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فيزياء 2

Physics 2



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① سقّم لحاجة الأجهزة

② تخزين الطاقة الكهربائية

chapter (26)

Capactance and dielectrics

المواد العازة ← العوازل

↳ combination of 2 conductors, called a (capacitor)

* capacitor (مكثف) (plates)

* capacitance (السعة)

• potential difference (ΔV)

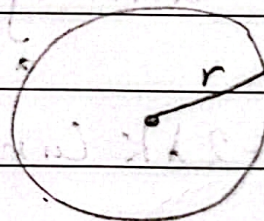
• Capacitance: ratio between the magnitude of the charge (Q) on either conductor to the magnitude of potential difference between them.

$$C = \frac{|Q|}{|\Delta V|} = \left(\frac{C}{V} \right) \rightarrow \text{الوحدة} = \text{Farad (F)}$$

تقريباً:
 $nF = 10^{-9}$, $\mu F = 10^{-6}$, $mF = 10^{-3}$, $PF = 10^{-12}$

① capacitance of an insulated charged sphere:

$$C = \frac{Q}{V} = \frac{Q}{\frac{Q}{4\pi\epsilon_0 r}} = 4\pi\epsilon_0 r$$



$$C = 4\pi\epsilon_0 r = \frac{r}{k_e}$$

$$V = \frac{k_e Q}{r}$$

② parallel plates capacitor:

between them $E = \frac{\sigma}{\epsilon_0}$

$$\Delta V = Ed$$

$$\Delta V = \frac{\sigma d}{\epsilon_0}$$

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

$$C = \frac{A \epsilon_0}{d}$$

③ cylindrical capacitor:

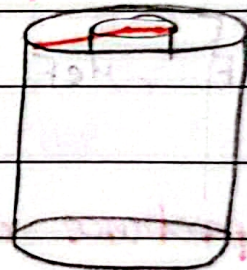
$$\Delta V = - \int_a^b E \cdot ds$$

$$= -2\lambda K \int_a^b \frac{1}{r} dr$$

$$= -2\lambda K \ln r \Big|_a^b = -2\lambda K (\ln b - \ln a)$$

$$= -2\lambda K \ln\left(\frac{b}{a}\right) \#$$

$$C = \frac{Q}{V} \rightarrow C = \frac{\lambda L}{2\lambda K \ln\left(\frac{b}{a}\right)}$$



$$C = \frac{L}{2k \ln\left(\frac{b}{a}\right)}$$

$$\therefore \frac{C}{L} = \frac{1}{2k \ln\left(\frac{b}{a}\right)}$$

per unit length

④ Spherical capacitor:

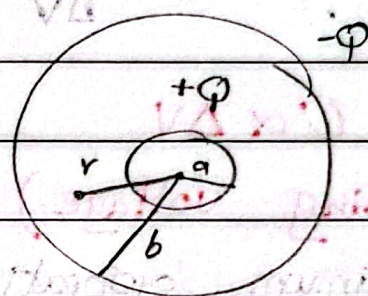
$$E = \frac{kQ}{r^2}$$

$$\Delta V = - \int_a^b E \cdot ds$$

$$= -kQ \int_a^b \frac{1}{r^2} dr = \left[\frac{kQ}{r} \right]_a^b$$

$$= kQ \left(\frac{1}{b} - \frac{1}{a} \right) = kQ \left(\frac{b-a}{ab} \right)$$

$$C = \frac{ab}{k(b-a)}$$



Energy stored in capacitor:

$$U = \frac{Q^2}{2C} = \frac{1}{2} Q \Delta V = \frac{1}{2} C (\Delta V)^2 \quad (\text{J})$$

← الوحدة

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

* $U \propto \Delta V$, $U \propto Q$

(Breaking voltage):

maximum operating (voltage) of the capacitors

• Parallel plate capacitor: [Energy]

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

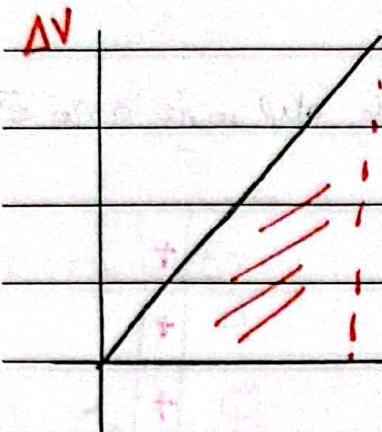
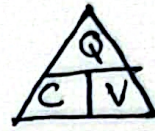
$$= \frac{1}{2} \left(\frac{A \epsilon_0}{d} \right) (E d)^2 = \frac{1}{2} \underbrace{A d}_{V \rightarrow \text{volume}} \epsilon_0 E^2$$

$$\therefore U = \frac{1}{2} V \epsilon_0 E^2$$

$$\therefore \frac{U}{V} = \frac{1}{2} \epsilon_0 E^2 \Rightarrow \text{energy per volume} \\ (\text{energy density}) \quad (\text{J/m}^3)$$



for any capacitor.



$$\text{slope} = \frac{\Delta V}{Q} = \frac{1}{C}$$

Area under the curve

= energy stored (U)

Q

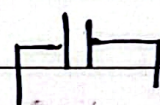
• Combination in series and parallel for capacitors:

