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SURVEYING

*) What is surveying? (Imp Q):

Surveying is the science and art of determining the relative positions of the points above, on or below the earth's surface and locating points in the field.

It is the first step of execution of any project.

Surveying as art: surveying is related to particular individual and coordination of each person/surveyor is different.
ie, variation in measurement techniques, processes and units

Surveying as science: surveying uses various mathematical relations to get positions of objects

*) Types of Surveying:

A) On the basis of work, surveying are of following types:

i) Control survey
ii) Topographical survey
iii) Levelling survey
iv) Hydrographic survey
v) Mine survey
vi) Canal survey
vii) Military survey
viii) Cadastral survey
ix) Route survey
x) Engineering survey
xi) Construction survey
xii) Archaeological survey
xiii) Geological survey

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i) Control Survey:
- Control survey is used to establish network of horizontal and vertical control points.
- Mostly focused on determination of horizontal ie, x-position
- Helps us establish control stations which is serves as reference framework for other survey.

- control survey stations are determined using GPS technology or by the data given by respective department.

(ii) Topographical Survey:
- Topographical survey is used to determine the topography related to an area.

- It helps us to visualize the landscape ie, terrain ~~after~~ of surrounding.
- Conducted after control station is determine.

(iii) Levelling Survey:
- Levelling survey ~~also~~ falls into control survey which is based on calculating the relative height ie, used for determination of vertical position

(iv) Hydrographic Survey:
- Hydrographic survey deals with surveying of water bodies for establishing hydropower, marine navigation, construction, offshore oil exploration, etc.

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v) Mine Survey:
- Mine survey is conducted for exploring mineral deposits, guiding ~~tr~~ tunnelling and various underground works.
- Mine survey is linked to the surface and measurements are then corrected.

(vi) Canal Survey:
- Canal survey is conducted to determine shortest route of water travelling considering factors relating to damage, discharge and fast flow.
- Helps fixing routes of canals for purposes of irrigation.

(vii) Military survey:
- Military survey is based on accurate positioning and it includes all surveys conducted considering military purpose.
- This survey method is extremely precise and the data is classified for security purpose.

(viii) Cadastral survey:
- Cadastral survey is identity of surveying in Nepal.
- It is conducted to establish boundaries of field and houses.

(ix) Route survey:
- Route survey is conducted to plan, design and execute a route for travel, pipeline, transmission lines, etc.

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x) Engineering survey:
- Engineering survey is specially done for engineering projects like designing roads, bridges, water supplies, etc.

xi) Construction survey:
- Construction survey is ~~done~~ done by laying out various survey points before starting construction works.

xii) Archeaological survey:
- Archaeological survey is a kind of field survey relating to determining location, distribution and organization of past human cultures.

xiii) Geological survey:
→ Geological surveying is done to determine different strata of earth's crust.
- Also conducted to meet geological objectives and for geographical exploration.

B): On the basis of instruments used, surveying are of following types:
i) Chain survey
ii) Compass survey
iii) Plane-table survey
iv) Levelling survey
v) Theodolite survey
vi) Tacheometric survey
vii) Photogrammetric survey
viii) EDM survey
ix) GPS survey.

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(i): Chain survey:
- Chain survey is conducted using chains which contain number of links.

(ii) Compass surveying:
- Compass surveying uses compass to survey areas where coverage is not available.
- Freely suspended magnet alignment helps conduct the survey.

(iii) Plane table survey:
- Plane table surveying is based on mapping and navigation to provide solid and levelled surface to make drawings, charts and maps.
- Here, field observation and plotting are done simultaneously.

(iv) Levelling survey:
- Levelling survey is based on measuring / verifying the ~~hight~~ heights of specific points.

(v) Theodolite survey:
- Theodolite survey useds theodolite as instrument which measures horizontal and vertical angles with tiny low telescope that moves within horizontal and vertical planes.

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(vi): Tacheometric survey:
- In tacheometric survey, a tachometer is used to measure horizontal and vertical distance between two points.

(vii): Photogrammetric survey:
- Photogrammetric survey utilizes UAV (Unmanned Aerial Vehicle) ie, drones for surveying purpose.
- It is expensive and is used only for larger scope of work.
- Utilized during hydrographic and topographic survey.

