تلخيص الطالب بشار عاصي

Physics 132

شرح الفصل الثاني 2015/2014

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Ch 1

:

Chapter 1
(Electric charge, Force, Field)

* Electric Charge :-

أصغر شحنة هي شحنة الإلكترون

- positively charged object, loze electrons.
- Negatively " " , gain electrons.

* charge $(q) = \pm ne$
- quantization of charge
- n is integer $= 1, 2, 3, \ldots$ etc

* $e = 1.6 \times 10^{-19}\ C$

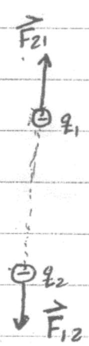
electron's charge $= -1.6 \times 10^{-19}\ C$

proton's charge $= +1.6 \times 10^{-19}\ C$

* Conservation of charge :-

(q) before reaction $= (q)$ after reaction

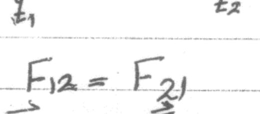
* Electric force :-



electric

the force between two similar charges is Repulsive.

تنافر



$F_{12} = F_{21}$

$\vec{F}_{12} = -\vec{F}_{21}$

Coulomb's law :-

The electric force between two **Point** charges directly proportional to $q_1 q_2$ and inversly proportional to r^2

يتناسب طرديا

$$F \propto \frac{q_1 q_2}{r^2}$$

$$F = \frac{K q_1 q_2}{r^2}$$

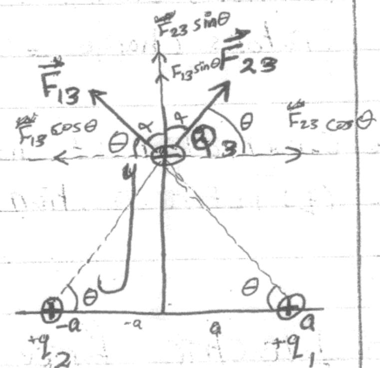
K: $9 \times 10^9 \ N.m^2/C^2$ depends on units and on the type of the medium between the charges.

وسط

$$K = \frac{1}{4\pi\epsilon_0} = 9 \times 10^9 \ N.m^2/C^2 \text{ in free space (the air)}$$

السماحية

$$\epsilon_0 = 8.85 \times 10^{-12} \ C^2/N.m^2$$



Ex 2 p.g. 14 — find the net electric force on Q ?

$$* \ \vec{F}_{13} = \frac{K q Q}{r^2} = \frac{K q Q}{y^2 + a^2}$$

$$* \ \vec{F}_{23} = \frac{K q Q}{y^2 + a^2}$$

* اذا خلى من جهة واحدة لا نأخذ نصف الكمية وذلك لأنه استنتج لا تلغى حينها

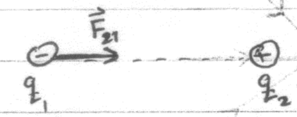
$$* \ (\Sigma F_3)_x = 0$$

عامل مشترك

$$* \ (\Sigma F_3)_y = \vec{F}_{23} \sin\theta + F_{13} \sin\theta = \frac{K q Q}{a^2 + y^2} [2 \sin\theta]$$

$$(F_3)_y = \frac{K q Q}{a^2 + y^2} \left[2 \frac{y}{\sqrt{a^2 + y^2}} \right] = \frac{2 K q Q y}{[a^2 + y^2]^{3/2}} \Rightarrow \vec{F}_3 = \frac{2 K q Q y}{[a^2 + y^2]^{3/2}} \hat{j}$$

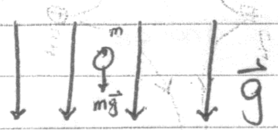
* $\vec{F}_{21} = \dfrac{k\overbrace{|q_1||q_2|}^{\text{بدون إشارة}}}{r^2}\hat{i}$



$\vec{F}_{12} = \dfrac{k|q_1||q_2|}{r^2}(-\hat{i})$

* Electric field :-

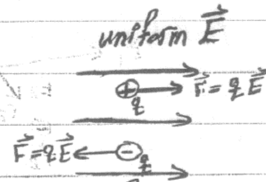
remember in phy 141 you studied the Gravitational field



$\vec{F}_g = m\vec{g}$ $\quad \vec{g} = \dfrac{\vec{F}_g}{m}$ (N/Kg) $\Rightarrow \vec{g} = 9.8$ N/Kg

* Electric field is the force acting on a charge of magnitude +

$\vec{E} = \dfrac{\vec{F}}{q}$



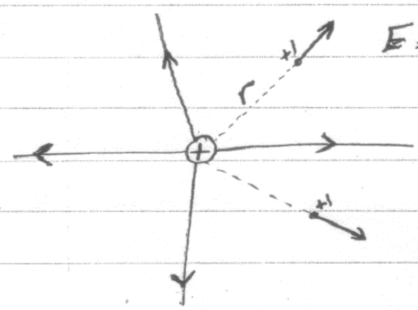
* $q\vec{E} = m\vec{a}$

$\vec{a} = \dfrac{q\vec{E}}{m}$ (constant) $\rightarrow$

* $V_x = V_0 + a_x t$
* $x - x_0 = V_{0x} t + \frac{1}{2} a_x t$
* $V_x^2 = V_{0x}^2 + 2a\Delta x$
* $\Delta x = \dfrac{V_{0x} + V_x}{2} t$

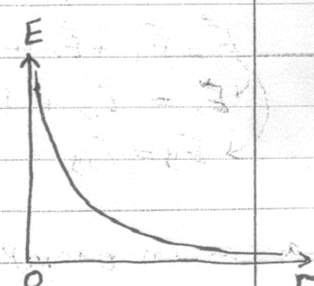
* The motion of free charge in Uniform $\vec{E}$

* $\vec{E}$ due to a point charge :-



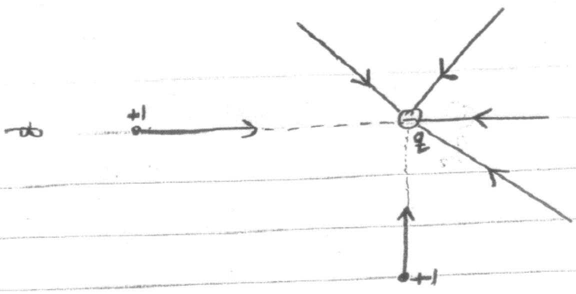
$E = \dfrac{kq}{r^2}$ N/C

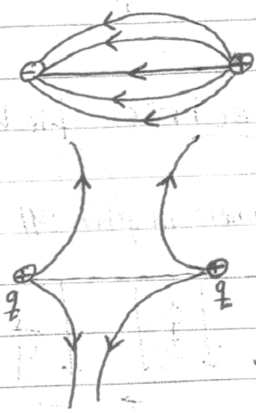
مجال غير منتظم



شحنة موجبة: E, F لهما نفس الاتجاه

شحنة سالبة: E, F متعاكسان

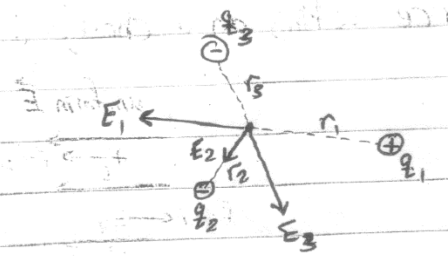




$$E = \frac{k\,|q|}{r^2}$$

* خطوط المجال لا تتقاطع

* $\vec{E}$ due to a set of Point Charges:



$$E_1 = \frac{k\,|q_1|}{r_1^2}$$

$$E_2 = \frac{k\,|q_2|}{r_2^2}$$

$$\vec{E} = \vec{E}_1 + \vec{E}_2 + \vec{E}_3$$

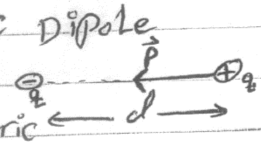
$$E_x = E_{1x} + E_{2x} + E_{3x}$$

$$E_y = E_{1y} + E_{2y} + E_{3y}$$

* as an example:

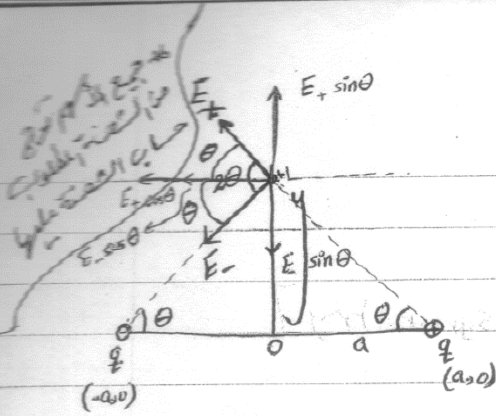
$\vec{E}$ due to an Electric Dipole

Electric dipole is



اتجاه $\vec{P}$ من السالب للموجب

$\vec{P} = q\vec{d}$ an Electric Dipole Moment



$$E_- = E_+ = \frac{kq}{r^2} = \frac{k|q|}{y^2+a^2}$$

* $\vec{P} = q(2a)(-\hat{i})$

$$E_y = E_+ \sin\theta + {}^{-}E_- \sin\theta = 0$$

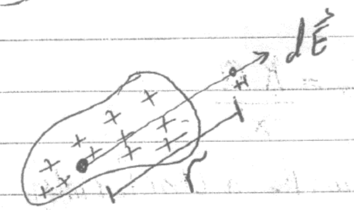
$$E_x = -\left[2E_+\cos\theta\right]$$
$$= -\left[\frac{2kq}{a^2+y^2}\,\frac{a}{\sqrt{a^2+y^2}}\right]$$

$$\vec{E} = \frac{kP}{(a^2+y^2)^{\frac{3}{2}}}(-\hat{i})$$

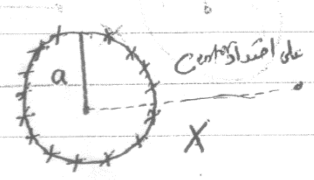
* $\vec{E}$ due to a continous charge distribution :-

$$d\vec{E} = \frac{k\,dq}{r^2}$$

$$\vec{E} = k\int \frac{dq}{r^2}$$

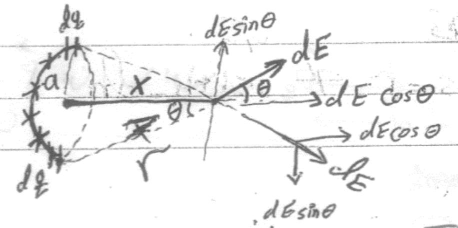


1) $\vec{E}$ due to a Uniformly charged Ring :-



Charge = Q
radius = a
$\lambda = \frac{Q}{2\pi a}$

* find E at a distance (x) above the center?
على امتداد المركز



يلغين بعض

$$dE = k\frac{dq}{r^2}$$

$$E_y = k\int \frac{dq}{r^2}\sin\theta = 0 \quad \text{[from symmetry]}$$

$$E_x = k\int \frac{dq}{r^2}\cos\theta$$

$$= k\int \frac{dq}{(x^2+a^2)} \cdot \frac{x}{\sqrt{a^2+x^2}} = k\int \frac{x\,dq}{(a^2+x^2)^{\frac{3}{2}}}$$

ثابت على محيط الدائرة مهما اختلفت النقطة

$$E_x = \frac{k\,x}{(a^2+x^2)^{\frac{3}{2}}}\int dq$$

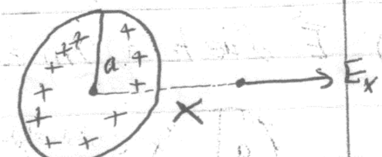
$$E_x = \frac{kQx}{(a^2+x^2)^{\frac{3}{2}}}$$

2) find E_x at $x \gg a$

$\Rightarrow a^2 \to 0$

$\Rightarrow E_x = \frac{kQ}{x^2}$ as point charg.

3) $\vec{E}$ due to a Uniformly Charged disk :-



radius = a

Charge = Q

σ كثافة سطحية $= \frac{Q}{\pi a^2}$ c/m²

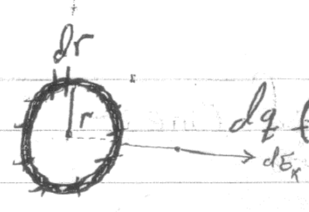
- find E at (x) above the Center

to find E :

قطرها سمكه

1) find E due to a ring of radius = r & width = dr

*



مساحة الرينج

$dq \text{ (on the ring)} = \sigma 2\pi r\, dr$

$$E_x = \frac{kQx}{(a^2+x^2)^{\frac{3}{2}}}$$

$$\Rightarrow E_x = \frac{k(\sigma 2\pi r\, dr)x}{(r^2+x^2)^{\frac{3}{2}}}$$

$$(E_x)_{disk} = \int_0^a (dE_x)_{ring}$$

$$E_x = k\sigma \int_0^a \frac{2\pi r\, dr\, x}{(x^2+r^2)^{\frac{3}{2}}}$$

ثابتة مش متغير

let $x^2 + r^2 = u$
$2r\, dr = du$

نغير حدود التكامل

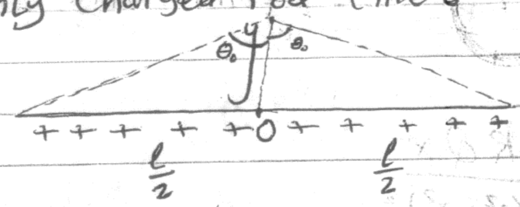
$$E_x = k\sigma\pi x \int \frac{du}{u^{\frac{3}{2}}}$$

$$\Rightarrow E_x = \frac{\sigma}{2\epsilon_0}\left[1 - \frac{x}{\sqrt{x^2+a^2}}\right]$$

** find E_x for an infinite disk ($a \gg x$) $x \to 0$

$$\frac{x}{\sqrt{x^2+a^2}} \to 0 \Rightarrow E_x = \frac{\sigma}{2\epsilon_0} \text{ (infinite plane)}$$

4) $\vec{E}$ due to a Uniformly Charged rod line :-

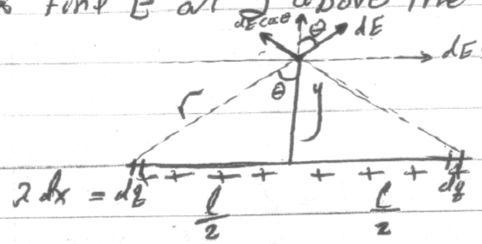


* find E at y above the center

length = l

Charge = Q

$\lambda = \frac{Q}{l}$



$dE = k\frac{dq}{r^2}$

$dE = k\frac{\lambda dx}{r^2}$

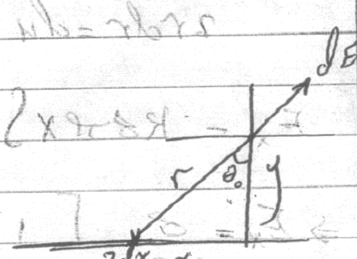
$dE_x = dE \sin\theta$

$E_x = 0$ (from symmetry)

$dE_y = dE\cos\theta$

~~E_y~~

$E_y = \int_{-\frac{l}{2}}^{+\frac{l}{2}} \cos\theta \, \frac{k\lambda dx}{r^2}$



* عندما نتحرك مع x-axis يتغير كل من (x, r, θ) ويبقى y ثابت

* $\tan\theta = \frac{x}{y}$

$x = y\tan\theta$

$dx = y\sec^2\theta \, d\theta$

* $\cos\theta = \frac{y}{r}$

$r = \frac{y}{\cos\theta} = y\sec\theta$

$\Rightarrow r = y\sec\theta$

$E_y = k\lambda \int_{-\theta_0}^{+\theta_0} \frac{\cos\theta \cdot y\sec^2\theta \, d\theta}{y^2\sec^2\theta} = \frac{k\lambda}{y}\int_{-\theta_0}^{+\theta_0}$

$$E_y = \frac{k\lambda}{y}\left[\sin(\theta_0) - \sin(-\theta_0)\right]$$

$$E = \frac{k\lambda}{y}(2\sin\theta_0)$$

* find E for infinite rod ?

