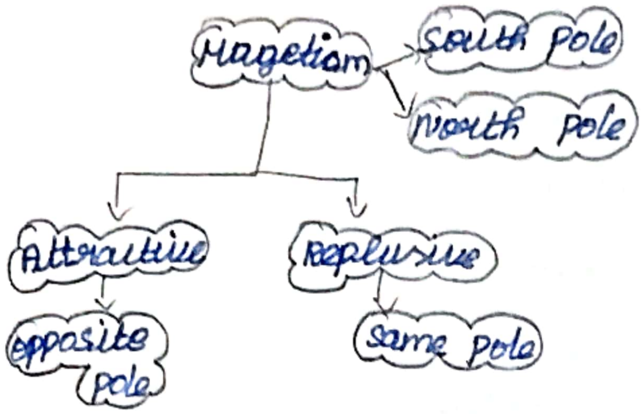
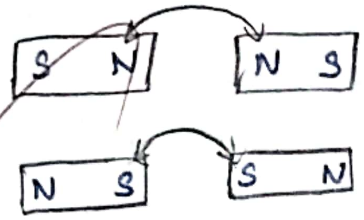
3-unit

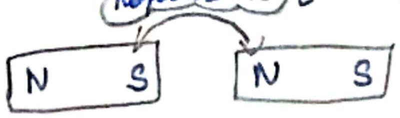
Magnetism and magnetic effects of Electric current



Bar magnet



Replusive (like poles)

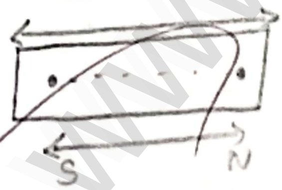


Attractive (unlike pole)

like pole → Replusive

unlike pole → Attractive

Geomentrical length



Magnetic length

Magnetic pole strength → Scalar quantity

unit → NT^{-1} T → Tesla

Everyday life magnetism uses

* Motors
* cycle dynamo
* Loudspeakers
* Magnetic taps
* Recording
* Mobile Phones
* head phones
* CD
* Pendrive
* used in audio and vedio hard disc of laptop Refrigerator door Generator
* MRI → Magnetic Resonance Imaging

Types of magnet

Artificial magnet
↓
strong
↓
Bar magnet
cylindrical shape
↓
desired shape
Regular shape

Natural magnet
↓
Fe → Iron
Ni → Nicken
Co → cobalt
↓
week
↓
not desired shape
↓
Irregular shape

Magnetic dipole

magnet → south to north pole

Bar magnet
freely suspended → North to south pole

1 mark (F)(S)

$$\frac{\text{magnetic length}}{\text{Geomentrical length}} = \frac{5}{6} = 0.8333$$

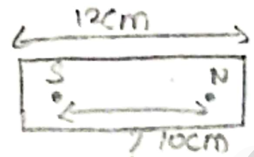
Example 3.3

Pg : 112

2m

2 mark (B)(S)

1) compute the magnetic length of uniform bar magnet of the geomentrical length 12 cm



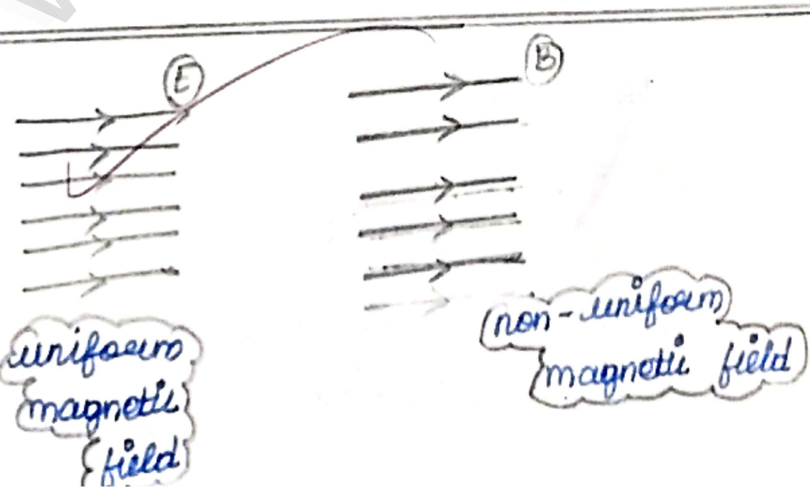
$$\frac{\text{magnetic length}}{\text{Geomentrical length}} = \frac{5}{6}$$

