Introduction 2\2\2016

NO.

→ Electricity & Magnetism ⇝ electromagnetism.

فرع

the branch of physics that is concerned with electric & magnetic phenomena.

→ Historical view :-

كهرمان

1. elecktron → the greek word for amber becomes electrefied

دلك

when rubbed.

منطقة

2. magnesia → the name of a district where the magnetite

شوهد

Fe_3O_4 stone was first observed.

3. colomb → electrostatic force

البوصلة ابرة اخترع

4. compass needle → invented by Arab

⇝ electricity & magnetism are related phenomena.

1 - Orsted → a compass needle when placed near an electric

دارة انحرفت

circuit will be deflected.

تنحرف إبرة البوصلة عند تقريبها من تيار كهربائي (التيار الكهربائي يولد مجالاً مغناطيسياً)

تيار

2 - Faraday → an electric current is established in a coin if it is

ينشأ

moved relative to magnet.

المجال المغناطيسي يولد تياراً كهربائياً.

3 - Maxwell → 4 equations for electromagnetism (electromagnetic theorem)

ظاهرة الحث المغناطيسي

23.1 properties of electric charges

→ Two types of electric charge :-

هذه الأسماء اصطلاحية

1) Positive charge

the charge on a glass rod rubbed (دلك) with silk. تنافر مع + ← +

2) Negative charge تجاذب مع + ← -

the charge on a rubber (مطاط) rod rubbed with fur (فرو).

→ Properties of electric charges

1) like charges repel (تنافر), unlike charges attract.

2) The total electric charge in an isolated system is conserved.

- charge is not created by rubbing, but it is (transfered) redistrubuted. (توزيع المادة)

مثل الدلك / لا يصلح الدلك إلا للمواد العازلة

3) electric charges can only occured on integral multiples of a fundemental unit (charge) = electric charge is quantized (مكماة).

$e = 1.6 * 10^{-19}$ C (colomb)

هذا يعني أن كولوم يكافئ عدد كبير من شحنة e

لذلك نستخدم وحدات صغيرة مثل Mc ..

→ q : charge (it comes from quantity of charge)

[q] = colomb = C (capital)

→ Examples :- (of charged particles)

1) electron → $q_e = -e$

2) proton → $q_p = +e$

3) neutron → $q_n = 0$

So for any q ⇝ $q = \pm Ne$

integer

عدم حفظ الارقام

NO. 23.3 4\2\2016

23.3 : Colomb's law

→ The force exerted between two point charges seperated by a distance r. $\vec{F}_e$ electric q_1, q_2

$|\vec{F}_e| \propto |q_1 q_2|$

$\propto \frac{1}{r^2}$ m $\Rightarrow |\vec{F}_e| = \text{constant} \frac{\overbrace{|q_1||q_2|}^{\text{scalar}}}{r^2} = \boxed{\frac{K_e |q_1||q_2|}{r^2}}$

فقط موجب

يعتمد على الوسط فقط

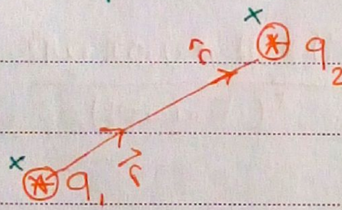
K_e : Colomb constant $= 8.899 * 10^9 \ N.m^2/C^2 \simeq 9 * 10^9 \ N.m^2/C^2$

$\boxed{K_e = \frac{1}{4\pi\epsilon}}$

ϵ : constant depends on the surrounding (الوسط المحيط) space

ϵ_0 : permitivity (نفاذية) of free (empty) space $= 8.85 * 10^{-12} \ C^2/m^2.N$

→ The direction for the colomb force is determine by the law of repulsion and attraction.



the point charge moves along the direction r.

الخط الواصل بين الشحنتين ← خط عمل القوى

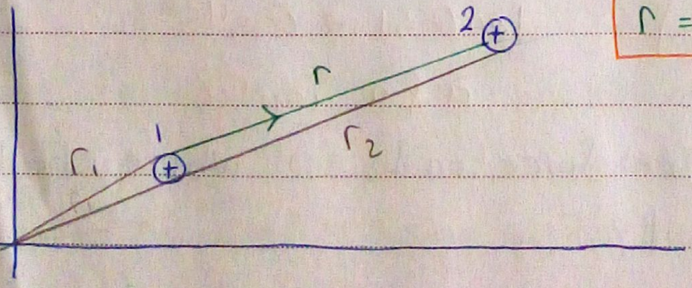
$$\vec{F}_e = \frac{K_e |q_1||q_2|}{r^2} \hat{r}$$

$$\vec{F}_{e\,1\,on\,2} = \frac{K_e |q_1 q_2|}{r^2} \hat{r} \qquad \vec{F}_{e\,2\,on\,1} = \frac{K_e |q_1 q_2|}{r^2} (-)\hat{r}$$

So ...

$|\vec{F}_{1\,on\,2}| = |\vec{F}_{2\,on\,1}|$ also ... $\vec{F}_{1\,on\,2} = -\vec{F}_{2\,on\,1}$

according to N. 3rd law. حتى لو كانت قيمة الشحنات مختلفة

→ 

$\boxed{r = \Delta x^2 + \Delta y^2}$

Scanned by CamScanner

→ For a set of point charges $q_1, q_2, \dots$

$\vec{F}_{e \text{ on } q_1} = \Sigma \vec{F}_{ei} = \vec{F}_{e\,2 \text{ on } 1} + \vec{F}_{e\,3 \text{ on } 1} + \dots$

vector equation (جمع متجهات)

→ In some cases :-

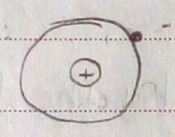
اذا كانت الكتلة صغيرة نهمل قوة الجاذبية لانها ستكون صغيرة جداً بالنسبة للقوة الكهربائية

net force = electric force + gravitational force

$\simeq$ zero

So... net force = electric force

→ See example 23.1 p. 695 Hydrogen atom



$m_e = 9.11 * 10^{-31}$ Kg $\quad q_e = -e$

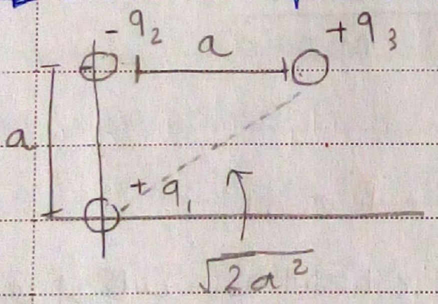
$m_p = 1.67 * 10^{-27}$ Kg $\quad q_p = +e$

$m_n = 1.67 * 10^{-27}$ Kg $\quad q_n = 0$

$F_e = \frac{K_e e^2}{r^2}$ (10^{10}, 10^{-38} → 10^{-28}) $\quad F_g = \frac{G\, m_e m_p}{r^2}$ (10^{-11}, 10^{-30}, 10^{-27} → 10^{-68}) $\quad F_g \rightarrow \frac{\text{ثابت الجذب} * \text{ك١} * \text{ك٢}}{(\text{المسافة})^2}$

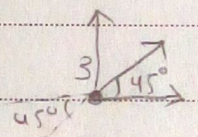
$\frac{F_e}{F_g} \simeq \frac{10^{-28}}{10^{-68}} \simeq 10^{40}$ So... $|\vec{F}_e| \ggg |\vec{F}_g|$ for elementary (الشحنات الأولية) charges.

→ See example 23.2 P.696 & 23.4 P.698



$\vec{F}_{e \text{ on } q_3} = \vec{F}_{e\,1 \text{ on } 3} + \vec{F}_{e\,2 \text{ on } 3}$

$\vec{F}_{e\,2 \text{ on } 3} = \frac{K_e |q_2||q_3|}{a^2} (-\hat{i})$



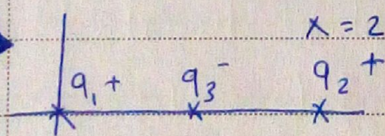
$\vec{F}_{e\,1 \text{ on } 3} = \frac{K_e |q_1||q_3|}{(\sqrt{2a^2})^2} [\cos\theta\, \hat{i} + \sin\theta\, \hat{j}]$

magnitude → $\sqrt{\square^2 + \square^2}$

direction → $\tan^{-1}\left(\frac{y}{x}\right)$ $\quad \tan\theta = 1 \rightarrow \theta = 45°$

لأنه يوجد a & a

→



the net force on $q_3 = 0$ where should we put it? $F_{e \text{ on } q_3} = 0 = F_{e\,1 \text{ on } 3} + F_{e\,2 \text{ on } 3}$

لو $q_1 = q_2$ ← في المنتصف $\quad r = x \quad r = 2 - x$

حلين ← المقبول أقل من ٢.

7/2/2015

NO. 23.4

23.4 Analysis model: particle in a field (electric)

مجال

→ Field forces (Forces at a distance) :-

Forces acting in a space even if there is no "physical" contact between object.

- Example of a field forces :-

1. electric force. 2. magnatic force.

→ Electric field $\vec{E}$ (vector quantity).

* the electric force $\vec{F_e}$ acting on a positive test charge q_0 شحنة اختبار موجبة devided by this test charge.

* q_0 is small (in order not to disturb the field of the source charge) يشوش مصدر

$$\boxed{\vec{E} = \frac{\vec{F_e}}{q_0}}$$

اتجاه المجال هو اتجاه القوة الكهربائية (لأن q_0 موجبة)

الشحنة التي تأثرت بالجسم المشحون q_0 = positive test charge

اصطلاحاً

it serves as a detector of the field & معرفة الشحنة المكونة للمجال

تخدم كاشف

* $[\vec{E}] = \frac{[F]}{[q]} = \frac{N}{C}$ in SI units & $\frac{V}{m}$ in SI units.

$1\ \frac{N}{C} = 1\ \frac{V}{m}$ there is no conversion factor. تحويل

* $\boxed{\vec{F_e} \text{ on } q_0 = q_0 \vec{E}}$ → electric field at point P point along the same direction of electric force on +ve test charge

Q ⊕ $+1 \rightarrow q_0$ P → $\vec{F_e}$ & $\vec{E}$ Q ⊖ +1 ← P

outward inward

q_0 يعني $+1$

$$\vec{F_e} = \frac{K_e q_1 q_2}{r^2}\hat{r} = \frac{K_e q_0 Q}{r^2}\hat{r}$$

$$\vec{E} = \frac{\vec{F_e}}{q_0} = \boxed{\frac{K_e|Q|}{r^2}\hat{r} = \vec{E}}$$ → electric field at point P due to point charge Q.

يوجد فرق بين شحنة متأثرة & مؤثرة (مصدر)

*For a set of point charges :-

$\vec{E}$ at point $p = \sum \vec{E}_i = K_e \sum \frac{q_i}{r_i^2} \hat{r}_i$

$\vec{E} = \vec{E}Q_1 + \vec{E}Q_2 + \vec{E}Q_3 + \dots$ جمع متجهات / الاتجاه حسب قانون التجاذب & التنافر

← المجال الكهربائي عند نقطة لا يعتمد على الشحنة الموجودة في النقطة أما القوة الكهربائية فالعكس.

Generally :-

$\boxed{\vec{F}_e \text{ on } q = q\,\vec{E} \text{ at point } p}$ vector equation

affected charge   due to source charge

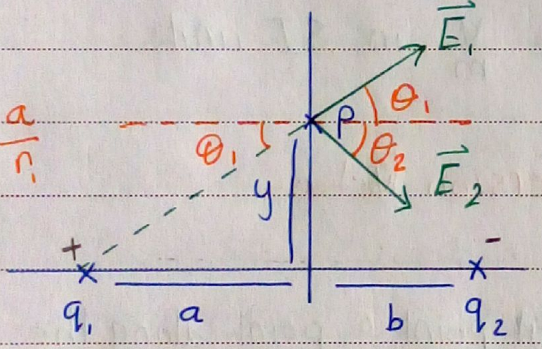
$\sum \vec{F}_e$ on $q = q \sum \vec{E}$ at point p ← لو نكينا القانون بطلع نفسه قانون كولوم

q → if q is +ve → $\vec{F}$ on q // $\vec{E}$

→ if q is -ve → $\vec{F}$ on q opposite $\vec{E}$

→ Example 23.6 p.702

$\cos\theta_1 = \frac{a}{r_1}$



a) $\vec{E}_1 = \frac{K_e q_1}{r_1^2} [\cos\theta_1 (\hat{i}) + \sin\theta_1 (\hat{j})]$

$\vec{E}_2 = \frac{K_e q_2}{r_2^2} [\cos\theta_2 (\hat{i}) + \sin\theta_2 (-\hat{j})]$

$\vec{E}$ at $p = \vec{E}_1$ at $p + \vec{E}_2$ at $p = \square$ N/C

b) if we place q_3 at point p, Find $\vec{F}_e$ on q_3

$\vec{F}_e$ on $q_3 = q_3 \vec{E} = \square$ N

نعوض بالإشارة ← + ← مع

- ← عكس

يوجد مثال آخر بدل b ← a سيكون $\frac{1}{y^3} \propto E$ اذا a <<< y (وتكون المسافة في النصف).

طالما يوجد شحنة ← أكيد يوجد مجال   الثنائي القطب الكهربائي

→ Electrical dipole

a system of two charges (equal in magnitude but with opposite signs) seperated by a distance.

⊕ —d— ⊖

23.5 $\vec{E}$ due to continuous charge distribution توزيع

→ Two types of continuous charge distribution.

1 Uniform con. ch. dis.

1) uniform linear charge density (1D) $\lambda = \frac{Q}{l}$ $[\lambda] = \frac{c}{m}$

2) uniform surface charge density (2D) $\sigma = \frac{Q}{A}$ $[\sigma] = \frac{c}{m^2}$

area → A

3) uniform volume charge density (3D) $\rho = \frac{Q}{V}$ $[\rho] = \frac{c}{m^3}$

Charge density here is constant

2 Non-uniform con. ch. dis.

1) non-uniform linear charge density (1D) $\lambda = \frac{dQ}{dL}$

2) non-uniform surface charge density (2D) $\sigma = \frac{dQ}{dA}$

3) non-uniform volume charge density (3D) $\rho = \frac{dQ}{dv}$

if charge density $= 2\,c/m$ charge density per 1 cm =

$2\,\frac{c}{m} * \frac{m}{100\,cm} = .02\,c/cm$

→ How to find electric field due to con. ch. dist. :-

1) devide the charge distribution into small element of charge $\Delta q = dq$

2) $\Delta\vec{E}\ (d\vec{E}) = \frac{K_e\,\Delta q}{r^2}\,\hat{r}$ (dq)

3) total Field $\vec{E}_{tot} = \sum \Delta\vec{E}$ if Δq is very small ⇒ $\sum \to \int$

$d\vec{E} = \frac{K_e\,dq}{r^2}\,\hat{r}$ $\vec{E}_{tot} = \int d\vec{E} = K_e \int \frac{dq}{r^2}\,\hat{r}$

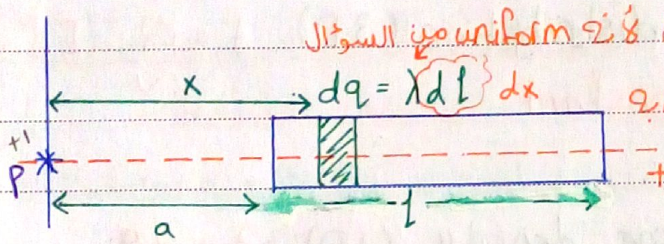
it must be one variable

4) to evaluate the integral use the symmetry of the problem to simplify the integral.

أمثلة لـ volume أسهل من الـ Potential

The Cases

1. $\vec{E}$ due to uniformly charge rod of finite length (l) at a point p a distance along the axis of the rod (example 23.7 p.705)



معطيات التكامل ؟ uniform من السؤال

نأخذ مقطع يخدم في التشابه

على افتراض أنها مشحونة بشحنة +

غير لو كان السؤال نقطة فوق الـ rod.

$$d\vec{E} = \frac{K_e\, dq}{r^2}\hat{r} = \frac{K_e \lambda\, dx}{x^2}(-\hat{i})$$

$$dE_x = \frac{K_e \lambda\, dx}{x^2} \quad \text{magnitude أخذنا} \qquad E_{total} = \int dE_x = K_e\lambda \int_{x=a}^{x=a+l} \frac{dx}{x^2}$$

$$= K_e\lambda\left(\frac{-1}{x}\right)\Big|_a^{a+l} = K_e\lambda\left[\frac{-1}{a+l} + \frac{1}{a}\right] = \frac{K_e \lambda l}{a(l+a)} \quad Q$$

$$\Rightarrow \boxed{E = \frac{K_e Q}{a(l+a)}}$$ → electric field due to uniformly charged rod of length l at a point at distance a on the axis of rod.

→ Special cases :-

1) if a much greater than l $a \ggg l$ (rod بعيدة عن a)

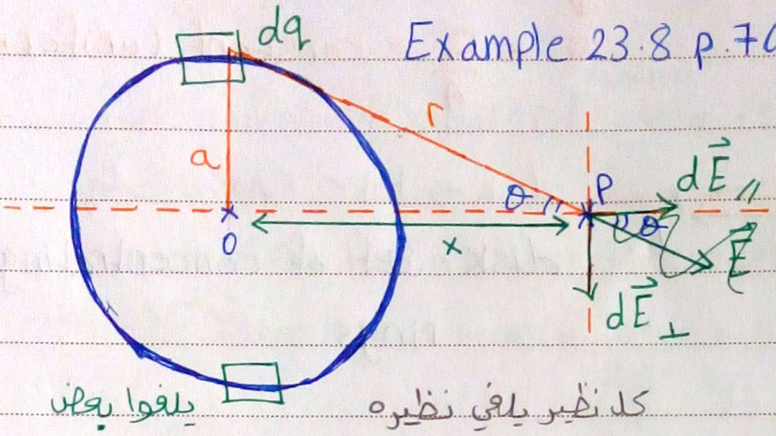
$$E \sim \frac{K_e Q}{a^2} \quad \text{(point charge)}$$

2) if $a \to 0$ (rod قريبة من a)

$$E \sim \infty$$

[2] $\vec{E}$ due to uniformly charged ring of radius "a" at point p a distance x from the center of the ring. سلك مشحون ملفوف على شكل دائرة

Example 23.8 p.706 + فرض أنه مشحون بشحنة



x & a are the same for all dq's

$$d\vec{E} = \frac{K_e\, dq}{r^2}\hat{r} = \frac{K_e\, dq}{x^2+a^2}\hat{r}$$

by symmetry all $dE_{\perp}$ add to zero. المركبات العمودية صفر

نحسب المركبات الأفقية فقط

$$E_{tot} = \int dE_x = \int \frac{K_e\, dq}{x^2+a^2}\cos\theta \qquad \frac{x}{r} = \frac{x}{(x^2+a^2)^{\frac{1}{2}}}$$

$$= \int \frac{K_e\, dq\, x}{(x^2+a^2)^{\frac{3}{2}}} = \frac{K_e x}{(x^2+a^2)^{\frac{3}{2}}}\int_0^Q dq = \frac{K_e Q x}{(x^2+a^2)^{\frac{3}{2}}}$$

$$\Rightarrow \boxed{E = \frac{K_e Q x}{(x^2+a^2)^{\frac{3}{2}}}} \quad \frac{N}{C}$$

→ E due to uniformly charged ring of radius "a" at point p a distance x from the center of the ring.

→ Special cases :-

1) at $x = 0$ (النقطة على المركز)

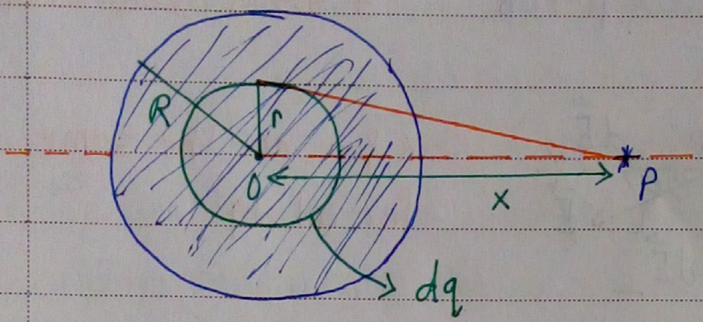
$E = 0$

2) $x \gg a$

$E \sim \frac{K_e Q}{x^2}$ (point charge).

3 $\vec{E}$ due to uniformly charged disk of radius R at point p a distance x from the center of the disk.

$\sigma = \frac{Q}{A}$ = constant (uniform)



disk → take ring as dq

disk: set of concentrating rings متحدات في المركز

$dE = \frac{K_e dq}{r^2}$ but we are going to use E ring

$dq = \sigma * (\text{area of the ring}) = \sigma \underbrace{2\pi r}_{\text{محيط}} \underbrace{dr}_{\text{سمك}}$

or $\sigma = \frac{Q}{A} = \frac{dQ}{dA}$ $dq = \sigma\, dA$ $(A = \pi r^2)$ $dA = 2\pi r\, dr$

$= \sigma\, 2\pi r\, dr$

$\rightarrow E_{tot\,x} = \int dE_{ring\,x} = \int \frac{K_e Q x}{(x^2+r^2)^{3/2}} = K_e 2\pi\sigma \int \frac{x r\, dr}{(x^2+r^2)^{3/2}}$

مو y تتشطب من Ering)

x = constant for all dq's (rings)

$= K_e 2\pi\sigma x \int_{r=0}^{r=R} \frac{r\, dr}{(x^2+r^2)^{3/2}}$ بالتعويض let $x^2+r^2 = u$

$2r\, dr = du$

$\rightsquigarrow 2\pi K_e \sigma \left[1 - \frac{x}{(x^2+R^2)^{1/2}}\right]$

$\Rightarrow \boxed{2\pi K_e \sigma \left[1 - \frac{x}{(x^2+R^2)^{1/2}}\right] = E}$ → E due to uniformly charged disk of radius R at point p a distance x from its center.