(viii) EDM survey ie, Electronic distance Measurement.
- EDM survey uses lasers and the noting of speed and time is done to find distances.
- EDM gives highly accurate data.

(ix): GPS survey:
- GPS survey is mostly used for map representation
- It mostly focuses on giving details but it is not an accurate surveying method.

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Principles of Survey:

(Imp Q): what is the main principle of survey? Explain its importance.

(i): Working from whole to part:

This is the main principle of surveying. In this method, the major control points are selected and measured with high precision minimizing errors and the minor details is collected later even with less degree of precision.

Eg: first of all we survey the boundary of the house before we start working on inside survey.

The main Importance of working from whole to part in surveying is to minimize errors and its propagation.

Theory of Error in survey claims that errors and survey goes hand in hand and survey always consists errors. It also takes that negative and positive errors equally prevail.

When we work from whole to part, the error is not localized to a single part but spread around. As a result, the error is not localized and error is not transferred from one part to another. This prevents accumulation of error.

Thus, we work from whole to part which is considered the main principle of surveying.

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(ii) Consistency in Work:
While conducting the whole surveying process, same method of survey and same instruments must be used throughout the surveying process.

(iii) Up to date:
Since due to technological advancement, precision has increased in survey works. Hence, we must adopt modern surveying methods.

(iv): Independent check.
- An independent point not related to the measurement sector must be selected which is used to correct blunders and the survey doesn't need to be reconducted.
- Errors in survey must not pass undetected.

(v): Economical:
- Based on the budget for survey and its scope and purpose, instrumentation, number of people and time consumption must be managed.

(vi) Fixing points related to localized points:
- Here, the measurement of two (or three) points are ~~don~~ taken for reference ~~or these points are already established~~.
- Then, the points are fixed on the survey area by taking ~~reference~~ position of the reference

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- Then, based on that localized point, the survey is conducted.

Phases / Steps of Good Survey Work.

(i): Planning:

Planning in survey work includes:

⇒ Scope : Accessible meaning we can travel.
: Inaccessible : we use satellite imaging and existing topographical map.

⇒ Time

⇒ Budget.

Here, area, time and concept ie, method of survey is determined.

(ii) Instrumentation:

After determining the scope of work and planning, the suitable instrument must be used to try and reach precision. More modern technology and methods must be used according to the scope.

(iii) Field work / Data Acquisition:

- the methods and instruments decided are used to survey in order to collect data.

Eg: In plane table survey, output is made on site by collecting data.

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(iv): Office work:
The measurements and data collected in the field must be converted into useable form.

(v) Setting out on Ground:
- The designs obtained after finishing office work is taken to the ground for the workers to start construction.

Importance of Surveying:

(i) Establishing the property boundaries of private and public lands

(ii) Preparing navigational charts for use on land, sea and air.

(iii) Mapping the earth above and below the mean sea level.

(iv) Determining the shape and size of the earth.

(v) Preparing astronomical charts showing the location of sun, moon, planets, stars and celestial bodies.

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Chain Surveying

- One of the traditional methods of surveying.
- Only linear measurements are made.
- Angle measurement is not directly conducted.

→ Instruments used: Chain or Tape.

→ Conditions needed to do chain survey:
i) Area to be surveyed must be flat, open and small.
ii) Detailed that are plotted must be simple.
iii) Plans to be plotted are to be drawn on large scale.
ie, scope of chain surveying is - small area with minimum undulations.

→ Why are chain used?
(i) To measure distance when highly pe: accurate measurement is not required.
(ii) Chain is easier to read and repair easily in the field if damaged/ broken.
(iii) It is a very economical method.

→ Procedure adopted in chain survey
i) Chain has to be suspended for which weight has is the issue.
ii) Only measurements are taken in field and the remaining work is done in office.
iii) Angle is not measured on the field.

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→ Types of Surveying Chains:

(i) Metric chain:
- 20 - 30 meters in length.
- Most common chain and measured in meters.
- tallies fixed at every 5 m.

(ii) Gunter's chain.
- 66 feet long
- contains 100 links and each link hus 0·66 feet

(iii) Engineer's chain:
- 100 feet long
- Has 100 links and each link is 1 feet long.