magnetic length $= \frac{5}{6} \times$ Geometrical length

magnetic length $= \frac{5}{6} \times 12$

$= 5 \times 2$

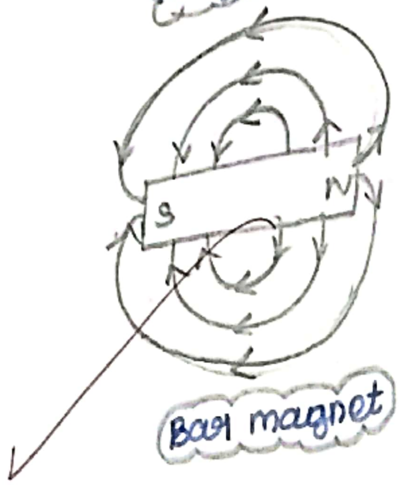
$= 10\text{cm}$



Direction or not a constant

both magnetic and direction are not constant

magnetic field lines



Bar magnet

16/05/24 Thursday

Magnetic flux ϕ_B

Magnetic field lines

$\phi_B = \oint \vec{B} \cdot d\vec{A}$

$\phi_B = \int B \, dA \cos\theta$ — $\cos\theta = 1$

$\phi_B = B \int dA \cos\theta$ — $\theta = 0°$

$\phi_B = B \int dA \cos(0)$ — $\int dA = A$

$\phi_B = BA(1)$

$\phi_B = BA$

B → Magnetic field

A → cross sectional area

scalar quantity

magnetic flux
- SI unit → weber (Wb)
- cgs unit → maxwell.

magnetic flux maximum

$\phi_B = BA\cos\theta \quad \theta = 0$

$\phi_B = BA\cos(0) \quad \cos(0) = 1$

$\phi_B = BA(1)$

$\phi_B = BA$

magnetic flux minimum : parallel

$\phi_B = BA\cos\theta \quad \theta = 90°$

$\phi_B = BA\cos(90)$

$\cos(90)° = 0$

$\phi_B = BA(0)$

$\phi_B = 0$

important question

Coulomb's Inverse square Law of magnetism

$F \propto \frac{q_{mA} q_{mB}}{r^2}$

(1) lesson → Formula $F \propto \frac{q_1 q_2}{r^2}$

F → Force

$m_A\ m_B$ → magnetic pole

$F = k\frac{q_{mA} q_{mB}}{r^2}$

H → Henry

$k = \frac{\mu_0}{4\pi}$

μ_0 → permeability of free space

$\mu_0 \to 4\pi \times 10^{-7}\ HM^{-1}$

$$\vec{F} = \frac{\mu_0}{4\pi} \frac{q_{mA} q_{mB}}{r^2} \hat{r}$$

$$F = \frac{\mu_0}{4\pi} \frac{q_{mA} q_{mB}}{r^2}$$

Pg: 135

(5) mark

(X)

Example 3.5 :

q_{mA} q_{mB} → Replusive

$q_{mA} = q_m$

$q_{mB} = q_m$

$q_{mA} q_{mB} = q_m q_m = q_m^2$

$r = 10 cm$

$Force = 9 \times 10^{-3} N$

Pole strength $q_m = ?$

$$F = k \frac{q_{mA} q_{mB}}{r^2}$$

$$F = \frac{\mu_0}{4\pi} \frac{q_{mA} q_{mB}}{r^2}$$

$$F = \frac{\mu_0}{4\pi} \frac{q_m^2}{r^2}$$

$\mu_0 = 4\pi \times 10^{-7} Hm^{-1}$

$r = 10 cm$

$r = 10 \times 10^{-2} m$

$q_m^2 = ?$

$F = 9 \times 10^{-3} N$

$$9 \times 10^{-3} = \frac{4\pi \times 10^{-7}}{4\pi} \frac{q_m^2}{(1 \times 10^{-2})^2}$$