→ Special cases :-

1) if $x \ggg R$

$E \to 0$

2) if $R \ggg x$ $(x \to 0$?) (infinitly large disk)

$$E \approx 2\pi K_e \sigma = \frac{\sigma}{2\epsilon_0} = \text{constant}$$

$$K_e = \frac{1}{4\pi\epsilon_0}$$

لا يعتمد على dimension تبع السؤال

→ for uniformly charged plate (صفيحة) (surface) of infinite extent ($R \ggg x$):

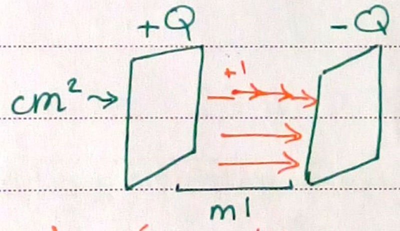
محصور نقطة قريبة

electric field above this surface

$$E_{\text{above this surface}} = \frac{\sigma}{2\epsilon_0} = \text{constant (uniform)}$$

- independant of distance from the surface
- independant of the shape of the plate

Example: electric capicity المواسع الكهربائي



$$\vec{E}_{tot} = \vec{E}_1 + \vec{E}_2$$

$$|\vec{E}| = \frac{\sigma}{2\epsilon_0} + \frac{\sigma}{2\epsilon_0} = \frac{\sigma}{\epsilon} = \text{constant}$$

مجال منتظم بعيداً عن الأطراف

direction → حسب نوع الشحنة المشحون بها & موقع الشحنة

مثلاً + مشحون ↑ ↓

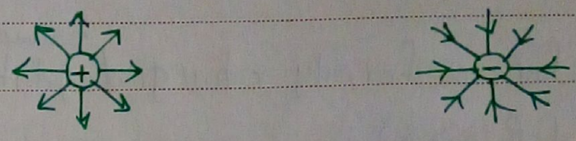
density = (drawn blob) / unit dimention (scalar).

11\2\2016

NO. 23.6

23.6 $\vec{E}$ (electric field) lines

→ 2D - pictorial representation = the direction of F_e acting on the test charge



الخط الناتج عن وضع شحنة اختبار موجبة بالقرب من شحنة نقطية.

→ Properties of $\vec{E}$ lines :-

1) they orginate from +ve charge & terminate into -ve charge.

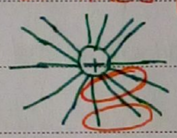
2) number of lines $\propto |Q|$ بغض النظر عن نوع الشحنة

3) density of $\vec{E}$ lines $\propto |\vec{E}|$

number of lines per unit area.

- عدد الخطوط لكل وحدة مساحة تدل على مقدار القوة (شدة المجال)

- أقرب ← $\vec{E}$ أكبر

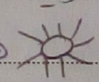


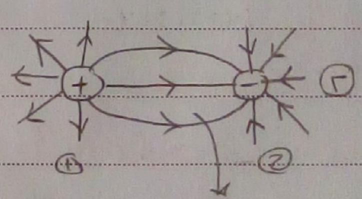
4) No two lines can cross.

اذا تقاطعوا ← يوجد اتجاهين ← قوتين . هذا غير ممكن !

فوائد خطوط المجال الكهربائي :-

① معرفة إذا المجال منتظم أم لا ، أي مجال يمثل على شكل خطوط متوازية و المسافات بينها متساوية هو مجال منتظم.

 ← مجال غير منتظم (radial) مواضع ← مجال منتظم نسبياً عند الأطراف

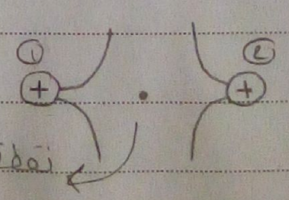


② عدد الخطوط الداخلة = عدد الخطوط الخارجة

$|q_1| = |q_2|$

لو عدد الداخلة = ٢ عدد الخارجة $|q_2| = 2|q_1|$

مستحيل بين dispose نحصل على نقطة انعدام ممكن في الخارج



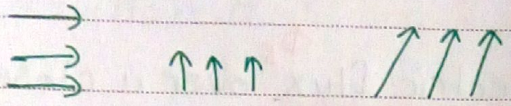
لو $q_1 = q_2$ ← نقطة انعدام المجال في النصف

نقطة انعدام المجال ← قوة = صفر

لو $q_1 \neq q_2$

23.7 Motion of a charged particle in uniform electric field $\vec{E}$

$\vec{E}$ is constant in magnitude & direction



→ $\vec{F_e} = q\vec{E}$ = constant

if $\vec{E}$ is uniform & $\Sigma\vec{F} = F_e$ only F_g بدون ⇒ $\vec{a}$ = constant

motion of particle under cons. $\vec{a}$

معادلة الحركة بتسارع ثابت.

→ $\Sigma\vec{F} = m\vec{a}$ $\vec{F_e} = m\vec{a}$ $q\vec{E} = m\vec{a}$

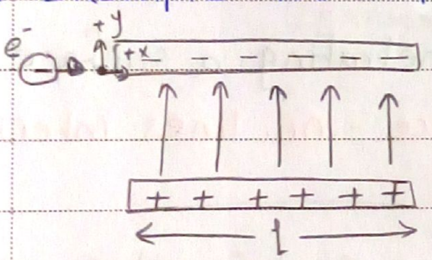
$$\boxed{\vec{a} = \frac{q\vec{E}}{m}}$$

q: + → a with the direction of $\vec{E}$

− → a with the opposite direction of $\vec{E}$

14\2\2016

→ Example 23.11 p.712



$q = -e$ $v_{ix} = 3\times10^6$ $E = 200$ $l = .1$

a? ① t? ② y_f? ③

مجال منتظم ← معادلات الحركة

Fe ثابتة لأن المجال منتظم

① $\Sigma\vec{F} = m\vec{a}$ $\Sigma\vec{F} = F_e + F_g$ but $|F_g| \lll |F_e|$ → $\Sigma\vec{F} = \vec{F_e}$

$\vec{F_e} = m\vec{a}$ $q\vec{E} = m\vec{a}$ $\vec{a} = \frac{q\vec{E}}{m} = \frac{1.6\times10^{-19}\times 200(-i)}{9.11\times10^{-31}} =$

$$\boxed{35.13\times10^{12}(-\hat{i})\ m/s^2}$$

② $\Delta x = .1$ $\Delta x = v_{ix}t + \frac{1}{2}at^2$ but $a_x = 0$

$\Delta x = v_i t$ $\boxed{t = .33\times10^{-7}\,s}$

③ $y_f = y_i + v_{iy}t + \frac{1}{2}at^2$ but $v_{iy} = 0$

$y_f = 0 + 0 + \frac{1}{2}\times -35.13\times10^{12}\times .11\times10^{-14} = \boxed{-1.95\times10^{-2}\ m}$

→ See example 23.10 p.711

طريقتين : ١/ معادلات الحركة

W = ΔK ٢/ حفظ الطاقة

Chapter 24 : Gauss's law

→ convenient to calculate $\vec{E}$ for highly symmetric charge distribution.

→ it connects (relates) the Electric flux Φ_E over a closed surface to the net charge enclosed (مغلقه) the surface to find $\vec{E}$.

$q_{net,\ enclosed}$

24.1 Electric flux Φ_E scalar quantity

يعتمد على عدد الخطوط

→ the product of the $|\vec{E}|$ and the surface area ⊥ to it.

→ Line density (density of $\vec{E}$ lines) $\propto |\vec{E}|$

$\dfrac{\text{number of lines}}{\text{area}} \propto |\vec{E}|$

$|\vec{E}| \times \text{area} \propto \text{no. of lines}$

$\Phi_E \propto$ net number of lines penetrating (leaving) a surface

number of lines leaving the surface − no. lines intering

⟹ For uniform $\vec{E}$

$\boxed{\Phi_E = \vec{E}\cdot\vec{A}} = |\vec{E}||\vec{A}|\cos\theta = EA\cos\theta$ scalar = vetor · vecton

θ: angle between $\vec{E}$ & $\vec{A}$

$\vec{A}$: a vector of magnitude equal to area

$|\vec{A}|$: area & it's direction is normal (⊥ = perpendicular) to surface.

- مغلق ← الاتجاه لمتجه المساحة دائماً للأعلى) دائماً في غاوس مغلق ← دائماً للأعلى (.

$[\Phi_E] = \frac{N}{C}\cdot m^2$ in SI units & $\frac{V}{m}\cdot m^2 = V\cdot m$

نفس الشيء ولكن أشهر

→ net lines → 0 → لايوجد شحنة

داخل → شحنة سالبة

خارج → شحنة موجبة

المساحة ← متجه مقداره مقدار المساحة

اتجاهه عمودي على المساحة

$\Phi_E = 0$ if $\theta = 90°$ $\rightarrow (\vec{E} \perp \vec{A})$ $(\vec{E} \parallel \text{surface})$ المجال لا يخترق السطح

$\Phi_E = EA$ if $\theta = 0°$ $\rightarrow (\vec{E} \parallel \vec{A})$ $(\vec{E} \perp \text{surface})$ أكبر ما يمكن

$\Phi_E = -EA$ if $\theta = \pi$ $\rightarrow (\vec{E}$ opposite $\vec{A})$ $(\vec{E} \perp \text{surface})$

antiparallel

$\Rightarrow$ For non uniform $\vec{E}$ مجال غير منتظم ← نقسم الى مساحات صغيرة

$$\Phi_E = \int_{\text{surface}} \vec{E} \cdot d\vec{A}$$ 2D not 1D (كأنو مجال منتظم) ← ∞ ← تكامل

For a closed surface $\Phi_{E\,net} = \oint \vec{E} \cdot d\vec{A}$

⇒ Gauss law :-

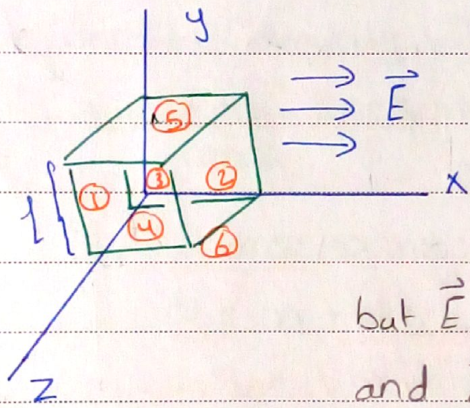
The net electric flux (Φ_E) over a closed surface (Gaussion surface) is equal to the net charge enclosed by the surface ($q_{net\ enclosed} = q_{net,in}$) (inside the surface) devided by ϵ_0.

$$\boxed{\Phi_E = \oint \vec{E} \cdot d\vec{A} = \frac{q_{net\ enclosed}}{\epsilon_0}}$$

useful to find $\vec{E}$ for highly symmetric charge distributions (volume, surface (planar), linear).

Φ_E يعتمد فقط على الـ $q_{net,in}$ وليس على أي شيء آخر.

→ Example 24.1



$\vec{E} = E\hat{i}$ ← uniform electric field

Find $\Phi_E = \oint \vec{E} \cdot d\vec{A}$

$\vec{E}_{tot} = \int_1 \vec{E} \cdot d\vec{A} + \int_2 \vec{E} \cdot d\vec{A} + \int_3 \vec{E} \cdot d\vec{A} + \int_4 \vec{E} \cdot d\vec{A} + \int_5 \vec{E} \cdot d\vec{A} + \int_6 \vec{E} \cdot d\vec{A}$

but $\vec{E}$ on surface $3 + 4 + 5 + 6 = $ zero

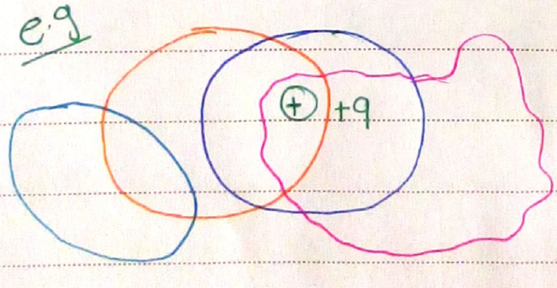
and $\vec{E}$ is uniform

$$\vec{E}_{tot} = E_1 \int d\vec{A} + E_2 \int d\vec{A} = E l^2 \cos 180 + E l^2 \cos 0 = \text{zero}$$

- لو كان هناك شحنة داخل الجسم $\Phi_E = q / \epsilon_0$ & لا يهم موقع الشحنة أو الحجم أو الشكل

⇒ $\Phi_{net\ E}$ over a closed surface depends on $q_{net\ in}$ (net of lines leaving the surface) & it is independent of the shape of the surface or the location of the charge or r (distance).

e.g



$\Phi_E = \Phi_E = \Phi_E$

$\Phi_E = $ zero

18/2/2016

NO. 24.2

⟹ Gaussian surface (G.S)

شكل هندسي

a mathematical construction (closed surface) & does not necessary

يتوافق

coincide with a real surface.

→ to simplify the integral $\oint \vec{E} \cdot d\vec{A}$ gaussian surface must have one or more of the following properties :-

1) if $|\vec{E}|$ = constant over the surface (gaussian surface).

2) $|\vec{E}| = 0$ over the surface (gaussian surface)

3) $\vec{E} \cdot d\vec{A} = E\,dA \rightarrow \vec{E} \parallel \vec{A}$ over the surface (gaussian surface)

4) $\vec{E} \cdot d\vec{A} = 0 \rightarrow \vec{E} \perp \vec{A}$ over the surface (gaussian surface).

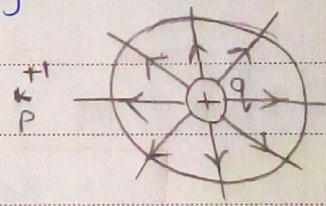
مراجعة قوانين المساحة & الاحجام (كرة, اسطوانة, ...)

→ Example : Find $\vec{E}$ due to a point charge using G. law

$\oint \vec{E} \cdot d\vec{A} = \dfrac{q_{net,in}}{\epsilon_0}$ $\quad \vec{E} \int d\vec{A}$ $\quad$ but $\theta = 0$

مجال ثابت مقداراً

واحد dot $\quad \cos\theta = 1$



نستطيع اخراجه

$E \int d\vec{A} = E(4\pi r^2) = \dfrac{q}{\epsilon_0}$

G.S : a sphere of radius r concentric with q

$E = \dfrac{q}{4\pi r^2 \epsilon_0} = \dfrac{K_e q}{r^2}$ # the same as colomb's law.

→ See example 24.2 conceptual question.

18/2/2016

NO. 24.3

Applications of G. law to various charge distribution

1 $\vec{E}$ due to uniformly charged insulating solid sphere of radius (a)

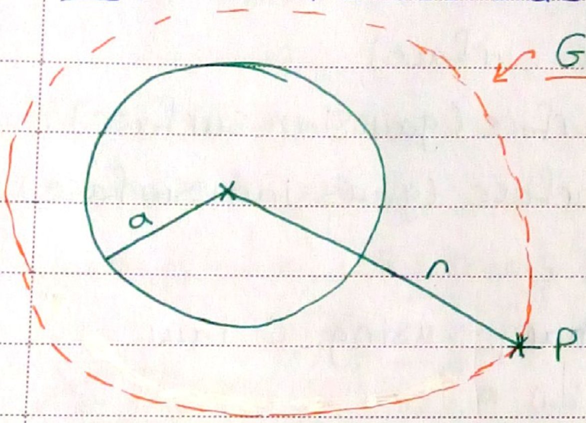
عازل ‏ مصمتة

(Example 24.3 | p. 731) (non-conducting) (dielectric)

$\rho = \frac{Q}{V}$ = constant (non-hollow) (non-shell)

المجوف

a $\vec{E}$ at $r > a$ (outside the insulating solid sphere)



G.S: a sphere of r concentric with the charged sphere.

متحد في المركز

من أجل حساب المجال خارج الكرة يلزمنا G.S أكبر من
الكرة الأصلية & متحدة معها في المركز

$\oint \vec{E} \cdot d\vec{A} = \frac{q_{net,in}}{\epsilon_0}$ but $\theta = 0$, $\cos\theta = 1$

$\oint E\, dA$ but E is constant $\rightarrow E \int dA = E(4\pi r^2) = \frac{Q}{\epsilon_0}$

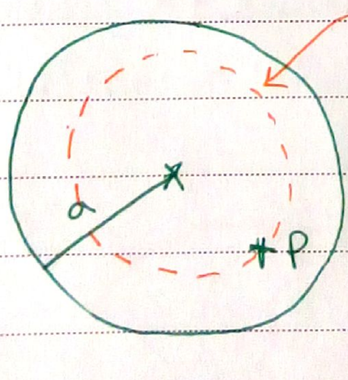
$$\boxed{E = \frac{K_e Q}{r^2} \quad r > a}$$ looks like a point charge

$Q = \rho V = \rho \frac{4}{3} \pi a^3$

الكرة الأصلية (المشحونة).

$$\boxed{E = \frac{K_e \rho \frac{4}{3} \pi a^3}{r^2}} \quad \propto \frac{1}{r^2}$$

b $\vec{E}$ at $r < a$ (inside the insulating solid sphere)



G.S: a sphere of $r < a$ concentric with the solid sphere.

$\oint \vec{E} \cdot d\vec{A} = \frac{q_{net,in}}{\epsilon^\circ} = E \int dA$ E is constant, $\theta = 0$

$E \int dA = E(4\pi r^2) = \frac{q_{net,in}}{\epsilon^\circ}$

$q_{net,in} = \rho V_{G.S} = \rho \frac{4}{3} \pi r^3$

$E(4\pi r^2) = \frac{\rho \frac{4}{3} \pi r^3}{\epsilon^\circ}$

$$\boxed{\underset{r<a}{E} = \frac{\rho r}{3\epsilon^\circ} = \frac{Q r}{4\pi \epsilon^\circ a^3}} \quad \propto r$$

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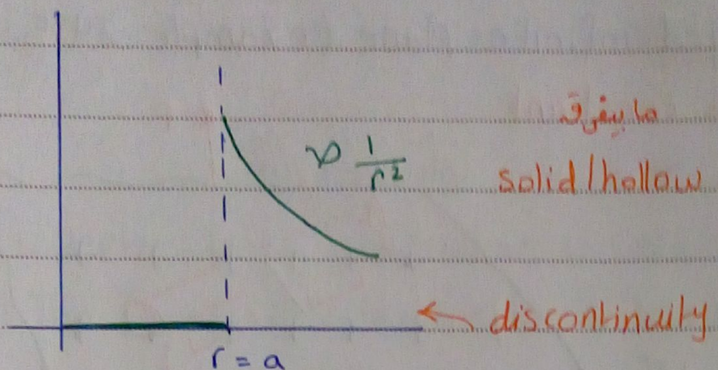
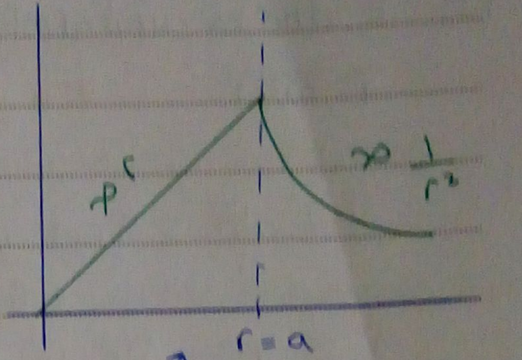
NO. 24.3





$\vec{E}$ conducting sphere uniformly charged

$\vec{E}$ solid insulating uniformly charged

21/2/2015

$\boxed{2}$ $\vec{E}$ at a distance r from a uniformly charged rod of infinite length (example 24.4 p.733 cylindrical charge distribution)

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

$$\oint \vec{E}\cdot d\vec{A} = \frac{q_{net,in}}{\epsilon_0}$$

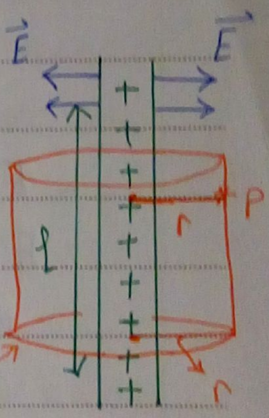
$$\int \vec{E}\cdot d\vec{A} + \int \vec{E}\cdot d\vec{A} = E\int dA = E(2\pi r l)$$

curved Part $E\int dA\ (\theta = 0)$ zero $(\theta = 90^\circ)$ المحيط & الارتفاع

$$\Longrightarrow E(2\pi r l) = \frac{\lambda l}{\epsilon_0}$$

$$\boxed{E \text{ at } p = \frac{\lambda}{2\pi\epsilon_0 r} = \frac{2K_e\lambda}{r}}$$

لو أخذنا مقطع عرضي
يصبح مثل شحنة نقطية



لو النقطة p داخل الحبل و يوجد الحبل بعملاً يكون G.S اسطوانة داخل الحبل

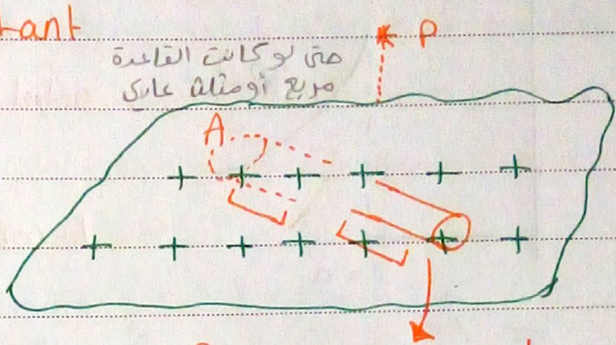
21/12/2016

NO. 24.3

3 $\vec{E}$ due to uniformly charged infinite plane (example 24.5 p. 734)

$\sigma = \dfrac{Q}{A_{total}}$ = constant

حتى لو كانت القاعدة مربع أو مثلث عادي



$\oint \vec{E}\cdot d\vec{A} = \dfrac{q_{net,in}}{\epsilon_0}$

$\underset{\substack{\text{end 1} \\ \text{(base)}}}{\int \vec{E}\cdot d\vec{A}} + \underset{\text{end 2}}{\int \vec{E}\cdot d\vec{A}} + \underset{\substack{\text{curved} \\ \text{part}}}{\int \vec{E}\cdot d\vec{A}}$

Pill-box shaped cylinder with 2 ends of area A equidistant from the plane.

على بعد متساوي

$E \parallel A \ (\theta = 0)$ $\qquad E \perp A \ (\theta = 90°)$

$\int_{end_1} E\,dA + \int_{end_2} E\,dA$ $\qquad EA + EA = 2EA$

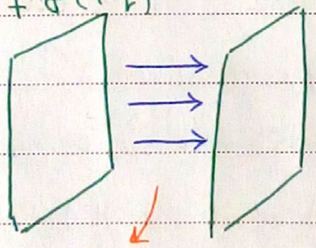
$2EA = \dfrac{\sigma A}{\epsilon_0}$ ← Pill box $\qquad \boxed{E = \dfrac{\sigma}{2\epsilon}}$

constant & independent of location of P; (distance of P from the plane), dimension and the shape of plane.

