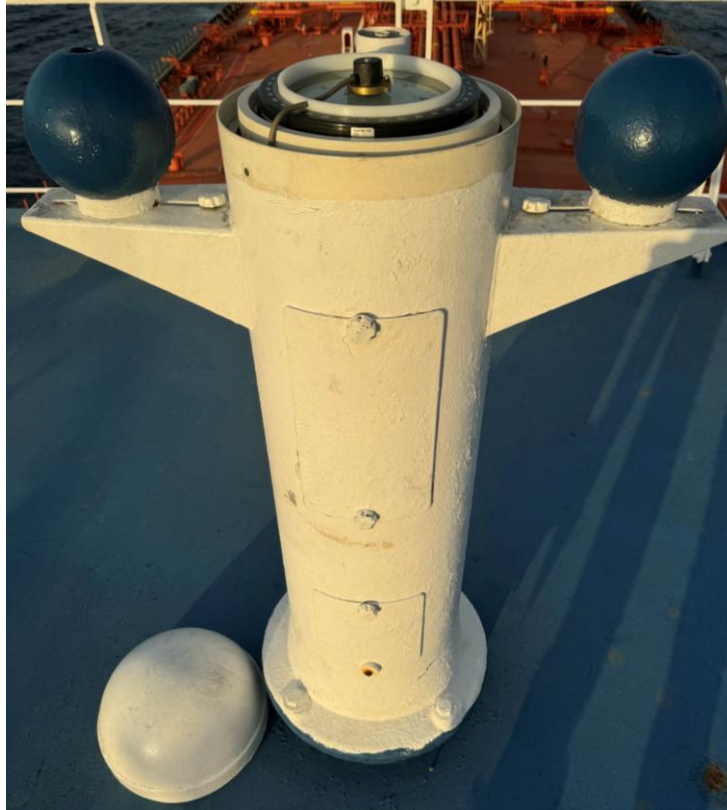


FUNCTION: NAVIGATION (Management Level)

PAPER: NAVIGATIONAL AIDS INCLUDING COMPASS

MAGNETIC COMPASS (THEORY)



Chief Mate-FG (Phase-II)

Notes by: Anupam Singh Rajput

For more notes visit the website

marineredition.com



: <mailto:smart@marineredition.com>



: [SMART MARINER](#) (Click to subscribe)



@SMART_MARINER_EDITION

1.a) Explain the Earth's Magnetism & the ship's magnetism. How does Earth's Magnetism & Ship's magnetism affect ship's magnetic compass? Use suitable sketches/diagrams. (2 times)

1.b) Explain angle of dip.

[Write answer from Ques 1.a](#)

1.c) Sketch the sets of Nine Soft Iron rods.

[Write answer from Ques 1.a](#)

2) Explain the functions of the following correctors of magnetic compass: (3 times)

a) Vertical magnet

b) Horizontal magnet

c) Flinders bar (or), What is the function of Flinders bar and how does it act?

d) Soft iron spheres

3) Explain the method of placement of permanent correctors in magnetic compass for compensating the effect of P, Q, and R. (6 times)

[Write answer from Ques 2.a & 2.b](#)

Q) Explain the permanent magnetism of the ship, its effect on the compass and how it is compensated.

[Write answer from Ques 1.a, 2.a & 2.b](#)

Q) Explain the type of corrector and the procedure used to compensate for deviation of the compass due to above cause stating the benefits of the corrector.

[Write answer from Ques 2.a, 2.b, 2.c & 2.d](#)

4) State the sequence of placing the correctors and the reasons for the same. (3 times)

5.a) If a ship has -PB and +PC, in which quadrant was she heading when built? (3 times)

b) If DF on N > DF on S, what coefficient is present and what is its sign? (3 times)

c) If DF on E > DF on W, what coefficient is present and what is its sign? (3 times)

6) With the help of a neat sketch explain how soft iron spheres increase mean directive force at compass position. (4 times)

(OR),

Explain how spheres increase Mean Directive Force at compass position. Justify your answer with diagrams.

7) Describe the deviation of standard magnetic compass which is caused by continuous athwartships horizontal soft iron in the vessel using suitable diagrams with respect to be following: (4 times)

i) Change in deviation due to a change in latitude of the vessel, and

ii) Means and method used to correct such a deviation.

8) How coefficient D is calculated and corrected.

(OR),

With help of suitable sketches, show clearly how ship's magnetic co-efficient "D" is created. How the error is corrected?

(OR),

Explain followings for coefficient D: Cause of Coefficient.

9) Onboard your vessel, you have noticed that "The Flinder's bar" is attached to the binnacle in a relative -slewed direction 015° instead of usual direction of ship's head.

a) Analyse and discuss in detail the reason(s) for such an arrangement.

b) What would have been the ship's heading on which maximum deviation would have occurred prior to "The Flinder's bar correction" made by compass adjuster

10) On board your vessel, you have noticed that soft iron spheres are attached to the binnacle in relative slewed direction that is 280° - 100° .

- a) Analyze and discuss in detail the reason(s) for such an arrangement.
- b) What would have been the ship's heading on which maximum deviation would have occurred prior to "Soft Iron correction" made by compass adjuster?

11) On board a vessel Flinders bar was observed to be placed at an angle of 15° towards port side from fore and aft line; soft iron spheres were placed athwartship. Explain with suitable sketches the reason(s) for such an arrangement. (4 times)

12) At Antofagasta, Chile. Ship was lying on a heading of 270° . Maximum deviation was found 3° E. If the permanent magnetism was corrected using Fwd & Aft Corrector magnets, state the possible reasons for getting this deviation & how the deviation can be corrected.

13) Describe the deviation of a standard magnetic compass on an upright vessel which varies directly as the **cosine of the ship's course** by compass using suitable diagrams with respect to the following: (2 times)

- a) Cause and Sign
- b) Change in deviation due to changes in magnetic latitude of the ship
- c) Means and methods used to correct such a deviation

14) In port of Chennai, your vessel is alongside and the flinders bar of your ships magnetic compass is removed. Values of Deviation remain unchanged. Vessel is shifted to another berth and the flinders bar is replaced in the casing. Value of deviation is observed to be different. Analyse and discuss the reasons for the change in value of Deviation.

15) Onboard your vessel you notice that the deviation curve of magnetic compass has an easterly bias i.e deviation values more easterly than westerly as vessel is swung around in 360° . Analyse and discuss in detail the cause(s) of such a deviation curve.

16) On board a vessel with constant 2° E/ 10° W deviation on all headings, following permanent corrector magnets were observed as placed in compass binnacle.

- i) Corrector magnet in F & A direction with Blue fwd and Red aft.
 - ii) Corrector magnet in athwartship direction with Red on Starboard and Blue on port. Explain with suitable sketches.
- a) What could be the reason for placement of correctors in above manner?
 - b) What could be the reason for constant deviation on all headings?

17) Explain why and when Coefficient "A" & "E" are applicable to vessels. (2 times)

18) Explain why a deviation curve made in one hemisphere and position cannot be used in the other hemisphere. (5 times)

19.a) List the preparations and precautions necessary for swinging ship for compass adjustment. (4 times)

19.b) Explain the occasion when an adjustment is necessary. (2 times)

20) How are Gaussian error and Retentive error caused? List the differences in deviation caused by each. What precautions are necessary when either of them may be present? (4 times)

21) What type of magnetic compass would you choose for a new ship where should it be placed?

22) Why is the ship swung and compass compensated instead of being swung and deviation noted on each heading?

①

FUNCTION: NAVIGATION

PAPER: NAVIGATIONAL AIDS INCLUDING COMPASS

Q. 3

MAGNETIC COMPASS (THEORY)

20/04/2026

Ques 1)

Explain the earth's magnetism & the ship's magnetism. How does the earth's magnetism & ship's magnetism affect ship's magnetic compass? Use suitable sketches and diagrams. (2 times)

Ans:-

* Earth's magnetism

First Law of magnetism: Like pole repel, Unlike pole attract

Second law of magnetism:- Every magnet creates a magnetic field around itself

a) field strength at any point is directly proportional to the pole strength of the magnet

b) field strength at any point is inversely proportional to the square of the distance from the poles.

c) The magnetic field is made of magnetic lines of force.

Third law of magnetism: Any magnetic material placed in magnetic field will be induced in the magnetism.

Three types of magnetic material: (i) Ferro magnetic (Easily magnetise, have strong magnetic properties, very good retentivity) Example:- iron, nickel

(ii) Para magnetic (low retentivity) Example:- tin

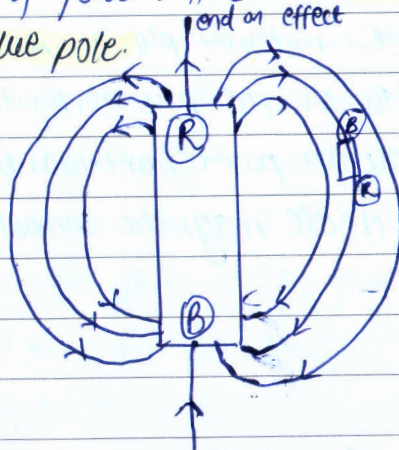
(iii) Dia magnetic (weak magnetic properties, sometimes with opposite polarity & repulsion) Example: led, zinc

* convention for naming the poles of a magnet

• Basic behaviour of a magnetic in the earth's magnetic field.

(i) A freely suspended magnet on the surface of earth will align itself with the earth's magnetic field with the red pole pointing northwards.

(ii) The lines of force will emit or emerge from the red pole & enter or converge at the blue pole.

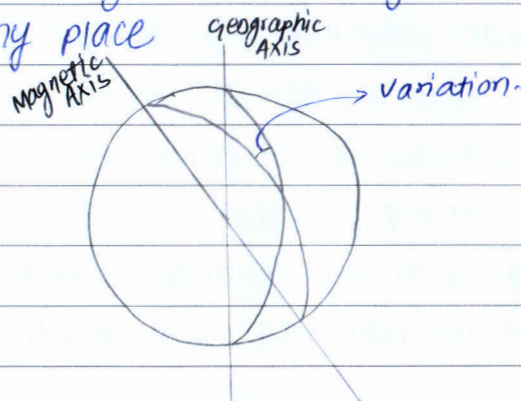
Broad side effect = $\frac{1}{2}$ of end on effect

(iii) So when a magnetic material is placed in a magnetic field, blue pole will be induced where the magnetic line of force enter the material & red pole will be induced where line of force emits or emerge from the material.

* Magnetic elements of the earth's magnetic field

1) Variation:-

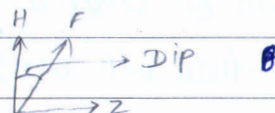
- It is the angle between magnetic meridian and geographic meridian at any place



- Magnetic variation at any place changes due to continuous movement of magnetic poles & magnetic axis

2) Dip

- It is the angle of inclination of the earth's magnetic field at any place below the horizontal (Dip is positive in NH & negative in SH)



- Dip is zero at magnetic equator.

3) Total magnetic field

- At any place will be tangent vector to the magnetic field (freely suspended magnet will align itself with this tangent)
- So the total magnetic field at any place is divided into two components

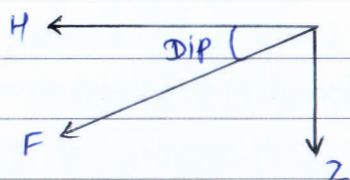
→ Horizontal (H) component

→ Vertical (Z) component

- F = Total magnetic field of earth

H = Horizontal component of earth's magnetic field

Z = Vertical component of earth's magnetic field



$$\text{Since } \cos \text{dip} = \frac{H}{F} \quad \& \quad \sin \text{dip} = \frac{Z}{F}$$

$$\therefore \tan \text{dip} = \frac{Z}{H} \quad \text{--- (1)}$$

③

$$F^2 = H^2 + Z^2$$

Conclusions:

- Dip increases from zero at magnetic equator & 90° at the poles.
- At the magnetic equator, dip is zero, so, $Z = 0$

$$\text{Hence, } H = F$$

- At the poles, dip is 90° . So, $H = 0$, $F = Z$
- At any other place, $H = F \cdot \cos \text{dip}$.
- The magnetic compass will use magnetic which will be kept horizontal & so will use horizontal components of the earth's magnetic field.

- Greater the value of H , better the working of compass.

Oral ques.

(For this reason, magnetic compass is not reliable at higher latitudes)

→ Effect of the earth's magnetism on ferro magnetic material (ship's magnetic compass)

- Magnetism will be induced
- Poles will be created; Blue pole where field will enter & red pole where field will come out.
- If the magnetism is retained by the material, it will become a permanent magnet will be known as "HARD IRON MAGNETISM".
- If the magnetism changes as soon as field is changed, it is called temporary induced magnetism or "SOFT IRON MAGNETISM".
- Deviation: It is the error or deflection of a magnet away from the magnetic meridian caused by magnetism of the ship.

Conclusion:

- * Directive force is the net or total magnetic field at the compass pointing northwards.
- So, it is the sum of the earth's horizontal field ' H ' & ship's horizontal magnetic field at the compass.

