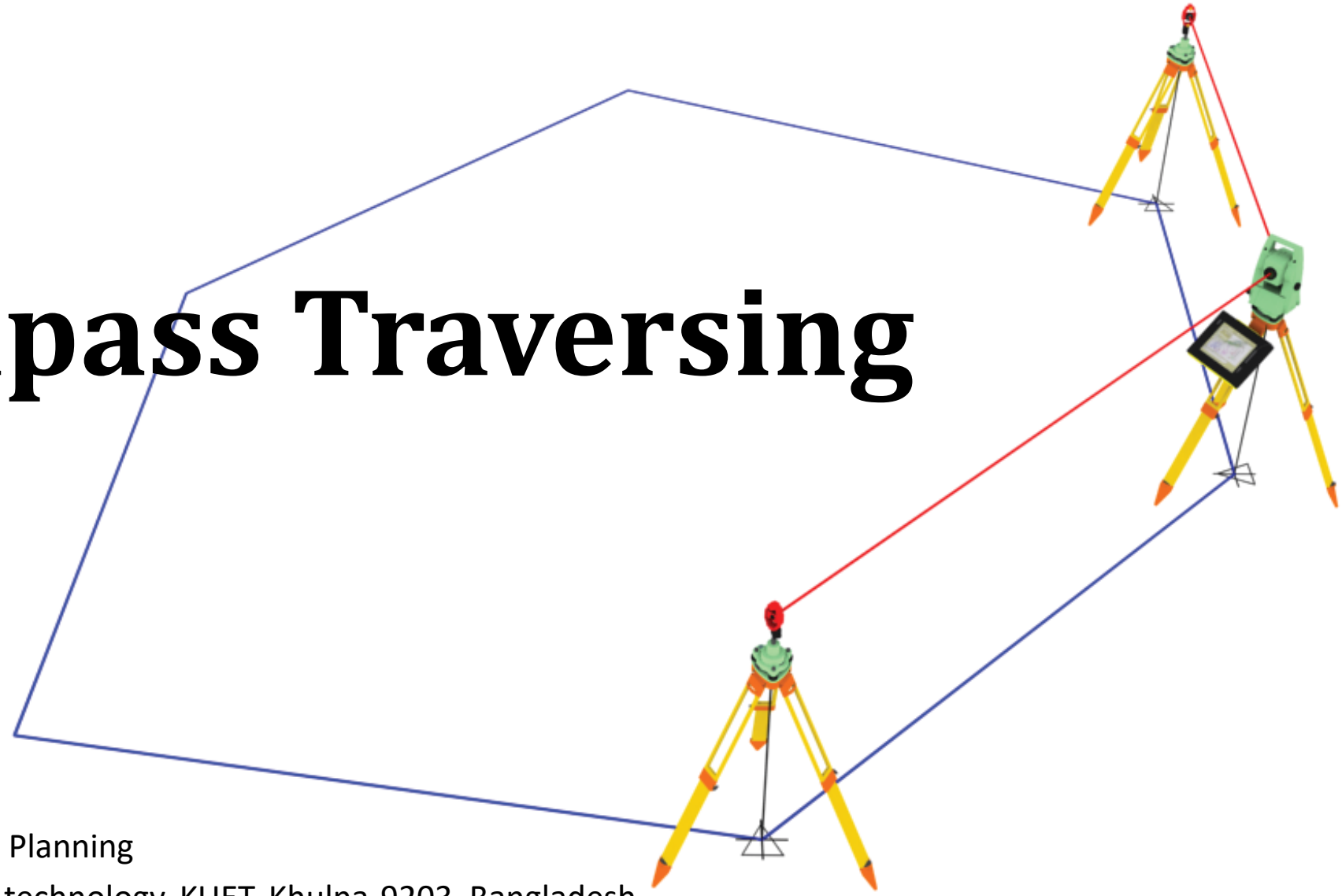
Compass Traversing



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Acknowledgement

- This presentation covers the basic understandings of compass traversing. I acknowledge the book "*Surveying and Levelling by N. N. Basak*" and all other internet sources where the photographs are collected for better understanding.

Principle of compass surveying

- The principle of compass surveying is traversing

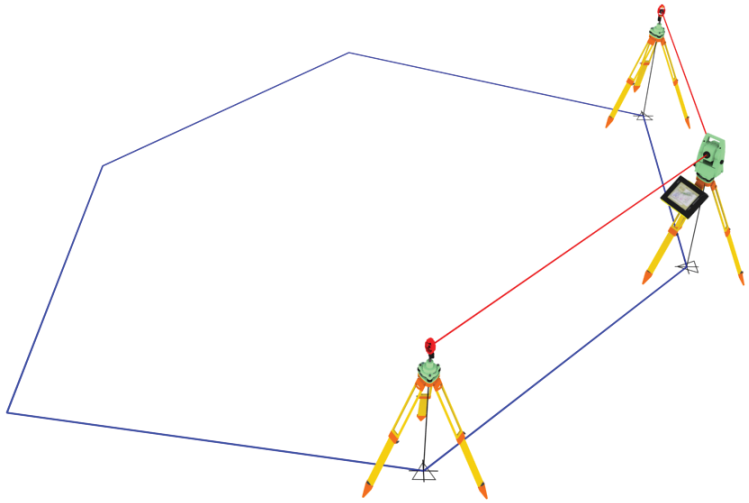
- Compass surveying is recommended:
  1. A large area to be surveyed
  2. The course of a river or coast line is to be surveyed
  3. The area is crowded with many details and triangulation is not possible

- Compass surveying is not recommended for areas:

  where local attraction is suspected due to the presence of magnetic substances like steel structures, iron-ore deposits, electric cables conveying current, and so on.

Traversing

- Surveying which involves a series of connected lines is known as ‘traversing’
- The sides of the traverse are known as ‘traverse legs’
- In traversing, the lengths of the lines are measured by chain and the directions are fixed by compass or theodolite or by forming angles with chain and tape



Methods of traversing

1. Chain traversing (by chain angle)

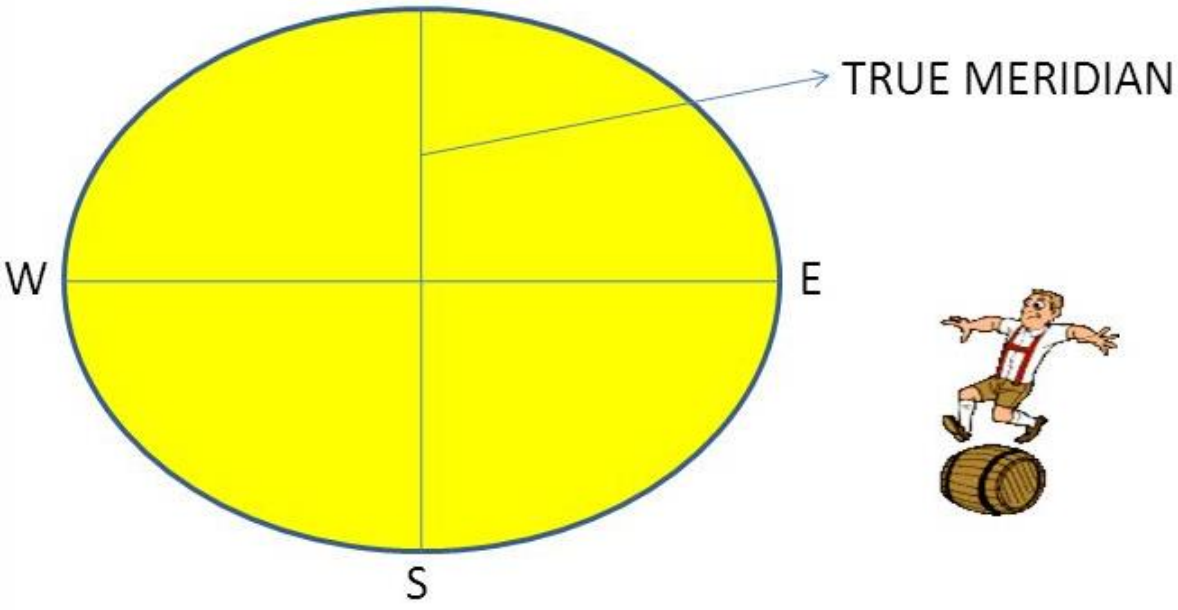
2. Compass traversing (by free needle)