□ parallel : (القائى) الفرق بين البطارية والمواضع

① $V_{eq} = V_1 = V_2 = V_3$

② $Q_{eq} = Q_1 + Q_2 + Q_3$

③ $C_{eq} = C_1 + C_2 + C_3$

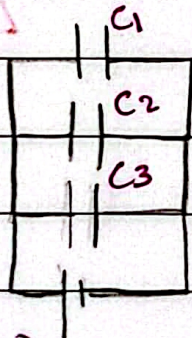


مواضع



بطارية

أكبر من أكبر وحدة منهم



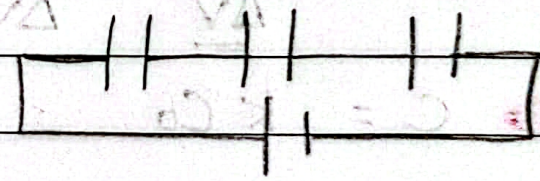
بطارية

□ Series : (التوالى)

① $Q_{eq} = Q_1 = Q_2 = Q_3$

② $V_{eq} = V_1 + V_2 + V_3$

③ $\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} \Rightarrow$



$C_{eq} = \frac{C_1 C_2}{C_1 + C_2}$

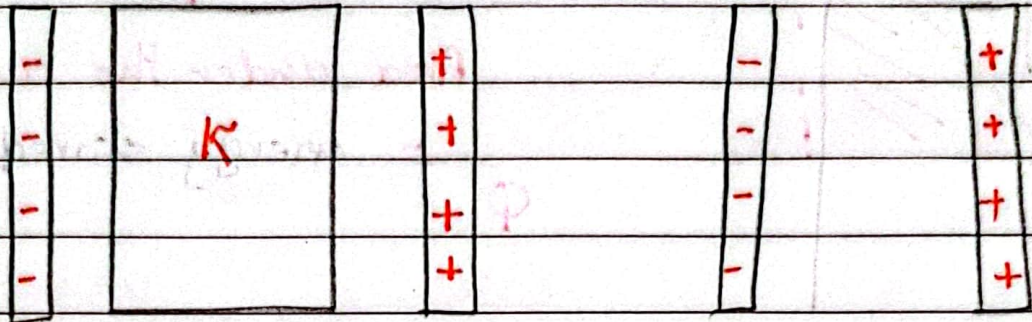
في حالة

مواضعتين فقط

أقل من أقل وحدة منهم

* Dielectric Materials:

مادة عازلة مثل الزجاج أو البلاستيك توضع بين الصفيحتين



$$V = \Delta V \quad \left[\begin{array}{c} \text{the same} \\ \text{after \& before} \end{array} \right] \quad V = \Delta V_0$$

$$Q = Q \quad \left[\begin{array}{c} \text{the same} \\ \text{after \& before} \end{array} \right] \quad Q_0 = Q$$

$$\Delta V = E d$$

$$= \frac{\sigma}{\epsilon} d$$

$$\epsilon = K \epsilon_0$$

$$= \frac{\sigma d}{K \epsilon_0} = \frac{\Delta V_0}{K}$$

$$\Delta V_0 = E_0 d$$

$$\rightarrow \Delta V_0 = \left(\frac{\sigma}{\epsilon_0} \right) d$$

$$\rightarrow C_0 = \frac{Q}{\Delta V_0}$$

K : dielectric constant

depends on the material type

$$\Rightarrow C = \frac{Q}{\Delta V} = \frac{Q K}{\Delta V_0}$$

$$\Rightarrow C = K C_0$$

before	$\phi = \phi$	after
① ΔV_0		② $\Delta V = \frac{\Delta V_0}{K}$

③ $E_0 = \frac{\Delta V_0}{d}$

② $E = E_0 / K$

③ $C_0 = \frac{Q_0}{\Delta V_0}$

$\Rightarrow$ ③ $C = K C_0$

④ $U_0 = \frac{Q_0^2}{2C_0}$

④ $U = \frac{U_0}{K} \rightarrow \text{decrease}$

* minimum value for K is (1) in air
 (if $k=1$) $\Rightarrow (E = K E_0) \rightarrow (E = E_0)$

in parallel plates capacitor

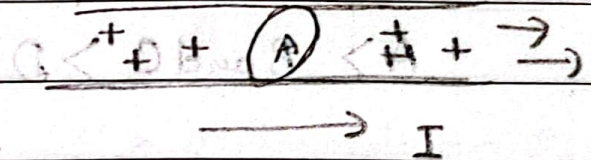
$$C = K \frac{E_0 A}{d}$$

chapter (27)

Current and Resistance:

Electric current: is the flow of electric charges through a conductor
(تيار كهربائي)

$$\Rightarrow I_{avg} = \frac{\Delta Q}{\Delta t}$$



$\hookrightarrow$ number of charges pass through A in unit time

الوحدة $I = \frac{C}{sec} = A$ (Ampere)

$\Rightarrow$ instantaneous current $I = \frac{dQ}{dt}$

Microscopic model of current:

$$Q = n q_e \cdot \underline{V}$$

$n = n^*$ = number of free carries per unit of Volume

$$Q = n^* q_e \underline{V}$$

$$\left(Q = n^* q_e (A \Delta x) \right) \div \Delta t$$

$$I = n^* q_e A v_d$$

v_d = drift velocity (speed)

