SURVEYING

Meridian:

Meridians are imaginary lines of longitude on the earth that extend from the North to South Pole. A principal meridian is one which is used as a reference line to survey a large area.

Meridian
- → Magnetic meridian
- → True meridian
- → Arbitrary meridian

Magnetic meridian:

The magnetic meridian is a line joining the magnetic north pole with the magnetic south pole inside the earth.

True meridian

The line on a plane passing through the geographical North Pole or geographical South Pole and any point on the surface of the earth is known as true meridian.

Arbitrary meridian

For the survey of a small area, if a convenient direction is assume as a meridian known as Arbitrary meridian.

Bearing
- → Magnetic bearing
- → True bearing
- → Arbitrary bearing

Whole circle bearing (WCB)

Reduced bearing (or) Quadrantal bearing [RB (or) QB]

WCB: WCB of a survey line is the horizontal angle measured in clockwise direction from a reference meridian on a full scale. It is measured from the north point of magnetic meridian.

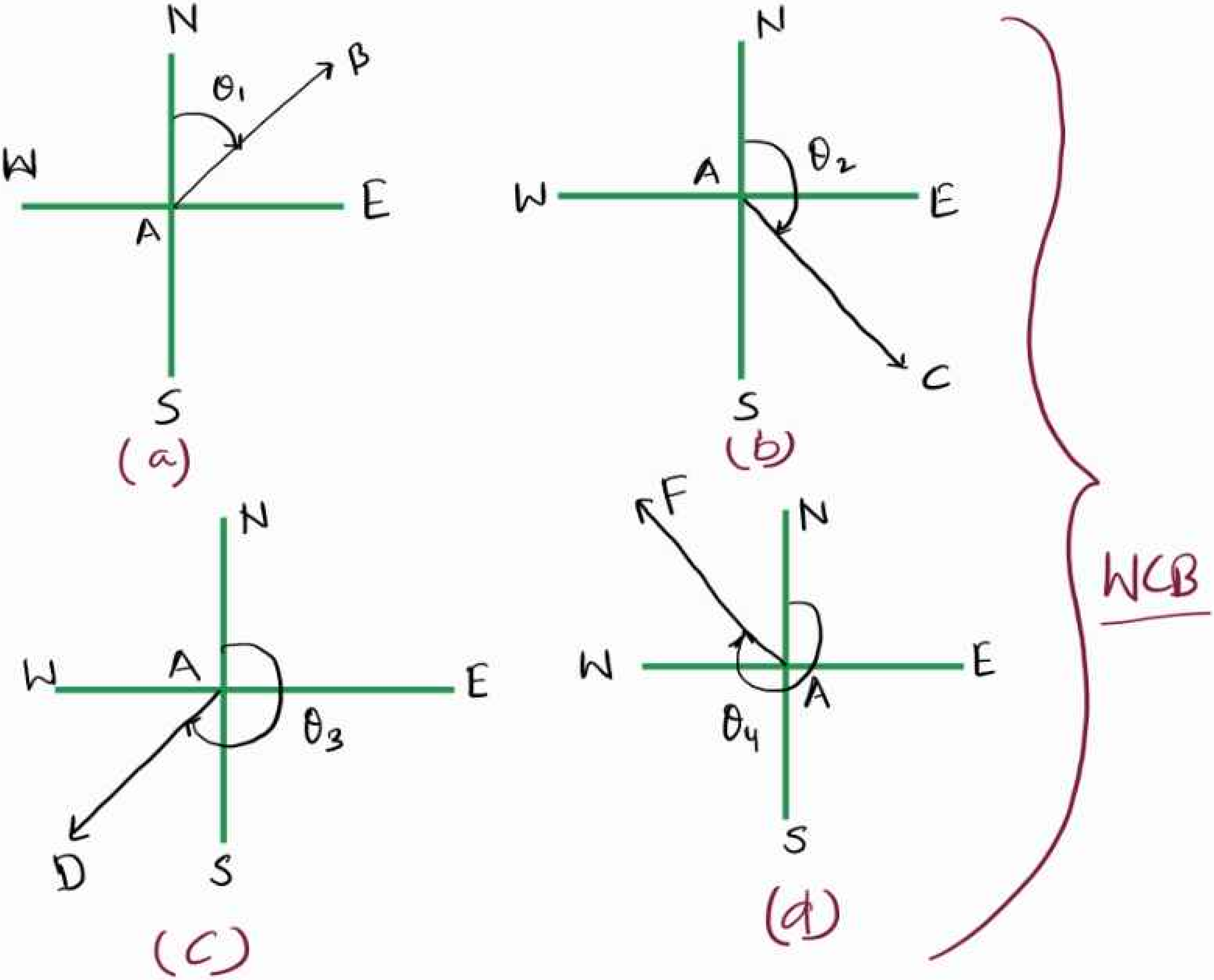
RB (or) QB:

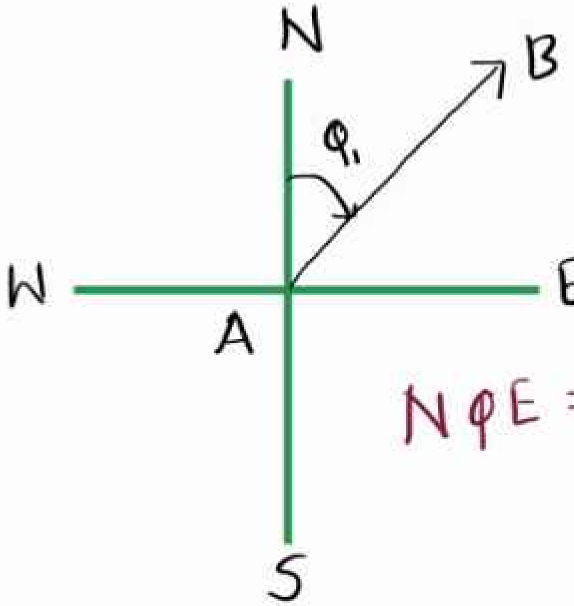
Reduced bearing of survey line is the horizontal angle measured clockwise (or) anticlockwise from north end (or) south end of the reference meridian towards east (or) west whichever is nearer.

* RB of a line has value from 0 to 90° with prefix N (or) S and suffix E (or) N.

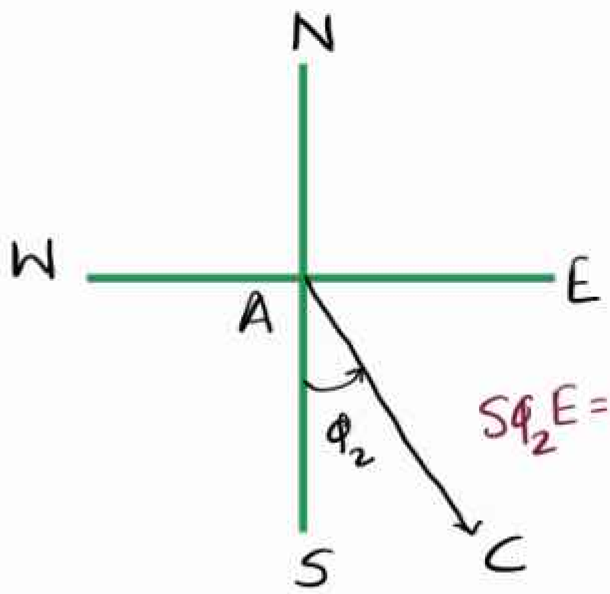
* Conversion of WCB to RB

Line	WCB	Quadrant	Rule of Conversion from WCB to RB	R.B.
AB	$0° - 90°$	NE	RB = WCB	$N\phi E$
AC	$90° - 180°$	SE	RB = $180°$ − WCB	$S\phi E$
AD	$180° - 270°$	SW	RB = WCB − $180°$	$S\phi W$
AF	$270° - 360°$	NW	RB = $360°$ − WCB	$N\phi W$