- E is downward (P below the plane)
- E is upward (P above the plane)

] if it have +ve charge

example : $\vec{E}$ between 2 uniformly charged plates



بعيداً عن الأطراف $E = \dfrac{\sigma}{\epsilon_0}$

سهل شحن العازل أما الموصل أصعب   NO. 24.4   21/2/2016

موصل

Conductors in electrostatic equilibrium

there is no net motion of charges inside the conductor

لو كان هناك net motion ← يحدث تيار كهربائي ← يولد $\vec{E}$

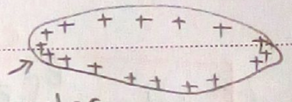
Properties of a conductor in electrostatic equilibrium

1) The $\vec{E}$ inside a conductor is always zero wether the conductor is solid or hollow.

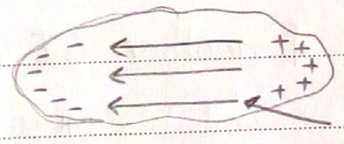
2) If the conductor is charged, the charge will instantly (لحظياً) reside on it's surface.

3) The electric field just outside the conductor is $\perp$ to surface and has a magnitude $\frac{\sigma}{\epsilon_0}$ (constant)

4) For an irregularly shaped conductor, the surface charge density (σ) is greatest when the radius of curvature is smallest (later we will prove it).



Proof of the properties

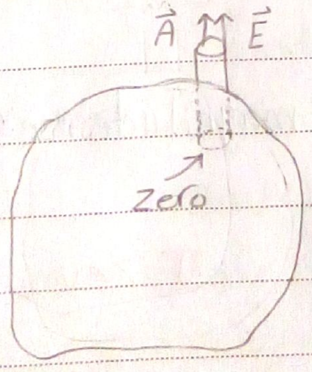
1) 

because there are free charge carrier

when $\vec{E}$ induced $= \vec{E}$ external E inside $=$ zero (equilibrium)

2) $\oint \vec{E} \cdot d\vec{A}$ (inside) $= \frac{q_{net}}{\epsilon_0}$

zero   zero

3) 

$\oint \vec{E} \cdot d\vec{A} = \frac{q}{\epsilon_0}$ $E\cancel{A} = \frac{\sigma \cancel{A}}{\epsilon_0}$ There is no $\vec{E}$ in curved part

$$\boxed{E \text{ above conductor} = \frac{\sigma}{\epsilon_0}}$$

(لا يوجد تحرك للشحنات)

25.1 Electric potential & Potential difference ← يوجد

الجهد الكهربائي — فرق الجهد الكهربائي

→ E. Force $\vec{F_e} = q\vec{E}$

it is conservative → الطاقة الميكانيكية الكلية للنظام محفوظة

الشغل لمسار مغلق = صفر (لا يعتمد الشغل على المسار)

it is associated with potential energy.

$\Delta U_{e.F} = -W_{e.F}$ — لو قوة خارجية نضع + بدل -

$$\Delta U_E = -W_{F_e} = -\int F_e \cdot d\vec{s} = -q\int \vec{E}\cdot d\vec{s}$$

$$\frac{\Delta U_E}{q} = -\int_A^B \vec{E}\cdot d\vec{s} \quad x\ \&\ y\ \&\ z$$

ΔV = electric potential difference / potential difference (P.D) / voltage.

= electrostatic potential energy (P.E) devided by test charge. Scalar quantity

P.D ← $\boxed{\Delta V = -\int_A^B \vec{E}\cdot d\vec{s}}$ → line integral (path) (not as $\int \vec{E}\cdot d\vec{A}$)

$[\Delta V] = \frac{J}{C}$ = volt = V $\qquad 1V = \frac{J}{C}$ & another SI unit

* مقدار الطاقة التي تكتسبها شحنة اختبار صغيرة موجبة اذا تحركت تحت فرق جهد = 1 فولت

for electric field is $\frac{V}{m}$ $\qquad \boxed{\frac{N}{C} = \frac{V}{m}}$

→ another unit for energy : E.V = electron volt (a non-SI unit of energy).

energy gained (كسب) / lost if a charge of magnitude "e" moves in P.D of 1 V.

$1\ eV = 1.6\times10^{-19}\ C \cdot 1\ V = 1.6\times10^{-19}\ J \qquad J > eV$

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

25/12/2015

NO. 25.1

$$\Delta V = -\int \vec{E} \cdot d\vec{s} = \frac{\Delta U}{q}$$

→ Electric potential : electrostatic potential energy devided by test charge q = e.P.E per unit charge.

$$\boxed{V = \frac{U}{q}}$$

& نستطيع معرفة مقدار V_A / V_B بشكل دقيق ، اذا أردنا معرفة ذلك يجب أن نعرف الظروف الابتدائية.

⇒ Potential difference in uniform $\vec{E}$:-

$$\Delta V = -\int_A^B \vec{E} \cdot d\vec{s} = V_B - V_A$$ if $\vec{E}$ is uniform (path independent)

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

$$\boxed{\Delta V = -\vec{E} \cdot \vec{S}}$$ for uniform E

$\vec{E}$ lines always point with decreasing potential.

كلما سرنا مع خطوط المجال يقل الجهد .

→ $\Delta V = -\vec{E} \cdot \vec{S} = 0$ if → $E = 0$

↳ $\vec{E} \perp \vec{S}$ $V_B = V_A$ = constant $\theta = 90°$

"equipotential surface" مفيدين للتنبؤ بخطوط المجال

$\vec{E}$ lines always $\perp$ to equipotential surfaces.

→ Equipotential surface :- أيضاً line ممكن

- surfaces with point of equal electric potential ($\Delta V = 0$)
- $\vec{E}$ lines $\perp$ on them
- no work is done to move any q on equipotential surface.

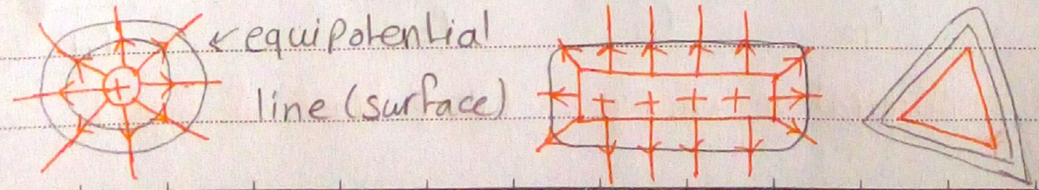
e.g conductor in electrostatic equilibrium

$\vec{E}$ inside conductor = 0 $\Delta V = 0$ → the conductor is equipotential surface.

* خطوط المجال تتجه نحو تناقص الجهد.

See example 25.1 P.750 & 25.2 P.751

* خطوط تساوي الجهد تأخذ شكل الجسم المشحون.



25/12/2015

NO. 25. 3

⇒ Electric Potential & Potential energy due to Point charges

$\Delta V = -\int_A^B \vec{E} \cdot d\vec{s}$ For a point charge $\vec{E} = \frac{K_e q}{r^2} \hat{r}$

$\Delta V = -\int_A^B \frac{K_e q}{r^2} \hat{r} \cdot d\vec{s}$ dr ds تتحول إلى من بعد يطلعوا كلهم ويضرب

$\Delta V = -K_e q \int_{r_A}^{r_B} \frac{dr}{r^2} = -K_e q \left(\frac{-1}{r}\right)\Big|_{r_A}^{r_B} = +K_e q \left(\frac{1}{r}\right)_{r_A}^{r_B}$

$V_B - V_A = \frac{K_e q}{r_B} - \frac{K_e q}{r_A}$ choose $V_A = 0$ at $r_A = \infty$ (reference configuration)

$V_B = \frac{K_e q}{r_B}$ Point charge → $\boxed{V = \frac{K_e q}{r}}$ نعوّض إشارة الشحنة

$V \to$ +ve for +ve q (with $V(\infty) = 0$)

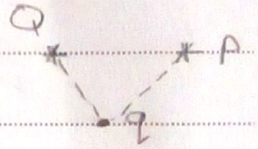
-ve for -ve q V is scalar

28/2

$\Delta U = q \, \Delta V$ P.E for a point charge $U = qV$

(U for charge Q at Point P = $q V_P$) $U = QV$

$V_P = \frac{K_e q}{r}$



→ P.E between 2 Point charges $\boxed{U = \frac{K_e q_1 q_2}{r}}$

if $q_1 q_2 > 0$ +ve repultion

if $q_1 q_2 < 0$ -ve attraction

→ For a set of Point charges

U_{system} = W done to bring these charges from infinity (external force)

$U_{system} = \frac{K_e q_1 q_2}{r_{12}} + \frac{K_e q_1 q_3}{r_{13}} + \frac{K_e q_2 q_3}{r_{23}} = K_e \sum \frac{q_i q_j}{r_{ij}}$

$i \neq j$ ≡ configuration energy. (Keep track of signs).

28/12/2016

NO. 25.3

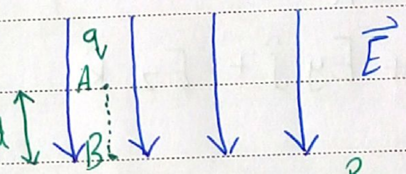
25.3 Electric Potential & Potential energy due to point charge

→ for a set of point charges

$V_P = k_e \sum \frac{q_i}{r_i}$ (Keep track of signs). جمع عادي

$\boxed{W \text{ transfer a charge from A to B} = q\,\Delta V = q\,(V_B - V_A)}$

Example: if $\vec{E} = -E\,\hat{j}$



$d\vec{s} = -dy\,\hat{j}$

$\Delta V = -\int_A^B \vec{E}\cdot d\vec{s} = -\int_A^B E\,\hat{j}\cdot dy\,\hat{j} = -\int_A^B E\,dy = -E\int_A^B dy = -Ed.$

$\boxed{\text{For uniform } \vec{E} \quad \Delta V = -Ed}$ الازاحة مع المجال

E is pointing in direction of decreasing V.

$\boxed{\Delta U = -qEd}$ ← $\Delta U = q\,\Delta V = -qEd$ for uniform $\vec{E}$

↳ if q is +ve → ΔU −ve because when +ve charge moves in $\vec{E}$ P.E ↓ & K.E ↑

↳ if q is −ve → ΔU +ve because when −ve charge moves opposite to $\vec{E}$ P.E ↑ K.E ↓

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25.4 Obtaining the value of $\vec{E}$ (magnitude) from e. Potential.

$\Delta V = -\int_A^B \vec{E} \cdot d\vec{s}$ $\quad$ $\vec{E}$ = - derivative of E.P (V) with respect to coordinates

if $V = V(x,y,z)$ (function)

$$E_x = \frac{-\partial V(x,y,z)}{\partial x} \qquad E_y = \frac{-\partial V(x,y,z)}{\partial y} \qquad E_z = \frac{-\partial V(x,y,z)}{\partial z}$$

$$\vec{E} = E_x \hat{i} + E_y \hat{j} + E_z \hat{k} \qquad \text{magnitude} = \sqrt{E_x^2 + E_y^2 + E_z^2}$$

if $V = V(r)$ $\quad$ $E_r = \frac{-\partial V}{\partial r} \Rightarrow \vec{E} = E_r \hat{r}$

Example: For the point charge

$$V = \frac{K_e q}{r} \qquad E_r = \frac{-\partial V}{\partial r} = -K_e q \frac{d}{dr}\left(\frac{1}{r}\right) = \frac{K_e q}{r^2}$$

$$\vec{E} = \frac{K_e q}{r^2} \hat{r} \quad \#$$

25.5 electric potential due to continuous charge distribution

We have two methods :-

1) for known charge distribution $\quad dV = \frac{K_e dq}{r}$

$V = K_e \int \frac{dq}{r}$ one variable (integral of scalar)

2) if $\vec{E}$ is known for the distribution (for highly symmetric charge distribution).

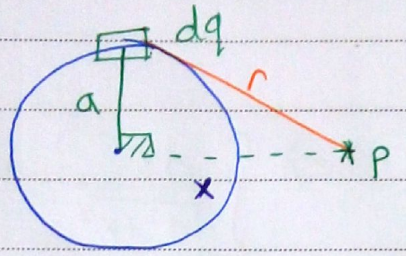
كرة $\qquad$ نتوقعه منه كسؤال

28/2/2016

NO. 25.5

[1] V due to uniformly charged ring of radius a at point p a distance x from the center of the ring on the axis passing through it's center.

$\lambda = \frac{Q}{L}$ = constant خارج التكامل ثابت $dq = \lambda\, dl$



$$dV = \frac{K_e\, dq}{r} \qquad V = K_e \int \frac{\lambda\, dl}{\sqrt{x^2+a^2}} =$$

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

$$\boxed{V_P = \frac{K_e q}{\sqrt{x^2+a^2}}}$$

$$E_x = \frac{-\partial V}{\partial x} = -K_e q \frac{(x^2+a^2)^{\frac{-1}{2}}}{dx} =$$

$$+K_e q \left(\frac{1}{\cancel{2}}\right)(x^2+a^2)^{\frac{-3}{2}}(\cancel{2}x)$$

$$\boxed{E_x = \frac{K_e q\, x}{(x^2+a^2)^{\frac{3}{2}}}}$$

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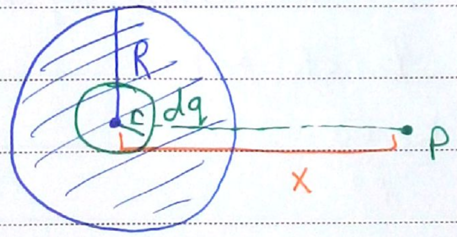
[2] V due to uniformly charged disk of radius "R" at point "p" a distance x passing through its center. (Example 25.6)

$$\sigma = \frac{Q}{A} = \frac{dq}{dA}$$



$$dV = \frac{K_e\, dq}{r} \qquad dq = \text{ring}$$

ن طريقتين (نفس كولوم)

$$dV = dV_{ring} = \frac{K_e\, dQ}{\sqrt{x^2+r^2}} \qquad dq_{ring} = \sigma 2\pi r\, dr$$

ring

$$dV = \frac{K_e \sigma 2\pi r\, dr}{\sqrt{x^2+r^2}} \quad \text{but } x \text{ is constant} \quad V = K_e \sigma 2\pi \int_{r=0}^{r=R} \frac{r\, dr}{\sqrt{x^2+r^2}}$$

$$\text{let } x^2+r^2 = u \qquad 2r\, dr = du \qquad \int_{x^2}^{x^2+R^2} \frac{du}{2u^{\frac{1}{2}}} = u^{\frac{1}{2}} \Big|_{x^2}^{x^2+R^2} = \sqrt{x^2+R^2} - x$$

$$\boxed{V = K_e \sigma 2\pi \left(\sqrt{x^2+R^2} - x\right)}$$ Function of x only / $\vec{E}$ along x only

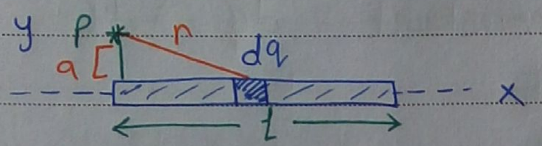
$$E_x = \frac{-\partial V}{\partial x} \qquad \boxed{E = \frac{\sigma}{2\epsilon^{\circ}}}$$ for infinitly charged disk

طريقة أخرى

1\3\2016

NO. 25.5

3 V due to uniformly charged rode of finite length "ℓ" at Point P a distance "a" $\perp$ rod. $dq = \lambda\, d\ell$ $\quad dq = \lambda\, dx$



(اتجاه $\vec{E}$ ← أو →)

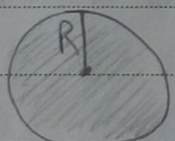
$$dV = \frac{K_e\, dq}{r} \qquad dV = \frac{K_e \lambda\, dx}{\sqrt{a^2+x^2}} \qquad V = K_e\lambda \int \frac{dx}{\sqrt{a^2+x^2}} \quad \ln\left(x + \sqrt{x^2+a^2}\right)$$

$$V = K_e\lambda \left[\ln\left(x+\sqrt{x^2+a^2}\right)\right]_0^{\ell} = K_e\lambda\left(\ln\left(\ell+\sqrt{\ell^2+a^2}\right) - \ln a\right)$$

$$\boxed{V = K_e\lambda \ln\left[\frac{\ell+\sqrt{\ell^2+a^2}}{a}\right]} = \frac{K_e Q}{\ell}\ln\left[\frac{\ell+\sqrt{\ell^2+a^2}}{a}\right]$$

$E = \dfrac{-\partial V}{\partial a}$ (y في الحقيقة) a نشتق بالنسبة ل   التكامل يكون غير [*] لو

— Example: V due to uniformly charged solid conducting sphere of radius R



$\Delta V = -\int \vec{E}\cdot d\vec{s}$ but E inside conducting sphere = 0

$E_{r<R} = 0$

$E_{r>R}$ solid sphere $= \dfrac{K_e Q}{r^2}$

→ Outside the sphere $\quad \vec{E}_{r>R} = \dfrac{K_e Q}{r^2}\hat{r}$

$$\Delta V = -\int \vec{E}\cdot d\vec{s} \qquad V_\infty - V_r = -\int_r^\infty \frac{K_e Q}{r^2}\, dr$$

$$\Delta V = -K_e Q \int_r^\infty \frac{dr}{r^2} = \frac{K_e Q}{r}\Bigg|_r^\infty = \frac{K_e Q}{\infty} - \frac{K_e Q}{r}$$

$$V_\infty - V_r = \frac{K_e Q}{\infty} - \frac{K_e Q}{r} \qquad \boxed{V_{r\,(r>R)} = \frac{K_e Q}{r}}$$

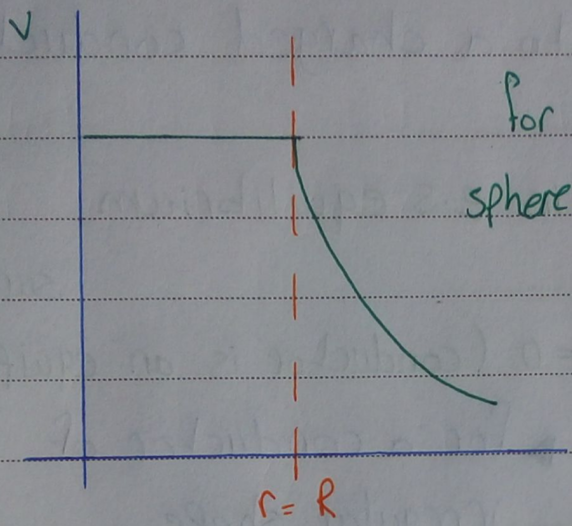
look like a point charge
سواء أكان shell أو solid
أو conductor المهم

$V_r = \dfrac{K_e Q}{R}$ لو $r = R$

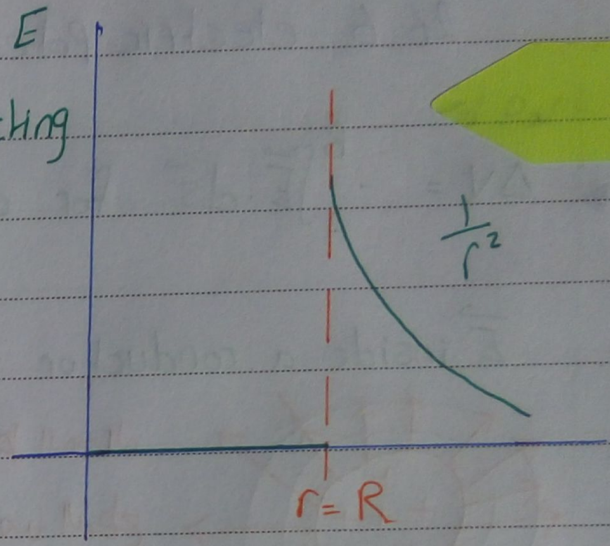
FIVE APPLE

1\3\2016

NO. 25.5



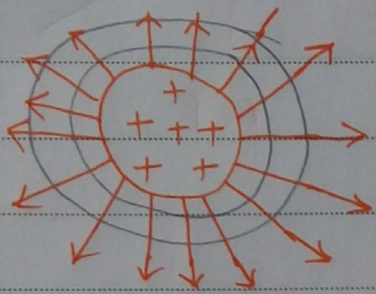
for solid conducting sphere قشرة



26.6 electric Potential due to a charged conductor

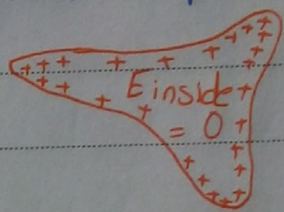
$\Delta V = -\int_A^B \vec{E} \cdot d\vec{s}$ for conductor in e.s equilibrium

$\vec{E}$ inside a conductor $= 0 \rightarrow \Delta V = 0$ (conductor is an equipotential surface).



خطوط المجال تبدأ من السطح الخارجي

→ for a conductor of irregular shape



اثبات رقم ٤ من خصائص الموصل

$|\vec{E}| \propto \sigma = \frac{Q}{A}$ σ is greatest for smallest radius of curvature

— Example 25.8 p.762

σ على 2 أكبر

البعدين الكرات أكبر من أضعاف أقطارهم

So they look like point charge

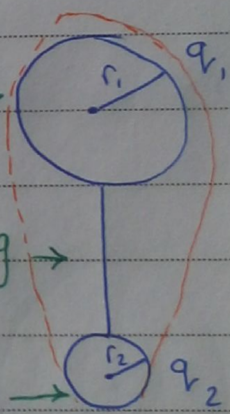
$\frac{E_1}{E_2}$??

conductor →

conducting wire

من أجل أن يتساوى الجهد وليس الشحنة

conductor →



$V_1 = V_2$

$\frac{K_e q_1}{r_1} = \frac{K_e q_2}{r_2}$ $\frac{q_1}{q_2} = \frac{r_1}{r_2} \rightarrow *$ $\frac{E_1}{E_2} = \frac{K_e q_1 / r_1^2}{K_e q_2 / r_2^2}$

$= \frac{q_1}{q_2} \frac{r_2^2}{r_1^2} = \frac{r_1}{r_2} \frac{r_2^2}{r_1^2} \Rightarrow \boxed{\frac{E_1}{E_2} = \frac{r_2}{r_1}}$ #

نستطيع تعويضها E outside conductor $= \frac{\sigma}{\epsilon_0}$ $E \propto \sigma$ & $\sigma \propto \frac{1}{\text{radius of curvature}}$

* ظاهرة أن العصافير على الأسلاك ذات الجهد الكهربائي لا تتكهرب بينما يتكهرب الإنسان؟

العصافير ← ΔV = 0 ← لا يسري تيار ← لا تتكهرب

الإنسان ← ΔV ≠ 0 ← يسري تيار كهربائي ← يتكهرب لأنه واقف على الأرض.

