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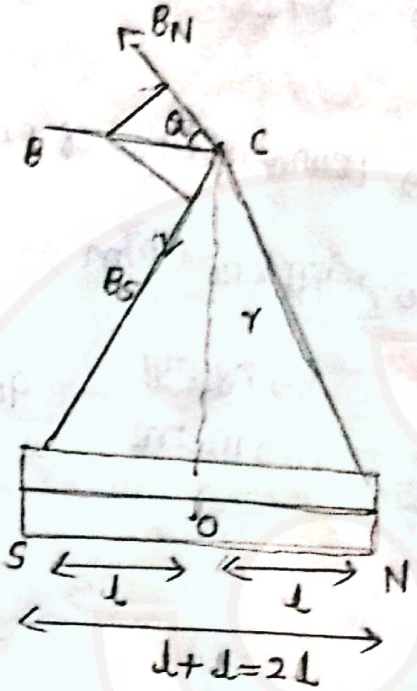
Important Derivations Physics

XII – Physics 15.8.2020

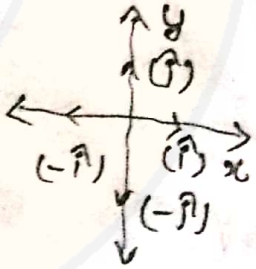
1) Equatorial line bar magnet :-

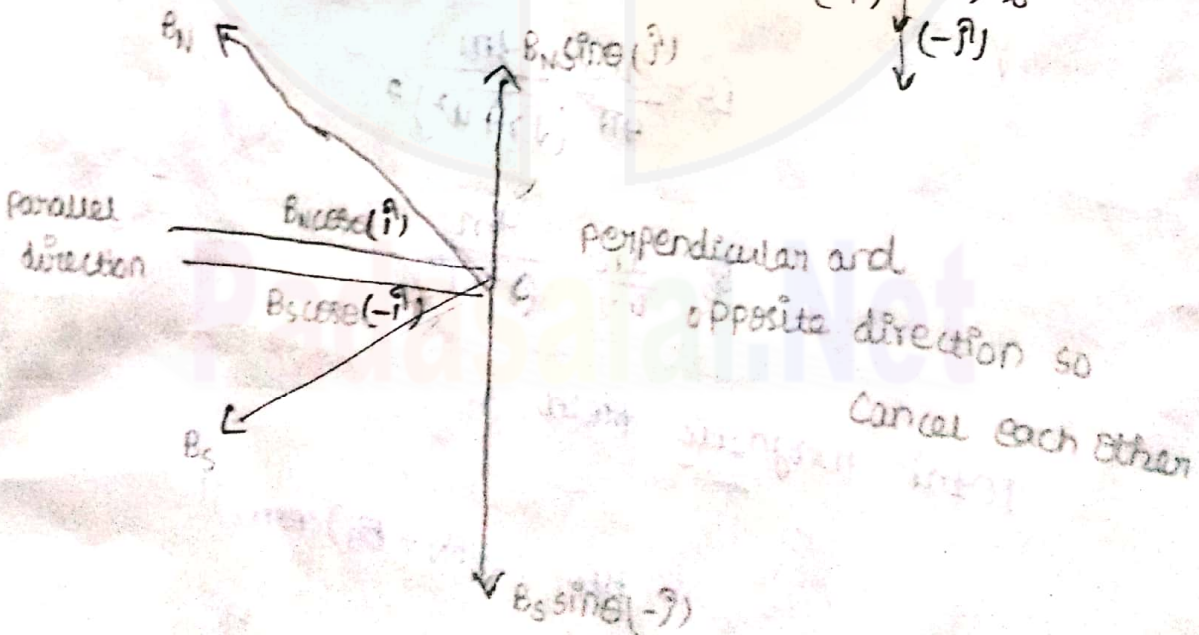


$r' = (r^2+l^2)^{1/2}$

(or)