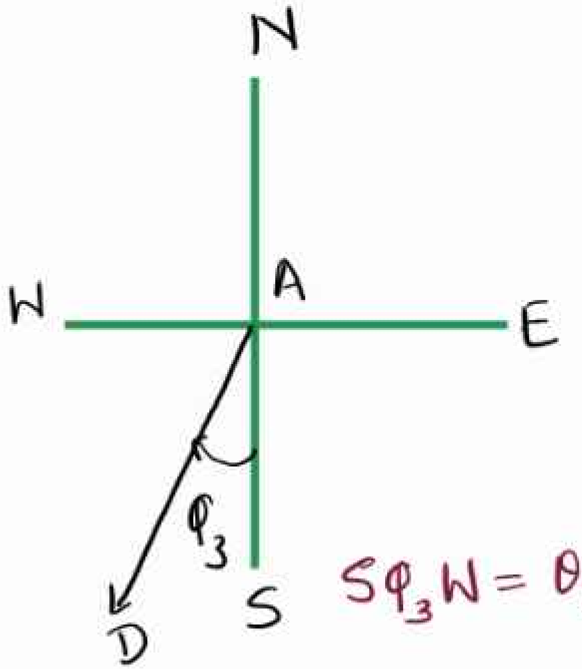




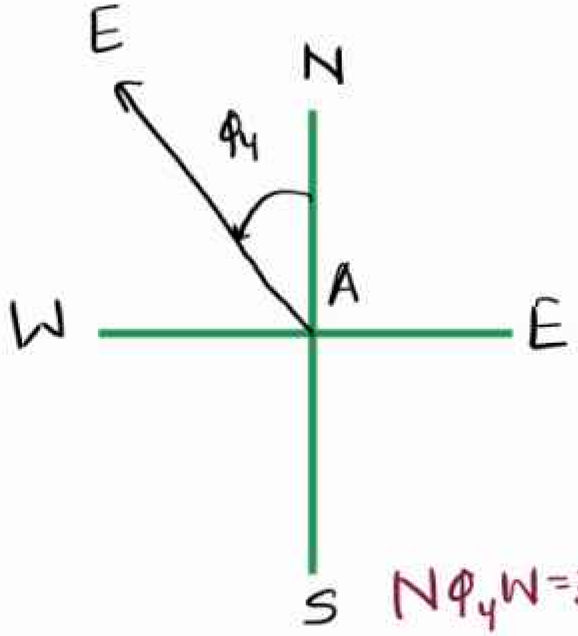
$N\varphi E = \theta_1$



$S\varphi_2 E = 180^\circ - \theta_2$



$S\varphi_3 W = \theta_3 - 180^\circ$



$N\varphi_4 W = 360^\circ - \theta_4$

Reduced bearing or Quadrental Bearings

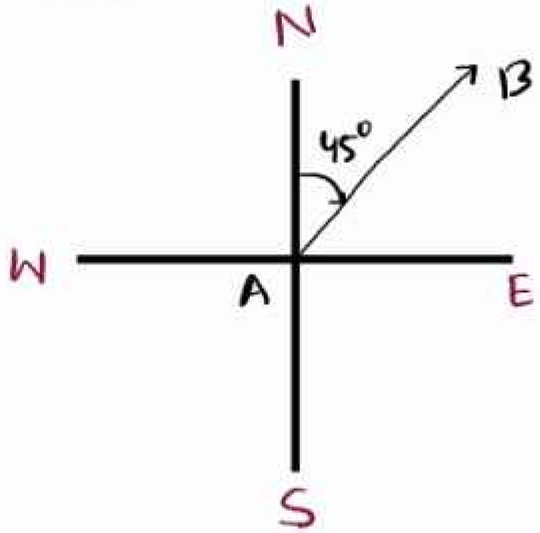
Conversion of Reduced bearing into W.C.B

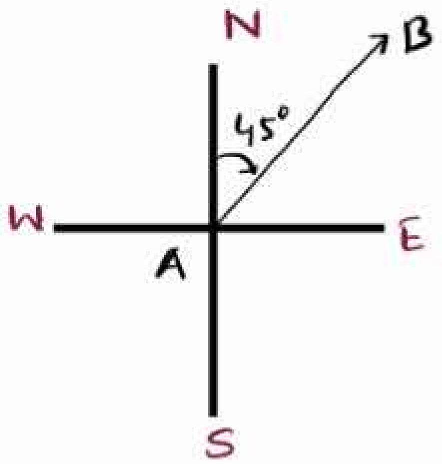
Line	Reduced Bearing	Rule of conversion from reduced bearing to WCB	WCB between
AB	$N\varphi_1 E$	WCB = RB	$0^\circ - 90^\circ$
AC	$S\varphi_2 E$	WCB = 180° − RB	$90^\circ - 180^\circ$
AD	$S\varphi_3 W$	WCB = 180° + R.B	$180^\circ - 270^\circ$
AE	$N\varphi_4 W$	WCB = 360° − R.B.	$270^\circ - 360^\circ$

Convert the following WCB of survey line to Reduced bearing

(i) AB = $49^\circ 15'$

WCB of AB = $49^\circ 15'$



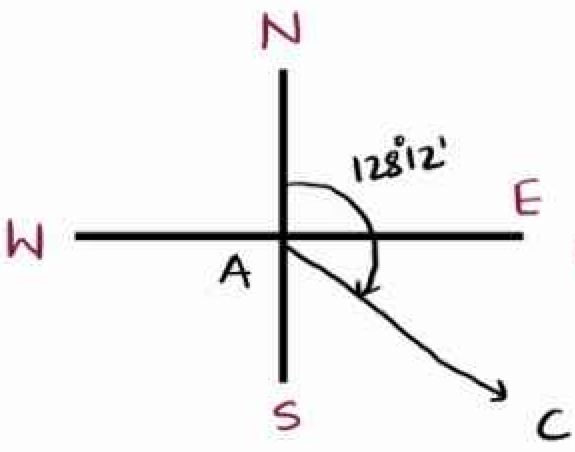


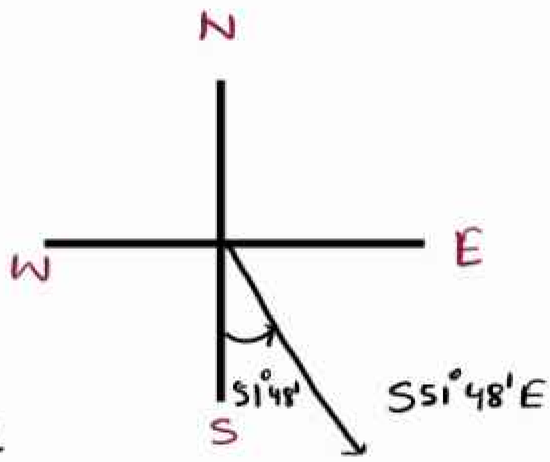
Reduced bearing of AB = N45°E

N45°E

(ii) AC = $128^\circ 12'$

WCB of AC = $128^\circ 12'$





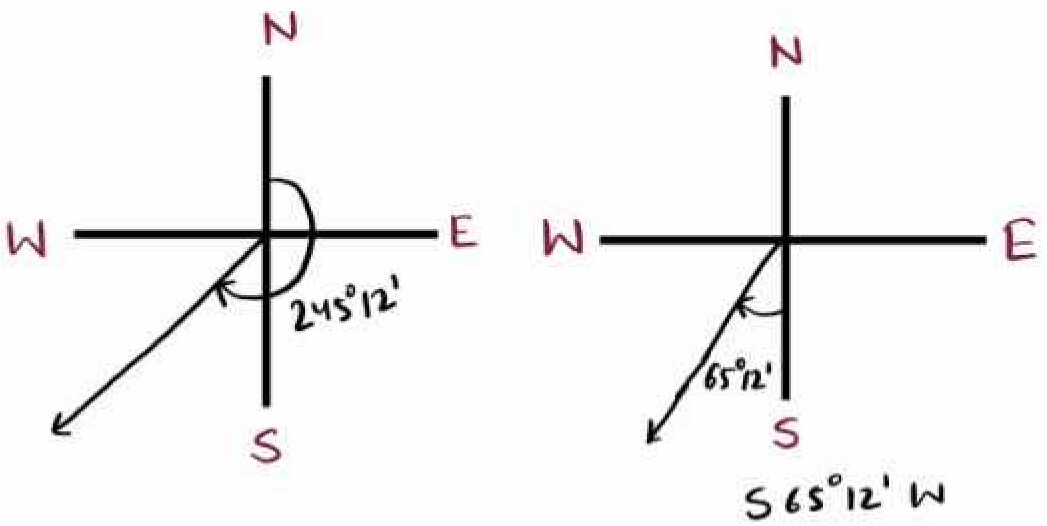
Reduced bearing = $180^\circ -$ WCB

$$= 180^\circ - 128^\circ 12'$$

$$= 51^\circ 48' \Rightarrow S\,51^\circ 48'\,E$$

(iii) AD = 245°12'

WCB of AD = 245°12'

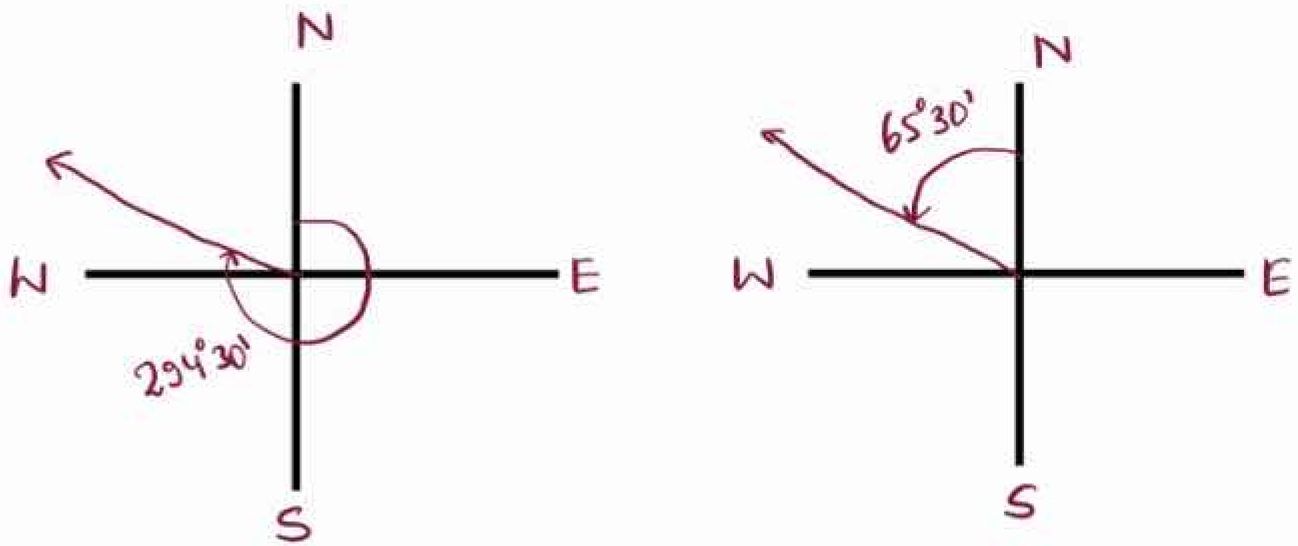


Reduced bearing of AD = 245°12' − 180°

= 65°12' ⇒ S65°12'W

(IV) AF = 294°30'

WCB of AF = 294°30'