$$9 \times 10^{-3} = 10^{-7} \frac{q_m^2}{100 \times 10^{-4}}$$

$9 \times 100 \times 10^{-3} \times 10^{-4} = 10^{-2} \times q_m^2$

$900 \times 10^{-7} = 10^{-7} q_m^2$

$900 = q_m^2$

$\sqrt{900} = q_m$

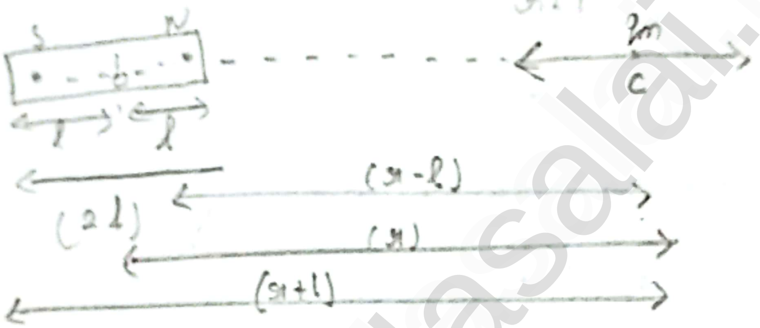
$\sqrt{30 \times 30} = q_m$

$q_m = 30 \, NT^{-1}$

26/05/24

7/06/24 Friday

Axial line Bar magnet



Bar magnet சட்ட காந்தம்

S → south pole தென்முனை

N → north pole வடமுனை

O → centre of the point மையப்புள்ளி

l → distance தூரம்

2l → small distance சிறிய தூரம்

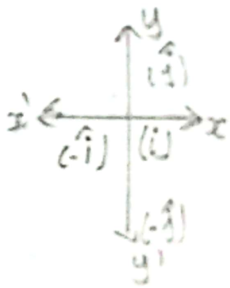
B_N → North pole magnetic field வடமுனை காந்தப்புலம்

B_S → south pole magnetic field தென்முனை காந்தப்புலம்

q_m → magnetic pole strength காந்த முனை வலிமை

SN → Geometrical length, magnetic length

B → magnetic field (காந்தப்புலம்)



$OS = l, \; ON = l, \; SN = l + l = 2l$

$NC = r - l, \; OC = r, \; SC = r + l$

$\mu_0 \rightarrow$ Permeability of free space

$\mu_0 \rightarrow 4\pi \times 10^{-7}\, Hm^{-1}$ (Henry)

Magnetic field at a point c in a north pole

$$\vec{B_N} = \frac{\mu_0}{4\pi} \left(\frac{q_m}{(r-l)^2}\right) \hat{i} \rightarrow (1)$$

magnetic field at a point c in a south pole

$$\vec{B_S} = \frac{\mu_0}{4\pi} \left(\frac{-q_m}{(r+l)^2}\right) \hat{i}$$

$$\vec{B_S} = -\frac{\mu_0}{4\pi} \frac{q_m}{(r+l)^2} \hat{i} \rightarrow (2)$$

Total magnetic field

$$\vec{B} = \vec{B_N} + \vec{B_S}$$

$$\vec{B} = \frac{\mu_0}{4\pi} \frac{q_m}{(r-l)^2} \hat{i} + \left(-\frac{\mu_0}{4\pi} \frac{q_m}{(r+l)^2} \hat{i}\right)$$

$$\vec{B} = \frac{\mu_0 q_m}{4\pi} \left[\frac{1}{(r-l)^2} - \frac{\mu_0 q_m}{4\pi} \frac{1}{(r+l)^2}\right] \hat{i}$$

$$\vec{B} = \frac{\mu_0 q_m}{4\pi} \left[\frac{1}{(r-l)^2} - \frac{1}{(r+l)^2}\right] \hat{i}$$

$$\vec{B} = \frac{\mu_0 q_m}{4\pi} \left[\frac{(r+l)^2 - (r-l)^2}{(r-l)^2 (r+l)^2}\right] \hat{i}$$