as $l \to \infty$

$\theta_0 \to \frac{\pi}{2}$

$$\Rightarrow E = \frac{k\lambda}{y}\left[2 \times 1\right]$$

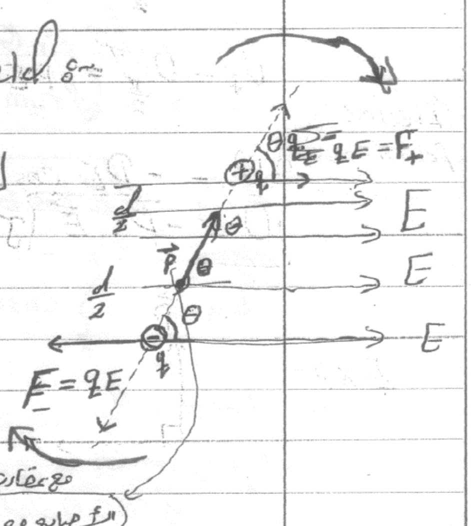
$$E = \frac{2k\lambda}{y}\sin\frac{\pi}{2}$$

θ_0

* Electric Dipole in an Electric field :-

$\vec{p} = q\vec{d}$ c.m is acted on by External $\boxed{E}$

$\ominus$ - - - - - - - $\oplus$
q $\qquad\qquad$ q



* $\vec{\tau} = \vec{r} \times \vec{F}$

the electric Dipole will rotate due to the presence of torque

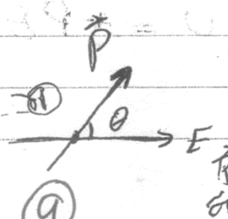
مع عقارب الساعة $\quad r \quad F$

* $\tau_+ = -\left(\frac{d}{2}\right)(qE)\sin\theta$
* $\tau_- = -\left(\frac{d}{2}\right)(qE)\sin\theta$

$\tau_{net} = -qdE\sin\theta$ N.m

$= -PE\sin\theta$

$$\boxed{\vec{\tau}_{net} = \vec{P} \times \vec{E}}$$



اتجاه الأصابع مع $\vec{p}$
الابهام على النقطة

⑨

Work done by $\vec{E}$ in rotating $\vec{P} = \int \tau \, d\theta$

$$W = \int_{\theta_i}^{\theta_f} \tau \, d\theta$$

the E is a conservative field, then :

$$W_E = -\Delta U$$

$$\Delta U = -W_E$$

$$U_f - U_i = -\int_{\theta_i}^{\theta_f} \tau \, d\theta$$

$$U_f - U_{\frac{\pi}{2}} = -\int_{\frac{\pi}{2}}^{\theta_f} -PE \sin\theta \, d\theta$$

$$U_f - U_{\frac{\pi}{2}} = PE \left[-\cos\theta\right]_{\frac{\pi}{2}}^{\theta_f}$$

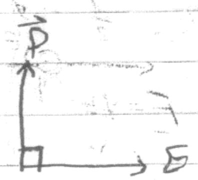
$$U_f - \cancel{U_{\frac{\pi}{2}}}^{\,0} = -PE\cos\theta_f + \cancel{PE\cos\frac{\pi}{2}}^{\,0}$$

Electric Potinsial Energy

$$U = -PE\cos\theta$$

$$\boxed{U = -\vec{P} \cdot \vec{E}} \text{ J} \quad \text{---- (2)}$$

Ex :-

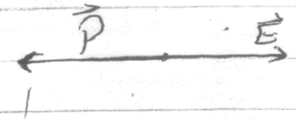


$\vec{\tau} = -PE\sin(90)$

$U = 0$

$\vec{\tau} = 0$

$U = -PE$



$\tau = 0$

$U = +PE$

Ch2

:

* 2 – Gauss' Law *

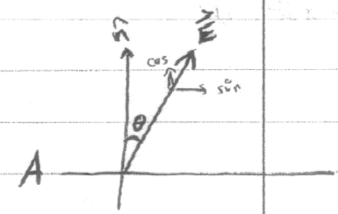
التدفق

* **Electric flux :-** ϕ

The number of electric field lines crossing the plane perpendicularly ($\perp$)

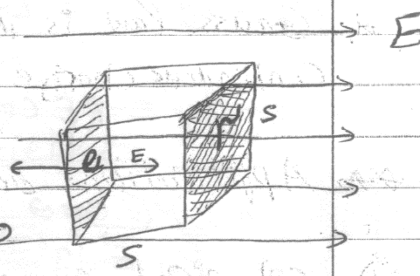
$$\phi = \vec{E} \cdot \vec{A} \quad \vec{A} \to \text{area} \to \text{دائماً عمودي على السطح ويكون باتجاه السطح}$$

$$= E A \cos\theta$$



$$\phi = \int \vec{E} \cdot d\vec{A} \quad (\text{for variable } \vec{E})$$

Ex:- find ϕ from each face of a cube



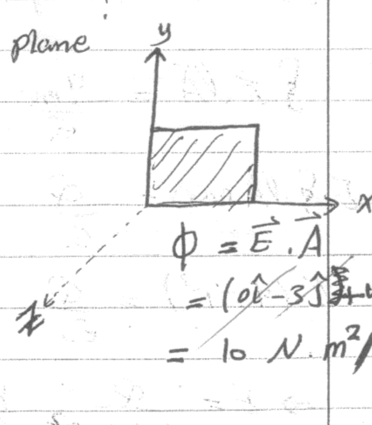
* $\phi_r = E s^2 \cos 0 = E s^2$
* $\phi_e = E s^2 \cos 180 = -E s^2$
* $\phi_t = \phi_{bot} = \phi_{front} = \phi_{ba} = E s^2 \cos 90 = 0$

$\phi_{cube} = 0 \to$ (لأنه لا يحتوي على الشحنة الناتج كان صفر)

Ex: $\vec{E} = 2\hat{i} - 3\hat{j} + 4\hat{k}$ N/C

- find ϕ in a plane $A = 2.5\ m^2$ in xy-plane ?
- find the ϕ through $A = 2.5\ m^2$ in x–z plane

$$\phi = (2\hat{i} - 3\hat{j} + 4\hat{k}) \cdot (2.5\hat{j})$$
$$= 7.5\ Nm^2/C$$

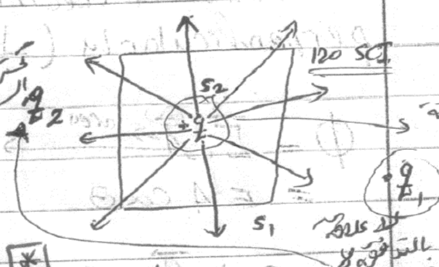


$$\phi = \vec{E} \cdot \vec{A}$$
$$= (0\hat{i} - 3\hat{j} + 4\hat{k}) \cdot (2.5\hat{k})$$
$$= 10\ N \cdot m^2/C$$

* The electric flux through Closed surface is directly proportional to q inside the closed surface

Closed surface ← $\oint \vec{E} \cdot d\vec{A} = \frac{q_{enc}}{\epsilon_0}$

Ex: (1)



[*] الفيض على سطح مغلق له علاقة فقط بالشحنة المحصورة (حتى لو تغير أي) على سطح ادرسه المغلق.

[*] المجال يكون ناتجاً من الشحنة المحصورة بالإضافة للشحنات الخارجية

$\phi_{s_1} = \frac{+q}{\epsilon_0}$

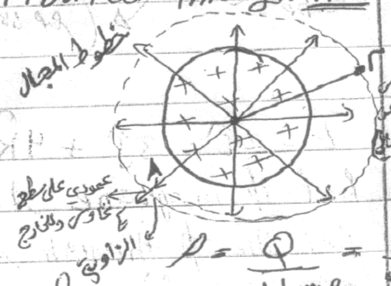
$\phi_{s_2} = \frac{+q}{\epsilon_0}$

* Gauss' law is useful in calculat~~e~~ing (مجال) $(\vec{E})$ for Continuous charge distribution having high symmetry

* Applications on Gauss' law :-

1) spherical symmetry :-

[1] a charge Q is uniformly distributed through non conducting sphere of radius $r = R$



$\rho = \frac{Q}{\text{Volume}} = \frac{Q}{\frac{4}{3}\pi R^3}$

find :

E outside the sphere (E at $r > R$)

$\oint \vec{E}\, d\vec{A} = \frac{q_{enc}}{\epsilon_0}$

$E \oint dA \cos 0 = \frac{Q}{\epsilon_0}$

$E (4\pi r^2) = \frac{Q}{\epsilon_0}$

$\Rightarrow E = \frac{Q}{4\pi \epsilon_0 r^2}$ بشرط $r \geq R$

ⓑ find E inside the sphere $r<R$

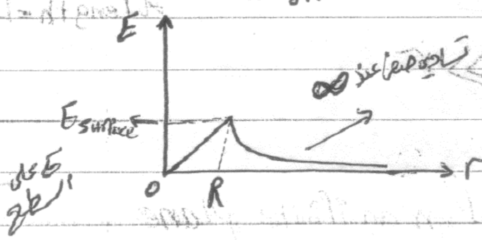
$$\oint \vec{E}\cdot d\vec{A} = \frac{Q}{\epsilon_0}$$

$$E \oint dA \cos 0 = \frac{\rho\left(\frac{4}{3}\pi r^3\right)}{\epsilon_0}$$

$$E(\cancel{4\pi} r^2) = \frac{\rho\left(\frac{\cancel{4}}{3}\cancel{\pi} r^{\cancel{3}}\right)}{\epsilon_0}$$

$$E = \frac{\rho r}{3\epsilon_0} \quad r \leq R$$ [يجب أن تتساوى مع المعادلة السابقة على سطح الكرة (R)]

Q بركز $E_{surface} = \dfrac{Q}{4\pi\epsilon_0 R^2}$

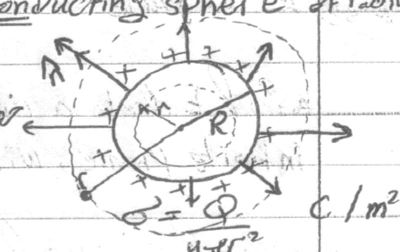


2) Q is uniformly distributed through a conducting sphere of radius (R)

find E at $\boxed{r<R}$

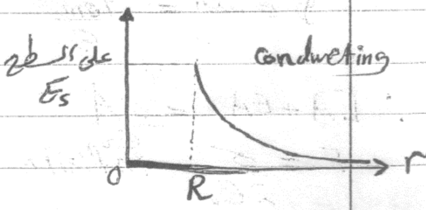
تتغير

Q is distributed on the surface only



$$\oint \vec{E}\cdot d\vec{A} = \frac{Q_{enc}}{\epsilon_0} \nearrow 0$$

$$\boxed{E = 0} \quad r<R$$



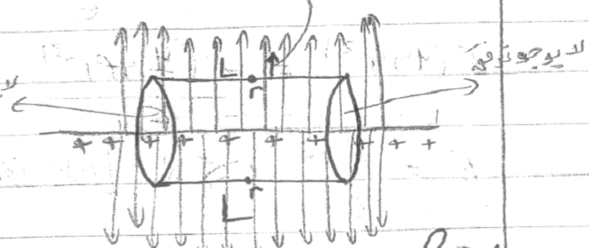
find E at $\boxed{r>R}$

$$\oint \vec{E}\cdot d\vec{A} = \frac{Q}{\epsilon_0}$$

$$E(\cancel{4\pi r^2}) = \frac{Q}{\epsilon_0 4\pi r^2}$$ شحنة نقطية $r>R$

II) line symmetry

find E due to a uniformly charged infinite wire, ~~wire~~ where λ is constant ?



$$\oint \vec{E} \cdot d\vec{A} = \frac{q_{en}}{\epsilon_0}$$

$$E\, 2\pi r L = \frac{\lambda L}{\epsilon_0}$$

$$E = \frac{\lambda}{2\pi\epsilon_0 r}$$

* G.S. is cylinder of radius $= r$ & Length $= L$

* infinite wire means Length of the wire $\gg r$

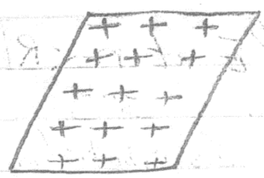
$\boxed{Ex\ 5}$ **III) Plane symmetry :-**

" " $\equiv$ charge distributed on an infinite plane

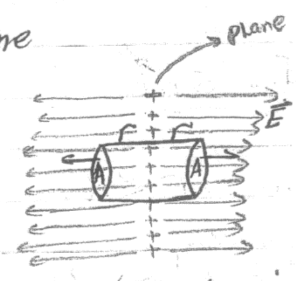
يجب ان تكون خطوط المجال عمودية على الورقة

$\vec{E} \perp$ plane

* find E due to a uniformly charged infinite plane, with σ is constant



\# G.S. is a cylinder crossing the plane (r) from each side



$$\oint \vec{E} \cdot d\vec{A} = \frac{q_{enc}}{\epsilon_0}$$

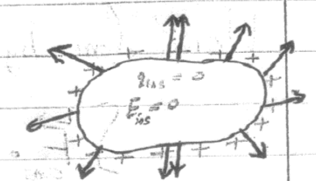
$$EA + EA = \frac{\sigma A}{\epsilon_0}$$

$$E = \frac{\sigma}{2\epsilon_0}$$ infinite plane $r \ll$ (Length + width)
nonconducting

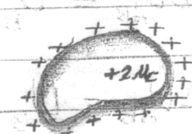
* Charge Conductor :-

Charge rest on the outer surface (تستقر الشحنة على السطح الخارجي)

$E_{\text{near the outer surface}} = \frac{\sigma}{\epsilon_0}$



[Ex 7] conductor charge = +1 μc
pg. 46



$\oint \vec{E} \cdot d\vec{A} = \frac{q_{enc}}{\epsilon_0}$
inside the conductor

$0 = \frac{q_{enc}}{\epsilon_0}$

$q_{enc} = 0$

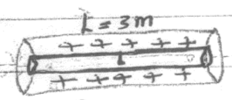
$\Rightarrow q_{inner} = -q$

$q_{\text{outer surface}} = +3\ \mu c$

$q_{\text{inner surface}} = -2\ \mu c$

[Ex 5] find 1) E of r = 1cm
2) E of r = 3cm

* Conductor



R = 2cm

q = 57 μC

L = 3m ≫ r
[r=2cm]

[1] G.S. is a cylinder of length = 3m, radius = 1 cm

$\oint \vec{E} \cdot d\vec{A} = \frac{q_{enc}}{\epsilon_0}$

$E = 0$

[2] G.S. is a cylinder of length = 3m of radius r = 3cm

$\oint \vec{E} \cdot d\vec{A} = \frac{q_{enc}}{\epsilon_0}$

$E\, 2\pi r L = \frac{q}{\epsilon_0}$

$E = \frac{q}{(2\pi r L)\, \epsilon_0}$

λ

Ch3
:

3- Electric Potential

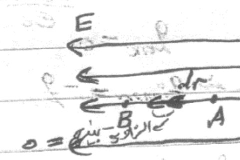
* Electric Potenial Energy [U] (طاقة الوضع)

Work done by a conservative force $= -\Delta U$ $\boxed{\text{by}}$

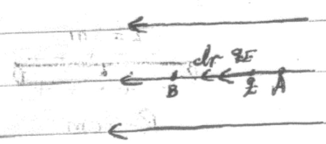
$$\int \vec{F}_{cons} \cdot d\vec{r} = -\Delta U$$

* $\Delta U_{AB} = U_B - U_A = -\int_A^B \vec{F}_{cons} \cdot d\vec{r}$

$$\Longrightarrow \boxed{\Delta U_{AB} = U_B - U_A = -\int_A^B q\vec{E} \cdot d\vec{r} \quad J}$$



* Electric Potential (V) :-



$$\frac{\Delta U_{AB}}{q} = \frac{U_B}{q} - \frac{U_A}{q} = -\int_A^B \vec{E} \cdot d\vec{r} \quad J/C$$

$$\Delta V_{AB} = V_B - V_A = -\int_A^B \vec{E} \cdot d\vec{r} \quad \text{Volt}$$

$V_B - V_A = -$ work done by E in moving $+1\,C$ from $(A \to B)$

$$\boxed{\Delta U = q\,\Delta V}$$

* let $V_\infty = 0$

$$V_B - V_\infty = -\int_\infty^B \vec{E} \cdot d\vec{r}$$

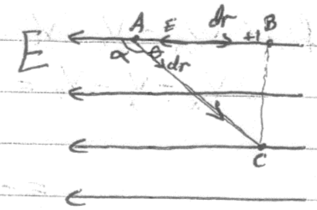
$$V_B = -\int_\infty^B \vec{E} \cdot d\vec{r} \quad J/C = \text{Volt}$$

* $V_B = -$ Work done by $\vec{E}$ in moving $+1\,C$ from $(\infty \to B)$

$V_B > V_A$

$E = 10\,N/C$

$\boxed{Ex}$ $r_{AB} = 3m$, $r_{BC} = 4m$, $r_{AC} = 5m$



① find $V_B - V_A = ?$

$$V_B - V_A = -\int_A^B \vec{E}\cdot d\vec{r}$$

$$= -E\int d\vec{r}\,\cos(180)$$

$$V_B - V_A = 30\ J/C$$

② $$V_C - V_B = -\int_B^C \vec{E}\cdot d\vec{r}$$

$$= \int E\cos 90\, dr$$

$$V_C - V_B = 0$$

$$\boxed{V_C = V_B}$$

③ $$V_C - V_A = ?$$

$$= -\int_A^C \vec{E}\cdot d\vec{r}$$

$$= -\int_A^C E\cos\alpha\, dr \ ,\quad \cos\alpha = -\cos\theta$$

$$= -\int_A^C E\,\bar{\cos}\,\theta\, dr$$

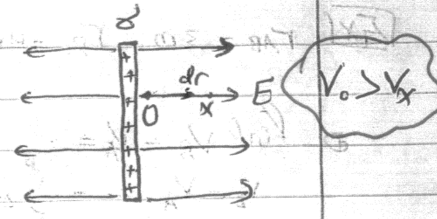
$$= +E\left(\tfrac{3}{5}\right)\int_A^C dr$$

α في الربع الثاني

$$= E\left(\tfrac{3}{5}\right)(5)$$

$$= 30\ J/C = \text{Volt}$$

$\boxed{Ex}$ find ΔV between 2 points near an infinite charged sheet with σ.