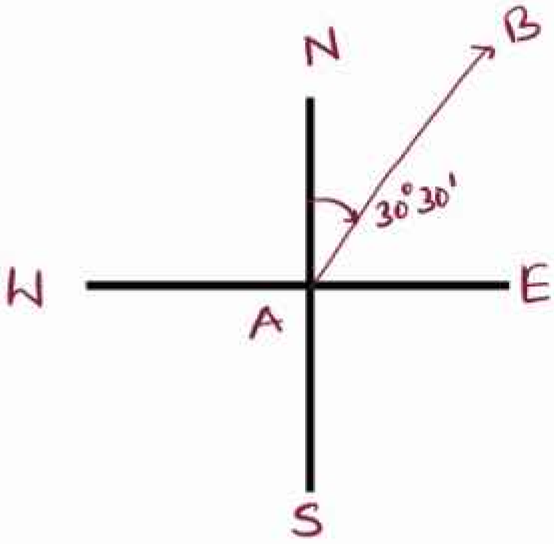
Reduced bearing of AF = 360° − WCB

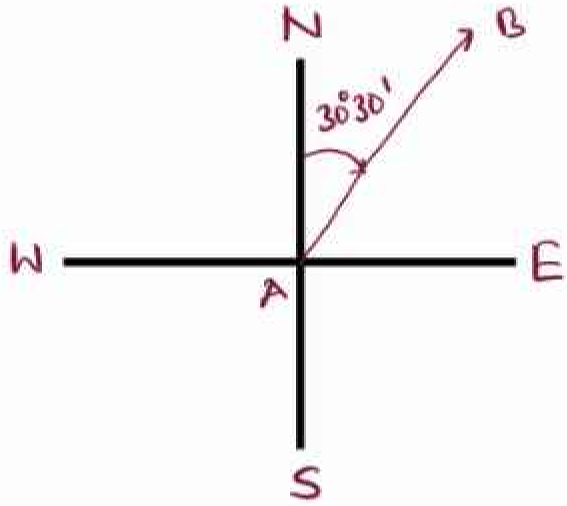
= 360° − 294°30'

= 65°30' ⇒ N65°30'W

Convert following reduced bearing of survey lines to WCB

(i) N30°30'E

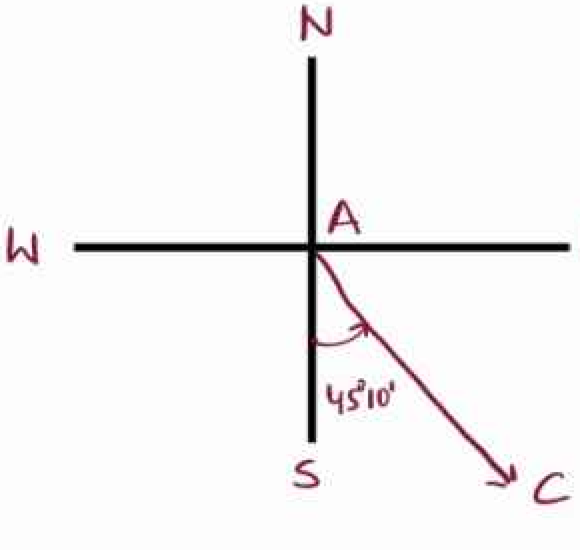


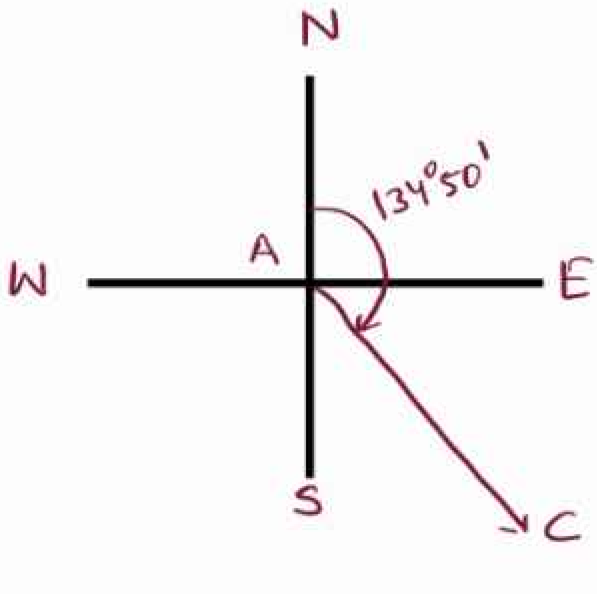


RB = N30°30'E

WCB = 30°30'

(ii) S45°10'E



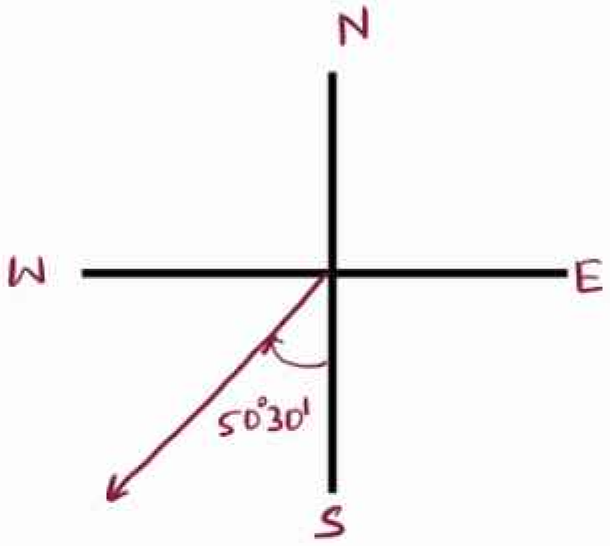


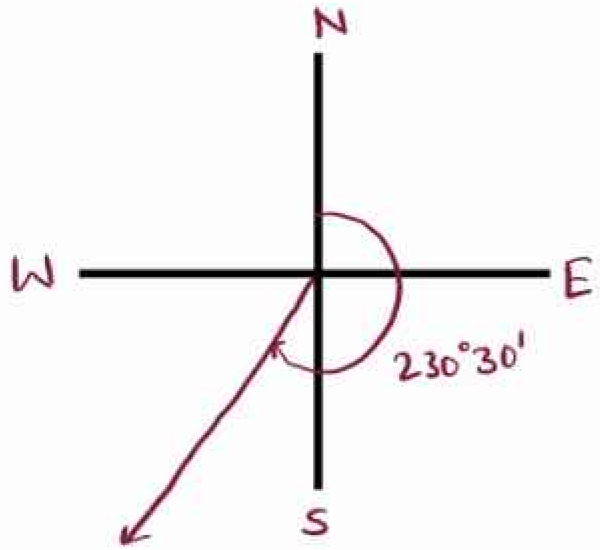
RB of line AC = S45°10'E

WCB of line AC = 180° − RB = 180° − 45°10'

= 134°50'

(iii) RB = S 50°30' W = RB of line AD





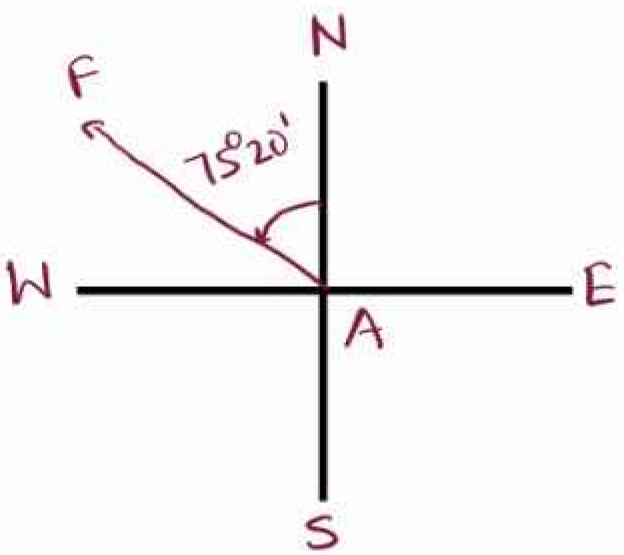
$$WCB = 180° + RB$$

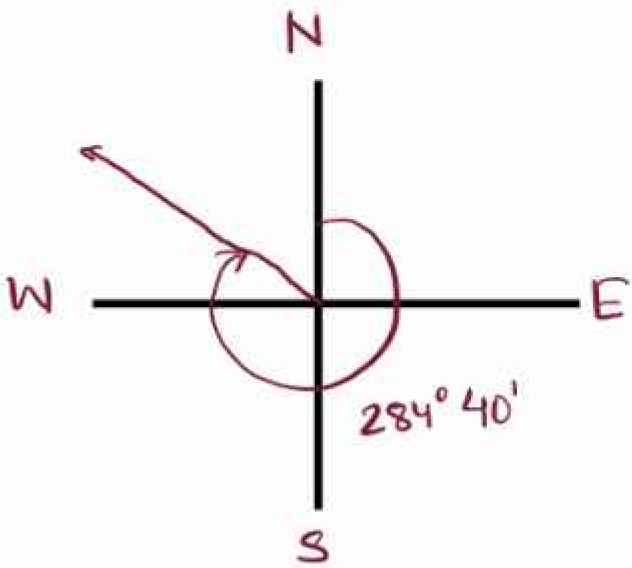
$$= 180° + 50°30'$$

$$WCB = 130°30'$$

(iv) AF = N 75°20' W

R.B. of line AF = N 75°20' W





$$WCB = 360° - RB = 360° - 75°20'$$

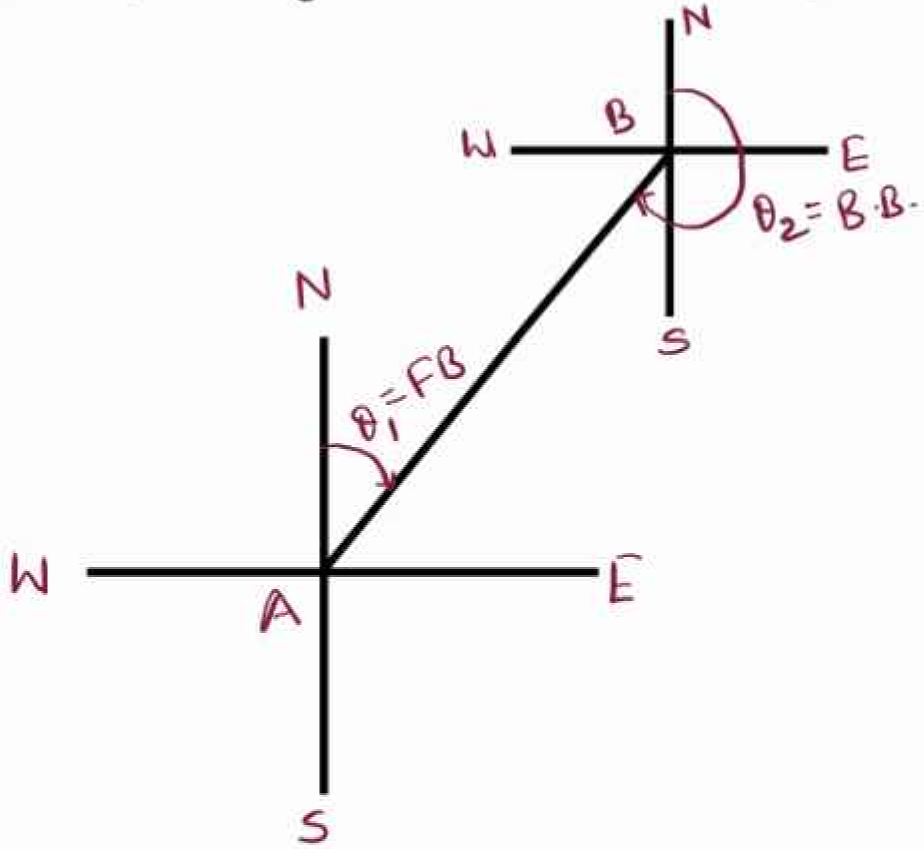
$$= 284°40'$$

Fore bearing (FB) and Back bearing (B.B.)

