1.5 Surveying and levelling: Fundamentals of surveying; measurements (linear distance, vertical distance, and angle and directions); levelling; topographic survey (principles and applications); Simple circular curves, principles and applications of GPS/GIS. (ACiE0105)

Day 2

NEC License Examination
PANA Academy

Prepared By
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MCQ.

1. Discrepancy means difference between

A. True value and error

B. Measured value and actual value

C. Two measured value of same physical quantity

D. Any of the above

2. If the smallest division of the vernier is shorter than smallest division of main scale, then the vernier is known as

A. Direct vernier

B. Simple vernier

C. Double vernier

D. Retrograde vernier

Types of Errors in Surveying

Mistakes:

- Due to inexperience, carelessness and poor judgment or confusion in the observer's mind.
- Also known as **gross errors/blunders**, and they cannot be measured.
- *Example: reading a 6 as 9 in staff.*

Systematic or Cumulative Errors:

- Due to surveying equipment, observation methods, and certain environmental factors.
- A systematic error always follows some definite mathematical or physical law, and correction can be applied.

Examples:

- Using an imperfectly adjusted instrument.
- if a tape is P cm short and is stretched N times, the total error in the length measurement will be P*N cm.

Compensating Errors:

This type of surveying error tends to occur in both directions, i.e., the errors may sometimes be positive and sometimes negative, thereby compensating each other.

Example:

- Too much Sag at one time is compensated by too much pull at second time.
- A person observes a reading one time higher and other time lower than what it is.

Accidental/random Errors:

- due to unavoidable circumstances like variations in atmospheric conditions.
- due to imperfection in measuring instruments and even imperfection of eyesight fall in this category.
- They are random and thus cannot be accounted for.

MCQ.

1. Which of the following error relies on Theory of probability?

A. Cumulative error

B. Curvature error

C. Compensating error

D. Accidental error

2. A surveyor made an error which is despite his skill and vigilance. Which type of error this surveyor has committed?

A. Mistake

B. Random error

C. Systematic error

D. None.

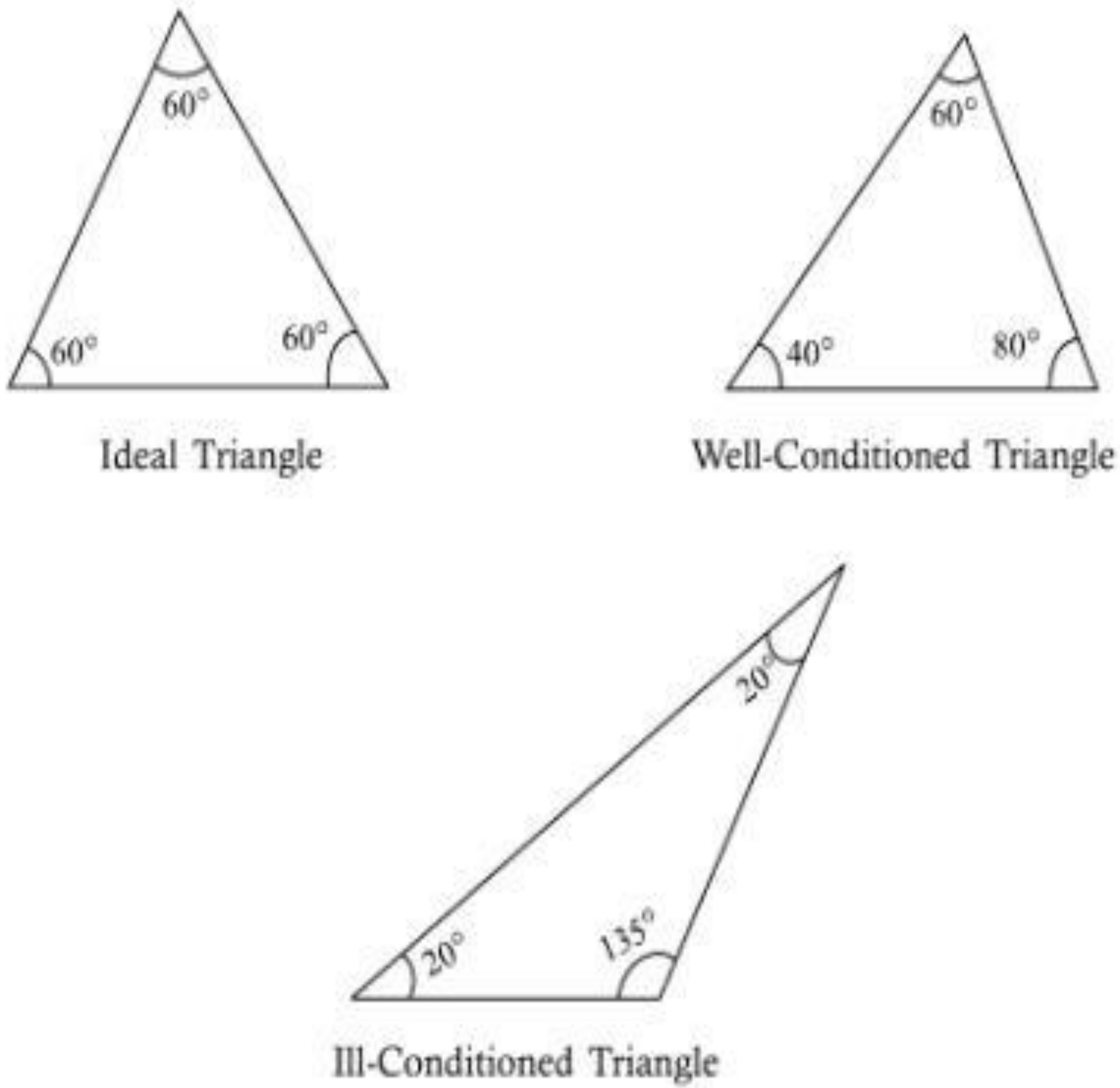
- **Error:** The difference between measured value and the true value is called error.
- **Discrepancy:** The difference between the two measured values of a quantity is called discrepancy
- **Residual error:** The difference between the measured value and the most probable value is called residual error

Chain surveying

- Principle: Triangulation

Possible Network of triangles:

- *Well conditioned*
- *Ill conditioned*
- *ideal*



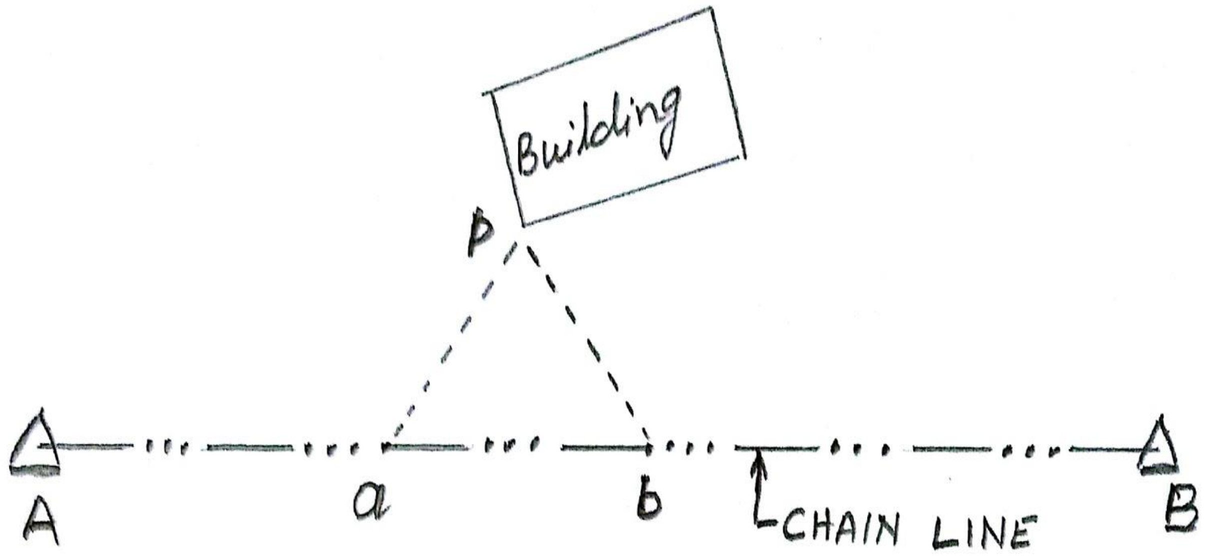
Offsets

Short offsets: < 15 m

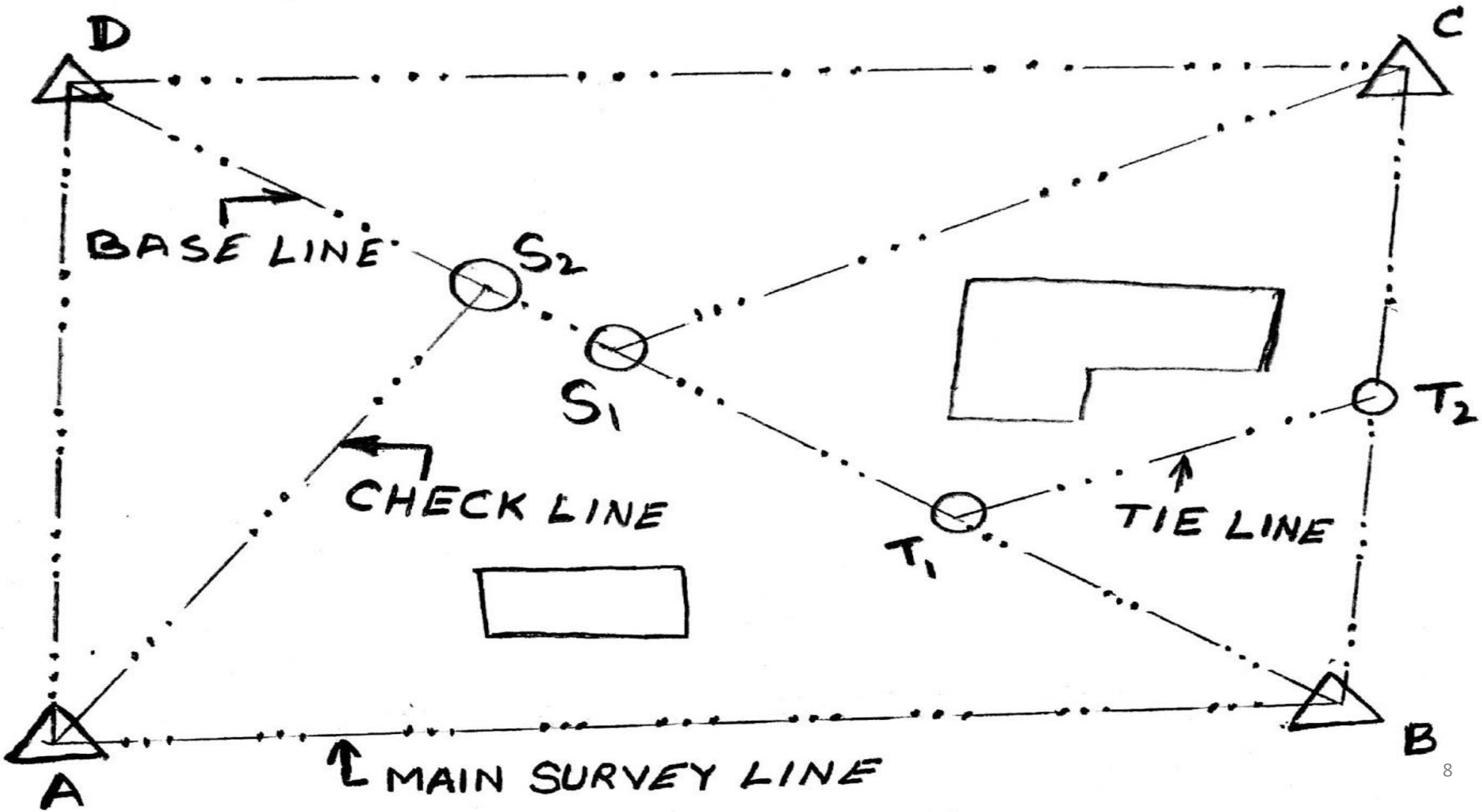
Long offsets: >15 m length.