$E = \frac{\sigma}{2\epsilon_0}$

∝ find $\Delta V_{0x} = V_x - V_0$

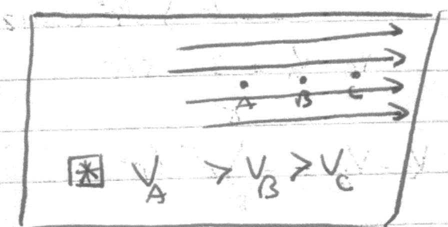
$$\Delta V_{0x} = V_x - V_0 = -\int_0^x \vec{E} \cdot \vec{dr}$$

$$= -\int_0^x \frac{\sigma}{2\epsilon} \cos 0 \, dr$$

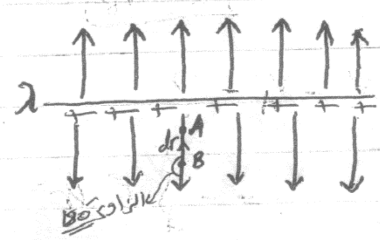
$$= \frac{-\sigma}{2\epsilon_0} x$$

∝ find $V_0 - V_x = ?$

$$= +\frac{\sigma}{2\epsilon_0} x$$



$\boxed{Ex}$ find ΔV between two points near an infinite charged Line with constant λ.



$$E = \frac{\lambda}{2\pi\epsilon_0 r}$$

$$V_A - V_B = -\int_B^A \vec{E} \cdot \vec{dr}$$

$$= -\int_{r_B}^{r_A} \frac{\lambda}{2\pi\epsilon_0 r} \cos 180 \, dr$$

$$= \frac{\lambda}{2\pi\epsilon_0} \int \frac{dr}{r}$$

$$= \frac{\lambda}{2\pi\epsilon_0} \left[\ln r\right]_{r_B}^{r_A}$$

$$V_A - V_B = \frac{\lambda}{2\pi\epsilon_0} (\ln r_A - \ln r_B)$$

$$= \frac{\lambda}{2\pi\epsilon_0} \left(\ln \left(\frac{r_A}{r_B}\right)\right)$$

* $\Delta U_{AB} = U_B - U_A = (-)q \int_A^B \vec{E}\, d\vec{r}$ (J) Electric potential energy difference

* $\Delta V_{AB} = V_B - V_A = -\int \vec{E} \cdot d\vec{r}$ volt $= J/C$ [Electric potential difference

$$\Delta U = q\, \Delta V$$

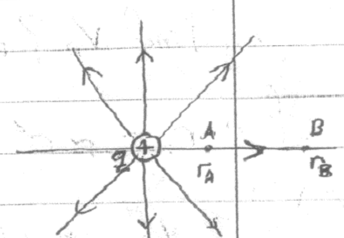
Electric potential $\boxed{V}$ due to a point charge :-

$$\Delta V_{AB} = V_B - V_A = -\int_{r_A}^{r_B} \frac{kq}{r^2}\, dr$$

$$V_B - V_A = -kq \int_{r_A}^{r_B} \frac{dr}{r^2}$$

$$V_B - V_A = -kq \left[-\frac{1}{r} \right]_{r_A}^{r_B}$$

$$V_B - V_A = \frac{kq}{r_B} - \frac{kq}{r_A}$$



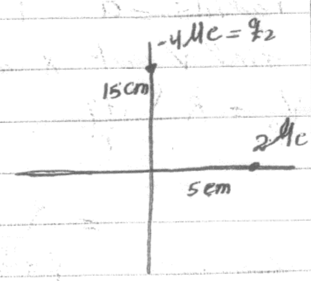
let $V_\infty = 0$

* $V_B - \cancel{V_\infty} = \frac{kq}{r_B} - \frac{kq}{r_\infty}$

$$\boxed{V_B = \frac{q}{4\pi\epsilon_0 r_B}} \text{ volt} \longrightarrow \frac{kq}{r}$$

$\boxed{\text{scaler quantity}}$

$\boxed{Ex}$ ① find $\underline{V}$ at the origine ?



$$V_o = \frac{1}{4\pi\epsilon_0} \sum \frac{q_i}{r_i}$$

$$= \frac{9 \times 10^9 + 2 \times 10^{-6}}{5 \times 10^{-2}} + \frac{9 \times 10^9 (-4 \times 10^{-6})}{15 \times 10^{-2}}$$

$$V_o = 3.6 \times 10^5 - 2.4 \times 10^5 = 1.2 \times 10^5 \; J/C = \text{volt}$$

② find the work done (by external agent / قوة خارجية) in moving $+5\mu c$ from ∞ to O ?

$$W_{\infty \to o} = q\, \Delta V = q\, (V_o - V_\infty)$$

$$= +5 \times 10^{-6} (1.2 \times 10^5 - 0) = 0.6\, J$$

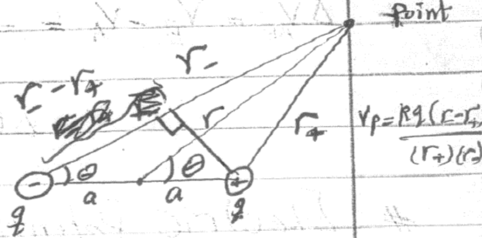
Conservative Electric force

$-\Delta U =$ شغل القوة المحافظة

$+\Delta U =$ شغل القوة الخارجية

$\boxed{Ex}$ Find V due to an electric Dipole at point P

$$V_p = k \sum \frac{q_i}{r_i}$$



$$V_p = \frac{k(-q)}{r_-} + \frac{k(+q)}{r_+}$$

$$= kq \, \frac{-r_+ + r_-}{(r_-)(r_+)}$$

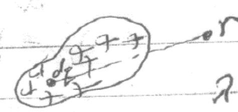
* (find V_p ? when $a \ll r$)

$r_+ r_- \approx r^2$, $\cos\theta = \frac{r_- - r_+}{2a}$

$$V_p = \frac{k\,q(2a)\cos\theta}{r^2} = \frac{k\,P\cos\theta}{r^2}$$

V due to a continuous charge distribution :-

$$V = k\int \frac{dq}{r}$$



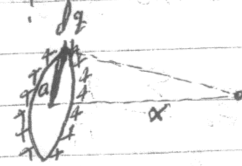
$\lambda = ?$

(1) V due to a uniformly charge ring

charge $= Q$
radius $= a$ } $\lambda =$

* find V at x above the origin ?

$$V_p = k\int \frac{dq}{r} = k\int \frac{dq}{\sqrt{x^2 + a^2}}$$



*المجال في المركز = صفر
*لأن الجهد لا يساوي الصفر

$$= \frac{k}{\sqrt{x^2+a^2}} \int dq$$

$$= \frac{Q\,k}{4\pi\epsilon_0 \sqrt{x^2 + a^2}} \text{ volt}$$

(a) for $x \gg a \Rightarrow V = \frac{kQ}{x}$

(b) for $x = 0$, $V = \frac{kQ}{a}$

* note the following :-

$$E_x = -\frac{dv}{dx} = -\frac{Q}{4\pi\epsilon_0}\left[\frac{(-\frac{1}{2})(2x)}{(x^2+a^2)^{\frac{3}{2}}}\right] = \frac{Q\,x}{4\pi\epsilon_0\left[x^2+a^2\right]^{\frac{3}{2}}}$$

المجال الكهربائي

$$E_{ring} = -\frac{\partial V}{dx}\,\text{ring} =$$

* Recall.

[1] $\Delta U_{AB} = U_B - U_A = -q \int_A^B \vec{E} \cdot d\vec{r}$ J

[2] $\Delta V_{AB} = V_B - V_A = - \int_A^B \vec{E} \cdot d\vec{r}$ $(J/C) =$ volt

[3] $V = \dfrac{q}{4\pi\epsilon_0 r} = \dfrac{qK}{r}$ (الجهد الناشئ عن شحنة نقطية)

[4] $V = \dfrac{1}{4\pi\epsilon_0} \sum \dfrac{q_i}{r_i} = K \sum \dfrac{q_i}{r_i}$ (عند وجود عدة نقط مشحونة)

[5] $V = k \int \dfrac{dq}{r}$

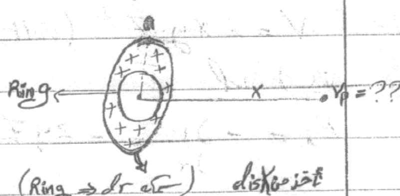
[6] $V_{ring} = \dfrac{Q}{4\pi\epsilon_0 \sqrt{a^2 + x^2}}$

[7] V due to a uniformly charged disk

$V_{disk} = \int d(V)_{ring}$

For disk ⇒ radius $= a$, Charge $= Q$, $\sigma = \dfrac{Q}{\pi a^2}$ c/m^2 كولوم

* Find V_{disk} at a distance x above the center ?



$q_{ring} = \sigma \pi r^2$

$dq = \sigma (\pi 2r\, dr)$

$dv_{ring} = \dfrac{\sigma 2\pi r\, dr}{4\pi\epsilon_0 \sqrt{r^2 + x^2}}$

* تكامل (dv_{ring}) من 0 — a ويكون هذا disk
* حيث أن التكامل (حدود التكامل) تكون محصورة في المنطقة التي تحتوي على شحنات

* $V_{disk} = \dfrac{\sigma \pi}{4\pi\epsilon_0} \int_0^a \dfrac{2r\, dr}{\sqrt{r^2 + x^2}}$ Let $u = r^2 + x^2$, $du = 2r\, dr$

$= \dfrac{\sigma}{4\epsilon_0} \int_0^a \dfrac{du}{\sqrt{u}}$

$= \dfrac{\sigma}{4\epsilon_0} \left(\dfrac{u^{\frac{1}{2}}}{\frac{1}{2}} \right) \Big|_0^a$

$= \dfrac{\sigma}{2\epsilon_0} \left(\sqrt{r^2 + x^2} \right) \Big|_0^a = \dfrac{\sigma}{2\epsilon_0} \left(\sqrt{a^2 + x^2} - x \right)$ V_{disk}

* From V_{disk} Find E_{disk} by Using $E = (-)\frac{dv}{dx}$

$$E_x = -\frac{\sigma}{2\epsilon_0}\left[(2x)\frac{1}{2}(x^2+a^2)^{-\frac{1}{2}} - 1\right]$$

$$E_x = \frac{\sigma}{2\epsilon_0}\left[1 - \frac{x}{\sqrt{a^2+x^2}}\right]$$

* Calculating E from V :-

$$\Delta V = -\int \vec{E} \cdot d\vec{r}$$

$$dV = -E\,dr$$

$$\boxed{E = -\left(\frac{dV}{dr}\right)}$$

* معنى ∂ (المائلة) ← (d)
- عندما نشتق x تكون y و z ثابتة
- عندما نشتق y تكون x و z ثابتة
- عندما نشتق z تكون x و y ثابتة

$$E_x = -\frac{\partial V}{\partial x}$$

$$E_y = -\frac{\partial V}{\partial y}$$

$$E_z = -\frac{\partial V}{\partial z}$$

Ex :- $V = 2xyz^2$ (volt)

(1) Find $\vec{E}$

$$E_x = -\frac{\partial V}{\partial x} = -2yz^2 \quad \hat{i}$$

$$E_y = -\frac{\partial V}{\partial y} = -2xz^2 \quad \hat{j}$$

$$E_z = -\frac{\partial V}{\partial z} = -4xyz \quad \hat{k}$$

$$\Rightarrow E = -2yz^2\hat{i} - 2xz^2\hat{j} - 4xyz\hat{k}$$

(2) Find E at $(3, -2, 4)$ m

$$E = -2(-2)(4)^2\hat{i} - 2(3)(4)^2\hat{j} - 4(3)(-2)(4)\hat{k}$$

$$= 64\hat{i} - 96\hat{j} + 96\hat{k}$$

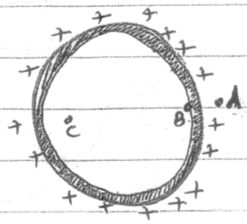
* V for charged conductor ⇒

[1] q at the out surface (يتم حسابها)

[2] $E_{in\,surface} = 0$

[3] $E_o = \frac{\sigma}{\epsilon_o}$

[4] $V_A = V_B = V_C = V$



Ex a conducting sphere of charge equal Q

* Find the following ⇒

[1] E at $r < a$ $= 0$

[2] E at $r = a$

$$E = \frac{Q}{4\pi\epsilon_o a^2} = \frac{kQ}{a^2}$$ (تم حسابها سابقا)

[3] E at $r > a$ يقل أكثر

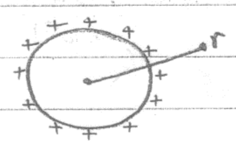
$$E = \frac{Q}{4\pi\epsilon_o r^2} = \frac{kQ}{r^2}$$

[4] $V_a = \frac{Q}{4\pi\epsilon_o a}$ ⇒ $V_a = -\int_{\infty}^{a} \vec{E}\, d\vec{r} = -\int_{\infty}^{a} \frac{Q}{4\pi\epsilon_o r^2} = \frac{-Q}{4\pi\epsilon_o}\int_{\infty}^{a} \frac{1}{r^2} = \frac{Q}{4\pi\epsilon_o a}$

[5] $V_{\frac{a}{2}} = \frac{Q}{4\pi\epsilon_o a}$ ⇒ * كل النقاط بداخل الـ (conductor) أو على سطحه أو خارجه الجهد يكون متساوي

[6] $V_{(o)} = \frac{Q}{4\pi\epsilon_o a}$

[7] Find V at $r > a$

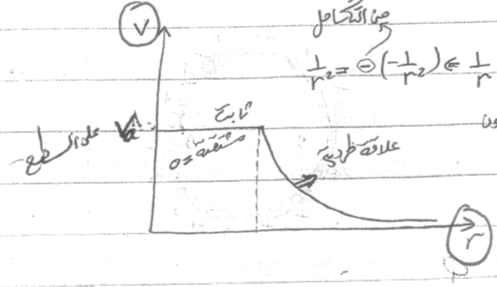


$$V(r) = \frac{Q}{4\pi\epsilon_o r}, \quad r \geq a$$

$$V = -\int_{\infty}^{r} \frac{Q}{4\pi\epsilon_o r^2} = \frac{-Q}{4\pi\epsilon_o}\int_{\infty}^{r} \frac{1}{r^2} = \frac{Q}{4\pi\epsilon_o r}$$

* الجهد يبقى متساوي حتى (a) ثم تصبح العلاقة طردية بين E ، r

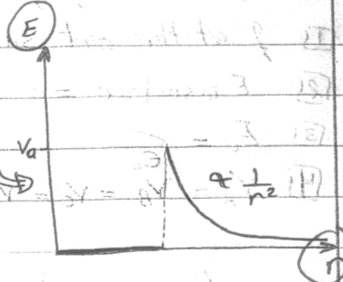
* Conducting sphere



من التكامل

* مشتقة $\frac{1}{r} \Leftarrow \ominus\left(-\frac{1}{r^2}\right) = \frac{1}{r^2}$