$r' = \sqrt{r^2+l^2}$





perpendicular and opposite direction so cancel each other

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North pole

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

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

$$r' = \frac{(Dr)}{\sqrt{r^2+d^2}}$$

$$B_N = \frac{\mu_0}{4\pi} \frac{q_m}{\left(\sqrt{(r^2+d^2)}\right)^2}$$

$$\boxed{B_N = \frac{\mu_0}{4\pi} \frac{q_m}{(r^2+d^2)}} \rightarrow (1)$$

$\mu_0 \rightarrow$ permeability of free space

$\mu_0 = 4\pi \times 10^{-7}$ h/m

h → henry

m → metre

$q_m \rightarrow$ magnetic pole

South pole

$$B_S = \frac{\mu_0}{4\pi} \frac{q_m}{r'^2} \qquad r' = \sqrt{r^2+d^2}$$

$$B_S = \frac{\mu_0}{4\pi} \frac{q_m}{\left(\sqrt{r^2+d^2}\right)^2}$$

$$\boxed{B_S = \frac{\mu_0}{4\pi} \frac{q_m}{(r^2+d^2)}} \rightarrow (2)$$

Total magnetic field

$$B_{tot} = -(B_N + B_S)\cos\theta \cdot \hat{i}$$

$$B_{tot} = (-B_N - B_S)\cos\theta \cdot \hat{i}$$

$$B_{tot} = -\frac{\mu_0}{4\pi}\frac{q_m}{(r^2+d^2)} - \frac{\mu_0}{4\pi}\frac{q_m}{(r^2+d^2)}\cos\theta \cdot \hat{i}$$

$$B_{tot} = -\frac{2\mu_0}{4\pi}\frac{q_m}{(r^2+d^2)}\cos\theta \cdot \hat{i}$$

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$$\cos\theta = \frac{l}{(r^2+l^2)^{1/2}}$$

$$B_{tot} = -\frac{2\mu_0}{4\pi} \frac{q_m}{(r^2+l^2)} \cdot \frac{l}{(r^2+l^2)^{1/2}} \cdot \text{①}$$

$$B_{tot} = -\frac{2\mu_0}{4\pi} \frac{q_m}{(r^2+l^2)^{3/2}} \cdot \text{①}$$

$(r >> l)$

l is neglected

$$B_{tot} = -\frac{2\mu_0}{4\pi} \frac{q_m}{(r^2)^{3/2}} \cdot \text{①}$$

$$B_{tot} = -\frac{2\mu_0}{4\pi} \frac{q_m}{r^3} \cdot \text{①}$$

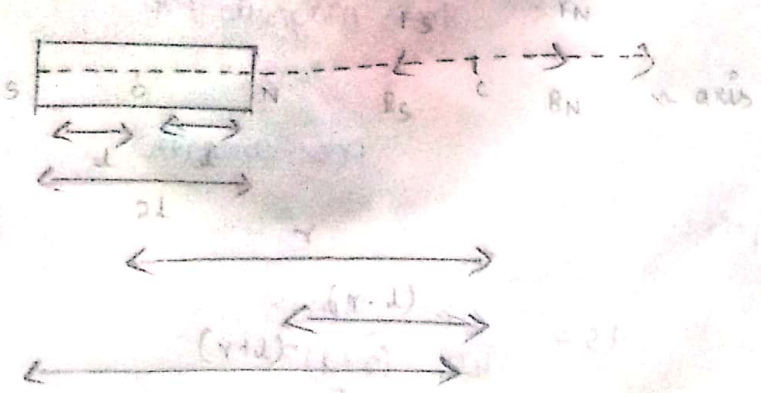
$$B_{tot} = -\frac{\mu_0}{4\pi} \left(\frac{2q_m}{r^3}\right) \cdot \text{①}$$

$2q_m = 2P_m$

$P_m \rightarrow$ magnetic dipole moment

$$B_{tot} = -\frac{\mu_0}{4\pi} \frac{2P_m}{r^3} \cdot \text{①}$$

Axis line Bar magnet :-



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S → south pole

N → North pole

Fs → South pole force

FN → North pole force

Bs → Magnetic field South pole

BN → magnetic field North pole

l → length

O → centre

r → distance

$2l$ → very small length

OS → l

ON → l

SN → $2l$

NC → $(r-l)$

SC → $(r+l)$

North pole :-

$$F_N = \frac{\mu_0}{4\pi} \frac{q_m \cdot \hat{i}}{(r-l)^2} \rightarrow (1)$$

μ_0 → permeability of free space

$\mu_0 = 4\pi \times 10^{-7}$ h/m

h → henry

m → metre

q_m → magnetic pole

(or)

pole strength

South pole :-

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

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Total magnetic field

$$B = F_N + F_S$$

$$B = \frac{\mu_0}{4\pi}\frac{q_m}{(r-d)^2} - \frac{\mu_0}{4\pi}\frac{q_m}{(r+d)^2} \cdot \hat{i}$$