In compass surveying there are two bearings. These bearings exactly differs with 180°.

Fore bearings (FB)

The bearing of a survey line taken in the direction of progress of survey (or) in forward direction.



Fore bearing is a angle measured from station A to Station B in the direction in which survey is conducted.

$\angle NAB = \theta_1 =$ Fore bearing

Back bearing (B.B)

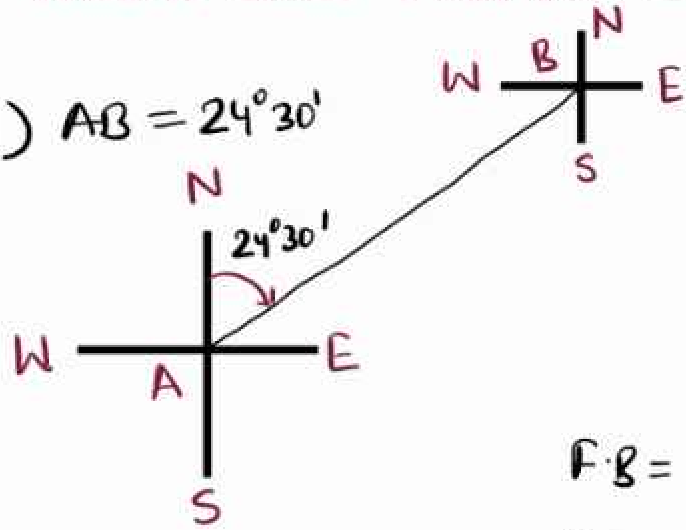
The bearing of a survey line taken in the direction opposite to the progress of survey.

$$F \cdot B - B \cdot B = 180^\circ$$

$$BB = FB \pm 180^\circ$$

(Q) The following are the observed fore bearings of the traverse lines. Find the back bearings.

(i) $AB = 24^\circ 30'$

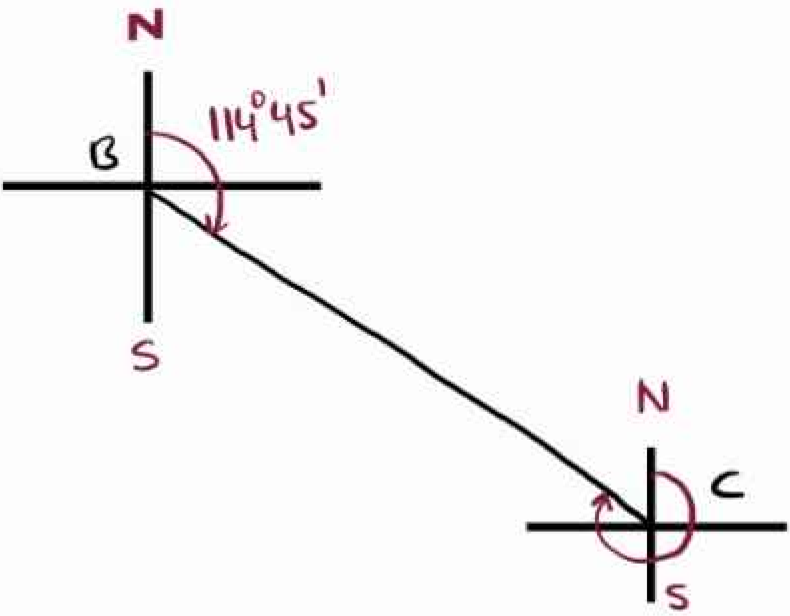


$F \cdot B = 24^\circ 30'$

$BB = 180^\circ + 24^\circ 30'$

$BB. = 204^\circ 30'$

(ii) $BC = 114^\circ 45'$



F.B. of $BC = 114^\circ 45'$

B.B. of $BC = 180^\circ + 114^\circ 45'$

$= 294^\circ 45'$

(iii) $CD = 213°30'$

(iv) $DE = 356°15'$

The fore bearings of survey lines are given as

(i) $PQ = N17°E$

(ii) $QR = N47°40'W$

(iii) $RS = S35°15'E$

(iv) $ST = S53°30'W$

First change these values in WCB

Find the Back bearing

(i) $WCB = 17°$

(ii) $WCB = 360° - 47°40' = 312°20'$

(iii) $WCB = 180° - 35°15' = 144°45'$

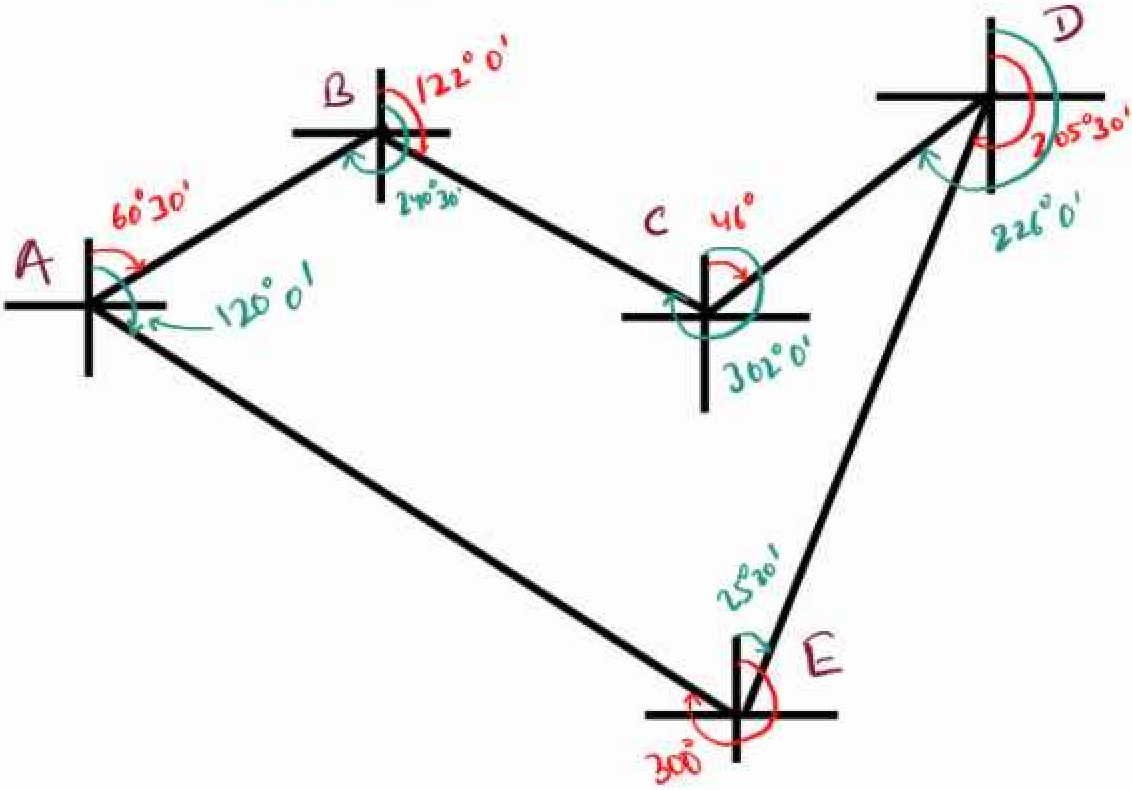
(iv) $WCB = 180° + 53°30' = 233°30'$

$$BB = FB \pm 180°$$

* If value of FB is less than 180° then use positive sign.
* If value of FB is greater than 180° then use negative sign.