$(r+l)^2 = (a+b)^2$

$= r^2 + l^2 + 2rl$

$(r-l)^2 = (a-b)^2$

$= r^2 + l^2 - 2rl$

$$\vec{B} = \frac{\mu_0 q_m}{4\pi} \left[\frac{(r^2+l^2+2rl) - (r^2+l^2-2rl)}{(r^2-l^2)^2}\right] \hat{i}$$

$$\vec{B} = \frac{\mu_0 q_m}{4\pi}\left[\frac{r^2+a^2+2rl-r^2-a^2+2rl}{(r^2-l^2)^2}\right].\hat{i}$$

$$\vec{B} = \frac{\mu_0 q_m}{4\pi}\left[\frac{4rl}{(r^2-l^2)^2}\right]\hat{i}$$

$r >> l$
$l \rightarrow$ neglected
$r \uparrow \; a \downarrow$

$$\vec{B} = \frac{\mu_0 q_m}{4\pi}\left[\frac{4rl}{(r^2)^2}\right].\hat{i}$$

$$\vec{B} = \frac{\mu_0 q_m}{4\pi}\left[\frac{4rl}{(r^4)}\right]\hat{i}$$

$$\vec{B} = \frac{\mu_0 q_m}{4\pi}\left[\frac{4l}{r^3}\right]\hat{i}$$

magnetic dipole moment
$p = q \times 2a$
$P_m = q_m \times 2l$

$$\vec{B} = \frac{\mu_0}{4\pi}\frac{q_m 4l\hat{i}}{r^3}$$

$$\vec{B} = \frac{\mu_0}{4\pi}\frac{2\vec{P_m}}{r^3}$$

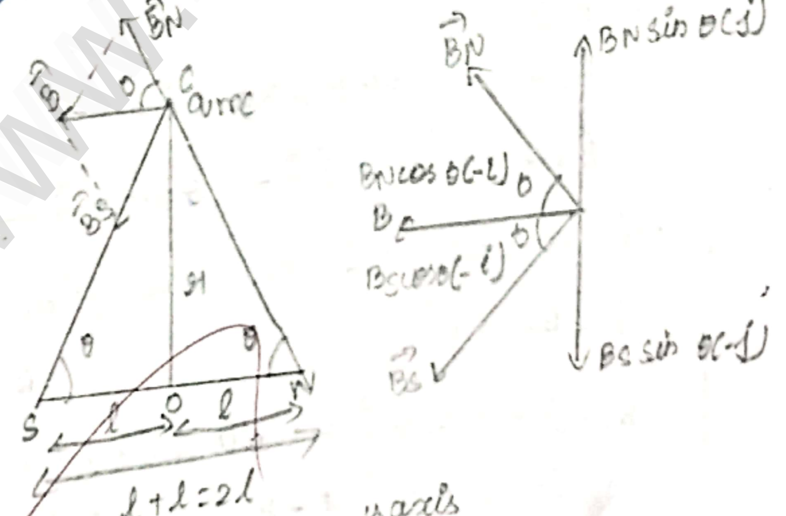
17/05/24

..05/24
..uesday

..mark (3)(5)

(Pg:192) Book Back: (6th Q) (L/a)

2) Obtain the magnetic field at a point on The equatorial line of a barmagnet



S → South pole (தென் முனை)

N → North pole (வட முனை)

θ → Angle (கோணம்)

r → Distance (தொலைவு)

l → Distance (தொலைவு)

2l → Small distance (சிறிய தொலைவு)

O → centre of the point (மையம்)

$\vec{B_S}$ → South pole magnetic field (தென் முனையின் காந்தப்புலம்)

$\vec{B_N}$ → North pole magnetic field (வட முனையின் காந்தப்புலம்)

$\vec{B}$ → Total magnetic field (மொத்த காந்தப்புலம்)

SN → Bar magnet

$B_N \sin\theta$, $B_S \sin\theta$ → opposite direction (எதிரெதிர் திசை)
↓
vertical components (செங்குத்து கூறு)

$B_N \cos\theta$, $B_S \cos\theta$ → same direction (ஒரே திசை)
↓
Horizontal components (கிடைத்தளக் கூறு)

North pole

$$\vec{B_N} = -B_N \cos\theta\,\hat{i} + B_N \sin\theta\,\hat{j}$$

South pole

$$\vec{B_S} = -B_S \cos\theta\,\hat{i} + B_S \sin\theta\,(-\hat{j})$$

$$\vec{B_S} = -B_S \cos\theta\,\hat{i} - B_S \sin\theta\,\hat{j}$$

Total magnetic dipole (magnetic field)

$$\vec{B} = \vec{B_N} + \vec{B_S}$$

$$\vec{B} = (-B_N \cos\theta\,\hat{i} + B_N \sin\theta\,\hat{j}) + (-B_S \cos\theta\,\hat{i} - B_S \sin\theta\,\hat{j})$$

$$\vec{B} = -B_N \cos\theta\,\hat{i} + B_N \sin\theta\,\hat{j} - B_S \cos\theta\,\hat{i} - B_S \sin\theta\,\hat{j}$$