* Deviation can be calculated by

a) Celestial: Azimuth

b) Terrestrial: Transit, bearing, berth

c) Compass comparison: Gyro error

④

* Ship's magnetism

Ship's are built of steel and it acquires magnetism in two types

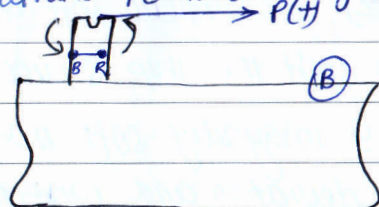
a) Permanent magnetism

b) Induced magnetism

⇒ PERMANENT MAGNETISM (Hard iron)

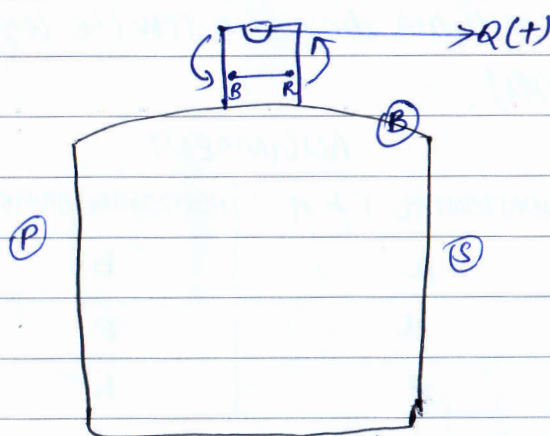
- Ship's permanent magnetism is acquired permanently by hard iron structure of the ship, when she is built.
- When the ship's heading is constant when built; the heating, hammering and heavy welding currents passed through the ship. It caused the molecules of hard iron structure to align themselves in the direction of the earth's total force.
- The vessel thus attains permanent magnetism both in the horizontal & vertical plane.

Force P: Horizontal fwd & aft



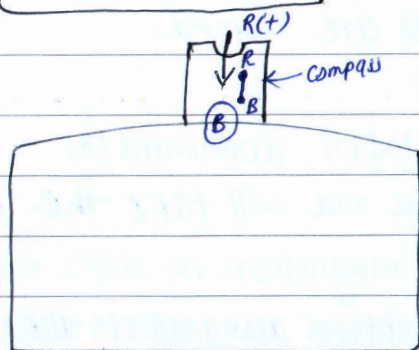
Blue pole forward (+ if fwd)

Force Q: Horizontal athwartship



Blue pole starboard. (+ if stbd)

Force R: vertical



Blue pole downward. (+ if downward)

• Permanent magnetism consist of three force name P, Q & R. These forces are perpendicular to each other.

• Force P: Horizontal F & A ; Force Q: Horizontal athwartship; Force R: vertical component

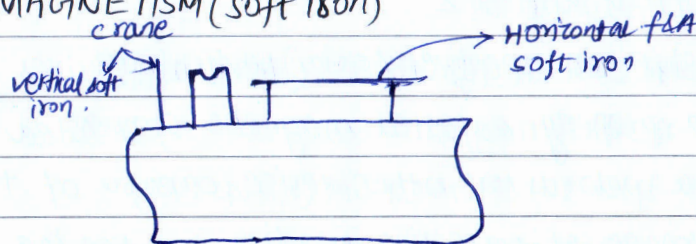
Effect of permanent magnetism on ship's magnetic compass :-

- Force P, Q & R are constant forces due to the ship's permanent magnetism.
- They do not vary with change of course nor with change of ship's latitude.
- Their effect in producing deviation of the compass however is not constant and changes with ship's head and latitude.

5

⇒ INDUCED MAGNETISM (Soft iron)

Horizontal
fwd & aft



- Soft iron magnetism of the ship is temporary magnetism based on
 - (i) the alignment of the soft iron.
 - (ii) the field it will create at the compass.
- The magnetism will be induced by earth's magnetic field
 - (i) Horizontal component (H) in horizontal soft iron (HSI)
 - (ii) Vertical component (Z) in vertical soft iron (VSI)
- It is not practical to split the ship structure into different soft irons. So concept of 9 imaginary soft iron rods will be used to check the pattern of deviation and correction of the component.
- These imaginary rods are dimensionless (i.e. length only with two poles at the two ends).

ALIGNMENT

FIELD AT COMPASS	HORIZONTAL F & A	HORIZONTAL ATWARTSHIP	VERTICAL
HORIZONTAL F & A	a	b	c
HORIZONTAL ATWARTSHIP	d	e	f
VERTICAL	g	h	k

- The soft iron rods are named
 - (i) As per the table
 - (ii) Forward (+), Stbd (+), downward (+)
 - (iii) The name of the rod will take the product of two poles.

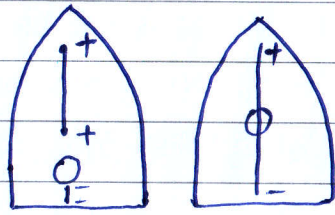
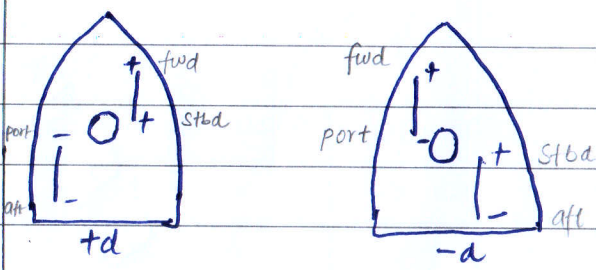
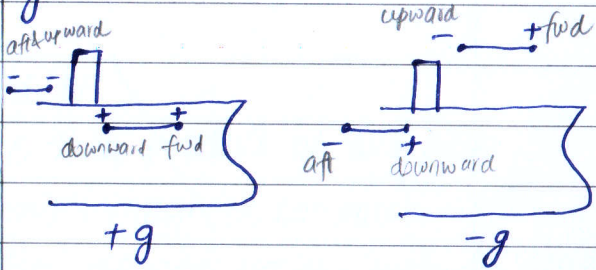
Effect of induced magnetism on ship's magnetic compass:

- The strength of induced magnetism depends on the latitude of ship.
- H is maximum at equator & reduces to NIL at poles.
- Z is maximum at poles & reduces to NIL at equator.
- Horizontal soft iron (HSI) are induced by H and not affected by Z
- Vertical soft iron (VSI) are induced by Z and not affected by H.
- Strength of induced magnetism in H.S.I depends on ship's heading. Max^m at N/S & NIL at E/W
- Strength of induced magnetism in V.S.I depends on hemisphere. Max^m at poles and zero at magnetic equator.

⑥

___/___/___

* SOFT IRON RODS (9 IMAGINARY SOFT IRON RODS)

ALIGNMENT FIELD AT COMPASS	HORIZONTAL F & A
HORIZONTAL F & A	a  +a -a symmetrical
HORIZONTAL ATWARTSHIP	d  +d -a
VERTICAL	g  +g -g

The sequence in which I remember :- a, e, k

b, c

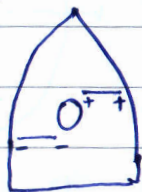
d, f, g, h

7

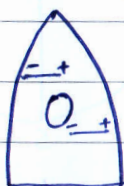
HORIZONTAL ATHWARTSHIP

VERTICAL

b



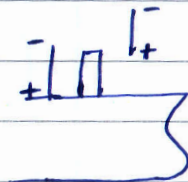
+b



-b

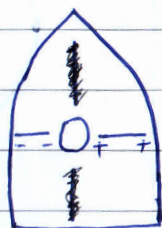


+c

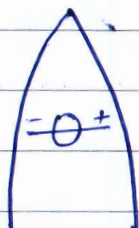


-c

e

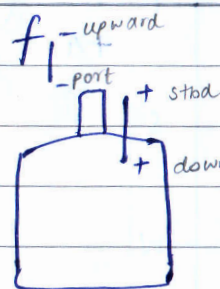


+e

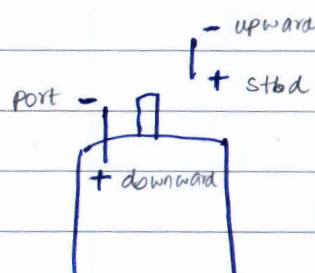


-e

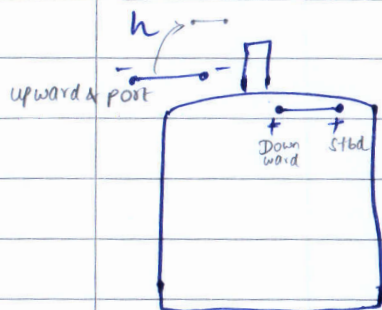
symmetrical



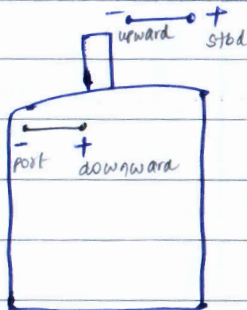
+f



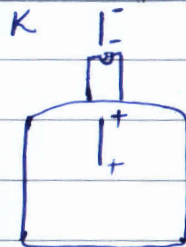
-f



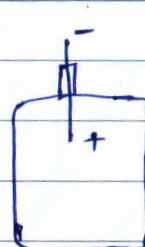
+h



-h



+K



-K

symmetrical.

8

___/___/___

Ques 1-b) Explain Angle of Dip

Ans:- Write answer from Ques 1-a

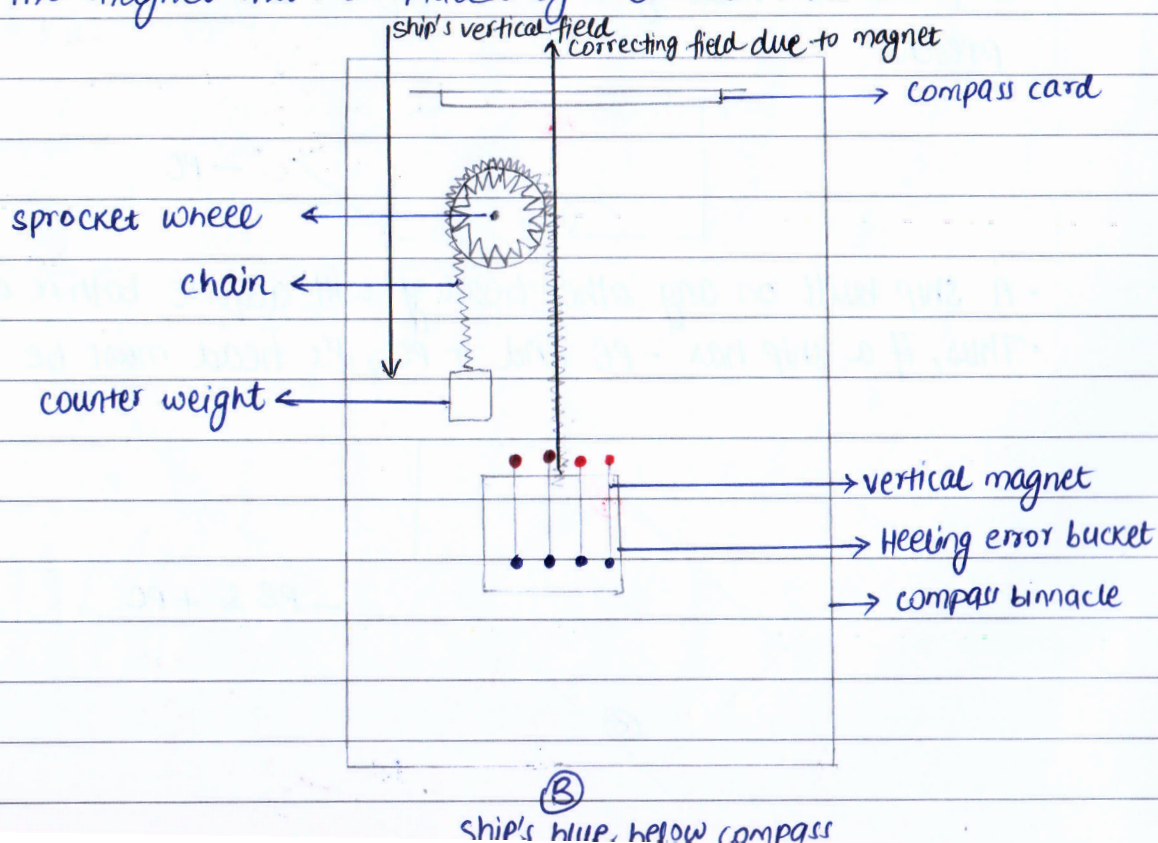
Ques 1-c) Sketch the sets of Nine soft iron rods

Ans:- Write answer from Ques 1-a

Ques 2) Explain the functions of the following correctors of magnetic compass:
(3 times)

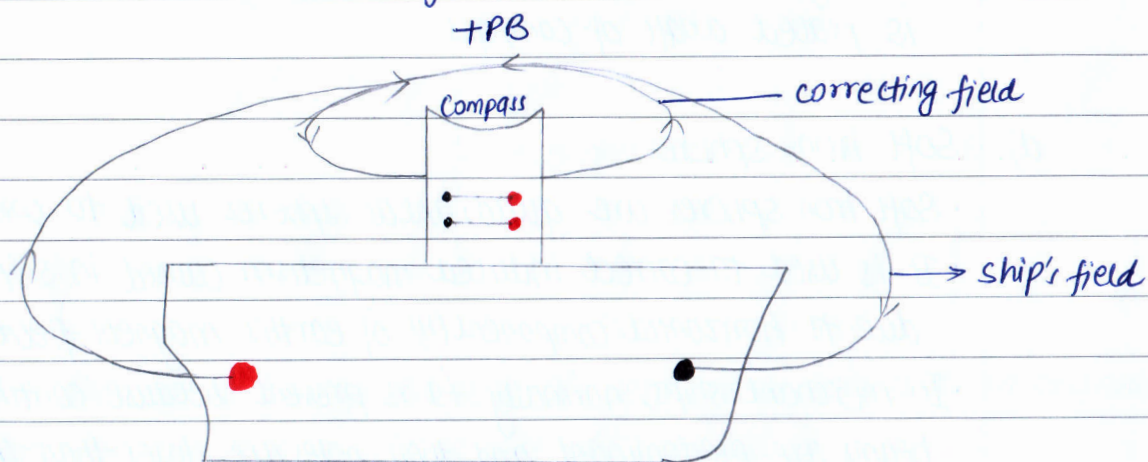
a) Vertical magnet

- Vertical magnet are permanent corrector used to correct heeling error.
- It is used to correct permanent magnetism caused in ship's hard iron due to Force R.
- Set of vertical magnets kept in the heeling error bucket which can be raised or lowered in the binnacle under the compass card.
- The amount of correction varies by increasing or decreasing the number of magnets or, by raising or lowering heeling error bucket.
- It is preferable to use more number of magnet at a greater distance below the card than a single magnet placed close under the card.
- The magnet must be placed symmetrical in the bucket.



b) Horizontal magnets

- Horizontal magnets are permanent correctors used to correct coefficient PB & PC.
- It is used to correct permanent magnetism caused in ship's hard iron due to Force P & Q.
- PB is caused due to Force P. Horizontal magnets are kept F & A to produce equal and opposite field.
- If a ship has +PB, these magnets are placed with their red end forward, & if the ship has -PB, these magnets are placed with their blue end forward.
- PC is caused due to Force Q. Horizontal magnets are kept athwartship to produce equal and opposite field.
- If a ship has +PC, these magnets are placed with their red end starboard, & if the ship has -PC, these magnets are placed with their blue end starboard.



c) Flinders bar (or), What is the function of flinders bar and how does it act?