The following bearings were observed with a compass. Determine the interior angles

Line	Fore bearings	back bearings
AB	60°30'	240°30'
BC	122°0'	302°0'
CD	46°0'	226°0'
DE	205°30'	25°30'
EA	300°0'	120°0'



Interior angle at A = B.B of line EA − F.B. of line AB

$= 120° - 60°30' = 59°30'$

Interior angle at B = B.B. of line AB − F.B. of line BC

$= 240°30' - 122°0'$

$= 118°30'$

Interior angle at C = B.B. of line BC − F.B. of line CD

$= 302°0' - 46°0'$

$= 256°0'$

Interior angle at D = B.B. of line CD − F.B. of line DE

$= 226°0' - 205°30'$

$= 20°30'$

Interior angle at E = B.B. of line DE − F.B. of line EA

$= 25°30' - 300°$

$= -274°30' + 360°$

$= 85°30'$

Sum of interior angles $= 59°30' + 118°30' + 256°0' + 20°30' + 85°30'$

$= 540°$ ✓

Check: Sum of interior angle $= (2n-4)\frac{\pi}{2}$

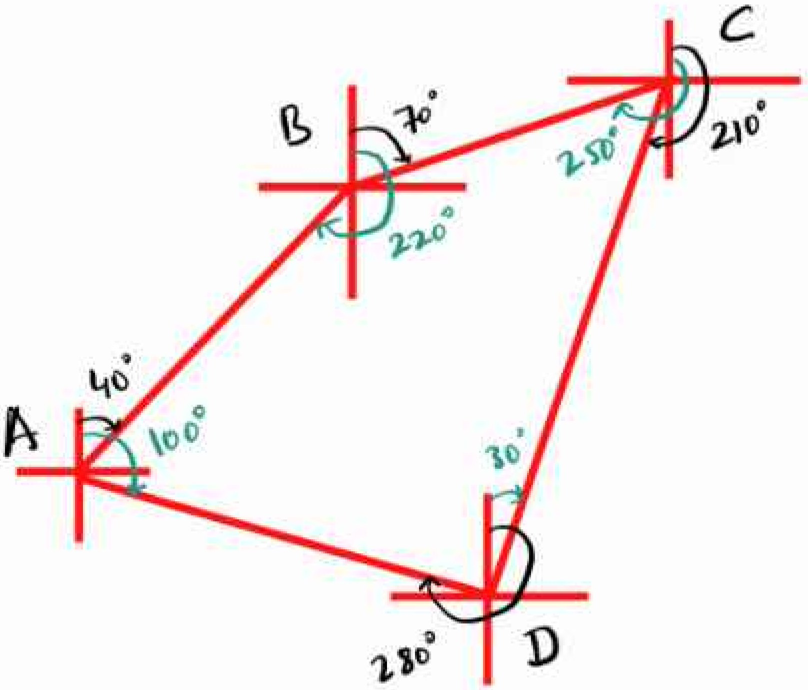
$= (2 \times 5 - 4)\,90°$

$= 6 \times 90° = 540°$ ✓

\# Determine the included angles (interior) of a closed compass traverse ABCDA.

line	F.B.	B.B.
AB	40°	220°
BC	70°	250°
CD	210°	30°
DA	280°	100°

Q7, Q8, R2, R3, S3, S8, S9, T1, T5, T9, V3, V7, V0, V2, V3, V4, V7, W6, W8,



Interior angle at A = B.B. of line DA − F.B. of line AB

$= 100 - 40° = 60°$

Interior angle at B = B.B. of line AB − F.B. of line BC

$= 220° - 70° = 150°$

Interior angle at C = B.B. of line BC − F.B. of line CD

$= 250° - 210° = 40°$

Interior angle at D = BB of line CD − FB of line DA

$= 30^\circ - 280^\circ = -250^\circ + 360^\circ$

$= 110^\circ$

Sum of interior angles = $60^\circ + 150^\circ + 40^\circ + 110^\circ$

$= 360^\circ$ ✓

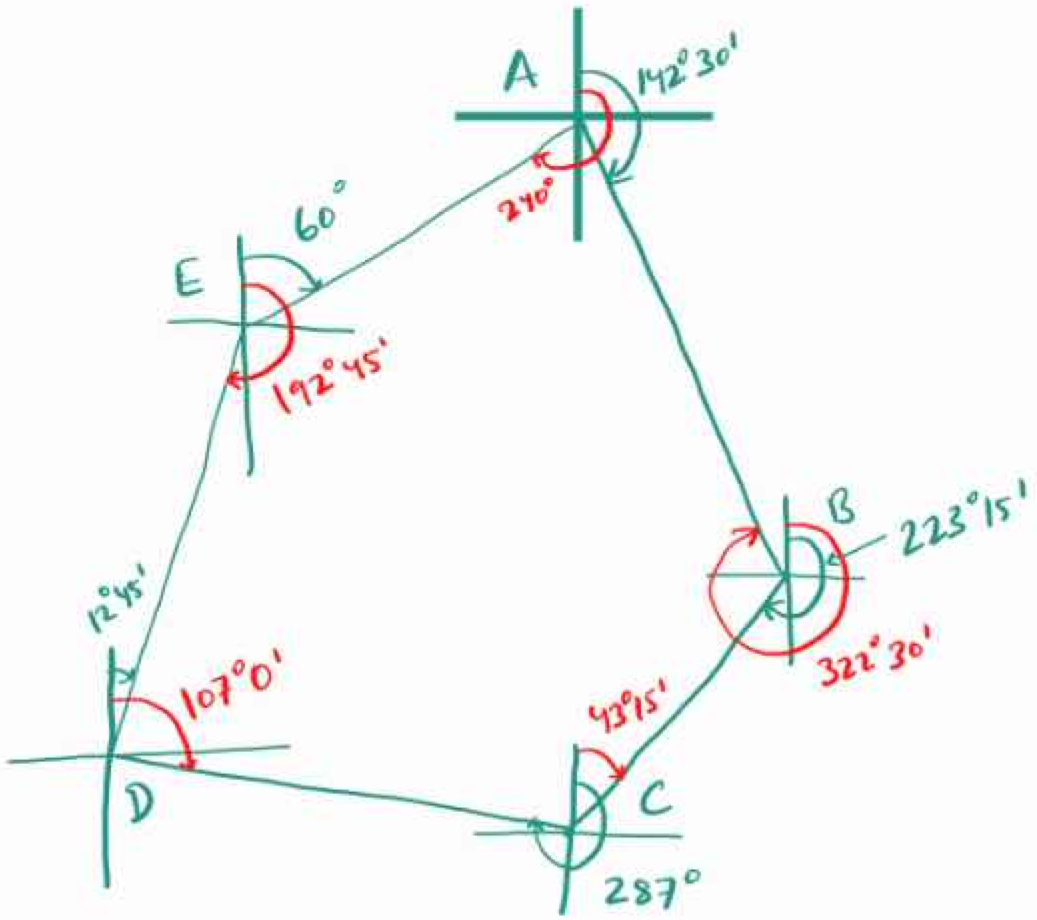
Check, sum of interior angles = $(2n-4)\,\pi/2$

$= (2\times 4 - 4)\,90^\circ$

$= 4 \times 90^\circ = 360^\circ$ ✓

following are the bearings taken in a closed compass travers

line	FB (RB)	FB (WCB)	BB
AB	S 37°30' E	142°30'	322°30'
BC	S 43°15' W	223°15'	43°15'
CD	N 73°00' W	287°0'	107°0'
DE	N 12°45' E	12°45'	192°45'
EA	N 60°00' E	60°0'	240°



Included angles = Back bearing of previous line − Fore bearing of next line

$\angle EAB$ = B.B. of line EA − F.B. of line AB

$= 240° - 142°30' = 97°30'$

$\angle ABC$ = B.B. of line AB − F.B. of line BC

$= 322°30' - 223°15' = 99°15'$

$\angle BCD$ = B.B. of line BC − F.B. of line CD

$= 43°15' - 287° + 360° = 116°15'$

$\angle CDE$ = B.B. of line CD − F.B. of line DE

$= 107°0' - 12°45' = 94°15'$

$\angle DEA$ = B.B of line DE − F.B. of line EA

$= 192^\circ 45^\circ - 60^\circ$

$= 132^\circ 45^\circ$

Sum of included angles $= 97^\circ 30' + 99^\circ 15' + 116^\circ 15' + 94^\circ 15' + 132^\circ 45^\circ$

$= 540^\circ 0'$

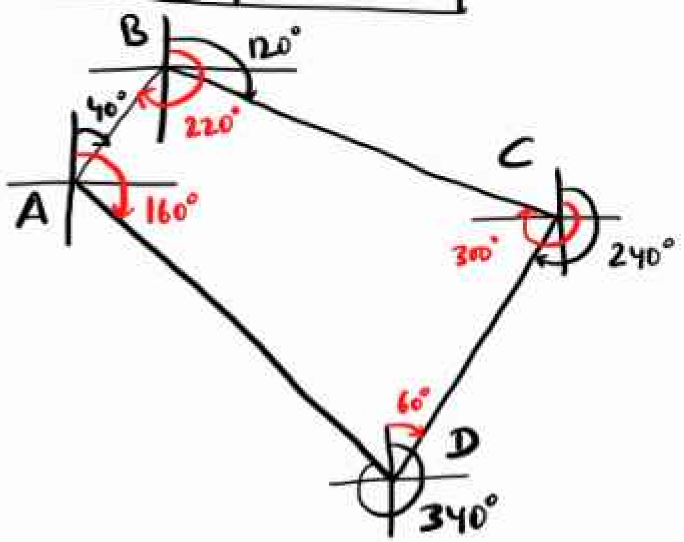
Check: Sum of included angles $= (2n-4)\frac{\pi}{2}$

$= (2\times 5-4)\frac{\pi}{2}$

$= 6\times 90^\circ = 540^\circ$

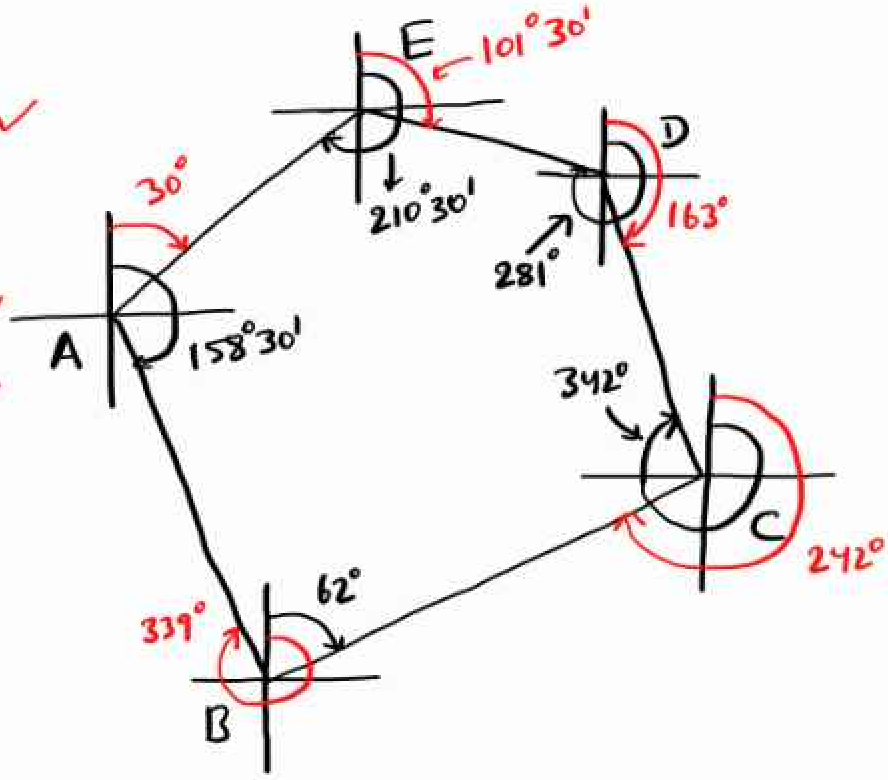
Determine the interior angles of the given closed traverse.