(iv) Revenue chain:
- 33 feet long
- Contains 16 links
- Commonly used to measure fields in cadastral survey.

→ Types of Surveying Tapes:
Surveying tapes are found to be more accurate than chains.

(i) Cloth / Linen tape:
- It is light and easy to handle.
- It is most likely effected by moisture.

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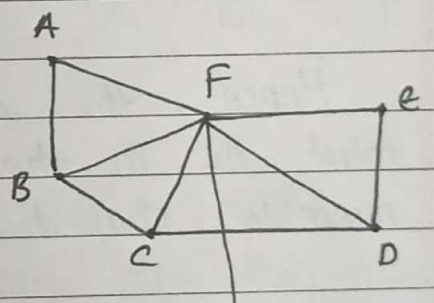
(ii) Metric steel Tape.
- It is made of steel. and has a ring on its outer end for holding.
- It is affected by temperature changes.

(iii) Invar tape:
- Highly accurate tape made up of invar (i.e, 35% Nickel and 65% steel).

→ Principle of Chain Surveying:

Network of triangles are formed because triangles can be plotted only using length.



The computation of angles of triangles can be done using cosine law after finding sides.

Formation of triangles helps us to maintain independency.

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→ Characteristics of triangles in Chain Survey.

i) First, ~~most importar~~ we ~~tried~~ try to obtain and equilateral triangle which is not practically feasible.

ii) If equilateral triangle is not possible, we try forming an ~~isosceles~~ well-conditioned triangle:
It is an isosceles Δ which has the base angles of 56° 14'. This triangle is also not practically feasible.

. Hence, the angles of triangles in chain survey must lie in the range of 30° - 120° and must resemble shaped of equilateral triangle.

Survey Stations.

In chain survey, survey stations is defined as the beginning or end point.

*) Types of survey station:

(i): Main station:
- They are the end of lines the commands the boundaries of survey.
- Line joining main stations are main survey lines or chain lines.

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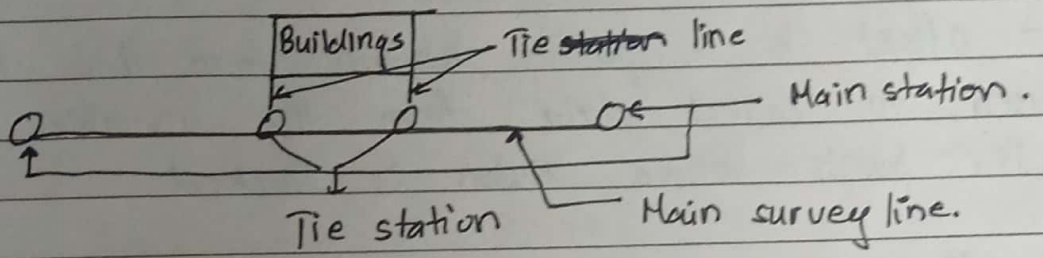
(ii) Subsidiary / Tie stations:

→ Points selected on main survey lines where its necessary to locate interior details.

- Helps running additional lines to locate the details that are away from main survey lines.



Survey lines

(i): Baseline:

- Baseline is the line that joins the initial known points.
- First line plotted on papes during survey and measured in kilometers.
- Mostly, it is the longest line running through the centre area to be surveyed.
- The baseline must be visible from all areas.
- Since other points are derived from baseline, accuracy of baseline helps increase accuracy of derived points.
- Base line can is regarded as a chain line.

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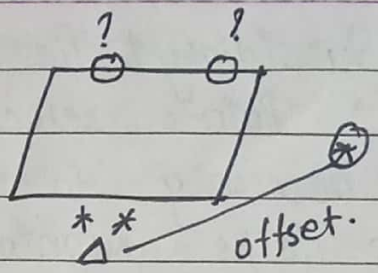
(ii) Offset:



- if obstacles block certain points during survey, offset is created.

- Offset is a point known from the baseline used to collect data from the invisible point ie, points whose vision is blocked.

- Offset is regarded as the line that connects a known point and established point to rectify invisibility problem.

- Since offset causes more errors, we try to make the baseline ~~visible~~ accordingly to prevent using offset as far as possible.

- Offset is regarded as a last resort in surveying.

(iii) Check line / Proof line:

- It is a line joining the apex of a triangle to some fixed point on any two sides of triangle.