- Flinders bars are correctors used to correct coefficient IB & IC.
- It is used to correct induced magnetism caused in vertical soft iron due to vertical component (Z) of earth's magnetic field.

Construction:

- Usually consist of small pieces of soft iron cylinders.
- They are placed in a brass casing fixed to the binnacle.
- Usually about 24 inch in height and 2 to 3 inch in diameter.
- The top of the casing is aligned with the magnetic compass bowl.

- The pieces are usually in 12", 6", 3", 1½", ¾" x 2
- Required length of soft iron should be on top.
- Similar pieces of wood or other non-magnetic materials are available to support it on bottom.

• The finders bar is clamped to the binnacle outside.

Correction:

- The value of the magnetism induced in the finders bar will depend upon its length.
- The correction are done by increasing or decreasing the length of finder's bar used.
- Usually, vertical soft iron are abaft the compass, and the finders bar is placed forward of compass.
- Unlikely, vertical soft iron are forward of compass, then finders bar is placed abaft of compass.

d) Soft iron spheres.

- Soft iron spheres are quadrantal spheres used to correct coefficient D & E
- It is used to correct induced magnetism caused in ship's soft iron due to horizontal component (H) of earth's magnetic field.
- In merchant ships, normally +D is present because continuous transverse beams are predominant and their poles are closer than those of F&A girders. Soft iron spheres are placed athwartship which will cause -D effect.
- If -D is present, soft iron spheres are to be placed F&A of the compass.
- If +E is present, -E is created by placing soft iron spheres on port bow and starboard quarter (diagonally at an angle of 45°)
- If -E is present, +E is created by placing soft iron spheres on starboard bow and port quarter (diagonally at an angle of 45°)

Construction:

- Quadrantal spheres are also known as Kelvin sphere.
- 6 to 8 inch in diameter
- It is hollow inside
- Fitted with threaded bolt arrangement.

(11)

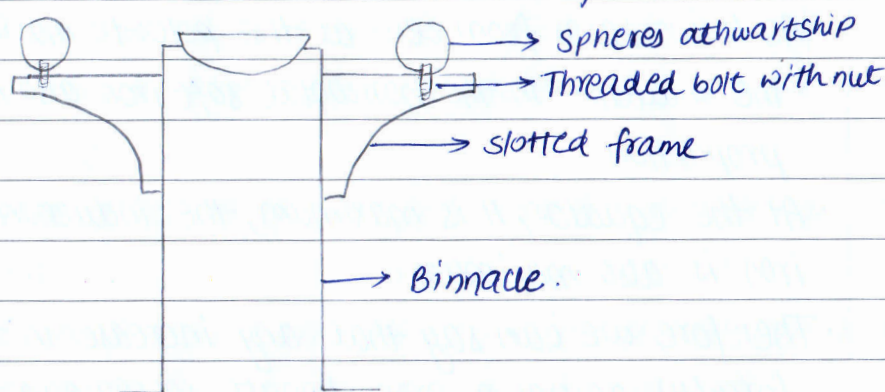
//_

- Mounted on a slotted frame.
- Tightened by nuts from below
- Centre of the spheres should be on the same plane as the compass magnetic plane.

• The slots are marked inches from the centre of compass bowl.

Advantages of sphere:

- Sphere is the most uniform geometric shape and so the magnetic field induced and created is also uniform.
- The spheres are hollow so only the surface is magnetized.
- The spheres are hollow, and, so, induced magnetism retention is much less.
- The spheres will provide minimum obstruction for taking 360° bearing.



Ques 3) Explain the method of placement of permanent correctors in magnetic compass for compensating the effect of P, Q and R (6 times)

Ans:- Write answers from Ques 2.a & 2.b

Q) Explain the permanent magnetism of the ship, its effect on the compass and how it is compensated.

Ans:- Write answers from Ques 1.a, 2.a & 2.b

Q) Explain the type of corrector and the procedure used to compensate for deviation of compass due to above cause stating the benefits of correctors.

Ans:- Write answers from Ques 2.a, 2.b, 2.c & 2.d

(12)

Ques 4) State the sequence of placing the correctors and the reason for same. (3 times)

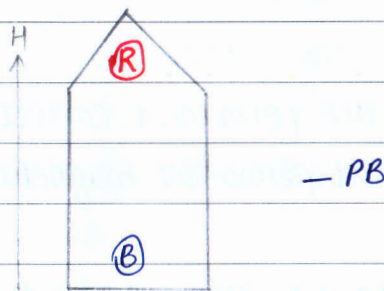
SEQUENCE OF CORRECTOR	NAME OF CORRECTOR	TYPE OF CORRECTOR	ALIGNMENT OF CORRECTOR	LOCATION OF CORRECTOR	CORRECTION FOR COEFFICIENT
01	FLINDER'S BAR	SOFT IRON	VERTICAL	OUTSIDE THE BINNACLE, OPP. TO THE NEAREST FUNNEL/MAST.	IB & IC
02	KELVIN'S SPHERE (QUADRANTAL CORRECTORS)	SOFT IRON	HORIZONTAL	OUTSIDE THE BINNACLE, ONE ON EACH SIDE (FOR COEFFICIENT +D, SPHERE AFTWARTSHIP)	D & E
03	HEELING ERROR BUCKET (Permanent correctors)	HARD IRON	VERTICAL	INSIDE THE BINNACLE, BELOW THE BOWL	Heeling error
04	FORE & AFT MAGNET (Permanent correctors)	HARD IRON	HORIZONTAL F & A	INSIDE THE BINNACLE, BELOW THE BOWL	PB
05	ATHWARTSHIP MAGNET (Permanent corrector)	HARD IRON	HORIZONTAL ATHWARTSHIP	INSIDE THE BINNACLE BELOW THE BOWL	PC

_____ / / _____

FIELD	CREATED BY	RELATION TO COMPASS	HEADING FOR	EFFECT ON	REASON FOR
COMPASS	FIELD	HEADING	CORRECTION	DIRECTIVE FORCE	SEQUENCE
IB: Horizontal	Z	$IB \propto \sin \text{hdg}$	IB: E & W	No mean change	C rod or F rod may create coefficient D and/or heeling error
IC: Horizontal athwartship		$IC \propto \cos \text{hdg}$	IC: N & S (For both resultant) 90° - slew		
D: Horizontal	H	$D \propto \sin 2 \text{hdg}$	For D: Inter cardinal	Increases mean	Increases mean
E: Horizontal		$E \propto \cos 2 \text{hdg}$	For D & E together: 45° - slew	DF	DF, so reduces residual deviation
Vertical	Force 'R' & Z in soft iron	$\propto \cos \text{Hdg}$ $\propto \sin \text{Heel}$	North & South	No effect	All vertical components & soft iron effect is corrected.
Horizontal F & A	P	$\propto \sin \text{hdg}$	East & West	No mean change	Greater first
Horizontal Athwartship	Q	$\propto \cos \text{hdg}$	North & South	No mean change	Lesser last

Ques 5. a) If a ship has $-PB$ and $+PC$, in which quadrant was she heading when built? (3 times)

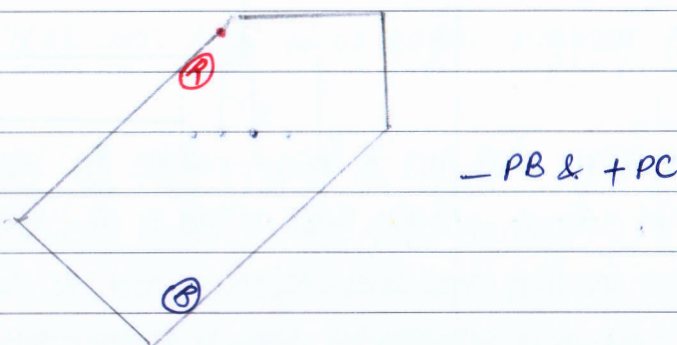
- Ans:-
- $-PB$ is caused due to hard iron deviation caused by permanent magnetism in the F&A of the compass.
 - Ship built on any northerly heading has permanent red pole forward and permanent blue pole aft of compass regardless of hemisphere.
 - Ship built on heading N/S will acquire only PB and no PC will be present.



- $+PC$ is semi-circular deviation which varies with cosine of compass course due to athwartship permanent magnetic field of ship (force $\propto$).
- Ship built on easterly heading has permanent red pole on the port side and permanent blue pole on the starboard side regardless of hemisphere.
- Ship built on heading E/S will acquire only PC and no PB will be present.



- A ship built on any other heading will acquire both PC and PB.
- Thus, if a ship has $-PB$ and $+PC$, its head must be NE quadrant.



(part 11) * Directive force

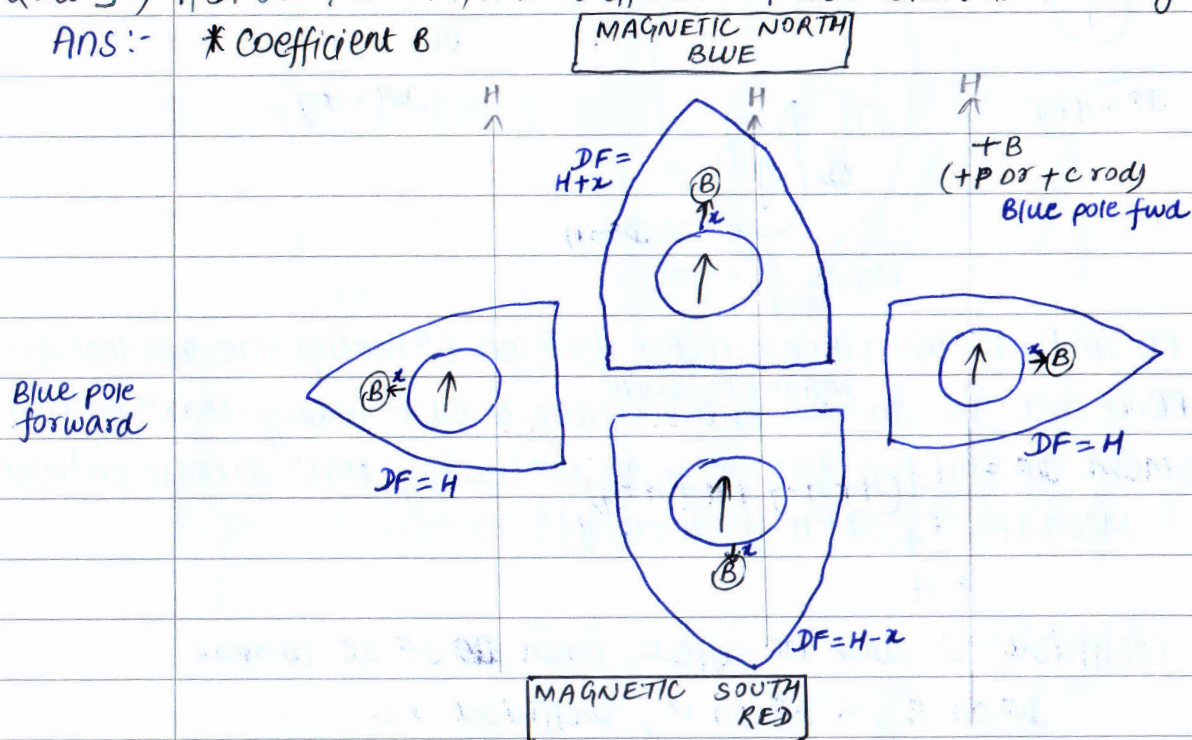
- It is the net horizontal magnetic field at the compass acting northwards.
- So it is the resultant of the earth's horizontal component of magnetic field i.e. H
- And, the ship's horizontal magnetic field.

* Effects of coefficient of deviation on directive force (DF)

- Coefficient A does not affect the DF because no north south component is created.

Ques 5-b) If $DF \text{ on } N > DF \text{ on } S$, what coefficient is present and what is its sign? (3 times)

Ans:- * Coefficient B



- +PB and +IB will cause directive force in N^{ly} heading more than that of on's.
- Cause: +PB is caused by permanent magnetism caused by ship's hard iron & +IB is caused by induced magnetism in vertical soft iron 'c' rod.
- Directive Force: The directive force increased on all N^{ly} heading. Max^m on 'N'. The directive force decrease on all S^{ly} heading. Max^m decrease on 'South'.

$$\text{Net DF} = \frac{1}{4} (H+x + H+x + H-x + H-x)$$

$$= H$$

That means, coefficient B does not have mean effect on DF

DF on N > DF on S ; Then, we have coefficient +B

DF on N < DF on S ; Then, we have coefficient -B.

