule of W.C.B.	W.C.B between
1	N-E	WCB=R.B	0^0 TO90^0
2	S-E	WCB =180-R.B	90^0 TO -180^0
3	S-W	WCB =R.B+180	180^0 TO -270^0
4	N-W	WCB =360-R.B	270^0 TO 360^0

Examples

- Convert the following WCB into Reduced Bearing.
- 49^0
- 240^0
- 133^0
- 335^0

Examples

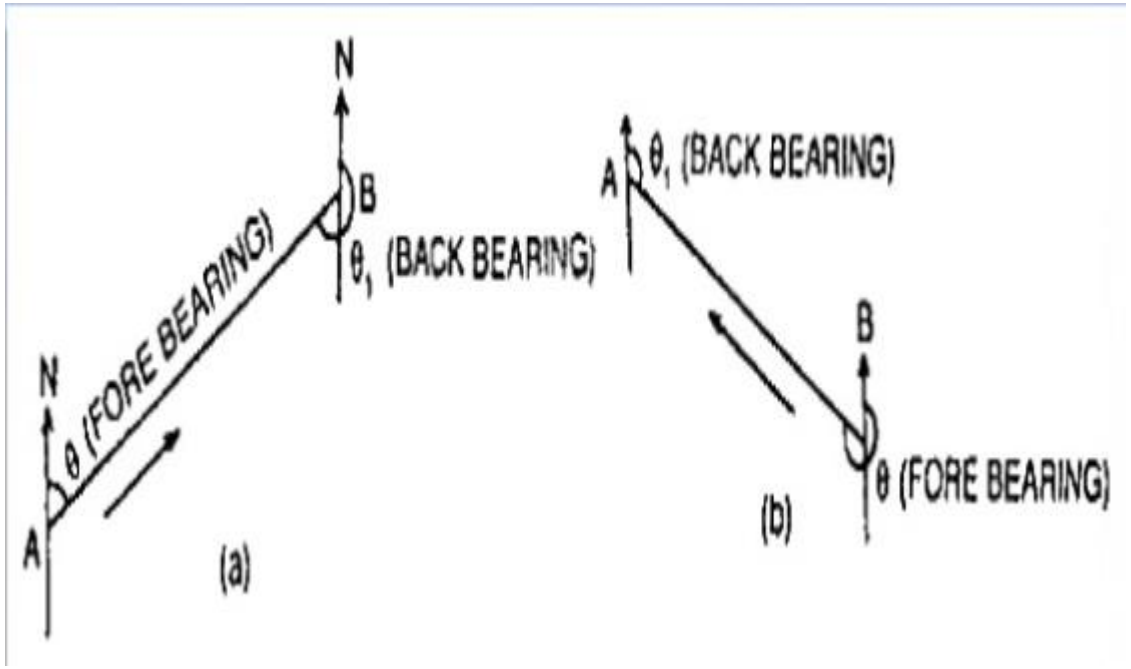
- Convert the following reduced bearings into whole circle bearings:
- N 65° E
- S 43° 15′ E
- S 52° 30′ W
- N 32° 42′ W

- The bearing of a line measured in the forward direction of survey line is called the 'Fore Bearing' (FB) of that line.
- The bearing of the line measured in the direction opposite to the direction of the progress of survey is called the 'Back Bearing' (BB) of the line.

- ForeBearing = Back Bearing ± 180°

- BB= FB ± 180 ^{0}
- + sign is applied when FB is < 180 ^{0}
- - sign is applied when FB is > 180 ^{0}

- In the quadrantal bearing (i.e. reduced bearing) system the FB and BB are numerically equal but the quadrant are just opposite.
- For example if the bearing of AB is N 60 ^{0} E, then its BB is S 60 ^{0} W.



Example

The Fore Bearing of the following lines are given Find the Back Bearing.

(a) FB of AB= $310^0\ 30'$

(b) FB of BC= $145^0\ 15'$

(c) FB of CD = $210^0\ 30'$

(d) FB of DE = $60^0\ 45'$

Example

FB of the following lines are given, find the BBs.