- It helps check accuracy of framework.

- Accuracy is checked as the length on ground should agree to corresponding length in paper.

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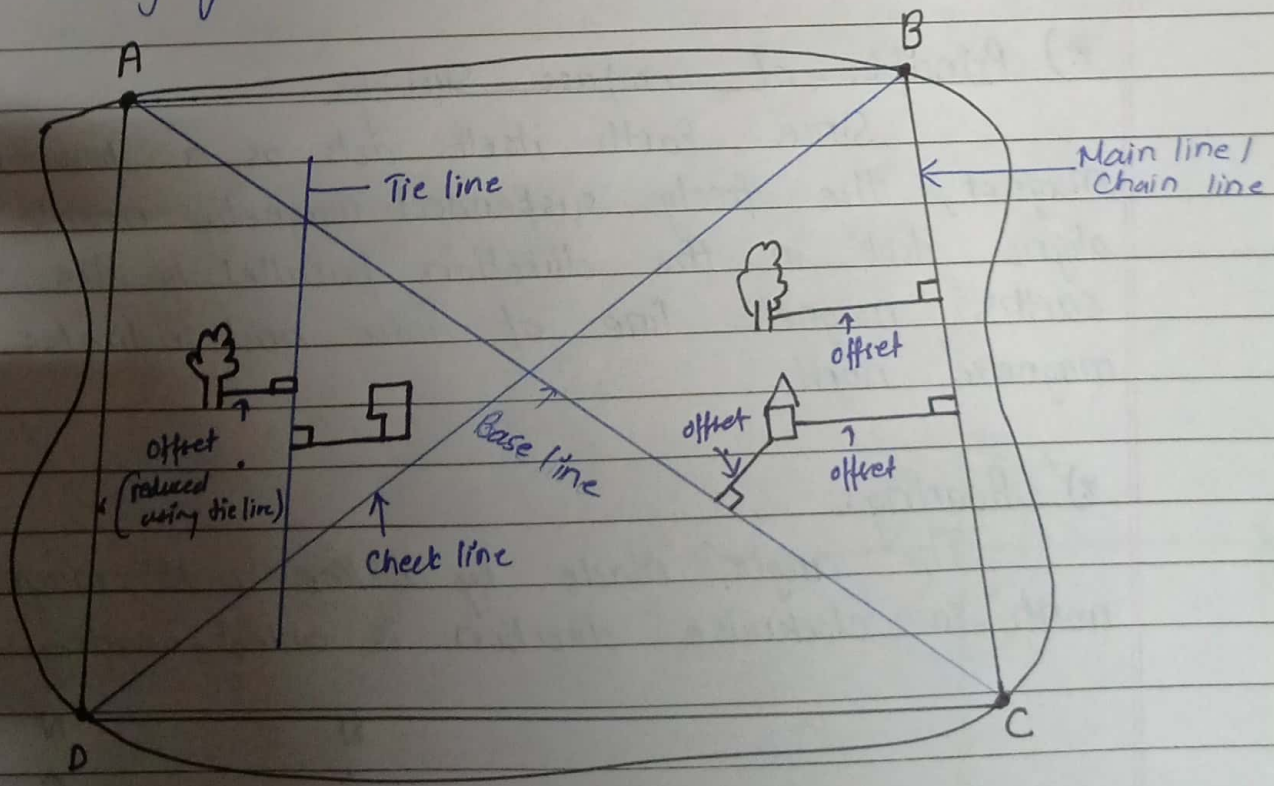
(iv): Tie line:

- Tie lines are the lines run to locate the interior details to prevent using long offsets.
- Tie stations are stations on the survey line / base line
- Helps collecting additional interior details by without making use of offsets.

Field Book

Standard field book which is used to keep/ record all observations and measurements taken in chain surveying.



A, B, C, D - stations.

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Compass Survey:

- The branch of surveying in which the position of an object is determined by angular measurement using a compass is called compass survey.

- It is used in places where coverage is not available ie, GPS cannot be used.

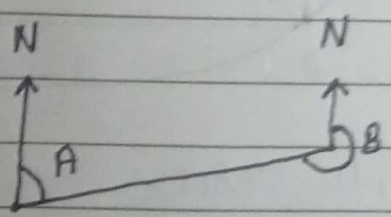
- Compass is a navigational tool and to tally maps.