Methods of taking offsets:

1. Perpendicular: When there is no obstruction,
2. Oblique offsets : used for long distant objects.



Lines in chain survey



MCQ:

In chain surveying tie lines are primarily provided

a) to check the accuracy of the survey
b) to take offsets for detail survey
c) to avoid long offsets from chain lines
d) to increase the number of chain lines

Q. Every 20 m chain should be accurate to within

a)± 5 mm

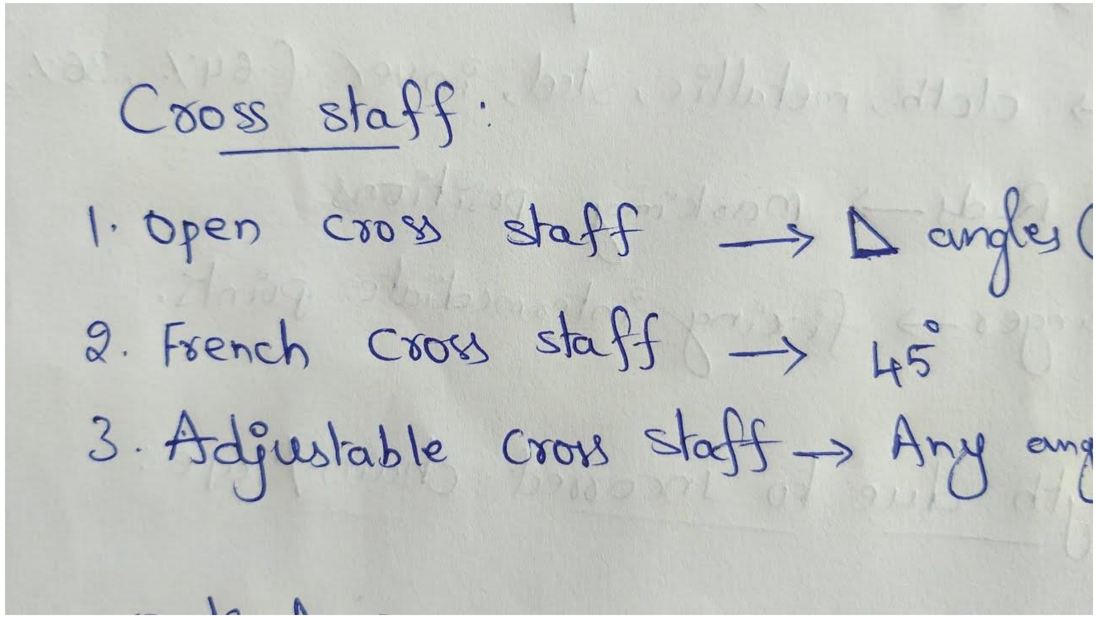
b)± 8 mm

c)± 3 mm

d)None of these

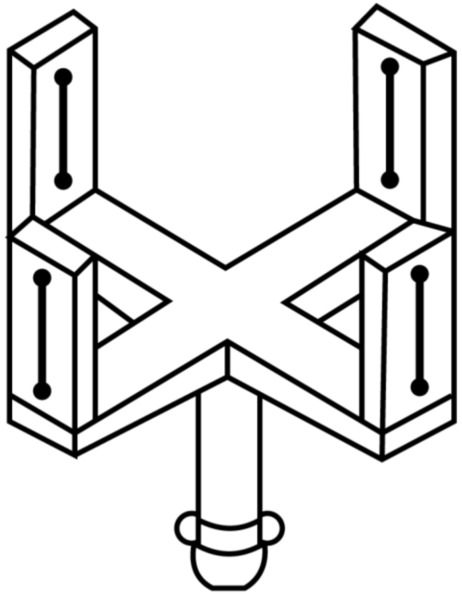
Accessories in Chain surveying

Cross staff



Cross staff:

1. Open cross staff → Δ angles (
2. French cross staff → 45°
3. Adjustable cross staff → Any ang



Open cross staff

French cross staff

- The French Cross Staff has Eight Faces on it.
- Each Face is connected to the other with a 45 Degree Angle.

Optical square and prism square

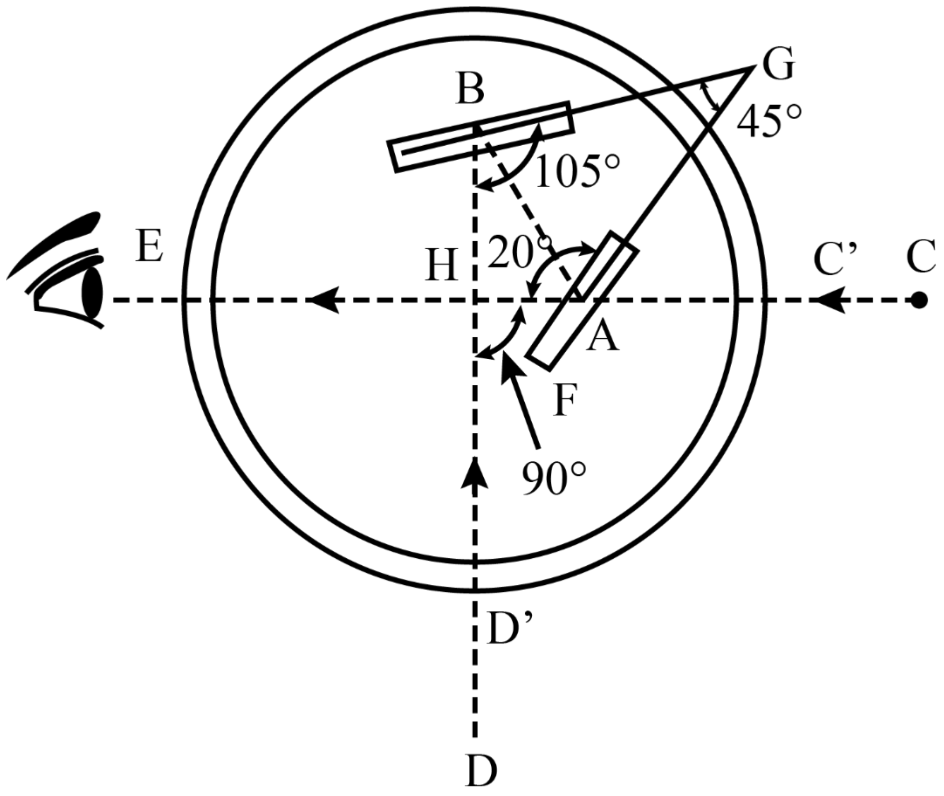
- To set out right angle to a chain line.

Optical Square:

- It is more accurate than cross-staff for setting out right angles.

- Consists of two mirrors making a 45° with each other.

Optical square ctd…



MCQ. ***The construction of optical square is based on the principle of***

A. Refraction

B. Reflection

C. Double refraction

D. Double reflection

Obstacles in chain survey

- **Obstacle to ranging**
- Hill/raised ground.
- These obstacles can be overcome by reciprocal ranging.
- **Obstacle to chaining**
- Ponds, lakes.
- **Obstacle to both chaining and ranging**
  Building.

Correct/limiting length of offset

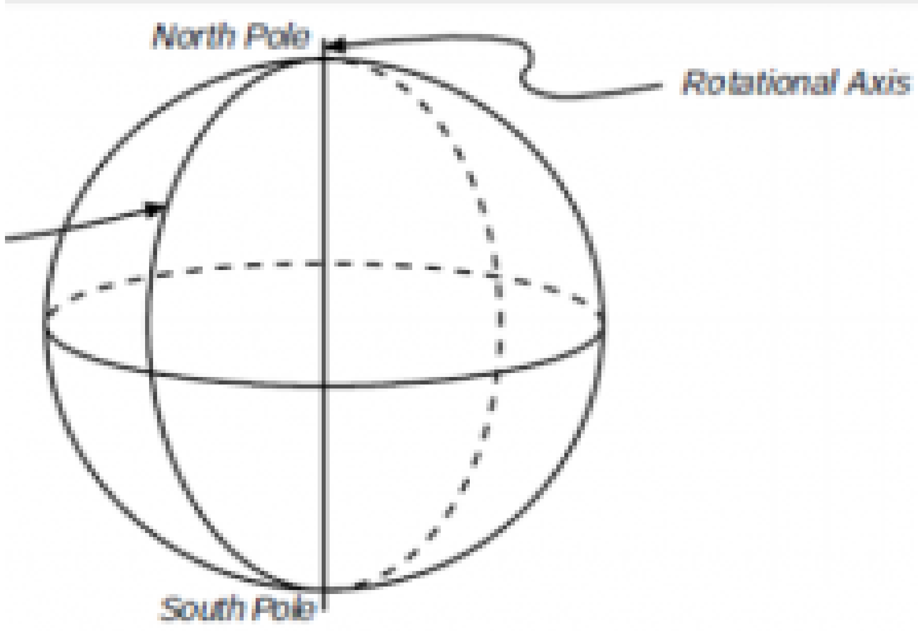
$L = 0.025n \operatorname{cosec}\alpha°$...... in m.