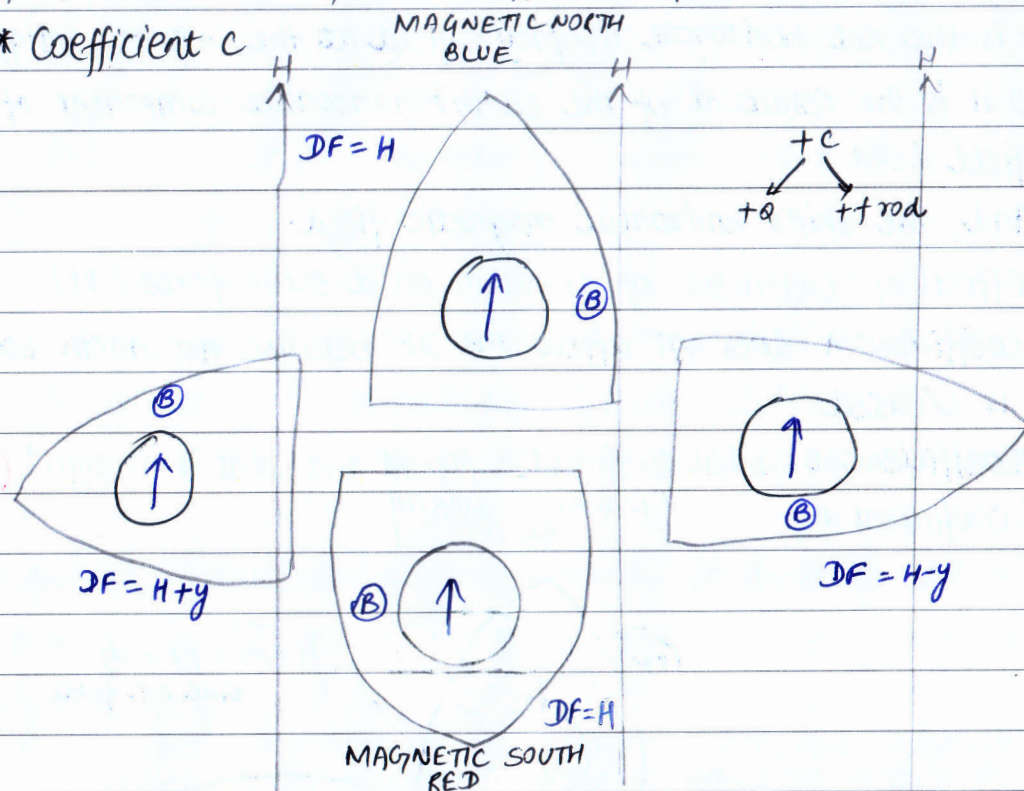
(15)

08/06/2026

Ques 5.c) If DF on $E > DF$ on W , what coefficient is present and what is its sign? (3 times)

Ans:-

* Coefficient c



• -PC and -IC will cause directive force on E' heading more than that of on W

• Directive force: The directive force increased on all E' heading. Max^m on 'East'
The directive force decrease on all W' heading. Max^m decrease on 'West'

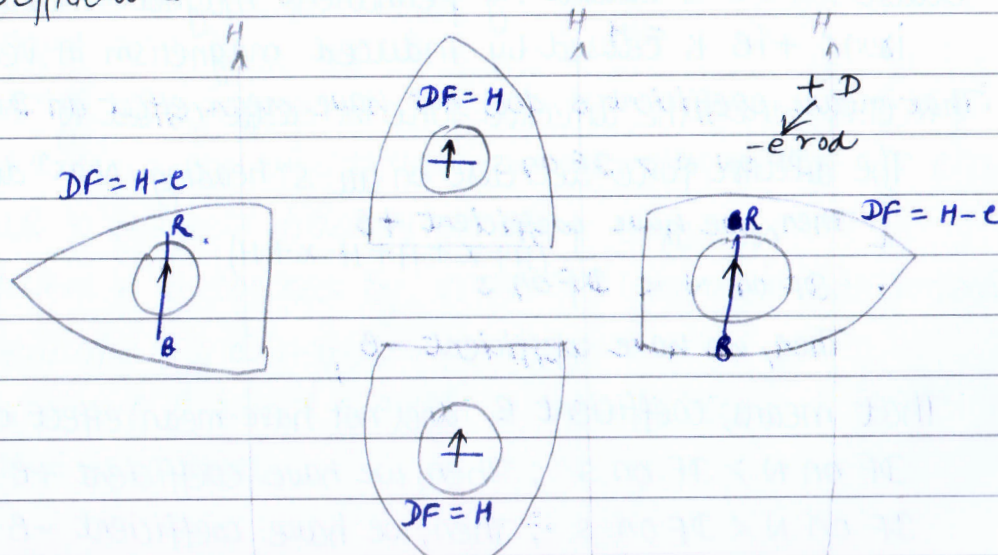
$$\text{Mean } DF = \frac{1}{4} (H + H - y + H + H + y) = H$$

coefficient ' c ' does not affect mean DF at compass

DF on $E < DF$ on W , coefficient $+c$

DF on $E > DF$ on W , coefficient $-c$

* Coefficient D



$$\text{Mean } DF = \frac{1}{4} (H + H - e + H + H - e) = H - \frac{1}{2}e$$

Mean DF is reduced in all heading

DF on $N/S > DF$ on $E/W \rightarrow +D$ spheres athwart ship
 DF on $N/S < DF$ on $E/W \rightarrow -D$ spheres fwd & aft

(17)

Ques 6)

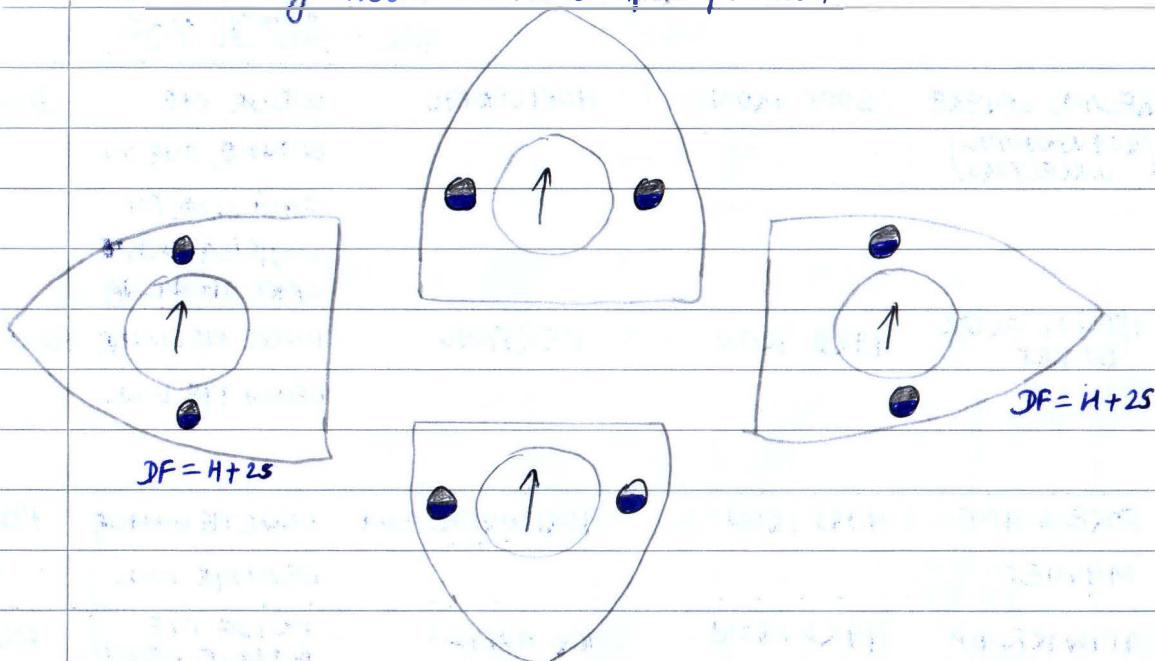
With the help of a neat sketch explain how soft iron spheres increases mean directive force at compass position (4 times)

Ans:-

* Correction of coefficient D

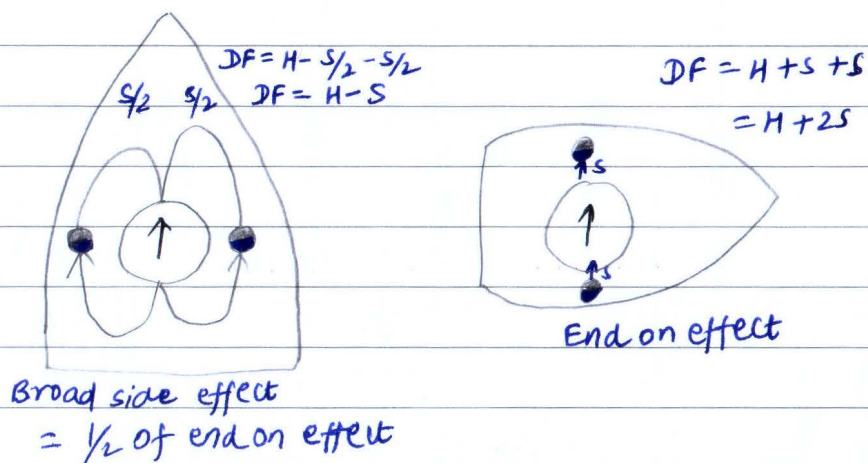
⇒ Spheres athwartship

- The divided soft iron spheres provides the very desirable effect of increasing mean DF at compass position.



- On N/S headings, the athwartship spheres decreases the DF

⇒



Broad side effect

= $\frac{1}{2}$ of end on effect

$$\text{mean DF} \Rightarrow \frac{1}{4} (H - S + H + 2S + H - S + H + 2S) = H + \frac{S}{2}$$

- If the spheres are considered as bar magnets, when on N/S headings they are broad side on to the compass needle, while, when on E/W headings they are End on to the compass needle.
- The field in the end on position is double than that in broad side position, at the same distance.
- The increase in DF on E/W heading is 2 times decrease in DF on N/S heading.
- Thus the mean DF at the compass is increased.

COEFFICIENT OF DEVIATION

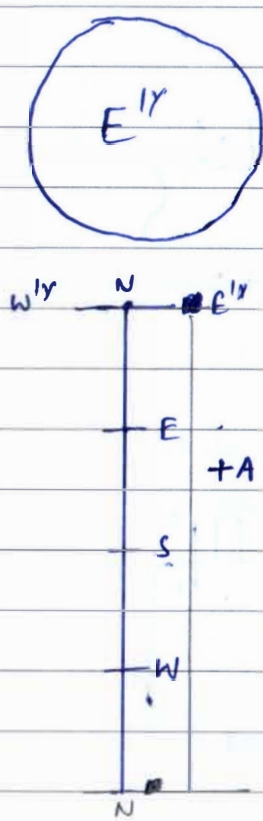
___/___/___

(A)

CONSTANT

A = Mean deviation on all heading

$$= \frac{1}{4} (\text{DEV ON N} + \text{S} + \text{E} + \text{W})$$

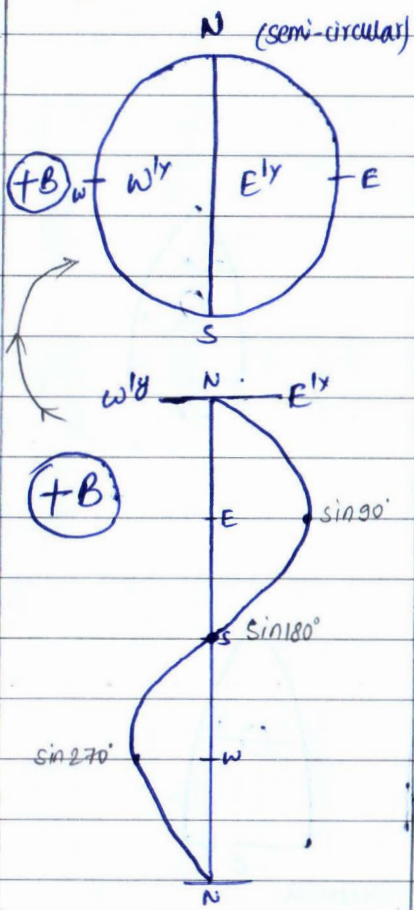


(B)

SEMI-^{SIN θ}CIRCULAR

B ∝ sin compass hdg

$$B = \frac{1}{2} (\text{DEV ON E} - \text{DEV ON W})$$

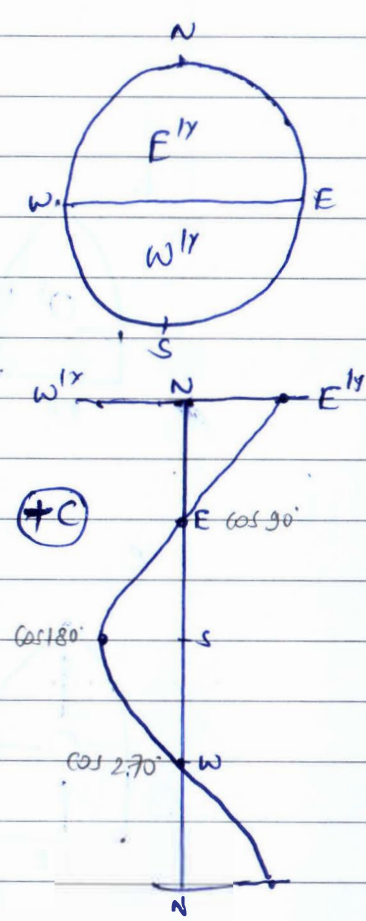


(C)