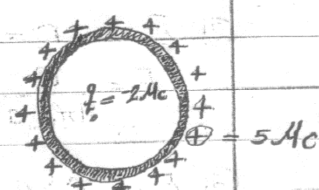
* مشتقة (V) ونضرب بـ سالب ليكون الجواب E ونرسمها



$\boxed{Ex}$ Charge on the spherical shell $Q = 5\mu c$

* $a = 10$ cm

q in the center $= -2\mu c$



1 find the following ⇒ V at $r = 15$ cm

$$V = \frac{q + Q}{4\pi\epsilon_0 r} \qquad r \geq a$$

$$= \frac{(9\times10^{9})(3\times10^{-6})}{(15\times10^{-2})} = 1.8\times10^{5} \text{ Volt}$$

* (داي خارج الكرة نتعامل معها على أساس أنها شحنة نقطية سواء في E أو V)

2 V at The surface

$$V_{(a)} = \frac{q + Q}{4\pi\epsilon_0 a} = \frac{(9\times10^{9})(3\times10^{-6})}{(10\times10^{-2})} = 2.7\times10^{5} \text{ Volt}$$

3 V at $r = 5$ cm

$$V_{(5)} = V_{\text{point charge}} + V_{\text{charged conducting sphere}}$$

$$= \frac{(9\times10^{9})(-2\times10^{-6})}{(5\times10^{-2})} + \frac{(9\times10^{9}) + (5\times10^{-6})}{(10\times10^{-2})} = 0.9\times10^{5} \text{ Volt}$$

*** الجهد الذي من الشحنة + الجهد مثل اللي في 1 السطح.

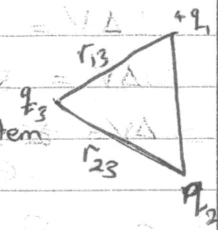
Ch4

:

4) Electrostatic Energy & Capacitors

* Electrostatic Energy = work done in arranging the system

in any system = work done in moving each charge from $\infty \rightarrow$ to its position in the system



$W = q\,\Delta V$

$= q\,(V_f - \cancel{V_\infty})$

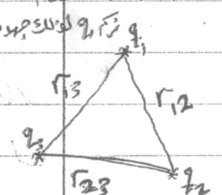
القوة التي يعملها الشخص تكون موجبة
أما القوة الخارجية تكون بالسالب

$U = \underset{q_1(\infty\rightarrow)}{W_1} + \underset{q_2(\infty\rightarrow)}{W_2} + \underset{q_3(\infty\rightarrow)}{W_3}$

السالب يعوض في القانون

$= 0 + q_2\left(\frac{k\,q_1}{r_{12}}\right) + q_3\left(\frac{k\,q_1}{r_{13}} + \frac{k\,q_2}{r_{23}}\right)$

بنبدأ نركب النظام خطوة خطوة
نركب q_1 لوحدها جهدها صفر



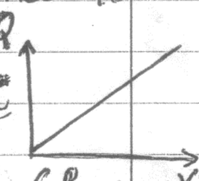
U is measured by J or in eV

$eV = 1.6 \times 10^{-19}$ J

* Electric capacitance is the amount of charge need to raise the potential of a conductor by +1V

* اللي يوصلنا ع أكبر
يرتفع الخط للأعلى لليسار

$C = \frac{Q}{V}$ Coulumb/Volt = F



(for any conductor)

* Capacitor :-

Consists from 2 conductors with insulating material between them to store $\left\langle \begin{matrix} Q \\ U \end{matrix} \right.$

* parallel plate capacitor :- (أبسط نوع)

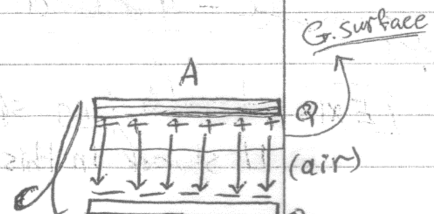
* To find C *

① find E by using Gausse law (G.L.)

$\oint E \cdot dA = \frac{q_{enc}}{\epsilon_0}$ → جميع الشحنة على الكاباسيتر

$EA = \frac{Q}{\epsilon_0}$

$\Rightarrow E = \frac{Q}{\epsilon_0 A}$



شحنة الكاباسيتر = صفر ولكن حفظنا الطاقة المخزنة من خلال فصل الموجب والسالب

② find $\Delta V = V_+ - V_- = -\int_-^+ \vec{E} \cdot d\vec{r}$

$\Delta V = -\int_-^+ \vec{E} \cos 180 \, dr$

$\Delta V = E \, d$

$\Rightarrow \Delta V = \frac{Q}{\epsilon_0 A} \cdot d$

③ $C = \frac{Q}{\Delta V} \Rightarrow C = \frac{\epsilon_0 A}{d}$

(السعة سواء مشحون أو لا تكون ثابتة)

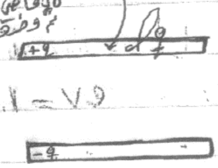
(إذا كان فاضي غير مشحون تكون طاقته صفر)

it depend on geomitry

* Electrostatic Energy stored in C = work done in charging the capacitor

$dU = V \, dq$ (work on moving dq from ∞ to

كان فاضي ثم وضعنا شحنة واحدة (الموجب)



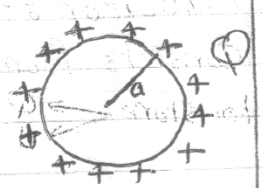
$V = \frac{q}{C}$

$U = \int_0^Q V \, dq = \int_0^Q \frac{q}{C} \, dq$

$U = \frac{1}{2} \frac{Q^2}{C} = \frac{1}{2} \frac{(CV)^2}{C}$

$\Rightarrow U = \frac{1}{2} C V^2$

[EX] a conducting sphere of radius = a , find C ?



$V_s = \frac{Q}{4\pi\epsilon_0 a}$

$C = \frac{Q}{V}$

$C = 4\pi\epsilon_0 a$ depends on geometry

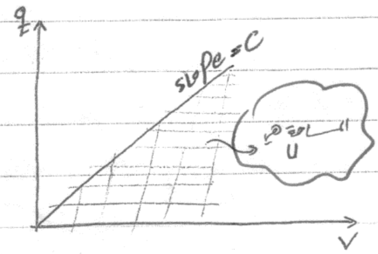
دايماً قيمة موجبة

[EX] A conducting sphere of radius = a charged with Q , find U stored in this spere ?

$U = \frac{1}{2} \frac{Q^2}{C} = \frac{Q^2}{2(4\pi\epsilon_0 a)} \, J$

* $C = \frac{Q}{V}$ → $C_{sphere} = 4\pi\epsilon_0 q$; → $C = \frac{\epsilon_0 A}{d}$

$U = \frac{1}{2} C V^2$
$= \frac{Q^2}{2C}$



* Capacitors with Dielectric material

air

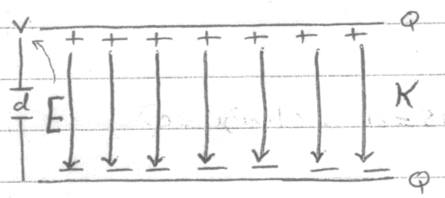
لو وضعنا مكان الهواء مادة عازلة السعة تزيد

K

* $C_0 = \frac{\epsilon_0 A}{d}$ $\qquad C = \frac{K \epsilon_0 A}{d}$

* K = dielectric constant > 1 $\qquad \boxed{K_{air} = 1}$

* Dielectric material → increase C ; → support



* Break down field : is the maximum field in the capacity

* $V = E d$
$V_{max} = E_{breakdown\ field}\, d$

* عند الوصول الى أكبر E فإن الجهد يكون أكبر جهد
* لا نستطيع زيادة عدد الشحنات فعند عدد معين يجب التوقف وعدم مجاوزتها

* $E_{breakdown} = 14$ MV/m (for paper as an insulator)

* (capacitors in parallel)

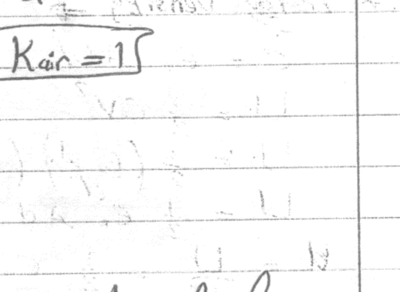
$q = q_1 + q_2 + q_3$

$V = V_1 = V_2 = V_3$

$q = C_1V_1 + C_2V_2 + C_3V_3$

$q = V(C_1 + C_2 + C_3)$

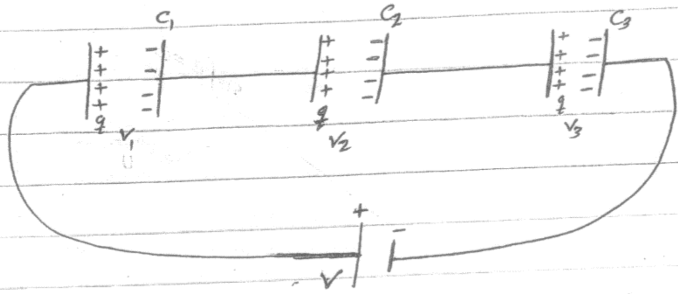
$\boxed{C = C_1 + C_2 + C_3}$



* $C = \frac{q}{V}$

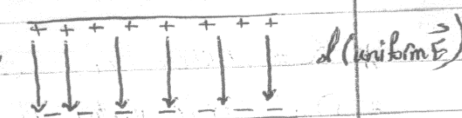
Example 3

* (Capacitors in series)



$$q_1 = q_2 = q_3 = q$$
$$V = V_1 + V_2 + V_3$$
$$V = \frac{q_1}{C_1} + \frac{q_2}{C_2} + \frac{q_3}{C_3}$$
$$V = q\left(\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}\right)$$
$$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$$

* Energy Density ⇒ $U = J/m^3$

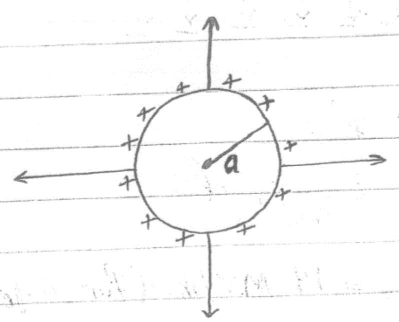


$$C = \epsilon_0 A/d$$
$$U = \frac{1}{2} CV^2$$
$$U = \frac{1}{2}\left(\frac{\epsilon_0 A}{d}\right)\left(E^2 d^2\right)$$
$$U = \frac{1}{2} \epsilon_0 A d E^2 \ J$$

(Ad) = volume ??

?? $$u = \frac{U}{Ad} = \frac{1}{2} \epsilon_0 E^2 \ J/m^3$$

* Example ⇒ conducting sphere radius = a , Charge = Q



$\boxed{a}$ find C

$$C = 4\pi \epsilon_0 a$$

$\boxed{b}$ find $u(r)$ at $r \geq a$?

$$u(r) = \frac{1}{2} \epsilon_0 \left[\frac{Q}{4\pi\epsilon_0 r^2}\right]^2$$
$$= \frac{Q^2}{32\pi^2 \epsilon_0 r^4} \quad J/m^3$$

** [C] find U stored by the charged conducting sphere?

$$U = \int_a^\infty u \, d\,\text{volume} \qquad dv = 4\pi r^2 dr$$

$$U = \int_a^\infty \frac{Q^2 \, (4\pi r^2 dr)}{32\pi^2 \epsilon_0 r^4}$$

$$U = \frac{Q_2}{8\pi\epsilon_0} \int_a^\infty \frac{dr}{r^2}$$

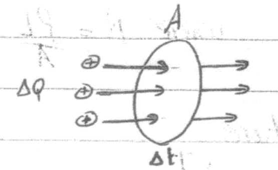
Ch5

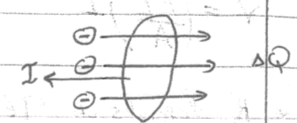
:

CH-5 [Electric current]

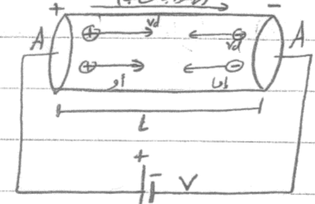
* Electric current $I = \frac{\Delta Q}{\Delta t}$ (عدد الشحنات / على زمن العبور) C/s = Ampere

"Is a scalar Quantity"





* Electric current (I) in a conductor :
 * a conducting wire
 → Length = L
 → cross sectional Area = A
 n ⇒ number of charge carries
 (free electron) m^{-3} ← لكل مادة رقم معين ويكون معروف



(الالكترونات هي التي تمشي في السلك)

** number of charge carriers in the wire = nAL
the amount of moving charge in the wire = $(nAL)e$

$Q = (nAL)e$ C devide by Δt

$\frac{L}{\Delta t}$ (طول السلك / الزمن) $= V_d$

$\frac{Q}{\Delta t} = I = nA\frac{L}{\Delta t}e$

(سرعة الانسياق)
$I = nAe(V_d)$

$V = EL$

V_d = drift speed

* current density $= \frac{I}{A} = J$
$\vec{J} = ne\vec{V_d}$ Amp/m^2
$I = \vec{J}\cdot\vec{A}$
I depends on ⇒ [1] Geometry (شكل هندسي) for the conductor
[2] Type of the conducter
[3] the applied $\vec{E}$
[4] the temperature

* OHM's Law :
$\vec{E} \propto \vec{J}$
$\vec{E} = \rho\vec{J}$
المقاومية

ρ : resistivity (يعتمد على نوع)
σ : $\frac{1}{\rho}$ = conductivity
موصلية

$\vec{E} = \rho \vec{J}$

$\frac{V}{L} = \rho \frac{I}{A}$

$V = RI$ OHM's law

$V = \left(\frac{\rho L}{A}\right) I$ where $R = \frac{\rho L}{A}$

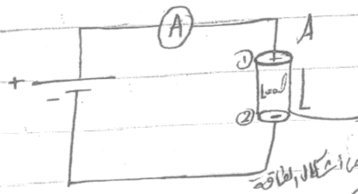
* R depends on Temperature

$R(T) = R_0 [1 + \alpha (T - T_0)]$

** الموصلات ⇐ إذا زادت الحرارة تزيد المقاومة

** العازلات ⇐ " " " تقل المقاومة

* **power in a circuit:**



طاقة الوضع تتحول الى طاقة حركة

وطاقة الحركة تتحول الى أي شكل من أشكال الطاقة

كما البطارية تعطي الطاقة و load تصرفه

* عندما تنتقل الشحنات من النقطة ① الى النقطة ② تتناقص طاقة الوضع ثم تتحول الى أي شكل من أشكال الطاقة

$[\Delta V]$ charge in energy $Q (1 \to 2)$ $= QV$ { U decrease and transfar to other type of energy]

* power transfer $= \frac{\Delta U}{\Delta t}$

$P = \frac{QV}{\Delta t}$

$P = IV, \; V = IR$

$P = I^2 R$

$P = \frac{V^2}{R}$

[1] Conductors موصلات

[2] Insulators عازلات

[3] semi - conductors - (Si , Ge) أشباه موصلات

[4] supper conductors فائقة الموصلية

[5] plasa density $= 10^{14}$ Kg/m^3

Ch6

:

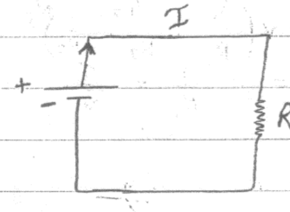
CH-6 [Electric circuits]

$R = \rho \frac{L}{A}$

$P_R = I^2 R$ $\qquad V = IR$

* Electromotive force :

is the work done by the source in moving +1 C from (-) terminal to (+) terminal inside the source



قوة دافعة $\mathcal{E} = \frac{dw}{dq}$ J/C

$dw = \mathcal{E}\, dq$

power done by the source $\frac{dw}{dt} = \mathcal{E} \frac{dq}{dt}$

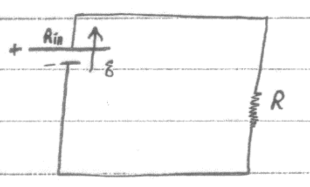
$P_{\mathcal{E}} = \mathcal{E} I$ watt

* from conservation of energy

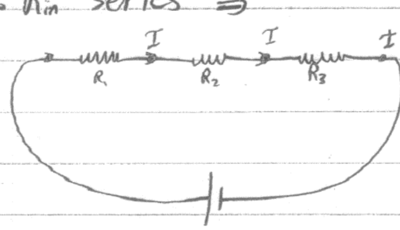
$P_{\mathcal{E}} = P_R$

$\mathcal{E} I = I^2 R$ $\qquad I = \frac{\mathcal{E}}{R}$

* Real Battery has R_{in} :



