Notebook

Physics 102

الدكتور

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الطالبة

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← شرح دكتور أحمد عوض .

* Chapter 21 :-

* المادة اكتسبت ē ← (−)	gain
* المادة فقدت ē ← (+)	Lost

$p = 10^{-12}$	$\mu = 10^{-6}$	$G = 10^{9}$
$n = 10^{-9}$	$M = 10^{6}$	$m = 10^{-3}$

- proton (+)
- electron (−)

$q = ne \rightarrow C$

gain → كسب   فقد

Q :- If An object Lost 3×10^{10} ē what is charg ?

$q = ne$

$= 3\times10^{10} * 1.6\times10^{-19}$

$= 4.8\times10^{-9}\ C = 4.8\ nC$

* Coulomb's Law :-

* تنشأ بين الاجسام المشحونة قوة كهربائية
  - تجاذب (−,+)
  - تنافر (−,−)/(+,+)

the Law is :-

$$F = k\frac{q_1 q_2}{r^2} \qquad k = \frac{1}{4\pi\epsilon_0} = 9*10^9$$

k: ثابت كولوم Coulomb's Law.

ϵ_0 in air $= 8.85*10^{-12}$

* اذاً القوة الكهربائية تعتمد على :-
1. الوسط
2. الشحنات الكهربائية (طردي)
3. مربع المسافة (عكسي)

eg₁:- $q_1 = 20\ nC$, $q_2 = 50\ nC$
$r = 30$ cm → Find the electric force ?

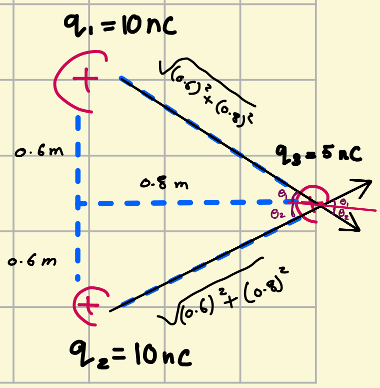
F_{21} ← $q_1 = 20nC$ $q_2 = 50nC$ → F_{12}

$$\vec{F} = k\frac{q_1 q_2}{r^2} = \frac{9*10^9 * 20*10^{-9} * 50*10^{-9}}{(30\times10^{-2})^2}$$

$= 1*10^{-4}\ N$

$\boxed{F_{12} = -F_{21}}$

eg₂:- What is the total force on q_3 ?



$\sum F_3 = F_{13} + F_{23}$

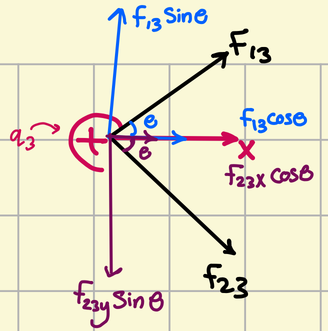
$\rightarrow F_{13} = k\frac{q_1 q_3}{r^2} = \frac{9\times10^9 * 10\times10^{-9} * 5\times10^{-9}}{(1)^2} = 4.5\times10^{-7}\ N$

$$\Sigma f_y = f_{23}\sin\theta - f_{23}\sin\theta = \text{zero}.$$

$$\Sigma f_x = f_{13}\cos\theta + f_{23}\cos\theta$$

$$= 4.5\times10^{-7} * 0.8 + 4.5\times10^{-7} * 0.8$$

$$= 7.2\times10^{-7}\ N.$$



* Electric field :-

* هو خاصية للحيز المحيط بالشحنة الكهربائية يظهر تأثيرة على شكل قوة كهربائية تؤثر في شحنة توضع في هذا المجال.

تكون شحنة نقطية موجبة

مهملة الأبعاد.

$$\vec{E} = \frac{F}{q_0}$$

F → electric force

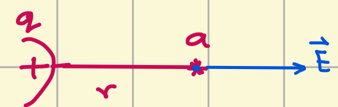
q_0 → test charge.

$$\left[\frac{N}{C}\right]$$

$$E = \frac{F}{q_0} = k\frac{q_1 \cancel{q_0}}{\cancel{q_0} r^2} = k\frac{q_1}{r^2}$$

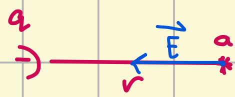
$$\vec{E} = \frac{kq}{r^2}\hat{r}$$

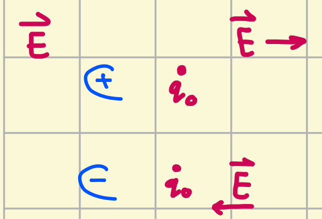
$\hat{i}$, $\hat{j}$, $\hat{k}$

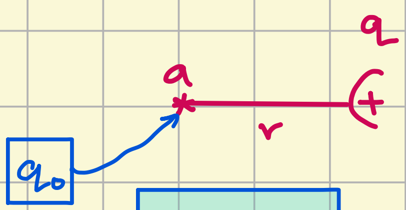


always +ve.

* لتحديد اتجاه المجال نضع test charge عند النقطة المطلوبة واتجاه حركة الشحنة يكون اتجاه المجال.







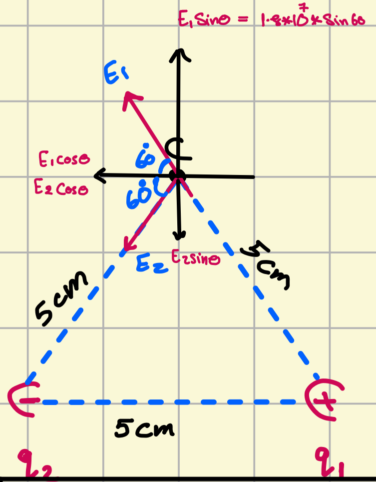
$$\boxed{F = q_0 E}$$

q_0 ≠ q_0

الشحنة المتأثرة

eg: $q_1 = 5\mu C$, $q_2 = -5\mu C$

Find $\vec{E}$ of point c :-



$$\vec{E}_{1c} = k\frac{q_1}{r^2} = 9\times10^{9} * \frac{5\times10^{-6}}{(5\times10^{-2})^2} = 1.8\times10^{7}\ N/C$$

$$E_{1c} = E_{2c}$$

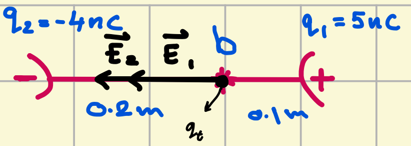
* $\vec{E}$ كمية متجهة لا تعوض اشارة الشحنة السالبة.

$$\Sigma f_y = E_1\sin\theta_1 - E_2\sin\theta_2 = 0$$

$$\Sigma F_x = E_1\cos\theta_1 + E_2\cos\theta_2 = 9\times10^{6}\ N/C$$

$$\vec{E} = 9\times10^{6}\ -\hat{i}$$

eg_1:- Calculate the E at b.



$$\Sigma \vec{E} = \vec{E}_1 + E_2$$

$$= \frac{kq_1}{r_1^2} + \frac{kq_2}{r_2^2}$$

$$= \frac{9\times10^9 * 5\times10^{-9}}{(1\times10^{-1})^2} + \frac{9\times10^9 * 4\times10^{-9}}{(2\times10^{-1})^2} = 54\times10^2 \ N/C \ (-\hat{i})$$

$\vec{E}$ مع f إذا +ve q_0 ∴ $\vec{E}$ مع

* يكون اتجاه القوة

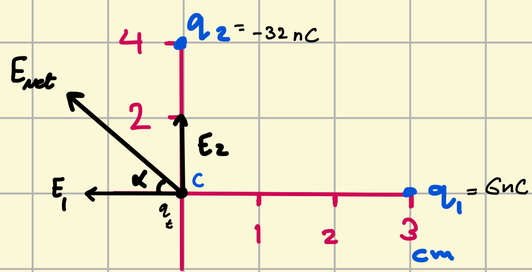
$\vec{E}$ عكس f إذا −ve q_0 ∴ $\vec{E}$ عكس

$b \leftarrow q_0 = 2\times10^{-3} C$

Find F?

$$F = q_0\vec{E} = 2\times10^{-3} * 54\times10^2 = 10.8 \ N \ (-\hat{i})$$

eg_2 :- Calculate the $\vec{E}$ at C?



$$E_1 = \frac{9\times10^9 * 6\times10^{-9}}{(3\times10^{-2})^2} = 6\times10^4 \ N/C$$

$$E_2 = \frac{9\times10^9 \times 32\times10^{-9}}{(4\times10^{-2})^2} = 18\times10^4 \ N/C$$

$$E_{net} = \sqrt{(E_1)^2 + (E_2)^2}$$

$$= \sqrt{(6\times10^4)^2 + (18\times10^4)^2} =$$

$$= 19\times10^4 \ N/C, \ 77.5°.$$

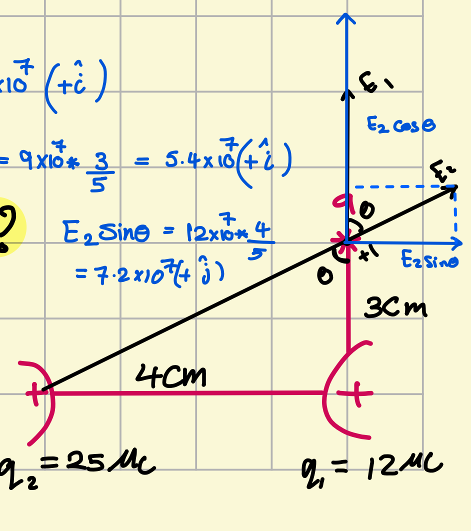
$$\tan\phi = \frac{18\times10^4}{6\times10^4} = 3 \rightarrow \tan^{-1}(3) \ \boxed{\therefore \phi = 71.5°}$$