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

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

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

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

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

$$B = \frac{\mu_0 q_m}{4\pi}\left[\frac{4rd}{(r^2-d^2)^2}\right] \cdot \hat{i}$$

$(r \gg d)$ d is neglected

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

$$B = \frac{\mu_0 q_m}{4\pi}\left[\frac{4rd}{r^4}\right] \cdot \hat{i}$$

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$$B = \frac{\mu_0 m}{4\pi}\left[\frac{4d}{r^3}\right]\cdot\hat{i}$$

$$B = \frac{\mu_0}{4\pi}\left[\frac{9m \times 4l}{r^3}\right]\cdot\hat{i} \qquad 2Pm = 9m \times 4l$$

Pm → magnetic dipole moment

$$B = \frac{\mu_0}{4\pi}\left[\frac{2Pm}{r^3}\right]\cdot\hat{i}$$

---

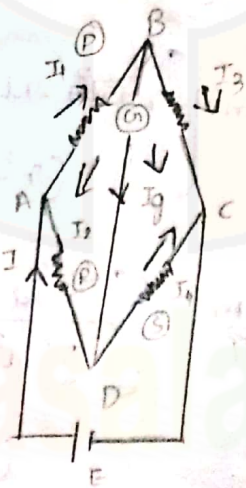
3) Wheatstone bridge :

unknown resistance

Kirchhoff rule < current rule, voltage rule

↓

ohm's law extend



PQRS → resistance

$I_1 I_2 I_3 I_4$ → current

ABCD → Junction

G → Galvanometer

↓

current measured

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E → Emf cell

Junction (B) (current rule)

$$I_1 - I_g - I_3 = 0 \rightarrow (1)$$

Junction (D) (current rule)

$$I_2 + I_g - I_4 = 0 \rightarrow (2)$$

ABDA Junction (voltage rule)

$$I_1 P - I_g G - I_2 R = 0 \rightarrow (3)$$

ABCDA Junction (voltage rule)

$$I_1 P + I_3 Q - I_4 S - I_2 R = 0 \rightarrow (4)$$

Galvanometer Zero deflection

$$I_g = 0$$

From equ (1),

$$I_1 - I_g - I_3 = 0$$

$$I_1 - 0 - I_3 = 0$$

$$I_1 - I_3 = 0$$

$$I_1 = I_3 \rightarrow (5)$$

From equ (2),

$$I_2 + I_g - I_4 = 0$$

$$I_2 + 0 - I_4 = 0$$

$$I_2 - I_4 = 0$$

$$I_2 = I_4 \rightarrow (6)$$

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From equ (3),

$$I_1P - I_g G - I_2R = 0$$

$$I_1P - 0 - I_2R = 0$$

$$I_1P = I_2R \rightarrow (7)$$

From equ (4),

$$I_1P + I_3Q - I_4S - I_2R = 0$$

$$I_1P + I_1Q - I_2S - I_2R = 0$$

$$I_1(P+Q) - I_2(R+S) = 0$$

$$I_1(P+Q) = I_2(R+S) \rightarrow (8)$$

$\frac{\text{equ (8)}}{\text{equ (7)}}$,

$$\frac{I_1(P+Q)}{I_1P} = \frac{I_2(R+S)}{I_2R}$$

$$\frac{P}{P} + \frac{Q}{P} = \frac{R}{R} + \frac{S}{R}$$

$$1 + \frac{Q}{P} = 1 + S/R$$

$$\frac{Q}{P} = S/R$$

(or)

$$\boxed{P/Q = R/S}$$

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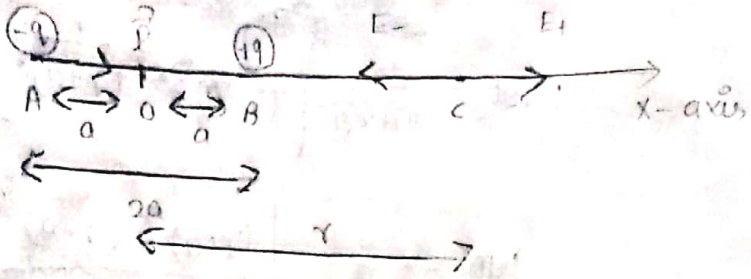
line in electric field:



$-q$ → negative charge

$+q$ → positive charge

$\vec{p}$ → electric dipole moment

E → total electric field

O → center

2a → very small distance

r → distance

a → distance

$+q$ charge (Electric field):

$$E_+ = \frac{1}{4\pi\varepsilon_0} \frac{q}{(r-a)^2} \rightarrow (1)$$

$-q$ charge (Electric field):

$$E_- = \frac{-1}{4\pi\varepsilon_0} \frac{q}{(r+a)^2} \rightarrow (2)$$

Total electric field

$$E_{tot} = E_+ + E_-$$

$$E_{tot} = \frac{1}{4\pi\varepsilon_0} \frac{q}{(r-a)^2} - \frac{1}{4\pi\varepsilon_0} \frac{q}{(r+a)^2}$$