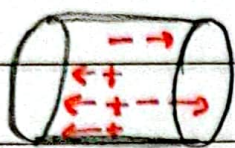
A: cross section

$\Rightarrow [I = n^* A q_e v_d]$

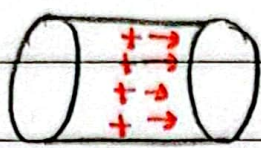
$q_e = 1.6 \times 10^{-19} C$

I تيار على مدار السلك

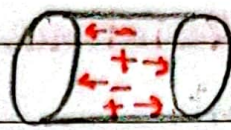
v_d تكون صغيرة نسبياً مقارنة بـ zigzag سبب التصادمات



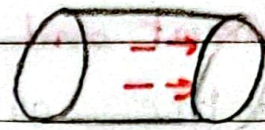
A



B



C



D

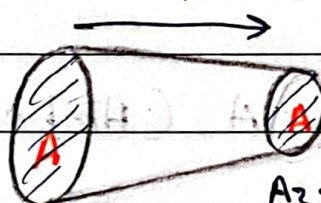
(I) (current) $\propto$ كثافة التيار

$$A > B \text{ and } C > D$$

التيار يتناسب عكسياً مع نصف القطر

* Current density: (J)

[non-uniform conductor]



I is constant.

(في المسلكين)

$$A_2 = \pi r_2^2$$

$$A_1 = \pi r_1^2$$

$$\Rightarrow J = \frac{I}{A} \quad \text{A/m}^2$$

$$J_1 = \frac{I}{\pi r_1^2}$$

$$J_2 = \frac{I}{\pi r_2^2}$$

$$[I = n^+ q_e A v_d \Rightarrow J = n^+ q_e v_d]$$

* *

$$J \propto E$$

$$\left(\frac{I}{A} \right) = \sigma \frac{\Delta V}{L}$$

A/m.Volt

$$[J = \sigma E]$$

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

σ electric conductivity

$$\Delta V = R I$$

$$\rho = \frac{1}{\sigma} \quad (\text{resistivity})$$

resistance

$$\frac{m \cdot v}{A}$$

$$\Delta V = \frac{R}{\Omega} \cdot \frac{I}{A} \quad \text{ohm's law} \quad \begin{matrix} \text{volt} & \Omega & A \end{matrix}$$

$$* R = \frac{\rho L}{A} = \frac{\Omega \cdot m}{A} \cdot \frac{m}{m^2} = \frac{\Omega \cdot m}{A} = \Omega \cdot \text{ohm}$$

$$* \rho = \frac{RA}{L} = \frac{\Omega \cdot m^2}{m} = \Omega \cdot m \quad * R \text{ depends on } \rho, L, A$$

(Type and Shape of material)

$$* \sigma = \frac{1}{\rho} = (\Omega \cdot m)^{-1}$$

* R independent on V and I

Power: (P) (القدرة)

* what is the power delivered in the resistor.

* what is the Heat power dissipated in the resistor

$$\left[P = I \Delta V, P = I^2 R, P = \frac{\Delta V^2}{R} \right] \Rightarrow \text{watt}$$

- Resistance and Temperature :-

ρ : depends on T & shape of material

$$\left[R(T) = R_0 (1 + \alpha \Delta T) \right] \quad \begin{matrix} T - T_0 \\ \hookrightarrow \\ \text{at } 20^\circ \text{C} \end{matrix}$$

$\hookrightarrow$ resistance at Temp (T)

α : from Tables, (thermal Resistance coefficient) ($^\circ\text{C}^{-1}$)

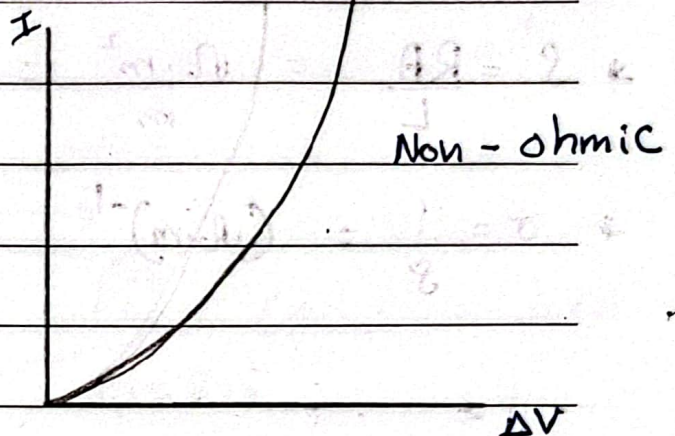
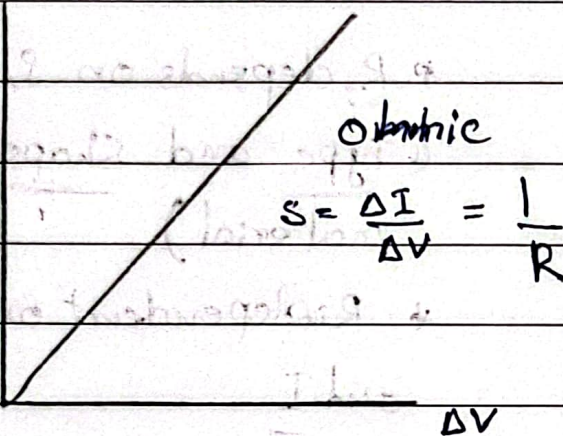
R_0 resistance at $T_0 = 20^\circ\text{C}$

$$\rho = \rho_0 (1 + \alpha \Delta T) \quad (*)$$

$$\alpha = \frac{1}{\rho_0} \frac{\rho}{\Delta T}$$

($^{\circ}\text{C}^{-1}$) [Temp. coefficient of resistivity]