$E_1 = 12\times10^7 \ (+\hat{i})$

$E_2\cos\theta = 9\times10^7 * \frac{3}{5} = 5.4\times10^7 (+\hat{i})$

$E_2\sin\theta = 12\times10^7 * \frac{4}{5}$
$= 7.2\times10^7 (+\hat{j})$

eg_3 :- what is the electric field at point a?



$$E_1 = \frac{kq_1}{r_1^2} = \frac{9\times10^9 * 12\times10^{-6}}{(3\times10^{-2})^2} = 12\times10^7 \ N/C$$

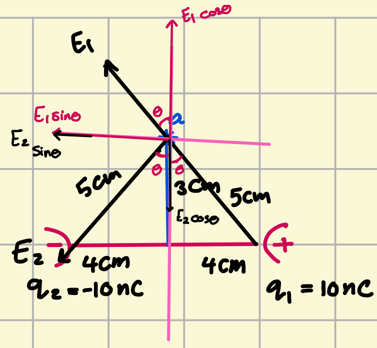
$$E_2 = \frac{9\times10^9 * 25\times10^{-6}}{(\sqrt{16+9})^2} = 9\times10^7 \ N/C$$

$$\Sigma E_x = 7.2\times10^7 \ N/C$$

$$\Sigma E_y = 12\times10^7 + 5.4\times10^7$$
$$= 17.4\times10^7$$

$$\Sigma E = \sqrt{(7.2)^2 + (17.4)^2} \times10^7$$
$$= 18.8\times10^7 \ N/C, \ 67.4°$$

eg_4 :- Find $\vec{E}_{net}$ at point a?



$$E_1 = \frac{9\times10^{9} * 10\times10^{-9}}{(5\times10^{-2})^2} = 3.6\times10^{4}\ N/C$$

$$E_2 = \frac{9\times10^{9} * 10\times10^{-9}}{(5\times10^{-2})^2} = 3.6\times10^{4}\ N/C$$

- $\sin\theta = \frac{4}{5}$
- $\cos\theta = \frac{3}{5}$

→ من الشكل

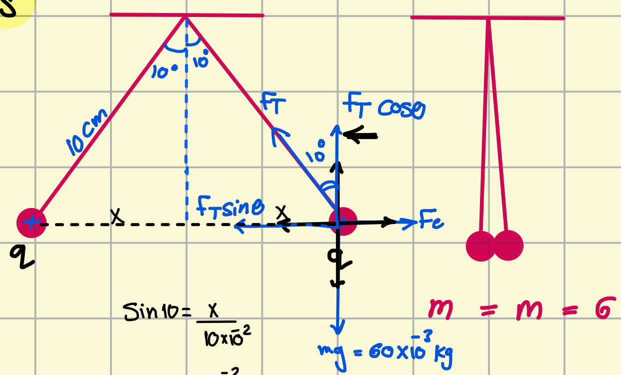
$$\Sigma E_x = E_1 \sin\theta + E_2 \sin\theta$$

$$= 28.8\times10^{3}\ N/C\ ,(-\hat{i})$$

$$\Sigma E_y = E_1 \cos\theta - E_2 \cos\theta$$

$$= \underline{\underline{\text{zero}}}.$$

eg_5 :- Find q if the System is at equilibrium?



$$\sin 10 = \frac{x}{10\times10^{-2}}$$

$$x = 17\times10^{-2}\ m$$

$$\Sigma F_y = F_T \cos 10 - mg = 0$$

$$\frac{F_T \cancel{\cos 10}}{\cancel{\cos 10}} = \frac{60\times10^{-3}}{\cos 10}$$

$$\boxed{F_T = 0.0609\ N.}$$

$$\Sigma F_y = F_T \sin 10 - F_e$$

$$= 0.0609 \times \sin 10$$

$$\boxed{F_e = 10.5\times10^{-3}\ N}$$

$$\rightarrow F_e = \frac{k q_1 q_2}{r^2}$$

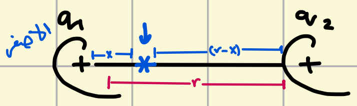
$$10.5\times10^{-3} = \frac{9\times10^{9} * q^2}{(34.7\times10^{-2})^2}$$

$$\sqrt{q^{\cancel{2}}} = \sqrt{1.36\times10^{-7}}$$

$$\boxed{q = 3.7\times10^{-4}\ C}$$

* equilibrium point :-

← هي النقطة التي ينعدم عندها المجال الكهربائي والقوة الكهربائية. $(E = 0)$



(+,+) or (-,-)

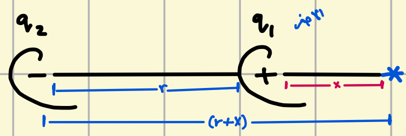
- شحنتان متشابهتين: نقطة التعادل تقع بينهما وأقرب للشحنة الأصغر.

$\boxed{\therefore E_1 = E_2}$ → قانون نقطة التعادل

$$\frac{kq_1}{r_1^2} = \frac{kq_2}{r_2^2}$$

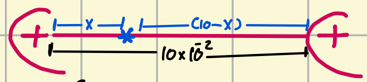
(+,-)

- شحنتان مختلفتان: نقطة التعادل تقع خارجهما أقرب للشحنة الأصغر.



eg1 :- If we have two point charges :- $q_1 = 4\,\mu C$, $q_2 = 9\,\mu C$, $r = 10$ cm

where is the equilibrium point (where is the point that has no net electric field)?

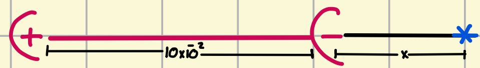


$q_1 = 4\times10^{-6}\,C$ $\qquad$ $q_2 = 9\times10^{-6}\,C$

$$E_1 = E_2$$

$$\frac{\cancel{k}q_1}{r_1^2} = \frac{\cancel{k}q_2}{r_2^2} \rightarrow \sqrt{\frac{\overset{2}{\cancel{4}}\times\cancel{10^{-6}}}{x^2}} = \sqrt{\frac{\overset{3}{\cancel{9}}\times\cancel{10^{-6}}}{(10\times10^{-2} - x)^2}} \rightarrow \frac{2}{x} = \frac{3}{0.1 - x} \rightarrow \begin{aligned} 3x &= 0.2 - \cancel{2x} \\ +2x & \qquad \cancel{+2x} \\ \hline 5x &= 0.2 \end{aligned} \rightarrow \boxed{x = 4\times10^{-2}\,m}$$

eg2: $q_1 = -4\,\mu C$, $q_2 = 9\,\mu C$, $r = 10$ cm. * لما اقرر مين الشحنة الاصغر بقارن بدون اشارات



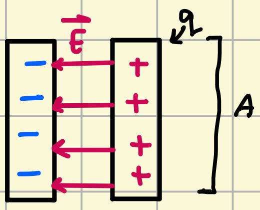
$q_2 = 9\,\mu C$ $\qquad$ $q_1 = -4\,\mu C$

$$E_1 = E_2$$

$$\frac{\cancel{k}q_1}{r_1^2} = \frac{\cancel{k}q_2}{r_2^2} = \sqrt{\frac{4\times\cancel{10^{-6}}}{x^2}} = \sqrt{\frac{9\times\cancel{10^{-6}}}{(0.1+x)^2}} = \frac{2}{x} = \frac{3}{0.1+x} = \begin{aligned} 3x &= 0.2 + \cancel{2x} \\ -2x & \qquad \cancel{-2x} \\ \hline x &= 0.2\,m \end{aligned}$$

* uniform Electric field :-

هو مجال كهربائي ينتج عن الصفائح ثابت مقدارًا واتجاه



(يخرج من الموجب ويدخل في السالب)

Charge density $(\sigma) = \frac{q}{A}$

- $E = \frac{\sigma}{\epsilon_0} = \frac{q}{\epsilon_0 A}$

eg:- A proton is placed in a uniform E ($v_1 = 0$)

$(E = 5\times10^{3}, \; q_p = 1.6\times10^{-19}, \; mass = 1.67\times10^{-27})$

find :-

1. magnitude of force:-

$E = \frac{f}{q} \rightarrow f = 5\times10^{3} * 1.6\times10^{-19} = \boxed{8\times10^{-16}\ N}$

2. proton acceleration:-

$\Sigma f = ma$

$\frac{8\times10^{-16}}{1.67\times10^{-27}} = \frac{\cancel{1.67\times10^{-27}}\, a}{\cancel{1.67\times10^{-27}}}$

$\boxed{a = 4.8\times10^{11}\ m/s^2.}$

3. Speed after $1\mu s$:-

$v_2 = \cancel{v_1}^{\,0} + at$

$v_2 = 4.8\times10^{11} * 1\times10^{-6}$

$\boxed{v_2 = 4.8\times10^{5}\ m/s.}$

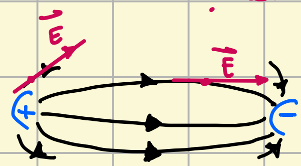
- المجال الكهربائي الناشىء عن شحنة نقطية هو مجال كهربائي غير منتظم.

- كلما ابتعدنا عن المصدر يقل المجال الكهربائي.