Where,

Scale of plan 1cm=n metre

Compass surveying

- Principle: Traversing



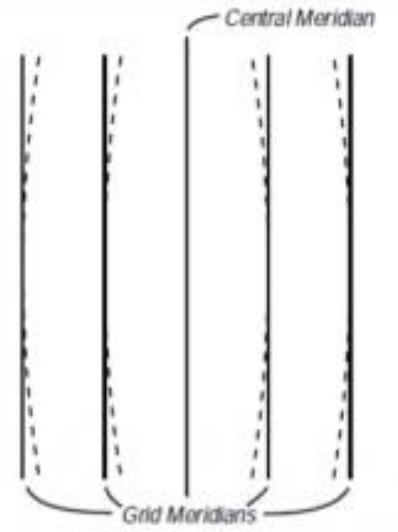
Type of meridians

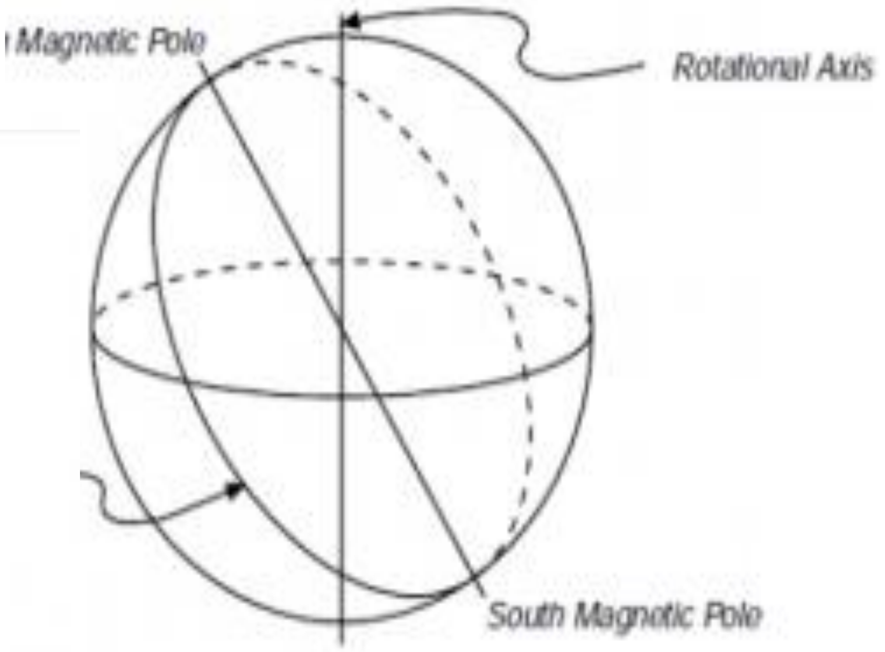
1. True Meridians(Astronomical)

2. Magnetic meridian
   - Shown by a freely suspended magnet.

3. Grid Meridian

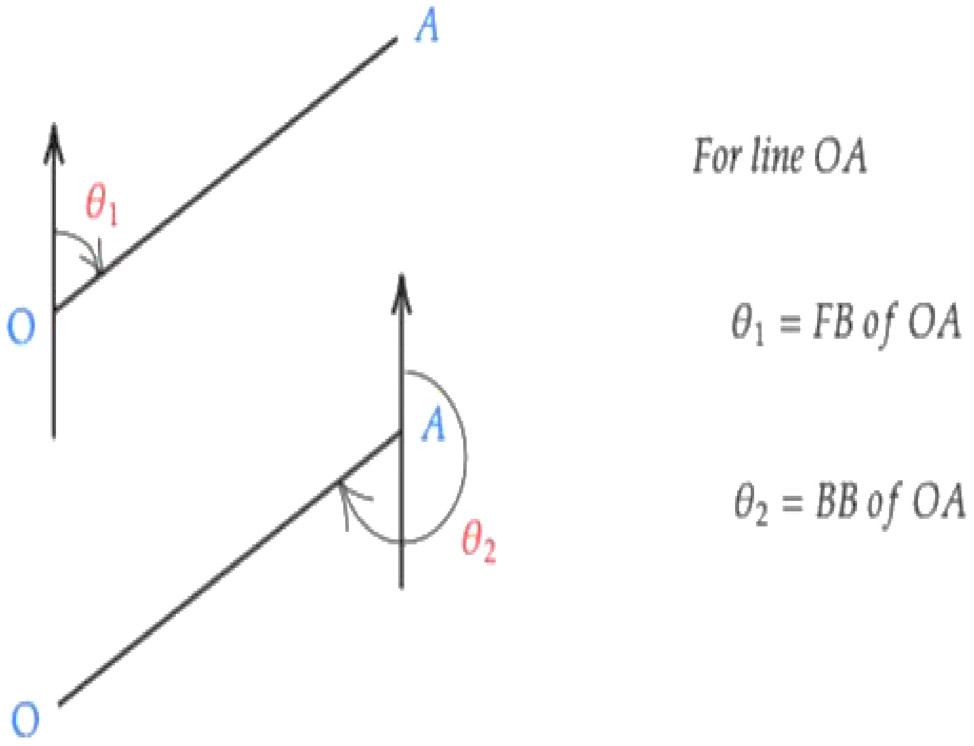
4. Arbitrary meridian
   - Randomly Assumed
   - Eg. Chimney top.

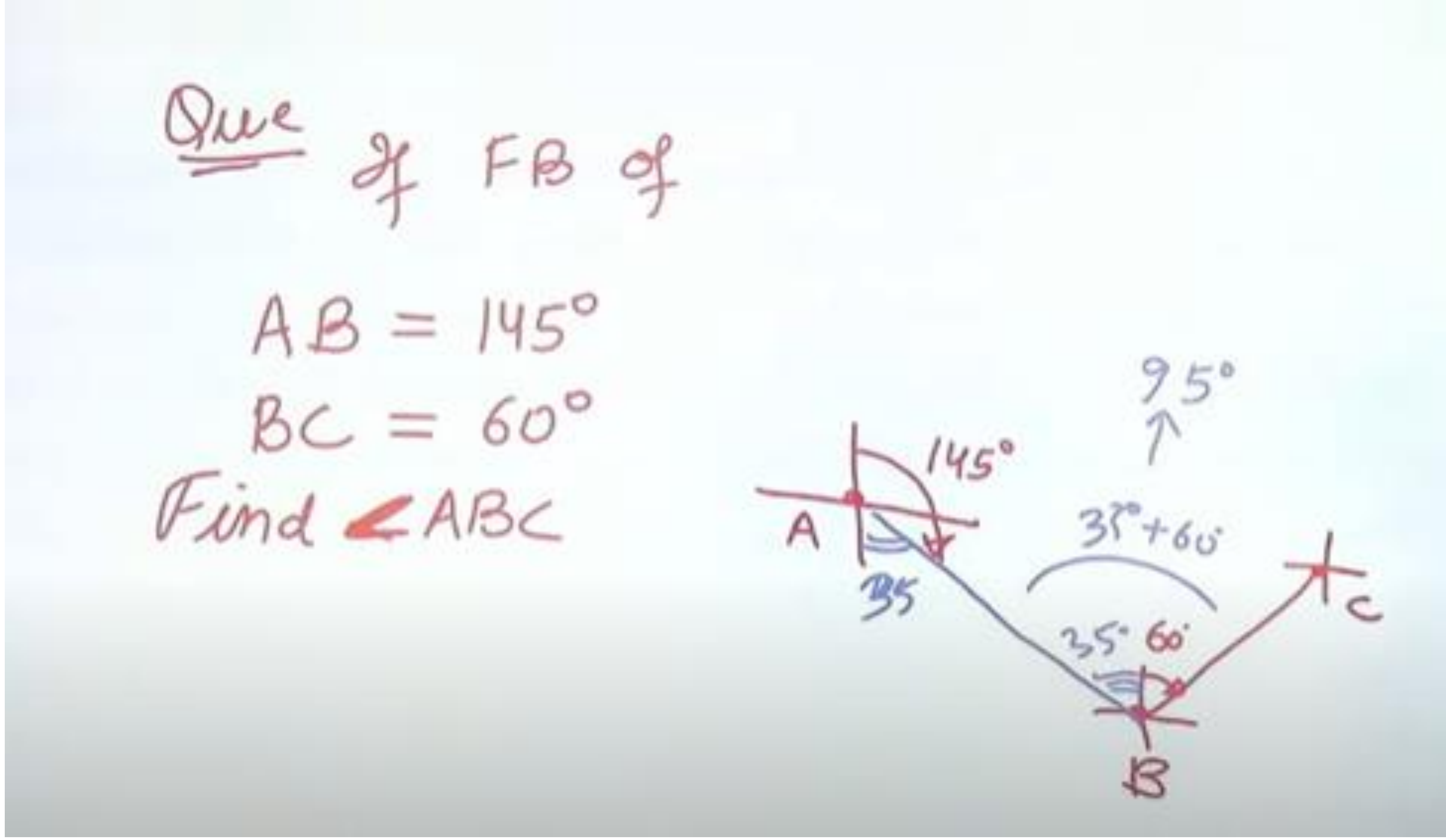




- **Bearing**: Horizontal Angle of a line with standard reference line or meridian.
- Fore bearing and back bearing

  FB =BB ± 180°





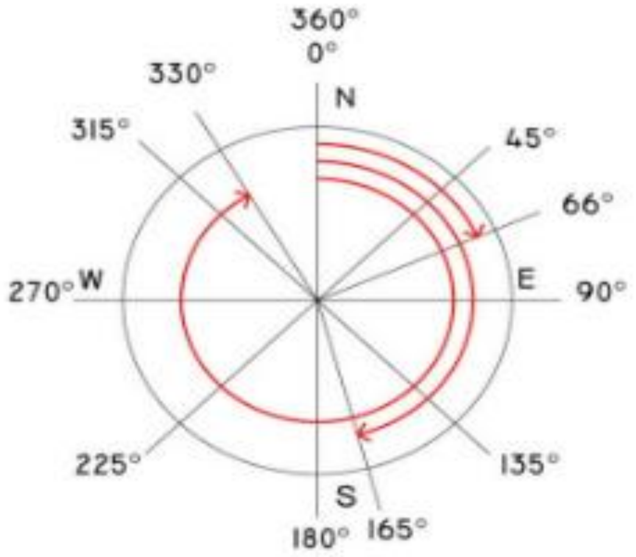
By formula,

Included angle=FB of new line- FB of previous line ± 180°

Designations of bearings

1.Whole circle bearing system/Azimuthal system

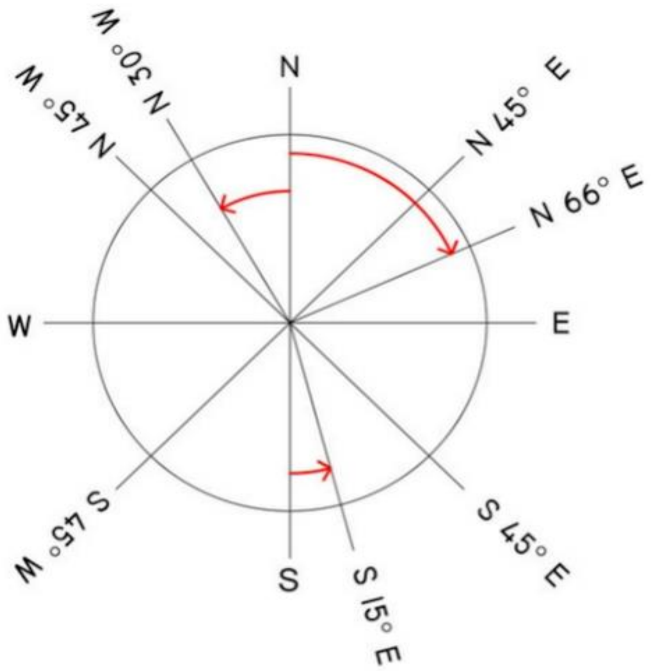
- The value of the bearing varies from 0 to 360 degrees.
- Bearing of a line is measured from magnetic north in a clockwise direc
- Prismatic compass is graduated in this system.