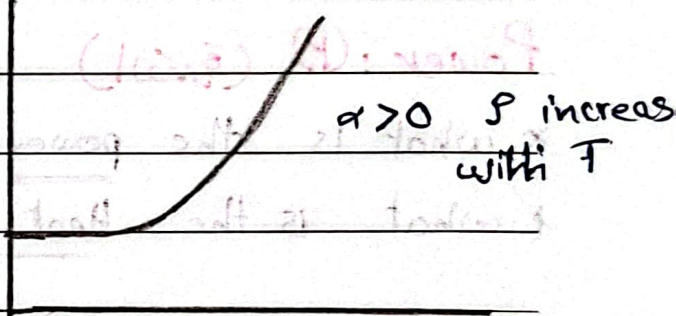
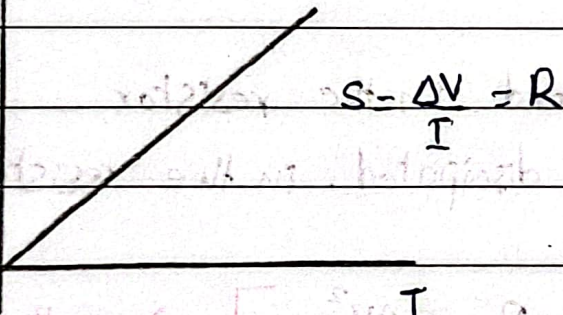
I



ΔV

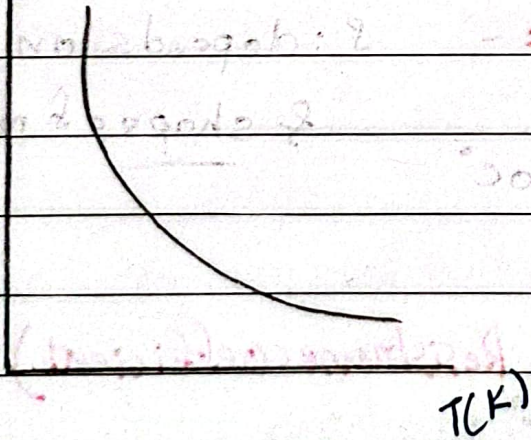
ρ

ΔV



metals

ρ



$\alpha < 0$ ρ decrease with T ↑ increasing

chapter (28)

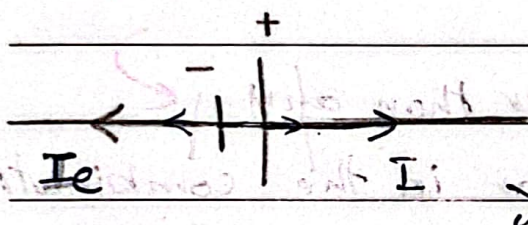
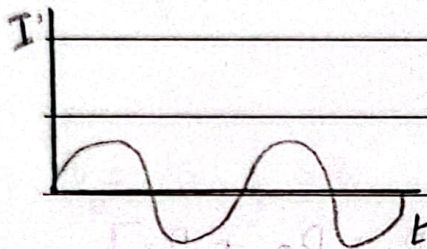
Direct current circuits:

AC

DC

Alternating current

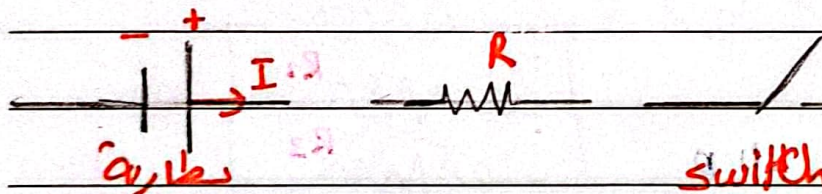
Direct current



(E) → electromotive force [volt]

القوة الدافعة الكهربائية

التيار الكهربائي (وحدات سعة)



* Electromotive force (emf) (E):

$$\Delta V = \mathcal{E} - (Ir)$$

$$\mathcal{E} = Ir + IR$$

$$I = \frac{\mathcal{E}}{r + R}$$

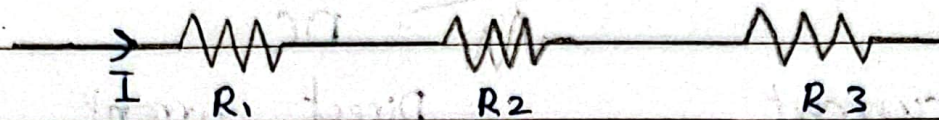
$$P_{\text{total}} = P_r + P_R$$

$$= I^2 r + I^2 R$$

$$= I^2 (r + R)$$

Resistors in Series and parallel:

(1) Series: (سلسلة)



* V is divided

* current is the same in all R

$$V = V_1 + V_2 + V_3$$

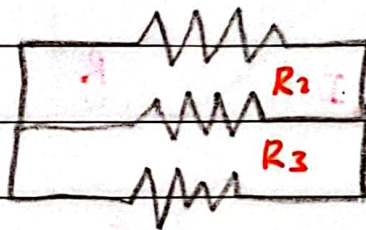
$$I R_{eq} = I R_1 + I R_2 + I R_3 \Rightarrow [R_{eq} = R_1 + R_2 + R_3]$$

greater than any resistor in the combination

(2) Parallel

* I is divided

* V is the same in all R



$$I_{eq} = I_1 + I_2 + I_3$$

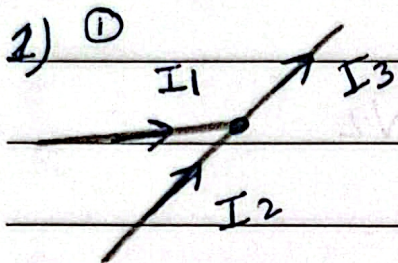
$$\frac{V}{R_{eq}} = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3} \Rightarrow \left[\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \right]$$

smaller than any R

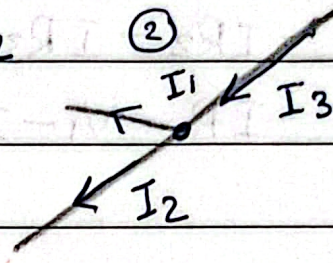
$$\left[R_{eq} = \frac{R_1 R_2}{R_1 + R_2} \right] \text{ only Two } R$$