*) Principle of Compass ~~Survey~~.

Since Earth itself acts as a powerful magnet, the freely suspended magnetic needle aligns itself in the direction parallel to the earth's magnetic line of force and indicates magnetic north.

*) Bearing:

The angle made by a line with magnetic north in clockwise direction is called bearing.



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*) Designation of Bearing:

Whole Circle Bearing (WCB)	Quadrant Bearing (QB)
- Magnetic bearing of a line is measured in clockwise direction from magnetic north.	- Quadrant bearing of a line is measured from north to south in anti-clockwise or ~~clockwise~~ clockwise direction, whichever is nearer.
- It's value lies between 0° and ~~360°~~ 359°.	- It's values lies between 0° and 90°
- WCB measured using prismatic compass.	- QB measured using surveyor compass.
- Called Azimuthal bearing	- Called Reduced bearing.

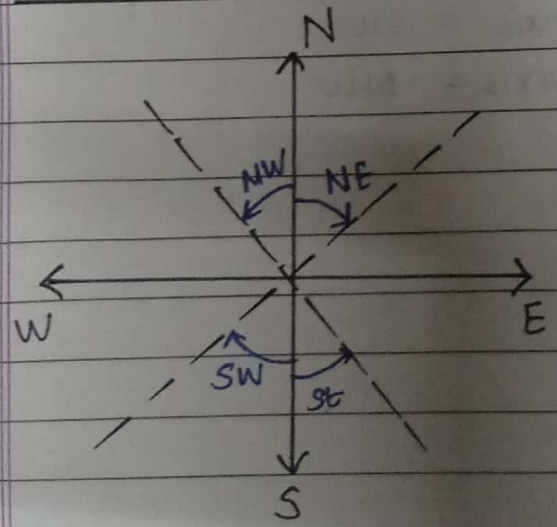

Fig: ~~WCB~~ QB

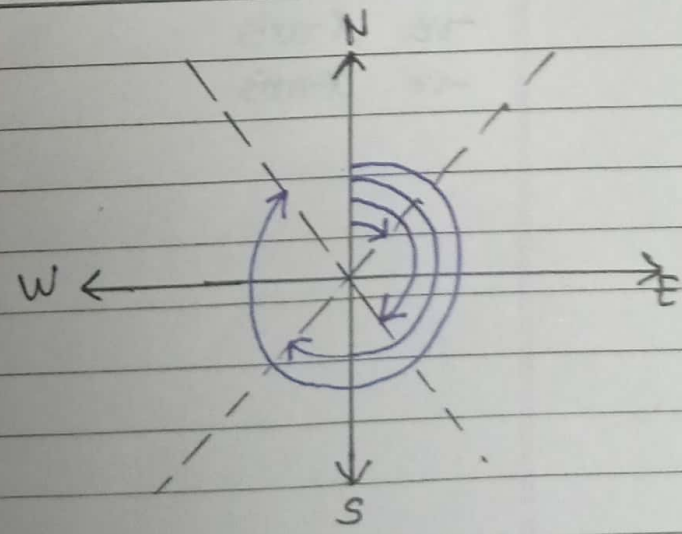

Fig: ~~WCB~~ WCB

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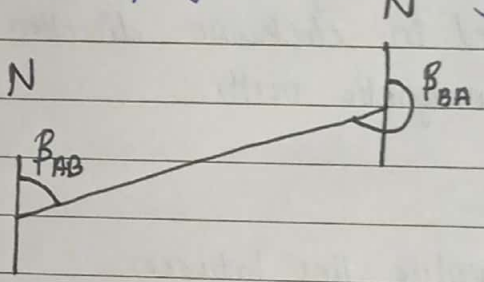
* Fore bearing and Back Bearing:

The bearing of a line in the direction of progress of survey is called fore bearing.

The bearing of a line in the direction opposite to the direction of progress of survey is called back bearing.



Bearing AB is ~~bad~~ backbearing BA and vice-versa.