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From eqn (1),

$$E_{tot} = \frac{1}{4\pi\varepsilon_0}\left[\frac{q}{(r-a)^2} - \frac{q}{(r+a)^2}\right]$$

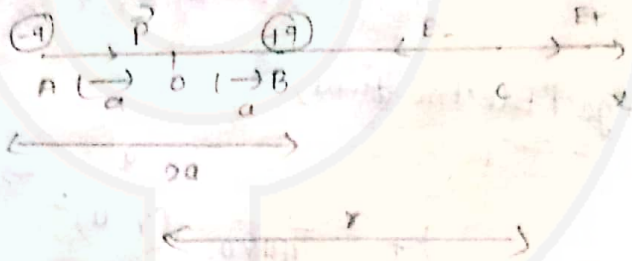
$$E_{tot} = \frac{q}{4\pi\varepsilon_0}\left[\frac{1}{(r-a)^2} - \frac{1}{(r+a)^2}\right]$$

$$E_{tot} = \frac{q}{4\pi\varepsilon_0}\left[\frac{(r+a)^2 - (r-a)^2}{(r-a)^2(r+a)^2}\right]$$

$$E_{tot} = \frac{q}{4\pi\varepsilon_0}\left[\frac{r^2+a^2+2ra-(r^2+a^2-2ra)}{(r^2-a^2)^2}\right]$$

$$E_{tot} = \frac{q}{4\pi\varepsilon_0}\left[\frac{r^2+a^2+2ra-r^2-a^2+2ra}{(r^2-a^2)^2}\right]$$

$$E_{tot} = \frac{q}{4\pi\varepsilon_0}\left[\frac{4ra}{(r^2-a^2)^2}\right] \quad (r \gg a)$$



a in distance is very small. so a is neglected.

$$E_{tot} = \frac{q}{4\pi\varepsilon_0}\left[\frac{4rq}{(r^2)^2}\right]$$

$$E_{tot} = \frac{q}{4\pi\varepsilon_0}\left[\frac{4rq}{r^4}\right]$$

$$E_{tot} = \frac{q}{4\pi\varepsilon_0}\left[\frac{4q}{r^3}\right]$$

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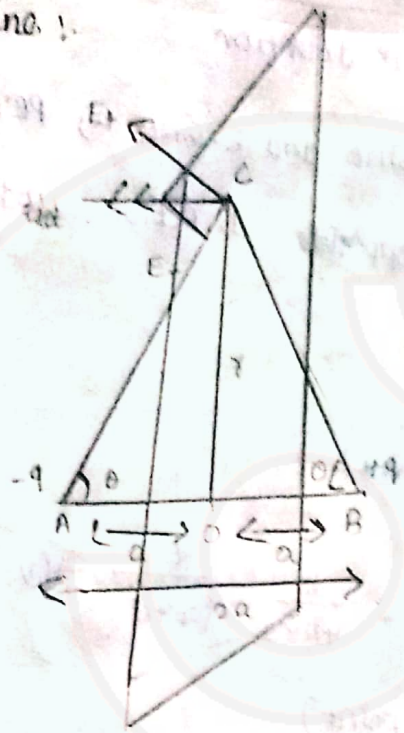
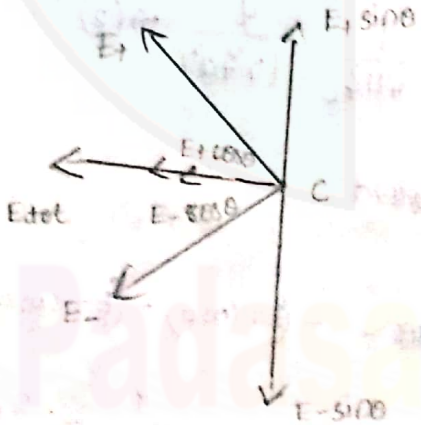
$$E_{net} = \frac{1}{4\pi\varepsilon_0}\left[\frac{q \times q}{r^3}\right]$$

$$2p = q \times q$$

$$E_{net} = \frac{1}{4\pi\varepsilon_0}\left[\frac{2p}{r^3}\right]$$

Equatorial line :





A and B → two point

−q → negative charge

+q → positive charge

θ → angle

O → centre

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r → distance

Oa → very small distance

E → total electric field

$E_+ \cos\theta$ and $E_- \cos\theta$ → Parallel component and same direction

$E_+ \sin\theta$ and $E_- \sin\theta$ → perpendicular component and opposite direction. and cancel each other.