* R_{in} series ⇒



$I_1 = I_2 = I_3 = I$

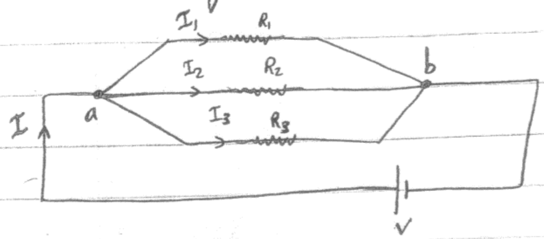
$V = V_1 + V_2 + V_3$

$V = I_1 R_1 + I_2 R_2 + I_3 R_3$

$V = I(R_1 + R_2 + R_3)$

$(R_1 + R_2 + R_3) = \sum R_i = R_{eq} = \frac{V}{I}$

* R in Parallel :-



* مقاومة كبيرة تأخذ تيار كبير

* $I = I_1 + I_2 + I_3$

$I = \frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_3}{R_3}$

$I = V\left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\right)$

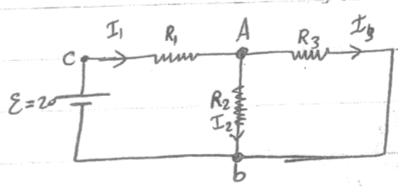
$\frac{1}{R_{eq}} = \Sigma \frac{1}{R_i} = \frac{I}{V}$

$\boxed{Ex}$ $R_1 = 10$

$R_2 = 4$

$R_3 = 6$

find I_1, I_2, I_3



1) $\frac{1}{R_{23}} = \frac{1}{R_2} + \frac{1}{R_3}$

$\frac{1}{R_{23}} = \frac{1}{4} + \frac{1}{6} = \frac{10}{24} \Rightarrow R_{23} = \frac{24}{10} = 2.4\,\Omega$

* $R_{eq} = R_1 + R_{23} = 12.4\,\Omega$

$I_1 = \frac{\mathcal{E}}{\underbrace{R}_{\text{الكلي}}} = \frac{20}{12.4} = 1.6$ Ampere

* $V_2 = V_3 = V$

$I_2 R_2 = I_3 R_3 = (1.6)(2.4)$

\# $4 I_2 = 6 I_3 = (2.4)(1.6)$

$\Rightarrow I_2 = 0.96\ A$, $I_3 = 0.61\ A$

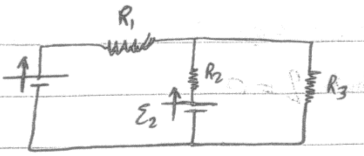
* إذا مشي مع القوة الدافعة موجب
* " " " " التيار سالب
* " عكس التيار موجب
* البطارية [من السالب ـ الموجب + / من الموجب + السالب −]

* find $V_c - V_b = ?$

$V_c + \mathcal{E} = V_b$

$\Rightarrow V_c - V_b = 20$

* Mutiloop circuits :-



* You have to apply Kerchoff's law :-

1) At any junction

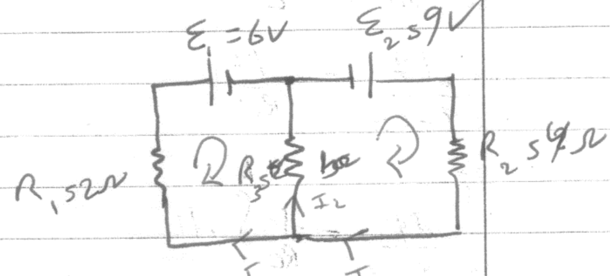
- $\Sigma I_i = 0$ مجموع التيارات = صفر *
- $\Sigma I_{entering} = \Sigma I_{out}$ مجموع التيارات الداخلة = الخارجة *

قانون حفظ الشحنة (Conservation of charge)

2) around any closed Loop

$\Sigma V_i = 0$

حفظ الطاقة (conservation of energy)



Ex 4 P.117   find I in each R ?

at a $\quad I_2 + I_1 = I_3 \rightarrow (1)$

$\Sigma V_{abeda} = 0$

$R_3 I_3 + {}^-R_1 I_1 - 6 = 0$

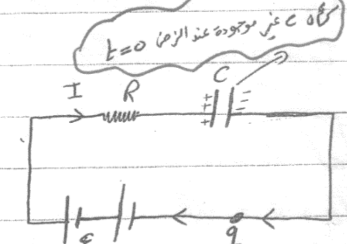
$10 I_3 + {}^-2 I_1 = 6$

$5I_3 - I_1 = 3 \rightarrow (2)$

$\mathcal{E}_{abeha} = I_3 R_3 + R_2 I_2 - 9 = 0$

$10 I_3 + 4 I_2 = 9 \rightarrow (3)$

* RC - Circuit :-



1) Charging a capacitor :-

at $t = 0$, $q_0 = 0$

$I_0 = \dfrac{\mathcal{E}}{R}$

find $q(t)$? $I(t)$?

* after a long time $I = 0$
$Q_{max} = C\mathcal{E}$

* from Kirchoff's rule ⇒

$\sum V_i = 0$

$\mathcal{E} + {}^{-}IR + \frac{-q}{C}$

C ⇐ من الموجب للسالب (-)

but $q = 0$

* $\mathcal{E} - R\frac{dq}{dt} - \frac{q}{C} = 0$

$-R\frac{dq}{dt} = \frac{q}{C} - \mathcal{E}$

$-R\frac{dq}{dt} = \frac{q - C\mathcal{E}}{C}$

$\frac{dq}{q - C\mathcal{E}} = \frac{-dt}{RC}$

$\int_0^Q \frac{dq}{q - C\mathcal{E}} = \frac{-1}{RC}\int_0^t dt$

$\ln|q - C\mathcal{E}| \Big|_0^Q = \frac{-t}{RC} \Big|_0^t$

$\ln|Q - C\mathcal{E}| - \ln|-C\mathcal{E}| = \frac{-t}{RC}$

$\ln \frac{Q - C\mathcal{E}}{-C\mathcal{E}} = \frac{-t}{RC}$

$\frac{Q - C\mathcal{E}}{-C\mathcal{E}} = e^{-t/RC}$

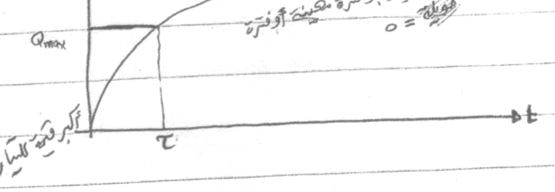
$Q - C\mathcal{E} = -C\mathcal{E}\, e^{-t/RC}$

① $Q(t) = C\mathcal{E}(1 - e^{(-t/RC)})$

$V = \frac{Q}{C}$ → $V(t) = \mathcal{E}(1 - e^{-t/RC})$

②

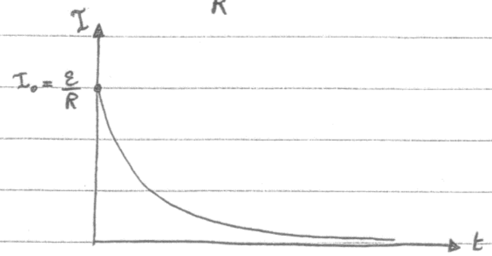
$I(t) = \frac{dQ}{dt}$



$$I(t) = \frac{dQ}{dt} = C\mathcal{E}\left(0 - -\frac{1}{RC}e^{-t/RC}\right)$$

$$= 0 + \frac{C\mathcal{E}}{RC}e^{-t/RC}$$

$$I(t) = \frac{\mathcal{E}}{R}e^{-t/RC} \Longrightarrow ②$$



* عندما تعرف Q تعرف كل شيء عن الدائرة

→ $V_R(t) = IR = \mathcal{E}e^{-t/RC}$ للمقاومة   تكتب (V_0)

$$P_R = I^2R$$

$$U_C = \frac{Q^2}{2C}$$

→ time constant = RC

→ $\tau = RC$ second

$$Q(t) = C\mathcal{E}(1 - e^{-1})$$

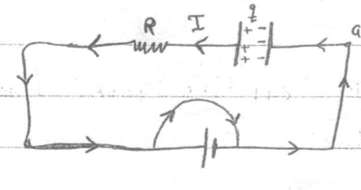
$$= C\mathcal{E}(1 - 0.37)$$

$$Q(\tau) = C\mathcal{E}(0.63)$$

$$Q(\tau) = C\mathcal{E}(0.63)$$

$$Q(\tau) = 0.63\, Q_{max}$$

[2] Discharging C ⇒



زيادة الجهد +

زيادة بالجهد

$$+\frac{q}{C} + -IR = 0$$

تناقص

$$I = -\frac{dq}{dt}$$

$$\frac{q}{C} + R\frac{dq}{dt} = 0$$

$$\frac{q}{C} = -R\frac{dq}{dt}$$

$$\frac{dt}{RC} = -\frac{dq}{q}$$

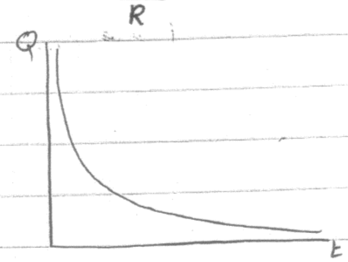
$$-\int\frac{dt}{RC} = \int\frac{dq}{q}$$

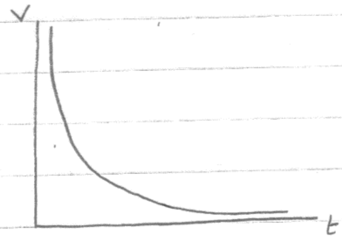
$\boxed{RC = \tau}$

$$Q(t) = Q_{max}\, e^{-t/RC} = Q_{max}\, e^{-1}$$

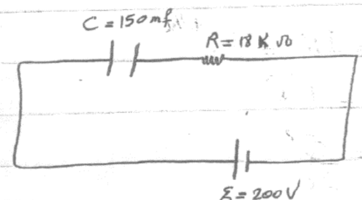
$$I = -\frac{dq}{dt} = \frac{Q_{max}}{RC} e^{-t/RC}$$

$$I = \frac{V_{max}}{R} e^{-t/RC}$$





(Example 5/122)



- find t ? when $V_c = 170\ V$

$$\tau = RC = (18)10^{3}(150) * 10^{-3} = 2700 \text{ sec}$$

$$V_c(t) = \mathcal{E}(1 - e^{-t/RC})$$

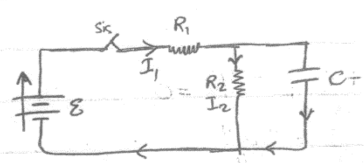
$$170 = 200(1 - e^{-t/\tau})$$

$$\frac{170}{200} = 1 - e^{-t/\tau}$$

$$e^{-t/\tau} = 0.15$$

$$\Rightarrow t = 5.1 \text{ sec}$$

(exeample 123)



(a) when S is closed find I_1 / I_2 at $t=0$

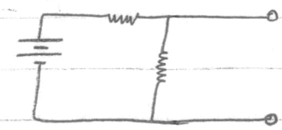
at $t=0$

$$I_2 = \frac{\mathcal{E}}{R_1}$$

after along time $t \to \infty$ (c أكبر مايمكن)

$Q = Q_{max}$

$$I_1 = I_2 = \frac{\mathcal{E}}{R_1 + R_2}$$



كأن الدارة مفتوحة

* لأن الـ capacitor أخذ أكبر شحنة ممكنة أي مقاومة أقل ما يمكن فصار مفتوحاً

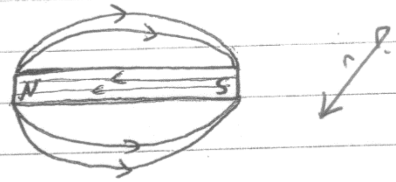
Ch7

:

7 - Magnetism - Force & Field

- Introduction :

- each magnet has 2 poles → North pole / → south pole
- there is No magnetic monople

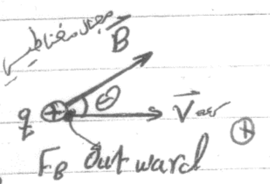


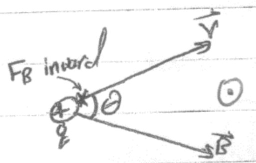
- there is attractive force between N-S
- there is repulsive force between N-N / S-S
- magnetic force (F_B) :-

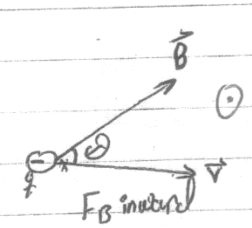
magnetic field ($\vec{B}$) acts a force on a moving charge according to:-

$$\vec{F}_B = q\vec{V} \times \vec{B}$$

$$|\vec{F}_B| = |q| VB \sin\theta$$







* الاتجاه بالعكس للشحنة السالبة

* Consider the following notes :-

1) $\vec{F}_B \perp (\vec{V} \,\&\, \vec{B})$ — • شغل القوة المغناطيسية = ٠

2) • F_B Changes the direction of $\vec{V}$ only — • شغل القوة المغناطيسية = صفر

3) Work done by F_B equal to Zero

4) $F_B = 0$ when $V = 0$; $q = 0$; $\theta = 0, 180$ — * المجال المغناطيسي لا يؤثر بقوة على الشحنة الساكنة

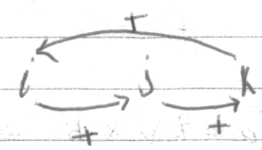
5) $|F_B| = |q| VB \sin\theta$

$$B = \frac{N}{C.m/s} = N.S/C.m = \text{Tesla}$$

$$1\ \text{Gauss} = 10^{-4}\ T$$

$\boxed{v \times B \neq B \times v}$

Ex. A magnetic field $\vec{B} = (5\hat{i} - 7\hat{j} + 4\hat{k})$ mT acts on a moving proton with $\vec{V} = (-2\hat{i} + 3\hat{j} + 6\hat{k})$ Km/s, find the magnetic force acting on the proton



$\vec{F}_B = q\vec{V} \times \vec{B}$

$= 1.6 \times 10^{-19} \begin{vmatrix} \hat{i} & -\hat{j} & \hat{k} \\ -2\times10^{3} & 3\times10^{3} & 6\times10^{3} \\ 5\times10^{-3} & -7\times10^{-3} & 4\times10^{-3} \end{vmatrix}$

$\vec{F}_B = 1.6\times10^{-19} \left[\hat{i}(12 - -42) - \hat{j}(-8 - 30) + \hat{k}(14 - 15) \right]$

$= 1.6\times10^{-19} \left[54\hat{i} + 38\hat{j} - \hat{k} \right]$

* Chek that if $\vec{F}_B \cdot \vec{V} = 0$ / if $\vec{F}_B \cdot \vec{B} = 0$?