* Kirchhoff's Rules:

- 1) junction Rule $\Rightarrow \sum I = 0$ یعنی مجموعہ صفر ہے
- 2) loop Rule (Voltage Rule) $\Rightarrow \sum \Delta V = 0$



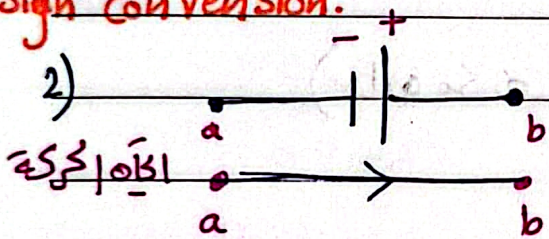
$$I_3 = I_1 + I_2$$



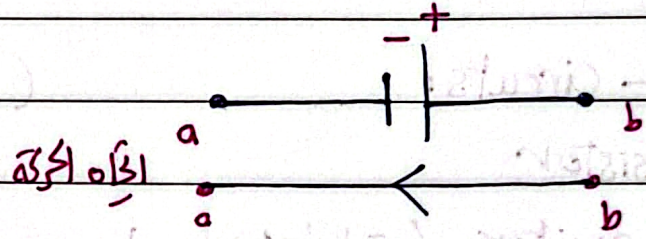
$$I_3 = I_1 + I_2$$

$$\boxed{\sum I_{in} = \sum I_{out}}$$

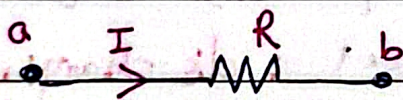
Sign convention:



$$\boxed{V = +\mathcal{E}}$$

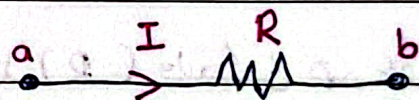


$$\boxed{V = -\mathcal{E}}$$



مائع سے I

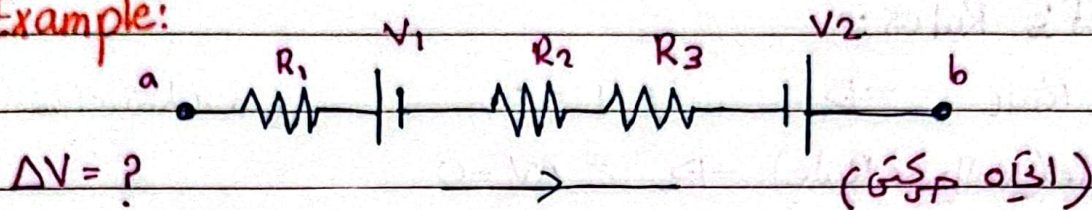
$$\boxed{V = -IR}$$



مائع سے I

$$\boxed{V = IR}$$

Example:



$$V_a - IR_1 - V_1 - IR_2 - IR_3 + V_2 = V_b$$

$$V_b - V_a = -IR_1 - V_1 - IR_2 - IR_3 + V_2$$

(*) إذا كانت $V_b = V_a$ فترى الجهد يساوي (صفر)

→ مثل ما تكون نقطة البداية هي نفسها نقطة النهاية $[ΔV=0]$

* RC - circuits: (دائرة مكونة من R و C)

R: Resistor

C: capacitor (مزانة السعات)

* charging: هي الحالة التي يتغير فيها البطارية (source) على مكثف (Capacitor)

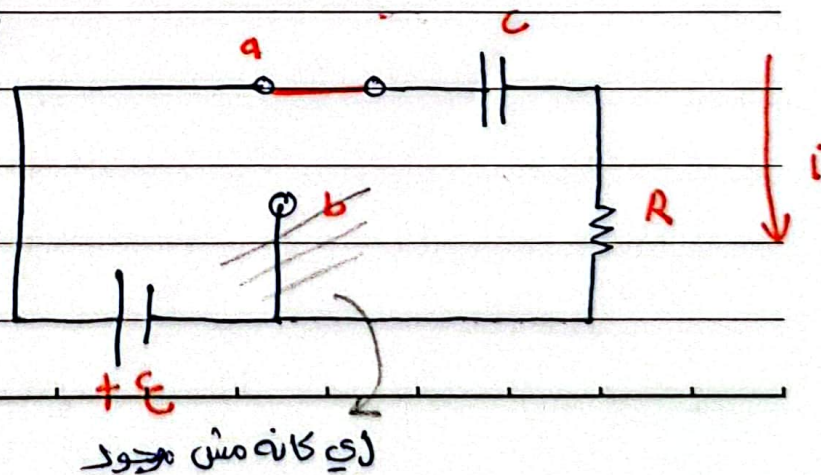
* discharging: استخدام (C) كمصدر لـ (R) ولكن هو غير دائم لأنه ما في مصدر (Source) حتى يدخل مشكوف