+q charge (B point)

$$E_+ = \frac{1}{4\pi\varepsilon_0} \frac{q}{(r^2+a^2)} \rightarrow (1)$$

-q charge (A point)

$$E_- = \frac{1}{4\pi\varepsilon_0} \frac{q}{(r^2+a^2)} \rightarrow (2)$$

Total electric field

$$E_{tot} = -(E_+ \cos\theta) - (E_- \cos\theta)$$

$$E_{tot} = -\frac{1}{4\pi\varepsilon_0} \frac{q}{(r^2+a^2)} \cdot 2\cos\theta$$

$$\cos\theta = \frac{a}{\sqrt{r^2+a^2}}$$

$$E_{tot} = -\frac{q}{4\pi\varepsilon_0} \frac{2 \times a}{(r^2+a^2)(r^2+a^2)^{1/2}}$$

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$$E_{tot} = -\frac{q}{4\pi\varepsilon_0} \frac{2a}{(r^2+a^2)^{3/2}} \quad (r>>l)$$

$$E_{tot} = -\frac{q}{4\pi\varepsilon_0} \frac{2a}{(r^2)^{3/2}}$$

$$E_{tot} = -\frac{q}{4\pi\varepsilon_0} \frac{2a}{(r^3)}$$

$$E_{tot} = -\frac{1}{4\pi\varepsilon_0} \left(\frac{q \times 2a}{r^3}\right)$$

$$\boxed{E_{tot} = -\frac{1}{4\pi\varepsilon_0} \left(\frac{2p}{r^3}\right)}$$

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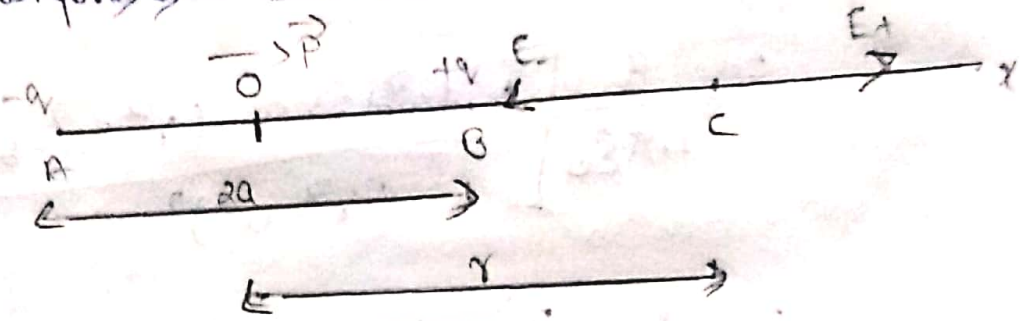
12 ஆம் வகுப்பு இயற்பியல் (2020-2021)

1) மின்புலத்தில் அழுத்தங்கள்.



-q - எதிர் மின்னூட்டம்

+q - நேர் மின்னூட்டம்

2a - தொலைவு

r - தொலைவு

E - மொத்த மின்புலம்

P - மின் அழுத்தம் கிடைக்கும் புள்ளி

+q மின்னூட்டம்

$$E_1 = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q}{(r-a)^2} \rightarrow (1)$$

-q மின்னூட்டம்

$$E_- = -\frac{1}{4\pi\varepsilon_0}\left(\frac{-q}{(r+a)^2}\right)$$

$$E_- = -\frac{1}{4\pi\varepsilon_0}\frac{q}{(r+a)^2} \rightarrow (2)$$

மொத்த மின்புலம்

$$E = E_+ + E_-$$

$$= \frac{1}{4\pi\varepsilon_0}\cdot\frac{q}{(r-a)^2} + \left(-\frac{1}{4\pi\varepsilon_0}\cdot\frac{q}{(r+a)^2}\right)$$

$$= \frac{1}{4\pi\varepsilon_0}\cdot\frac{q}{(r-a)^2} - \frac{1}{4\pi\varepsilon_0}\cdot\frac{q}{(r+a)^2}$$