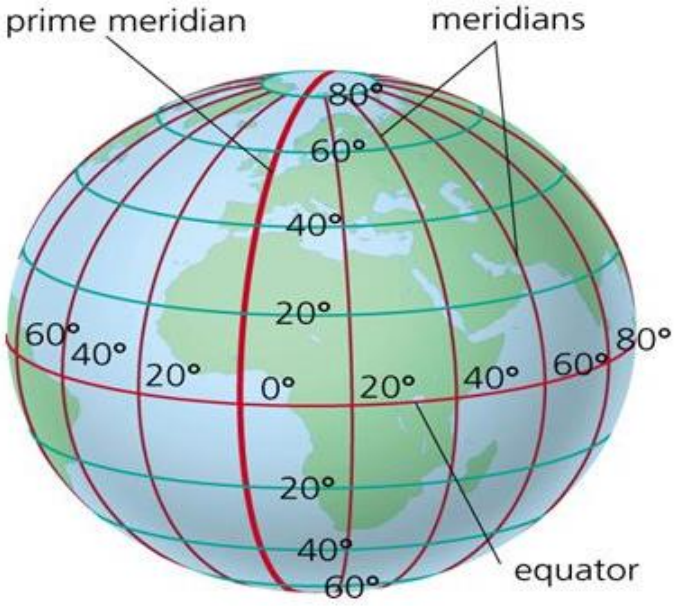
3. Theodolite traversing (by fast needle)

4. Plane table traversing (by plane and table)

True Meridian

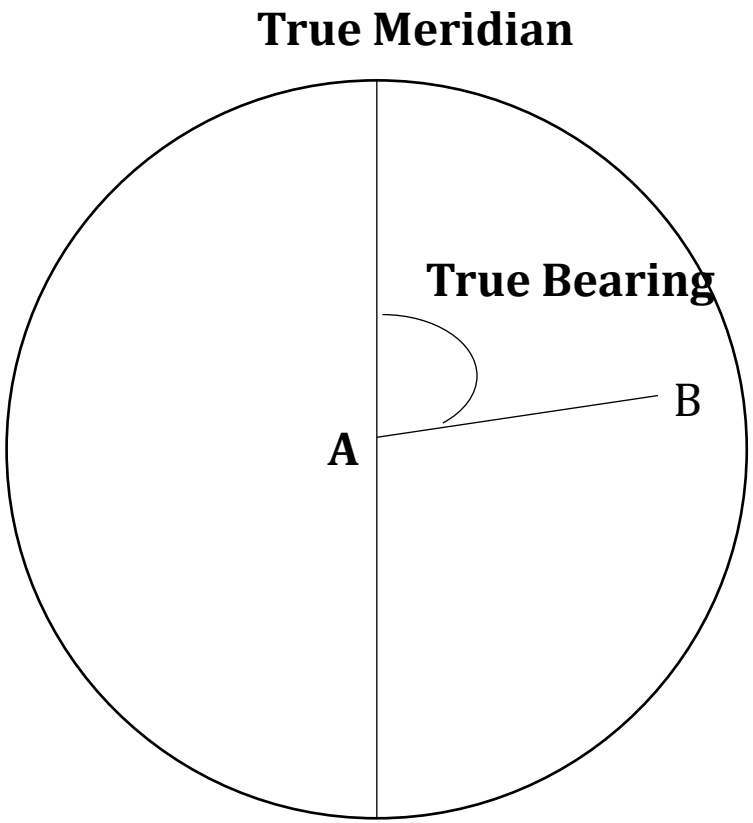
The line or plane passing through the geographical north pole, geographical south pole and any point on the surface of the earth, is known as the 'true meridian' or 'geographical meridian'





True Bearing

The angle between the true meridian and a line is known as ‘true bearing’ of the line. It is also known as the ‘azimuth’

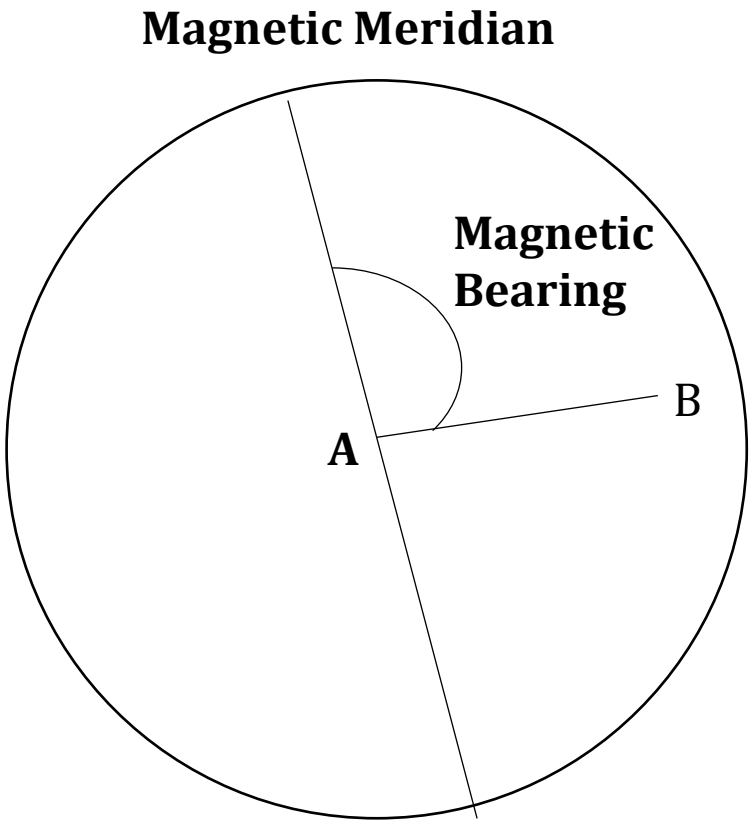


Magnetic Meridian

When a magnetic needle is suspended freely and balanced properly, unaffected by magnetic substances, it indicates a direction. This direction is known as the 'magnetic meridian'