* Charging:

$$V = IR, \quad C = \frac{Q}{V}$$

تغير مع الزمن $I(t)$
(Not constant)

$Q(t)$: Not constant with time



(أي كانه مش موجود)

$$\mathcal{E} = V_C + V_R$$

$$\mathcal{E} = \frac{Q(t)}{C} + IR$$

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

$$\left(\mathcal{E} = \frac{Q(t)}{C} + \frac{dq}{dt} R \right) \div R$$

$$\frac{\mathcal{E}}{R} = \frac{Q(t)}{RC} + \frac{dq}{dt}$$

$$RC = \tau$$

time constant

$$\frac{\mathcal{E}}{R} = \frac{Q(t)}{\tau} + \frac{dq(t)}{dt}$$

$$[\tau] = \Omega \cdot F = \text{sec.}$$

$$q(t) = \underbrace{C\mathcal{E}}_{q_0} (1 - e^{-t/\tau})$$

$\Rightarrow q_{\text{max}}$

$$\therefore q(t) = q_0 (1 - e^{-t/\tau})$$

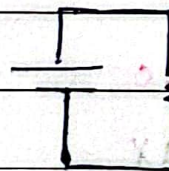
$$\therefore I = I_0 e^{-t/\tau}$$

$$I_0 = \frac{\mathcal{E}}{R} = I_{\text{max}}$$

* Case (1) at $t = 0$

$$1] \quad q(t) = 0$$

$$2] \quad I = I_0 \text{ (Max)}$$



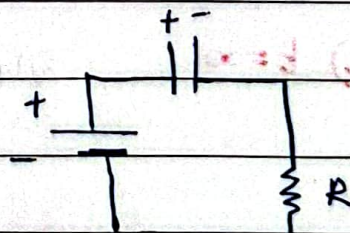
دائرة شوی علی

R

* Case (2) at $[t = \infty]$

$$1] \quad q(t) = q_0 \text{ (Max)}$$

$$2] \quad I = 0$$



* Case (3) at any time (حالة التوازن)

1) $Q = q_0 (1 - e^{-t/\tau})$

2) $I = I_0 e^{-t/\tau}$

$Q_{max} = \epsilon C$

$I_{max} = \frac{\epsilon}{R}$

* $V_C = \frac{Q}{C} (1 - e^{-t/\tau})$

* $V_R = I_0 R (e^{-t/\tau})$

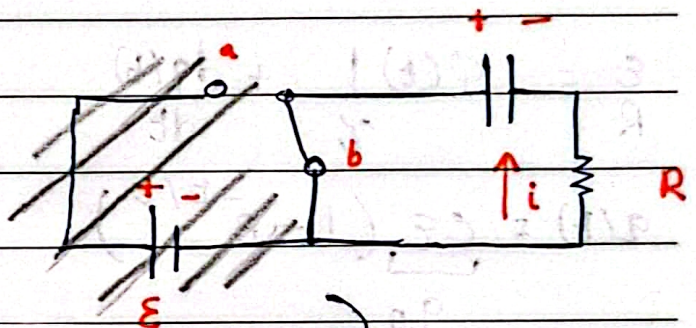
* Discharging:

$0 = V_R + V_C$

① $q = q_0 (e^{-t/\tau})$

② $I = -I_0 e^{-t/\tau}$

هناج تغيرات في الشحنة



$I = \frac{V}{R} = \frac{Q}{C} \cdot \frac{1}{R}$

$I = -\frac{Q_0}{CR} e^{-t/\tau} \quad (Max)$

① case (1) $t=0$

① $q = q_0 \quad Max$

② $I = -I_0$

ملاحظة: الاتجاه في البداية (يعني التيار)

② case (2) $t=\infty$

عكس الاتجاه (التيار العكسي) لا يتغير عن تقريبا

① $q = 0$

(I)

② $I = 0$

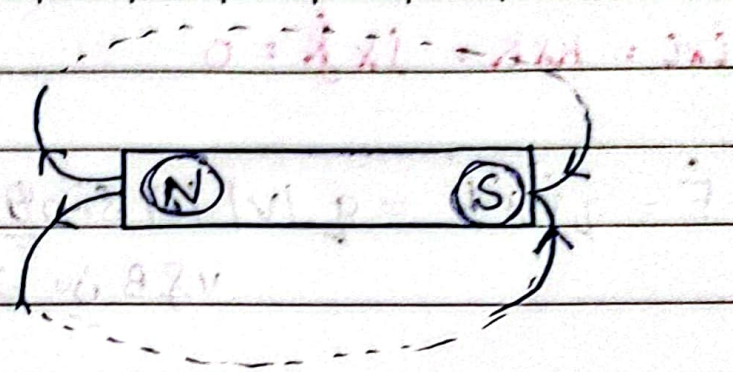
Chapter (29)

Magnetic fields:

N: North شمال

S: South جنوب

* مستطيل يكون مغناطيس N كماله
او S كماله (قطب كمال)



poles

* خطوط المجال:

inside

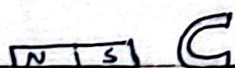
outside

S → N

N → S

* دائماً خطوط المجال المغناطيسي (خطوط مغلقة)

[closed path]



المغناطيسية

Magnet

* نقيبين من

* ناتج من توليد الكهولياء

* Magnetic field ($\vec{B}$) : The effect of B on q

E on q

B on q

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

$$\vec{F} = q\vec{v} \times \vec{B}$$

[$q \neq 0$ charged

[$q \neq 0$ charged

[q inside $\vec{E}$ $\vec{E} \neq 0$

[q must have v [$\vec{v} \neq 0$]

[$B \neq 0$ q inside B

[$\vec{v} \perp \vec{B}$ not parallel.