* If $\vec{B}$ & $\vec{E}$ acting on moving charge $\vec{F}_q = \vec{F}_E + \vec{F}_B$

جمع متجهات $\vec{F}_q = q\vec{E} + q\vec{V} \times \vec{B}$

قانون لورنتز

[illegible] الزاوية الصغيرة

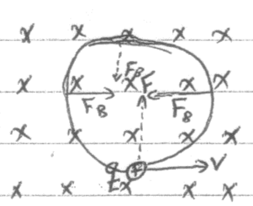
* Applications on magnetic Force :-

1) Uniform Circular motion
2) cyclotron (f doesn't depend on R or V)
3) Mass spectrometer
4) spiral motion (Helical motion)
5) Velocity selector منتقي السرعة
6) Hall Effect

1. Uniform Circular Motion

if $\vec{B} \perp \vec{V}$, q will move in a uniform Circular motion

إذا لم تكن الزاوية = 90 تتحرك حركة (spiral motion)



B inward

$\vec{F}_B = q\vec{V} \times \vec{B}$, $\theta = 90$

$F_B = qVB$

$qVB = \frac{mV^2}{R}$

$R = \frac{mV}{qB}$

period time $= \frac{2\pi R}{V} \Rightarrow T = \frac{2\pi m}{qB}$

$\frac{1}{T}$ frequancy (f) $= \frac{qB}{2\pi m}$

R لا تعتمد على

40

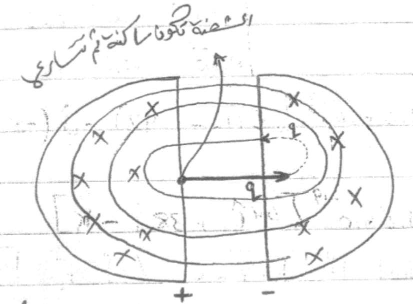
(2) cyclotron ⇒ (to accelerate charges)

* f does not depend on $\underline{R}$ or $\underline{\vec{V}}$

* (عندما تزداد السرعة يزيد نصف القطر ويبقى f ثابت)

* $\vec{F}_B = q\vec{V} \times \vec{B}$ ⇒ Uniform circular $\vec{B} \perp \vec{V}$

$$f = \frac{qB}{2\pi m}$$



* الطاقة $\vec{V}$ يزيد ونصف القطر يزدادان / f ثابتة

$$* \overset{\text{طاقة حركية}}{K} = \overset{\text{عدد مرات الدوران}}{N}(qV)$$

$f_{cyclotron} = f_{circular\ motion}$

- ΔV between the 2 Dees accelerate
- B to move the charge in a circular motion

$$\Delta V = \Delta V_{max} \sin(2\pi f t)$$

$$f_{cyclotron} = \frac{qB}{2\pi m}$$

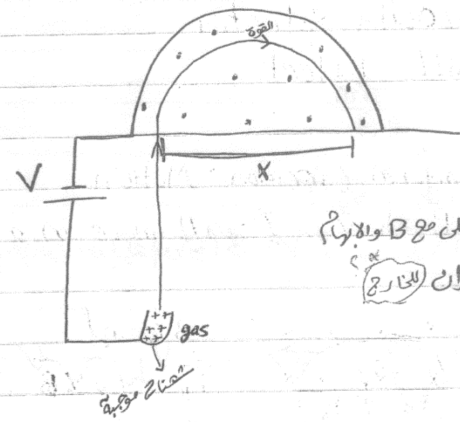
K = K

F = F

(3) Mass spectrometer ⇒ (مطياف الكتلة)

to measure the mass of ions

(q) mass = m ?



* الأصابع للأعلى مع B والإبهام مع القوة والدوران (للخارج)

(1) V accelerate the charge

$$K = qV = \frac{1}{2} m V^2$$

$$\vec{V} = \sqrt{\frac{2qV}{m}}$$

(2) $\vec{B}$ act $\perp$ on V

$$\frac{mV^2}{r} = qVB$$

$$\vec{V} = \frac{qBr}{m} \qquad r = \frac{x}{2}$$

* From [1] + [2] ⇒

$$\sqrt{\frac{2qV}{m}} = \frac{qBr}{m}$$

$$\frac{2qV}{m} = \frac{q^2B^2r^2}{m^2}$$

$$m = \frac{qB^2r^2}{2V} \quad \text{where } r = \frac{x}{2}$$

$$\Rightarrow \boxed{m = \frac{qB^2x^2}{8V}}$$

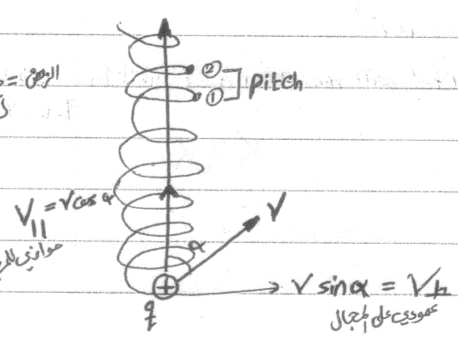
[4] spiral Motion (Helical Motion) الحركة اللولبية

* $\theta \neq 90^\circ$ أول شرط

(زاوية حادة)

- If the angle between $\vec{B}$ + $\vec{V}$ $\neq 90^\circ$ then charge will move in spiral motion

الزمن = دوري [1]



* $V_\perp = V\sin\alpha$ causes a circular motion

$V_{11} = V\cos\alpha$ causes the linear motion

* السرعة الموازية للمجال تتحرك باتجاه المجال

الزمن الدوري نفسه للحركتين العمودية والموازية

$$T = \frac{2\pi m}{qB}$$

$$\text{Pitch} = V_{11}\,T$$

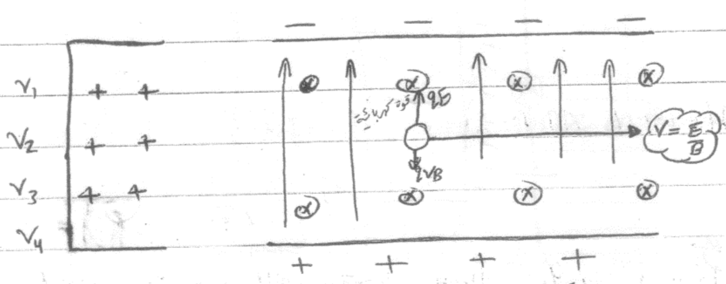
* $\frac{mV_\perp^2}{r} = qV_\perp B$ (العمودية هي التي تقوم بعمل الحركة الدورانية)

$$r = \frac{mV_\perp}{qB} \Rightarrow V_\perp = V\sin\theta$$

Ex electron with Kinetic energy = 22 eV, $B = 0.12\,T$, $\theta = 65^\circ$, find?

1. the electron's speed — 2.78×10^{6} m/s
2. radius of the helical motion — 1.2×10^{-4} m
3. T (periodic time) — 2.7×10^{-10} s
4. pitch المسافة بين — 3.2×10^{-4} m

5 Velocity selector (منتقي السرعات)



(E) is known

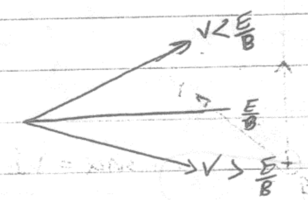
قوة كهربائية $F_E = qE$ upward

قوة مغناطيسية $F_B = qvB$ downward

∴ the charge selected will move in a stright line when $qE = qvB$

∴ when $\Sigma F = 0$

$qE - qvB = 0 \Rightarrow v = \frac{E}{B}$



η

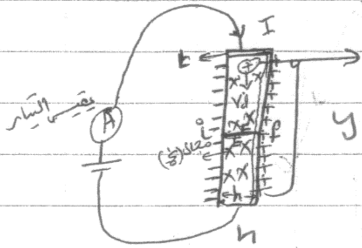
* $\vec{F} = q\vec{V} \times \vec{B}$

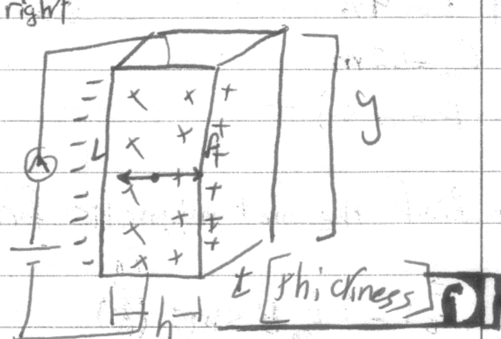
(6) Hall Effect :- (تأثير هول)

* aim :- find V_d ?

(2) to find n ? ($I = neAV_d$)

(3) the type of moving charges in the conductor ?





* metalic strip :-

width = h , length = y

thickness = t (علو الورقة)

n?

Apply B ⊥ surface (hxy) (عمودية)

$\boxed{\cdot}$ t parallel with the magnetic Field

* $F_E = eE$ to the left

At equilibrium

$$\boxed{eE = eV_d B \qquad \vec{V_d} = \frac{E}{B}}$$

فرق الجهد بين أ و ب $V_H = Eh$

↳ measured by voltemeter

$V_H = Eh$

$V_d = \frac{V_H}{hB}$

* $$V_H = \frac{IB}{nqt}$$

$V_d = \frac{I}{neA} = \frac{I}{ne(ht)}$ مساحة على الورقة

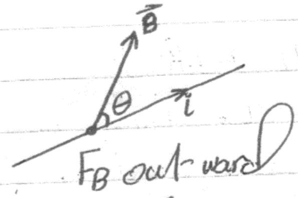
* $E_H = \frac{V_H}{h}$

$V_d = \frac{V_H}{hB}$

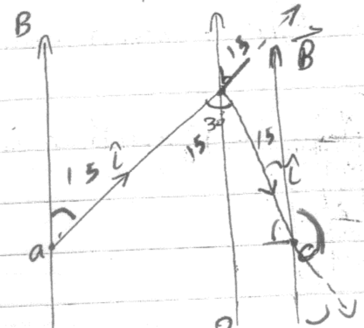
$\frac{V_H}{hB} = \frac{I}{neht} \Rightarrow n = \frac{IB}{V_H e t}$ (t: thickness)

* $\vec{B}$ acts a force on a Conductor carrying current:

$$\vec{F}_B = i\vec{L} \times \vec{B}$$



$$|\vec{F}_B| = iLB\sin\theta$$

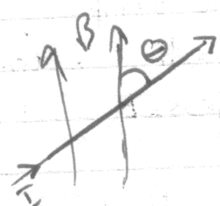


$\boxed{Ex}$ $i = 4A$

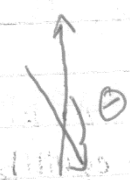
$L_{ab} = 1.2m$

$\vec{B} = 0.5\hat{j}\ T$

* find the net magnetic force on the wire?



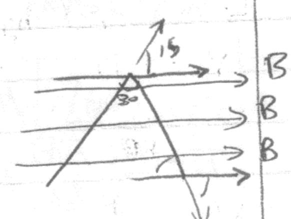
$$(\vec{F}_B) = iL_{ab}B\sin 15\ (\hat{k})$$
$$= 4(0.5)(1.2)(\sin 15)\ \hat{k}$$
$$= 0.62\ \hat{k}\ N$$



$$\vec{F}_{bc} = iL_{bc}B\sin 15\ \hat{k}$$
$$= 4(1.2)(0.5)\sin(165)\ \hat{k}$$
$$= 0.62\ \hat{k}\ N$$
$$\vec{F}_B = 1.24\ \hat{k}\ N$$

* Problem:

In previous example let $\vec{B} = 0.5\hat{i}\ T$ find the net force on the wire?



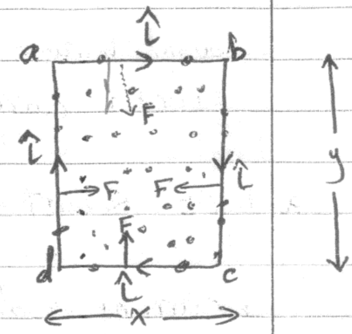
the net force = zero

$\otimes$

$\odot$

* Magnetic force on a loop-carrying current:

Case 1: $F_{ab} = i(x)B\sin 90$



$\vec{F}_{ab} = iBx(-\hat{j})$

$\vec{F}_{dc} = iBx(+\hat{j})$

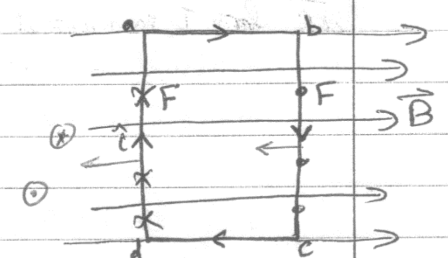
$\vec{F}_{da} = iyB(+\hat{i})$

$\vec{F}_{bc} = iyB(-\hat{i})$

$\Rightarrow \vec{F}_{net} = 0$

$\vec{\tau}_{net} = 0$

Case 2:- $\vec{F}_{ab} = ixB\sin 0 = 0$



$\vec{F}_{cd} = ixB\sin 180 = 0$

$\vec{F}_{da} = iyB\sin 90(-\hat{k})$

$\vec{F}_{bc} = iyB\sin 90(+\hat{k})$

$\Rightarrow \vec{F}_{net} = 0$

$\vec{\tau}_{net} \neq 0$

the loop will rotate

$\tau = (iyB)(x)$ N.m

* Loop with N turns

$\tau = NiAB$ N.m

let $\vec{\mu} = Ni\vec{A}$ (magnetic Dipole moment)

in general $\vec{\tau} = \vec{\mu} \times \vec{B}$

لبرا لم

الاتجاه : حسب قاعدة اليد اليمنى تعتبر الدايبول مغناطيسيا له قطبين

$U = -\vec{\mu} \cdot \vec{B}$

(حساب مجال كهربائي ناتج عن تيار كهربائي)

* origin of the magnetic field (B) $\Rightarrow$

moving charges $\longrightarrow$ B

Electric current $\longrightarrow$ B

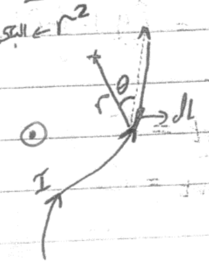
* Biot - savart law :-

a current produces B , where $d\vec{B} = \left(\frac{\mu_0}{4\pi}\right) I \frac{d\vec{L} \times \hat{r}}{r^2}$

طول السلك

r = البعد عن السلك

اتجاه $d\vec{B}$ عمودي على $\hat{r}$, $d\vec{L}$

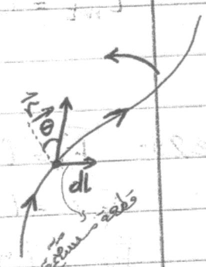


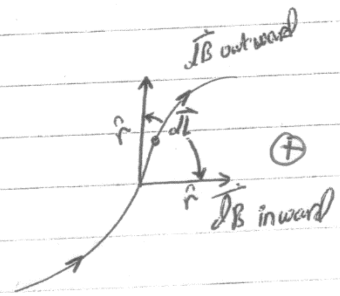
$\hat{r}$ متجه طوله 1 باتجاه

* Note :-

1. $d\vec{B} \perp (\vec{r} + d\vec{L})$
2. $\mu_0 = 4\pi \times 10^{-7}$ T.m/Ampere
3. $d\vec{B}$ from I in a wire of Length = $d\vec{L}$

الأصابع مع dL والدوران مع $\hat{r}$ والإبهام هو $d\vec{B}$

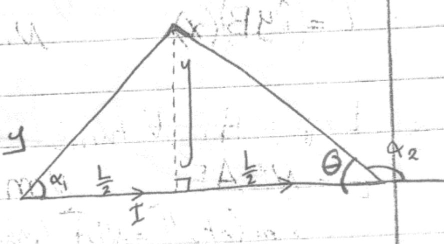




* B from I in a straigh wire :-

$\tan \alpha_1 = \frac{y}{L/2}$

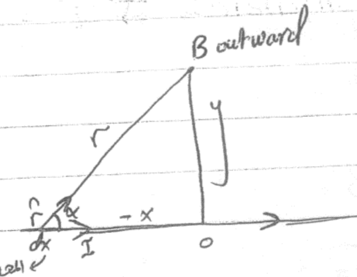
* Length (L), current (I) ; find B a distance y from the wire



$d\vec{B} = \frac{\mu_0}{4\pi} I \frac{d\vec{L} \times \hat{r}}{r^2}$

$d\vec{B} = \frac{\mu_0}{4\pi} I \frac{\cancel{dx} \times \hat{r} \sin\alpha}{r^2}$

$B = \frac{\mu_0}{4\pi} I \int_{-\frac{L}{2}}^{\frac{L}{2}} \frac{\sin\alpha}{r^2}\, dx$



المجال عند النقطة هذه

$$\tan\alpha = \frac{-y}{x}$$

$$x = \frac{-y}{\tan\alpha} = -y\cot\alpha$$

$$dx = -y(-\csc^2\alpha\, d\alpha)$$

$$dx = y\csc^2\alpha\, d\alpha$$

$$\sin\alpha = \frac{y}{r}$$

$$r = y\csc\alpha$$

$$r^2 = y^2\csc^2\alpha$$

$$B = \frac{\mu_0 I}{4\pi}\int \frac{\sin\alpha\, \cancel{y}\cancel{\csc^2\alpha}\, d\alpha}{y^{\cancel{2}}\, \cancel{\csc^2\alpha}}$$

$$= \frac{\mu_0 I}{4\pi y}\int \sin\alpha\, d\alpha$$

$$B = \frac{\mu_0 I}{4\pi y}\left[\cos\alpha_1 - \cos\alpha_2\right] \quad \text{General}$$