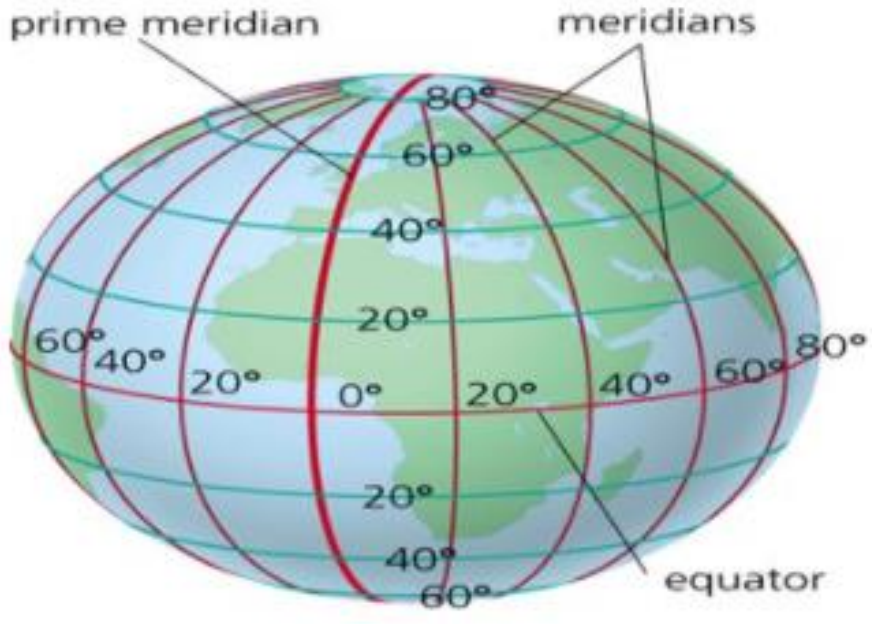
Magnetic Bearing

The angle between the magnetic meridian and a line is known as the 'magnetic bearing' or simply the 'bearing' of the line



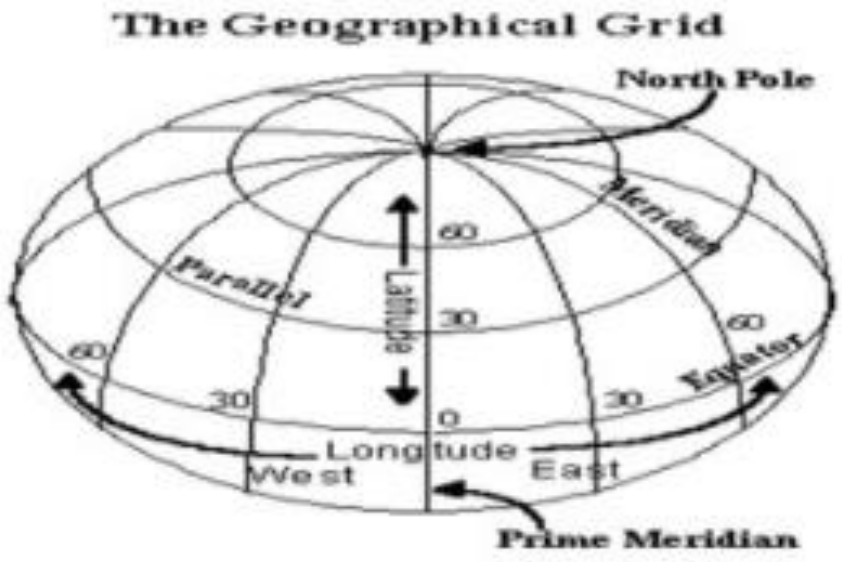
Arbitrary Meridian

- Sometimes for the survey of a small area, a convenient direction is assumed as a meridian, known as the ‘arbitrary meridian’
- Sometimes the starting line of a survey is taken as the arbitrary meridian.
- The angle between the arbitrary meridian and a line is known as the ‘arbitrary bearing’ of the line



Grid Meridian

- Sometimes, for preparing a map, some state agencies assume several lines parallel to the true meridian for a particular zone
- These lines are termed grid lines and the central line the ‘grid meridian’.
- The bearing of a line with respect to the grid meridian is known as the grid bearing of the line



Designation of Magnetic Bearing

- Magnetic bearings are designated by two systems:

(a) Whole circle bearing (WCB),

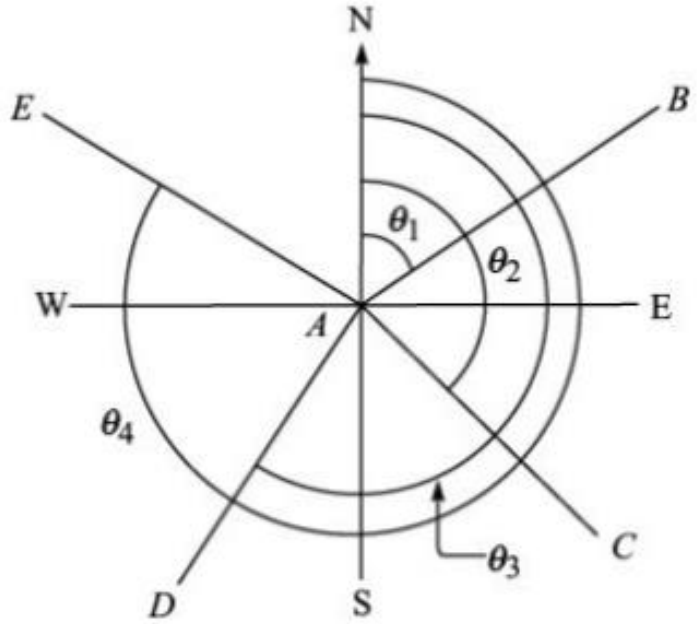
(b) Quadrantal bearing (QB)

Whole Circle Bearing (WCB)

- The magnetic bearing of a line measured clockwise from the north pole towards the line, is known as the 'whole circle bearing, of that line
- Such a bearing may have any value between 0° and 360°

Example:

WCB of AB = θ1
WCB of AC = θ2
WCB of AD = θ3
WCB of AE = θ4

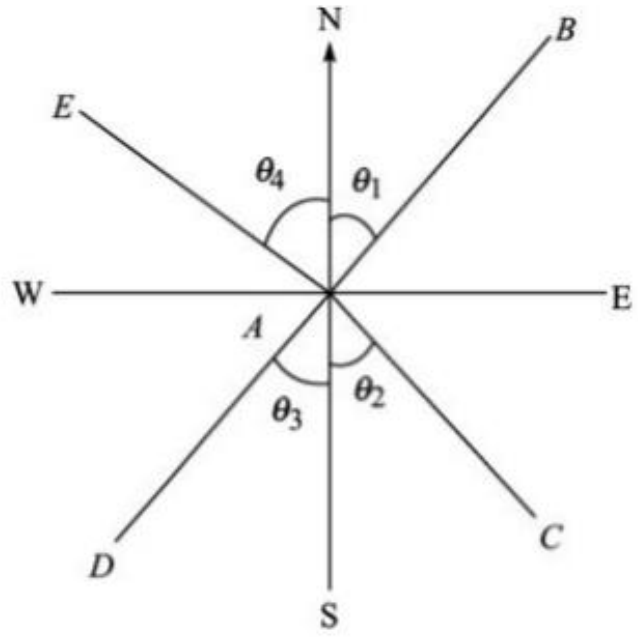


Quadrantal Bearing (QB)

- The magnetic bearing of a line measured clockwise or counterclockwise from the North Pole or South Pole (whichever is nearer the line) towards the East or West, is known as the 'quadrantal bearing' of the line
- This system consists of four quadrants—NE, SE, SW and NW. The value of a quadrantal bearing lies between 0° and 90°

Example:

QB of AB = Nθ1 E
QB of AC = Sθ2 E
QB of AD = Sθ3 W
QB of AE = Nθ4 W

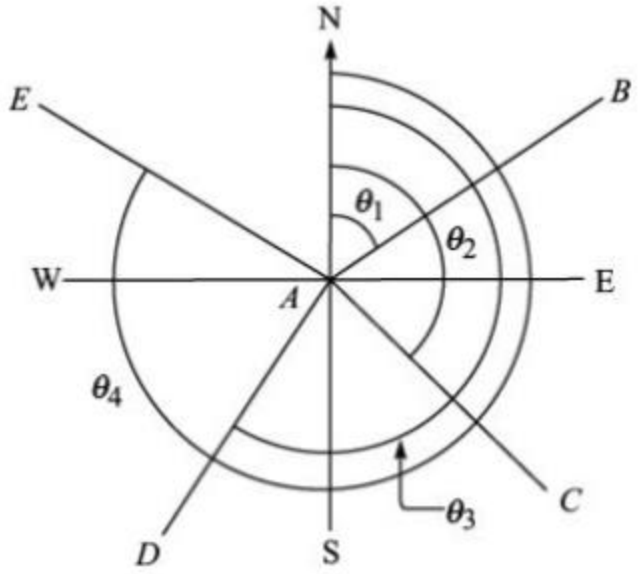


Reduced Bearing (RB)

When the whole circle bearing of a line is converted to quadrantal bearing, it is termed the 'reduced bearing'. Thus, the reduced bearing is similar to the quadrantal bearing.

Example:

WCB between	Corresponding RB	Quadrant
0° and 90°	$RB = WCB$	NE
90° and 180°	$RB = 180° - WCB$	SE
180° and 270°	$RB = WCB - 180°$	SW
270° and 360°	$RB = 360° - WCB$	NW



Solved Problem:

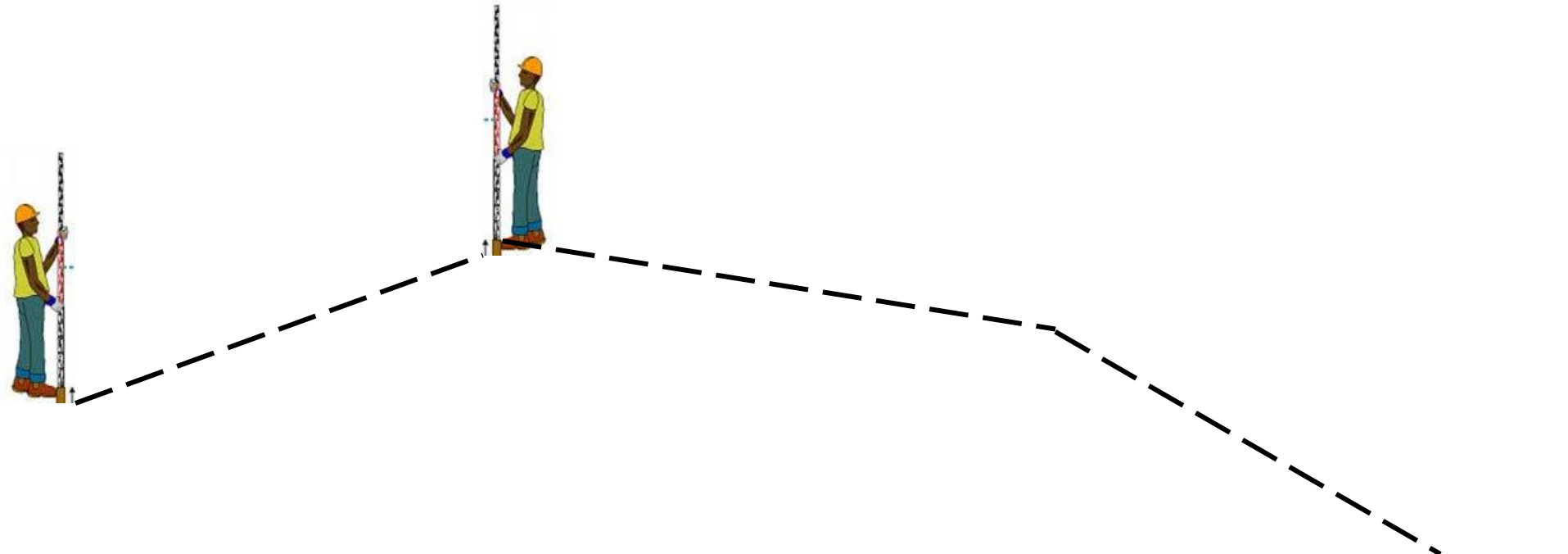
Convert the following WCBs to QBs

- (a) WCB of AB = 45°30 ′
- (b) WCB of BC = 125°45 ′
- (c) WCB of CD = 222°15 ′
- (d) WCB of DE = 320°30 ′

- (a) QB of AB = N 45°30′ E
- (b) QB of BC = 180°0′ – 125°45′ = S54°15′ E
- (c) QB of CD = 222°15′ – 180°0′ = S42°15′ W
- (d) QB of DE = 360°0′ – 320°30′ = N39°30′ W

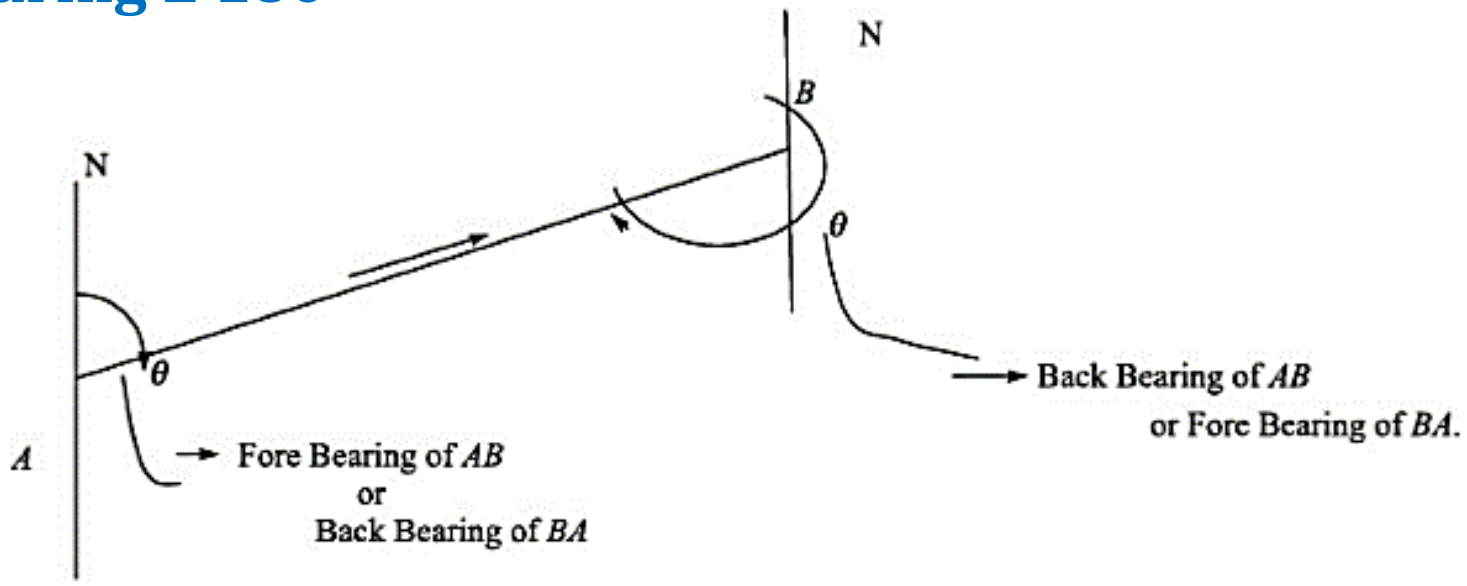
Fore and Back Bearing

- Every line has two bearings: one is observed along the progress of the survey or forward direction, and is called ‘fore bearing’,
- And the second is observed in the reverse or opposite direction and is called ‘back bearing’