(a) FB of AB = **S 30^0 30' E**

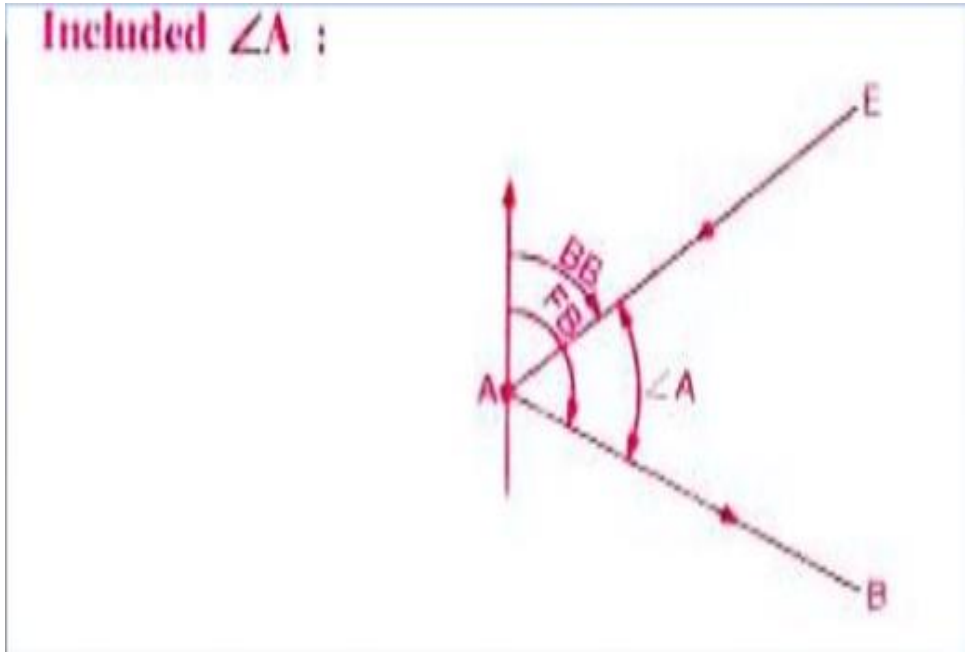
(b) FB of BC = **N 40^0 30'W**

(c) FB of CD= **S 60^0 15' W**

(d) FB of DE = **N $45^0$30' E**

Computation of Angles

- Observing the bearing of the line of a closed traverse, it is possible to calculate the included angles, which can be used for plotting the traverse.
- At the station where two survey lines meet, two angles are formed, an exterior angle and an interior angle. The interior angle or included angle is generally the smaller angle ($< 180^0$).



$$\angle A = FB \text{ of } AB - BB \text{ of } EA$$

- While calculating the interior or included angles, it is strongly recommended that a rough sketch of the traverse must be drawn for the purpose of calculating the interior angles or bearing from included angles. A sketch always gives a better idea for calculations.

- At any survey stations generally FB of one line and BB of another line are measured. Then difference of these two bearings will give you either an interior angle or an exterior angle depending upon the station position.

Computation Of Angles

- In a closed traverse the following bearings were observed with a compass. Calculate the interior angles.