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$$E = \frac{q}{4\pi\varepsilon_0}\frac{1}{(r-a)^2} - \frac{q}{4\pi\varepsilon_0}\frac{1}{(r+a)^2}$$

$$E = \frac{q}{4\pi\varepsilon_0}\left[\frac{1}{(r-a)^2} - \frac{1}{(r+a)^2}\right]$$

$$= \frac{q}{4\pi\varepsilon_0}\left[\frac{(r+a)^2 - (r-a)^2}{(r^2-a^2)^2}\right]$$

$$= \frac{q}{4\pi\varepsilon_0}\left[\frac{r^2+a^2+2ra-(r^2+a^2-2ra}{(r^2-a^2)^2}\right]$$

$$= \frac{q}{4\pi\varepsilon_0}\left[\frac{r^2+a^2+2ra-r^2-a^2+2ra}{(r^2-a^2)^2}\right]$$

$r \gg a$

$$E = \frac{q}{4\pi\varepsilon_0}\left[\frac{2ra+2ra}{(r^2)^2}\right]$$

$$= \frac{q}{4\pi\varepsilon_0}\left[\frac{4ra}{r^4}\right]$$

$$= \frac{q}{4\pi\varepsilon_0}\cdot\frac{4a}{r^3}$$

$$= \frac{1}{4\pi\varepsilon_0}\cdot\frac{q\times 4a}{r^3}$$

$$E = \frac{1}{4\pi\varepsilon_0}\cdot\frac{2p}{r^3}$$

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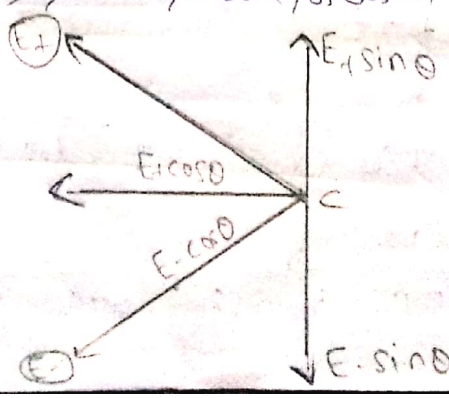
2) மின்புலத்தில் நகர்வதனால்



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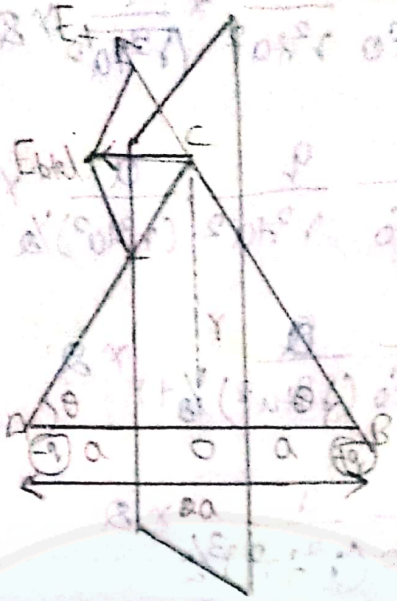

$-q$ - எதிர் மின்னூட்டம்

$+q$ - நேர் மின்னூட்டம்

r - தொலைவு

$2a$ - தொலைவு

θ - இணைவம்

A, B - புள்ளி

$E_+ \sin\theta$, $E_- \sin\theta$ - சமமற்ற ஆனால் எதிரெதிரானது

$E_+ \cos\theta$, $E_- \cos\theta$ - சமமான ஆனால், ஒத்ததிசையது

$+q$ மின்னூட்டம்

$$E_+ = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q}{r^2+a^2}$$

$-q$ மின்னூட்டம்

$$E_- = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q}{r^2+a^2}$$

$$E = -(E_+ \cos\theta) - (E_- \cos\theta)$$

$$= -\frac{1}{4\pi\varepsilon_0} \frac{q}{r^2+a^2} - \frac{1}{4\pi\varepsilon_0} \frac{q}{r^2+a^2} \cos\theta$$

$$= -\frac{1}{4\pi\varepsilon_0} \frac{q}{r^2+a^2} 2\cos\theta$$

$$\cos\theta = \frac{a}{\sqrt{r^2+a^2}}$$

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$$E = \frac{-1}{4\pi\varepsilon_0} \frac{q}{r^2 + a^2} \times \frac{a}{\sqrt{r^2+a^2}} \times 2$$

$$= \frac{-1}{4\pi\varepsilon_0} \frac{q}{r^2+a^2} \cdot \frac{a}{(r^2+a^2)^{1/2}} \times 2$$

$$= \frac{-q}{4\pi\varepsilon_0} \frac{a}{(r^2+a^2)^{1/2+1}} \times 2$$

$$= \frac{-q}{4\pi\varepsilon_0} \frac{a}{(r^2+a^2)^{3/2}} \times 2 \qquad r \gg a$$

a புறக்கணிக்கலாம்.