Chapter 26 : Capacitance & Dielectrics

26.1 Definition of capacitarce

⇒ Capacitor :-

a device used to store electric charge consist of 2 conductors seperated by a dielectric (insulating = non conducting material) carrying charges of equal in magnitude but opposite sign when attached to a potential difference.

بغض النظر عن شكل المواسع

⇒ What is capacitance ? (مواسعة)

it is a major of how much charge is stored on a capacitor at certain potential difference.

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

C : capacitance (it is scalar & always +ve).

Q : charge on a capacitor (the quantity of charge on any plate of the capacitor)

ΔV : $|\Delta V| = |P.D|$

$$[C] = \frac{[Q]}{[V]} = \frac{C}{V} = \text{Farad} = F$$ ← كمية كبيرة جداً

→ micro Farad = μF = mF يقول السؤال أ؟ micro

→ micromicro Farad = picofarad = pF = 10^{-12} F = mmF

→ nanoFarad = nF = 10^{-9} F

$C = \frac{Q}{\Delta V}$ ⇐ النسبة ثابتة $\frac{\uparrow}{\downarrow}$ = same (constant)

⇒ Capacitance depends on :-

1) geometry of capacitory (size & shape). .... البعد بين الصفيحتين

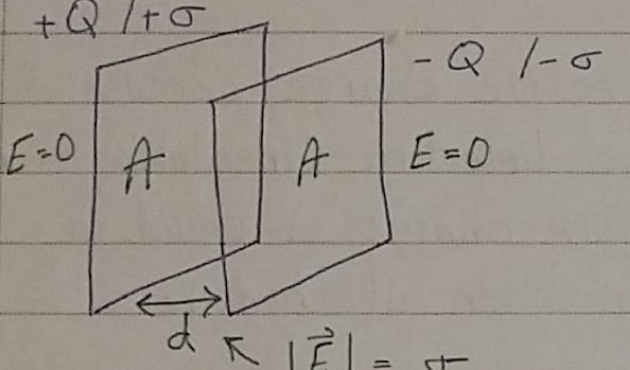
2) dielectric material.

* هناك ٣ أشكال للمواسع:-

C is independent of Q & ΔV ١) كرة ٢) أسطوانة ٣) صفيحة

26.2 Calculating the capacitance

1 Parallel plate capacitor



2 parallel conducting plates each of area A, seperated by d
(d ⋘ length & width of the plate)

$\leftarrow |\vec{E}| = \frac{\sigma}{\epsilon_0}$ $C = \frac{Q}{\Delta V}$ $\Delta V = -\int_A^B \vec{E} \cdot d\vec{s}$

for uniform $\vec{E}$ $\Delta V = -Ed$ $|\Delta V| = Ed$

$C = \frac{Q}{Ed}$ but $E = \frac{\sigma}{\epsilon_0}$ $\rightarrow$ $C = \frac{Q}{\frac{\sigma}{\epsilon_0} d} = \frac{Q\epsilon_0}{\frac{Q}{A} d} = \frac{\epsilon_0 A}{d}$

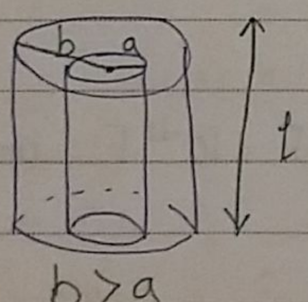
$$\boxed{C = \frac{\epsilon_0 A}{d}}$$

$\propto A$

$\propto \frac{1}{d}$ ← practical to increase C

لو وسط غير الهواء ϵ / كلما كان الوسط عازل أكثر ← $C \uparrow$

2 C for a cylindrical capacitor



$b > a$

2 cylidrical conductors of a solid cylinder of charge Q (radius a) coaxial with a cylindrical shell of charge -Q (radius b)
the length = ℓ
(ℓ ⋙ a & b).

$C = \frac{Q}{\Delta V}$ ($\Delta V \rightarrow V_B - V_A$)

$\Delta V = V_b - V_a = -\int_a^b \vec{E} \cdot d\vec{s} = -\int_a^b \frac{2k_e\lambda}{r} dr =$ or

$-\int_a^b \frac{\lambda}{2\pi\epsilon_0 r} dr = \frac{-\lambda}{2\pi\epsilon_0} \int_a^b \frac{dr}{r} = \frac{-\lambda}{2\pi\epsilon_0} \ln\left(\frac{b}{a}\right) =$

$$-\frac{2K_eQ}{\ell}\ln\left(\frac{b}{a}\right) \qquad b>a \rightarrow +ve$$

لو سالب نعكسها ← $\frac{a}{b}$

$$|\Delta V| = \frac{2K_eQ}{\ell}\ln\left(\frac{b}{a}\right) \qquad b>a$$

$$C = \frac{Q}{2K_e\frac{Q}{\ell}\ln\left(\frac{b}{a}\right)} = \frac{\ell}{2K_e\ln\left(\frac{b}{a}\right)} \qquad K_e = \frac{1}{4\pi\epsilon^\circ}$$

$$C = \frac{\ell}{2K_e\ln\left(\frac{b}{a}\right)}$$ C for cylidrical capacitor

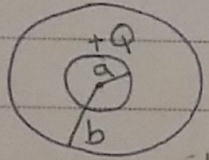
→ capacitance for unit length
more practical

$$\boxed{\frac{C}{\ell} = \frac{1}{2K_e\ln\left(\frac{b}{a}\right)}}$$

مهمة (المواسع) : يمرر التيار & يخزن طاقة

لا يعطي الطول أهمية

3 C for a spherical capacitor



$-Q$

$(b>a)$

2 spherical conductors seperated by dielectric / a spherical conducting shell $(b, -Q)$ concentric with a solid conducting sphere $(a, +Q)$

أو الشحنات

بالعكس المهم مختلفة في الشحنة

$$C = \frac{Q}{\Delta V} \qquad \Delta V = -\int_a^b \vec{E}\cdot d\vec{s} \qquad V_b - V_a = -\int_a^b \vec{E}\cdot d\vec{s}$$

$$= -\int_a^b \frac{K_eQ\,dr}{r^2} = -K_eQ\int_a^b \frac{dr}{r^2} = \frac{K_eQ}{r}\Big|_a^b =$$

قلبنا لأن $b>a$ مشان يطلع موجب

$$K_eQ\left(\frac{1}{b}-\frac{1}{a}\right) = \frac{K_eQ(b-a)}{ab} = |\Delta V| \qquad b>a$$

$$C = \frac{Qab}{K_eQ(b-a)} \qquad \boxed{C = \frac{ab}{K_e(b-a)} = \frac{4\pi\epsilon^\circ ab}{b-a}}$$ for spherical capacitor

اذا زدنا b لا نعرف كم تزيد C لازم نعرف النسبة

6/3/2016

NO. 26.2

→ Special case

isolated spherical conductor (when $b \to \infty$) →

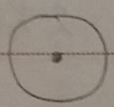
$C_{\text{isolated spherical conductor}} = \lim_{b \to \infty} C_{\text{spherical conductor}}$

$$= \lim_{b \to \infty} \frac{4\pi\epsilon_0 ab}{b-a} \approx 4\pi\epsilon_0 \frac{a\cancel{b}}{\cancel{b}}$$

C isolated spherical conductor of radius a =

$$4\pi\epsilon_0 \underbrace{a}_{\text{radius of conductor}} = \frac{a}{K_e}$$

طريقة أخرى للاشتقاق



$$V = \frac{K_e q}{r} = \frac{K_e q}{a} \qquad C = \frac{q\,a}{K_e q} = \frac{a}{K_e} \quad \#$$

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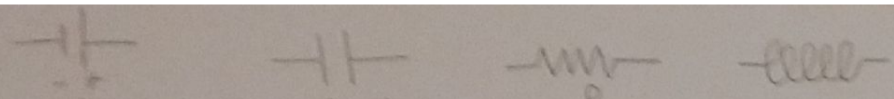
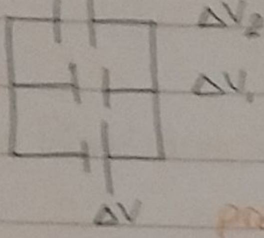


(المواسعة) المكثف
(تخزين الشحنة)

NO. 26.3 — 8/3/2016

26.3 Combination of capacitors
التواصل يعكس المقاومة -

⇒ **Parallel combination** (الأقطاب المتشابهة مع بعض)



1 → $\Delta V_1 = \Delta V_2 = \Delta V = \cdots$ نفس الجهد في التيار يختلف

2 → $C_{equ.p} = C_1 + C_2 + \cdots$

→ $C_{equ.p} >$ largest C

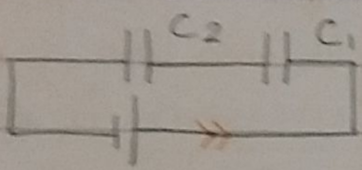
proof of 2:

$Q_{tot} = Q_1 + Q_2 + \cdots$ but $C = \frac{Q}{\Delta V}$

$C\Delta V = C_1 \Delta V_1 + C_2 \Delta V_2 + \cdots$

but $\Delta V = \Delta V_1 = \Delta V_2 \rightarrow C_{equ.p} = C_1 + C_2 + \cdots$

⇒ **Series combination** (opposite polarity with each other).



1 → $\Delta V_{tot} = \Delta V_1 + \Delta V_2 + \cdots$

2 → $\frac{1}{C_{equ.s}} = \frac{1}{C_1} + \frac{1}{C_2} + \cdots$

→ $C_{equ.s} <$ least C

proof of 2:

$\Delta V_{tot} = \Delta V_1 + \Delta V_2 + \cdots$

$\frac{Q}{C_{equ.s}} = \frac{Q_1}{C_1} + \frac{Q_2}{C_2} + \cdots$ but $Q = Q_1 = Q_2$

Remember to take the inverse → $\frac{1}{C_{equ.s}} = \frac{1}{C_1} + \frac{1}{C_2} + \cdots$

→ For 2 capacitors in series

$$\boxed{C_{equ.s} = \frac{C_1 C_2}{C_1 + C_2}}$$

Just for 2 capacitors in series.

See example 26.3 p 785

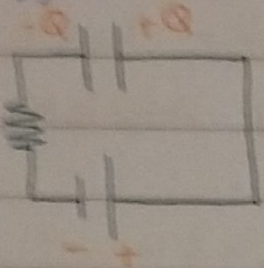
Series → same current → same charge.

parallel → same voltage

8/3/2016

NO. 26.3

⇒ energy stored in a charged capacitor



$dw = \Delta V\, dq$ (dq variable with time)

$w = \int \Delta V\, dq \qquad \Delta V = \frac{q}{C}$

$= \int \frac{q}{C}\, dq$ but C is constant

$= \frac{1}{C}\int_0^Q q\, dq = \frac{1}{C}\frac{q^2}{2}\Big|_0^Q = \frac{1}{2}\frac{Q^2}{C} = \frac{Q^2}{2C}$

capital → $\boxed{U = \frac{Q^2}{2C}}$ the energy stored in a charged capacitor

مشهورة

but $C = \frac{Q}{\Delta V}$ $\qquad \boxed{U = \frac{1}{2} C (\Delta V)^2}$ it looks like $\frac{1}{2} m v^2$

$\boxed{U = \frac{1}{2} Q \Delta V}$

$[U] = [\text{energy}] = J$

⇒ Energy density ≡ energy per unit volume

$u = \frac{U}{\text{Volume}} \qquad [\text{energy density}] = J/m^3$

e.g. parallel plate capacitor

$C = \frac{\epsilon_0 A}{d} \qquad \Delta V = -Ed$

$U = \frac{1}{2}\frac{\epsilon_0 A}{d} E^2 d^2 = \frac{1}{2}\epsilon_0 E^2 (Ad)$ → volume

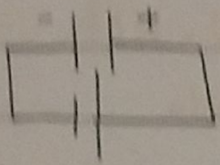
E → magnitude

$\boxed{u_E = \frac{1}{2}\epsilon_0 E^2}$ valid for any capacitor & يكون نظام كهربائي يحوي طاقة كهربائية

10\3\2016

NO. 26.5

26.5 Capacitors with dielectrics



V capacitor = V battery → open circuit

* Dielectric / non conducting material
  e.g. air / wax / rubber / wood / ...

→ to improve the capacitance of a capacitor (parallel plate capacitor)

$C = \frac{\epsilon A}{d}$
→ by decreasing d (seperation between 2 conductors)
→ by inserting dielectric (أكثر عازلية من الهواء)

[A] → if dielectric is inserted

$\boxed{C = K C_0}$ C_0: without dielectric (dielectric of air = 0)

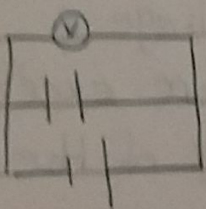
$C > C_0$ K: $K > 1$ dielectric constant

[K] = unitless ([illegible] K [illegible])

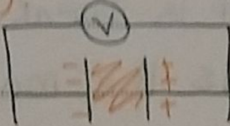
$\boxed{C = \frac{K \epsilon_0 A}{d}} = \frac{\epsilon A}{d}$ ϵ: permitivity of substance

$C = Q / \Delta V$ $C_0 = Q_0 / \Delta V_0$

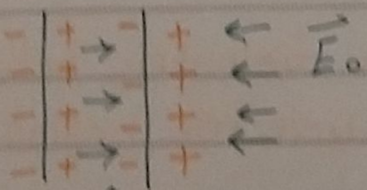
① → inserting dielectric in a capacitor while the battery is dissconnected. Potential difference will change / Q same (decrease)



$C_0 = \frac{Q_0}{\Delta V_0}$



$C = K C_0$ → $Q = Q_0$
→ $\Delta V \downarrow$ → $\Delta V = \frac{\Delta V_0}{K}$



$\vec{E}$ induced

$\vec{E} = \vec{E}_0 - \vec{E}$ induced / × d

$\vec{V} = \vec{V}_0 - \vec{V}$ induced

لا تُصبح E = 0 فقط
[illegible] conductor
conductor كَنزيز [illegible] carriers

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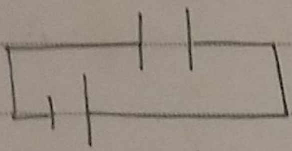
NO. 26.5

② → inserting dielectric in a capacitor while the battery is still connected   Q increases $Q = KQ_o$

ΔV remains $= \Delta V_o$



$$C = \frac{KQ_o}{\Delta V_o} = KC_o$$

لازم في السؤال نعرف
أي الحالتين بقصد

لأن الجهد أصبح متساوي
← open circuit ويتوقف
التيار الكهربائي

→ examples of K :-

أكثرها الهواء ٣-٤ مرات

$K(\text{dry air}) = 1.00059$ $K(\text{nylon}) = 3.4$ $K(\text{vacum}) = 1.00000$ (free space)

See table Page 791

[B] → C can be improved (increased) by inserting dielectric or by decreasing d

This way is limited (districted) محددة بقيود

$\Delta V = -Ed$ $E = \frac{\Delta V \uparrow}{d \downarrow}$ (E constant)

اذا قللنا المسافة في conductor بصبح ΔV كبيرة
جداً وتفقد المادة عازليتها

⟹ $\Delta V > \Delta V_{max}$ → material will loose its properties by the break down voltage of the capacitor.

* What is breakdown voltage ≡ operating voltage ?

it is the max voltage of a capacitor before exceeding (تجاوز) the dielectric strength of the insulating of the dielectric material.

the maximum electric field on a dielectric before breaking down occurs (before dielectric begins to conduct).

10/3/2016

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$E = \dfrac{\Delta V}{d} < E_{max}$ ✓ $\qquad E = \dfrac{\Delta V}{d} > E_{max}$ ✗

ينهار نظام المواسع الكهربائي :

when we decrease d

see example 26.5 p.793

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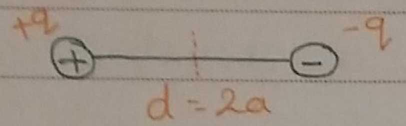
NO. 26.6

26.6 Electric dipole in an uniform electric field

ثابت مقدارا & اتجاها

⇒ electric dipole :-

a system of 2 charges equal in magnitude with opposite sign $(+q, -q)$ seperated by a distance $(d = 2a)$



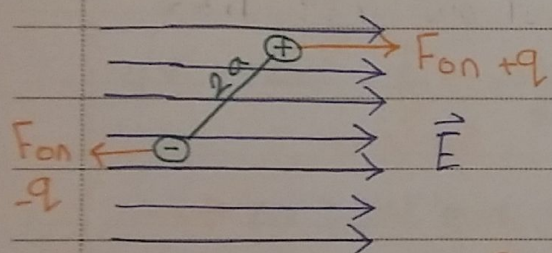
⇒ electric dipole moment (p) vector

$\vec{p} = q\,\vec{d} = q\,2\vec{a}$ $\quad |\vec{p}| = qd = q\,2a$

$[p] = C.m$ & it points from $-q$ to $+q$ الاتجاه الاصطلاحي

⇒ insert an electric dipole in uniform $\vec{E}$

makes an angle θ with $\vec{E}$



$\vec{F}_{on\,+q} = +q\,\vec{E}$ $\quad \vec{F}_{on\,-q} = -q\,\vec{E}$

$\vec{E}$ ⇝ $\Sigma\vec{F}$ on dipole → translational equilibrium

But the 2 forces have a net torque.

So... rotationally.. the system is not in equilibrium.

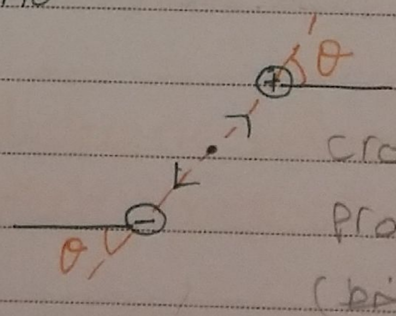
$\vec{\tau} = \vec{r} \times \vec{F}$ $\quad |\vec{\tau}| = rF\sin\theta$ $\quad \tau_1 = aqE\sin\theta$

$\tau_2 = aqE\sin\theta$ $\quad \Sigma\tau = \underbrace{2aq}_{P}E\sin\theta$

$\Sigma\tau = PE\sin\theta$

$\boxed{\tau = \vec{P} \times \vec{E}}$ $\quad \vec{P} = q\vec{d}$

N.m $\quad \frac{N}{C} = \frac{V}{m}$



cross product

(ضرب خط)

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$\Rightarrow$ energy stored in e-dipole - $\vec{E}$ system

$$dU = dW = \tau \, d\theta \quad (\text{if it is external force} \rightarrow +)$$

($\vec{E}$ is external)

$$W = \int \tau \, d\theta = \int PE \sin\theta \, d\theta = PE \int \sin\theta \, d\theta =$$

$$\boxed{U = -PE\cos\theta} \quad \boxed{U = -\vec{P} \cdot \vec{E}}$$

Chapter 27 : Current & resistance

27.1 Electric current ≡ current I

⇒ **Current :-**

the rate of flow of electric charges (charge carriers) on a region.

↳ Average current $\bar{I} \equiv I_{avg}$

$$\frac{\Delta Q}{\Delta t}$$

↳ inst. current I

$$\lim_{\Delta t \to 0} I_{avg} = \frac{dq}{dt}$$

$$[I] = \frac{[Q]}{[t]} = \frac{C}{s} \rightarrow \text{Ampere} = A = \text{Amp}$$

I is scalar & it has a direction. (اتجاه حركة الشحنات +)(الاتجاه المعاكس)

→ the direction of current (conventional) تقليدي

it is the same as the direction of the flow of the charges.

→ current is produced by moving charges (mobile charge carriers) due to potential difference.

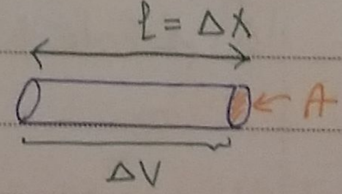
if
- $P.D = \Delta V = 0 \rightarrow I = 0$
- $P.D = \Delta V \neq 0 \rightarrow I \neq 0$

→ mobile charge carriers are 3 types :-

1) +ve — protons / H^+ / any atom when we remove e^- (in particle accelerators)
2) -ve — in most of conductors (like metals) ← الأشيع
3) both — in gases and electrolytes

⇒ **Microscopic model of electric current**

a segment (مقطع) of uniform conductor



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

→ ΔQ : no. of free charges carriers x charge of each charge carrier.

$\Delta Q = Ne = n e V_{olume}$

عدد الشحنات شحنة number density of charge carriers

→ $n = \frac{\text{total no. of charge carriers}}{V_{olume}} = \frac{N}{V_{olume}}$ $[n] = m^{-3}$

$V_{olume} = A \Delta X$ $\Delta Q = neA\Delta X$

$I_{avg} = neA \frac{\Delta X}{\Delta t}$ V_d سرعة الانسياق

$\boxed{I_{avg} = n e V_d A}$ (*)

→ Drift velocity = V_d = average velocity of the mobile charge carriers on conductor.

→ if $P.D \neq 0$ → $V_d \neq 0$ → $I \neq 0$ ← كلما كانت المادة أكثر موصلية

→ if $P.D = 0$ → $V_d = 0$ → $I = 0$ $\uparrow I$ $\uparrow V_d$

explanation of (*)

n : number density of charge carrier $[n] = m^{-3}$

e : 1.6×10^{-19} C قيمة شحنة e

A : cross sectial area. مساحة المقطع العرضي

See example 27.1 P.811 important.