Fore and Back Bearing

- we consider the direction of meridian as upward
- Bearing is measured clockwise from the meridian
- **Back bearing = Fore Bearing ± 180°**



- In case of quadrantal bearing system, the numerical value of fore bearing and back bearing is equal but the quadrants are just opposite.
- For example, if the fore bearing is N30° E then its back bearing is S30°W

Solved Problem:

The FBs of the following lines are given. Find the BBs

- (a) FB of AB = 310°30 ′
- (b) FB of BC = 145°15 ′
- (c) FB of CD = 210°30 ′
- (d) FB of DE = 60°45 ′

Solution

- (a) BB of AB = 310°30′ – 180°0′ = 130°30′
- (b) BB of BC = 145°15′ + 180°0′ = 325°15′
- (c) BB of CD = 210°30′ – 180°0′ = 30°30′
- (d) BB of DE = 60°45′ + 180°0′ = 240°45′

Solved Problem:

The fore bearings of the lines AB, BC, CD and DE, are 45°30 ′ 120°15 ′, 200°30 ′ and 280°45 ′, respectively. Find angles ∠B, ∠C and ∠D.

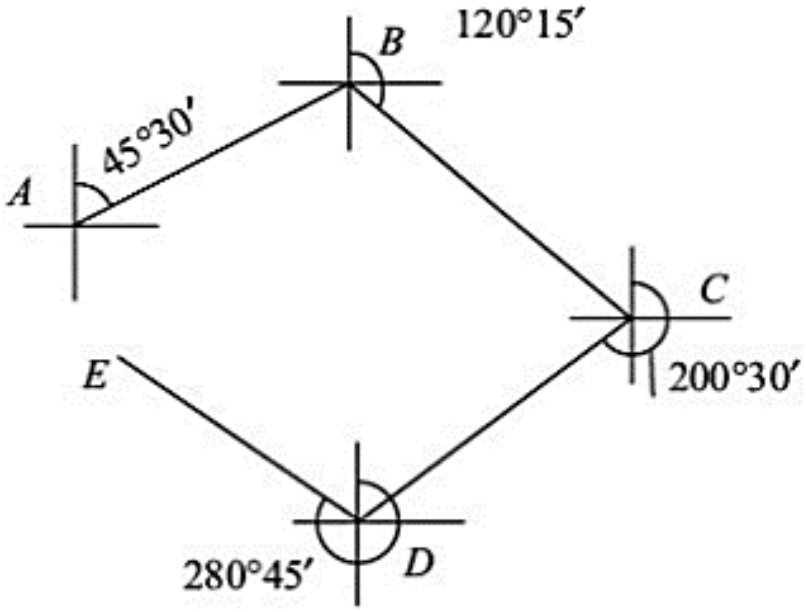
Solution:

Interior ∠B = BB of AB – FB of BC = (45°30′ + 180°0′) – 120°15′ = 225°30′ – 120°15′ = 105°15′

Interior ∠C = BB of BC – FB of CD = (120°15′ + 180°0′) – 200°30′ = 300°15′ – 200°30′ = 99°45′

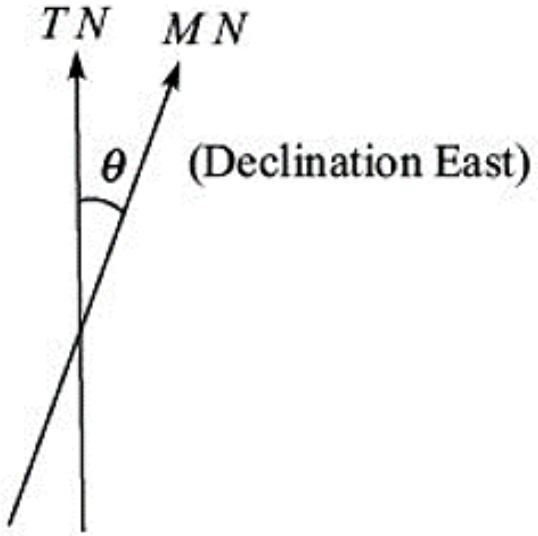
Exterior ∠D = FB of DE – BB of CD = 280°45′ – (200°30′ – 180°0′) = 280°45′ – 20°30′ = 260°15′

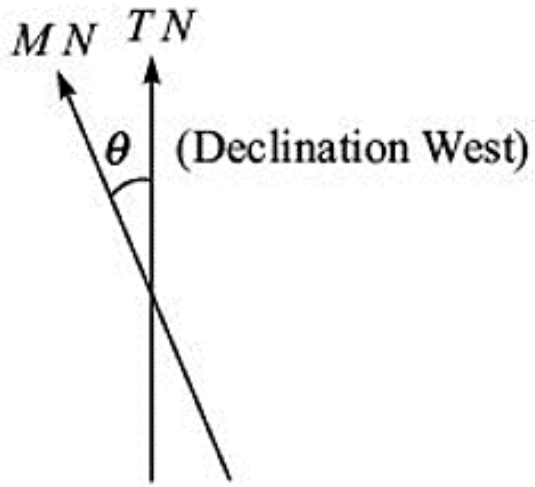
Interior ∠D = 360°0′ – 260°15′ = 99°45′



Magnetic Declination

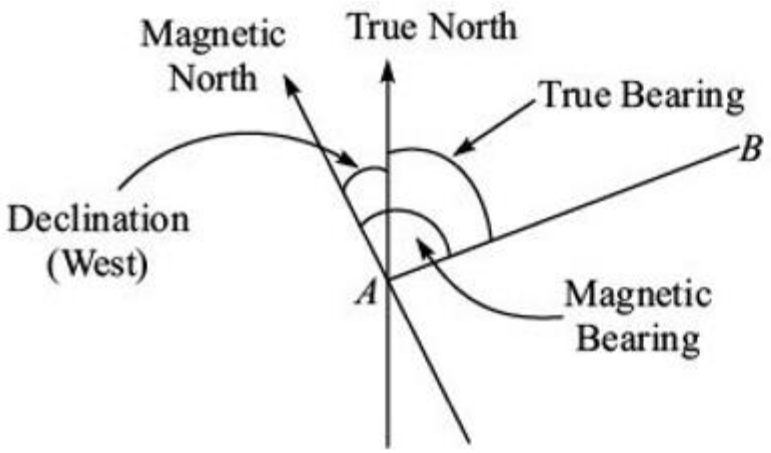
- The horizontal angle between the magnetic meridian and true meridian is known as ‘magnetic declination’
- When the north end of the magnetic needle is pointed towards the west side (+) of the true meridian, the position is termed Declination West (θ W).
- When the north end of the magnetic needle is pointed towards the east side (-) of the true meridian, the position is termed Declination East (θ E)

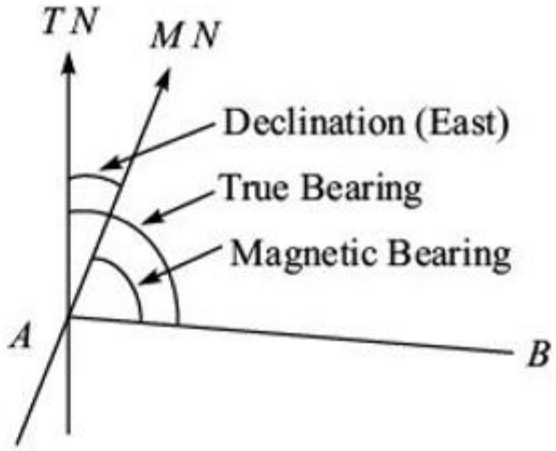




Magnetic Declination

- **True bearing = Magnetic bearing ± Declination**
- **Magnetic bearing = True bearing ± Declination**





Solved Problem:

(a) The magnetic bearing of a line AB is 135°30 ′. What will be the true bearing, if the declination is 5°15 ′ W.