$k\frac{q}{r^2} \quad E \propto \frac{1}{r^2}$.

- خطوط المجال الكهربائي :-

1. تخرج من الشحنة الموجبة وتدخل في الشحنة السالبة.



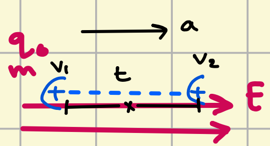
2. الخطوط تكون متقاربة عند المجال الاقوى.
3. اتجاه المجال الكهربائي هو المماس لاي نقطة في الخطوط.
4. خطوط المجال الكهربائي لا تتقاطع.

← لانه رح يصير عندي اكثر من مماس فبالتالي مافي اتجاه صحيح للمجال.

* تطبيقات :-

[1] حركة جسيم مشحون داخل هذا المجال؟

→ Motion of a small charged particle inside the uniform electric field.



$f_E = \underbrace{q_0 E}_{\text{ثوابت}} = m\underbrace{a}_{\text{له ثابتة}}$

بسبب

$w = f\,x \cos\theta_{fx}$

$\Delta KE = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$

* اذا كانت قوة المجال الكهربائي هي القوة الوحيدة المؤثرة على الجسم

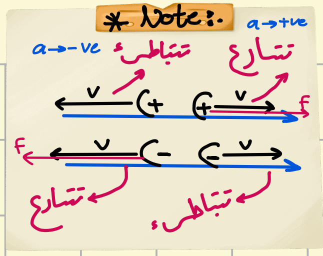
$\therefore W_{total} = \Delta KE$

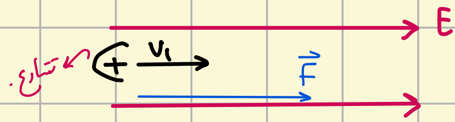
$v_2^2 = v_1^2 + 2a\Delta x$

$v_2 = v_1 + at$

$\Delta x = v_1 t + \frac{1}{2}at^2$

eg₂: An Object of mass 2×10^{-4} kg and Charge of 6×10^{-8} C, enters a uniform electric field with Speed of 2×10^{4} m/s for 10^{3} sec.
↳ if $E = 4000$ N/C as in figure, **Find :-**





1) acceleration :

$F_E = q_0 E$

$\boxed{= 2.4\times10^{-4}}$

$\Sigma F = ma$

$\frac{2.4\times10^{-4}}{2\times10^{-4}} = \frac{\cancel{2\times10^{-4}}\, a}{\cancel{2\times10^{-4}}}$

$\boxed{a = 1.2\ m/s^2.}$

2) final speed :

$V_2 = V_1 + at$

$= 2\times10^{4} + 1.2\times10^{3}$

$\boxed{= 212\times10^{2}\ m/s}$

3) traveled displacment :-

$\Delta x = v_1 t + \frac{1}{2}at^2$

$= 2\times10^{4}\times10^{3} + 1/2\,(1.2)(10^{3})^2$

$= 20\times10^{6} + 0.6\times10^{6}$

$\boxed{= 20.6\times10^{6}\ m}$

4) force exerted :-

$F_E = q_0 E$

$\boxed{= 2.4\times10^{-4}}$

5) Work done :-

$W = F\,\Delta x \cos\theta$

$= 2.4\times10^{-4} * 20.6\times10^{6} * 1$

$\boxed{= 4944\ J}$

6) ΔKE ??

$\Delta KE = \frac{1}{2}mv_2^2 - \frac{1}{2}mv_1^2$

$= \frac{1}{2}(2\times10^{-4})(212\times10^{2})^2 - \frac{1}{2}(2\times10^{-4})(2\times10^{4})^2$

$\boxed{= 4944\ J}$

eg₃: If an object of mass 0.1 g and charge -2×10^{-6} C Start moving with speed of 20 m/s inside a uniform electric field and with the Field direction, the distance traveled is 200 m untill the particle was stopped.
↳ what is the magn of the Electric Field ?

* في معادلات الحركة السالب يعوض
سالب والموجب يعوض موجب اما
في قانون E و f_E لا تعوض
الاشارات.

$v_2^2 = v_1^2 + 2ax$

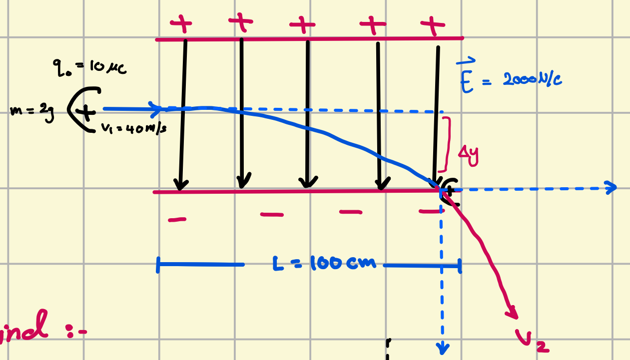
$0 = 400 + 2a\times200$

$\boxed{a = -1\ m/s^2}$

$\frac{\cancel{q_0}E}{\cancel{q_0}} = \frac{ma}{q_0}$

$E = \frac{0.1\times10^{-3} * 1}{2\times10^{-6}} = 50\ N/C$

eg_4 :



y axis	x axis
$v_{2y} = v_{1y} + at$	$v_{2x} = v_{1x}$
$v_{2y}^2 = v_1^2 + 2gy$	
$y = v_1 t + \frac{1}{2} g t^2$	$x = v_{1x} t$

↳ Find :-

1) acceleration? (a_y)

$v_{1x} = v_1 \cos 0 = 40 \ m/s$

$v_{1y} = v_1 \sin 0 = 0$

$a_x = 0$

$q_o E = m a_y$

$10 \times 10^{-6} * 2000 = 2 \times 10^{-3} a_y$

$\boxed{a_y = +10 \ m/s^2}$

2) Final velocity (speed) ?

$V_{2x} = V_{1x} = 40$

$V_{2y} = V_{1y} + a_y t \rightarrow$ $\boxed{x = v_{1x} t \quad 1 = 40t \quad t = 25 \times 10^{-3} s}$

$V_{2y} = 0 + 10 * 25 \times 10^{-3}$

$\boxed{V_{2y} = 25 \times 10^{-2} \ m/s}$

$V_2 = 40\hat{i} - 0.25\hat{j}$

$\boxed{\text{speed} = \sqrt{(40)^2 + (0.25)^2}}$

3) vertical displacment ?

$\Delta y = \cancel{v_{1y} t} + \frac{1}{2} a t^2$

$= \frac{1}{2}(10)(0.025)^2$

$= 3.125 \times 10^{-3} \ m.$

4) time ?

$x = v_{1x} t$

$1 = 40t$

$t = 25 \times 10^{-3} s$

---

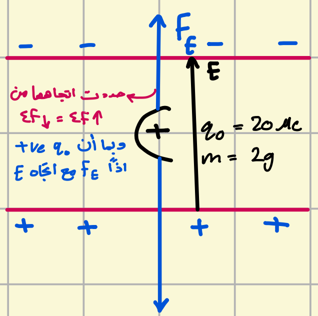
eg_1: A particle of mass 2g and charge of $20\mu c$, what is the magnitude and direction of E ?

$\Sigma F_\uparrow = \Sigma F_\downarrow$

$q_o E = w$

$20 \times 10^{-6} E = 2 \times 10^{-2}$

$\boxed{E = 1 \times 10^{-3} \ N/C}$



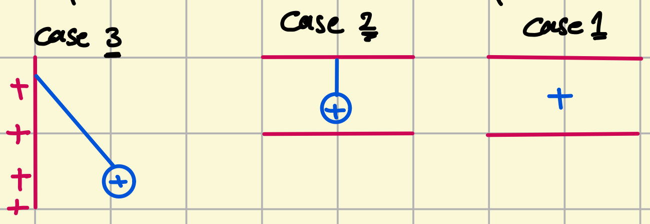
$W = mg$

$= 2 \times 10^{-3} \times 10$

$= 2 \times 10^{-2} N$

تطبيق [2] ؟

اتزان الجسيم المشحون داخل المجال المنتظم.



↲ الخطوات ؟

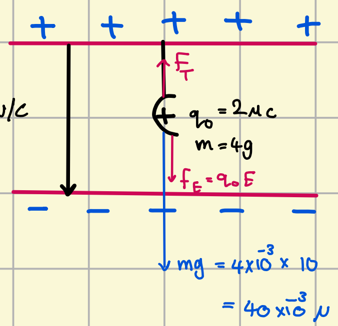
١) نحدد اتجاه القوى المؤثرة

٢) نحدد محاور مناسبة ونحلل القوة الغير منطبقة على المحاور.

٣) نطبق قوانين الاتزان ؟ $\Sigma F_\uparrow = \Sigma F_\downarrow$

$\Sigma F_\rightarrow = \Sigma F_\leftarrow$

eg$_2$: What is the tension in the Cord?



$\Sigma F_{\uparrow} = \Sigma F_{\downarrow}$

$F_T = F_E + F_g$

$= qE + mg$

$= 2\times10^{-6} * 4\times10^{3} + 40\times10^{-3}$

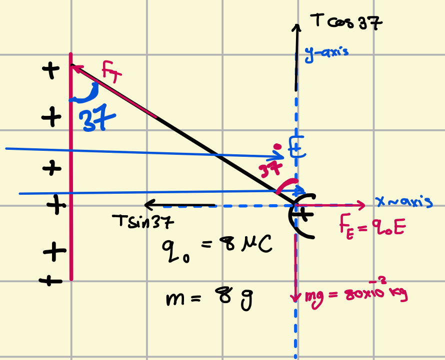
$= 8\times10^{-3} + 40\times10^{-3}$

$\boxed{= 48 \times 10^{-3}\ N}$

---

eg$_3$:-

Find E?