* Cross product → vector (3D)

$$\vec{A} \times \vec{B} = |\vec{A}| |\vec{B}| \sin \theta$$

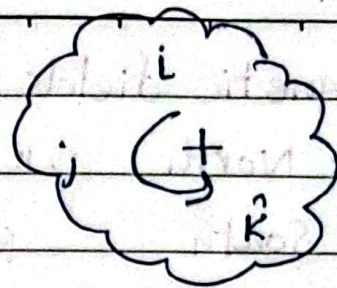
$$\vec{A} \times \vec{B} \neq \vec{B} \times \vec{A}$$

$$\vec{A} \times \vec{B} = -\vec{B} \times \vec{A}$$

i	j	k
a_x	a_y	a_z
b_x	b_y	b_z

$$\vec{A} \times \vec{B} = i(a_y b_z - a_z b_y) - j(a_x b_z - a_z b_x) + k(a_x b_y - a_y b_x)$$

$$i \times i = k \times k = j \times j = 0$$



$$\vec{F} = q \vec{v} \times \vec{B} = q |\vec{v}| |\vec{B}| \sin \theta$$

$\vec{v} \perp \vec{B}$ ←

$$B = \frac{F}{q v \sin \theta} = \frac{N}{C \cdot m} = \frac{N}{A \cdot m} = T \text{ (Tesla)}$$

$$1 T = 10^4 \underline{G} \quad (\text{Gauss وحدة B سى})$$

← SI unit → Non SI unit

* Ex: Find F on a proton of

$$\vec{v} = 3\vec{i} - \vec{k} \quad \text{and} \quad \vec{B} = 5\vec{j} + 2\vec{k}$$

Sol: $\vec{F} = q \vec{v} \times \vec{B}$

$$= (1.6 \times 10^{-19}) (5\vec{i} - 6\vec{j} + 15\vec{k})$$

i	j	k
3	0	-1
0	5	2

$$= 5\vec{i} - 6\vec{j} + 15\vec{k} \quad (*) \text{ إشارة السالبة (قوى على الـ i)}$$

القوة (F)

$$F = 0$$

$q = 0$ (neutral object)

$$v = 0$$

(static object)

$$\theta = 0, 180$$

$$F_{\max} \text{ when } \theta = \frac{\pi}{2} \Rightarrow F = q v B$$

$$\leq q_0$$

Direction:



Inside the page
(-Z)

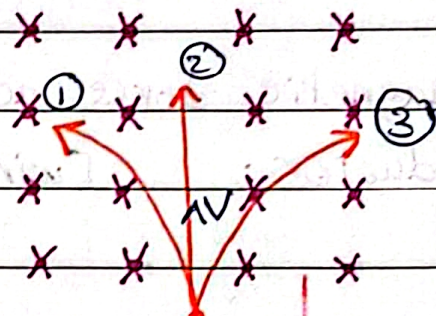
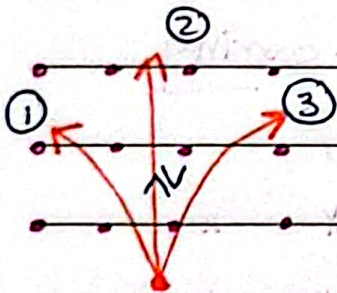
out of the page (+Z)

(*) الأيونات (V) جانب الأضلاع (B) جانب اليد اليمنى (F)

case (1)

case (2)

B



1 → -q

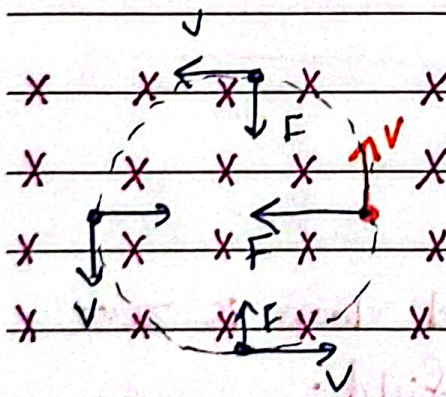
1 → +q

2 → uncharged (لا يتأثر بالحقول)

2 → uncharged

3 → +q

3 → -q



$$[F_r = F_B]$$

$$F = \frac{mv^2}{R} \quad \text{Centripetal force}$$

$$qvB \sin 90^\circ = \frac{mv^2}{R}$$

$$qvB = \frac{mv^2}{R}$$

+q → ccw

-q → cw

$$R = \frac{mv}{qB} \quad \rightarrow \quad R \propto m$$

$$\textcircled{f} \frac{1}{T} = \frac{v}{2\pi r}$$

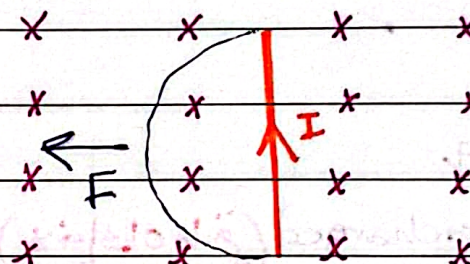
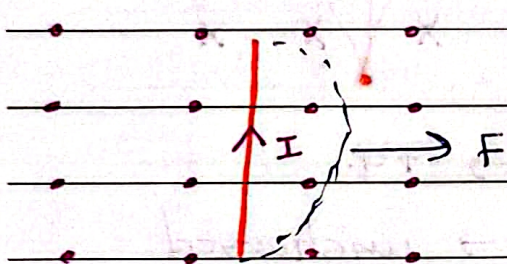
↳ (frequency)

$$\omega = \frac{v}{r} \quad [\text{angular velocity}]$$

$$\omega = \frac{qB}{m} \quad \text{rad/sec}$$

$$T = \frac{2\pi r}{v} = \frac{2\pi}{\omega} = \frac{2\pi m}{qB} \quad \text{sec}$$