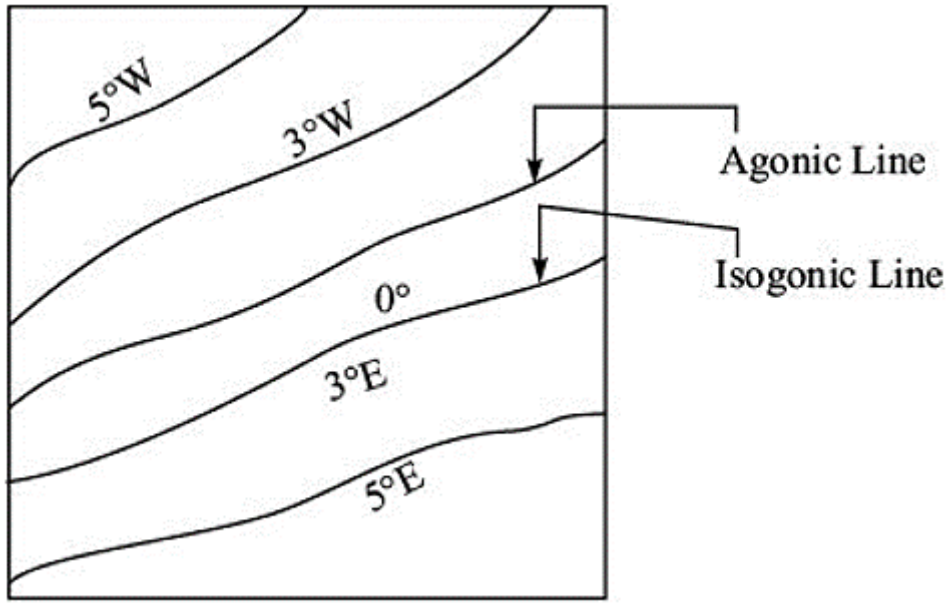
(b) The true bearing of a line CD is 210°45 ′. What will be its magnetic bearing, if the declination is 8°15 ′ W.

Solution

- (a) True bearing of AB = Magnetic bearing – Declination = 135°30′ – 5°15′ = 130°15′
- (b) Magnetic bearing = True bearing + Declination = 210°45′ + 8°15′ = 219°0′

Isogonic and Agonic Lines

- Lines passing through points of equal declination are known as ‘isogonic’ lines.
- The line passing through points of zero declination is said to be the ‘agonic’ line



Local Attraction

- A magnetic needle indicates the north direction when freely suspended or pivoted. But if the needle comes near some magnetic substances, such as iron ore, steel structures, electric cables conveying current; etc. it is found to be deflected from its true direction, and does not show the actual north. This disturbing influence of magnetic substances is known as 'local attraction'.
- To detect the presence of local attraction, the fore and back bearings of a line should be taken.
- If the difference of the fore and back bearings of the line is exactly 180° then there is no local attraction.
- If the FB and BB of a line do not differ by 180° then the needle is said to be affected by local attraction, provided there is no instrumental error

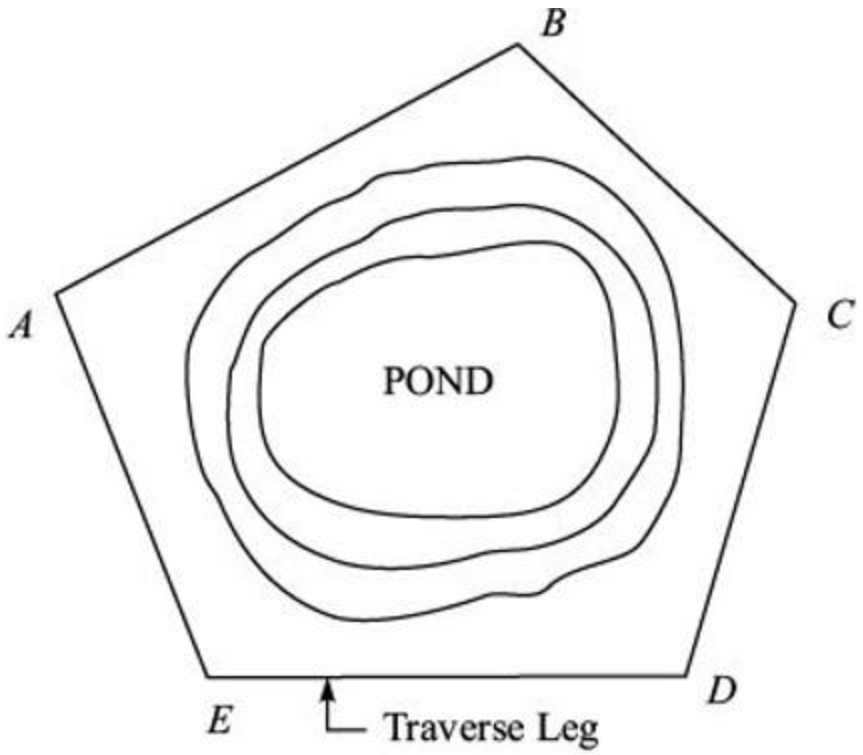
Method of Application of Correction

(a) **First Method** The interior angles of a traverse are calculated from the observed bearings. Then an angular check is applied. The sum of the interior angles should be equal to $(2n - 4) \times 90°$ (n being the number of sides of the traverse). If it is not so, the total error is equally distributed among all the angles of the traverse.

(b) **Second Method** In this method, the interior angles are not calculated. From the given table, the unaffected line is first detected. Then, commencing from the unaffected line, the bearings of the other affected lines are corrected by finding the amount of correction at each station.