SEMI-^{COS θ}CIRCULAR

C ∝ cos compass hdg

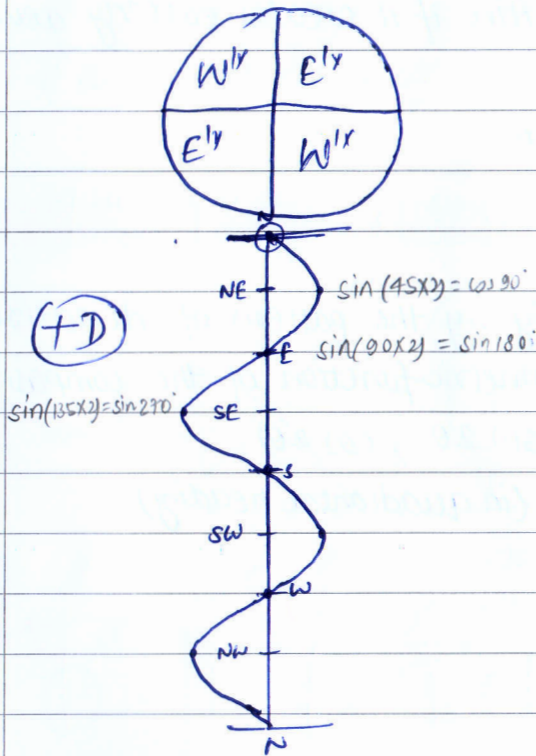
$$C = \frac{1}{2} (\text{DEV ON N} - \text{DEV ON S})$$



①

$\sin 2\theta$
QUADRANTAL
Dev $\sin 2$ compass hdg

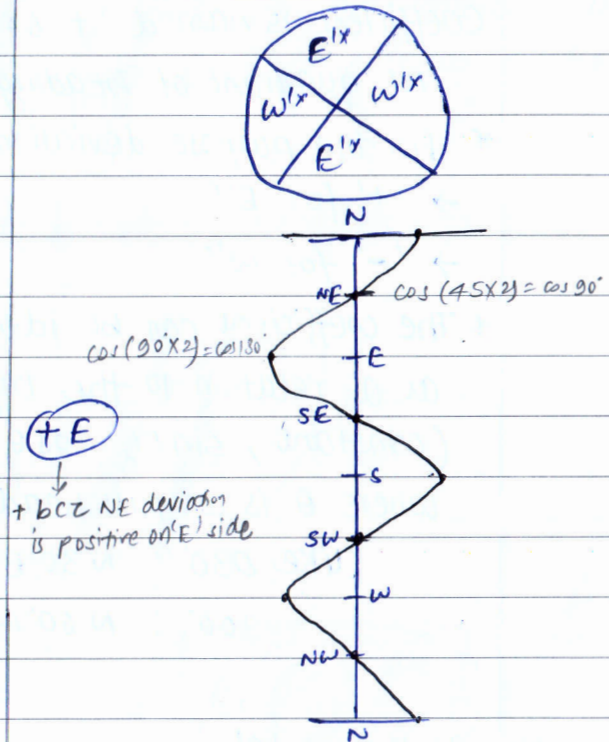
$$D = \frac{1}{4} \{ (\text{DEV ON NE} + \text{DEV ON SW}) - (\text{DEV ON SE} + \text{DEV ON NW}) \}$$



②

$\cos 2\theta$
QUADRANTAL
E $\cos 2$ compass hdg

$$E = \frac{1}{4} \{ (\text{DEV ON N} + \text{DEV ON S}) - (\text{DEV ON E} + \text{DEV ON W}) \}$$



* Coefficient of deviation

Coefficient of deviation are the maximum values of deviation caused by individual component of the ship's magnetic field.

value is in degree($^{\circ}$)

{Individual component: Hard iron or soft iron, fwd & aft, athwartship & vertical}

Coefficient is named '+' or positive if it creates easterly deviation in the NE quadrant of headings.

* For this purpose deviations are

→ '+' for E'

→ '-' for W'

* The coefficient can be identify by the pattern of deviation curve as a relation to the trigonometric-function of the compass heading.

(constant, $\sin \theta$, $\cos \theta$, $\sin 2\theta$, $\cos 2\theta$)

where θ is compass heading (in quadrantal heading)

like 030° : N 30° E

300° : N 60° W

* Coefficient 'B'

Definition:

- It is the maximum value of semi-circular deviation.
- varies as $\sin(\text{compass hdg})$
- Caused by the horizontal fore & aft components.
- of the ship's permanent magnetic field at the compass (force P)
- and/or the induced magnetism

in vertical soft iron.

situated forward or aft of the compass. (rod c)

$$B = \frac{1}{2} (\text{DEV ON 'E'} - \text{DEV ON 'W'})$$

$$B = PB + iB$$

(permanent B)
(induced B)

PB → Force P

(21)

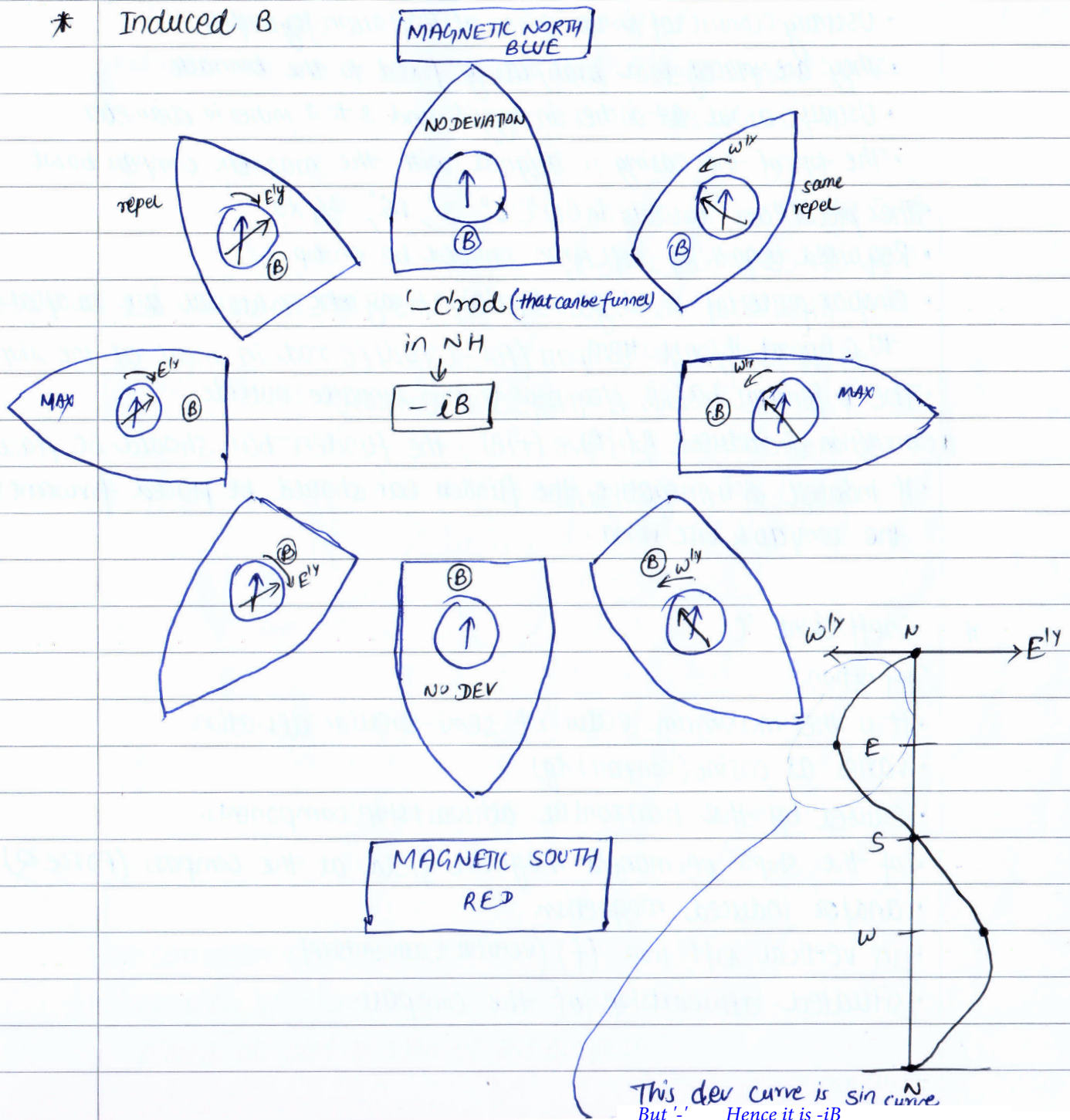
___/___/___

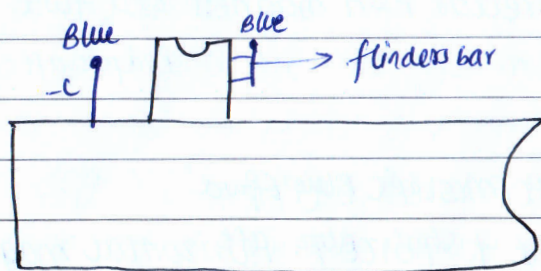
Force $P^+ \rightarrow$ If PB is $+$, corrector $F \& A$ magnets ^{pole} Red fwd, ship's blue fwd
Force $P^- \rightarrow$ If PB is $-$, " " " Red aft, ship's blue aft

$\Rightarrow$ Correction of Permanent B (PB)

- PB is caused due to Force P. Horizontal magnets are kept F & A to produce equal and opposite field.
- If a ship has $+PB$, these magnets are placed with their red end forward, & If a ship has $-PB$, these magnets are placed with their blue end forward.

* Induced B





* Flinders bar

Flinders bar is used to correct induced B and induced c

→ If only one of them is present

- For iB , it is placed forward or aft of compass.
- For ic , it is placed port or starboard of compass.

→ If both together are present

- It is slewed at an angle.

⇒ Correction of induced B (iB)

To correct induced B (iB),

- If induced B is negative ($-iB$), the flinders bar should be placed forward of the compass (For $-c$ rod) (c rod in most of the ship is funnel which is abaft the compass)
- If induced B is positive ($+iB$), the flinders bar should be placed abaft of the compass.

* Coefficient 'c'

Definition.

- It is the maximum value of semi-circular deviation.
- Varies as cosine (compass hdg)
- Caused by the horizontal athwartship components.
- of the ship's permanent magnetic field at the compass. (Force $\mathcal{Q}$)
- and/or induced magnetism
- in vertical soft iron (f) (vertical + athwartship)
- situated athwartship of the compass.

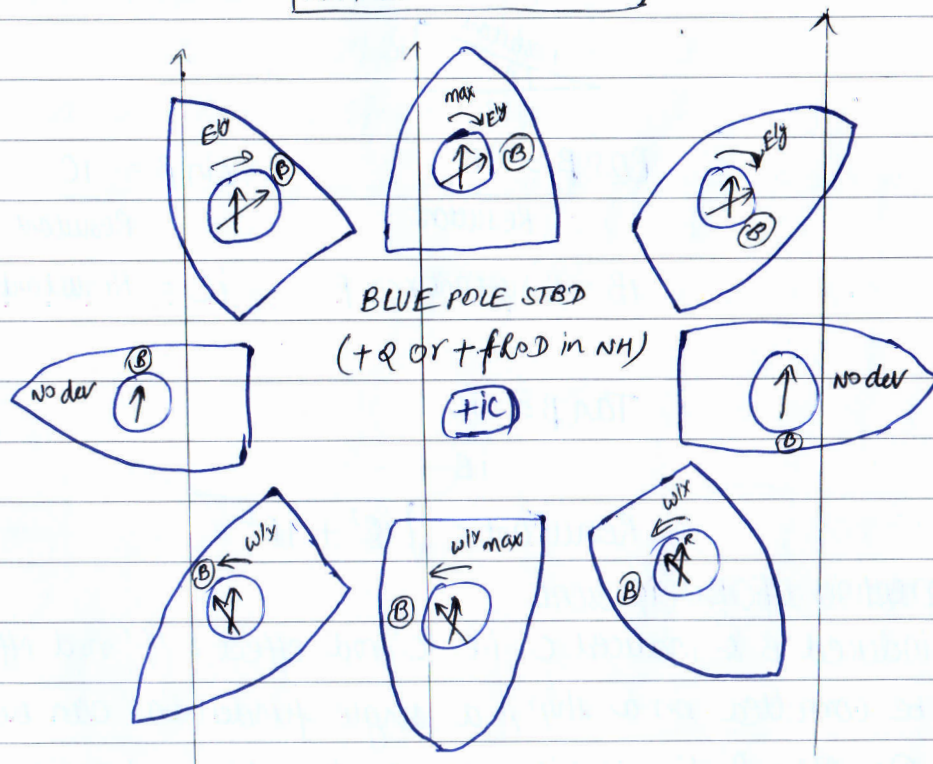
$$C = PC + iC$$

Induced 'C' $\rightarrow$ 'f' rod $\rightarrow$ vertical soft iron on opposite side

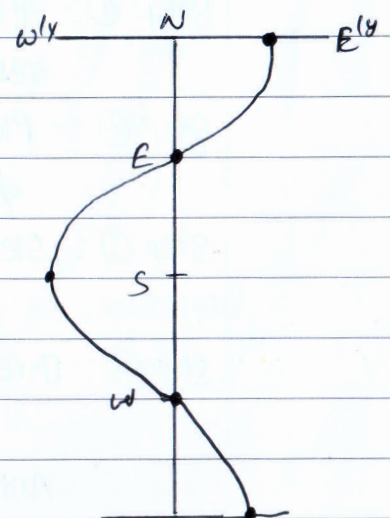
finder bar to port for f^+ rod

- PC is caused due to Force Q. Horizontal magnets are kept athwartship to produce equal and opposite field.
- If a ship has +PC, these magnets are placed with their red end starboard & if a ship has -PC, these magnets are placed with their blue end starboard.

MAGNETIC NORTH BLUE



MAGNETIC SOUTH RED

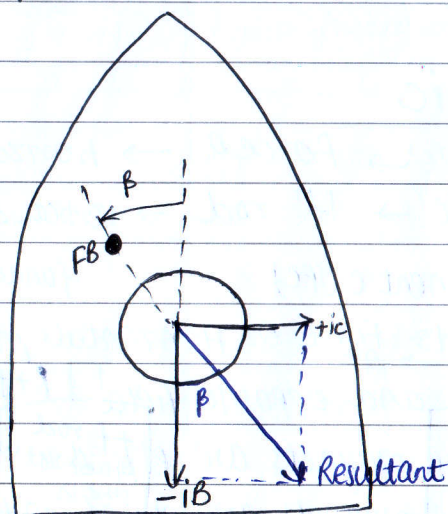


cos curve
'+C', +iC

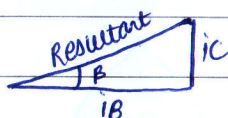
⇒ Correction of induced C. (ic)

Unlikely, if ship having IC, the flinders bar to be placed at port or starboard of the compass.