$\Sigma F_{\uparrow} = \Sigma F_{\downarrow}$

$T\cos 37 = 80\times10^{-3}$

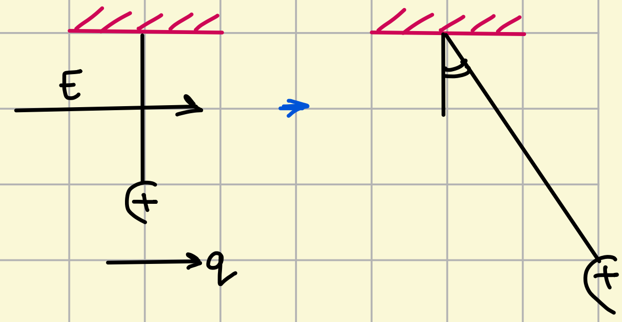
$\boxed{T = 0.1\ N}$

$\Sigma F_{\leftarrow} = \Sigma F_{\rightarrow}$

$T\sin\theta = f_E$

$\frac{0.1 * 0.6}{8\times10^{-6}} = \frac{8\times10^{-6} E}{8\times10^{-6}} \rightsquigarrow E = 7522.7\ N/C$

way 2



لو كانت E معطاه طابرسمها
على الرسمة بعطيني اياها مع
مع اتجاه.

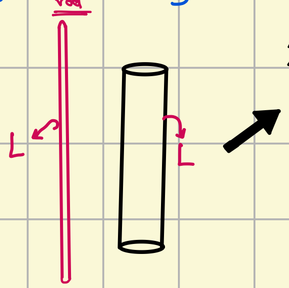
$E = 400\ N/C(\hat{i})$

---

* Electric Field due to distribution of Charge.

"المجال الناتج عن توزيع الشحنات"

1) Linear charge distribution:



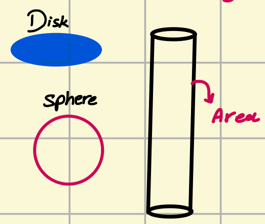
كثافة الشحنة الطولية

Linear Charge density (λ)

$q = \lambda L$

$dq = \lambda dL$

2) Surface charge dist:-



كثافة الشحنة السطحية

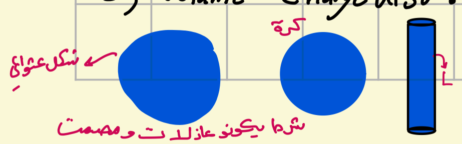
Surface Charge density (σ)

$q = \sigma A$

$dq = \sigma dA$

---

3) Volume Charge dist:



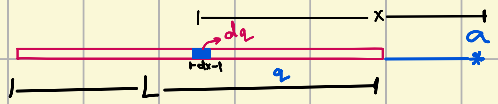
كثافة الشحنة الحجمية

Volume charge density (ρ)

$q = \rho V$

$dq = \rho dV$

rod



$$q = \lambda L$$
$$dq = \lambda\, dx$$

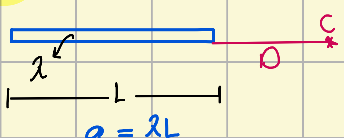
$$\int dE = \frac{k\,dq}{r^2} \quad \int \frac{k\lambda\, dx}{x^2}$$

$$E = \int_a^{L+a} \frac{k\lambda}{x^2}\,dx = k\lambda \int_a^{L+a} \frac{dx}{x^2} = k\lambda\left[\frac{-1}{x}\right]_a^{L+a} = k\lambda\left\{\frac{-1}{L+a} + \frac{1}{a}\right\} = k\lambda\left[\frac{L+\cancel{a}-\cancel{a}}{a(L+a)}\right] = \frac{k\overbrace{\lambda L}^{q}}{a(a+L)}$$

★ important :-

[1] rod :-

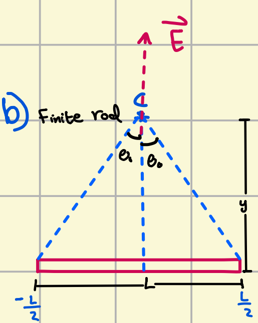
a)



$q = \lambda L$

$$\Rightarrow \boxed{E_c = \frac{k\lambda L}{D(D+L)}}$$

b) Finite rod

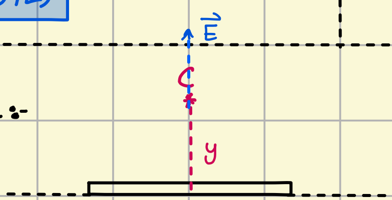


$$\boxed{E = \frac{2k\lambda \sin\theta_0}{y}}$$

or

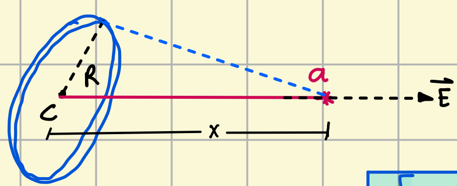
$$E = \frac{\cancel{2}k\lambda L}{\cancel{2}y\sqrt{\frac{L^2}{4}+y^2}}$$

c) infinite rod :-



$$\boxed{E_c = \frac{2k\lambda}{y}}$$

[2] Ring :



$$\boxed{E_A = \frac{k\lambda(2\pi R)x}{(x^2+R^2)^{3/2}}}$$

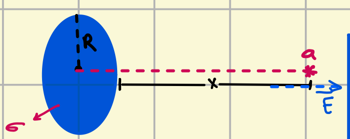
$$\boxed{E_c = 0}$$

λ ?

$Q = \lambda L = \lambda(2\pi R)$

محيط الدائرة

[3] Disk :



$$\boxed{E = 2\pi k\sigma\left[1 - \frac{x}{\sqrt{R^2+x^2}}\right]}$$

$Q = \sigma A$

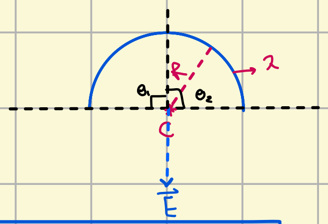
$= \sigma\pi R^2$

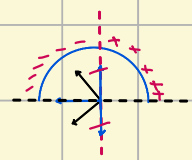
37 : 40

[4] Simi Circle :-

$Q = \lambda L$ → نص محيط دايرة

$= \lambda \pi R$





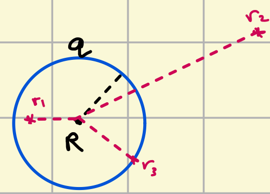
$$\boxed{E_c = \frac{k\lambda}{R}\left[\sin\theta_1 + \sin\theta_2\right]}$$

---

[5] Conducting sphere

كرة مجوفة ← "Spherical Shell"

$q = \sigma(4\pi R^2)$



At $r_1 < R$

$$\boxed{E_{in} = 0}$$

At $r_2 > R$

$$\boxed{E = \frac{kq}{r^2}}$$

At $r_3 = R$

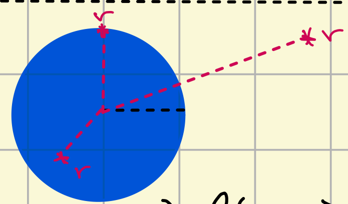
$$\boxed{E = \frac{kq}{R^2}}$$

---

[6] Solid isulator sphere

مصمتة ← Solid ; عازل ← isulator

$q = \rho\left(\frac{4}{3}\pi R^3\right)$



1) At $r < R$:-

$$\boxed{E_{in} = \frac{kqr}{R^3} \quad , \quad E = \frac{\rho r}{3R^3}}$$

2) At $r > R$:-

$$\boxed{E_{out} = \frac{kq}{R^2} \quad , \quad E = \frac{\rho R^3}{3\epsilon_0 r^2}}$$

3) At $r = R$:-

$$\boxed{E_{Surface} = \frac{\rho R}{3\epsilon_0}}$$

---

[7] Conducting infinte Cylinder

اسطوانة

$\sigma = \frac{\lambda}{2\pi R}$

" Cylindrical shell "

1) At $r < R$:-

$$\boxed{E = 0}$$

2) At $r > R$:-

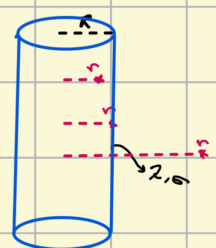
$$\boxed{E = \frac{\lambda}{2\pi\epsilon_0 r} \quad , \quad \frac{2k\lambda}{r}}$$

$E_{out} = \frac{R\sigma}{\epsilon_0 r}$

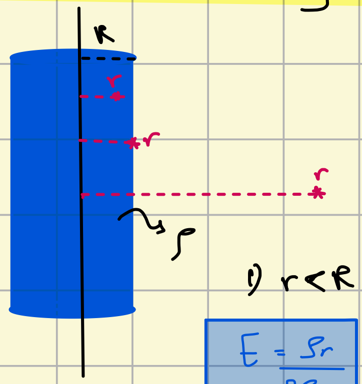
3) At $r = R$:-

$$\boxed{E = \frac{\lambda}{2\pi\epsilon_0 R}}$$

$E_{Surface} = \frac{\sigma}{\epsilon_0}$



[8] infinite Solid insulating Cylinder



1) $r < R$ (in)

$$\boxed{E = \frac{\rho r}{2\epsilon_0}}$$

2) $r > R$ (out)

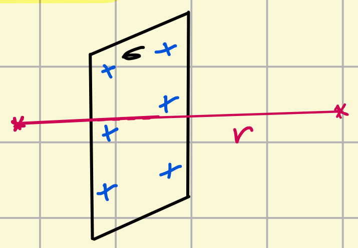
$$\boxed{E = \frac{\rho R^2}{2\epsilon_0 r}}$$

3) $r = R$ (surface)

$$\boxed{E = \frac{\rho R}{2\epsilon_0}}$$

---

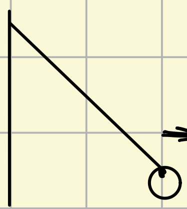
[9] Infinite plate:-



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

كيف بقدر استفيد منها

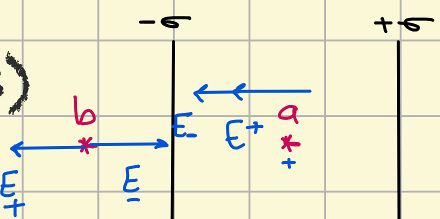
A)



$\rightarrow$ Find E? | Find σ?