Line	F.B	B.B
AB	40°	220°
BC	120°	300°
CD	240°	60°
DA	340°	160°



The following fore and back bearing were observed in transversing with a compass in place where local attraction was suspected. Find corrected F.B & B.B. of lines using included angles.

Line	F.B.	B.B.
AB	158°30'	339° ✓
BC	62°	242°
CD	342°	163° ✓
DE	281°	101°30' ✓
EA	210°30'	30°0' ✓



$\angle EAB$ = B.B. of EA − F.B. of AB

$= 158°30' - 30° = 128°30'$

$\angle ABC$ = B.B. of line AB − F.B. of line BC

$= 339° - 62° = 277°0' - 360° = -83° = 83°$

$\angle BCD$ = B.B. of line BC − F.B. of line CD

$= 242° - 342° = -100° \simeq 100°$

$\angle CDE$ = B.B. of line CD − F.B. of line DE

$= 163° - 281° = -118° = 118°$

$\angle DEA$ = B.B. of line DE − F.B. of line EA

$= 101°30' − 210°30' = 109°0'$

Sum of included angles $= 128°30' + 83° + 100° + 118° + 109°$

$= 538°30'$

<u>Check</u>: Sum of included angles $= (2n-4)\frac{\pi}{2}$

$= (2\times5-4)\times 90°$

$= 540°$

Correction $= 540° - 538°30' = 1°30'$ (positive)

Sum of included angles are diffitent with 1°30°

So, divided 1°30' into 5 equal parts and add into all included angles.

So, Error for every angles $= \frac{1°30'}{5} = 0°18'$

$\angle A = 128°30' + 0°18' = 128°48'$

$\angle B = 83° + 0°18' = 83°18'$

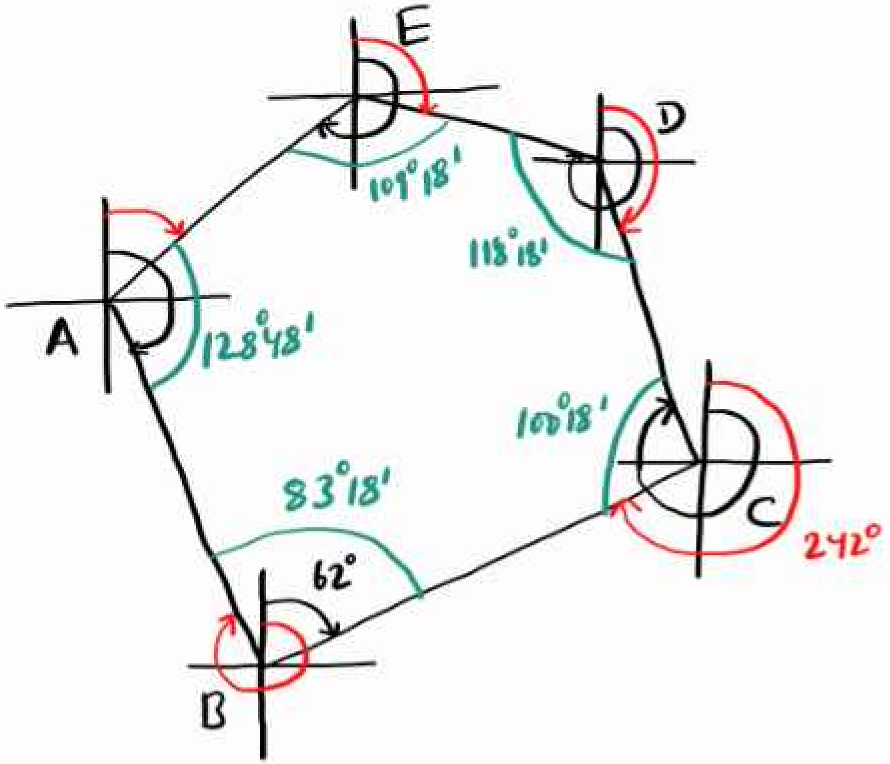
$\angle C = 100° + 0°18' = 100°18'$

$\angle D = 118° + 0°18' = 118°18'$

$\angle E = 109° + 0°18' = 109°18'$

Corrected bearings

line	F.B	B.B	Corrected bearings F.B.	Corrected bearings B.B
AB	158°30'	339°	158°32'	338°42'
BC	62°	242°	62°	242°
CD	342°	163°	342°18'	162°18'
DE	281°	101°30'	280°36'	100°36'
EA	210°30'	30°	209°54'	29°54'



F.B. of line CD = B.B. of BC + included angle at C

= 242° + 100°18' = 342°18'

B.B. of CD = F.B. of CD -180° = $342^\circ 18' - 180^\circ = 162^\circ 18'$

F.B. of DE = B.B. of CD + included angle at D

$= 162^\circ 18' + 118^\circ 18' = 280^\circ 36'$

B.B. of DE = F.B. of DE $- 180^\circ$

$= 280^\circ 36' - 180^\circ = 100^\circ 36'$

F.B. of EA = B.B. of DE + included angle at E

$= 100^\circ 36' + 109^\circ 18^\circ = 209^\circ 54'$

B.B. of EA = F.B. of EA $-180^\circ = 209^\circ 54' - 180^\circ$

$= 29^\circ 54'$

F.B. of AB = B.B. of EA + included angle at A.

$= 29^\circ 54' + 128^\circ 48' = 158^\circ 42'$

B.B. of AB = F.B. of AB $+ 180^\circ$

$= 158^\circ 42' + 180^\circ = 338^\circ 42'$

Magnetic Declination

True bearing = magnetic bearing $\pm$ magnetic declination

+ve sign, if declination is in East
−ve sign, " " " in West

The magnetic bearing of line PQ is $124^\circ 35'$. Find the true bearing, if the magnetic declination is $10^\circ 10'$W.

Sol^n True bearing = Magnetic bearing − declination

$$= 124^\circ 35' - 10^\circ 10'$$
$$= 114^\circ 25'$$

The magnetic bearing of line PQ is S 40° E and the magnetic declination is $8^\circ 5'$E. What is true bearing of line.

If the true bearing of a line is $34^\circ 20'$ and magnetic bearing of a line is $36^\circ 40'$. What will be the magnetic declination.

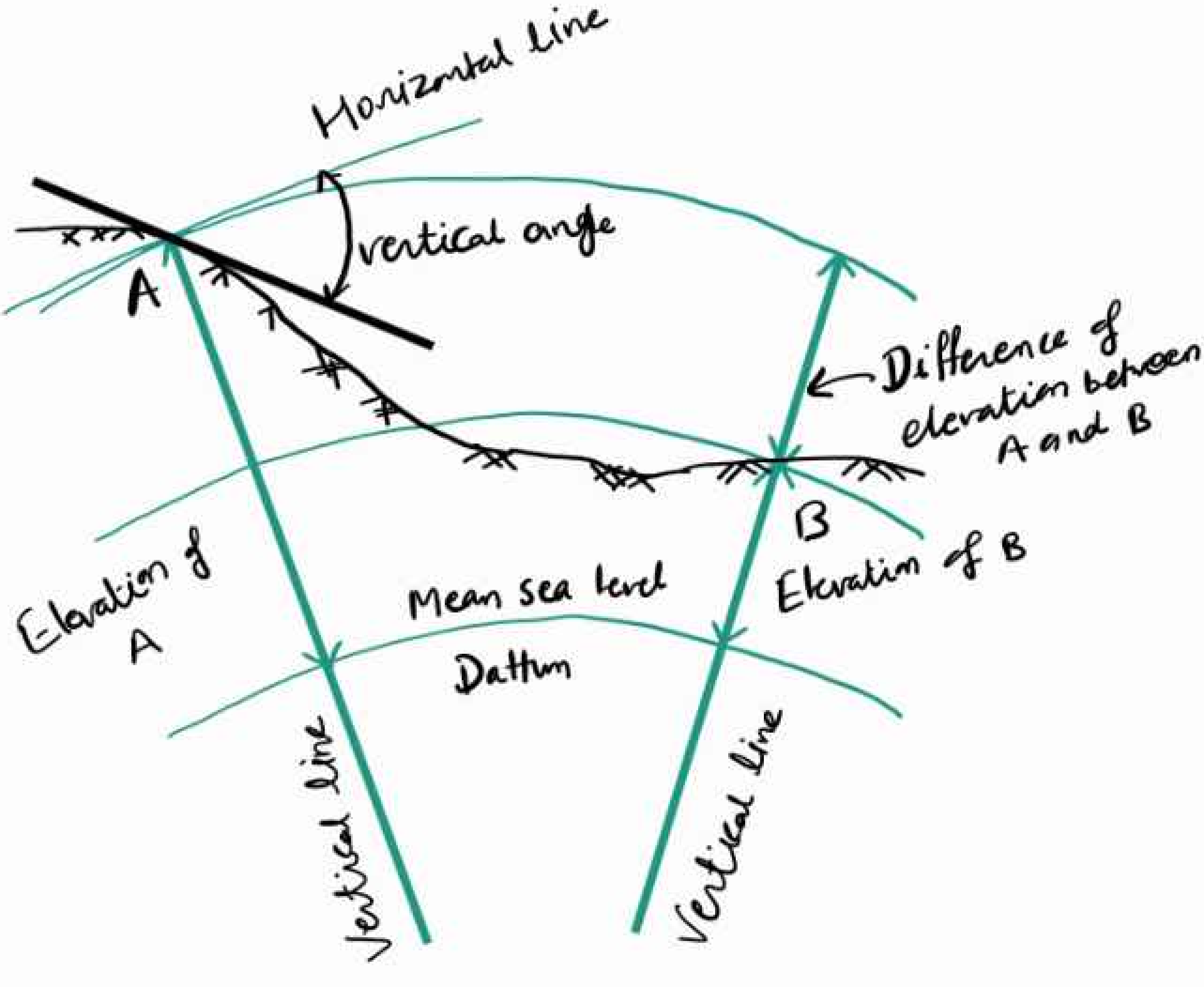
Levelling

levels:

The heights of a point above (or) below a datum (reference surface) are referred as levels.

levelling:

Operation of determining the difference of elevation of points with respect to each other on the surface of earth is called levelling.



level surface:

A surface parallel to the mean spheroidal surface of the earth is called level surface. A level surface is a curved surface, every point on which is equidistant from the centre of the earth.