⇒ Current density = $\vec{J}$

current per unit area $|\vec{J}| = J = \frac{I}{A}$ $[J] = Amp/m^2$

27.2 Resistance = R

a major of how much opposition مقاومة a material exhibits to electric current.

$$R = \frac{\text{P.D between the ends of a conductor}}{\text{current passing through it}}$$

حالة خاصة من قانون أوم

$$\boxed{R = \frac{\Delta V}{I}}$$

$$[R] = \frac{\text{Volt}}{\text{Amp}} = \text{Ohm} = \Omega$$

⇒ Ohm's law :-

For many conductors (e.g materials); the ratio of the current density J & the electric field E through this conductor is constant = σ & it is independent of $|\vec{E}|$

$\vec{J} \propto \vec{E}$ النسبة $\frac{Q}{A}$

$\vec{J} = \text{const.}\ \vec{E}$

$\vec{J}$ و $\vec{E}$ لا يتغير

$$\boxed{\vec{J} = \sigma \vec{E}}$$

$[J] = \text{Amp}/m^2$

$[E] = \frac{N}{C} = \frac{V}{m}$

$[\sigma] = (\Omega \cdot m)^{-1}$

if $J \propto E$ → ohmic material

if not → not Ohmic material

$I_{avg} = n e v_d A$

$J = \frac{I}{A} = n e v_d$

⇝ for a segment of uniform conductor (metal)

$J = \sigma E \quad \frac{I}{A} = \frac{\sigma \Delta V}{\ell} \quad R = \frac{\Delta V}{I} = \frac{\ell}{A\sigma}$ if it is ohmic

$$\boxed{R = \frac{\ell}{\sigma A}}$$

R depends on 1) the material of a conductor
2) geometry of a conductor.

$R \propto \ell \quad R \propto \frac{1}{A}$

$[R] = (\Omega \cdot m)^{-1}$

$$\boxed{R = \frac{\ell}{\sigma A} = \frac{\rho \ell}{A}}$$

σ : conductivity $[\sigma] = (\Omega \cdot m)^{-1}$

ρ : resistivity $[\rho] = (\Omega \cdot m)$

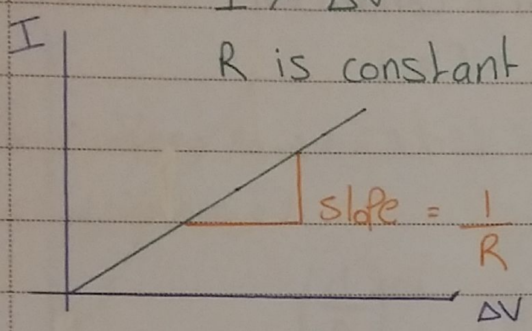
$\rho = \frac{1}{\sigma}$

$$\frac{I}{\Delta V} = \frac{A\sigma}{l} = \frac{A}{\rho l} = \frac{1}{R}$$

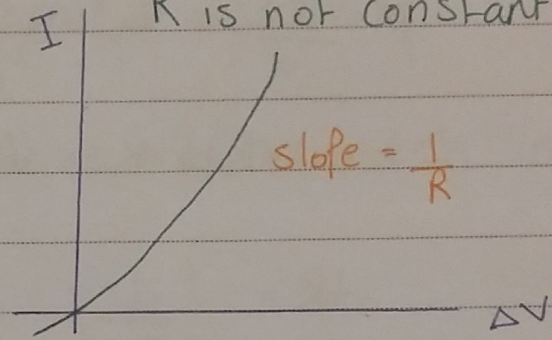
if the material is ohmic $\rightarrow \frac{I}{\Delta V} = \text{constant} = \frac{1}{R}$

Ohmic material — $I \propto \Delta V$, R is constant

Non-Ohmic material — R is not constant تعتمد على الجهد والتيار



linear



not linear

high R at +ve ΔV
low R at -ve ΔV
لو الوصلة بالعكس ينعكس الكلام

e.g diode صمام ثنائي

⇒ Resister

a device that controls current in a circuit.

→ There are two types of resisters :-

① composition resistor مقاومة بقيمة محددة

e.g carbon resistor → color coding of carbon resistors

نقرأ من الجهة الأقرب للطرف

a: brown
b: red
c: orange

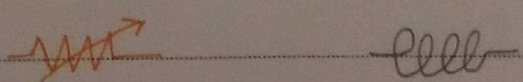
a b c ↘ uncertainly: gold ± 5%, silver ± 10%, colorless → ± 20%

$R = ab \times 10^c \mp \text{uncertainly}$

See page 813

$12 \times 10^3 \pm 5\%$ (if it is gold for example) $= 12\,K\Omega$

② wire - wound resistor مثل الريوستات



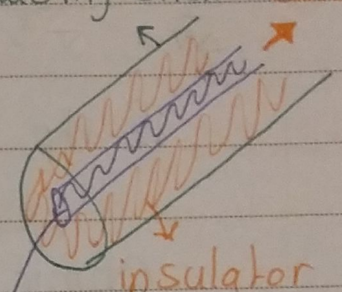
شكله الحقيقي

→ Example 27.3 p. 815

a → smaller radius b → larger radius

→ current must be conducted along the length of coaxial label (not throug the insulator) مو بالعرض R ?

$R = \frac{\rho l}{a}$ ← لا نستطيع تطبيق



element of R $dR = \frac{\rho\, dr}{A}$ dr: سماكة مقطع من الموصل (أسطوانة صغيرة)

$dR = \frac{\rho\, dr}{2\pi r l}$ $R = \frac{\rho}{2\pi l} \ln\left(\frac{b}{a}\right)$

كلما زادت R ← current is more shielded

27.3 is not included

R تتغير بتغير شكل الموصل

ρ تعتمد على الحرارة / نوع المادة

↑ حرارة موصلية ↓ مقاومية ↑

27.4 Resistance & temperature

For conductors

$$\boxed{\rho = \rho_0 [1 + \alpha (T - T_0)]}$$ → dimentionless

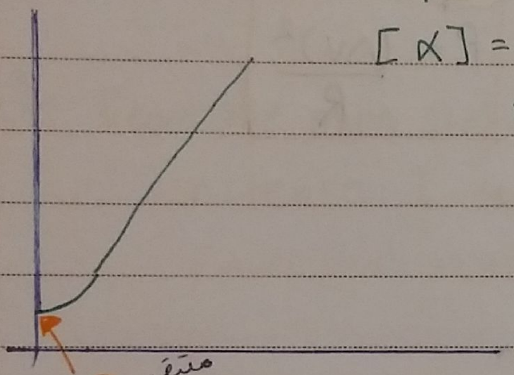
- العلاقة ليست خطية بسبب وجود الرقم 1

$\rho_0 = \rho(\text{at } T = T_0 = 20°C)$ عادة

$\rho(\Omega.m)$ α : temperature cooficient of resistivity

$[\alpha] = 1\backslash C° = (C°)^{-1}$

high temperature → approximately linear



$T(C°)$

مبتقي

ρ residual due to collision with impurities in the material.

فقط ρ residual تعتمد على الشوائب / الشوائب عيوب بالنسبة للموصلات و العكس صحيح

$$\rho = \rho_0 [1 + \alpha (T - T_0)] \backslash \times \frac{L}{A}$$

$R_0 = R$ if $T_0 = T$

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

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

α ← كمية ثابتة لكل مادة

- اذا زادت T تزيد ρ

see page 814

→ α always positive for conductors

$\Delta T \uparrow$ $\Delta \rho \uparrow$

→ for semi conductors α always negative

$T \uparrow$ $\rho \downarrow$

17/3/2016

NO. 27.5

27.5 electrical Power قدرة

electric energy produced (transfered نقل / consumed مستهلك)
per unit time.

$\Delta U = q\,\Delta V \qquad dU = dq\,\Delta V$

$$\text{power} = \frac{dU}{dt} = \frac{dq}{dt}\Delta V \qquad \boxed{P = I\,\Delta V}$$

$$R = \frac{\Delta V}{I} \qquad \boxed{P = I^2 R} \qquad \boxed{P = \frac{(\Delta V)^2}{R}}$$

نستطيع حساب الطاقة من خلال الاسلاك Joule heating low

$$[P] = \frac{J}{s} = \text{Watt} = W$$

20/3/2016

NO. 27.5

⇒ Transporting E energy through power lines

* We have high power :-

$\boxed{P = I \Delta V}$

→ at low current & high voltage أوفر اقتصاديا

→ at high current & low voltage أكثر أماناً

chosen for economic reason.

→ Power lost $= I^2 R$ through the cable (wires) minimized.

e.g. from the main station $\Delta V \approx 700$ KV

increase $I \rightarrow \Delta V$ reduced to 4 KV by transformer

Power that reach the consumer = 240 V   ↓V ↑I

Chapter 28 : Direct - current circuits

⇒ Two types of current :-

1. direct current (DC)

current that is constant in direction

↳ steady state current (constant in magnitude & direction)

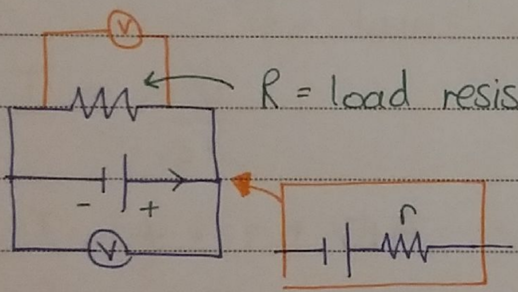
2. alternating current (AC)

current that changes its direction periodically.

28.1 electromotive force ($emf \equiv \mathcal{E} \equiv E$) القوة الدافعة الكهربائية

it is not a force

[emf] = volt it is a potential difference (voltage).



R = load resistor

$V = V$

سميت كذلك لأنها تجبر البطارية على احداث فرق جهد وتحريك الالكترونات في الدارة الكهربائية

$$\mathcal{E} = Ir + IR = I(r+R) \qquad \boxed{\mathcal{E} = I(r+R)}$$

→ electromotive force : (أكبر شي عندما تكون الدارة مفتوحة أو $r=0$ مستحيل)

work done by the battery per unit charge ≡ max P.D that a battery can provide to circuit ≡ terminal voltage when the circuit is open. (قراءة V أقل من $\mathcal{E}$ الأهمية بدون r)

→ terminal voltage = P.D through the external resistance = P.D measured by a voltmeter = $\mathcal{E}$ if → $r = 0$ / open circuit.

$\mathcal{E} = Ir + IR \quad / * I$

$\underbrace{I \cdot \mathcal{E}}_{\text{total}} = \underbrace{I^2 r}_{\text{lost by the internal resistance}} + \underbrace{I^2 R}_{\text{consumed by the device}} \qquad P_{\mathcal{E}} = P_r + P_R$

total — produced by $\mathcal{E}$

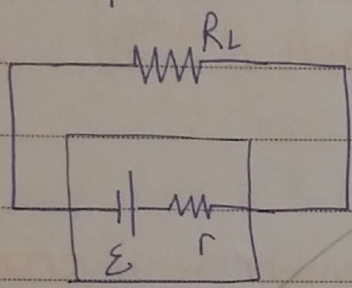
lost by the internal resistance

consumed by the device

r : مقاومة أي شيء في الدارة ما عدا الجهاز المقصود (الأسلاك، أجهزة أخرى، ...)

→ See example 28.1

→ example 28.2 p. 835 important [matching load] Power transfer



Find R_L for which P_L is maximum ?

$P_L = I^2 R_L$? maximum → نشتق مرتين

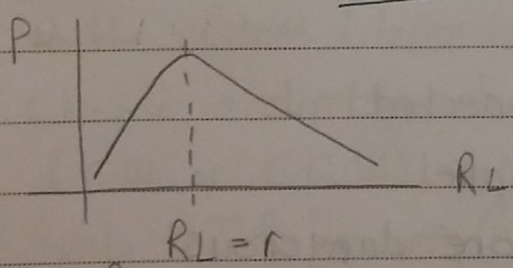
$P_L = I^2 R_L$ (one variable)

$\mathcal{E} = Ir + IR_L = I(r + R_L)$

$I = \frac{\mathcal{E}}{r + R_L}$ I depends on R_L

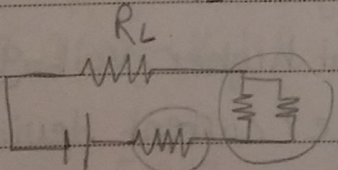
$P_L = \frac{\mathcal{E}^2 R_L}{(r + R_L)^2}$ $\qquad \frac{dP_L}{dR_L} = 0 = \frac{[2\mathcal{E}(r+R_L)^2 + \mathcal{E}^2 2(r+R_L)]}{(r+R_L)^4}$

$[\;] = 0 \implies \boxed{R_L = r}$ لو يوجد نقطة أخرى أيضاً نشتق مرة أخرى



يجب أن تكون مقاومة الجهاز مساوية للمقاومات الأخرى →

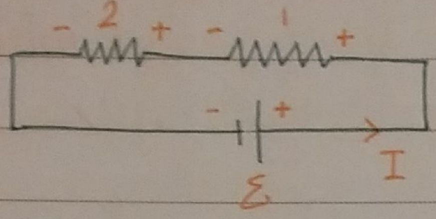
r : internal resistance ≡ equivalent resistance of all resistors in the curcuit exept the device.



R_L = other resistors to have high power

28·2 Resistors in series & parallel

⟹ Series combination of resistors



$\mathcal{E} = \Delta V_1 + \Delta V_2$

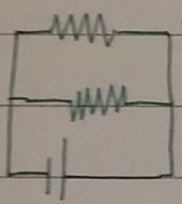
$\mathcal{E} = I_1 R_1 + I_2 R_2$ but I is equal

$R_{equ.s} = R_1 + R_2$

current same ⟶ $R_{equ.s} = R_1 + R_2 + \cdots$

voltage seperated $R_{series} >$ greatest R

⟹ Parallel combination of resistors



⟶ $\frac{1}{R_{equ.p}} = \frac{1}{R_1} + \frac{1}{R_2} + \cdots$

remember to inverse

$R_{equ.p} <$ least R

only for 2 resistors in parallel $R_{equ.p} = \frac{R_1 R_2}{R_1 + R_2}$

→ in household combination

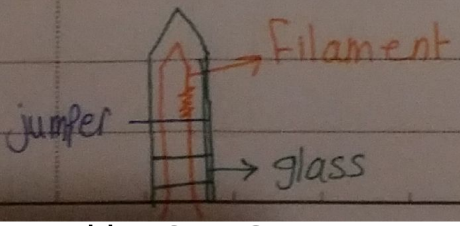
parallel combination of resistors → operate independantly

⟶ light strings combined (connected)

series	parallel
safer	more dangerous
same current / voltage devided	operated at higher voltage
operated at lower voltage	same voltage / current devided
less brightness / lower temp.	brighter / hotter
dependently operated	independently operated

→ we use miniature (صغير) light strings wired in series

see example 28·4 & 28·5



التيار يختار المسار ذو الأقل مقاومة

عندما نخرجه يصبح كأنه سلك ويسلك التيار المسار الآخر &

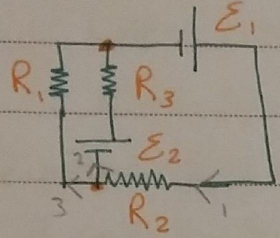
تزداد شدة الإضاءة وتزداد درجة الحرارة / يجب تصليحها

28.3 Kirchhoff's Rules (to analyze complicated circuits).

نقطة تفرع

[1] Junction rule ≡ K.J.R ≡ conservation of electric charge

$\sum I = 0 \qquad \sum I_{in} = \sum I_{out} \qquad \left(I = \frac{dq}{dt} \right)$



3 loops $\quad I_1 = I_2 + I_3$

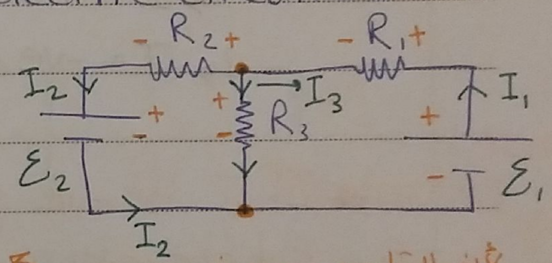
2 nods → one independent node

[2] Loop rule ≡ K.L.R ≡ conservation of energy

for every closed loop → $\sum \Delta V = 0$ $\quad \Delta U / q$

⇒ Steps to apply K-Rules in analyzing electric circuits:-

1. Assign a direction for every current in every node.
2. label the polarity for every element in the current (depends on step 1)
3. Choose a direction for your path (C.W or C.C.W) independent
4. Apply K.J.R for every node in the circuit
5. Apply K.L.R for every loop.
6. Solve the equations of unknowns



لأن التيار بيسير من الجهد الأعلى إلى الجهد الأقل

$I_1 = I_2 + I_3$

→ $\overset{I}{\rightarrow} \overset{+\;R\;-}{\text{wwv}}$ $\quad \overrightarrow{\text{my path}}$ $\Delta V = -IR$ $\quad \overleftarrow{\text{my path}}$ $\Delta V = +IR$

→ if resistor is transerved along the direction of I → Potential drop (-)

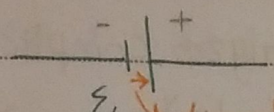
→ if resistor is transerved at the opposite direction of I → Potential gain (+)

★ no. equations = no. unknowns لا أقل ولا أكثر

★ علامة independent node أقل بواحد من الموجودين فعلياً في الدارة

24/3/2016

NO. 28.3



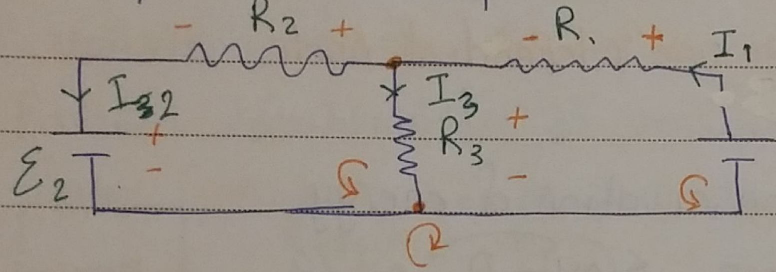
direction of $\mathcal{E}$

$\overrightarrow{\text{my path}}$ $\Delta V = +I\mathcal{E}$

$\overleftarrow{\text{my path}}$ $\Delta V = -I\mathcal{E}$

- if an e.m.f is transerved along emf → potential gain
- if an e.m.f is transerved opposite to emf → potential drop.

- the previous example



① $\mathcal{E}_1 - I_1R_1 - I_3R_3 = 0$

② $I_3R_3 - I_2R_2 - \mathcal{E}_2 = 0$

③ $\mathcal{E}_2 + I_2R_2 + I_1R_1 - \mathcal{E}_1 = 0$

* Result:

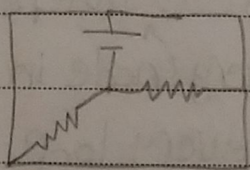
↳ I = +ve → you guess for the correct direction.

↳ I = -ve → magnitude is correct but in the opposite direction.

* If I is -ve you should continue to use -ve value in all subsequent calculations. (يكون عكس المطبقة نقلبها لاحقاً")

→ see example 28.6 & 28.7

closed path → loop



3 loops.

26/3/2016

NO. 28.4

28.4 R-C curcuits

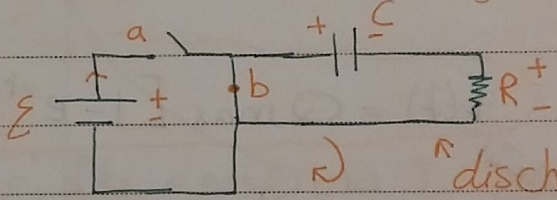
circuits with resistor & capacitors connected in series.

→ R-C circuits are two types :-

1. Charging R.C circuits
   - capacitors is being charged.
   - with power supply
2. Discharging R.C circuits
   - capacitor is being discharged
   - without battery

⇒ I in R.C circuit depends on time (changing in magnitude and constant in direction). it is DC (not steady state)

$I = I(t) \neq$ constant



circuit discharging (سلكين في طرفي C)

⇒ R-C charging circuit

المقاومة تستغرق وقت

at $t=0$ capacitor is initially uncharged $q(t=0)=0$

at any t → apply K.L.R

$$\Sigma \Delta V = 0 \qquad \varepsilon - \Delta V_C - \Delta V_R = 0$$

$\Delta V_C = \frac{q}{C}$, $\Delta V_R = IR$ — q & I not constant

$$\varepsilon - \frac{q}{C} - IR = 0 \qquad \text{but } I = \frac{dq}{dt}$$

فرع تكامل — فرع مشتقة

$$\varepsilon - \frac{q(t)}{C} - \frac{dq(t)}{dt}R = 0 \qquad \varepsilon - \frac{q}{C} = \frac{dq}{dt}R$$

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

$$\frac{1}{RC}dt = \frac{dq}{\varepsilon C - q} \qquad \frac{-1}{RC}dt = \frac{dq}{q - \varepsilon C}$$

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→ initial conditions

① $t=0 \rightarrow \mathcal{E} = I_{(t=0)} R = I_0 R$ $\boxed{I_0 = \frac{\mathcal{E}}{R}}$ I max

$\Delta V_R = \mathcal{E}$

② $t=\infty \longrightarrow$ capacitor becomes fully charged $\boxed{q = Q_{max} = \mathcal{E} C}$

$\Delta V_C = \mathcal{E}$ $I_{(t=\infty)} = 0$

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

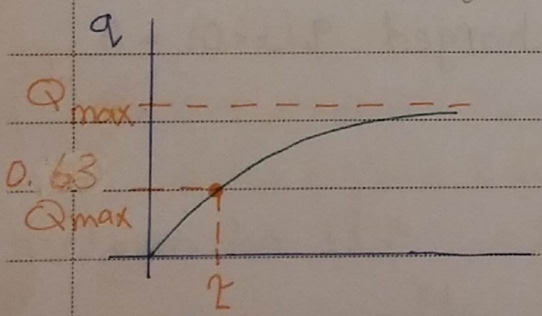
$$\int_0^t \frac{-1}{RC}\,dt = \int_0^q \frac{dq}{q - \mathcal{E}C} \qquad \frac{-t}{RC} = \ln|q - \mathcal{E}C|\Big|_0^q$$

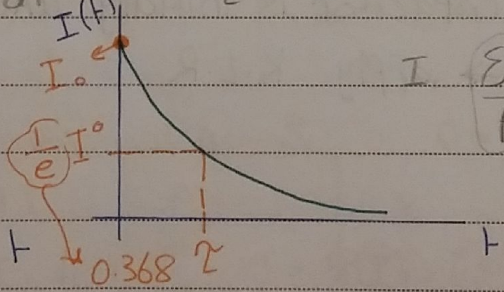
$$\frac{-t}{RC} = \ln\left[\frac{q - \mathcal{E}C}{-\mathcal{E}C}\right] \qquad e^{\frac{-t}{RC}} = \frac{q - \mathcal{E}C}{-\mathcal{E}C}$$

$$\mathcal{E}C - \mathcal{E}C e^{\frac{-t}{RC}} = q(t) \qquad q(t) = \mathcal{E}C\left(1 - e^{\frac{-t}{\tau}}\right)$$

$$q(t) = Q_{max}\left[1 - e^{-t/\tau}\right] \qquad I = I_0 e^{-t/\tau}$$

اشتقاق $I_{charging} = \frac{dq}{dt} = \frac{Q_{max}}{\tau} e^{-t/\tau} = \frac{\mathcal{E}C}{\tau} e^{-t/\tau}$





$I = \frac{\mathcal{E}\cancel{C}}{R\cancel{C}} e^{-t/\tau} = I_0 e^{-t/\tau}$

→ what is τ ?