$E = \checkmark$ | $\sigma = 2E\epsilon_0$

B)



$$\boxed{\Sigma E_b = 0}$$

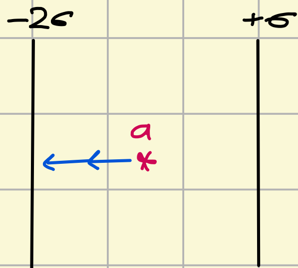
$E_+ = \frac{\sigma}{2\epsilon_0}$

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

$\Sigma E_a = E_+ + E_-$

$$\boxed{= \frac{\sigma}{\epsilon_0}}$$

C)



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

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

$\Sigma E_a = \frac{\sigma}{2\epsilon_0} + \frac{2\sigma}{2\epsilon_0}$

$$\boxed{= \frac{3\sigma}{2\epsilon_0}}$$

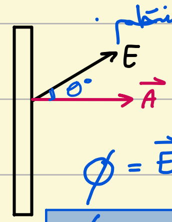
* Chapter 22 :- Electrical Flux and Gauss's Law.

التدفق الكهربائي

ϕ : عدد خطوط المجال الكهربائي التي تخترق سطحًا ما عموديًا عليه

ϕ

١) سطح منتظم يخترقه مجال منتظم.

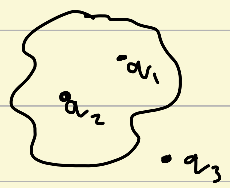


$$\phi = \vec{E} \cdot \vec{A}$$

$$\boxed{\phi = E \cdot A \cos\theta_{E \cdot A}}$$

٢) سطح مغلق بداخله شحنات

$$\phi = \frac{\sum q_o}{\epsilon_o}$$

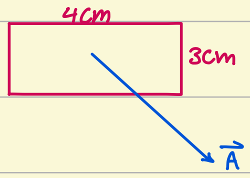


$$\phi = \frac{q_1 + q_2}{\epsilon_o}$$

* السالب يعوض *

---

eg 1.1 :- If $\vec{E} = 4\hat{i} + 2\hat{j} + 5\hat{k}$ and the area is rectangular with dim. 4cm x 3cm Lying on the xy plane, Find the electrical Flux ?



$A = 4\times10^{-2} * 3\times10^{-2}$

$\boxed{= 12 \times 10^{-4}\ m\ \hat{k}}$

$\phi = \vec{E} \cdot \vec{A}$

$= (\cancel{4\hat{i}} + \cancel{2\hat{j}} + 5\hat{k}) \cdot (12\times10^{-4}\hat{k})$

$\boxed{= 60\times10^{-4}\ N.m^2/C .}$

---

eg 1.2 :- If the E is given by : $\vec{E} = 4\hat{i} + \hat{j} - 2\hat{k}$ and $\vec{A}$ is given by : $3\hat{i} + 2\hat{j} + \hat{k}$, Find ?

A) The net Flux

$\phi = \vec{E} \cdot \vec{A}$

$= (4\hat{i} + \hat{j} - 2\hat{k}) * (3\hat{i} + 2\hat{j} + \hat{k})$

$= 12 + 2 - 2 = \boxed{12\ N.m^2/C}$

B) angle between $\vec{E}$ and $\vec{A}$?

$\theta = \cos^{-1}\left(\frac{A \cdot E}{|A|\,|E|}\right) = \cos^{-1}\left(\frac{12}{\sqrt{21}\ \sqrt{14}}\right)$

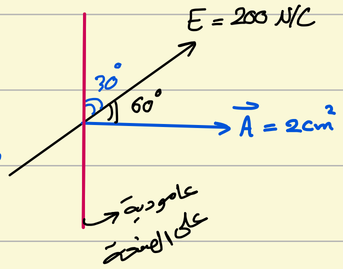
$\boxed{\theta = 45.6}$

eg 1.3 :- In the figure, Calculat the net Flux?

$\phi = \vec{E}\cdot\vec{A}\ \cos 60$

$= 200 * 2\times10^{-4} * \cos 60$

$= 2\times10^{-2}\ N\cdot m^2/C$



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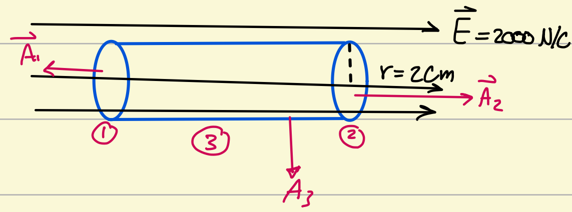
eg 1.4 :- Find the net Electrical Flux through the below Cylinder?



$\phi_1 = \vec{E}\cdot\vec{A}\cos\theta$

$= 2000 * \pi(2\times10^{-2})^2 \cos(180)$

$= -0.8\pi\ N\cdot m^2/C$

$\phi_2 = \vec{E}\cdot A \cos(0)$

$= 0.8\pi\ N\cdot m^2/C$

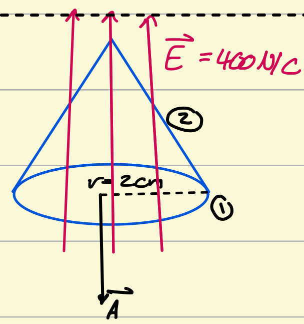
$\phi_3 = \vec{E}\cdot A\ \cancel{\cos 90}$ 0

$= 0\ N\cdot m^2/C$.

$\phi_{Net} = -0.8\pi + 0.8\pi + 0 = \underline{\underline{Zero}}$.

---

eg 1.5 :- Find the flux through each Surface?



$\phi_1 = \vec{E}\cdot\vec{A}\cdot\cos\theta$

$= 400 * \pi(2\times10^{-2})^2 \cos 180$

$= -16\pi\times10^{-2}\ N\cdot m^2/C$

$\phi_{Net} = 0$

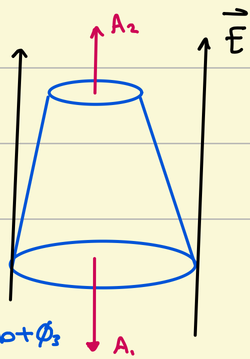
$\phi_1 = -\phi_2$

$+16\pi\times10^{-2} = +\phi_2$

$\phi_2 = 16\times10^{-2}\ N\cdot m^2/C$.

---

eg 1.6 :-



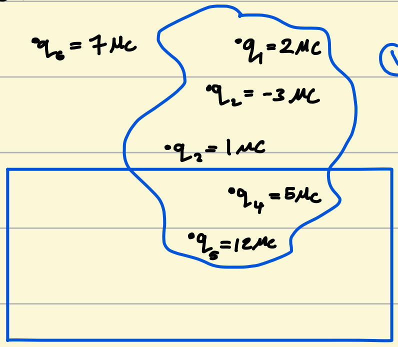
$\phi_1 = EA_1 \cos 180$

$\phi_2 = EA_2 \cos 0$

$\phi_3 = ?$

$\phi_{Net} = \phi_1 + \phi_2 + \phi_3 \quad = 0 = -(a) + b + \phi_3$

$eg_{2.1}$:- Find the Flux through each Surface ?



$$\phi_1 = \frac{\Sigma q_{ins}}{\epsilon_0}$$

$$= \frac{2\mu + -3\mu + 1\mu + 5\mu}{\epsilon_0}$$

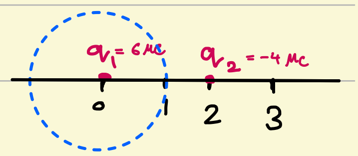
$$= \frac{5\times10^{-6}}{8.85\times10^{-12}} = 0.56\times10^{6}\ N\cdot m^2/C$$

$$\phi_2 = \frac{\Sigma q_{ins}}{\epsilon_0}$$

$$= \frac{5\mu + 12\mu}{\epsilon_0} = \frac{17\times10^{-6}}{8.85\times10^{-12}} = 1.92\times10^{-6}\ N\cdot m^2/C$$

$eg_{2.2}$:- If we Have two Charges, $q_1 = 6\mu C$ at the Origin, $q_2 = -4\mu C$ at $x=2$, Find the net Flux through a sphere of radious, $r = 1cm$, Centered at the Origin?