Whole Circle Bearing

2. Quadrantal/Reduced bearing system

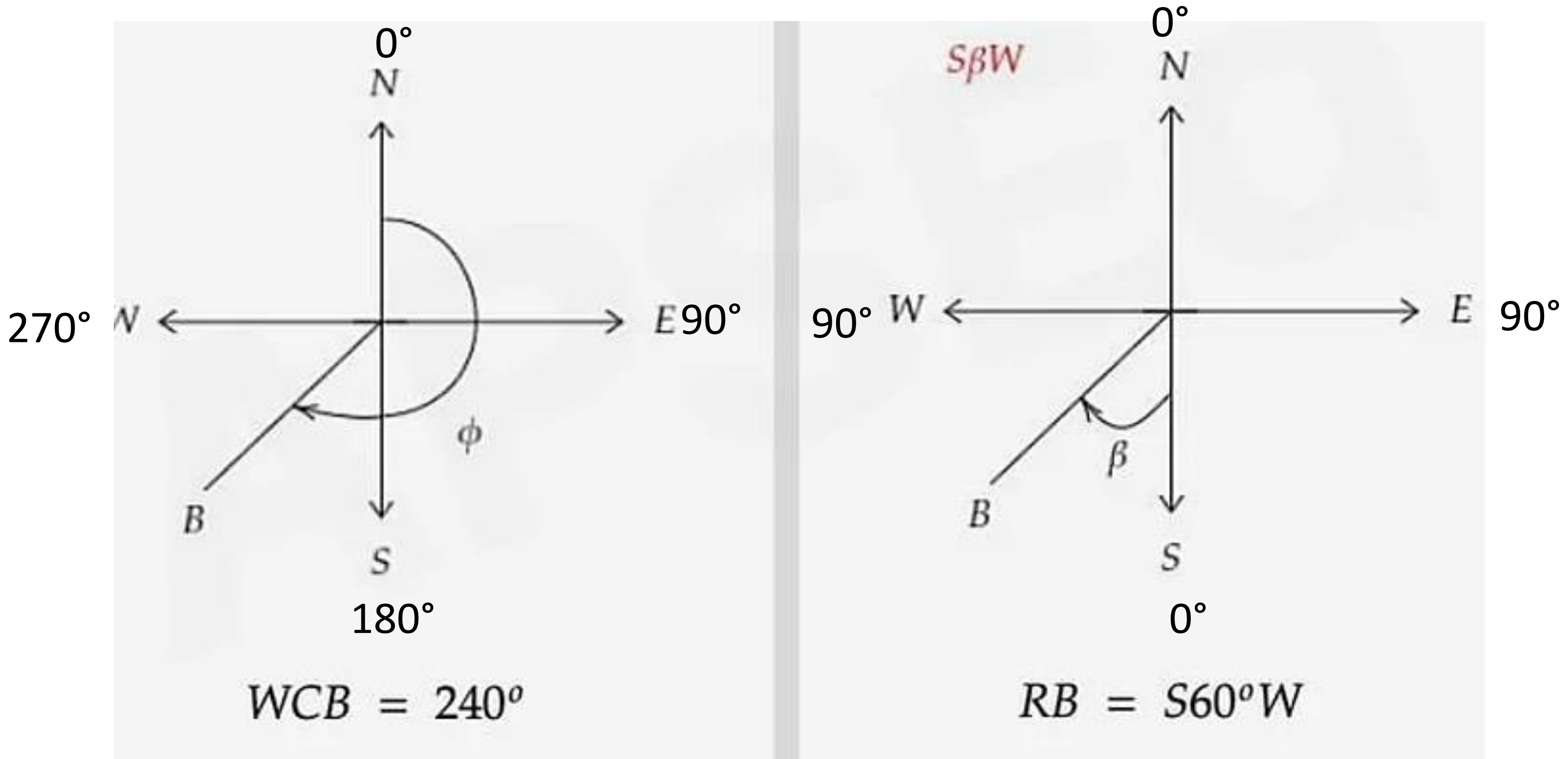
- The value of the bearing thus varies from 0 to 90 degrees.
- Bearing of a line is measured from north or south, whichever is near.
- Direction can be either clockwise of anticlockwise.
- Surveyor compass.



Quadrantal Bearing

Whole circle bearing(WCB) and quadrant or reduced bearing(QB) systems.

Q. Write 240° in Reduced bearing system.

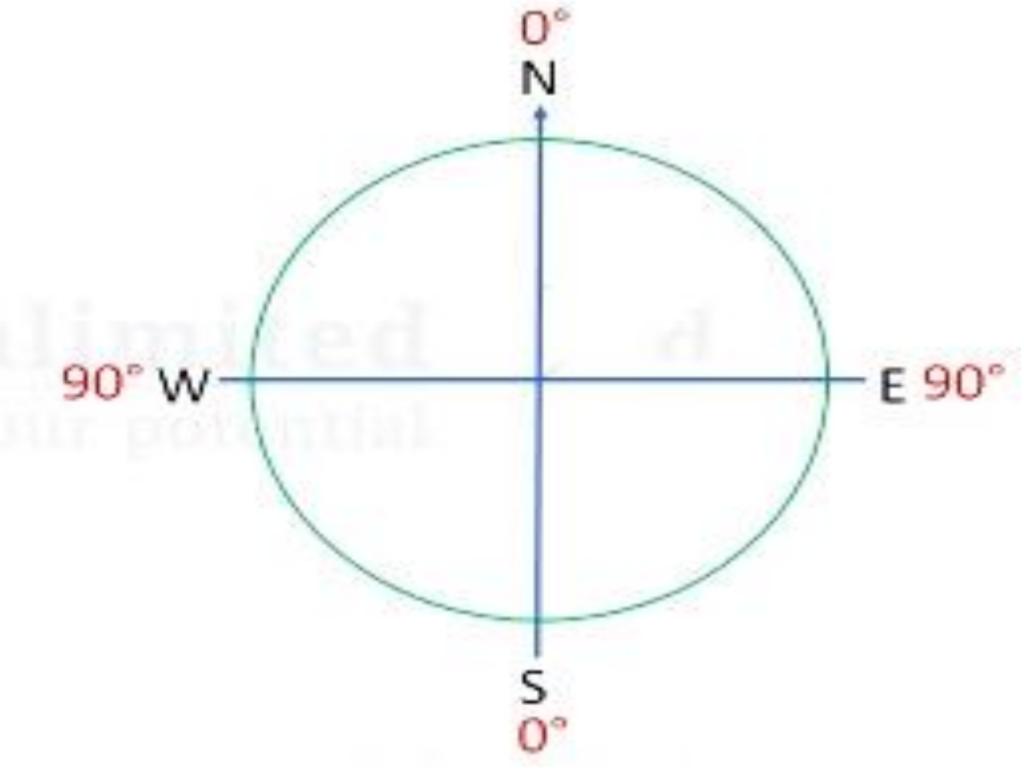


When a line exactly lies along the directions.:

WCB	RB
0°	N or N 0°
90°	E90°
180°	S or S 0°
270°	W 90°

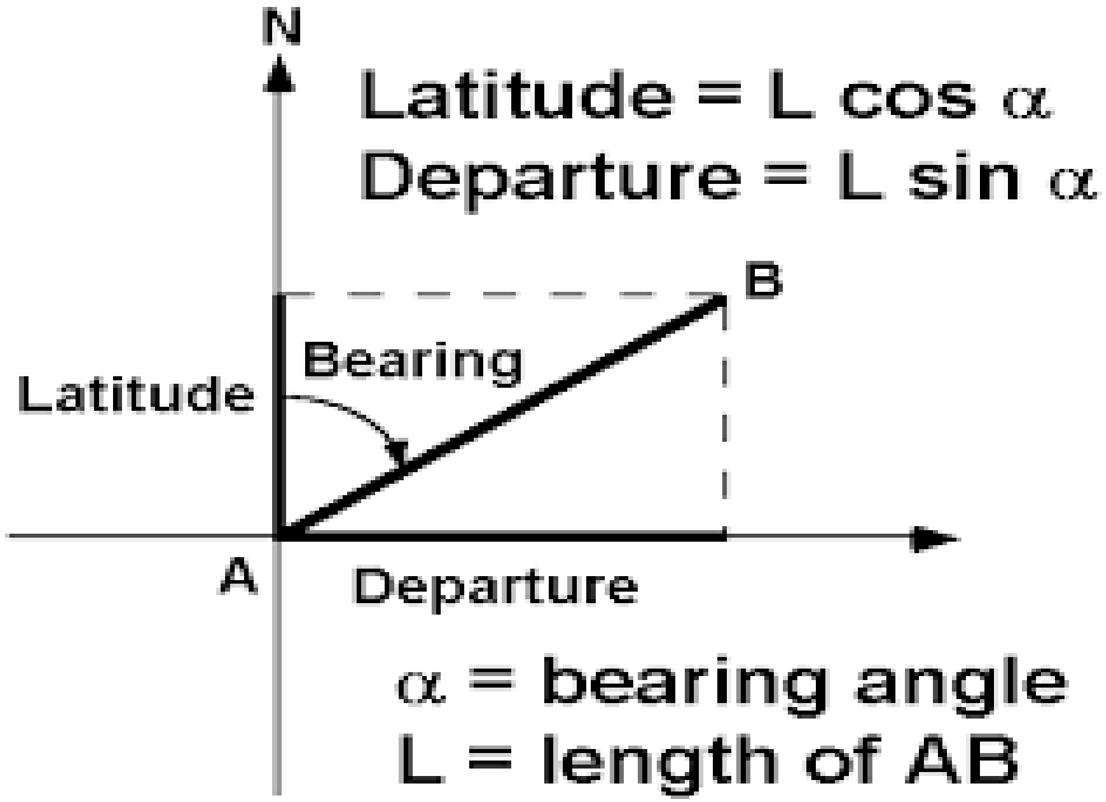
In case of quadrantal bearing system, The numerical value of FB & BB is equal but the quadrants are just opposite.