* In QB:

+ve	X-axis	+ve Y-axis	= NE
+ve	X-axis	-ve Y-axis	= SE
-ve	X-axis	-ve Y-axis	= SW
-ve	X-axis	+ve Y-axis	= NW

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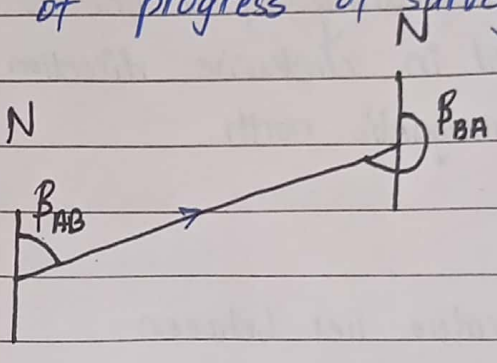
* Fore bearing and Back Bearing:

The bearing of a line in the direction of progress of survey is called fore bearing.

The bearing of a line in the direction opposite to the direction of progress of survey is called back bearing.



Bearing AB is ~~back~~ backbearing BA and vice-versa.

* In QB:

+ve	X-axis	+ve	Y-axis = NE
+ve	X-axis	-ve	Y-axis = SE
-ve	X-axis	-ve	Y-axis = SW
-ve	X-axis	+ve	Y-axis = NW

We use north and south as reference.

*) Converting WCB to RB (QB):

a): In 1st quadrant:

Angle: $0° - 90°$

Here, WCB = RB Designation: NE

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b) In 2nd quadrant,
Angle: 90° - 180°
RB = 180° - WCB
Designation: SE

c) In 3rd quadrant,
Angle: 180° - 270°
RB = WCB - 180°
Designation: SW

d): In 4th quadrant,
Angle: 270° - 359°
RB = 360° - WCB
Designation: NW

*) Local attraction:

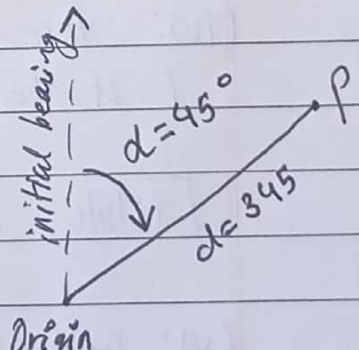
Magnetic compass needle normally points the true magnetic north but if there are magnetite in the ground, the true magnetic north is not shown.

Local attraction: The difference between true magnetic north and north pointed by the magnetic needle at a particular station is called local attraction.

F.B and B.B should differ by 180° but it doesn't occur due to local attraction.

* Coordinate calculation

Easting = distance * x sin (angle)
Northing = distance x cos (angle)



Here, angle meaning bearing.
the angle between initial bearing to the line

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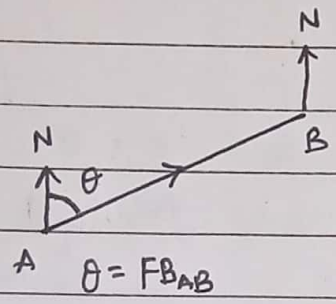
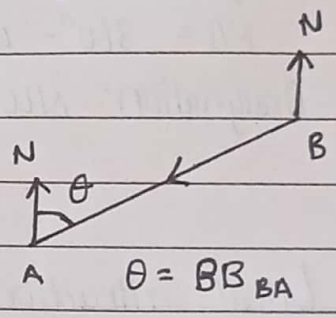
*) Computation of Bearing:

⇒ Formulae needed:

(i): Fore bearing of a line = Back bearing of that line in opposite direction.





~~(ii) Fore bearing of a line =~~

ii) Back bearing of a line = Fore bearing of that line ± 180°
ie, BB = θ ± 180°

If θ < 180°, BB = θ + 180°

If θ > 180°, BB = θ − 180°

(iii): Fore bearing of a line = Back bearing of preceeding line + included angle
[∵ If the M.north falls outside the traverse]

(iv): Fore bearing of a line = Back bearing of preceeding line − exterior angle
[∵ If the M.North falls inside the traverse]

[While solving through traverse in anti-clockwise direction]