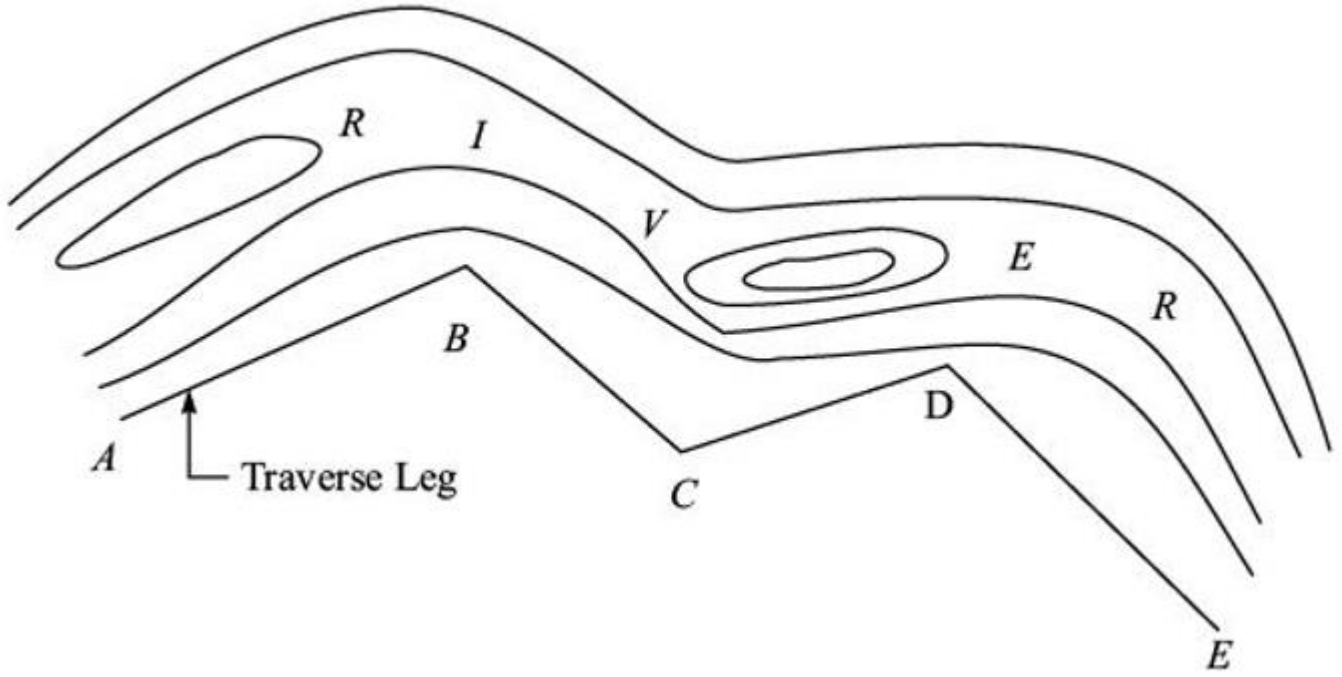
Closed traverse

- When a series of a connected lines forms a closed circuit, i.e, when the finishing point coincides with the starting point of a survey, it is called a ‘closed traverse’.
- Here ABCDEA represents a closed traverse



Open traverse

- Open Traverse When a sequence of connected lines extends along a general direction and does not return to the starting point, it is known as ‘open traverse’ or ‘unclosed traverse’
- Here, ABCDE represents an open traverse



Check on closed traverse

1. **Check on Angular Measurements:**

- (a) The sum of the measured interior angles should be equal to $(2N - 4) \times 90°$ where N is the number of sides of the traverse.
- (b) The sum of the measured exterior angles should be equal to $(2N + 4) \times 90°$
- (c) The algebraic sum of the deflection angles should be equal to $360°$. Right-hand deflection is considered positive and left-hand deflection, negative.

2. **Check on Linear Measurement**

The lines should be measured once each on two different days (along opposite directions). Both measurements should tally.

Solved Problem:

The following are the bearings observed in traversing, with a compass, an area where local attraction was suspected. Calculate the interior angles of the traverse and correct them if necessary

Line	*FD*	*BB*
AB	*150°0′*	*330°0′*
BC	*230°30′*	*48°0′*
CD	*306°15′*	*127°45′*
DE	*298°00′*	*120°00′*
EA	*49°30′*	*229°30′*

Solved Problem:

Solution:

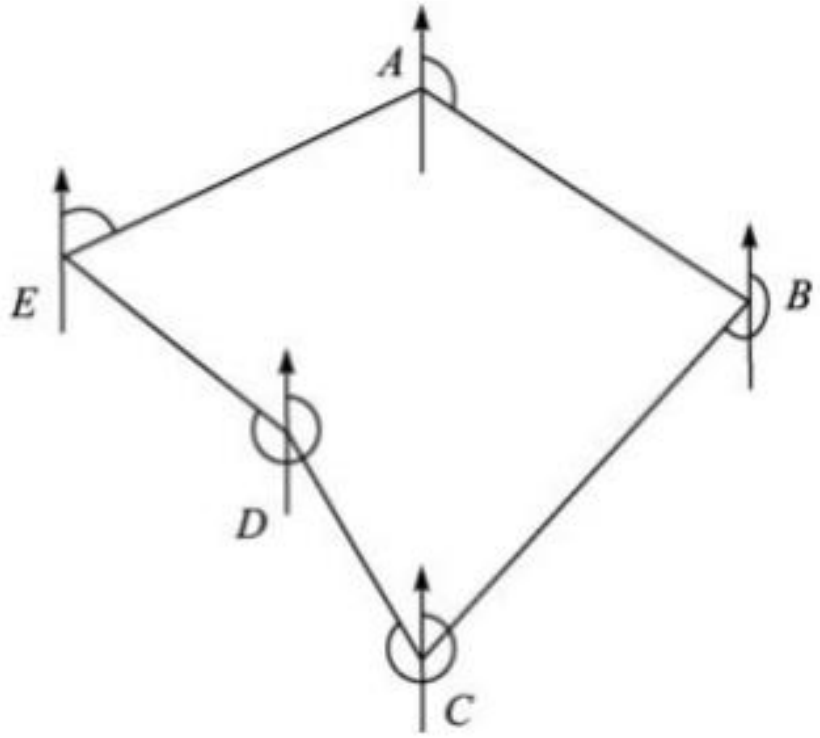
(a) Interior ∠A = BB of EA – FB of AB = 229°30′ – 150°0′ = 79°30′

(b) Interior ∠B = BB of AB – FB of BC = 330°0′ – 230°30′ = 99°30′

(c) Exterior ∠C = FB of CD – BB of BC = 306°15′ – 48°0′ = 258°15′ Interior ∠C = 360°0′ – 258°15′ = 101°45′

(d) Exterior ∠D = FB of DE – BB of CD = 298°00′ – 127°45′ = 170°15′
Interior ∠D = 360°0′ – 170°15′ = 189°45′

(e) Interior ∠E = BB of DE – FB of EA = 120°0′ – 49°30′ = 70°30′



Solved Problem:

- Check Sum of interior angles

$= \angle A + \angle B + \angle C + \angle D + \angle E = 541°0'$

- But, the sum of angles should be $(2N - 4) - 90° = 540°0'$
- Here, Error = $541° - 540° = +1°$
- Correction per angle

$= -(60'/5) = -12'$

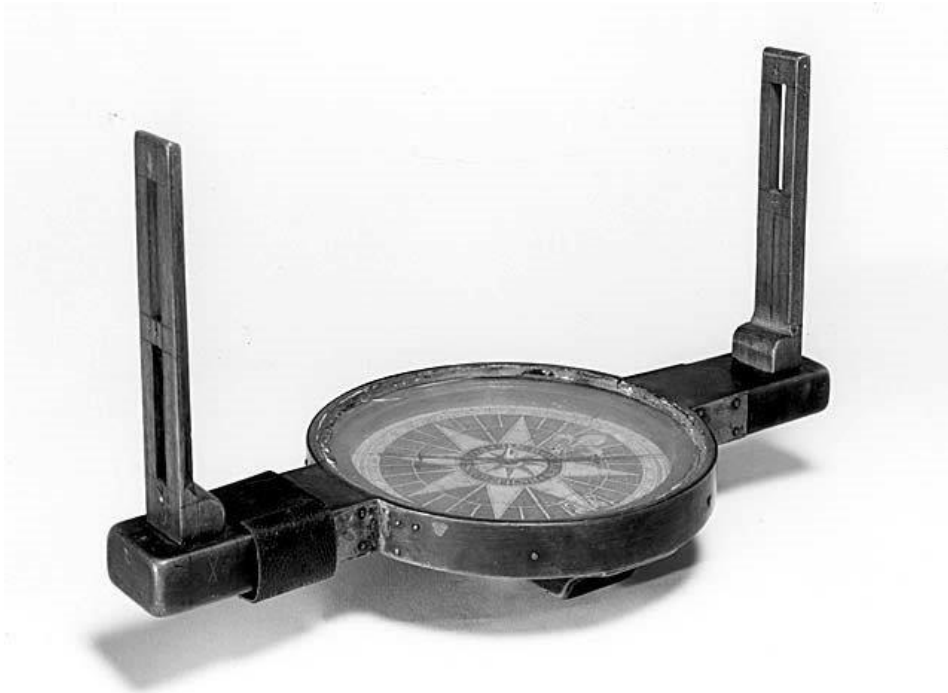
The error should be equally distributed among all the angles