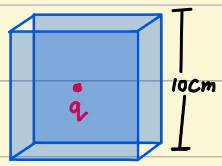
$$\phi = \frac{\Sigma q_{in}}{\epsilon_0} = \frac{6\times10^{-6}}{8.85\times10^{-12}} = 0.68\times10^{6}\ N\cdot m^2/C.$$



$eg_{2.3}$:- Cube of Side 10 Cm, Contains a Charge at its Center $q = 12\mu C$, Find ?

A) net flux ?

$$\phi = \frac{\Sigma q}{\epsilon_0} = \frac{12\times10^{-6}}{8.85\times10^{-12}} = 1.4\times10^{6}\ N\cdot m^2/C$$



B) Flux through each Surface?

$$\phi_{face} = \frac{\phi_{net}}{6} = \frac{1.4\times10^{6}}{8.85\times10^{-12}} = 0.23\times10^{6}\ N\cdot m^2/C$$

$\boxed{\text{* Gauss's Law}}$

$$\phi = \phi$$

$$\boxed{E A \cos(0) = \frac{\Sigma q_{in}}{\epsilon_0}} \rightarrow \int E\, dA = \frac{q_{ins}}{\epsilon_0}$$

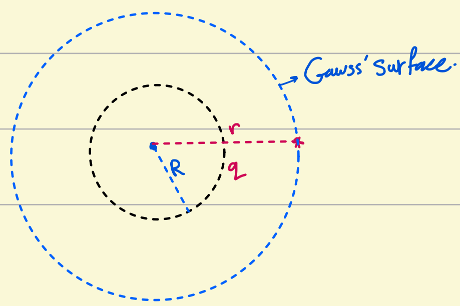
q_{ins}:
- q
- $\lambda L = \int \lambda dx$ — $\lambda(x)$
- $\sigma A = \int \sigma dA$ — $\sigma(x)$
- $\rho V = \int \rho dv$ — $\rho(x)$
- 0

function of x.

E: المجال المطلوب حسابه

A: مساحة Gauss's surface

Σq_{in}: الشحنة الكلية داخل سطح غاوس



eg 3.1 :-

$r<R$

$$EA = \frac{\Sigma q_{ins}}{\epsilon_0}$$

$$E\,2\pi r L = \frac{0}{\epsilon_0}$$

$$E\,2\pi r L = 0$$

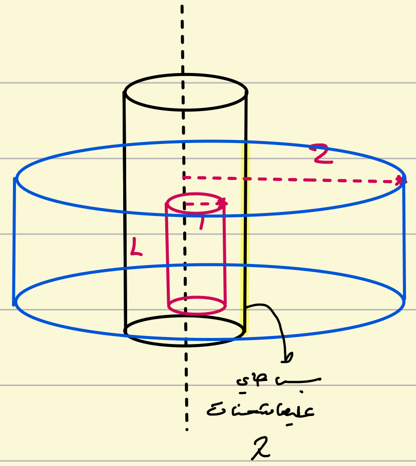
$$\boxed{E_{ins} = 0}$$

$r>R$

$$EA = \frac{\Sigma q_{out}}{\epsilon_0}$$

$$E(2\pi r \cancel{L}) = \frac{\lambda \cancel{L}}{\epsilon_0}$$

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



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eg 3.2 :-

1) $r<R$:-

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

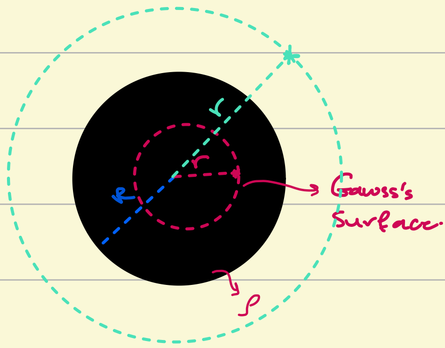
$$E(4\pi r^2) = \frac{\rho(\frac{4}{3}\pi r^3)}{\epsilon_0}$$

$$\boxed{E = \frac{\rho r}{3\epsilon_0}}$$

2) $r>R$

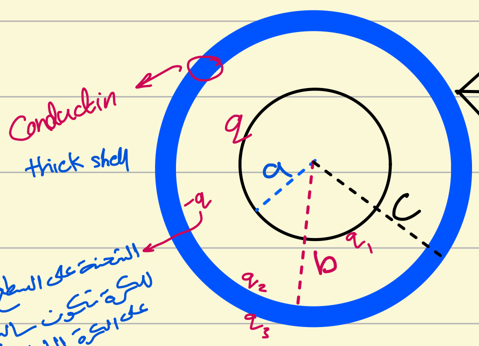
$$E(2\pi r^2) = \frac{\rho(\frac{4}{3}\pi R^3)}{\epsilon_0}$$

$$\boxed{E = \frac{\rho R^3}{3\epsilon_0 r^2}}$$



---

eg 3.3 :-



الشحنة على السطح الداخلي للكرة تكون سالب الشحنة على الكرة الداخلية.

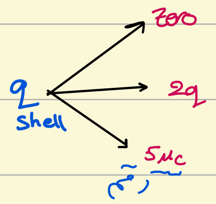
اذا اعطاني σ (موحدة) بجيب q

$q = \sigma A$

اذا اعطاني ρ على طول بجيب q

$q = \rho V$

$$\boxed{q_2 = -q_1}$$



$\rightarrow q_{shell} = q_2 + q_3$

مثلاً $0 = -q + q_3$

$$\boxed{q_3 = q}$$

or

$q_{shell} = q_2 + q_3$

$2q = -q + q_3$

$$\boxed{q_3 = 3q}$$

(volt)
(v) الجهد الكهربائي

* Chapter 23 :- → Electrical potential.

→ introduction :

a * ← $\oplus\, q_0$ → b *
V_b

V_a ← الجهد للنقطة ناتج عن الشحنة
لا يوجد جهد للشحنة يوجد طاقة فقط

U : potential energy

$$\underbrace{U_a}_{\text{potential energy}} = \overset{\text{point charge}}{q_0}\, \underbrace{V_a}_{\text{potential}}$$

$$U_b = q_0\, V_b$$

$$\to \Delta U_{a\to b} = q_0\, [V_b - V_a] = q_0\, \Delta V_{a\to b}$$

* $\Delta V_{ba} = \Delta V_{a\to b}$

$\Delta V_{earth} = Zero$
$\Delta V_{\infty} = Zero$
→ $\Delta U = Zero$

[1] V due to point charge

$$W_{a\to b} = \Delta U_{a\to b} = q_0\, \Delta V_{a\to b} \quad So \quad \boxed{\Delta KE = 0}$$

[2] V due to uniform $\vec{E}$

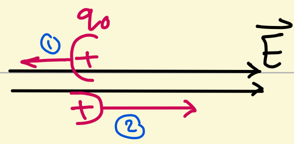
$q_{0_1} \to$ $\quad W_{a\to b} = \Delta U_{a\to b} = q_0\, \Delta V_{a\to b}$. So $\boxed{\Delta KE = 0}$

شغل قوة خارجية

or

$q_{0_2} \to$ $\quad W_{a\to b} = \Delta KE = -\Delta U_{a\to b} = -q_0\, \Delta V_{a\to b}$.

شغل قوة المجال الكهربائي.



[3] V due to dist of Charges

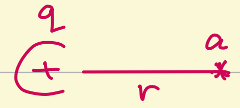
$$W_{a\to b} = \Delta U_{a\to b} = q_0\, \Delta V_{a\to b} \quad . \; So \quad \boxed{\Delta KE = 0}$$

كل ما تحركنا باتجاه المجال الكهربائي قلت قيمة الجهد

[1] Electrical potential due to point Charge ?

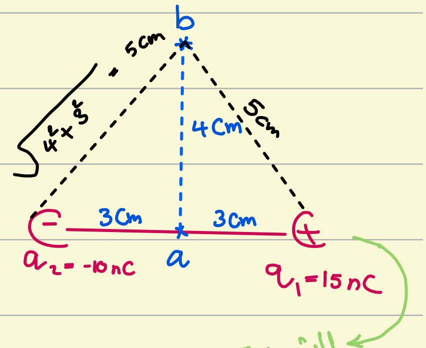
* الاشارة السالبة تعوض في القانون *

* الجهد ليس له اتجاه *



$$\boxed{V = \frac{Kq}{r}}$$

$\therefore V_{total} = V_1 + V_2 + V_3 \cdots$



الشحنة تؤثر بجهد كهربائي على محيطها ولا تأثر على نفسها $\therefore$ q_1 يؤثر عليها جهد من q_2 فقط

Ex, 8- In the Figure Find ?

[1] Potential differance between a and b ?

$V_a = V_1 + V_2 = \frac{9\times10^{9} * 15\times10^{-9} + 9\times10^{9} * -10\times10^{-9}}{3\times10^{-2}} = 15\times10^{2}$ Volt

$V_b = V_1 + V_2 = \frac{9\times10^{9} * 15\times10^{-9} + 9\times10^{9} * -10\times10^{-9}}{5\times10^{-2}} = 9\times10^{2}$ volt

$\Delta V_{b\to a} = (15-9)\times10^{2} = 6\times10^{2}$ Volt.

[2] Work needed to bring $q_o = 2\mu C$ from a to b ?

$W_{a\to b} = q_o \Delta V_{ba} = 2\times10^{-6} * -6\times10^{2} = -12\times10^{-4}$ J.

[3] Work needed to bring $q_o = 2\mu C$ form a to ∞ ?