Line	Fore bearing
AB	65° 00′
BC	125° 30′
CD	200° 00′
DE	265° 15′
EA	330° 00′

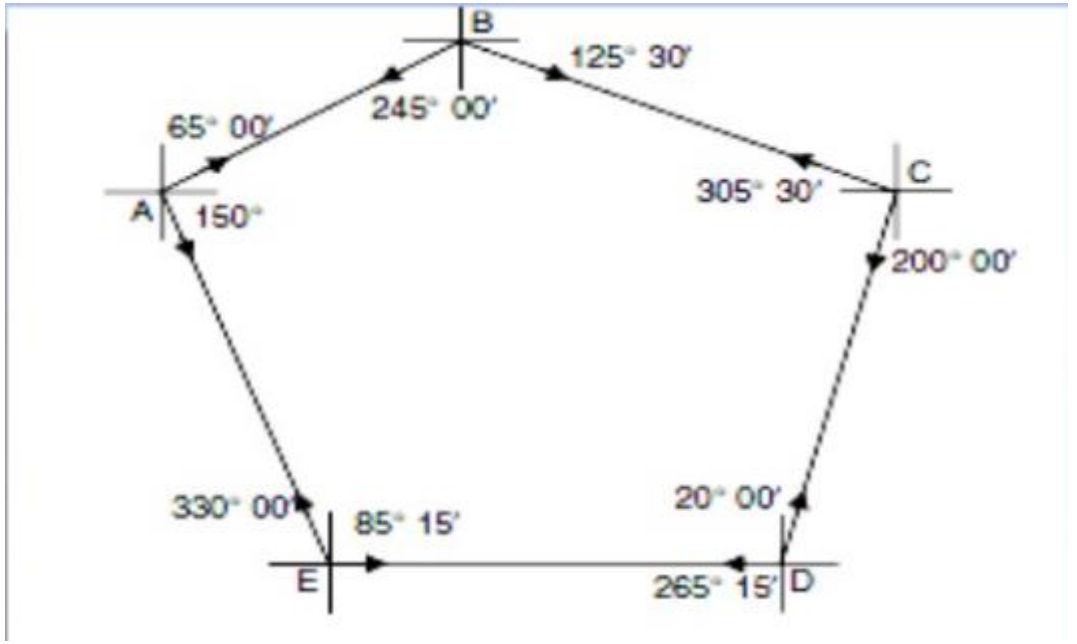
We find,

Back Bearing = Fore Bearing ± 180

+ 180 is used if θ is less than 180 and

– 180 is used when θ is more than 180

Line	*Fore bearing*	*Back bearing*
AB	65° 00′	245° 00′
BC	125° 30′	305° 30′
CD	200° 00′	20° 00′
DE	265° 15′	85° 15′
EA	330° 00′	150° 00′



Referring to Figure:

∠A = 150 00′ – 65 00′ = 85 00′

∠B = 245 00′ – 125 30′ = 119 30′

∠C = 305 30′ – 200 00′ = 105 30′

∠D = (360 – 265 15′) + 20 00′ = 114 45′

∠E = (360 – 330 00′) + 85 15′ = 115 15′

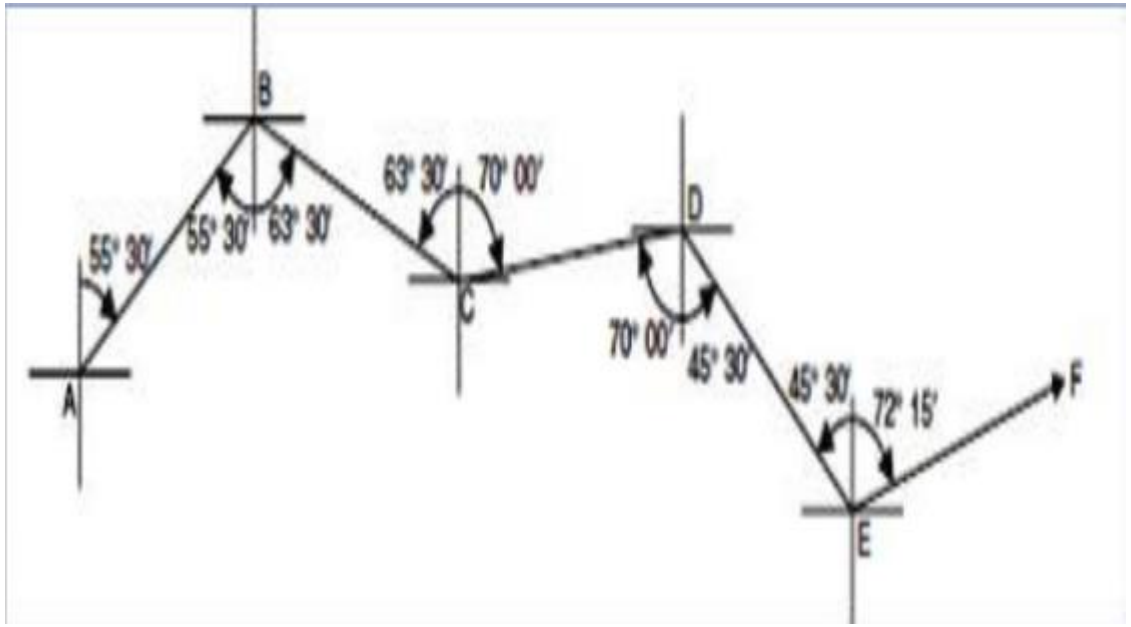
Computation Of Angles

- The angles observed with a surveyor compass in traversing the lines AB, BC, CD, DE and EF are as given below.
- Compute the included angles and show them

Line	Fore bearing
AB	N 55° 30′ E
BC	S 63° 30′ E
CD	N 70° 00′ E
DE	S 45° 30′ E
EF	N 72° 15′ E

In case of RB, back bearing of a line can be obtained by interchanging N and S at the same time E and W

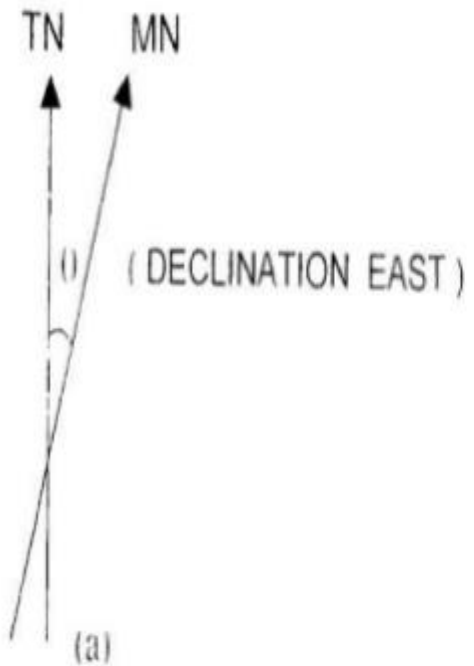
Line	FB	BB
AB	N 55° 30′ E	S 55° 30′ W
BC	S 63° 30′ E	N 63° 30′ W
CD	N 70° 00′ E	S 70° 00′ W
DE	S 45° 30′ E	N 45° 30′ W
EF	N 72° 15′ E	S 72° 15′ W.

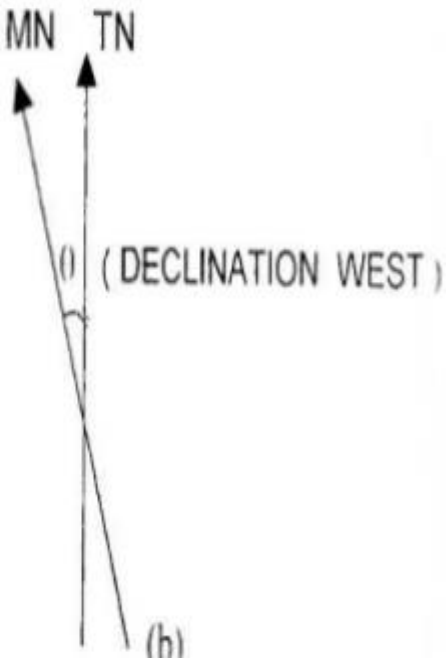


- Referring to the figure, we find
- $\angle B = 55\ 30' + 63\ 30' = 119\ 00'.$
- $\angle C = 63\ 30' + 70\ 00' = 133\ 30'.$
- $\angle D = 70\ 00' + 45\ 30' = 115\ 30'.$
- $\angle E = 45\ 30' + 72\ 15' = 117\ 45'.$

Magnetic Declination

- The horizontal angle between the magnetic meriadian and true meridian is known as 'Magnetic declination'
- When the north end of the magnetic needle is pointed towards the west side of the true meridian the position is termed as 'Declination West (ϴW).
- When the north end of the needle is pointed towards east side of the true meridian the position is termed as 'Declination East (ϴ E)