Eg. FB is **N30^{0}E** then its BB is **S30^{0}W**



Important Point

- Least count of **Prismatic Compass** = 30 minutes = 30′
- Least Count of **surveyor's Compass** = 15 minutes = 15′



In a closed traverse,
Sum of internal angles = $(2N - 4) \times 90^{\circ}$
Sum of external angels = $(2N + 4) \times 90^{\circ}$
Algebraic sum of deflection angles = 360°

Adjusting the traverse

1. Bowditch's rule/compass rule:

- When linear and angular measurements are of equal precision.

2. Transit rule:

When angular measurements are more precise than linear one.

Dip and declination

- **Dip :-**

❖ Inclination of needle with horizontal in the vertical plane.

❖ 0 degree at equator and 90 degree at poles.

- **Declination: -**

❖ Horizontal angle between magnetic and true north in the horizontal plane.

❖ True bearing = magnetic bearing ± declination angle

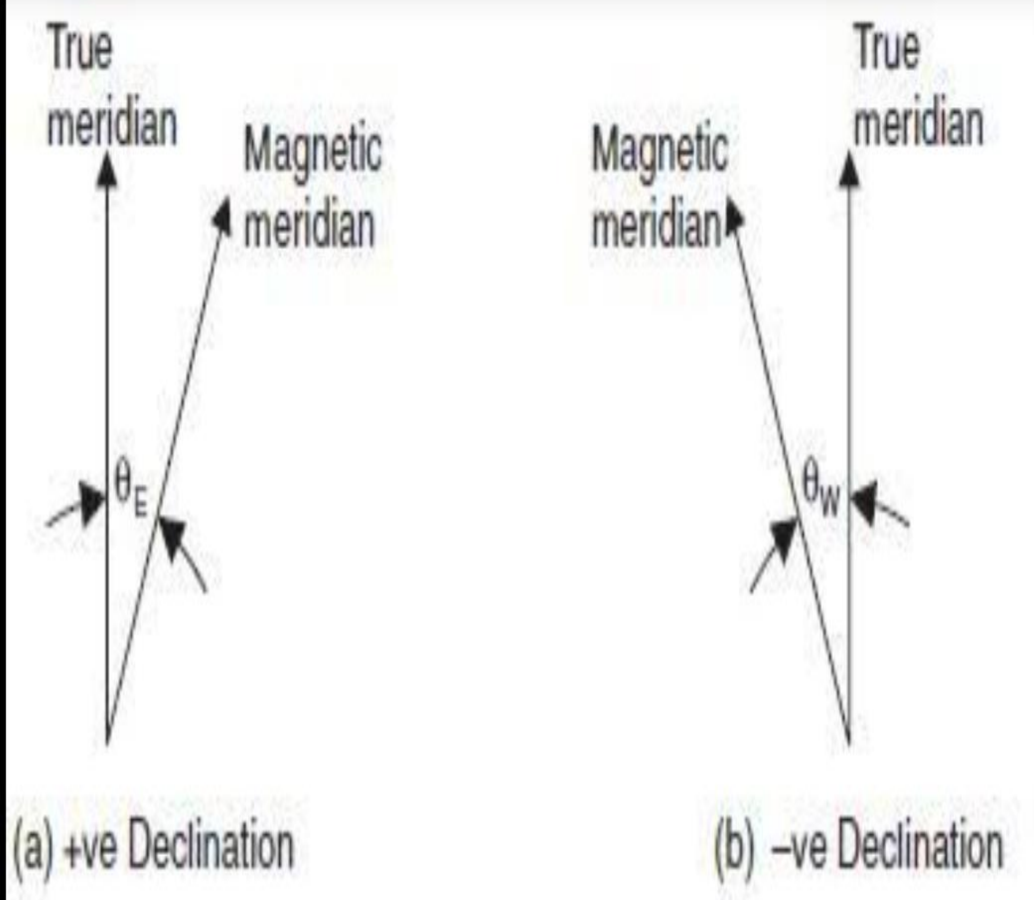


Fig. 13.7. Magnetic declination

Magnetic Lines	Definition
Agonic Line	The line joining the places of zero declination.
Aclinic Line	The line joining the places of zero dip
Isoclinic Line	**The line joining the places of the same dip**
Isogonic lines	Isogonic are the lines joining points of equal declination at a time of observation.

1.The operation of making the algebraic sum of latitudes and departures of a closed traverse, each equal to zero, is known

A. balancing the sights

B. balancing the departures

C. balancing the latitudes

D. balancing the traverse.

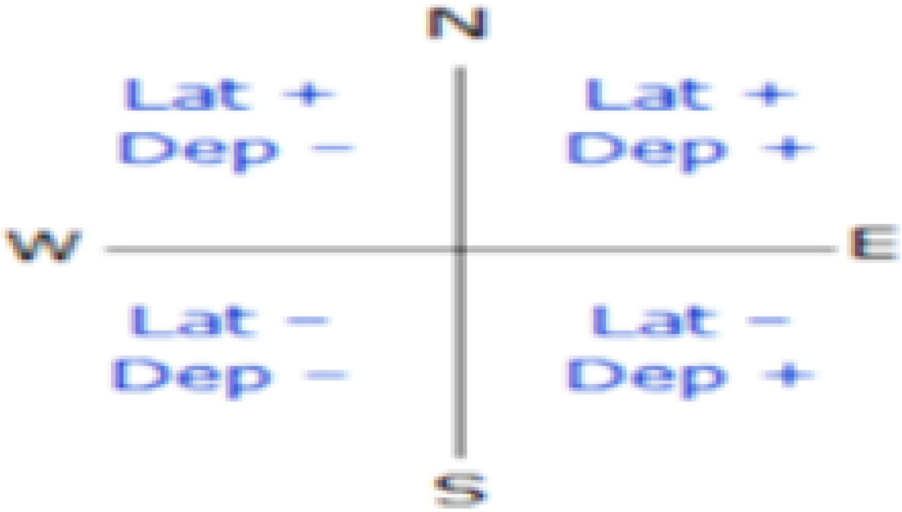
2. In a closed traverse, sum of south latitudes exceeds the sum of north latitudes and the sum of east departures exceeds the sum of west departures, then, the closing line will lie in

A. north-west quadrant

B. north east quadrant

C. south-east quadrant

D. south-west quadrant.



Levelling

The following are important terms used in leveling:

(a) ***Level surface:*** It is a surface parallel to the mean spherical surface of the earth, e.g. the surface of still water in a lake. A level surface may be regarded as a curved surface; every point on which is equidistant from the centre of the earth. It is normal to the plumb line at all points. Any line lying in a level surface is called a level line.

(b) ***Horizontal surface:*** A horizontal surface through any point is a surface tangential to the level surface at that point. It is perpendicular to the plumb line. Any line lying in the horizontal surface is called a horizontal line and it is tangential to the level line.

(c) ***Vertical surface:*** A vertical surface through any point is a surface normal to the level surface at that point. Any line lying in the vertical surface is called a vertical line and is normal to the level line.

(d) ***Datum:*** Datum is any surface to which elevations are referred. It is an arbitrary surface or line from which the elevation of points is measured and compared.

(e) ***Elevation of a point*:** It is a vertical distance above or below the datum. It is also known as reduced level (RL). The elevation of a point is positive or negative according as the point lies above or below the datum.

(f) ***Line of collimation :*** The line passing through the optical centre of the objective and the point of intersection of the cross hair stretched in front of the eye piece and its continuation is called line of collimation.

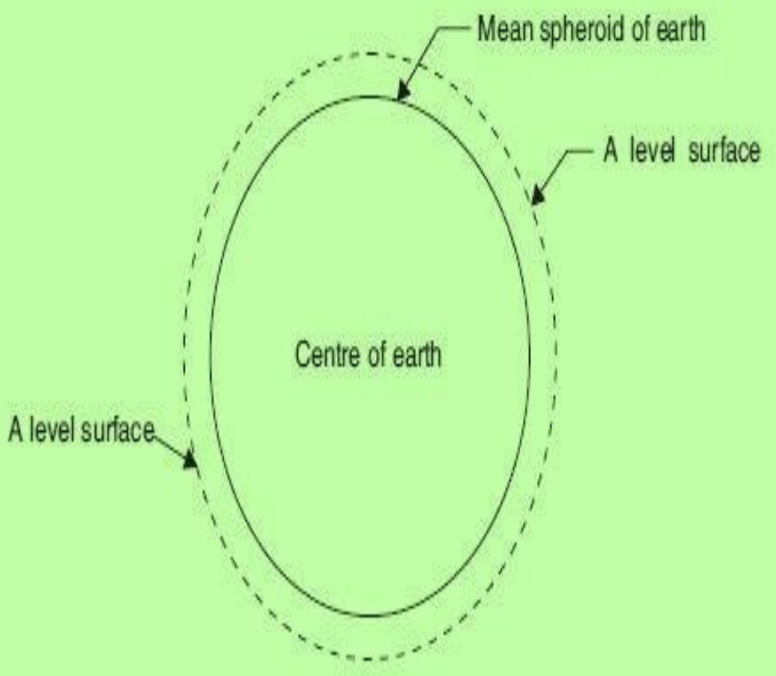


Fig. 15.1. A level surface

(g) ***Bench mark :*** It is a fixed reference point of known elevation. Depending up on permanency and precision, BMs are permanent, temporary, arbitrary Bench Mark.

(h) ***Back sight (BS):*** It is a staff reading taken on a point of known elevation as on a bench mark or a change point. It is the first staff reading taken after the level is set up and levelled. It is also called a plus sight.

(i) ***Foresight (FS):*** It is a staff reading taken on a point whose elevation (or reduced level) is to be determined as on a change point. It is the last staff reading taken before shifting of the level to another position. It is also called a, minus sight.