(v): Sum of all int. angles = (n − 2) × 180°

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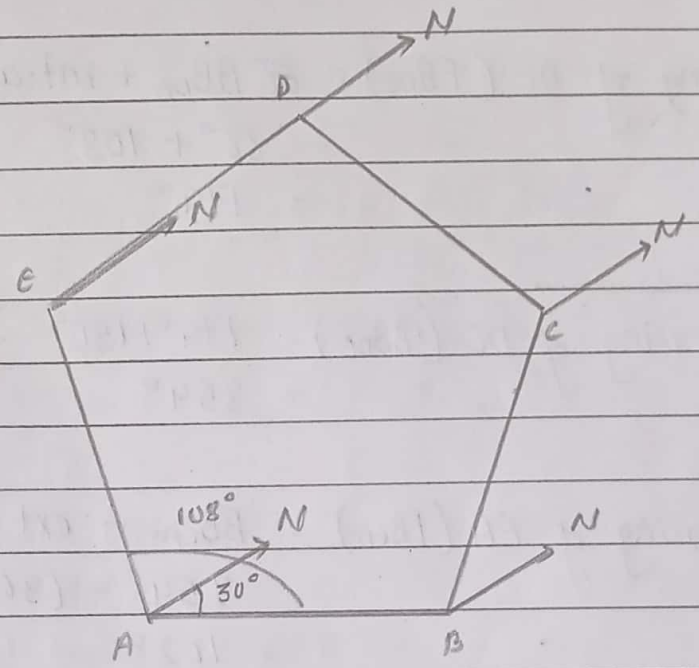
Q.17: Calculate the bearing of all other lines of a regular ~~ABCDE traverse~~ pentagon traverse ABCDE and bearing of AB is 30°.

Sol^n:

Given,

no. of sides in pentagon (n) = 5

Each interior angle for regular pentagon = $\frac{(n-2)\times 180^\circ}{n} = 108^\circ$



Fore bearing of AB (FB_{AB}) = 30°

Now,

(i): Backbearing of AB (BB_{AB}) = 30° + 180°
= 210°

(ii): Forebearing of BC (FB_{BC}) = BB_{AB} + int. angle
= 210° + 108° = 318°

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(iii): Backbearing of BC (BB_{BC}) = $318° - 180°$
= $138°$

(iv): Forebearing of CD (FB_{CD}) = BB_{BC} + int. angle
= $138° + 108°$
= $246°$

(v): Backbearing of CD (BB_{CD}) = $246 - 180°$
= $66°$

(vi) Forebearing of DE (FB_{DE}) = BB_{DE} + int. angle
= $66° + 108°$
= $174°$

(vii): Backbearing of DE (BB_{DE}) = $174° + 180°$
= $354°$

(viii): Forebearing of EA (FB_{EA}) = BB_{EA} - ext. angle E
= $354° - (360° - 108°)$
= $102°$

The bearing of AB = $30°$, BC = $318°$, CD = $246°$,
DE = $174°$, EA = $102°$.

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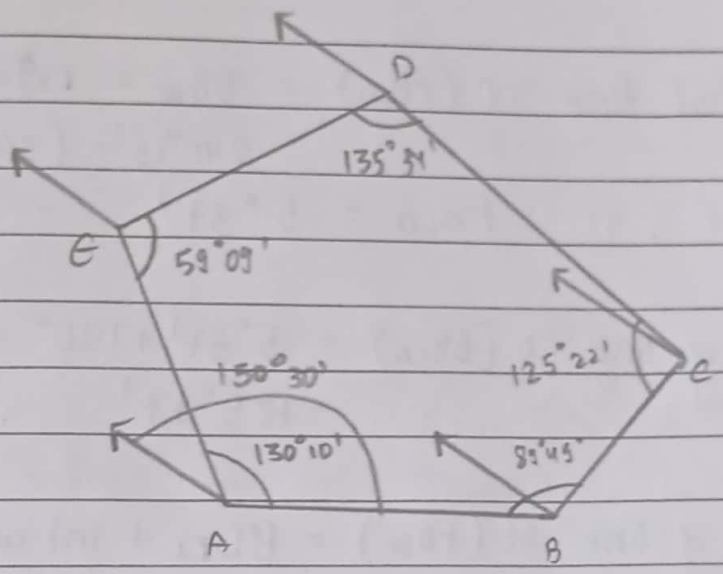
(Q.2): In a closed traverse ABCDE, the bearings of the line AB was measured at 150°30'. The included angles were measured as under: A = 130°10', B = 89°45', C = 125°22', D = 135°34', E = 59°09'. Calculate the bearing of all other lines.