Determination of True bearing and and Magnetic Bearing

- **True Bearing = Magnetic Bearing ± Declination**
- Use + sign when declination is towards East
- Use – sign when declination is towards West

- **Magnetic Bearing = True Bearing ± Declination**
- Use + sign when declination is towards West
- Use – sign when declination is towards East

Example

- The magnetic bearing of a line AB is $135^0\ 30'$. What will be the true bearing, if the declination is $5^0\ 15'$ W
- The true bearing of a line CD is $210^0\ 45'$, what will be its be its magnetic bearing of the declination is $8^0\ 15'$ W

- True Bearing of AB = Magnetic Bearing – Declination
  $= 135^0\ 30' - 5^0\ 15' = 130^0\ 15'$
- Magnetic Bearing of AB = True bearing – Declination
  $= 210^0\ 45' + 8^0\ 15' = 219^0$

Local Attraction

- North end of a freely suspended magnetic needle will always point towards the magnetic north, if it is not influenced by any other external forces except the earth's magnetic field. It is common experience that the magnetic needle gets deflected from its normal position, if placed near magnetic rocks, iron ore, cables carrying currents or iron electric poles., therefore , not reliable unless these are checked against the presence of local attraction at each station and their elimination.

- It may be noted that local attraction at any station affects all the magnetic bearings by an equal amount and hence, the included angles deduced from the affected bearing are always correct.

- In case the fore and back bearing of neither line of traverse differ by the permissible error of reading, the mean value of the bearing of the line least affected may be accepted. The correction to other stations, may be made according to the following methods.
- **By calculating the Included Angles at the affected stations**
- **By checking the required correction, starting from the unaffected bearing.**

Detection of Local Attraction

- The presence of local attraction at any station may be detected by observing the fore and back bearing of the line. If the difference between fore and back bearing is 180^0, both end station are free from local attraction. If not, the discepancy may be due to
- An error in observation of either fore and back bearing or both
- Presence of Local Attraction at either station
- Presence of local Attraction at both the stations

Sources of Error in Compass Survey

The errors may be classified as

(i) Instrumental Error

(ii) Error of manipulation and sighting

(iii) error due to external influence

Error due to Manipulation and Sighting

- Inaccurate centring of the compass over the station occupied
- Inaccurate leveling of the compass box when the instrument is set up
- Imperfect bisection of the ranging rods at station or other objects
- Carelessness is reading the needle or in reading the graduate circle through the prism in a wrong direction.
- Carelessness in recording the observed reading.

Instrumental Errors

- Needle not being perfectly straight
- The pivot being bent, i.e. not being at the centre of the graduated circle.
- The needle being sluggish, i.e. the needle having lost its magnetism
- The pivot point being dull
- The needle neither moving horizontally nor moving freely on the pivot due to the dip of the needle.
- The plane of sight not passing through the centre of the graduated ring
- The vertical hair being too thick or loose.

Error due to External Influences

- Magnetic changes in the atmosphere on a cloudy or stormy day.
- Irregular variation due to magnetic storms, earthquakes, sun spots, lunar perturbations etc.
- Variation in declination, viz, secular, annual and diurnal.
- Local attraction due to proximity of steel structure, electric lines.

Precaution to be taken in Compass Surveying

The following precaution should be taken conducting a compass traverse

- The centring should be done perfectly
- To stop the rotation of the graduation ring, the break pin should be pressed very gently and not suddenly.
- Reading should be taken along the line sight and not from any side.
- When the compass has to be shifted from one station to other, the sight vane should be folded over the glass cover. This is done to lift the ring out of the pivot to avoid unnecessary wear of the pivot.
- The compass box should be tapped gently before taking the reading. This is done to find out whether the needle rotates freely.
- The station should not be selected near magnetic substances.
- The observer should not carry magnetic substances.
- The glass cover should not be dusted with a handkerchief, because the glass may be charged with electricity and the needle may be deflected from its true direction. The glass cover should be cleaned with a moist finger.