(j) ***Intermediate sight (IS):*** It is any other staff reading taken on a point of unknown elevation (or reduced level) from the same setup of the level. All sights taken between the back sight and fore sight are intermediate sights.

(k) ***Change point:*** It is point denoting the shifting of the level. It is a point on which the fore and back sights are taken.

(l) ***Station:*** It is a point whose elevation is to be determined. It may be noted that it is a point where the staff is held and the reading taken during the process of levelling.

(m) ***Height of instrument (HI):*** It is the elevation (or reduced level) of the plane of collimation when the instrument is correctly levelled. It is equal to the reduced level of bench mark plus the back sight.

(n) ***Elimination of Parallax :*** When the image formed by the object glass does not fall in the plane of the diaphragm there is said to be parallax. It is due to faulty focusing of the object glass. Parallax is eliminated in two steps: (i) focusing the eye-piece for distinct vision of cross hair (ii) focusing the objective so that the image is formed in the plane of cross hair.

(o) ***Temporary adjustment of a level:*** These are performed to make the axis of rotation vertical and to eliminate the parallax every time, when the instrument is shifted and set up in new position. It is done in the following three stages, namely

- Fixing the instrument on stand.
- Levelling up of the instrument.
- Focusing.

(p) ***Reduced levels (RL) :*** Reduction of levels may be done by the following two methods:

(i) *Rise and fall Method*

In this method, the difference of level between two consecutive points for each setting of the instrument.

(ii) *Height of Collimation Method*

In this method height of the instrument is calculated for the first setting of instrument by adding the back sight to the reduced level of the given Bench Mark. The reduced level of the first station is obtained by subtracting its fore sight from the instrument height (H.I.). But there is no check for intermediate sight readings.

(q) ***Reciprocal Levelling*** : When it is not possible to set up the level midway between two points as in the case of levelling across large water bodies, the reciprocal levelling is employed to carry forward the levels on the other side of the obstruction

(r) ***Curvature and refraction correction:*** Curvature makes the objects appear 'lower' than they really are.

$$C_c = \frac{d^2}{2R} = \frac{d^2}{12742}\text{km} = 0.0785d^2\text{metres.}$$

Refraction makes appear the objects 'higher' than they really are

$C_R = 0.0112\ d^2$

$\therefore$ Combined correction for Curvature and Refraction

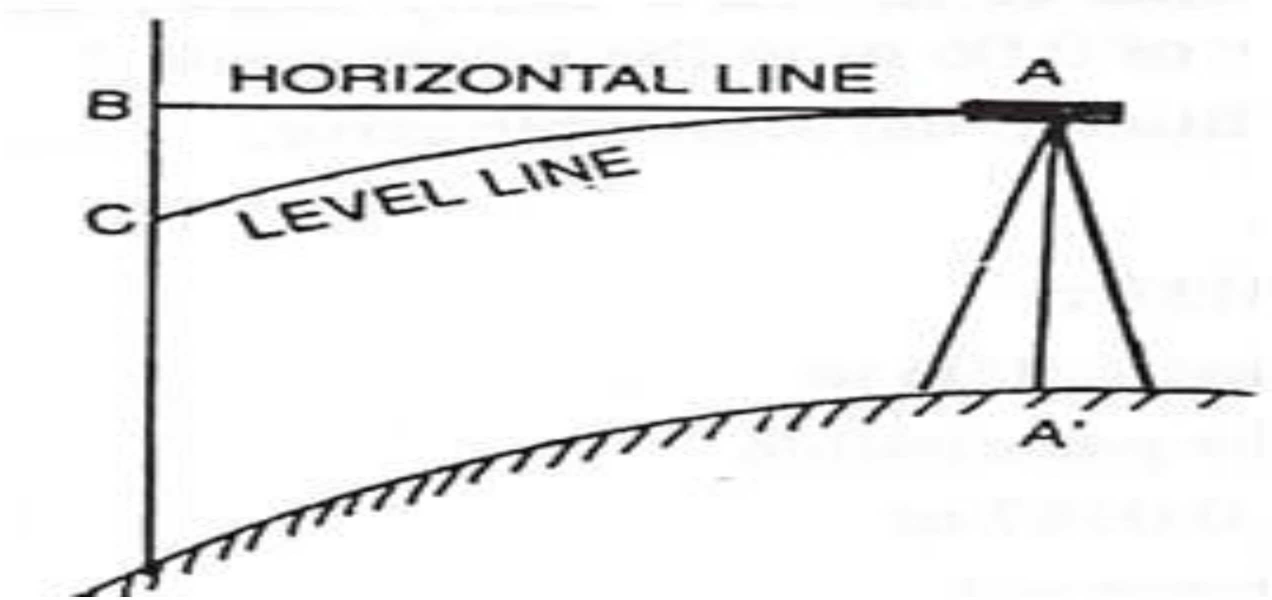
$(C_R + C_c) = 0.0673\ d^2$

Where 'd' is distance in km.

Curvature and refraction correction

- The effect of refraction is therefore **1/7th** of the of that of the curvature, but is of opposite nature.

- Curvature makes object to appear lower than they really are thereby increasing the reading, so error + and correction-.



MCQ:

1. Permanent adjustment of level is done by:

a. Centering

b. Leveling

c. Two peg test

d. All of the above

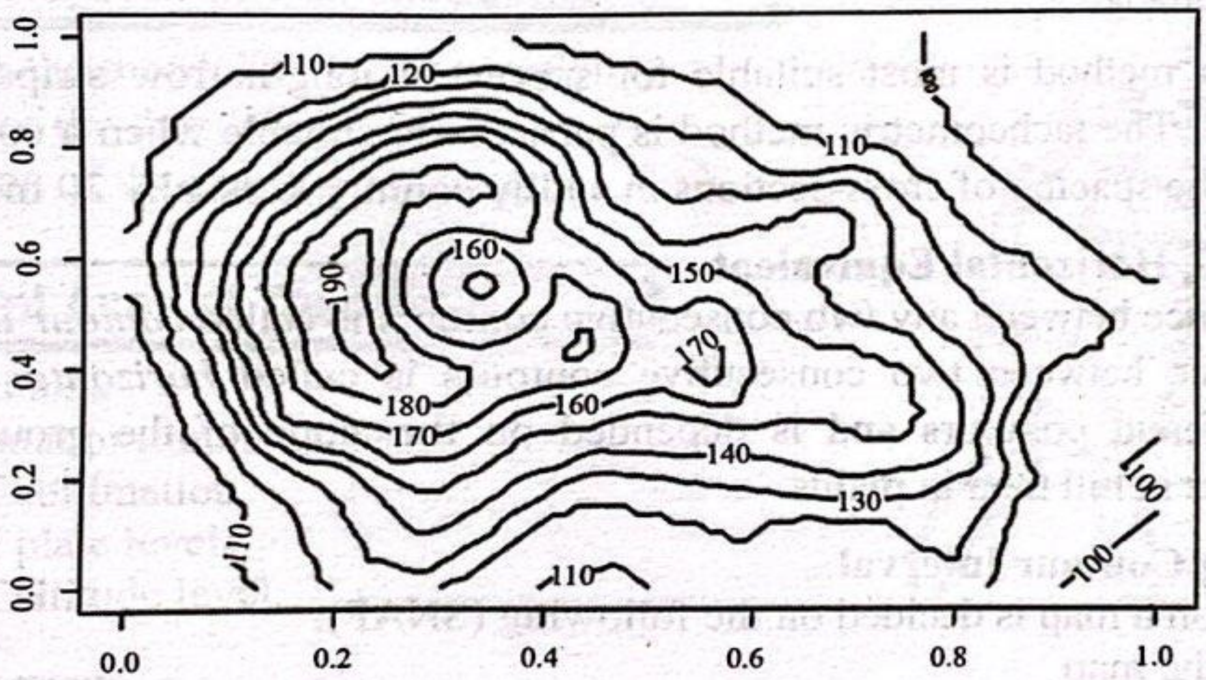
MCQ:

2. Reciprocal leveling can not eliminate completely:

a. Collimation
b. Curvature
c. Refraction
d. Any of the above

Contouring

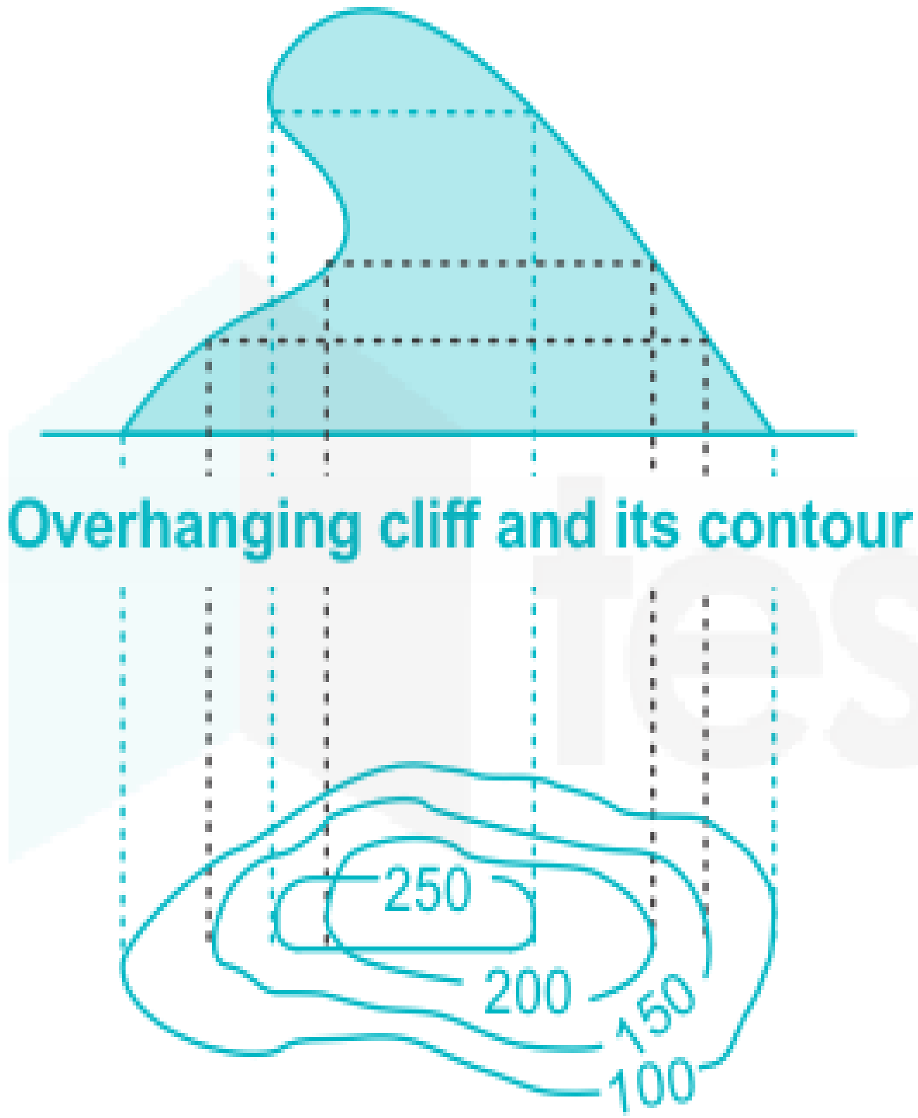
A contour or a contour line maybe defined as a line joining the points having the same elevation above the datum surface. The process of tracing contour lines on the surface of the earth is called contouring and the maps upon which these lines are drawn are called contour maps.