Vertical line:

It is a line from any point on the earth's surface to the centre of the earth.

level line

It is a line lying on a level surface. It is normal to the plumb line at all the points.

Horizontal plane:

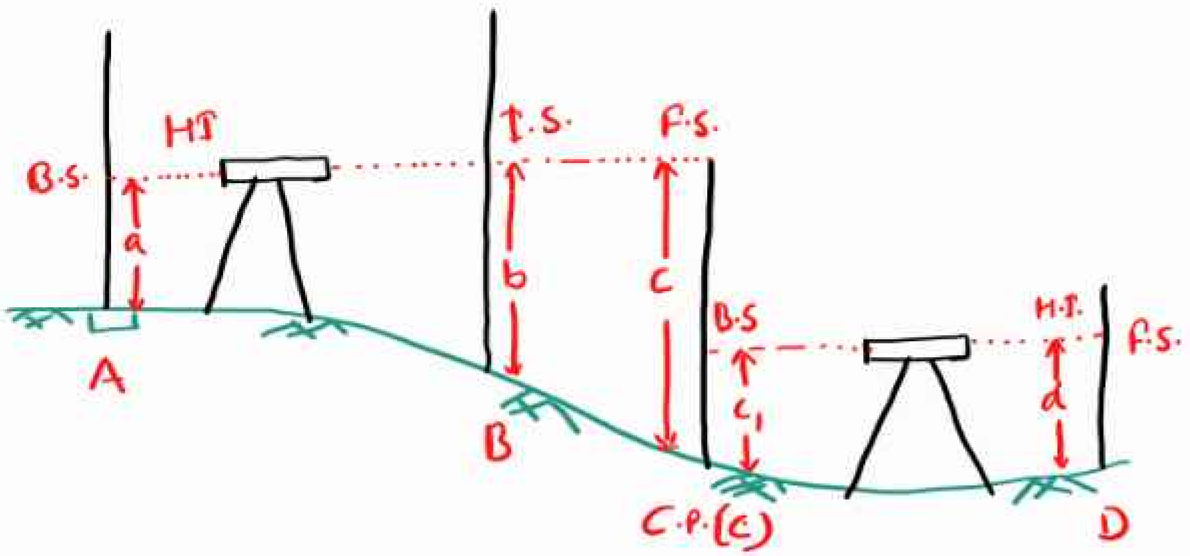
It is a plane tangential to the level surface at the point under consideration. It is perpendicular to the plumb line.

Horizontal line:

It is line lying in the horizontal plane. It is a straight line tangential to the level line.

Axis of telescope

It is a line joining the optical centre of the objective to the centre of the eyepiece.



Height of Instrument (HI) : It is the elvation of the plane of collimation when instrument is levelled.

Back sight (B.S.) : It is a staff reading taken on a point of known elevation. i.e. sight on a bench mark (station A)

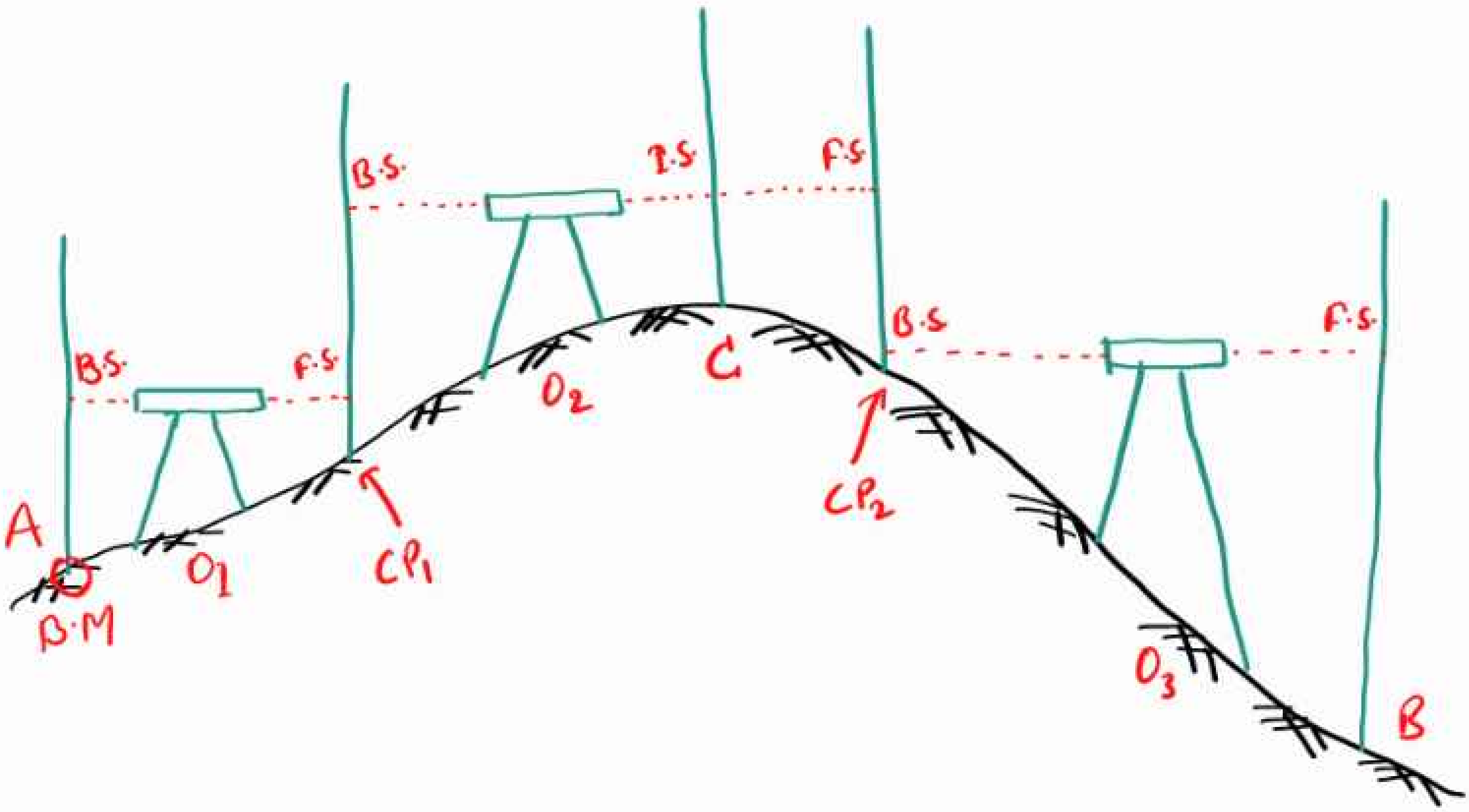
Fore sight (F.S.) : It is staff reading taken on a point whose elevation is to be determined.

Intermediate sight (I.S.) : It is a staff reading taken on a point of unknown elevation between backsight and fore sight.

Change point (C.P.) (or) turning point (T.P.) : It is a point, denoting the shifting of level. Both F.S and B.S. reading are taken on this point.

Station : A point, whose elevation is to be determined is called station.

Bench mark (B.M) : It is a fixed reference point of known elevation.



Method of levelling

Method 1

Height of Instrument method

Height of Instrument (H.I) = R.L. of B.M. + B.S. reading on that B.M.

R.L. of other staff station = Height of Instrument (H.I.) − I.S/F.S. readings.

After calculation, it is checked for correction.

Difference between the sum of back sight (B.S.) and sum of fore sight (F.S.) should be equal to difference between reduced level (R.L.) of Starting bench mark and reduced level of closing point.

$$\boxed{\sum B.S - \sum F.S = \text{last } R.L - \text{First } R.L}$$

Question The following staff readings were observed successively with a level, the instrument have been moved after third and sixth readings.