R-C time constant, time needed for I in R-C circuit to reach $\frac{1}{e}$ of its max value (I_0) or time needed for q to reach 0.63 of its max value (q_0)(Q_{max})

* time → $e^{-t/\tau}$ e^{ω} → unitless unitless = $\frac{-t}{\tau}$ → time / time

or → $[\tau] = [R][C] = \Omega \cdot F = \frac{\cancel{V}}{A} \frac{C}{\cancel{V}} = \frac{s}{c} c = s$ #

* constant → $\tau = RC$ R & C are independent of time.

→ if we want $\Delta V_R(t) = IR$

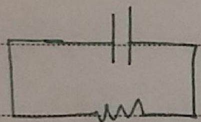
$\Delta V_R = I_{ch}(t) R = \mathcal{E} e^{-t/\tau}$ $\boxed{\Delta V_R = \mathcal{E} e^{-t/\tau}}$

→ if we want $\Delta V_c(t) = q/C$

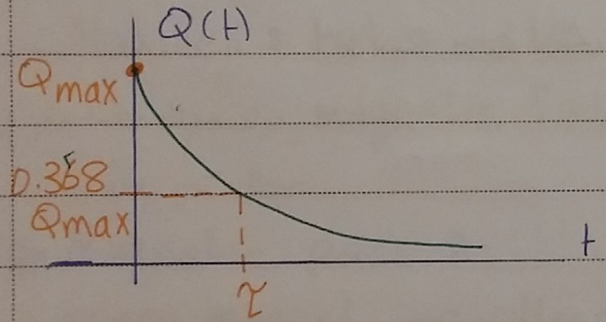
$\Delta V_c = \frac{q_{ch}(t)}{C} = \mathcal{E}(1-e^{-t/\tau})$ $\boxed{\Delta V_c = \mathcal{E}(1-e^{-t/\tau})}$

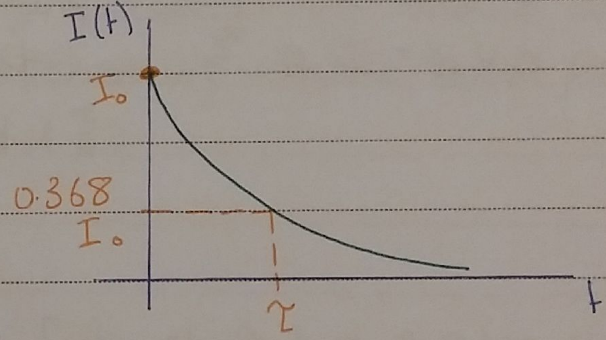
→ we can also find the energy $= \frac{1}{2}\frac{q^2}{C}$

⇒ R-C discharging circuit



$Q_{disch}(t) = Q_{max} e^{-t/\tau}$ $I_{disch}(t) = I_o e^{-t/\tau}$





$|I_{ch}| = |I_{disch}|$

$\Delta V_c = \frac{q}{C} = \frac{Q_{max} e^{-t/\tau}}{C} = \frac{\mathcal{E} C e^{-t/\tau}}{C} = \mathcal{E} e^{-t/\tau}$

and so on ...

⇒ Notes :

1) initially uncharged C behaves as a short circuit (مثل سلك مقاومته صفر)

2) Fully charged C behaves (the circuit is open circuit) (انقطع السلك) (تيار = صفر)

Chapter 29 : Magnetic Field

⇒ Historical review :-

- The compass needle was invented by Arabs.
- Greak first observed that the stone magnetite (Fe_3O_4) attracts pieces of iron.

* Electricity and magnetism are related phenomena.

→ Orsted : a compass needle is deflected when placed near an electric current.

→ Faraday : observed that an electric current can be produced by changing mag. field → moving a magnet relative to loop. / changing current in a nearby circuit.

يولد تيار كهربائي من مجال مغناطيسي

→ Maxwell : he proved that changing electric field producec magnetic field ($\vec{B}$)

يولد مجال مغناطيسي من مجال كهربائي

⇒ Magnetic poles :-

- every magnet regardless of its shape has 2 poles ; north (N) and south (S).
- magnetic poles are always found in pairs (single magnetic pole (monopole) has never been isolated yet).
- like mag. poles repel each other, and opposite poles attract
- mag. poles are named according to the way the magnet behaves
  - → north mag. pole → its north seeking pole (it points toward north geographic pole) (south mag. pole of earth).
  - → south mag. pole → south seeking pole (south geographic) (north magnetic pole of earth).

عكس الكهربائية (يوجد شحنة + -)

بتوافق الكهربائية

القطب الباحث عن الشمال الجغرافي (يؤشر للجنوبي) والعكس صحيح

2/4/2016

NO. Ch 29

بحث

→ Magnetism of earth (still under investigation)

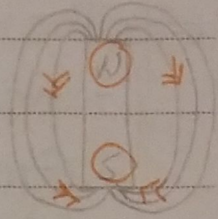
3 hypotheses :

1. iron core

الحمل الحراري

2. convection currents

3. earth's rotation.



$B_{earth} \approx 0.5$ Gauss $= 0.5 \times 10^{-4}$ Tesla

2/4/2016

NO. 29.1

29.1 Analysis model: particle in a field (magnetic)
magnetic forces and fields

⇒ Magnetic field $\vec{B}$

$[B]$ = Tesla in SI unit = T   Gauss $= 10^{-4}$ T $1G = 10^{-4}$ T

surrounding a bar magnet or in space surrounding moving electric charge.

⇒ Magnetic force $\vec{F}_B$

* properties of $\vec{F}_B$ observed by experiment (e charge q moving at velocity v in $\vec{B}$):
  1. $|\vec{F}_B| \propto |\vec{v}|$ & $|\vec{B}|$
  2. $|\vec{F}_B| \propto q$
  3. $\vec{F}_B$ on +ve q is opposite to $\vec{F}_B$ on -ve charge.
  4. $\vec{F}_B = 0$ if $\vec{v} \parallel \vec{B}$
  5. if v makes an angle θ with B → $|\vec{F}_B| \propto \sin\theta$

not magnitude? $\theta \propto |\vec{F}_B|$

$\boxed{\vec{F}_B = q\,\vec{v} \times \vec{B}}$ v: velocity of the moving charge

* Direction:

$\vec{B}$ → its direction is the direction of deflection of magnetic compass (needle).

$\vec{F}_B$ → ⊥ $\vec{v}$ & $\vec{B}$ and its direction is the same direction as $\vec{v} \times \vec{B}$ if q is +ve, opposite if q is -ve.

* $\vec{v} \times \vec{B}$ (right hand rule)

allign your 4 fingures along $\vec{v}$ with your palm (كف) facing $\vec{B}$, and then rotate $\vec{v}$ towards $\vec{B}$ → your thumb along $\vec{v} \times \vec{B}$

↳ +q → $F_B \parallel \vec{v} \times \vec{B}$

↳ -q → opposite

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NO. 29.1

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

θ : the smaller angle between $\vec{v}$ & $\vec{B}$
(head to head / tail to tail)

$[F_B]$ = Newton = N

$[B] = \dfrac{[F]}{[q][v]}$ $T = \dfrac{N}{C \cdot \frac{m}{s}} = \dfrac{N}{Amp \cdot m}$

Amp

⟹ Differences between electric & magnetic forces :-

1. $\vec{F}_e$ acts on electric charges while moving or at rest.
   $\vec{F}_B$ acts on electric charges only when moving.
2. $\vec{F}_e$ is always along $\vec{E}$ (parallel or antiparallel)
   $\vec{F}_B$ is always $\perp$ $\vec{B}$
3. $\vec{F}_e$ does work when displacing electric charges.
   $\vec{F}_B$ does zero work when steering electric charges.
   توجيه
   $(\vec{F}_B \perp \vec{v})$ $W = \vec{F} \cdot \Delta\vec{r}$

$dW = \vec{F} \cdot d\vec{r} = \vec{F} \cdot \vec{v}\, dt$ $\theta = 90$ $\cos 90 = 0$

$\vec{F}_e \rightarrow$ تسريع الشحنات $\vec{F}_B \rightarrow$ توجيه الشحنات دون كسب/خسران طاقة

ع التشابه :

يزيدوا بزيادة المجال , بزيادة الشحنة , القوة على الموجبة عكس اتجاه السالبة

* Direction of $\vec{B}$:

x into page · out of page ↗ in the plane of the page

2/4/2016

NO. 29.2

29.2 Motion of a charged particle in uniform magnetic field

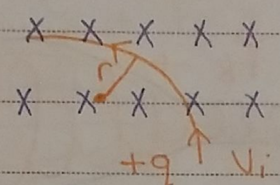
constant in magnitude & direction

$\vec{F}_{eB} = q\,\vec{v} \times \vec{B}$

- special case $\vec{v}_i \perp \vec{B}$

$\vec{F}_B = q\,\vec{v}\,\vec{B}\sin\theta \quad \theta = 90 \quad \sin 90 = 1 \quad \vec{F}_B = q\vec{v}\,\vec{B}$ max value

e.g



$F_B = qvB$

it leads to uniform circular motion

$\vec{F}_B$ is F centripetal $\quad F_c = \dfrac{mv^2}{r} \qquad q\cancel{v}B = \dfrac{mv^{\cancel{2}}}{r}$

$\boxed{r = \dfrac{mv}{qB}}$ r depends on v

$\propto mv \qquad \propto \dfrac{1}{qB}$

- angular frequency ≡ angular velocity = $\omega = \dfrac{v}{r}$

$\boxed{\omega = \dfrac{qB}{m}}$ independent of v & r

depends on q, B, and m.

- period T $\qquad T = \dfrac{2\pi r}{v} = \dfrac{2\pi}{\omega}$ الزمن اللازم للفة واحدة

$\boxed{T = \dfrac{2\pi m}{qB}}$ independent of v & r $\quad$ depends on q, B, m

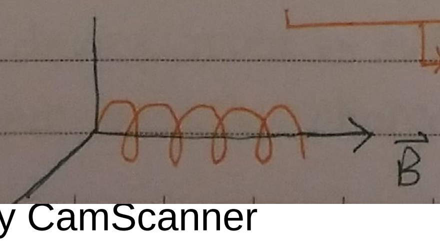
- If v is not $\perp \vec{B}$ (v makes an angle θ with $\vec{B}$)

$\vec{v} = \vec{v}_{\perp\vec{B}} + \vec{v}_{\parallel\vec{B}}$

affected by $\vec{F}_B$ → circular motion

will not be affected by $\vec{F}_B$ → translational (linear) motion

→ hellical motion (axis along $\vec{B}$)



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NO. 29.2

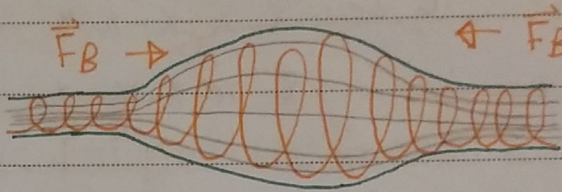
e.g if $\vec{B} = B\hat{i}$ $F_x = 0$ definitely $\vec{v} = v_x\hat{i} + v_y\hat{j} + v_z\hat{k}$

$v_\perp = \sqrt{v_y^2 + v_z^2}$

*** if q moves at $\vec{v}$ but in non-uniform $\vec{B} \rightarrow$ motion is more complicated

[1] magnetic bottle

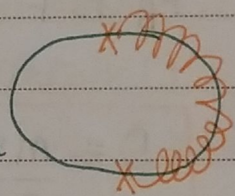
$\vec{B}$ is strong at ends and weak in the middle.



[2] Van Allen Radiation Belt حزام أشعة

عزل istolation around earth

earth



electric & mag fields
يوجد
20 [illegible]

2/4/2016

NO. 29.3

29.3 Applications involving charged moving in a uniform magnetic field

⇒ **Lorenz force**

total force acting on a charged particle q moving at velocity v in magnetic and electric fields

$$\vec{F} = \vec{F}_e + \vec{F}_B = q\vec{E} + q\vec{v} \times \vec{B} \qquad \boxed{\vec{F} = q\vec{E} + q\vec{v} \times \vec{B}}$$

vector equation

if $\vec{F} = 0$ $\quad |\vec{F}_e| = |\vec{F}_B|$ & opposite in direction

1 Velocity selector :-

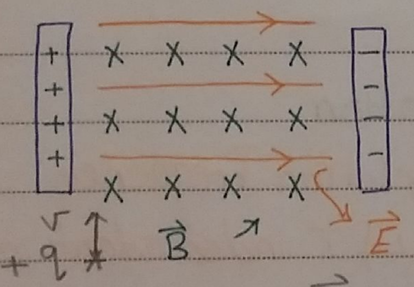
مشحونة طبعاً

a device allows particles of specific speeds only to pass.

$\boxed{v = \dfrac{E}{B}}$ $\quad \vec{E}$ & $\vec{B}$ crossed → uniform & mutually ⊥ on other.

متبادل

parallel plots



$$\vec{F}_B = q\vec{v} \times \vec{B} = qvB(-\hat{i}) \quad \text{to left} \qquad F_e = q\vec{E} = qE(\hat{i}) \quad \text{to right}$$

$$\vec{F} = \vec{F}_e + \vec{F}_B = qE(\hat{i}) + qvB(-\hat{i}) = qE\hat{i} - qvB\hat{i}$$

if $F_{tot} = 0$ $\quad |F_e| = |F_B|$ $\quad qE = qvB$ $\quad \boxed{v = \dfrac{E}{B}}$ # لا يهم الشحنة أو الكتلة

→ only those charged particles will pass

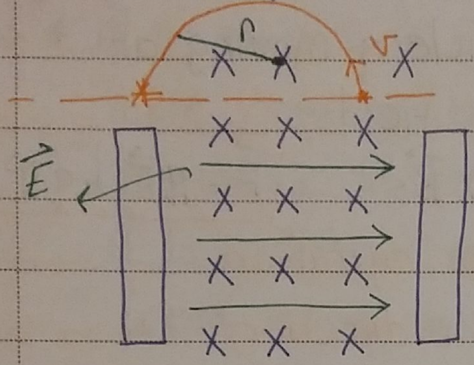
→ others with velocity $< v$ $\quad F_e > F_B$ will not pass right

→ others with velocity $> v$ $\quad F_B > F_e$ will not pass left

2 Mass spectrometer

a device used to seperate charged particles according to their mass to charge ratio (m/q)

→ velocity selector followed by a region of uniform B_0 (magnetic field) only in the same direction as that of velocity selector ($\vec{E} = 0$).



the selected particle cotinuous in uniform circular motion.

$v = \frac{E}{B}$ $F_c = \frac{mv^2}{r}$

$qvB_0 = \frac{mv^2}{r}$ $qB_0 = \frac{mv}{r}$, $v = \frac{E}{B}$

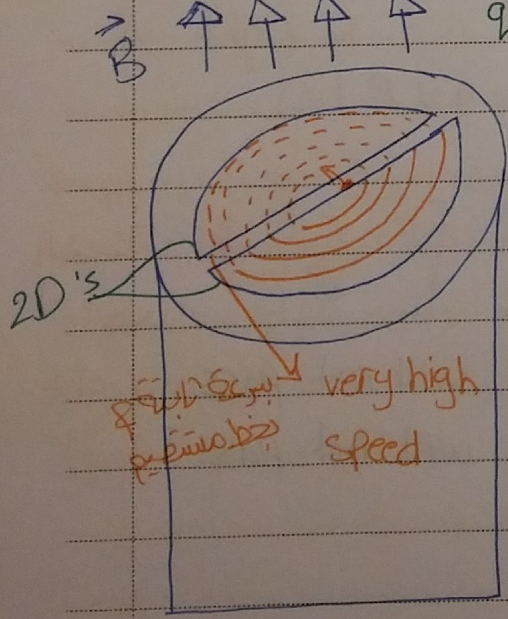
$qB_0 = \frac{mE}{rB}$ $\boxed{\frac{m}{q} = \frac{rBB_0}{E}}$ useful to seperate the isotopes (different mass no.) of a certain ion. بس $\frac{q}{m}$ نفسه

[3] Cyclotron في المستمعلة

$\vec{v}_i \perp \vec{B} \rightarrow$ uniform circular motion

$r = \frac{mv}{qB}$ $\boxed{w = \frac{qB}{m}}$ cyclotron frequency

w & T independent of r & v



- a device used to accelerate charged particles to very high speeds
- alternating ΔV A.C تعكس القطبية

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

- consists of 2D's placed at the north pole of a huge magnet.
- the particle takes time T to couple one revolution, but after $t = \frac{T}{2}$ the polarity ΔV is reserved (its K.E increases by $q\Delta V$).

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NO. 29.3

its $v\uparrow$ $r\uparrow$ so it inters D with greater r & so on.

$$qvB = \frac{mv^2}{r} \qquad v = \frac{rqB}{m}$$

$$K.E = \frac{1}{2}mv^2 = \frac{1}{2}\frac{mr^2q^2B^2}{m^2}$$

أكبر نصف قطر ممكن $r = R$

$$\boxed{K.E = \frac{R^2q^2B^2}{2m}}$$

تنعكس القطبية عندما يقطع الجزئ نصف الدائرة

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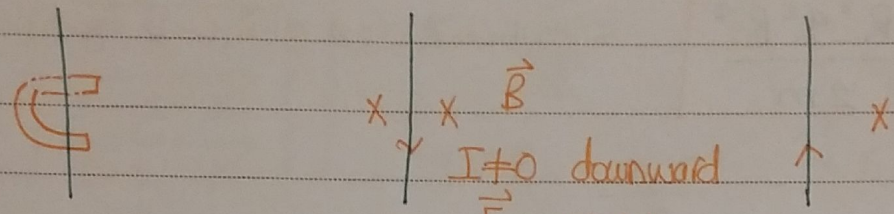
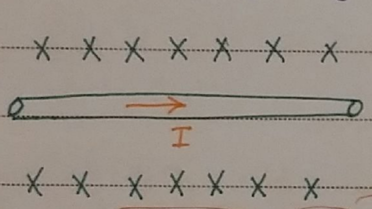
29.4 magnetic force acting on a current carrying conductor

is a collection of e. charges in motion.
(affected by $\vec{F}_B$ when placed in $\vec{B}$).