$\vec{B} = -B_S \cos\theta\,\hat{i} + B_S \sin\theta\,\hat{j} - B_S \cos\theta\,\hat{i} - B_S \sin\theta\,\hat{j}$

$\vec{B} = -B_S \cos\theta\,\hat{i} - B_S \cos\theta\,\hat{i}$

$\vec{B} = -2 B_S \cos\theta\,\hat{i}$

North pole

$B_N = \frac{\mu_0}{4\pi}\frac{q_m}{r'^2}$ $r' = \sqrt{r^2+l^2}$

$r' = (r^2+l^2)^{1/2}$

$B_N = \frac{\mu_0}{4\pi}\frac{q_m}{((r^2+l^2)^{1/2})^2}$

$B_N = \frac{\mu_0}{4\pi}\frac{q_m}{r^2+l^2}$

South pole

$B_S = \frac{\mu_0}{4\pi}\frac{q_m}{r'^2}$

$B_S = \frac{\mu_0}{4\pi}\frac{q_m}{((r^2+l^2)^{1/2})^2}$

$B_S = \frac{\mu_0}{4\pi}\frac{q_m}{r^2+l^2}$

$\vec{B} = \vec{B_N} + \vec{B_S}$

$\vec{B} = -2B_S\cos\theta\,\hat{i}$

$\vec{B} = -2\frac{\mu_0}{4\pi}\frac{q_m}{(r^2+l^2)}\cos\theta\,\hat{i}$

$\vec{B} = -\frac{\mu_0}{4\pi}\frac{2q_m}{(r^2+l^2)}\frac{l}{\sqrt{r^2+l^2}}\hat{i}$ $\cos\theta = \frac{l}{\sqrt{r^2+l^2}}$

$\vec{B} = -\frac{\mu_0}{4\pi}\frac{2q_m l\,\hat{i}}{(r^2+l^2)(r^2+l^2)^{1/2}}$

$\vec{B} = -\frac{\mu_0}{4\pi}\frac{2q_m l\,\hat{i}}{(r^2+l^2)(r^2+l^2)^{1+1/2}}$

$q_m \times 2l\,\hat{i} = \vec{p_m}$

$$\vec{B} = -\frac{\mu_0}{4\pi} \frac{P_m}{(r^2+l^2)^{3/2}}$$

$r >> l$ $r\uparrow$ $l\downarrow$ l neglected

$$\vec{B} = -\frac{\mu_0}{4\pi} \frac{\vec{P_m}}{(r^2)^{3/2}}$$

$$\vec{B} = -\frac{\mu_0}{4\pi} \frac{\vec{P_m}}{r^3}$$

22/05/24 wednesday

Example 3.6 Pg:138

Imp 5 mark

1) Solution:

$P_m = 0.5\ J\ T^{-1}$

$r = 0.1 m$

Axial line

$$\vec{B}_{axial\ line} = \frac{\mu_0}{4\pi} \frac{2\vec{P_m}}{r^3}$$ $\mu_0 = 4\pi \times 10^{-7} Hm^{-1}$

$$\vec{B}_{axial\ line} = \frac{4\pi \times 10^{-7}}{4\pi} \frac{2 \times 0.5}{(0.1)^3}$$