* Correction of both induced B (iB) & induced C (iC)



$\beta = \text{Angle of slew}$



$$\cos \beta = \frac{iB}{\text{Resultant}}$$

$$\sin \beta = \frac{iC}{\text{Resultant}}$$

$$iB = \text{Resultant} \times \cos \beta$$

$$iC = \text{Resultant} \times \sin \beta$$

$$\tan \beta = \frac{iC}{iB}$$

$$\text{Resultant} = \sqrt{iB^2 + iC^2}$$

If both iB & iC are present,

If induced B & induced C i.e. 'C' rod effect & 'f' rod effects are both to be corrected on a ship, a single funder bar can be used.

Step ① :- After finding iB & iC, steady the ship on heading on which resultant will produce maximum deviation.

Step ② :- Place the funder bar initially to correct induced B (For -iB forward & for +iB aft of compass)

Step ③ :- Slewing the funder bar. If β is angle of slew then,

$$\tan \beta = \frac{iC}{iB}$$

Step ④ :- Direction of slew

Clockwise if iB & iC are same sign

Anti-clockwise if iB & iC are opposite sign.

In the above sketch, iB is negative & iC is positive
 So, $\tan B$ is negative and finders bar to be slewed anti-clockwise.

Step ⑤: Correction of resultant : Adjust the length of finders bar to
 correct resultant = $\sqrt{iB^2 + iC^2}$

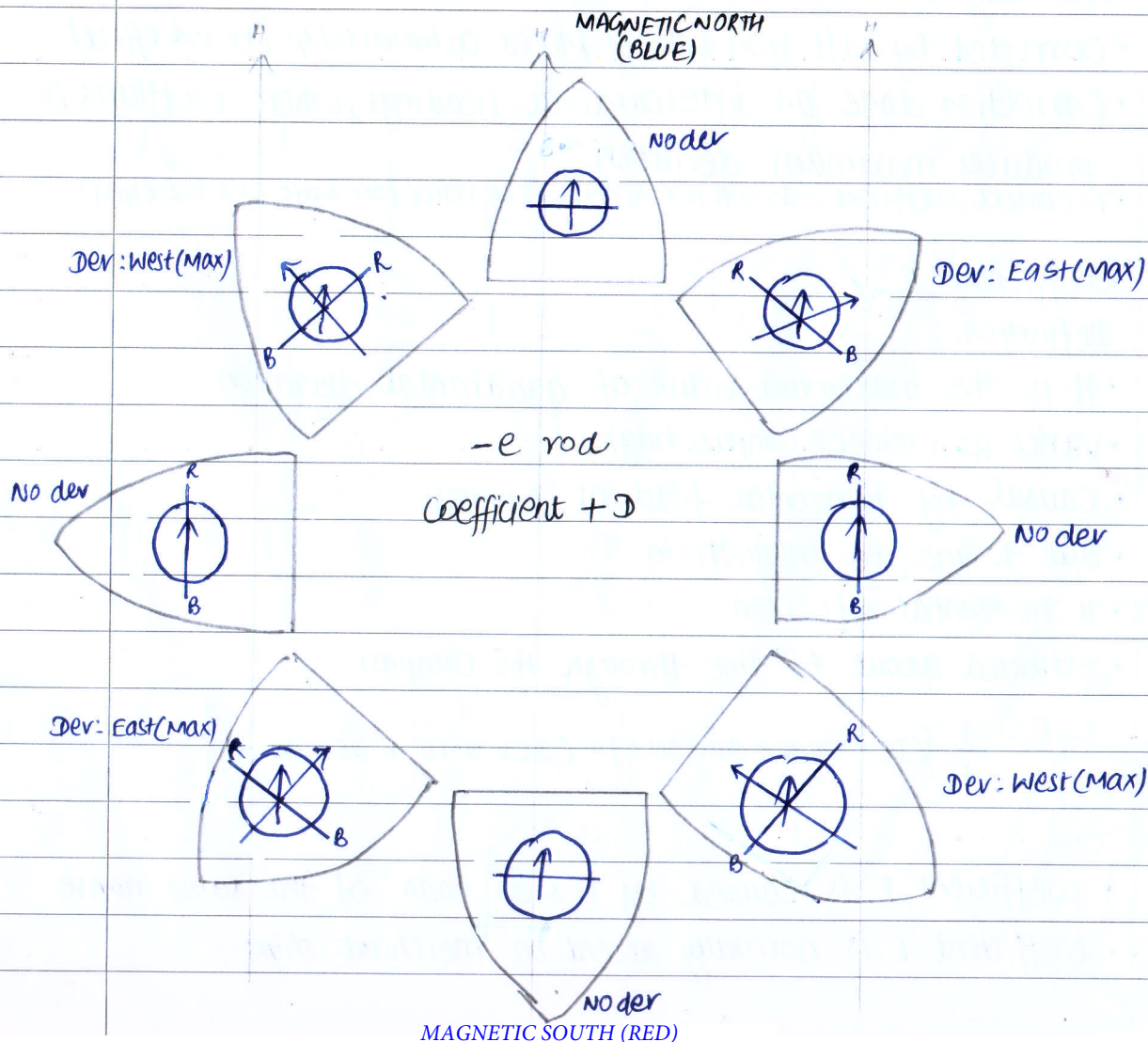
Thus, if finders bar is slewed 15° anti-clockwise from ship's head, that indicates both iB & iC are of opposite sign.

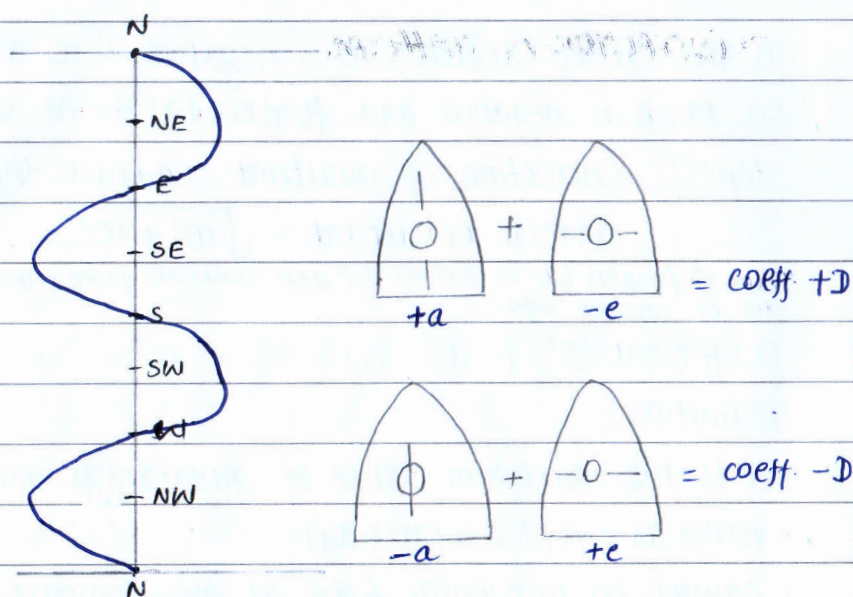
* Coefficient 'D' (In this coefficient D, there is no permanent component)

Definition:

- It is the maximum value of quadrantal deviation.
- varies as $\sin(2 \text{ compass hdg})$
- caused by horizontal field at the compass
- due to induced magnetism
- in horizontal soft iron (rod 'a')
- situated fore & aft of the compass

$$D = \frac{1}{4} \{ (\text{DEV ON NE} + \text{DEV ON SW}) - (\text{DEV ON SE} + \text{DEV ON NW}) \}$$





(Bridge wing)

- On merchant ships, the transverse beam (-e rods) and F&A girders (+a rods) are the structure that produce coefficient D.
- Deviation due to D will be NIL at cardinal heading and max^m at inter-cardinal headings.
- ⇒ correction of coefficient D
- Normally on vessels, +D is present
Corrected by soft iron spheres placed athwartship. (+e rod effect)
- Correction done on intercardinal headings, where coefficient D produces maximum deviation.
- To correct coefficient -D, soft iron spheres to be placed fore & aft (+a rod effect)

* Coefficient E Definition.

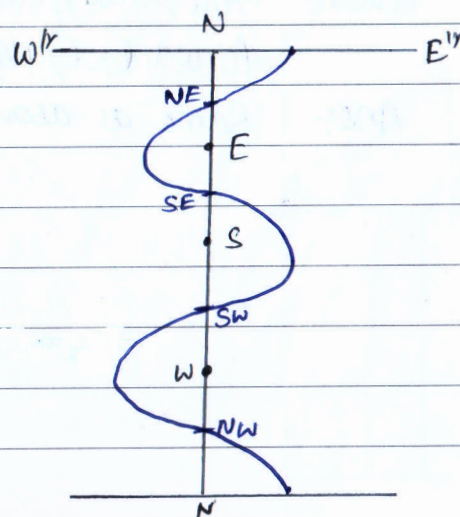
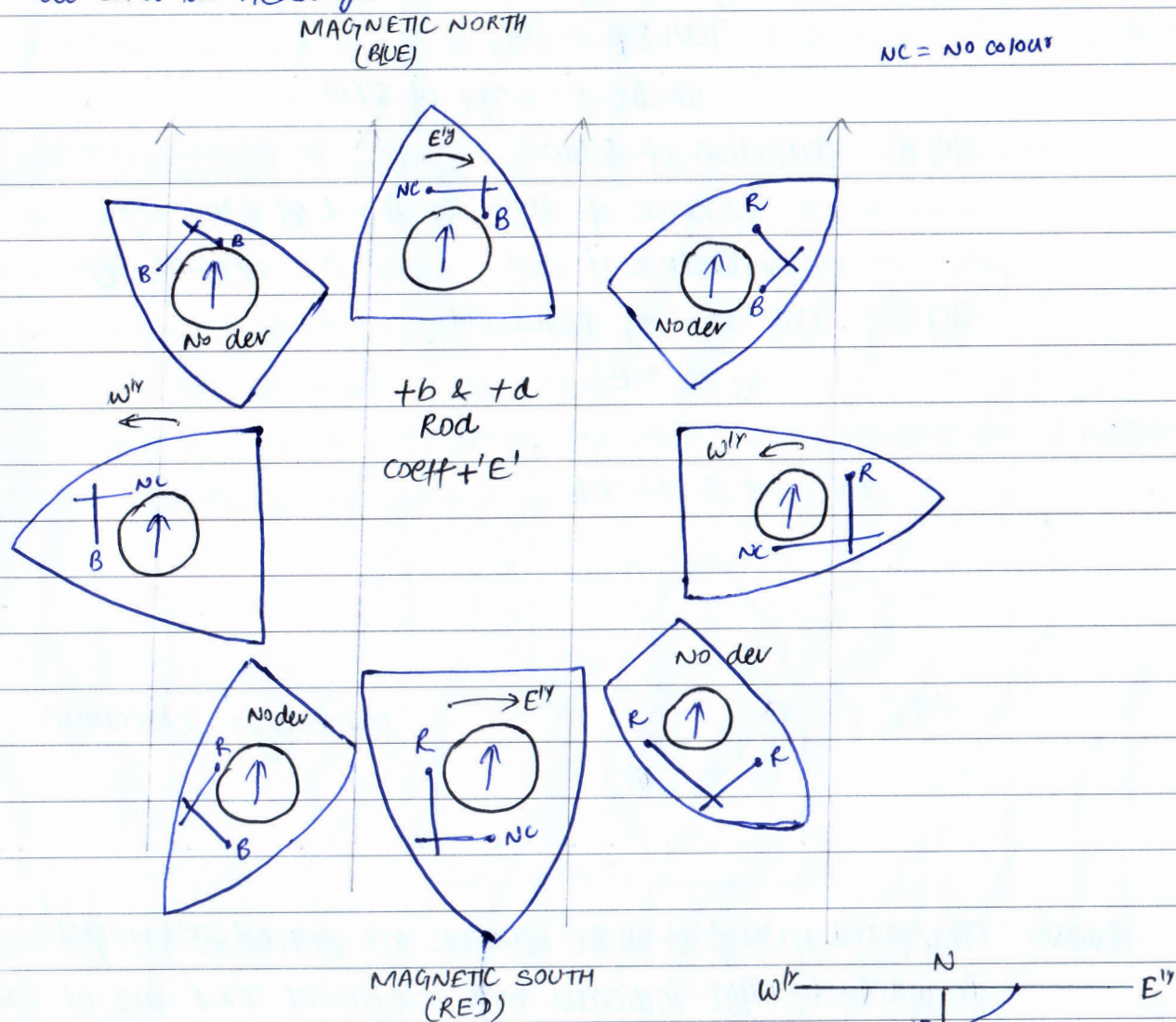
- It is the maximum value of quadrantal deviation
- Varies as cosine(2 compass hdg)
- caused by horizontal field at compass
- due to induced magnetism
- in horizontal soft iron
- situated about 45° line through the compass.

$$E = \frac{1}{4} \{ (\text{DEV ON N} + \text{DEV ON S}) - (\text{DEV ON E} + \text{DEV ON W}) \}$$

- coefficient E is caused by b & d rods of the same name
- coefficient E is normally absent on merchant ships.

⇒ Correction of coefficient E

- Correction to be done by soft iron spheres placed diagonally
- If +E is present, -E is created by placing soft iron spheres on port bow and starboard quarter.
- If -E is present, +E is created by placing soft iron spheres on starboard bow and port quarter.
- Deviation due to E will be NIL at intercardinal heading and max^m at cardinal headings.