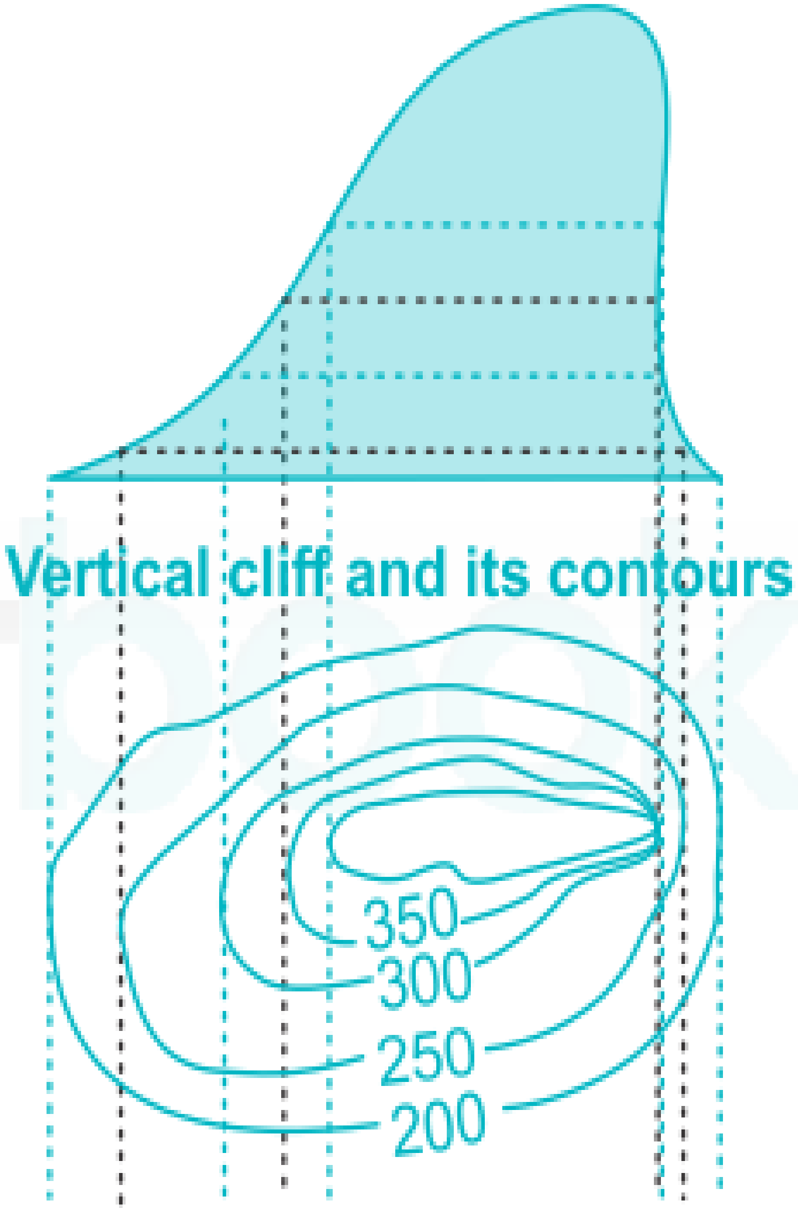
8.1 Characteristics of Contours

The following are important characteristics of contours

1. All points in a contour line have the same elevation.
2. When the contour lines are widely separated, it indicates a flat ground and when they run close together, it indicates a steep ground.
3. When the contour lines are uniformly spaced, it indicates a uniform slope and when they are straight, parallel and equally spaced, it indicated a plane surface.
4. A series of closed contour lines on the map indicates a hill, if the higher values are inside.
5. A series of closed contour lines on the map indicates a depression, if the higher values are outside.
6. The contour lines cross at ridge or valley lines at right angles. If the higher values are inside the bend or loop in the contour, it indicates a ridge and if the higher values are outside the bend, it indicates a valley.
7. When the contour lines merge or cross one another on map, it indicates an overhanging cliff.



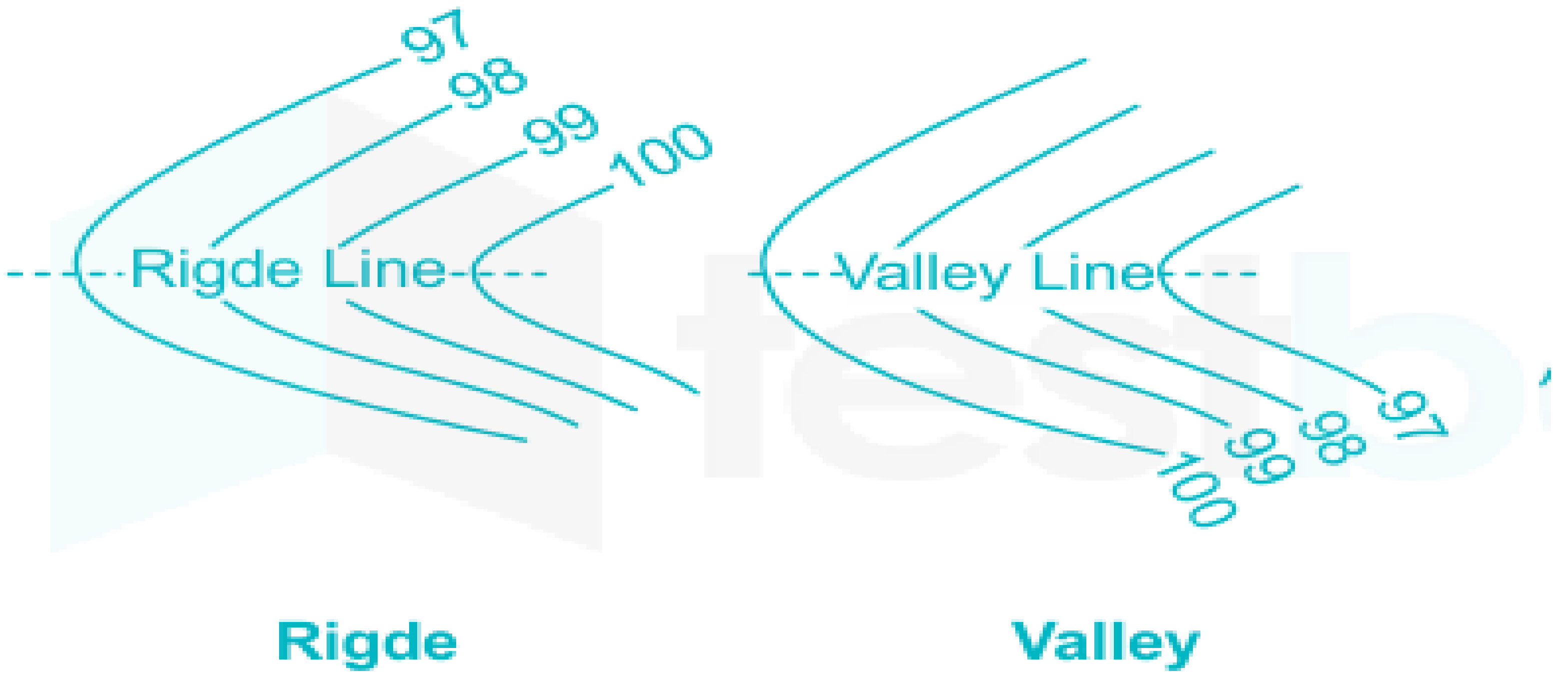
Overhanging cliff and its contour



Vertical cliff and its contours

- U-shaped contour with concavity towards higher ground: ridge

- V-shaped contour with concavity toward lower ground :valley



Numerical on C.I

Find a suitable contour interval on a map on scale 1:10,000.

Solution.

On a scale 1:10,000

10,000m = 1 m = 100cm

$$1000\text{m} = 1\text{km}, \ = 100 \times \frac{1000}{10,000} = 10$$

$$\text{C. I} = \frac{25}{\text{no. of centimeters per km}}$$

$$\therefore \text{C. I} = \frac{25}{10}\text{m} = 2.5\text{m}$$

- **Contour interval within the limits of a map**

a. May be kept constant
b. May not be kept constant
c. Must be kept constant
d. May vary according to the configuration

- **An imaginary line connecting the points of equal elevation on the ground surface is known as**
- a. Contour line
- b. Contour interval
- c. Horizontal equivalent
- d. Contour gradient

- **2. An imaginary line lying through the surface of ground, having a constant inclination to the horizontal is known as**
- a. Contour line
- b. Contour gradient
- c. Contour interval
- d. Horizontal equivalent

Methods of contouring

Direct Method

It consists in finding vertical and horizontal controls of the points which lie on the selected contour line. For vertical control levelling instrument is commonly used.

Indirect Method

In this method, levels are taken at some selected points and their levels are reduced, i.e. in this method horizontal control is established first and then the levels of those points found. For selecting points any of the following methods can be used:

(1) Method of Squares

(2) Method of Cross-Section

(3) Radial Line Method

Contour Interpolation

For interpolating contour points between the two points any one of the following method may be used:

(a) Estimation

(b) Arithmetic calculation

(c) Mechanical or graphical method.