⇒ Demonestration of $\vec{F}_B$ acting on a current carrying conductor
straight wire of current I



⇒ F_B on a straight current carrying conductor (wire of current I, length ℓ)



$\vec{F}_B$ on wire $= \sum \vec{F}_B$ on q
$= F_B$ on q * no. of charge carriers
$= q\vec{v}_d * \vec{B}$ * no. of charge carriers

no. = density * volume
= n * volume
= $n \ell A$

$\vec{F}_B = q\, v_d\, B \sin 90\, n \ell A = q\, v_d\, B\, n \ell A$

but ... $I = n e v_d A$ $\quad F_B = I \ell B$

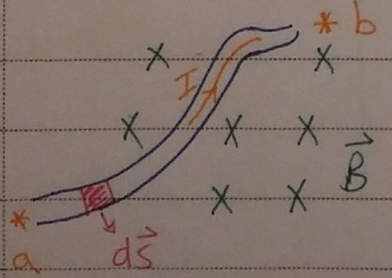
F_B on a straight wire of length ℓ, I placed in uniform $\vec{B}$

$$\boxed{\vec{F}_B = I\, \ell \times \vec{B}}$$

حسب قاعدة اليد اليمنى

* More generalized case :-

$B \neq$ uniform & wire of arbitrarily shape



take an element of this wire

$d\vec{F}_B = I\, d\vec{s} \times \vec{B}$

constant

$\vec{F}_{B\,tot} = \int_a^b I\, d\vec{s} \times \vec{B} = I \int_a^b (d\vec{s} \times \vec{B})$

B function of s

$$\boxed{\vec{F}_{B_{tot}} = I \int_a^b (d\vec{s} \times \vec{B})}$$

2/4/2016

NO. 29.4

→ Special cases :-

1) if $\vec{B}$ is uniform but the wire is not straight (arbitrarily shaped)

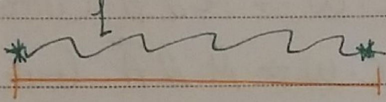
$$\vec{F}_B = I\left[\int_a^b d\vec{s}\right] \times \vec{B} = I\, L_{effective} \times B$$

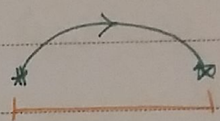
take B outside integral but still inside cross product

- what is $L_{effective}$??

$$L_{effective} = \int_a^b d\vec{s}$$ المسافة العمودية على المجال

e.g





2) straight line (discussed before)

$L_{effective} = l \qquad \vec{F}_B = I\, \vec{l} \times \vec{B}$

3) $\vec{B}$ = uniform but the current carrying conductor forms a closed loop

$$F_B = I\left[\int_a^b d\vec{s}\right] \times \vec{B} \quad \text{for a closed loop} \Rightarrow b = a$$

zero

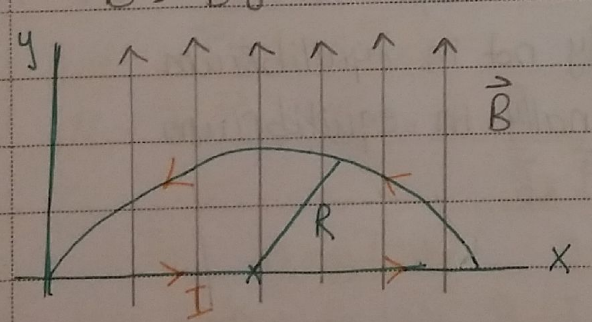
$$= I\left(\oint d\vec{s}\right) \times \vec{B} = 0$$

يشترط أنّ المجال منتظم

Example 29.4 :-

$\vec{B} = B\hat{j}$ $\qquad F_B \rightarrow$? $\qquad F_B \frown$? $\qquad F_B \circlearrowleft$?

zero because B is uniform



$F_B \rightarrow = I\,\vec{l} \times \vec{B}$ $\qquad$ اتجاه I بنفس اتجاه l

$= I\, l\,\hat{i}\, B\hat{j} = I\, l\, B\, \hat{k} =$

$2RIB\,\hat{k}$

$F_B \frown = I\, L_{effective} \times \vec{B} = I\, 2R * -\hat{i} * B\hat{j} = -2RIB\,\hat{k}$

or $\quad dF_B = I\, d\vec{s} \times \vec{B} \qquad s = r\theta \qquad ds = R\,d\theta$

$= I R\, d\theta \sin\theta\, B$

$\frown F_B = IRB \int_0^{\pi} \sin\theta\, d\theta = -2IRB\,\hat{k}$

$-\cos\theta \Big|_0^{\pi} = 1 - -1 = 2$

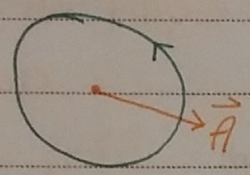
29.5 Torque on a current loop in uniform $\vec{B}$

$\vec{p}$: electric dipole moment $= q\vec{d}$

$\tau = P \times \vec{E} \qquad U_E = -\vec{P}\cdot\vec{E}$

$\Rightarrow$ Magnetic dipole moment for a current loop $\equiv \vec{\mu}$

$$\vec{\mu} = I * \vec{A}$$



$A \perp$ to the surface of the loop determined by right hand rule $\quad |\vec{A}|$ = area of loop

أصابع ـ تيار

A/μ ← إبهام

if I is → C.W → $\vec{\mu} \parallel \vec{A}$ (into page)
↘ C.C.W → $\vec{\mu} \parallel \vec{A}$ (out of page).

$$[\mu] = [A][I] = Amp \cdot m^2$$

→ For a coil (loop) of N turns

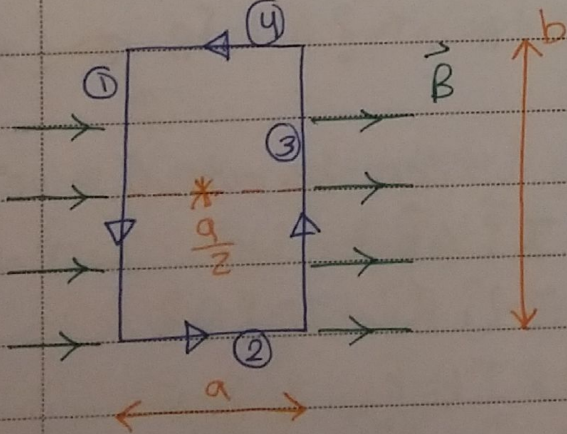
$$\vec{\mu} = N I \vec{A}$$

→ $\boxed{\vec{\mu} = I\vec{A}}$ $\boxed{\vec{\tau} = \vec{\mu} \times \vec{B}}$ torque exerted on current loop of $\vec{\mu}$ placed in <u>uniform</u> $\vec{B}$

→ $U_B = \int \tau \, d\theta = -\vec{\mu}\cdot\vec{B}$

$\boxed{U_B = -\vec{\mu}\cdot\vec{B}}$ energy stored in magnetic dipole moment current loop and $\vec{B}$ system

e.g rectangular current loop placed in uniform $\vec{B}$ (to prove $\vec{\tau} = \vec{\mu} \times \vec{B}$)
Perpendicular



rotationally not in equilibrium

translationally in equilibrium

$F_B = I \vec{l} \times \vec{B}$

(2) $F_B = 0 \qquad$ (4) $F_B = 0$

(3) $F_B = IbB(-\hat{k})$ (into page)

(1) $F_B = IbB(+\hat{k})$ (out of page)

$\sum F_B = \vec{F}_{B_1} + \vec{F}_{B_2} + \vec{F}_{B_3} + \vec{F}_{B_4} = 0$ → no translational motion

2/4/2016

NO. 29.5

But... F_1 & F_3 → net torque

$$\tau = r \times \vec{F} = rF\sin\theta \quad \theta = 90^\circ \quad \tau = rF$$

$$\Sigma \vec{\tau} = IbB\,\frac{a}{2}\sin 90^\circ + IbB\,\frac{a}{2}\sin 90^\circ = IbBa$$

but $A = ba$ $\qquad \tau = IAB = \mu B \qquad \vec{\tau} = \vec{\mu} \times \vec{B}$ #

من تطبيقاته المحرك الكهربائي

→ See example 29.5 & 29.6

10/14/2016

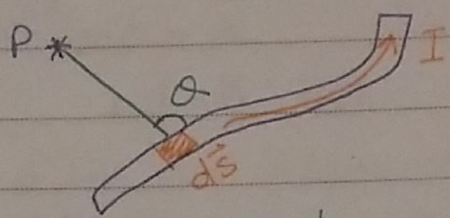
NO. Chapter 30

Chapter 30 : Sources of magnetic field

30.1 The Boit - Savart law (experimental)

used to find the magnetic field produced by a segment of current.

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



I : the amount of current in this segment

$|d\vec{s}|$: element of length $d\vec{s} \parallel \vec{I}$ (direction of the current)

r : distance between the current segment & observation point p.

$\hat{r}$: position vector between $d\vec{s}$ & P

θ : head to head or tail to tail.

$\mu_0 : 4\pi \times 10^{-7}$ نفاذية permeability of free space.

$[\mu_0] = T.m/Amp$

$|d\vec{B}| \propto \frac{1}{r^2}$ $\quad |d\vec{B}| \propto I$

إذا مقدارها ثابت

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

over the whole distribution of the current.

⟹ Quick comparison between coulomb & Biot-Savart law

Biot - Savart law	Vs	Coulomb law
1. e^- charges produce $\vec{E}$		electric current produce $\vec{B}$
2. $\vec{E}$ can be produced by isolated point charges		$\vec{B}$ can be produced by current must be a part of a complete circuit.
3. $\lvert\vec{E}\rvert \propto \frac{1}{r^2}$		$\lvert\vec{B}\rvert \propto \frac{1}{r^2}$

10/4/2016

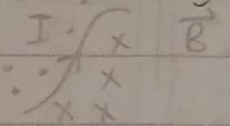
NO. 30.1

4. $\vec{E}$ is always radial $\qquad$ $\vec{B}$ always $\perp$ to $d\vec{s}$ & $\hat{r}$

$$E = K_e \int \frac{dq}{r^2}\hat{r} \qquad d\vec{B} \propto \frac{d\vec{s} \times \hat{r}}{r^2}$$

→ use right hand rule for direction of $\vec{B}$ produced by a segment of current

grasp the wire with your right hand, if your thumb is along I, then your four fingures wrapped with $\vec{B}$



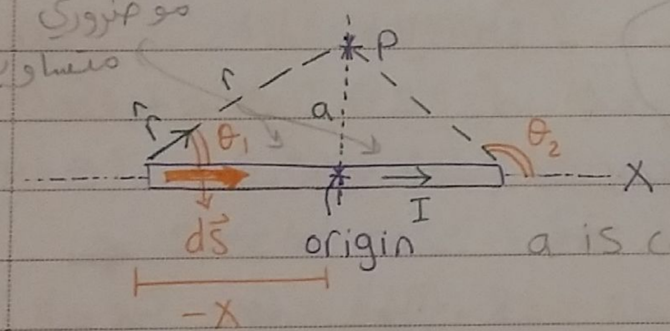
12/4/2016

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

$\boxed{\text{Case 1}}$ $\vec{B}$ due a thin straight current carrying wire (Finite wire)

السلك جزء من الدارة

مو ضروري متساويين



a is constant

$$|d\vec{s} \times \hat{r}| = |d\vec{s}||\hat{r}|\sin\theta = d\sin\theta$$

$$d\vec{s} \times \vec{r} = dx\sin\theta\,\hat{k}$$

$$\sin\theta = \frac{a}{r} \qquad r = \frac{a}{\sin\theta} = a\csc\theta$$

$$\tan\theta = \frac{a}{-x} \qquad -x = \frac{a}{\tan\theta}$$

$$-x = a\cot\theta$$

$$dx = a\csc^2\theta\, d\theta$$

$$dB = \frac{\mu_0 I}{4\pi} \frac{d\vec{s} \times \hat{r}}{r^2} = \frac{\mu_0 I}{4\pi} \frac{dx\sin\theta}{r^2}$$

$$dB = \frac{\mu_0 I}{4\pi} \frac{\cancel{a}\,\cancel{\csc^2\theta}\,\sin\theta}{a^{\cancel{2}}\,\cancel{\csc^2\theta}}$$

$$B = \frac{\mu_0 I}{4\pi a} \int_{\theta_1}^{\theta_2} \sin\theta\, d\theta = \frac{-\mu_0 I}{4\pi a} \cos\theta \Big|_{\theta_1}^{\theta_2}$$

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

due a straight wire at point p a distance a ⊥ to the wire

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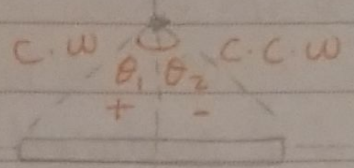
serway way:

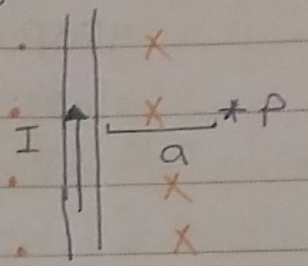


$$B = \frac{\mu_0 I}{4\pi a}[\sin\theta_1 - \sin\theta_2]$$

→ special case: for infinitely long straight wire

θ_1 decrease $\theta_2 = \pi$

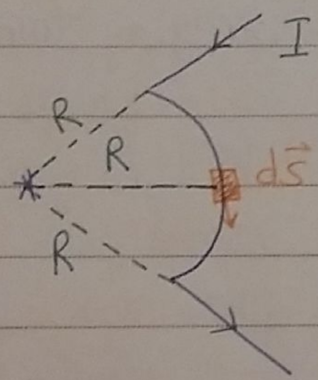
$$\boxed{B = \frac{\mu_0 I}{2\pi a}}$$ for infinitely long wire



• الاتجاه حسب قاعدة اليد اليمنى

Case 2

$\vec{B}$ due a curved wire segment



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

$d\vec{B}$ due to 2 straight parts is zero

$d\vec{s}\times\hat{r} = 0$ $d\vec{s} \parallel \hat{r}$ $(\theta = 0 \rightarrow \sin\theta = 0)$

For the curved part $d\vec{s} \perp \hat{r}$ $(\theta = 90°)$

$|d\vec{s}\times\hat{r}| = ds$

$$d\vec{B} = \frac{\mu_0 I}{4\pi}\frac{ds}{r^2} = \frac{\mu_0 I}{4\pi}\frac{ds}{R^2}$$ R is the same for all current element $d\vec{s}$

$$B = \frac{\mu_0 I}{4\pi R^2}\int ds$$ or $s = r\theta$ $ds = r\,d\theta$ (θ in radiant)

$$\boxed{B = \frac{\mu_0 I s}{4\pi R^2}}$$ or $$\boxed{B = \frac{\mu_0 I \theta}{4\pi R}}$$ due to curved wire circuit. (θ in radiant)

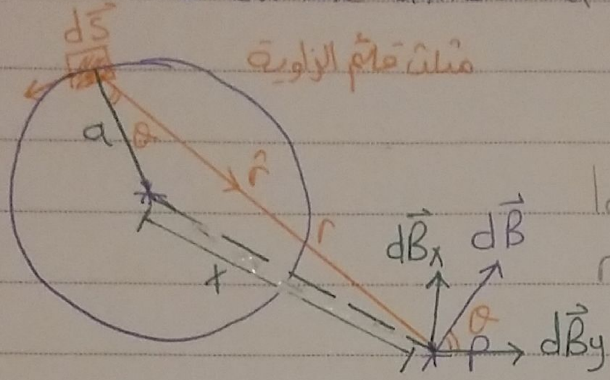
→ special case: for a circular loop $\theta = 2\pi$

$$B = \frac{\mu_0 I\, 2\pi}{4\pi R}$$ $$\boxed{B = \frac{\mu_0 I}{2R}}$$ at the center of circular current loop

Direction by R.H.R

case 3

$\vec{B}$ on the axis of a circular current loop



مثلث قائم الزاوية

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

$|d\vec{s} \times \hat{r}| = ds \; (\theta = 90)$

$r^2 = x^2 + a^2$ $\quad$ $d\vec{B} \perp$ plane of $d\vec{s}$ & $\hat{r}$

$\int d\vec{B}_x \longleftrightarrow \int d\vec{B}_y$

$dB_x \cos\theta$ $\quad$ zero by symmetry

$$\vec{B}_{tot} = \int d\vec{B}_x = \frac{\mu_0 I}{4\pi} \int \frac{ds \cos\theta}{x^2 + a^2}$$ but $\cos\theta = \frac{a}{r} = \frac{a}{\sqrt{x^2 + a^2}}$

$$\vec{B}_{tot} = \frac{\mu_0 I a}{4\pi} \int \frac{ds}{(x^2 + a^2)^{\frac{3}{2}}}$$ a, x are the same for all element

$$\vec{B}_{tot} = \frac{\mu_0 I a}{4\pi (x^2 + a^2)^{\frac{3}{2}}} \int ds = \frac{\mu_0 I a S}{4\pi (x^2 + a^2)^{\frac{3}{2}}}$$ but $S = 2\pi a$

$$\vec{B}_{tot} = \frac{\mu_0 I a^2 2\pi}{4\pi (x^2 + a^2)^{\frac{3}{2}}}$$

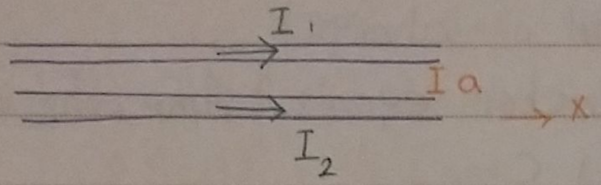
$$\boxed{\vec{B} = \frac{\mu_0 I a^2}{2(a^2 + x^2)^{\frac{3}{2}}}}$$

→ special case : for $x = 0$ (the point at the center)

$$B = \frac{\mu_0 I}{2a}$$ نفس القانون في case 2

30.2 Magnetic force between 2 parallel current carrying conductors

every current wire carrying conductor produces it own $\vec{B}$ & is affected by external $\vec{B}$ if exist.



infinitely long wires
the two wires exert $\vec{B}$ on each other

B due to very long wire $= \dfrac{\mu_0 I}{2\pi a}$ $\quad$ $\vec{F}_B$ exerted on a current wire by external $\vec{B}$ $= I\vec{L} \times \vec{B}$

- wire 1 produces B_1 (into page)
- affected wire 2
- $F B_1$ on 2 is upward.

- wire 2 produces B_2 (out page)
- affected wire 1
- F_{B_2} on 1 is downward

$\rightsquigarrow \vec{F}_{2 \text{ on } 1} = -\vec{F}_{1 \text{ on } 2}$

$$F_{B_1 \text{ on } 2} = |I_2 \vec{L}_2 \times \vec{B}_1| = \frac{I_2 L \mu_0 I_1}{2\pi a}$$

$$F_{B_2 \text{ on } 1} = |I_1 \vec{L}_1 \times \vec{B}_2| = \frac{I_1 L \mu_0 I_2}{2\pi a}$$

$$\boxed{F_B = \frac{\mu_0 I_1 I_2 L}{2\pi a}}$$ between 2 parallel current wires too infinitely long seperated by a distance a

$\rightsquigarrow$ Direction
- if the two currents have the same direction → attractive force
- opposite direction → repulsive force.

→ Force per unit length

$$\frac{F_B}{l} = \frac{\mu_0 I_1 I_2}{2\pi a} \quad \propto I_1 \, \& \, I_2 \quad \propto \frac{1}{a}$$

14/4/2016

NO. 30.2 & 30.3

* Ampere (the SI unit of current)

حط مكان كل وحدة واحد

when the F_B per unit length exerted between two parallel wires seperated by 1m equals $2\times10^{-7}\ \frac{N}{m}$, the current in each wire is 1 A.

* Coulomb C (the SI unit of charge)

when a current in a conductor equals 1 Amp, the charge that flows in 1 second is 1 C.

used for highly symmetric current distribution

30.3 Ampere's law

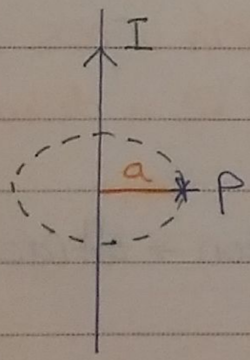
The path integral of $\vec{B}\cdot d\vec{s}$ (element of length) over any closed path is equal to $\mu_0 I$, I is the total steady current

Amperian loop : closed path of any shape (mathematical construction)

$$\boxed{\oint \vec{B}\cdot d\vec{s} = \mu_0 I_{net}}$$

$B \parallel$ or $\perp$

[1] $\vec{B}$ due to infinitely long straight current carrying wire & thin ليس لها سُمك



$\oint \vec{B}\cdot d\vec{s} = \mu_0 I_{net}$ but B is constant

$B \cdot \oint d\vec{s} = \mu_0 I$ but $\theta = 0$ $B \parallel d\vec{s}$

$B \oint d\vec{s} = \mu_0 I$ $B\, 2\pi a = \mu_0 I$

here ... $I_{net} = I_{wire}$

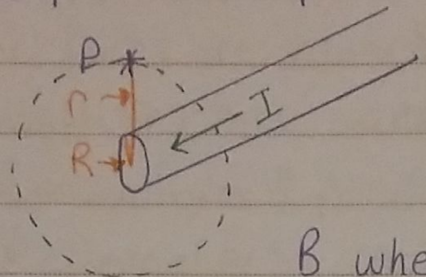
$$\boxed{B = \frac{\mu_0 I}{2\pi a}}$$

see example 30.4

14/4/2016

NO. 30.3

2 example 30.5 p.913



I is uniformly distributed

$J = \frac{I}{A}$ = constant

B when a) $r \geq R$ b) $r \leq R$

a For $r \geq R$ (outside the wire)

$\oint \vec{B} \cdot d\vec{s} = \mu_0 I_{net}$ but $\theta = 0$ & B is constant

$B \oint d\vec{s} = \mu_0 I_{net}$ $B 2\pi r = \mu_0 I$

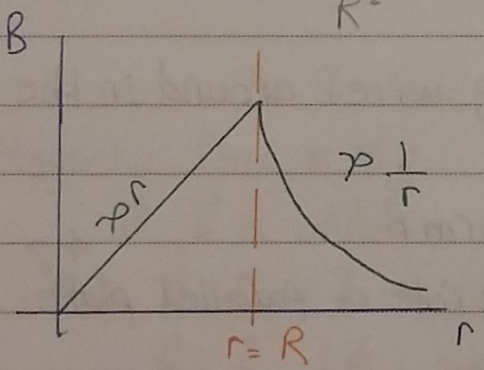
$\boxed{B = \frac{\mu_0 I}{2\pi r}}$ when $r \geq R$ $\propto \frac{1}{r}$

b For $r \leq R$ (inside the wire)

$\oint \vec{B} \cdot d\vec{s} = \mu_0 I_{net}$ $B 2\pi r = \mu_0 I_{net}$

but $J = \text{constant} = \frac{I}{A}$ $I_{net} = J A_{inside} = \frac{I}{A_{outside}} * A_{inside}$

$B 2\pi r = \frac{\mu_0 I r^2}{R^2}$ $\boxed{B = \frac{\mu_0 I r}{2\pi R^2}}$ $\propto r$ when $r \leq R$



17/4/2016

** $\vec{B}$ produced by a Toroid

a device consists of conducting wire wrapped around a ring (torus) of non-conducting material (solid, air)

- used to produce a strong $\vec{B}$ (almost uniform) within a certain region.

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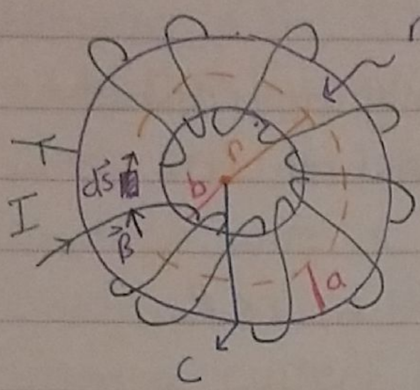
NO. 30.3 & 30.4



non-conducting
b: inner radius
c: outer radius
a: radius of cross section

The Amperian loop: $b<r<c$

$\oint \vec{B} \cdot d\vec{s} = \mu_0 I_{net}$ but $\theta = 0$ & B is almost uniform

$B \oint d\vec{s} = \mu_0 I_{net}$ $\quad B(2\pi r) = \mu_0 N I$ $\quad N$: no. of turns

$$\boxed{B = \frac{\mu_0 N I}{2\pi r}}$$ by toroid $\propto \frac{1}{r}$ تتغير r

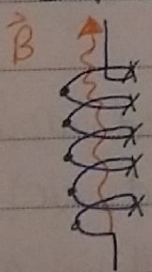
But if $r \ggg a$ (cross section) $\rightarrow$ B inside toroid $\approx$ constant (B is almost uniform)

30.4 The magnetic field of a solenoid

⇒ Solenoid:
long conducting wire (carrying wire) around in the form of helix.