* Correction of both Coefficient D & Coefficient E

If both coefficient D & coefficient E are present & to be corrected on a ship, a single pair of quadrantal correctors (Kelvin spheres) can be used.

Step ①: After finding coefficient D & coefficient E, steady on heading on which resultant will produce maximum deviation

$$\text{Heading} = 045^\circ - \text{Angle of slew}$$

Step ②: Place the Kelvin sphere initially to correct coefficient 'D' (for +D athwartship & for -D fwd & aft)

Step ③: Slewing the sphere

$$\tan 2\beta = E/D$$

where, β = angle of slew

Step ④: Direction of slew

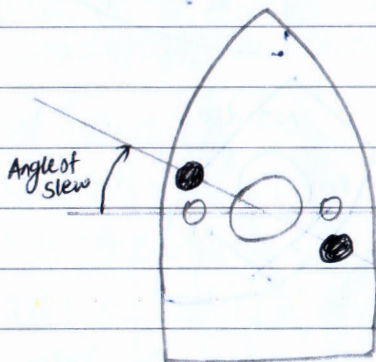
clockwise if coefficient D & E are same sign

Anticlockwise if " " " " " opposite sign

Step ⑤: Correction of Resultant

$$\sqrt{D^2 + E^2}$$

For +D & +E

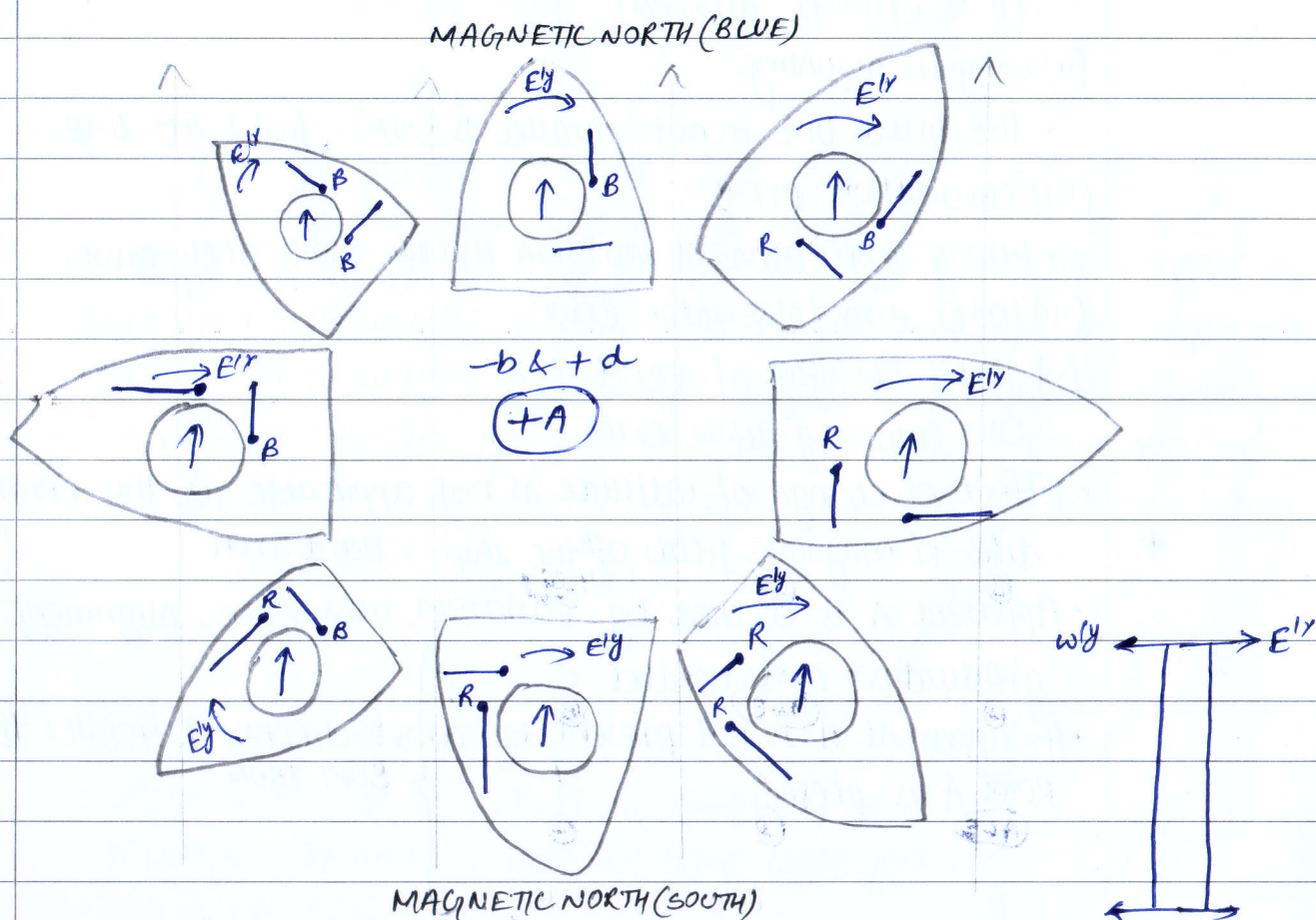


same sign: clockwise

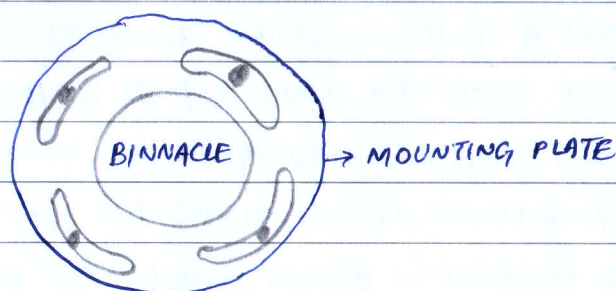
Thus, if the spheres are slewed 10° clockwise i.e. from 270°-90° to 280°-100°, that indicates both coefficient D & E are of same sign.

* Coefficient 'A'

- Coefficient 'A' is the constant deviation on all headings.
- Due to the horizontal magnetic field of the ship at the compass.
- Caused by induced magnetism
- In unsymmetrical pair of horizontal soft iron.
- Or, due to errors in design, construction or observation (calculation)
- Coefficient A consist of Real A and Apparent A
 $\Rightarrow$ Real A
- Real 'A' is the magnetic component
- Real 'A' is caused by magnetic field in combination of b & d δ ds of opposite name, but of equal value.
- $+A$ is produced by $-b$ & $+d$ rod.
- $-A$ is produced by $+b$ & $-d$ rod.
- $+A$ will produce constant easterly deviation on all headings.
- $-A$ will produce constant westerly deviation on all headings.
- Change of latitude does not affect deviation.
- It is very rare that a coefficient A exists
- If present, it is likely to be of very small value, constant on all headings.
- It is corrected by shifting lubber line of the compass.



* Correction of coefficient 'A'



- If coefficient A exists, its value may be obtained as the mean of the deviation on atleast four equidistant headings.
- It is corrected by moving the binnacle (arrangement are so provided)
- It is not practicle to seperate real 'A' & apparent 'A'
- And so, after checking & re-checking, if coefficient 'A' is high, then the binnacle can be slewed to slew the lubber line for correcting coefficient 'A'.

⇒ Apparent A

- Non-magnetic components creating coefficient A are called Apparent A
- It is caused by factors other than the magnetic field of the ship.
- Causes of apparent A.

(i) Design

- The magnetic axis is not aligned with $000^\circ - 180^\circ$ of the compass card. (0.5° error is allowed)

(ii) Compass mounting.

- The lubber line is not parallel to ship's fwd & aft line.

(iii) calculation error

- Wrong application of variation usually most likely cause.

(iv) Index error/observation error

(v) Rapid swinging of vessel

- Can cause gaussian error
- Effect of change of latitude is not applicable as this error is not due to magnetic field of the ship.
- Apparent A is checked by variation, lubber line, alignment of card graduation and needles.
- If apparent A is not present by above checks, it implies that a Real A is present.

(31)

___/___/___

Ques 7) Describe the deviation of standard magnetic compass which is caused by continuous athwartship horizontal soft iron in the vessel using suitable diagrams with respect to be following:
i) change in deviation due to a change in latitude of the vessel, and
ii) Means and method used to correct such a deviation. (4-times)

Ans:- Deviation caused by athwartship horizontal soft iron is coefficient D
Write answers from * coefficient D (Page 25 & 26)

(i) Effect of change in latitude.

- We know that all horizontal soft irons are magnetised by the earth's horizontal force (H).
- At the poles, H is zero, therefore, there is no induction by H .
- As H increases from zero at the pole to maximum at the equator, the induction in the horizontal soft iron also increases in the same proportion.
- At the equator, H is maximum, the induction in the horizontal soft iron is also maximum.
- Therefore, we can say that any increase in the earth's horizontal force (H), causes a proportionate increase in the induction in ship's horizontal soft iron.
- Therefore, deviation due to coefficient D is unaffected by change in latitude of the vessel.

(ii) Means and method to correct such a deviation

Write answer from $\Rightarrow$ Correction of coefficient D (Page 26)

Ques 8) How coefficient D is calculated and corrected.

(OR)

With help of suitable sketches, show clearly how ship's magnetic coefficient D is created. How the error is corrected?

(OR)

Explain following for coefficient D : Cause of coefficient

Ans:- Write answer from * coefficient D (Page 25 & 26)

$\Rightarrow$ Correction of coefficient D (Page 26)

Ques 9)

On-board your vessel, you have noticed that "The Flinder's bar" is attached to the binnacle in a relative-slewed direction 015° instead of usual direction of ship's head.

- Analyze and discuss in detail the reasons for such an arrangement.
- What would have been the ship's heading on which maximum deviation would have occurred prior to "The Flinder's bar correction" made by compass adjuster.

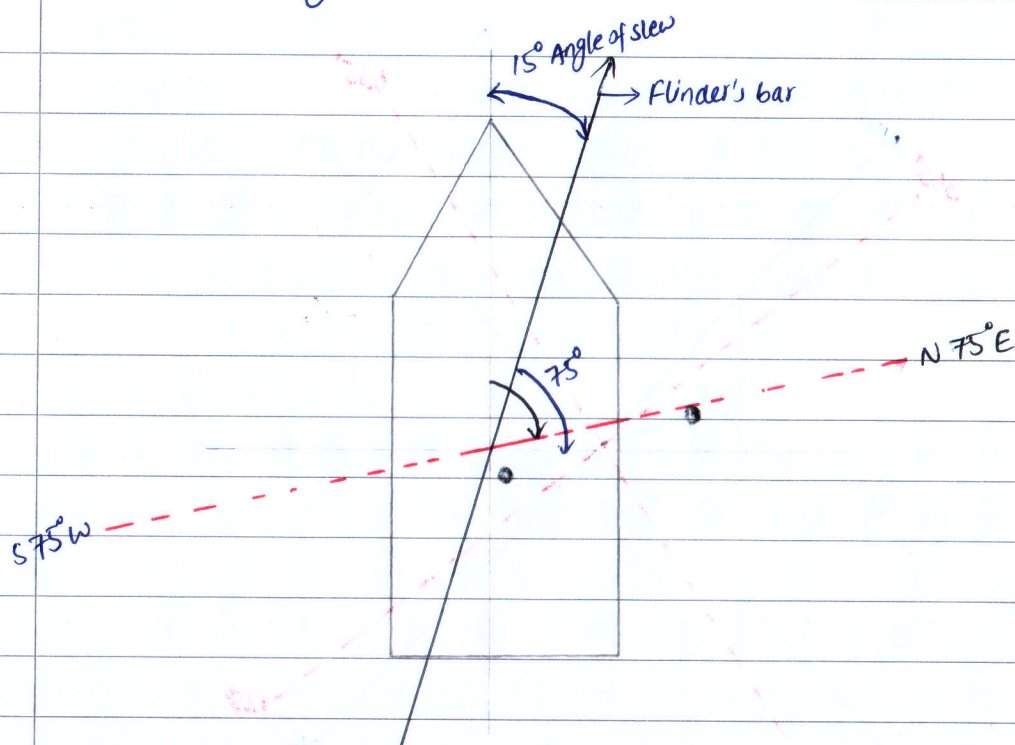
Ans:-

a) Write answer from * Flinders bar (Page 22)

* Correction of both induced B (iB) & induced C (iC) (Page 24)

b) Maximum deviation:

- Maximum deviation produced by iB & iC are $\sqrt{iB^2 + iC^2}$
- iB and iC are caused due to vertical soft iron and will produce maximum deviation when deviating force is perpendicular to the compass needle.
- For maximum deviation to occur, the flinder's bar should coincide with E/W line.
- In this case, the flinder's bar is placed 015° , thus, the ship must be swung 75° to std.
- Ship's heading will be $N 75^\circ E$ or $S 75^\circ W$



Ques 10) On board your vessel, you have noticed that soft iron spheres are attached to the binnacle in relative slewed direction that is 280° - 100° .