Index contour

If a topomap is prepared with 5m C.I the index contour is generally shown at

a. Every 5^{th} contour

b. Every 3^{rd} contour

c. Every 10^{th} contour

d. Every 7^{th} contour

- **1. The included angles of theodolite survey are generally measured**
- a) Clockwise from back station
- b) Anti clockwise from back station
- c) Clockwise from forward station
- d) Anti clockwise from forward station\

- **2. In a closed traverse the closing error should not be more than**
- a) N X Least count of instrument
- b) $\sqrt{N}$ X Least count of instrument
- c) $\frac{1}{N}$ X Least count of instrument
- d) $\frac{1}{\sqrt{N}}$ X Least count of instrument

Elements of a Horizontal curve

Deflection angle (Δ) = 180 - Observed clockwise angle *or*

Observed clockwise angle - 180

The radius of every curve is assumed according to deflection angle. Then tang
MC, EC & apex length is calculated using following formula:

Tangent Length (T) = $R \times Tan(\Delta/2)$

Length of Curve (L) = $\pi \times R \times \Delta/180$

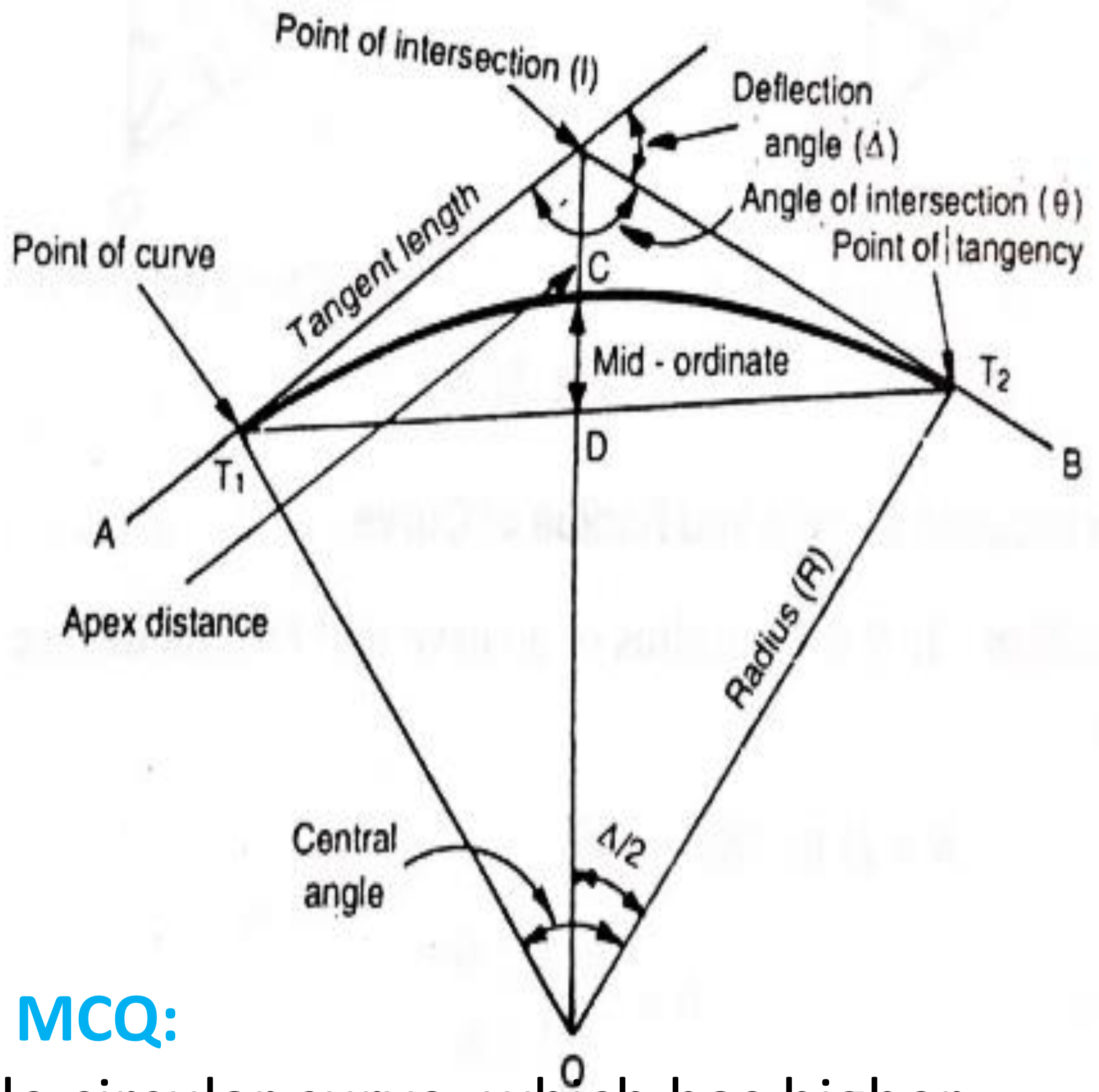
Apex Distance (E) = $R(\sec\Delta/2-1)$

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

Chainage of BC (T_1) = Chainage of IP - T

Chinage of Mid of curve (MC) = Ch. of T1 +L /2

Chainage of T_2 (EC) = Chainage of T1+ curve length



NEC Past MCQ:

In a simple circular curve, which has higher chainage; Intersection point or mid point of curve?

What is the degree of the curve (in degree) for a radius of 573 m using chain of 20 m length?

1. 1
2. 2
3. 3
4. 5

The principle and application of **GPS**

Principle of GPS:

GPS is a **satellite-based navigation system** that uses signals from satellites to determine the position, velocity, and time of a receiver on the earth's surface.

The system is based on the **trilateration principle**.

Applications of GPS: Surveying and mapping, navigation, agriculture, and transportation.

Principle of GIS: GIS is a **computer-based system** for capturing, storing, analyzing, and visualizing data related to the earth's surface.

Applications of GIS: **Urban planning**, **natural resource management, environmental management, Watershed analysis**. In urban planning, GIS is used to manage land use and development, to analyze demographic data, and to plan transportation systems

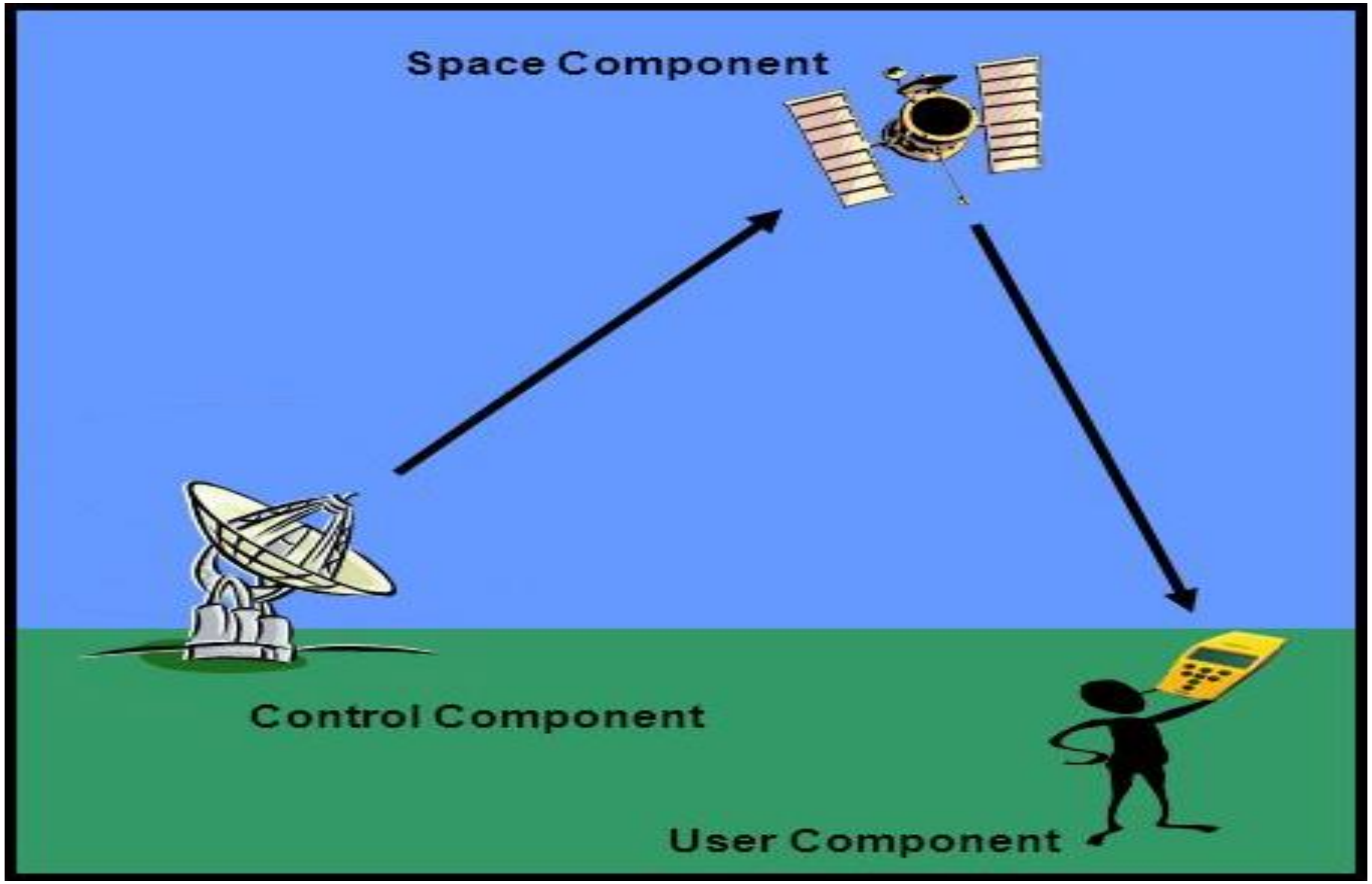
Components/Segments of Global Positioning System (GPS)

- From an operational point of view, GPS is divided into three main components:

i. Space Segment

ii. Control Segment

iii. User Segment (Users Receiver)



- Satellite system consists of constellations of **24 satellites** in at **6 Earth orbital planes**, each with **4 satellites**, orbiting at **20200 Km** above the earth surface and travelling at a speed of **14000 Km/h.**
- While we only need three satellites to produce a location on earth surface, a fourth satellites is often used to validate the information from the other three.
- The fourth satellite also moves us into the 3-D and allows us to calculate the altitude of a device.

MCQ.

Minimum number of satellites needed for a GPS to determine the position accurately is

a. 2
b. 3
c. 4
d. 24

8. Which of the following can indicate the correct set of GPS segments?

a) Navigation, space
b) User, navigation
c) Control, user
d) Control, navigation

- Which country developed gps?

a) USA

b) UK

c) Russia

d) China

- The GPS project was started by the U.S. Department of Defense in 1973. The first prototype spacecraft was launched in 1978 and the full constellation of 24 satellites became operational in 1993.

- GIS applications are _________ tools.

a) Mobile

b) Computer

c) Machinery

d) None of the above

- The sag of 50 m tape weighing 1 kg under 5 kg tension is roughly
- 0.053 m
- 0.063 m
- 0.073 m
- 0.083 m

Sites to be referred

1. Indiabix
2. Testbook
3. Examveda
4. Sanfoundry, etc.