$W_{a\to\infty} = q_o \Delta V_{a\to\infty} = 2\times10^{-6} * (\underbrace{\cancel{V_\infty}}_{0} - 15\times10^{2}) = -30\times10^{-4}$ J

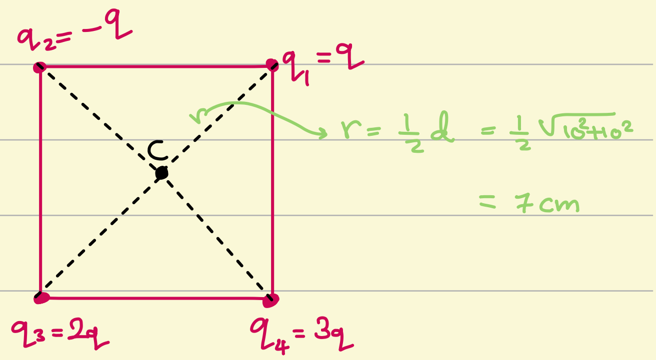
[4] What is the potential at the position of q_1 ?

$V_{at\ q_1} = \frac{Kq_2}{r_{12}} = \frac{9\times10^{9} * -10\times10^{-9}}{6\times10^{-2}} = -15\times10^{2}$ Volt.

(a)

Ex$_2$:- Find the Electrical potential at C?

$q = 7nC$



$$V_c = V_1 + V_2 + V_3 + V_4$$

$$= k\left[\frac{q_1 + q_2 + q_3 + q_4}{r}\right]$$

$$= k\left[\frac{\cancel{q} \cancel{-q} + 3q + 2q}{7\times10^{-2}}\right] = \frac{9\times10^{9} * 5(7\times10^{-9})}{7\times10^{-2}}$$

$$= 45\times10^{2} \text{ Volt}.$$

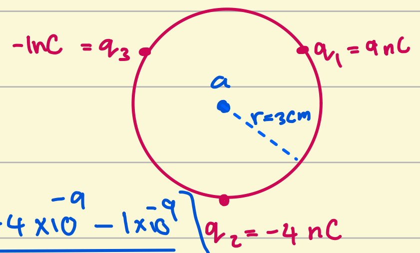
(b) If we want the Work to bring an electron from ∞ to C?

$-1.6\times10^{-19}C$

$$W_{\infty\to C} = q_o \, \Delta V_{\infty\to C} = -1.6\times10^{-19} * (45\times10^{2} - 0)$$

$$= -7.2\times10^{-16} \text{ J}.$$

Ex$_3$:- What is the work needed to bring a proton from ∞ to a?



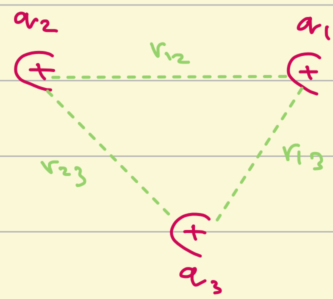
$$W_{\infty\to a} = q_o \, \Delta V_{\infty\to a} = q_o [V_a - \cancel{V_\infty}]$$ 0

$$= 1.6\times10^{-19}\left(k\left[\frac{9\times10^{-9} + -4\times10^{-9} - 1\times10^{-9}}{}\right]\right)$$

$$= 1.6\times10^{-19}\left(9\times10^{9}\left[\frac{1.3\times10^{-7}}{3\times10^{-2}}\right]\right)$$

$$= 1.92\times10^{-21} \text{ J}.$$

*** Energy Stored in q_1?**



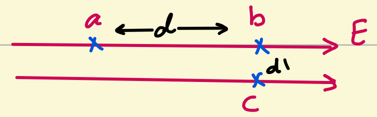
$$U_1 = U_{12} + U_{13}$$

$$= \frac{kq_1q_2}{r_{12}} + \frac{kq_1q_3}{r_{13}}$$

*** Energy Stored in the System?**

$$U_{sys} = U_{12} + U_{13} + U_{23} \rightarrow \frac{kq_2q_3}{r_{23}}.$$

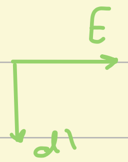
[2] Electric potential due uniform $\vec{E}$:-



$$V_{ba} = \underset{a\to b}{\Delta V} = -E\,d\cos\theta \quad Ed$$

$$= -\vec{E}\cdot\vec{d}$$

$$* \ \underset{b\to c}{\Delta V} = -E\,(d)'\cos 90^\circ$$



$$\underset{b\to c}{\Delta V} = 0$$

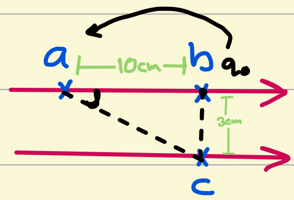
$$V_c - V_b = 0 \longrightarrow \boxed{V_c = V_b}$$

$$* \ \underset{a\to c}{\Delta V} = \underset{a\to b}{\Delta V} + \underbrace{\cancel{\underset{b\to c}{\Delta V}}}_{0}$$

→ If we know V_a → What is V_b?

$$\underset{a\to b}{\Delta V} = \text{number} \rightsquigarrow V_b - V_a = \text{number} \rightsquigarrow V_b = V_a + \text{number}$$

<u>Ex</u> :- A) Find potential difference between a and b? b and c? a and c?



$$\vec{E} = 3000 \ N/C$$

$$\underset{b\to a}{\Delta V} = -E\,d\cos 180$$
$$= -3000 * 10\times10^{-2} * \cos 180$$
$$= 300 \text{ Volt.}$$

,

$$\underset{b\to c}{\Delta V} = -E\,d\cos 90^\circ$$
$$= \text{Zero.}$$

,

$$\underset{a\to c}{\Delta V} = -E\,d\cos\theta$$
$$= -3000 * \cancel{10.4\times10^{-2}} * \frac{-10\times10^{-2}}{\cancel{10.4\times10^{-2}}}$$
$$= 300 \text{ Volt.}$$

B) Find the Work needed to move $q_0 = 2\mu c$ From a → b?

$$\underset{a\to b}{W} = -q_0 \underset{a\to b}{\Delta V} = -2\times10^{-6} * -300 = 6\times10^{-4}\ J.$$

[C] If q_o in part (2) Start from rest $(m = 2\,g)$ what is final speed?

$$\Delta K = W$$

$$\frac{1}{2} m (v_f^2 - v_i^2) = 6\times10^{-4} \longrightarrow \cancel{\frac{1}{2}}(\cancel{2}\times\cancel{10^{-3}})(v_f^2) = 6\times\cancel{10^{-4}}^{\,-1} \longrightarrow v_f = 0.77 \text{ m/s}.$$

[d] Find the work needed to move $q_o = 5\mu C$ from $b \rightarrow a$?

$$W_{b\rightarrow a} = q_o \Delta V_{b\rightarrow a} = 5\times10^{-6} * 300 = 15\times10^{-4}\,J.$$

[E] Find the work needed to move $q_o = 1\mu C$ from a to b?

$$W_{a\rightarrow b} = -q_o \Delta V_{a\rightarrow b} = -1\times10^{-6} * 300 = -3\times10^{-4}\,J.$$

[F] If $V_a = 20$ Volt, what is V_b?

$$\Delta V_{a\rightarrow b} = -300 \text{ Volt} \rightarrow \Delta V_{a\rightarrow b} = V_b - V_a = -300 = V_b - \cancel{20} = -300 = -280 \text{ Volt}.$$
$$\cancel{+20} \quad +20$$

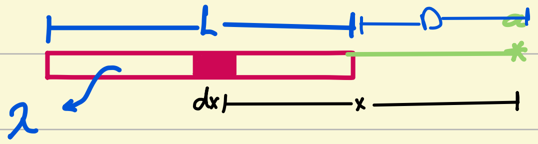
[G] What is the work needed to move q_o from $a \rightarrow a$ along the path $a \rightarrow b \rightarrow c \rightarrow a$?

$$W_{a\rightarrow a} = q_o\left[\Delta V_{a\rightarrow b} + \Delta V_{b\rightarrow c} + \Delta V_{c\rightarrow a}\right] = q_o\left[-300 + 0 + 300\right] = \text{zero}.$$

[3] potential due to distribution of charges?

$$q = \lambda L \;,\; q = \sigma A \;,\; q = \rho V$$

Ex :-



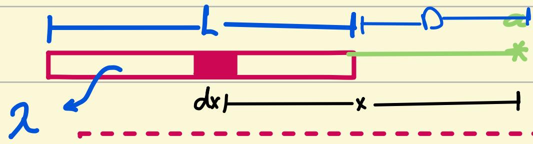
$$V = \frac{kq}{r} = dV = \int \frac{k\,dq}{r} = \int \frac{k\,\lambda\,dL}{x}$$

$$V = k\lambda \int \frac{dx}{x} = V = k\lambda \ln|x| \Big|_{D}^{D+L}$$

• Important Laws :-

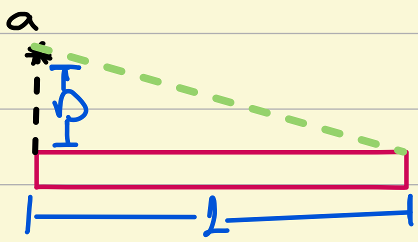
① rods :-

Ⓐ



$$\boxed{V = k\lambda \ln\left(\frac{D+L}{D}\right)}$$

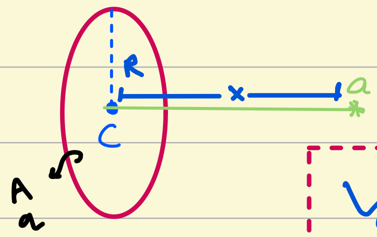
Ⓑ



$$\boxed{V = k\lambda \ln\left[\frac{L + \sqrt{D^2 + L^2}}{D}\right]}$$

② Ring :-

$q = \lambda(2\pi R)$



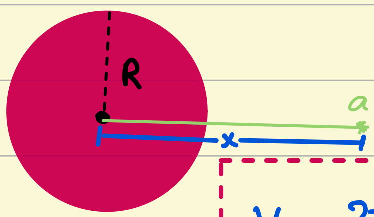
A)

$$\boxed{V_a = \frac{kq}{\sqrt{R^2 + x^2}}}$$

B)