Angle	Calculated value	Correction	Corrected value
$\angle A$	79°30′	–12′	79°18′
$\angle B$	99°30′	–12′	99°18′
$\angle C$	101°45′	–12′	101°33′
$\angle D$	189°45′	–12′	189°33′
$\angle E$	70°30′	–12′	70°18′
	Total = 541°0′		540°00′

Types Of Compasses

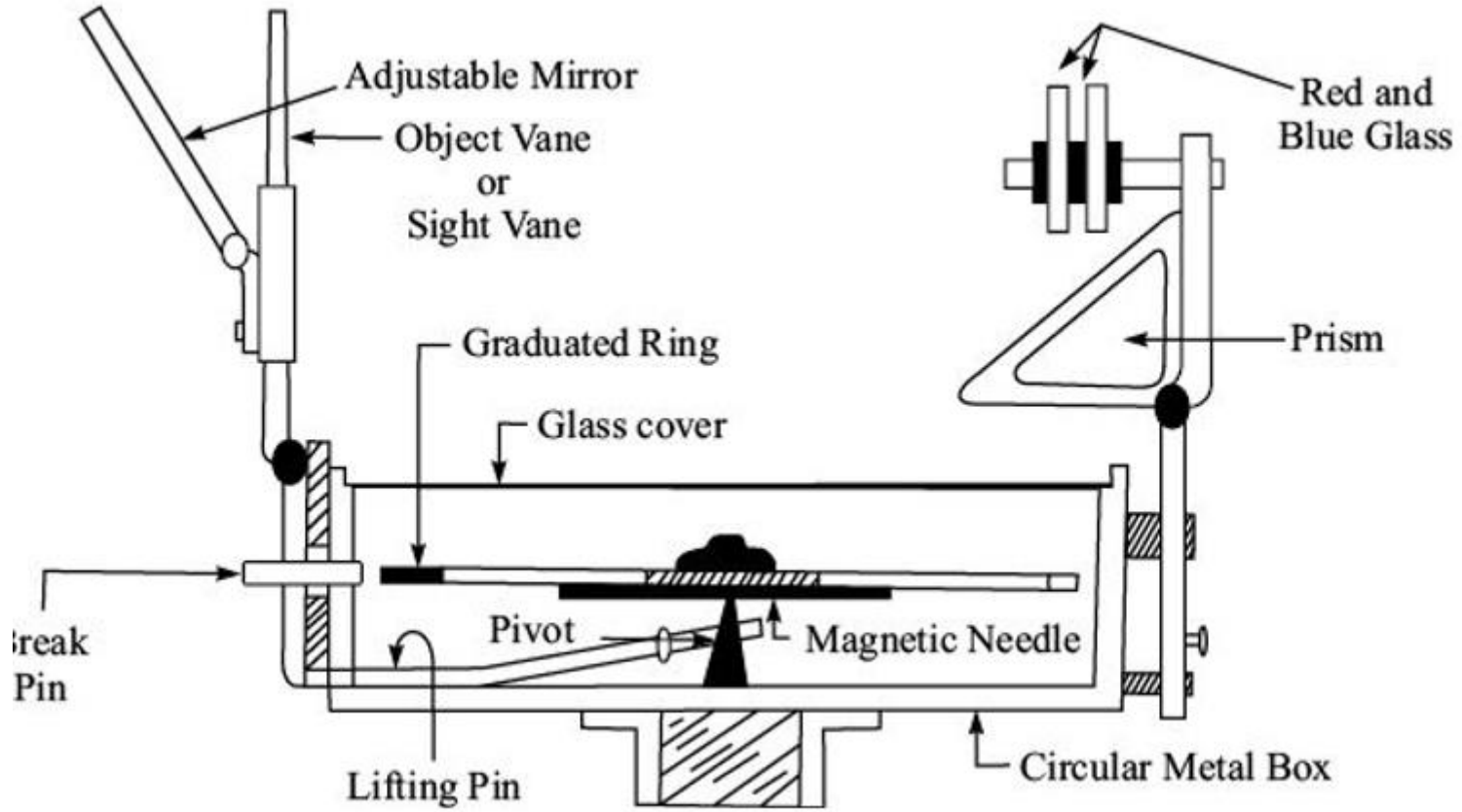
There are two types of compasses:

1. The prismatic compass



2. The surveyor’s compass

Prismatic compass



Sources of error in a compass

1. Instrumental Errors

(a) The needle may not be perfectly straight and might not be balanced properly

(b) The pivot point may be eccentric

(c) The graduations of the ring may not be uniform

(d) The ring may not rotate freely on account of the pivot point being blunt

(e) The sight vane may not be vertical

(f) The horse hair may not be straight and vertical

Sources of error in a compass

2. Personal Errors

(a) The centring may not be done perfectly over the station.
(b) The graduated ring may not be levelled
(c) The object might not be bisected properly.
(d) The readings may be taken or entered carelessly.
(e) The observer may be carrying magnetic substances.

3. Other Sources of Error

- (a) There may be local attraction due to the presence of magnetic substances near the station.
- (b) The magnetic field could vary on account of some natural causes.
- (c) The magnetic declination might vary.

Precautions to be taken in compass surveying

1. The centring should be done perfectly
2. To stop the rotation of the graduated ring, the brake pin should be pressed very gently and not suddenly
3. Readings should be taken along the line of sight and not from any side
4. When the compass has to be shifted from one station to another, 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 head
5. The compass box should be tapped gently before taking the reading. This is done to find out whether the needle rotates freely
6. The stations should not be selected near magnetic substances
7. The observer should not carry magnetic substances
8. 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.

Problems for practice:

- The bearings of the lines OA, OB, OC, OD are 30°30 ′, 140°15 ′, 220°45 ′ and 310°30 ′, respectively. Find the angles ∠AOB, ∠BOC and ∠COD.
- A traverse is done by three stations A, B and C in clockwise order in the form of an equilateral triangle. If the bearing of AB is 80°30 ′, find the bearings of the other sides.
- The following are the fore and back bearings of the sides of a closed traverse Calculate the interior angles of the traverse

Side	*FB*	*BB*
AB	*150°15′*	*330°15′*
BC	*20°30′*	*200°30′*
CD	*295°45′*	*115°45′*
DE	*218°0′*	*38°0′*
EA	*120°30′*	*300°30′*

Problems for practice:

- The following are the fore and back bearings of the sides of a closed traverse Calculate the interior angles of the traverse

Side	*FB*	*BB*
AB	*N 45°30′ E*	*S 45°30′ W*
BC	*S 60°0′ E*	*N 60°0′ W*
CD	*S 10°30′ W*	*N 10°30′ E*
DA	*N 75°45′ W*	*S 75°45′ E*

Thank You