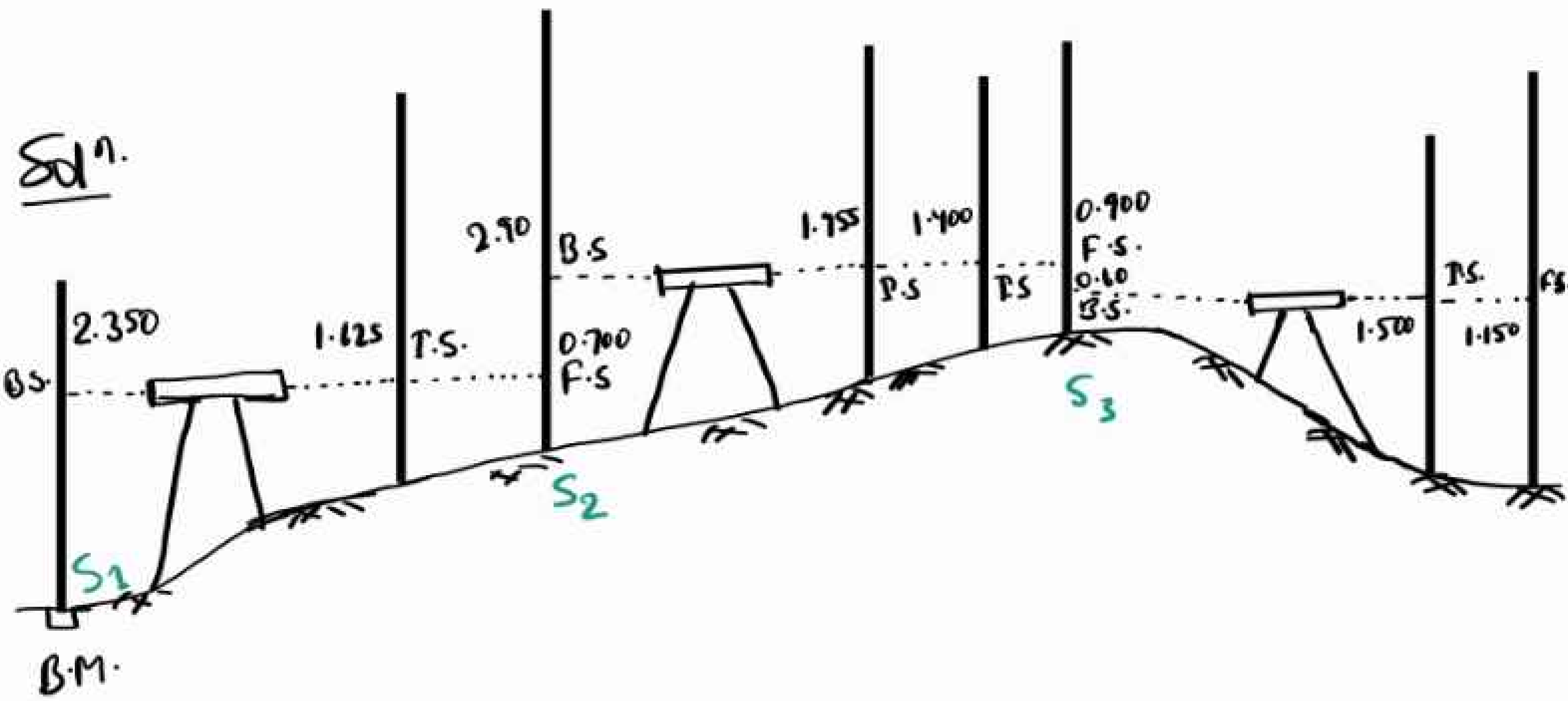
2.350, 1.625, 0.700, 2.900, 1.955, 1.400, 0.900, 0.600, 1.500, 1.150

Enter the above reading in a page of a field level book.

Calculate the RL^s of all points by Height of Instrument (or) Collimation method. The first reading was taken with a staff held on a bench mark of R.L 100m.

Also apply arithmetical check.

Soln.



Instrument Station	Staff Station	Back sight (B.S)	Intermediate sight (I.S)	Fore sight (F.S.)	Height of instrument	Reduced level of all station	Remark
S_1	1	2.350			102.350	100.000	B.M.
	2		1.625		102.350	100.725	
S_2	3	2.90		0.700	104.55	101.65	
	4		1.955		104.55	102.595	
	5		1.400		104.55	103.15	
S_3	6	0.600		0.900	104.25	103.65	
	7		1.500		104.25	102.75	
	8			1.150	104.25	103.10	
	9						
	ΣB.S.	5.850	ΣF.S.	2.750			

<u>Instrument setup S_1</u>

$$H.I.\ at\ S_1 = R.L. + B.S = 100 + 2.350 = 102.350$$

R.L. of intermediate point 2 = H.I. at S_1 − I.S/F.S. at point 2.

$$= 102.350 - 1.625 = 100.725$$

R.L. of intermediate point 3 = H.I. at S_1 − I.S/F.S at S_3

$$= 102.350 - 0.700 = 101.650$$

<u>Instrument station S_2</u>

$$H.I.\ at\ S_2 = R.L.\ at\ point\ 3 + B.S. = 101.650 + 2.900$$
$$= 104.55$$

R.L. of intermediate point 4 = H.I. at S_2 − I.S. at 4

$= 104.55 - 1.955 = 102.595$

R.L. of intermediate point 5 = H.I. at S_2 − I.S. at 5

$= 104.550 - 1.400 = 103.15$

R.L. of intermediate point 6 = H.I. at S_2 − I.S. at 6

$= 104.550 - 0.900 = 103.650$

Instrument setup S_3

H.I. of instrument at S_3 = R.L. of point 6 + B.S.

$= 103.650 + 0.600 = 104.250$

R.L. of intermediate point 7 = H.I. at S_3 − I.S. at 7

$= 104.250 - 1.500 = 102.750$

R.L. of intermediate point 8 = H.I. at S_3 − I.S. at 8

$= 104.250 - 1.150 = 103.100$

Arithmetical Check:

$\Sigma B.S - \Sigma F.S.$ = Last R.L. − First R.L.

$5.850 - 2.750 = 103.100 - 100 \Rightarrow 3.100$

RISE AND FALL METHOD

In this method, the difference of level between the two consecutive points are obtained by comparing the staff readings taken from the same setup of the instrument.

⇒ R.L. of any point found by adding (or) substracting the respective Rise or fall values from the R.L. of the previous points.

Rule: Difference in level between the two consecutive points in rise & fall method is —

⇒ First staff reading − Second staff reading = ± Rise/fall

R.L. of any point = R.L. of the previous point ± rise/Fall of that point

Arithmetical Check:

$$\sum B.S. - \sum F.S. = \sum Rise - \sum Fall = \text{Last } R.L. - \text{First } R.L.$$

Question The following staff readings were observed successively with a level, the instrument have been moved after third and sixth readings.

2.350, 1.625, 0.700, 2.900, 1.955, 1.400, 0.900, 0.600, 1.500, 1.150

Enter the above reading in a page of a field level book.

Calculate the RL's of all points by Rise & Fall method.

The first reading was taken with a staff held on a bench mark of R.L 100m.

Also apply arithmetical check.

Soln.

Staff station	Back sight (B.S.)	Intermediate site (I.S.)	Fore sight (F.S.)	Rise	Fall	R.L.	Remark
1	2.350					100	B.M
2		1.625		0.725		100.725	
3	2.900		0.700	0.925		101.650	$C.P_1$
4		1.955		0.945		102.595	
5		1.400		0.555		103.150	
6	0.600		0.900	0.500		103.650	CP_2
7		1.500			0.900	102.750	
8			1.150	0.350		103.100	

$\sum B.S = 5.850$ $\sum F.S. = 2.750$ $\sum Rise = 4.000$ $\sum Fall = 0.900$

Calculation of Rise & fall of points

Compare B.s. of 1 and F.S. of 2 (Reading on 1 is greater, therefore rise form 1-2)

difference in levels between staff stations 1-2 = 2.350 − 1.625
= 0.725 (Rise) ✓

difference in levels between staff stations 2–3 = 1.625 − 0.700
= 0.925 (Rise) ✓

difference in levels between staff stations 3-4 = 2.900 − 1.955
= 0.945 (Rise) ✓

difference in levels between staff station 4-5 = 1.955 − 1.400 = 0.555 (Rise) ✓

difference in levels between staff station 5-6 = 1.400 − 0.900 = 0.500 (Rise) ✓

difference in levels between staff station 6-7 = 0.600 − 1.500 = −0.900 (fall) ✓

difference in levels between staff station 7-8 = 1.500 − 1.150 = 0.350 (Rise) ✓

Calculation of R.L. of points

R.L. of station 1 is BM = 100.00

R.L. of Station 2 = 100 + 0.725 = 100.725

R.L. of Station 3 = 100.725 + 0.925 = 101.650

R.L. of station 4 = 101.650 + 0.945 = 102.595

R.L. of station 5 = 102.595 + 0.555 = 103.150

R.L. of Station 6 = 103.150 + 0.500 = 103.650

R.L. of Station 7 = 103.650 − 0.900 = 102.750

R.L. of Station 8 = 102.750 + 0.350 = 103.100

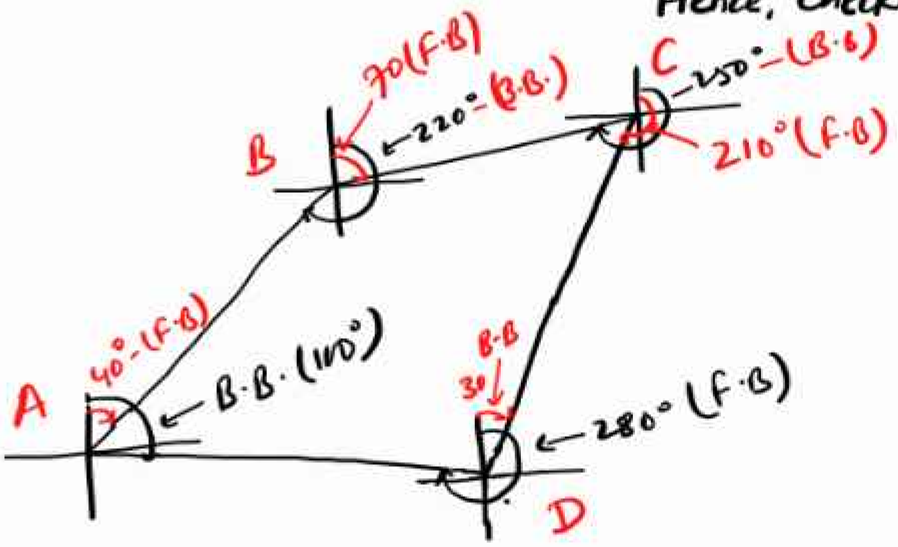
Arithmetical Check

$$\sum B.S. - \sum F.S. = \sum Rise - \sum Fall = Last\ R.L. - First\ R.L.$$

$$5.850 - 2.750 = 4.000 - 0.900 = 103.100 - 100$$

$$3.100 = 3.100 = 3.100$$

Hence, Checked.



$\angle A = 60°$ | $\angle C = 40°$

$\angle B = 150°$ | $\angle D = 360° - 280° + 30° = 110°$

$$60 + 150 + 40 + 110 = 360°$$

$$(2n-4)\frac{\pi}{2} = (2 \times 4 - 4)\frac{\pi}{2} = 360°$$