$$= \frac{-q}{4\pi\varepsilon_0} \frac{a}{(r)^{3/2}} \times 2$$

$$= \frac{-q}{4\pi\varepsilon_0} \frac{a}{r^3} \times 2$$

$$= \frac{-q \times 2a}{4\pi\varepsilon_0 r^3} \qquad \boxed{q \times 2a = P}$$

$$= \frac{-P}{4\pi\varepsilon_0 r^3}$$

$$E = \frac{-1}{4\pi\varepsilon_0} \cdot \frac{P}{r^3}$$

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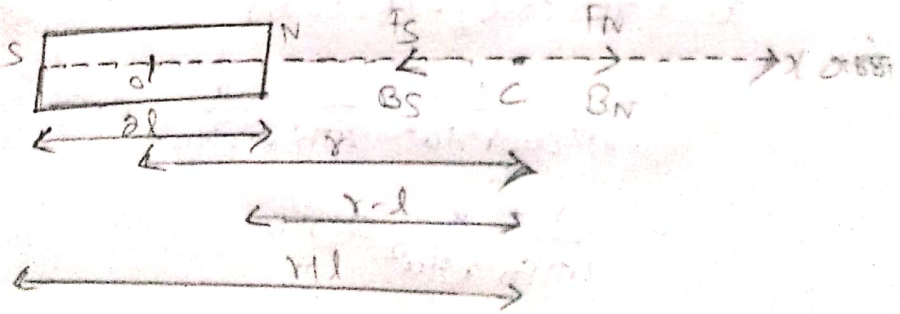
2) காந்தபலத்தில் அதன்திசை



S - தென்துருவம் l - காந்தம்

N - வடதுருவம் B_S - தென்துருவ காந்தபலம்

C - மையம் B_N - வடதுருவ காந்தபலம்

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F_S - தென்துருவ விசை OC = r

F_N - வடதுருவ விசை NC = r-l

OS = l SN = 2l. SC = r+l

ON = l

வடதுருவம்,

$$F_N = \frac{\mu_0}{4\pi} \frac{q_m}{(r-l)^2} \cdot \hat{i} \rightarrow (1)$$

μ_0 - வெற்றிடத்தின் ஊடுருவும் திறன்

தென்துருவம்,

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

மொத்த காந்தபுலம்

$$B = F_N + F_S$$

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

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

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

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

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

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

$r \gg l$

$$B = \frac{\mu_0 q_m}{4\pi} \left[\frac{2rl + 2rl}{r^4}\right] \cdot \hat{i}$$

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$$B = \frac{\mu_0 q_m}{2\pi}\left[\frac{2dl}{y^4}\right]\cdot\hat{i}$$

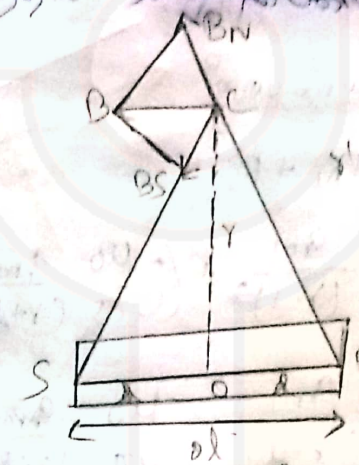
$$B = \frac{\mu_0 q_m}{4\pi}\left[\frac{4l}{y^3}\right]\cdot\hat{i}$$

$$B = \frac{\mu_0}{4\pi}\cdot\frac{q_m \times 4l}{y^3}\cdot\hat{i} \qquad [q_m \times 4l = 2P_m]$$

$$B = \frac{\mu_0}{4\pi}\frac{2P_m}{y^3}\hat{i}$$

P_m - காந்த இருமுனை திருப்புதிறன்

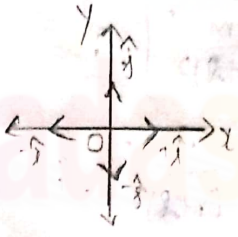
1) காந்தத்துவத்தில் முனைகளால் ஏற்படும்

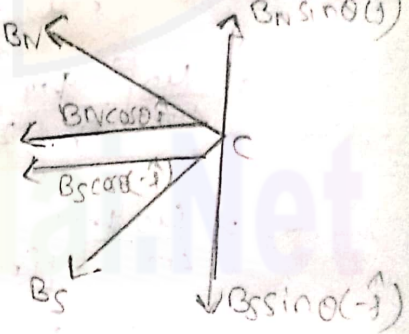


$r' = (r^2+l^2)^{1/2}$

(or)