$\alpha_1 = 60$

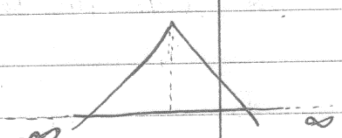
$\alpha_2 = 180 - 60 = 120$

* Note the following 2 cases

1) infinite wire

$\phi = 0$, $\phi_2 = 180$ $\qquad \cos 0 = 1$

$\phi_1 \rightarrow 0 \qquad \phi_2 \rightarrow 180$ $\qquad \cos 180 = -1$



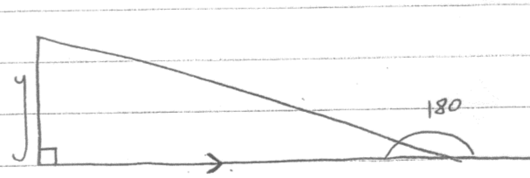
$$B = \frac{\mu_0 I}{4\pi y}(1 - -1)$$

$$B = \frac{\mu_0 I}{2\pi y}$$ for infinite wire

2) semi - infinite wire

$\phi_1 = 90$

$\phi_2 = 180$

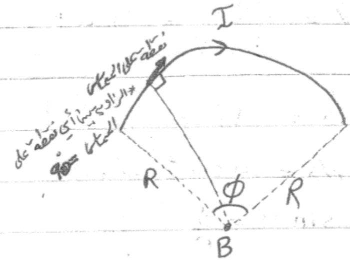


$$B = \frac{\mu_0 I}{4\pi y}(0 - -1)$$

$$B = \frac{\mu_0 I}{4\pi y}$$ B due to I in a curved wire

B due to I in a curved wire (I, R, ϕ)

find B at the center?



$$d\vec{B} = \frac{\mu_0 I}{4\pi} \frac{d\vec{L} \times \hat{r}}{r^2}$$

$$dB = \frac{\mu_0 I}{4\pi} \left(\frac{dL \sin 90}{R^2} \right)$$

$$B = \frac{\mu_0 I}{4\pi R^2} \int dL$$

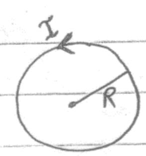
$$B = \frac{\mu_0 I L}{4\pi R^2}$$

$$B = \frac{\mu_0 I (R\phi)}{4\pi R^2}$$

$$B = \frac{\mu_0 I \phi}{4\pi R}$$ تقدير دائري

* Note the following cases ⇒

١



الأصابع مع التيار والابهام هو B

for complete circle $\phi = 2\pi$

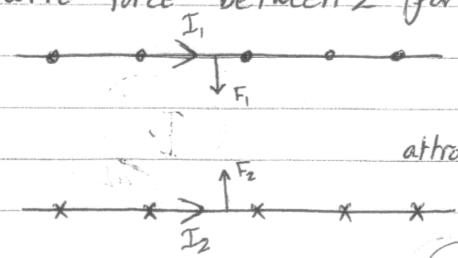
$$B = \frac{\mu_0 I}{2R} \text{ (out ward)}$$

٢ For N turns

$$B = \frac{\mu_0 I N}{2R}$$ عدد الحلقات

* Magnatic force between 2 Parallel wires

①



attractive force

* السلك يؤثر بمجال مغناطيسي على ?

* force on wire 1

$B_2 = \frac{\mu_0 I_2}{2\pi d}$ on wire 1

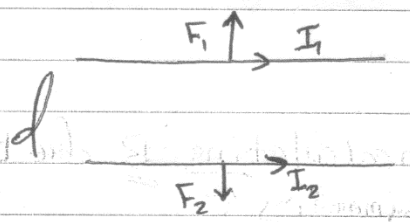
$F_1 = L_1 I_1 \times B_2$

$F_1 = I_1 \left(\frac{\mu_0 I_2}{2\pi d} \sin\theta\right) L_1$

قوة لكل وحدة طول $\frac{F_1}{L_1} = \frac{\mu_0 I_1 I_2}{2\pi d}$ N/m

$\vec{F_1} = \vec{F_2}$

②

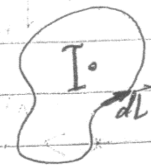


$\frac{F_1}{L_1} = \frac{F_2}{L_2} = \frac{\mu_0 I_1 I_2}{2\pi d}$

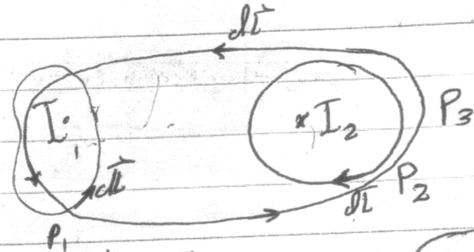
repulsive force

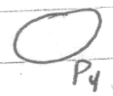
* Ampere's Law :-

$$\boxed{\oint \vec{B} \cdot d\vec{l} = \mu_0 I_{\text{inclosed incircle}}}$$



Ex)





→ يوجد مجال هنا لكن هو صفر $\oint \vec{B} \cdot d\vec{L} = 0$

$$\oint_{P_1} \vec{B} \cdot d\vec{L} = {}^{+}\mu_0 I_1$$

$$\oint_{P_2} \vec{B} \cdot d\vec{L} = {}^{+}\mu_0 I_2$$

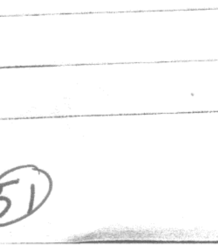
$$\oint_{P_3} \vec{B} \cdot d\vec{L} = \mu_0 ({}^{+}I_1 + {}^{-}I_2)$$

$$\oint_{P_4} \vec{B} \cdot d\vec{L} = 0$$

* Ampere's law is useful in calculating <u>B</u> due to I in a system having <u>High symmetry</u> :-

Ex:A By using Ampere's law find B due to I passing in an infinite wire of radius = R

1) inside the wire



$$\boxed{J_1 = \frac{I}{\pi R^2} = \frac{I_s}{\pi r^2}}$$

$$\oint_{1} \vec{B} \cdot d\vec{L} = \mu_0 I_{enc}$$

$$B\, 2\pi r = \mu_0 [J \pi r^2]$$

$$B\, 2\pi r = \mu_0 \left[\frac{I}{\pi R} \cdot \pi r^2\right]$$

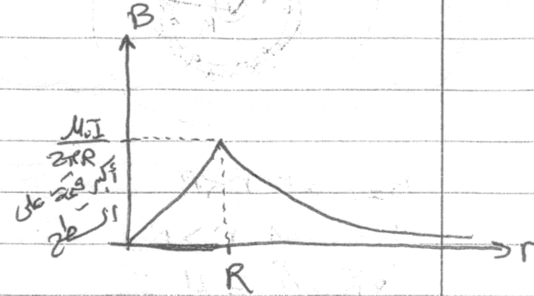
$$B = \left(\frac{\mu_0 I}{2\pi R^2}\right) r \quad , \; r \leq R$$

ii> B outside the wire at $r > R$

$$\oint \vec{B} \cdot \vec{dl} = \mu_0 I_{enc}$$

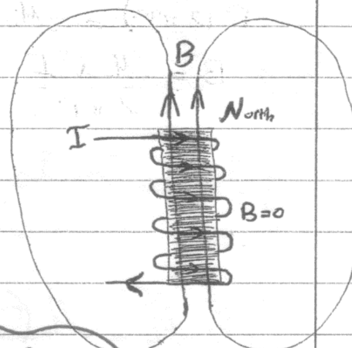
$$B(2\pi r) = \mu_0 I$$

$$B = \frac{\mu_0 I}{2\pi r} \quad , \quad r \geq R$$



* A Solenoid:

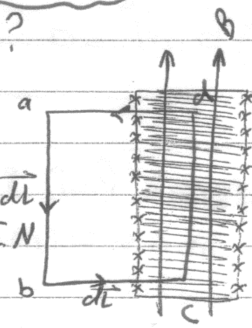
- find B due to I in an ideal solenoid $R \ll$ length



* B inside the ideal solenoid is uniform $\boxed{B_{outside} \approx 0}$ near the center find B inside the solenoid ?

$$\oint \vec{B} \cdot \vec{dl} = \mu_0 I_{enc}$$

$$\int_a^b \vec{B} \cdot \vec{dl} + \int_b^c \vec{B} \cdot \vec{dl} + \int_c^d \vec{B} \cdot \vec{dl} + \int_d^a \vec{B} \cdot \vec{dl} = \mu_0 I N$$



$$0 + 0 + BL + 0 = \mu_0 N I$$

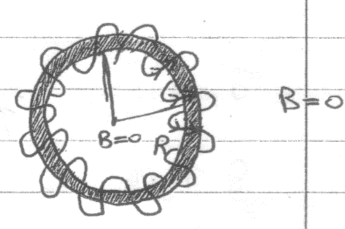
$$B = \mu_0 \frac{N I}{L}$$

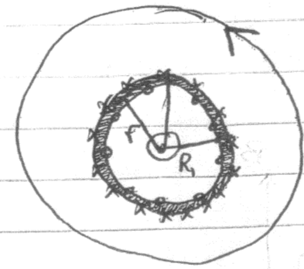
$$\boxed{B = \mu_0 n I} \; , \; \boxed{n = \frac{N}{L}} \text{ number of turns / m}$$

لفة/متر

* Toroide:

number of turns $= N$ inner radius $= R_1$ / outer radius $= R_2$ / current $= I$ find B ? everywhere.





$B = 0$ at $r < R_1$

$B = 0$ at $r > R_2$

$\oint \vec{B} \cdot d\vec{l} = \mu_0 I_{enc}$

$B(2\pi r) = \mu_0 N I$

$B = \dfrac{\mu_0 N I}{2\pi r}$, $R_1 \leq r \leq R_2$

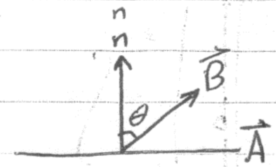
Ch8

:

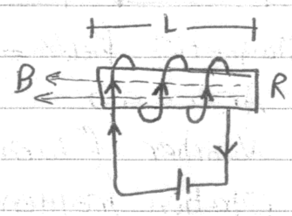
8 - Electromagnetic Induction

* Magnetic Flux :-

$$\Phi_B = \int \vec{B} \cdot d\vec{A}$$
$$= \vec{B} \cdot \vec{A} \quad T.m^2 = Weber$$

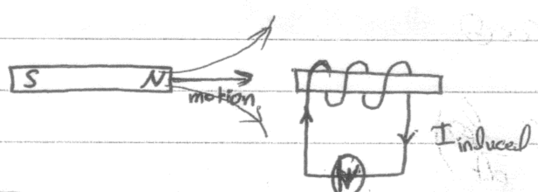


Ex: $B = \mu_0 n I$, $n = \frac{N}{L}$



$$\Phi_B = \vec{B} \cdot \vec{A}$$
$$\Phi_B = \mu_0 n I \pi R^2 \quad \text{from 1 turne}$$
$$* \quad \Phi_B = N [\mu_0 n I \pi R^2] \quad \text{لعدد اللفات}$$

* Induced current :-



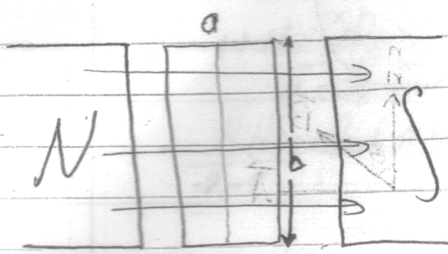
I_{ind} is due to the relative motion between the circuit & the magnet

* Faraday's Law :-

$$\mathcal{E}_{ind} = (-) N \frac{d \Phi_B}{dt} \text{ volt}, \quad \Phi_B = B A \cos\theta$$

You produce $\mathcal{E}_{ind}$ by changing 1) B 2) A 3) θ 4) Any combination B, A, θ,

- Electring Generator :-



Magnetic field = B
Area = ab
Number of turns = N
rotation frequency = f

$$\mathcal{E}_{ind} = (-) N \frac{d\Phi_B}{dt}$$

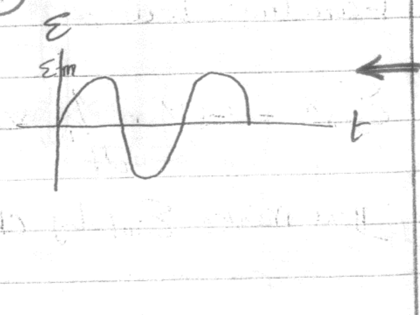
$$= (-) N \frac{d}{dt}\left[Bab \cos\theta \right]$$

$$= (-) NBab \frac{d}{dt} \cos\theta$$

$$= (-) NBab \left(-\sin\theta \frac{d\theta}{dt} \right)$$

$$\mathcal{E}_{ind} = (NabBw) \sin\theta \quad , \quad w = \frac{d\theta}{dt} \text{ rad/s}$$

$$\mathcal{E}_{ind} = (2\pi f NabB) \sin(wt)$$

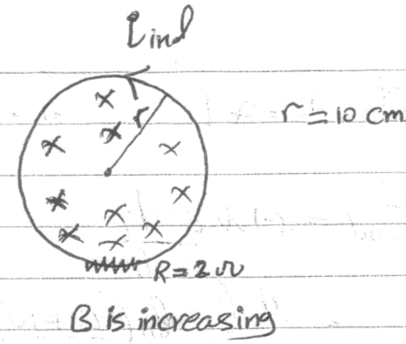


$$\boxed{\mathcal{E}_{ind} = \mathcal{E}_m \sin(wt)}$$

- $w = 2\pi f$

Ex 8 where $\frac{dB}{dt} = 0.1$ T/s

find $\mathcal{E}_{ind}$, i_{ind} ?



$$\mathcal{E}_{ind} = (-)\frac{d\Phi_B}{dt}$$

$$= (-)\frac{d}{dt}\left(B\pi r^2\right)\cos 180$$

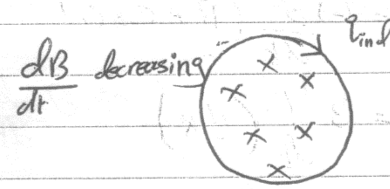
$$= (-)\pi r^2 \frac{dB}{dt}$$

$$\mathcal{E}_{ind} = (-)3.14 \times 10^{-3}\ V$$

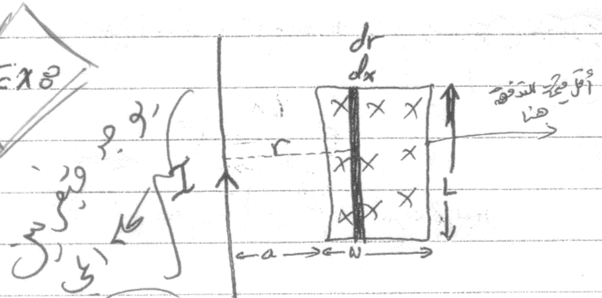
$$i_{ind} = \frac{\mathcal{E}_{ind}}{R} = 1.6 \times 10^{-3}\ Amp$$

* Lenz' Law

The direction of (i_{ind}), such that its magnetic field opposites the change in Φ_B



Ex 8



* التغير في التدفق موجب
⇐ (ب) بعكس (ب) الاصلي ليقاوم
الزيادة فيه
* التغير في التدفق سالب
⇐ (ب) بنفس اتجاه (ب) الاصلي ليقاوم
النقص فيه

$$B = \frac{\mu_0 I}{2\pi r}$$

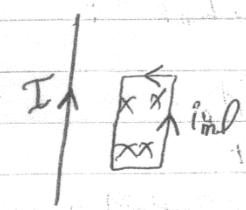
$$\Phi_B = \int \vec{B}\cdot d\vec{A} = \int_a^{w+a} \frac{\mu_0 I}{2\pi r}\,(L\,dx), \quad dx = dr$$

$$= \frac{\mu_0 I l}{2\pi} \int_a^{a+w} \frac{dr}{r}$$

if $I \neq$ ct find $\mathcal{E}_{ind}$ I متغيرة مع الزمن

$$\mathcal{E}_{ind} = (-) N \frac{d\phi_B}{dt}$$

$$= \frac{\mu_0 l}{2\pi} \ln\left(\frac{a+w}{a}\right) \frac{dI}{dt}$$

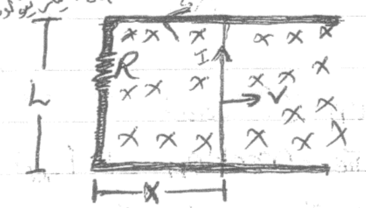


* $\mathcal{E}_{ind} = (-) N \frac{d\phi_B}{dt}$, $\phi_B = BA\cos\theta$

- induced current & Energy :-

B inward ?
move ① by a velocity

يتولد تيار حثي يقاوم الزيادة
ومن اتجاه التيار يتولد مجال للخارج ⊙



find $\mathcal{E}_{ind}$?