$$= \frac{10^{-7} \times 2 \times 1/2}{(0.1)^3}$$

$$= \frac{10^{-7} \times 1}{0.1 \times 0.1 \times 0.1}$$

$$= 10^{-7} \times \frac{1}{0.001}$$

$$= 10^{-7} \times \frac{1}{1 \times 10^{-3}}$$

$$= 10^{-7} \times 1 \times 10^{+3}$$

$$= 1 \times 10^{-4}\ T$$

Equatorial line

$P_m = 0.5\ J\ T^{-1}$

$r = 0.1 m$

Bequatorial line $= -\frac{\mu_0}{4\pi} \frac{\vec{P_m}}{r^3}$

$= -\frac{4\pi \times 10^{-7}}{4\pi} \times \frac{0.5}{(0.1)^3}$

$= -10^{-7} \times \frac{0.5}{0.1 \times 0.1 \times 0.1}$

$= -10^{-7} \times \frac{0.5}{0.001}$

$= -10^{-7} \times \frac{0.5}{10^{-3}}$

$= -0.5 \times 10^{-7+3}$

$= -0.5 \times 10^{-4} \hat{i}$ T

---

3) Example 3.10 Pg: 143

2 mark

Solution :

x magnet 500 Am^{-1}

y magnet 2000 Am^{-1}

magnetising field 1000 Am^{-1}

$\chi_m \rightarrow$ susceptibility of material (no unit)

$\chi_m(x) = \left|\frac{\vec{M}}{\vec{H}}\right| = \frac{500\ Am^{-1}}{1000\ Am^{-1}} = \frac{5}{10} = \frac{1}{2} = 0.5$ A

$\chi_m(y) = \left|\frac{\vec{M}}{\vec{H}}\right| = \frac{2000\ Am^{-1}}{1000\ Am^{-1}} = \frac{2}{1} = 2$

Material y can be easily magnetise

Classification of magnetic material

1 mark

1) Diamagnetic } Artifical
2) Paramagnetic }

3) Ferromagnetic → natural (weak)

a) Diamagnetic Example:

Bismuth (Bi)
copper (Cu)
water (H_2O)

b) Paramagnetic Example

Aluminium (Al)
Platinum (Pt)
~~Chromium (Cr)~~
oxygen (O_2)

c) Ferromagnetic Example

Iron (Fe)
Nickel (Ni)
Cobalt (Co)

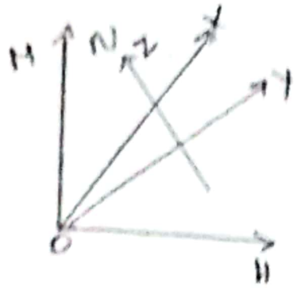
Pg: 144
3 mark

① Properties of diamagnetism

Diamagnetism	Paramagnetism	Ferrom
1) magnetic susceptibility (-)	Magnetic susceptibility is (+)	Magnetic susceptibility is (+) large
2) Relative Permeability (Less Than)	greater Than	Large
3) magnetic field line Repelled	attracted	strongly attracted

Temperature Independent	Inversely Proportional temperature	Inversely Proportional temperature

Pg:190 3) Example 3.11



$\chi_m = \frac{M}{H}$

X magnet
Positive large Ferromagnetism

Y magnet
Positive small Ferromagnetism (less)

Z magnet
Negative Diamagnetism

Pg: 143 4) Example: 3.9

using the relation $\vec{B} = \mu_0(\vec{H} + \vec{M})$ show that $\chi_m = \mu_r - 1$

solution:

$\vec{B} = \mu_0(\vec{H} + \vec{M})$ $\chi_m = \mu_r - 1$

	unit
M → Intensity of magnetisation	Am^{-1}
H → Magnetising field	Am^{-1}
χ_m → magnetic susceptibility	no unit
μ_r → Relative Permeability	no unit
μ_0 → Permeability of free space	HM^{-1}
B → magnetic field	

$\vec{B} = \mu_0(\vec{H} + \vec{M})$,

magnetic susceptibility

$\chi_m = \frac{M}{H}$

$M = \chi_m H$

$\vec{B} = \mu_0(\vec{H} + \chi_m \vec{H})$

$\vec{B} = \mu_0(\chi_m + 1)H$

$\mu = \mu_0(\chi_m + 1)$

$B = \mu H$

$\mu = \mu_0(\chi_m + 1)$

$\frac{\mu}{\mu_0} = \chi_m + 1$

$\frac{\mu}{\mu_0} = \mu_r$

$\mu_r = \chi_m + 1$

$\mu_r - 1 = \chi_m$

23/05/24

2-Lesson

25/05/24 Saturday

Pg: 120

Long answer

5 mark (R)(B)

1) Describe the (small) microscopic model of current and obtain microscopic form of ohm's law (Or)

Relation between current and drift velocity