$r' = \sqrt{r^2+l^2}$





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

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

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

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

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

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

$$= \left[-\frac{\mu_0}{4\pi} \frac{q_m}{r^2 + l^2} - \frac{\mu_0}{4\pi} \frac{q_m}{r^2 + l^2} \right] \cos\theta\,\hat{i}$$

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

$$\cos\theta = \frac{l}{(r^2 + l^2)^{1/2}} \quad (or) \quad \frac{l}{\sqrt{r^2 + l^2}}$$

$$= -\frac{2\mu_0}{4\pi} \cdot \frac{q_m}{r^2 + l^2} \cdot \frac{l}{\sqrt{r^2 + l^2}} \cdot \hat{i}$$

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

$$= -\frac{2\mu_0}{4\pi} \cdot \frac{q_m \, l}{(r^2 + l^2)^{3/2}}$$

$r \gg l$

$$B = -\frac{2\mu_0}{4\pi} \cdot \frac{q_m \, l}{(r^2)^{3/2}}$$

$$B = -\frac{2\mu_0}{4\pi} \cdot \frac{q_m \, l}{r^3}$$

$$B = -\frac{\mu_0}{4\pi} \cdot \frac{2 \times q_m \, l}{r^3} \qquad P_m = 2 \times q_m l$$

$$B = -\frac{\mu_0}{4\pi} \cdot \frac{P}{r^3}$$

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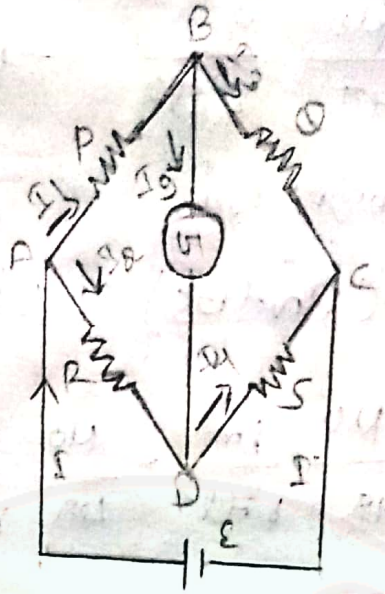
(5) வீட்ஸ்டன் பாலம் விளக்குக



PQRS - மின்தடை

ABCD - இணைப்பு

I_1, I_2, I_3, I_4 - மின்னோட்டம்

ε - மின்னியக்க விசை

B சந்திப்பு (மின்னோட்ட விதி)

$$I_1 - I_g - I_3 = 0 \quad \rightarrow (1)$$

D சந்திப்பு

$$I_2 + I_g - I_4 = 0 \quad \rightarrow (2)$$

ABDA (மின்னழுத்த வேறுபாடு)

$$I_1 P + I_g G - I_2 R = 0 \quad \rightarrow (3)$$

ABCDA (மின்னழுத்த வேறுபாடு)

$$I_1 P + I_g Q - I_4 S - I_2 R = 0 \quad \rightarrow (4)$$

$\boxed{I_g = 0}$

(1) $I_1 - I_g - I_3 = 0$

$$I_1 = I_3 \quad \rightarrow (5)$$

(2) $I_2 + 0 - I_4 = 0$

$$I_2 = I_4 \quad \rightarrow (6)$$

(3) $I_1 P + 0 - I_2 R = 0$

$$I_1 P = I_2 R \quad \rightarrow (7)$$

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Equation (4)

$$I_1P + I_3Q - I_4S - I_2R = 0$$

$$I_1P + I_1Q - I_2S - I_2R = 0$$

$$I_1(P+Q) - I_2(S-R) = 0$$

$$I_1(P+Q) - I_2(R+S) = 0 \quad \rightarrow (8)$$

(8)/(7) $\quad \dfrac{I_1(P+Q)}{I_1P} - \dfrac{I_2(R+S)}{I_2R} = 0$

$$\frac{P+Q}{P} - \frac{R+S}{R} = 0$$

$$\frac{P+Q}{P} = \frac{R+S}{R}$$

$$1 + \frac{Q}{P} = 1 + \frac{S}{R}$$

$$\frac{Q}{P} = \frac{S}{R} \quad (or)$$

$$\frac{P}{Q} = \frac{R}{S}$$

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