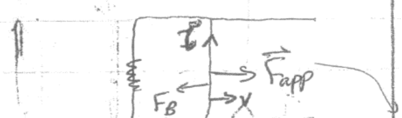
$$\mathcal{E}_{ind} = (-) \frac{d}{dt} (BA\cos\theta)$$

$$= B \frac{d}{dt} (lx)$$

$$= BL \frac{dx}{dt}$$

$$\mathcal{E}_{ind} = BL\vec{V} \text{ volt}$$

يتحرك بسرعة ثابتة وذلك بسبب وجود قوتين متعاكستان



اتجاه التيار مع ⊗ المجال

قوة خارجية تعطي طاقة

$$I_{ind} = \frac{\mathcal{E}_{ind}}{R} = \frac{Blv}{R}$$

* power dissipated in $R = I^2 R$
  $P = IV$
  $$= \frac{B^2 l^2 V^2}{R} \text{ watt (thermal Power)}$$

* power supplied by $F_{app} = \vec{F}_{app} \cdot \vec{V} = F_{app} V \cos\theta$
  $P = \vec{F} \cdot \vec{V}$

* there are 2 Forces acting on ℓ :
  1. F_{app} to the right
  2. $\vec{F}_B = i\, \vec{L} \times \vec{B}$, $F_B = iLB$ to the Left

- $\vec{F}_{net} = 0$ on the wire (ℓ)

  $F_{app} = iLB$

* Power done by $F_{app} = F_{app} \vec{V}$

$$= iLB\vec{V} \qquad * \; I_{ind} = \frac{BLV}{R}$$

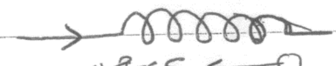
$$= \frac{BLV}{R} (\ell B V)$$

$$= \frac{B^2 \ell^2 V^2}{R}$$

$\Rightarrow$ Input power by F_{app} = dissipated Power i in R

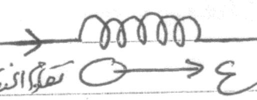
حث ذاتي

Self Induction :-

1. $\frac{di}{dt}$ is increasing 

   $\mathcal{E}_L$ تقاوم الزيادة

   قوة دافعة حثية

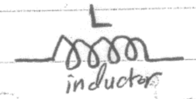
2. $\frac{di}{dt}$ decreasing 

   تقاوم النقصان $\mathcal{E}_L$

* self induction ..... producing $\mathcal{E}_{ind}$ by changing i in the circuit

$$\mathcal{E}_{ind} \propto \frac{di}{dt}$$

$$\mathcal{E}_L = (-) L \frac{di}{dt}$$

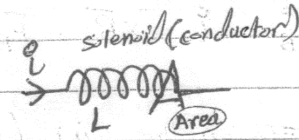
* L inductance  for the inductor

$$L = \frac{N \Phi_B}{I} \quad \text{Henry} = \text{weber / Amp}$$

فقط هالشكل شائع

Ex86 find L for a solenoid of N turns & length $= L$

$$L = \frac{N\Phi_B}{I}$$



$B = \mu_0 n I$ (from Ampere's Law)

$\Phi_B = \mu_0 n I A$

$$L = \frac{N \mu_0 n I A}{I} \quad , N = nl$$

$L = \mu_0 n^2 (Al) = \mu_0 n^2$ Volume Henry

- $R = \frac{V}{i} \Rightarrow R = \frac{\rho l}{A}$

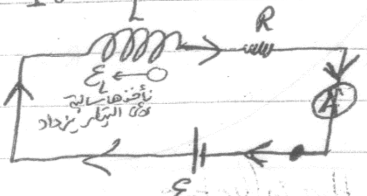
- $C = \frac{q}{V} \Rightarrow C = \frac{\epsilon_0 A}{d}$

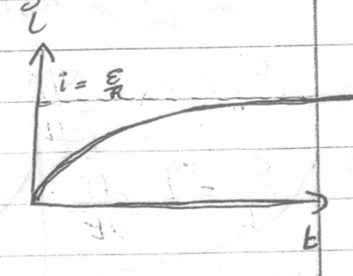
- $L = \frac{N\Phi_B}{I} \Rightarrow L = \mu_0 n^2$ volume

تعتمد فقط على الابعاد

RL - circuit :-

- case 1:





i increases gradually from $0 \rightarrow i_{final} = \frac{\mathcal{E}}{R}$

$$* \; I = I_{(10)} \, e^{\left(-\frac{\Delta t}{L}\right)} \quad , \Delta t = 15 - 10$$

* find $i(t)$?

By using Kirchhoff's law:

$$* \; +\mathcal{E} - L\frac{di}{dt} - iR = 0$$

$$\mathcal{E} = L\frac{di}{dt} + iR$$ Looks like RC-circuit

$$\left[\begin{array}{l} \mathcal{E} = iR + \frac{q}{C} \\ \mathcal{E} = R\frac{dq}{dt} + \frac{q}{C} \end{array}\right]$$

$$i(t) = \frac{\mathcal{E}}{R}\left(1 - e^{-t/\tau_L}\right)$$

* increasing:

$$\mathcal{E}_L = -\mathcal{E} \, e^{-\frac{t}{\tau}}$$

$$* \; \tau_L = \frac{L}{R} \; (S)$$

decreasing

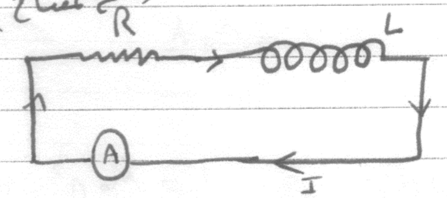
$$\mathcal{E}_L = \mathcal{E} \, e^{-\frac{t}{\tau}}$$

$$* \; q(t) = C\mathcal{E}\left(1 - e^{-t/\tau_C}\right)$$

$$\tau_C = RC \; (S)$$

* بعد انغلاق الدائرة مباشرة ⇐ التيار الابتدائي المار = صفر ، ولكن الجهد بالعكس

Case II بدون بطارية (فتح المفتاح)

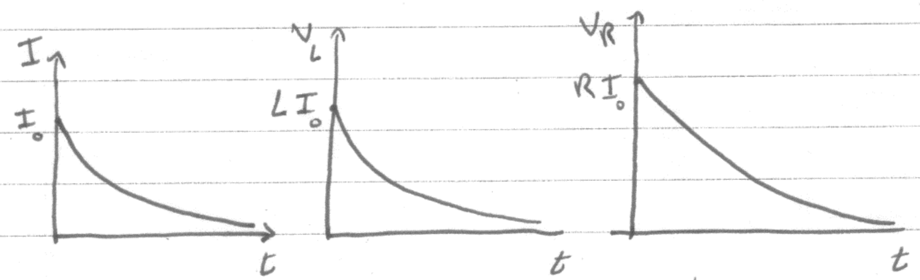


from Kirchoff rule

$$iR + L\frac{di}{dt} = \mathcal{E}$$

* القوة المغناطيسية تخزن الطاقة مثل القوة الكهربائية

$$I(t) = I_0 \, e^{-t/\tau_L}$$



نضرب بـ R

from Q 56

$$\frac{dI}{dt} = \frac{\mathcal{E}_0}{L} \, e^{-\frac{Rt}{L}}$$

$$\frac{\mathcal{E}}{L} = \frac{dI}{dt}$$

after very long time:

$$* \; \frac{dI}{dt} \rightarrow 0$$

$$* \; I = \frac{\mathcal{E}_0}{R}$$

* Magnetic Energy $\Rightarrow$

$$\mathcal{E} = IR + L\frac{dI}{dt}$$ نضرب بـ I

$$\mathcal{E} I = I^2 R + LI\frac{dI}{dt}$$

* $LI\frac{dI}{dt}$: Averege power stored

* $I^2R = P_R$ (thermal Power in R) (watt) (w)

* $\mathcal{E} I$: Power supplied to the circuit, the power source($\mathcal{E}$)

معدل الطاقة التي تزود من البطارية

* $\frac{dU_B}{dt} = LI\frac{dI}{dt}$ [The storied energy rate in the magnetic Field]

$$\int_0^{U_B} dU_B = \int_0^I LI\,dI$$

$$U_B = \frac{1}{2}LI^2 \quad (J)$$

• الطاقة المغناطيسية المخزنة في المحث

• stored magnetic energy in L

* Magnetic energy density

* عند قسمتها على Volume يصبح لدينا :

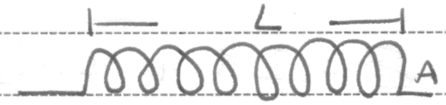
* Stored energy in various system:-

1. $U_g = mgh$
2. $U_s = \frac{1}{2}Kx^2$
3. $U_E = \frac{1}{2}CV^2$
4. $U_B = \frac{1}{2}LI^2$

* لأن كل القوى هنا متساوية/محفوظة لذلك الشغل المبذول يخزن ولا يضيع

$u_E = \frac{1}{2}\varepsilon_0 E^2$

* Magnetic Energy Density :-



~~U_B =~~

$$u_B = \frac{U_B}{\text{Volume}} \quad J/m^3$$

$$u_B = \frac{\frac{1}{2} L I^2}{\text{Volume}} = \frac{\mu_0 n^2 \cancel{(Al)} I^2}{2 \cancel{(Al)}} = \frac{\mu_0 n^2 I^2}{2}$$

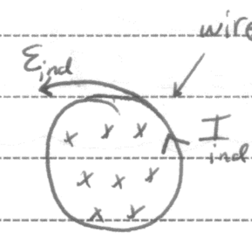
* but $B = \mu_0 n I$

$$u_B = \frac{\mu_0^2 n^2 I^2}{2 \mu_0} = \frac{B^2}{2 \mu_0} \quad J/m^3 \qquad \left(* \frac{\mu_0}{\mu_0}\right)$$

$$u_B = \frac{B^2}{2 \mu_0}$$

$$u_E = \frac{1}{2} \varepsilon_0 E^2 \quad J/m^3$$

* Induced Electric Field



$\frac{dB}{dt}$ is increasing

ε_{ind} and I_{ind} in circuit * لكن المجال الحثي الخارج * (تعمل دائرة)

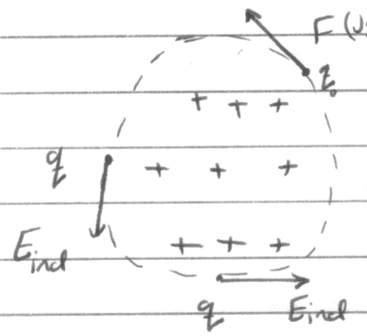
$$\varepsilon_{ind} = (-) \pi r^2 \frac{dB}{dt}$$

Work done by ε_{ind} moving q_0 around a complete circle :

* $w = \varepsilon_{ind} \, q_0$ رشل

* Changing B Produce induced ~~circle~~ electric Fileel

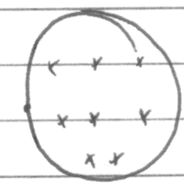
في حالة عدم وجود سلك



ع ازاحة سلك

No wire *

* اذا يوجد electric field, سيؤثر عليها



* دائماً على المماس يوجد E_{ind}

* $\frac{dB}{dt}$ Produce induced Electric Field in a circular Force

* work done By E_{ind} in moving q_0 around a circle :

$$\boxed{w = \oint q \vec{E} \cdot d\vec{l}}$$

$\boxed{\oint \text{ جمع مغلق}}$

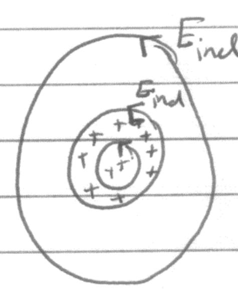
* E_{ind} ؛ عند ما تنقل ~~على~~ لانه شغله على مسار مغلق يساوي صفر

$$q_0 \mathcal{E} = q_0 \oint \vec{E}_{ind} \cdot d\vec{l}$$

* $\mathcal{E}_{ind} = \oint E_{ind}\, d\vec{l}$

* $$\boxed{\mathcal{E}_{ind} = (-) \frac{d\Phi_B}{dt}}$$

* E_{ind} is nonConservativ field



* $\mathcal{E}_{ind} = (-) \frac{d\Phi_B}{dt}$

$\oint \vec{E} \cdot d\vec{l} = (-) \frac{d\Phi_B}{dt}$

] faraday's Law

$\frac{dB}{dt}$ increasing

في الداخل وعلى المحور في الخارج

* اذا تغير التدفق المغناطيسي مع الزمن في الهواء يتولد مجال كهربائي على شكل دوائر

Ch10

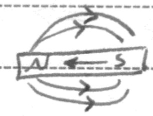
:

Ch 10:-

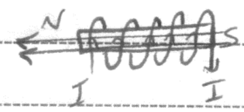
Maxwell's Equations

Magnatic Dipole Moment:

- Natural magnett



- solenoid



- circular current:-

$\vec{M} = N I \vec{A}$

* Magnatic Monople do not Exist

⟹ Gauss' Law in Magnetism:

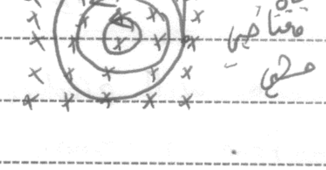
closed $\oint \vec{B} \cdot d\vec{A} = 0$ "represent the fact that is no magnetic monopole"

⟹ Farady's Law of induction:-

$$\mathcal{E}_{ind} = (-) \frac{d \Phi_B}{dt}$$

$$\oint \vec{E} \cdot d\vec{L} = (-) \frac{d \Phi_B}{dt}$$

$\frac{dB}{dt}$ is increasing, will produce $\vec{E}$ in a circular form



Maxwell's Law :-

Changing Electric flux will produce Magnetic Field in a circular form

$$\frac{d\Phi_B}{dt} \Rightarrow B$$

where $\oint \vec{B}\cdot d\vec{L} = \mu_0 \varepsilon_0 \frac{d\Phi_E}{dt}$ (~~from~~ Max. Law)

<u>proof</u>

$$\oint \vec{B}\cdot d\vec{L} = \mu_0 I \quad \text{(Amper's Law)}$$

$$\oint \vec{B}\cdot d\vec{L} = \mu_0 i + \mu_0 \varepsilon_0 \frac{d\Phi_E}{dt}$$

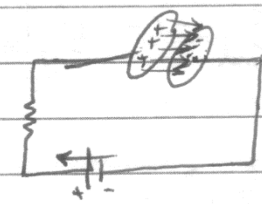
Ampere-Maxwell Law

$$I_d = \epsilon_0 \frac{d\Phi_E}{dt} \to E$$

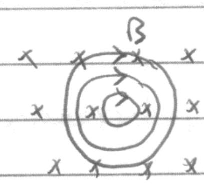
I_d : displacement current (A)
Φ_E

* Example : Charging a capacitor :

→ During charging a capacitor, Q increase and E increase



→ So Φ_E is increasing



* will produce magnetic field in a circular form between the plates at $r \leq R$ at $r \geq R$

* Maxwell's Equation :-

1) $\oint \vec{E} \cdot d\vec{A} = \frac{q_{enc}}{\varepsilon_0}$

2) $\oint \vec{B} \cdot d\vec{A} = 0$

* 3) $\oint \vec{E} \cdot d\vec{l} = (-)\frac{d\Phi_B}{dt}$

4) $\oint \vec{B} \cdot d\vec{l} = \mu_0 i + \mu_0 \varepsilon_0 \frac{d\Phi_E}{dt}$

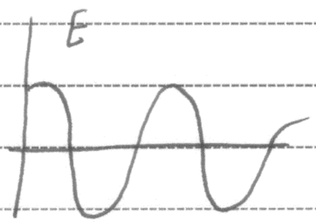
From these 4 equations, proves the existence.

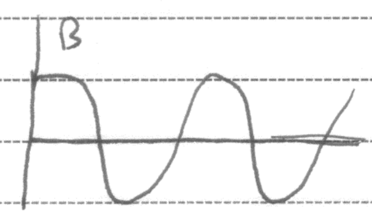
* Electromagnetic waves consist from $\vec{E} \perp \vec{B} \perp \vec{C}$

"speed of (EMW)"

$\vec{E} = E_{max} \cos(Kx - wt)\ \underline{i}$

$\vec{B} = B_{max} \cos(Kx - wt)\ \underline{j}$





$C = \frac{1}{\sqrt{\mu_0 \varepsilon_0}} = 3 \times 10^8\ m/s$

سرعة الضوء

بالتوفيق