* Magnetic force acting on a current-carrying conductor: [wire]



$$\vec{F}_B = (q \vec{v} \times \vec{B}) \quad nAL$$

$$F_B = I \vec{L} \times \vec{B} = I L B \sin\theta$$

* The total force acting on the closed loop is zero carrying (I) in a uniform magnetic field.

$$\textcircled{M} \rightarrow J$$

$$10^3 (1.6 \times 10^{-19})$$

Chapter (30)

Sources of Magnetic fields:

* Two sources:

- 1) Electric current (moving charges) تيار كهربائي
- 2) Magnetic materials

* (30.1) Biot-Savart law:

1) $d\vec{B} \perp d\vec{s}$

2) $d\vec{B} \perp \hat{r}$

3) $d\vec{B} \propto \frac{1}{r^2}$

4) $d\vec{B} \propto I$

5) $d\vec{B} \propto |d\vec{s}|$

6) $dB \propto \sin\theta$
between $d\vec{s}$ and $\hat{r}$

The result

$$\int d\vec{B} = \frac{\mu_0 I}{4\pi} \int \frac{d\vec{s} \times \hat{r}}{r^2} \rightarrow ds r \sin\theta$$

$$\left[\vec{B} = \frac{\mu_0 I}{4\pi} \int \frac{d\vec{s} \times \hat{r}}{r^2} \right]$$

↳ Biot-Savart law

$$\mu_0 = 4\pi \times 10^{-7} \text{ T}\cdot\text{m/A}$$

↳ permeability of free space

Ex: $\vec{B}$ $\vec{C}$



$$\vec{B}_C = \vec{B}_B > \vec{B}_A$$

$$\vec{B}_A = 0 \quad d\vec{s} \times \hat{r} \rightarrow [\theta = 0]$$

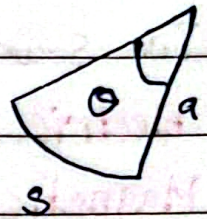
* infinite wire: $-\infty \rightarrow +\infty$

$$\theta_1 = \frac{\pi}{2}, \theta_2 = -\frac{\pi}{2}$$

$$\left[\vec{B} = \frac{\mu_0 I}{2\pi a} \hat{k} \right]$$

* قوس

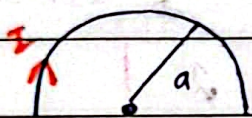
$$B = \frac{\mu_0 I}{4a\pi} (\sin\theta_1 - \sin\theta_2)$$



$$(s = \theta a)$$

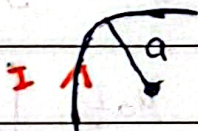
$$(s = 2\pi a)$$

* $B = \frac{\mu_0 I}{4\pi a} \theta$ (أ. م. ح. ٤)



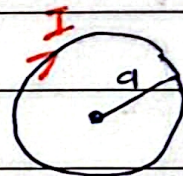
$$\theta = \pi$$

$$B = \frac{\mu_0 I}{4a}$$



$$\theta = \pi/2$$

$$B = \frac{\mu_0 I}{8a}$$



$$\theta = 2\pi$$

$$B = \frac{\mu_0 I}{2a}$$

* Ring

$$B_x = \frac{\mu_0 I a^2}{2(a^2 + x^2)^{3/2}}$$

$$\text{at } x=0 \rightarrow B = \frac{\mu_0 I}{2a}$$

* استخدام قاعدة اليد اليمنى

الاتجاه I وباتجاه الاصابع (B)

(30.2) Magnetic Force between Two parallel conductors.

$$\vec{F} = \frac{\mu_0 I_1 I_2 l}{2\pi a}, \quad \vec{F} = \frac{\mu_0 I_1 I_2}{2\pi a} \text{ (per unit length)}$$

* parallel conductors carrying I in the same direction [attract each other]

* parallel conductors carrying I in the opposite direction [repel each other]

(30.3) Ampere's law:

$$\oint \vec{B} \cdot d\vec{s} = \mu_0 I$$

ds : $\vec{B}$ و $d\vec{s}$ في المساحة

S : المساحة الكلية لـ $d\vec{s}$

[$2\pi r$ محيط الدائرة]



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

التيار الكلي

Total current

Extra: (في المساحة)

$$\oint_a \vec{B} \cdot d\vec{s} = \mu_0 (1+5-2) = 4\mu_0$$

$$\oint_b \vec{B} \cdot d\vec{s} = \mu_0 (1-2) = -\mu_0$$

$$\oint_c \vec{B} \cdot d\vec{s} = \mu_0 (1+5) = 6\mu_0$$

$$\oint_d \vec{B} \cdot d\vec{s} = \mu_0 (5-2) = 3\mu_0$$