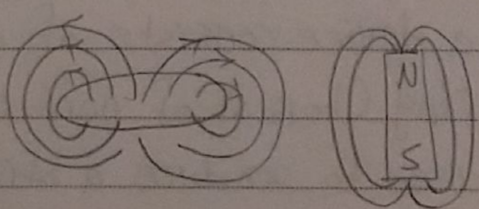
- used to produce a strong & uniform $\vec{B}$

(solenoid in magnetism plays the role of parallel plate capacitor in electricity)



اذا زادت اللفات
$\vec{B}$ almost straight

يشبه magnetic bar



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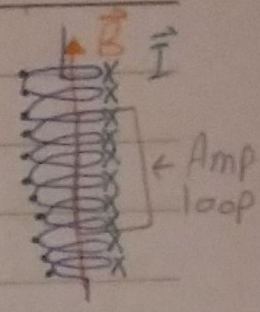
NO. 30.4 & 30.5

** ideal solenoid

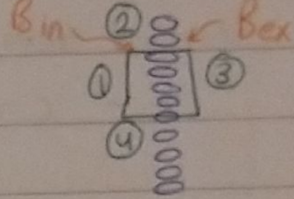
the turns are closely spaced and its length ⋙ cross sectional radius.

$\vec{B} \approx$ uniform & parallel to the axis of solenoid

$\vec{B}_{external} \approx 0$



By Ampere's law



$\oint \vec{B} \cdot d\vec{s} = \mu_0 I_{net}$ remember $B_{ex} = 0$

$\oint_1 \vec{B} \cdot d\vec{s} + \oint_2 \vec{B} \cdot ds + \oint_3 \vec{B} \cdot d\vec{s} + \oint_4 \vec{B} \cdot d\vec{s}$

$\theta = 90°$ zero zero zero

$(B_{in} = 0$ & $B_{ex} = 0)$ $(B_{ex} = 0)$ $(B_{in} = 0\ (\theta = 90)$ & $B_{ex} = 0)$

$\oint_1 \vec{B} \cdot d\vec{s} = \mu_0 I_{net}$ but B is uniform $B_1 \int ds = \mu_0 I_{net}$

$B\ell = \mu_0 N I$ N: no. of turns

$$\boxed{B = \frac{\mu_0 N I}{\ell}}$$ N & I & ℓ depends on

$n = \frac{N}{\ell}$ = no. of turns per unit length

$$\boxed{B = \mu_0 n I}$$ independent on geometry

لو غيرنا الطول & عدد اللفات

n نفسها

30.5 Gauss's law in magnetism

Magnetic flux $\equiv \phi_B$ $\boxed{\phi_B = \int \vec{B} \cdot d\vec{A}}$ scalar product

if $\vec{B}$ is uniform $\phi_B = B \cdot \int d\vec{A} = \vec{B} \cdot \vec{A} = BA\cos\theta$

if $\vec{B} \perp \vec{A}$ ($\vec{B} \parallel$ surface) $\cos 90 = 0$ $\phi_B = 0$

$\vec{B} \parallel \vec{A}$ ($\vec{B} \perp$ surface) $\cos 0 = 1$ $\phi_B = BA$ max

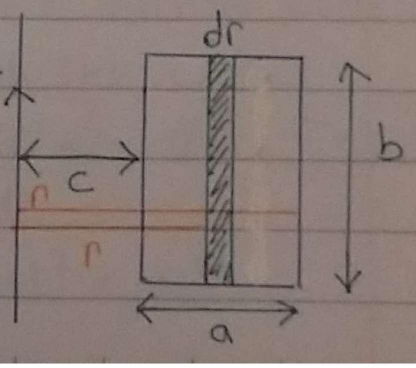
$[\phi_B] = [B][A] = T \cdot m^2$ is SI = weber = Wb

- example 30.7 p.917

what is ϕ_B through the loop?

B is not uniform

B due to long wire $= \frac{\mu_0 I}{2\pi r} \propto \frac{1}{r}$



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NO. 30.5

$\phi_B = \int \vec{B} \cdot d\vec{A} = \frac{\mu_0 I}{2\pi} \int \frac{1}{r} dA$ but $A = r * b$ & b is cons.

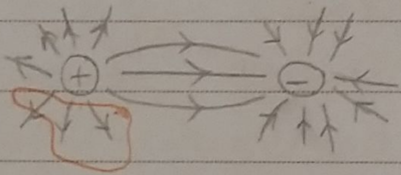
$\phi_B = \frac{\mu_0 I b}{2\pi} \int_c^{a+c} \frac{1}{r} dr = \boxed{\frac{\mu_0 I b}{2\pi} \ln\left[1 + \frac{a}{c}\right]}$ يعتمد على ابعاد loop
بعد loop عن wire

Special case :

- $c \to 0 \to \phi_B \to \infty$
- $c \to \infty \to \phi_B \to 0$

⇒ Gauss law in electricity

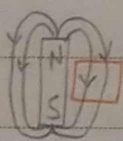
$\phi_E = \oint \vec{E} \cdot d\vec{A} = \frac{q_{net,enc}}{\epsilon_0}$



net closed surface $\neq 0$

⇒ Gauss law in magnetism

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



net closed surface $= 0$

$\phi_B \propto$ net number of lines (lines intering - lines leaving)

because $\vec{B}$ lines are closed loops (no specific end or start)

Chapter 31 : Faraday's law

31.1 Faraday's law of induction توليد تيار كهربائي من مصدر مغناطيسي

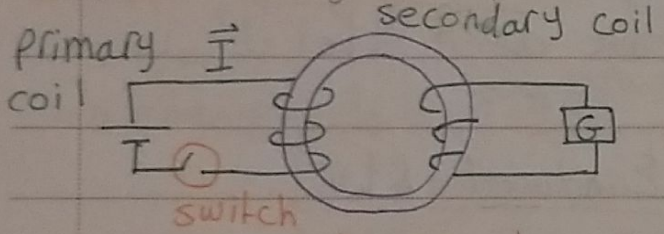
→ Demonestration of e.m induction :-

- while moving the magnet into/away relative to the loop, the gelvanometer deflects and returns to zero.
- if the magnet and loop are stationally relative to each other, the gelvanometer reads zero.

I is induced due to change in magnetic flux

التغير في التدفق المغناطيسي (التغير في عدد خطوط المجال) هو الذي يولد التيار

→ Faraday's experiment



permanent current

on → Iprimary = 0 ⌉ induced equal zero
off → Iprimary = I ⌋

* switch is closed

$I = I_{primary} \neq 0$ $\quad I_{induced} \neq 0$

* when switch is opened

$I_{primary} = 0$ $\quad I_{induced} \neq 0$

* when Iprimary is zero or steady

$I_{induced} = 0$

* the current induced due to change in magnetic flux

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

→ ϕ_B can be changed by :-

مقدار واتجاه 1. changing $\vec{B}$ 2. changing A 3. changing angle between $\vec{B}$ & $\vec{A}$ 4. any combination of 1-3

→ The induced e.m.f ($\mathcal{E}_{induced}$) in a circuit is directly proportional to the time rate of change in ϕ_B through the circuit

$$\mathcal{E}_{induced} \propto \left| \frac{d\phi_B}{dt} \right|$$

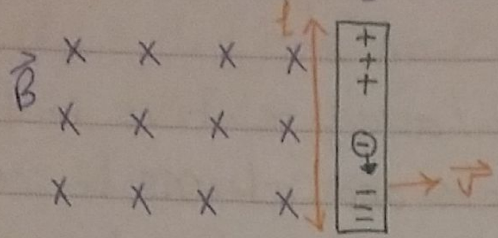
زيادة او نقصان عشان هيك قيمة مطلقة

$$\boxed{\mathcal{E}_{induced} = -\frac{d\phi_B}{dt}} \qquad \phi_B = \int B \cdot d\vec{A}$$

$$\boxed{I_{induced} = \frac{|\mathcal{E}_{induced}|}{R}} \qquad [\mathcal{E}_{induced}] = \text{volt}$$

31.2 Motional induced emf

induced by moving a conductor in uniform $\vec{B}$



$\downarrow \vec{E}$ $\uparrow \vec{F_e}$

$\mathcal{E}_{induced}$

$\uparrow F_e$ ⊖ $\downarrow F_B$ $F_e = F_B$

a slab of conductor is moving in uniform $\vec{B}$

$|\mathcal{E}_{induced}| = \left|\frac{d\phi_B}{dt}\right|$ by pulling the conductor to right F_B (on every charge carrier) $= q\vec{v} \times \vec{B}$ (downward)

$\vec{F_e} = q\vec{E}$ (upward)

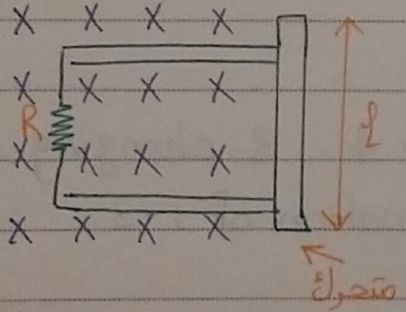
* electrons will continue to move until $|\vec{F_e}| = |\vec{F_B}|$

$qE = qvB$ $\boxed{E = vB}$ توقف الالكترونات

$|\Delta V| = E\ell$ $\boxed{\mathcal{E}_{induced} = B\ell v}$

$\mathcal{E}_{induced}$ المسافة $\mathcal{E}_{motional}$ اذا كان يتحرك عموديا على $\vec{B}$

→ if the conducting slab is a part of a circuit of zero resistance has R resistance



$\phi_B = \vec{B}\cdot\vec{A}$ $\theta = 0$ $\phi_B = B x \ell$

$\mathcal{E}_{induced} = \left|\frac{d\phi_B}{dt}\right|$

$\mathcal{E}_{induced} = B\ell\frac{dx}{dt} = B\ell v$

لانها دارة مغلقة $I_{induced} = \frac{|\mathcal{E}_{induced}|}{R} = \frac{B\ell v}{R}$ $\boxed{I_{induced} = \frac{B\ell v}{R}}$

التيار الأخاي (حركة الشحنات +)

التيار الاصطلاحي عكس حركة الالكترونات

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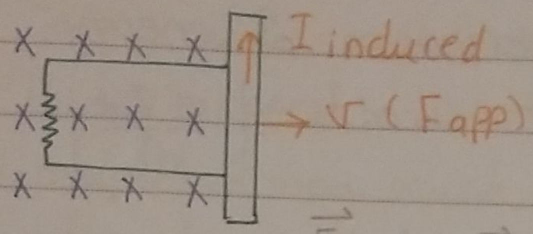
24/4/2016

NO. 31.2

31.2 motional e.m.f



$\mathcal{E}_{\text{(motional induced)}} = B\ell v$ $\qquad I_{\text{induced}} = \frac{B\ell v}{R}$

$|\vec{F}_B| = |\vec{F}_{app}|$

$\vec{F}_B = I\vec{L} \times \vec{B}$ $\qquad F_B = \frac{B^2\ell^2v^2}{R}$

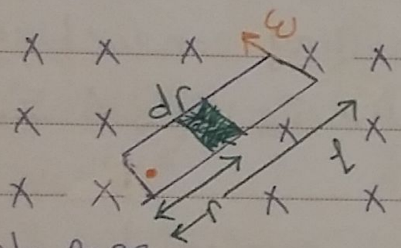
Power $= I^2R$

power $= \vec{F}_{app} \cdot \vec{v}$

→ example 31.1 p.942

$F_{app} = m\,a = m\frac{dv}{dt}$ $\qquad F_{app} = -F_B$ $\qquad v = v_i\, e^{\frac{-t}{\tau}}$

→ example 31.4 p.943 rotational motion



take element of length → translationally

For a conducting bar of length ℓ ...

rotating about axis passing through one of it's end

$\vec{B}$ into page

$\mathcal{E}_{\text{induced motional}} = \frac{B^2\ell^2v^2}{R}$ $\qquad d\mathcal{E}_{\text{induced}} = Bv\,dr$

$\mathcal{E}_{\text{induced}} = B\int v\,dr$ but $v = r\omega$ $\qquad \mathcal{E}_{\text{induced}} = B\omega\int_0^{\ell} r\,dr$

$$\boxed{\mathcal{E}_{\text{induced}} = \frac{1}{2}B\omega\ell^2}$$

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suggested سوف
website
موجود

13.3 Lenz's law (not new law)

it is a consequence of conservation of energy

$$\mathcal{E}_{induced} = -\frac{d\phi_B}{dt} \qquad |\mathcal{E}_{induced}| \propto \left|\frac{d\phi_B}{dt}\right|$$

سوف نتكلم عنها

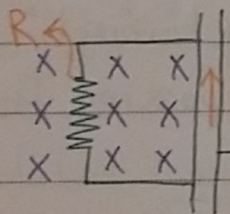
→ The induced current and induced $\mathcal{E}$ in a loop flow in a direction that creats $\vec{B}$ that opposes (يعاكس) the change in ϕ_B through the area of loop.

اتجاه التيار الحثي و القوة الدافعة الكهربائية في ملف (مسار مغلق) يكون باتجاه يولّد مجالاً مغناطيسياً معاكساً للتغير في التدفق المغناطيسي الذي أنشأه.

→ The induced current flows in such a direction as to oppose the change that produced it (current)

يكون اتجاه التيار الحثي معاكساً للتغير الذي أنشأه

- Example: I induced in a moving conducting bar



I induced

→ Fapp (v)

C.C.W A↓ ϕ_B↓ → A ما بزبط
→ B ✓

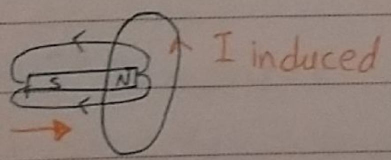
in order to compensate decrease in ϕ_B

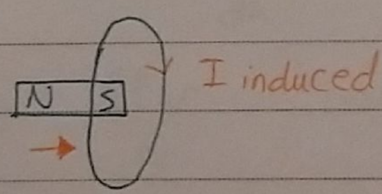
moved to right → C.C.W (I) ϕ_B↑ A↑ $\vec{B}$ out

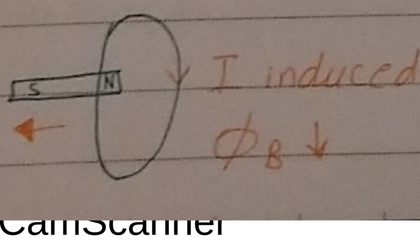
moved to left → C.W (I) ϕ_B↓ A↓ $\vec{B}$ in

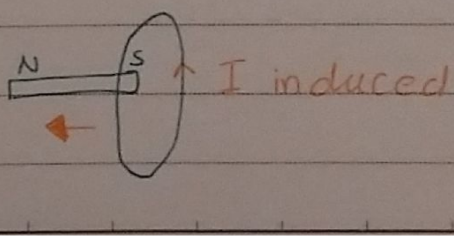
العكس صحيح لو كان out page

→ I induced in a stationary loop by moving a bar magnet into & away from the loop.









Chapter 32 : inductance

32.1 Self - inductor & inductance

→ **Inductance :-**

a major of how much opposition a loop (coil) offers to any change in current.

→ unit of inductance = $\frac{V.S}{A}$ = Henry = H

→ **Self inductance L :**

the opposition of a loop to any change in its current.

$\mathcal{E}_{induced} \propto -\frac{d\phi_B}{dt}$ $\qquad \phi_B \propto B \qquad B \propto I \qquad$ So...

$\mathcal{E}_{induced} \propto -\frac{dI}{dt} \qquad \mathcal{E}_{induced} = -\underbrace{\text{constant}}_{\text{independent of } I \,\&\, t \,=\, L} \frac{dI}{dt}$

$\mathcal{E}_{induced} = -L\frac{dI}{dt} \qquad L = \frac{-\mathcal{E}_{induced}}{dI/dt} = \frac{-\mathcal{E}_L}{dI/dt}$

مقاومة التغير في التيار $\boxed{L = \frac{-\mathcal{E}_L}{dI/dt}}$ سالب

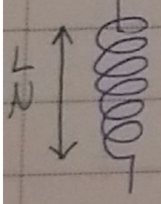
looks like $R = \frac{\Delta V}{I}$ مقاومة التيار

L is always +ve

$[L] = \frac{V.S}{A}$ = Henry = H

But $\mathcal{E}_{induced} = \frac{-N\,d\phi}{dt}$ $\qquad \boxed{L = \frac{N\phi_B}{I}}$

- example 32.1 p.972 [L of a solenoid]



$\uparrow \vec{B} \qquad L = \frac{N\phi_B}{I}$ $\qquad$ B is uniform $\quad \phi_B = \vec{B}\cdot\vec{A} \quad \theta = 0$

$\phi_B = BA$

B for a solenoid $B = \mu_0 n I$, $n = \frac{N}{l}$ $\qquad \phi_B = \mu_0 n I A$ or

$\boxed{L_{solenoid} = \frac{\mu_0 N^2 A}{l}}$ $\qquad \phi_B = \mu_0 \frac{N}{l} I A$

$\boxed{L_{solenoid} = \mu_0 n^2 (Al) = \mu_0 n^2 \, Volume}$

لكن واحد capacitor مثل Solenoid
المغناطيسية و واحد للكهربائية.

Solenoid ← B منتظم
Plallel plate capacitor ← E منتظم

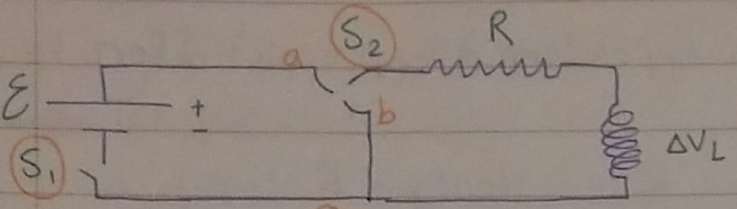
26/4/2016

R — L

NO 32.2

32.2 RL circuit

circuit of resistor & inductor in series connected
without battery with battery



- S_2 must be on eaither a or b.

→ at $t=0$ ① S_1 is closed & S_2 at a

$I(t=0)=0 \qquad \varepsilon = \Delta V_L \qquad \Delta V_R = 0$

→ as time passes $t>0$

$\varepsilon = \Delta V_L + \Delta V_R$

كيرشوف $+\varepsilon - IR - L\dfrac{dI}{dt} = 0$

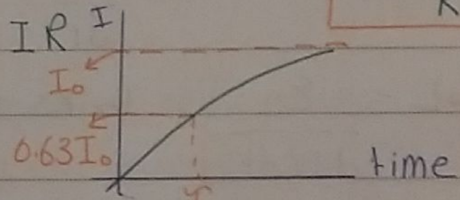
$\boxed{I(t) = I_0\left(1-e^{\frac{-t}{\tau}}\right)}$ with battery

$\boxed{I_0 = \dfrac{\varepsilon}{R}}$

τ: time constant of RL circuit $\boxed{\tau = \dfrac{L}{R}}$

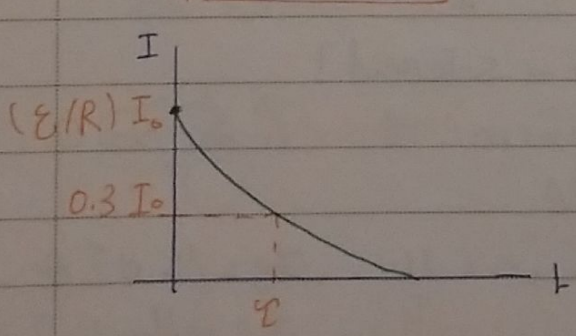
كأنه inductor غير موجود → as $t \to \infty$ $\qquad \varepsilon = \Delta V_R = IR$

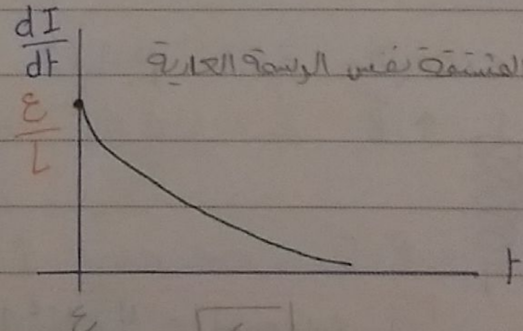
$[\tau] = \dfrac{H}{\Omega} = \dfrac{V.S}{A\Omega} = \dfrac{V.S}{A.\frac{V}{A}} = S$ وحدة زمن



② if S_2 at t (after sufficient time being at a)
R-L circuit without battery

$\boxed{IR = L\dfrac{dI}{dt}} \qquad \boxed{I = I_0\, e^{\frac{-t}{\tau}}} \qquad \tau = \dfrac{L}{R} \qquad I_0 = \dfrac{\varepsilon}{R}$





رسمة المشتقة نفس الرسمة العادية

$\dfrac{dI}{dt} \propto e^{\frac{-t}{\tau}}$

$\dfrac{\frac{\varepsilon}{R}}{\frac{L}{R}} = \boxed{\dfrac{\varepsilon}{L}}$

FIVE APPLE

$\dfrac{dI}{dt}$ ثابت ← لا يوجد inductor

32.3 Energy stored in magnetic field

→ RL circuit with battery

$$\mathcal{E} = \Delta V_R + \Delta V_L = IR + L\frac{dI}{dt} \quad / \times I$$

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

Power produced by $\mathcal{E}$ power stored in L

Power dissipated (consumed) by R

- power of L = $IL\frac{dI}{dt}$

$$\frac{dU_B}{dt} = LI\frac{dI}{dt} \qquad \int dU_B = L\int I\,dI$$

$$\boxed{U_B = \frac{1}{2}LI^2} \text{ for any } \vec{B} \qquad [U_B] = J$$

→ For a solenoid

$L_{solenoid} = \mu_0 n^2 \text{Volume}$

$B_{solenoid} = \mu_0 n I \qquad I = \frac{B}{\mu_0 n}$

$$U_B = \frac{1}{2}\cancel{\mu_0}\cancel{n^2}\,\text{Volume}\,\frac{B^2}{\cancel{\mu_0^2}\cancel{n^2}} = \frac{B^2}{2\mu_0}\text{Volume}$$

$$\boxed{\text{energy density} = \underset{\text{small}}{u_B} = \frac{B^2}{2\mu_0}} \qquad [u_B] = \frac{J}{m^3}$$