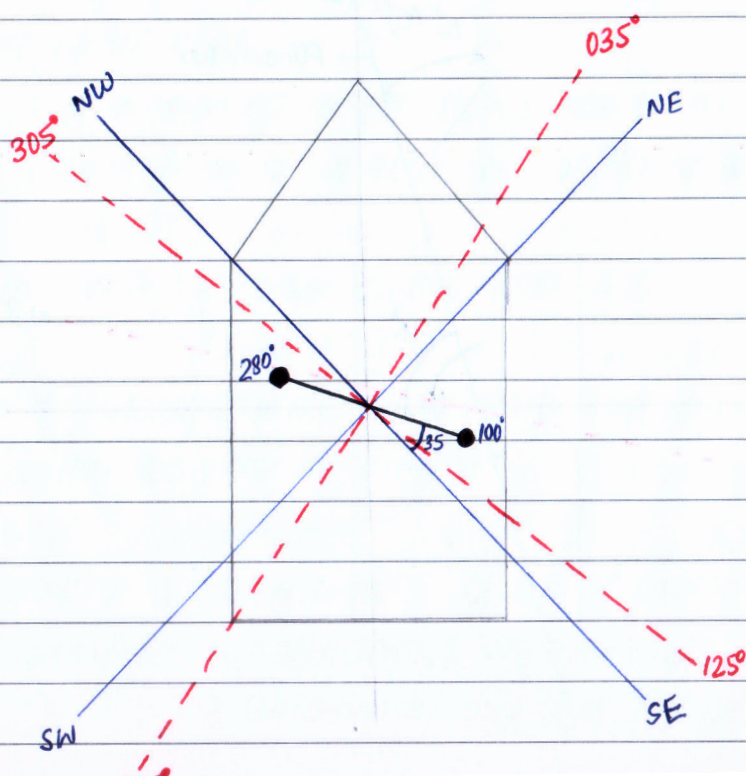
- Analyze and discuss in detail the reason(s) for such an arrangement
- What would have been the ship's heading on which maximum deviation would have occurred prior to "Soft Iron correction" made by compass adjuster?

Ans:- a) Write answers from 2.d soft iron spheres (Page 10)

* Correction of both coefficient D & E (Page 28)

b) Maximum deviation

- Maximum deviation produced by D & E are $\sqrt{D^2 + E^2}$
- Coefficient D & E are caused due to horizontal soft irons and will produce maximum deviation when they lie in NE-SW or NW-SE.
- For maximum deviation to occur, the soft iron sphere should coincide with this line.
- In this case, the soft iron spheres is placed 280° - 100° and to bring it to quadrantal heading SE or 135° , ship has to swing 35° to stbd. i.e. $N 35^{\circ} E$.
- Other heading on which maximum deviation would occur are 125° , 215° , 305° .



Ques 11) On-board a vessel Flinders bar was observed to be placed at an angle of 15° towards port side from fore and aft line; soft iron spheres were placed athwartship. Explain with suitable sketches the reasons for such an arrangement (4-times)

Ans:- If flinder's bar is slewed at an angle, that means, both iB and iC are present
Write answer from * Correction of both induced $B(iB)$ & induced $C(iC)$ (Page 24)

If soft iron spheres were placed athwartship, that means coefficient $+D$ is present

Write answer from * coefficient D (Page 25 & 26)

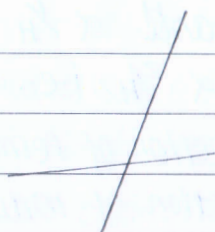
Ques 12) At Antofagasta, Chile ship was lying on a heading of 270° . Maximum deviation was found $3^\circ E$. If the permanent magnetism was corrected using fwd & aft corrector magnets, state the possible reasons for getting this deviation & how the deviation can be corrected.

- Ans:-
- Chile is in SH and the ship is heading west with having $3^\circ E$ deviation.
 - Coefficient $A(+A)$ and coefficient $B(-PB, -iB)$ and coefficient $E(-E)$ are the coefficient which could cause an easterly deviation when heading west.
 - Coefficient A & E are not usually present on merchant ships as b and d rods are usually not present.
 - Permanent magnets were placed fore and aft that eliminates $-PB$.
 - Thus, $-iB$ could be present which is causing $3^\circ E$ deviation.

Induced B

Write answer from * Induced B (page 21)

$\Rightarrow$ Correction of Induced B (Page 22)



Ques 13) Describe the deviation of a standard magnetic compass on an upright vessel which varies directly as the cosine of the ship's course by compass using suitable diagrams with respect to the following:

a) Cause and sign

b) Change in deviation due to changes in magnetic latitude of the ship

c) Means and methods used to correct such a deviation.

Ans:-

a) Write answer from * Coefficient C (Page 22 & 23)

* Induced C (Page 23)

b) Effect of change in latitude.

⇒ Effect of change in latitude on deviation due to PC:

- PC → Force & Earth's horizontal components (H)
- Force & causing deviation is constant.
- Earth's horizontal component (H) varies with latitude. Zero/Nil at poles and maximum at equator.
- When H is large, the resultant force is small and when H is small, the resultant force is large.
- As a ship moves to a lower latitude, Earth's horizontal component (H) decreases and the deviation due to PC increases and vice versa.
- Deviation due to PC $\propto 1/H$

⇒ Effect of change in latitude on deviation due to IC:

- IC → f rod & vertical soft iron
- Vertical soft iron are magnetised by Earth's vertical component (Z).
- Earth's vertical component (Z) varies with latitude. Maximum at poles and zero/nil at equator.
- As Z increases, the induction and the DF & deviation would increase. As Z decreases, the deviation would decrease.
- As a ship moves to a lower latitude, Earth's vertical component (Z) increases and the deviation due to IC increases and vice versa.
- Deviation due to IC $\propto Z$ and $\propto 1/H$
Hence, deviation due to IC $\propto Z/H$ i.e. $\propto \tan \text{dip}$.

c) Write answer from ⇒ Correction of Permanent C (PC) (Page 23)

⇒ Correction of Induced C (IC) (Page 23)

Ques 14)

In port of Chennai, your vessel is alongside and the flinders bar of your ship's magnetic compass is removed. Values of deviation remain unchanged. Vessel is shifted to another berth and the flinders bar is replaced in the casing. Value of deviation is observed to be different. Analyze and discuss the reasons for the change in value of deviation.

Ans:-

- Flinders bar is used to correct iB and iC .
- Normally iC will not present on ship with a well placed compass.
- iB is caused due to the presence of 'C' rod.
- Vertical soft iron 'C' rod in most of the ship is funnel which is abaft the compass with blue pole on top.
- Chennai, in N.H, vertical soft iron (VSI) will acquire a blue pole on top and red pole at bottom.
- V.S.I i.e. Flinders bar placed forward of compass will result in -C rod causing a $-iB$.
- The deviation caused due to $-iB$ will be Nil in N/S heading and maximum in E/W heading.
- Thus, vessel at first berth must be heading North-South and hence no deviation was found even after removing the flinders bar.
- In the next berth, vessel must be on heading other than North-South and deviation is found due to the effect of -C rod at the magnetic field of the compass.

Draw diagram from * Induced B (Page 21)

Ques 15)

Onboard your vessel you notice that the deviation curve of magnetic compass has an easterly bias i.e. deviation values more easterly than westerly as vessel is swung around in 360° . Analyze and discuss in detail the causes of such a deviation curve.

Ans:-

- +PB and +iB of Coefficient B causes maximum easterly deviation on easterly heading and maximum westerly deviation on westerly heading.
- If deviation values are more easterly than westerly, then addition to Coefficient B, Coefficient A is present.
- Coefficient A alone cannot be present as deviation is constant on all heading.

Thus, a combination of coefficient A (+A) and coefficient B (+PB & +B) is causing an easterly bias.

Ques 16) On-board a vessel with constant $2^{\circ}\text{E}/10^{\circ}\text{W}$ deviation on all headings, following permanent corrector magnets were observed as placed in compass binnacle.

(i) Corrector magnets in F&A direction with Blue fwd & Red aft

(ii) Corrector magnet in athwartship direction with Red on starboard and blue on port. Explain with suitable sketches.

a) What could be the reason for placement of correctors in above manner?

b) What could be the reason for constant deviation on all headings?

Ans:- a) Reason for placement of correctors.

(i) If a ship has -PB,

the permanent corrector magnets are placed in F&A direction with blue end forward and red end aft.

ii) If a ship has +PC

the permanent corrector magnets are placed athwartship with red end starboard and blue on port.

Hence, the reason for placement of correctors in above manner is a ship having -PB & +PC.

b) Reason for constant deviation.

(i) If constant 2°E deviation on all heading, that means, coefficient +A is present.

+A will produce constant easterly deviation on all heading.

(ii) If constant 10°W deviation on all heading, that means, coefficient -A is present

-A will produce constant westerly deviation on all heading.

Draw diagram from * Coefficient A (Page 29)

//_

Ques 17) Explain why and when coefficient A & E are applicable to vessels. (2-times)

Ans:- Write answer from * Coefficient A (Page 29)

* Coefficient E (Page 26 & 27)

Ques 18) Explain why a deviation curve made in one hemisphere and position cannot be used in the other hemisphere. (5-times)

Ans:- Write answer from Q.1 $\Rightarrow$ Permanent magnetism (Page 4)

$\Rightarrow$ Induced magnetism (Page 5)

Conclusion:

Hence, each of the component has to be treated separately as the deviations they produce vary with change of ship's heading, magnetic latitude and hemisphere.

Thus, the deviation curve made in one hemisphere and position cannot be used in the other hemisphere.

Ques 19 a) List the preparations and precautions necessary for swinging ship for compass adjustment. (4-times)

Ans:-

- All derricks, cranes, davits etc. should be stowed and secured. Anchors should be housed and secured.

- Vessel must be upright.

- The accuracy of the lubber line should be checked to ensure that it is parallel to the ship's fore and aft line.

- The azimuth mirror must be checked for accuracy by taking the bearing of an object.

- Remove all metal objects from the vicinity of the compass.

- As a ship is a large steel object, there must be no vessel within 3 to 4 cables

- Test the flinders bar & soft iron spheres, it must not have any residual magnetism and if it has residual magnetism must be de-magnetised.

- In order to de-magnetise flinders bar or soft iron sphere, they must be heated to red hot and then allowed to cool slowly. Repeat the test.

- If only slight magnetism is found to remain in the sphere, it can be got rid of by rolling them on the deck.
- Person required to be near the compass when adjustments are being made should ensure that there is no magnetic materials like key etc are present.

Ques 19-b) Explain the occasion when an adjustment is necessary. (2 times)

- Ans:-
- Three to six months after the first correction, due to the likelihood of changes having taken place, during that period, in her permanent magnetism.
 - Once every year as a routine.
 - After carriage and discharging of cargoes of a magnetic nature.
 - After loading and unloading by electromagnets.
 - When the ship re-enters service after being laid up for some period.

Ques 20) How are Gaussin error and Retentive error caused? List the differences in deviation caused by each. What precautions are necessary when either of them may be present? (4 times)

Ans:- Gaussin error.

- When a vessel alters course rapidly, the different parts of ship's structure cuts the Earth's magnetic field at varying rates.
- This sets up an EMF and therefore an electric current in ship's hull.
- This current sets up a magnetic field of its own, which act in an opposite direction of the ship's swing.
- There is also a short lag in the shift of the induced poles in the ship's soft iron structures.

Deviation:

- Due to these effects,
If the ship swings to starboard, the compass deviates to the west.
If the ship swings to port, the compass deviates to the east.
- The name of the deviation remains the same for all 360° provided the direction of swing remains the same.
- However, the amount of deviation will increase and decrease quadrantly.

due to unsymmetrical shape of the ship.

- This error is present only while the ship is swinging and ceases within a couple of minutes as the ship steady on her next course.

Precaution: • Bearing observed while the ship is swinging should not be relied upon.

Retentive error

- A vessel on steady course for a considerable period acquires a certain amount of sub-permanent magnetism in her structure due to vibration, pounding etc.
- It acquires magnetism with a red pole to the northward of the compass and a blue pole to the southward of the compass.
- As the vessel alters course thereafter, these poles are retained for a few hours and they gradually decay.

Deviation: • This sub-permanent will cause an

- westerly deviation on any new course upto 180° to the right of original heading, as the red pole will then be carried to the east and the blue pole will then be carried to the west of the compass.
- easterly deviation on any new course upto 180° to the left of original heading, as the red pole will then be carried to the west and the blue pole will then be carried to the east of the compass.

Precaution: • Therefore, when the vessel alters course after steering a steady course for a considerable period, the compass error should be checked frequently over the next six hours.

Ques 21) What type of magnetic compass would you choose for a new ship and where should it be placed?

Ans:- The magnetic compass must meet the following performance standards in order to be placed on ship:

(a) Compass card

- The card should be graduated in 360 single degrees, clockwise from 000° for north.
- The directional error of the compass card shall not exceed 0.5° .
- The card of steering compass should be clearly readable at a distance of

1.4m in both daylight and artificial light. The use of magnifying glass is permitted.

(b) Material

- The magnets of the compass card and corrector magnets should have coercivity of atleast 11.2 kA/m.
- The material of soft iron corrector should have low remanance and coercivity.
- All other material used in the magnetic compass and binnacle should be non-magnetic.

Constructional Errors:

- The error due to friction should not exceed $(\frac{3}{4})^\circ$ at a temperature of $20 \pm 3^\circ\text{C}$ where H is the flux density of the horizontal field in micro tesla.
- After a deflection of 40° , the half period of the card should be atleast 12 seconds where H is 18 micro tesla.
- After a deflection of 90° , the card should return finally to within 1° of the magnetic meridian within 60 seconds.

Construction:

- Primary and emergency illumination should be provided for the card together with the facility for dimming.
- No electric power should be necessary for operating the compass other than for illumination.
- The material used for manufacturing the compass should be of sufficient strength.

Positioning

- The compass should when practicable, be installed on the ship's FLA centreline.
- The main lubber mark should indicate the ship's head with an accuracy of atleast 0.5° .
- The standard compass should be so positioned that the view from the site is uninterrupted for taking terrestrial and celestial bearings.

/

Ques 22) Why is the ship swung and compass compensated instead of being swung and deviation noted on each heading?

- Ans:-
- Magnetic field at the compass is affected by ship's permanent magnetism and induced magnetism.
 - Strength of permanent magnetism is constant, their effect on the magnetic field of compass varies with change in ship's heading.
 - Strength of induced magnetism on both horizontal soft iron (HSI) and vertical soft iron (VSI) varies with change in latitude.
 - If the ship swung and deviation noted without compensating, deviation would be erratic.
 - Also, deviation would be very large and different in various courses and latitudes.
 - Thus, compass must be compensated.