Sol:



Given,

Bearing of AB = 150°30'.

Int angle A = 130°10'

Int angle B = 89°45'

Int angle C = 125°22'

Int angle D = 135°34'

Int angle E = 59°09'

Now,

(i): Backbearing of line AB (BB_{AB}) = 150°30' + 180°

= 330°30'

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(FBBC)

(ii): Forebearing of line BC = BB$_{AB}$ - Ext angle B.
= 330°30' - (360° - 89°45')
∴ FB$_{BC}$ = 60°15'

(iii) Backbearing of line BC (BB$_{BC}$) = 60°15' + 180°
= 240°15'

(iv) Forebearing of line CD (FB$_{CD}$) = BB$_{BC}$ - ext angle C
= 240°15' - (360° - 125°22')
∴ FB$_{CD}$ = 5°37'

(v): Backbearing of line CD (BB$_{CD}$) = 5°37' + 180°
= 185°37'

(vi): Forebearing of line DE (FB$_{DE}$) = BB$_{CD}$ + int angle D
= 185°37' + 135°34'
∴ FB$_{DE}$ = 321°11'

(vii): Backbearing of line DE (BB$_{DE}$) = 321°11' - 180°
= 141°11'

(viii) Forebearing of line EA (FB$_{EA}$) = BB$_{DE}$ + int angle E
= 141°11' + 59°09'
= 200°20'

The forebearing AB = 150°30', BC = 60°15', CD = 5°37'
DE = 141°11' & EA = 200°20'

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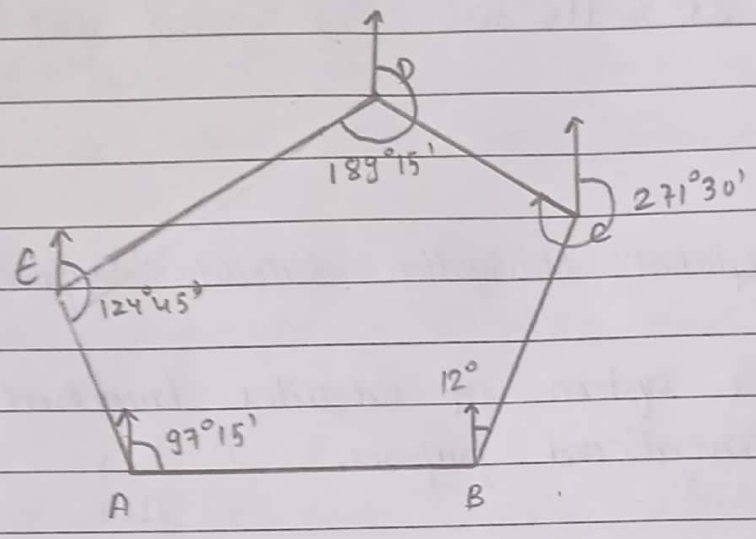
Q.3: The bearing of the sides of a traverse ABCDE are as follows; Calculate all the int. angles.

Side	FB	BB
AB	97°15'	277°15'
AC	12°0'	192°0'
CD	271°30'	91°30'
DE	189°15'	9°15'
EA	124°45'	304°45'

Soln:



Now,

(i): Forebearing AB = Backbearing EA - Ext. angle A

$97°15' = 304°45' - 360° + \text{int. angle A}$

or, $\angle A = 97°15' + 360° - 304°45'$

$\therefore \angle A = 152°30'$

(ii): Forebearing BC = Backbearing AB - ext. angle B

or, $12° = 277°15' - 360° + \text{int angle B}$

or, $\angle B = 12° + 360° - 277°15'$

$\therefore \angle B = 94°45'$

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(iii) Forebearing CD = Backbearing BC + int angle C

or, $271°30' = 192° + \angle C$

$\therefore \angle C = 79°30'$

(iv) Forebearing DE = Backbearing CD + int angle D

or, $189°15' = 91°30' + \angle D$

$\therefore \angle D = 97°45'$

(v): Forebearing EA = Backbearing DE + int angle E

or, $124°45' = 9°15' + \angle E$

$\therefore \angle E = 115°30'$