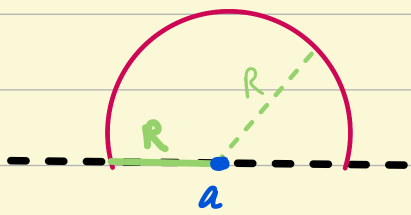
$$\boxed{V_{Center} = \frac{kq}{R}}$$

③ Disk :-



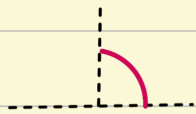
$$\boxed{V_a = 2\pi k\sigma\left[\sqrt{R^2+x^2} - x\right]}$$

④ Simi Circale :-



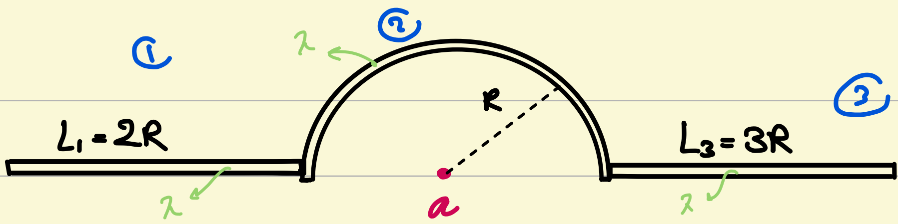
$V = k\lambda\theta$

$\theta \downarrow \pi = 3.14$



$V = k\lambda\theta$

$\theta \downarrow \frac{\pi}{2} = \frac{3.14}{2}$



$$V_a = V_1 + V_2 + V_3 .$$

$$= k\lambda \ln \frac{D+L}{D} + k\lambda\theta + k\lambda \ln \frac{D+L}{D}$$

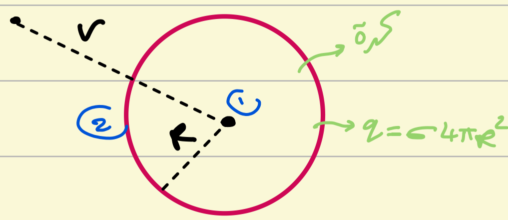
$$= k\lambda \ln\left[\frac{2R+R}{R}\right] + k\lambda\pi + k\lambda \ln\left[\frac{3R+R}{R}\right]$$

$$= k\lambda \ln 3 \quad + k\lambda\pi + k\lambda \ln 4 .$$

5 Conducting sphere :-

1) $r \leq R$:-

$$V_{in} = V_{surface} = \boxed{\frac{kq}{R}}$$

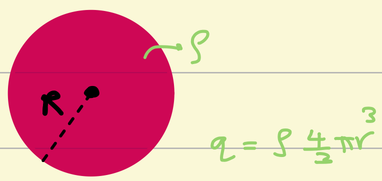


2) $r > R$:-

$$V_{out} = \boxed{\frac{kq}{r}}$$

6 inslating sphere

1) $r < R \rightarrow V_{in} = \boxed{\frac{kq}{2R}\left(3 - \frac{r^2}{R^2}\right).}$



2) $r \geq R \rightarrow V_{out} = \boxed{\frac{kq}{r}}$

* اذا اعطاني السؤال $\vec{E}$ وطلب V ؟

$$\boxed{\Delta V = -\int E_{\hat{i}}\,dx - \int E_{\hat{j}}\,dy - \int E_{\hat{k}}\,dz - \int E\,dr}$$

Ex:- If $E = \frac{4}{r^2}$, find $\underline{V}$ from ∞ to 5 cm ?

$$V = -\int_{\infty}^{5cm} \frac{4}{r^2} = \frac{4}{5\times10^{-2}} - 0 = 80 \text{ volt}.$$

* اذا اعطاني V على شكل معادلة، وطلب $\vec{E}$ ؟

$$\boxed{E = -\hat{i}\frac{dv}{dx} - \hat{j}\frac{dv}{dy} - \hat{k}\frac{dv}{dz} - \hat{r}\frac{dv}{dr}}$$

Ex:- If $V = 2x^2yz^3 + 5xz$, find ?

A) $\vec{E}$ at $(1,2,-1)$

$$\vec{E} = 4xyz^3 + 5z\,dx\,\hat{i} \quad 2x^2z^3dy\,\hat{j} \quad 6x^2yz^2 + 5x\,dz\,\hat{k}$$

$$= 4(1)(2)(-1)^3 + 5(-1)\,\hat{i} \quad 2(1)(-1)^3\,\hat{j} \quad 6(1)^2(2)(-1)^2 + 5(1)\,\hat{k}$$

$$= -13\hat{i} - 2\hat{j} + 17\hat{k}$$

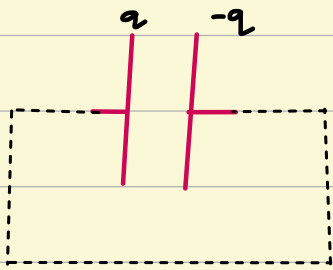
B) magnitude of $\vec{E}$ at $(1,2,-1)$

$$|\vec{E}| = \sqrt{(13)^2 + (2)^2 + (17)^2} = (\ ) \text{ N/C}$$

C) if $q_o = 2\mu C$, find force.

$$\vec{F} = q_o\vec{E} = 2\times10^{-6}(-13\hat{i} - 2\hat{j} - 17\hat{k}).$$

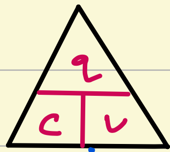
* Chapter 24 :- → Capacitors .



المواسعة الكهربائية

C = capacitance

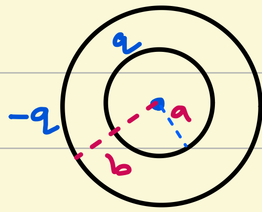
$$C = \frac{q}{\Delta V}$$ ↳ $V_+ - V_-$



farad ≡ $\frac{c}{v}$

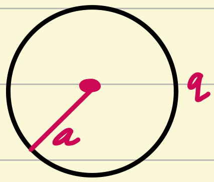
① Spherical Capacitor :-

-+ ← $$\boxed{C = \frac{4\pi\epsilon_0}{\frac{1}{a} - \frac{1}{b}}}$$



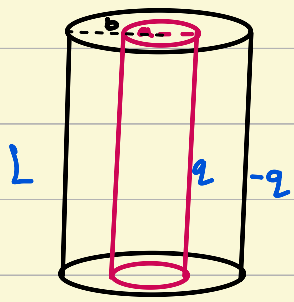
② Sphere :-

$$\boxed{C = 4\pi\epsilon_0 a}$$



③ Cylindrical capacitor :-

$$\boxed{C = \frac{2\pi\epsilon_0 L}{\ln\left(\frac{b}{a}\right)}}$$

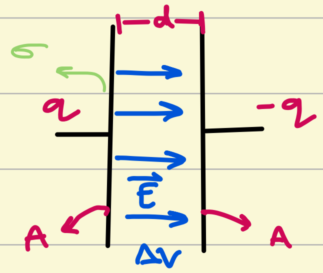


مواسعة ذات لوحين متوازيين

④ Two parallel plates Capacitors:-

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

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

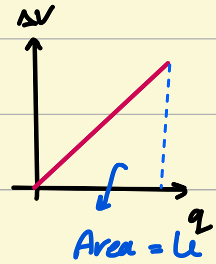


$$\boxed{C = \frac{\sigma}{\epsilon_0}}$$ $\to q = \sigma A$

$$\boxed{\Delta V = Ed}$$

* Energy Stored in Capacitor:-

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



$$W = \Delta U = U_f - U_i$$

$\therefore$ u = Energy density كثافة الطاقة

energy per unit Volume.

$$\boxed{u = \frac{U}{\text{Volume}} = \frac{1}{2} \epsilon_0 E^2}$$

Ex:- two parallel plates Capacitor has a Surface charge density $(\sigma) = 2\times10^{-6}\, C/m^2$ and area of $2\,cm^2$ with Seporation 10cm, Find ?

البعد بين اللوحين

1) Capacitance ? $C = \frac{\epsilon_0 A}{d}$

2) Charge? $q = \sigma A$

3) potential differance accrose the Cap? $C = \frac{q}{\Delta V} \rightarrow \Delta V = \frac{q}{C}$

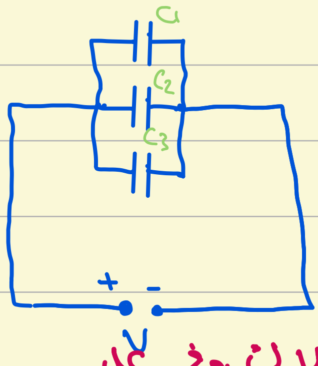
4) Electric field? $\Delta V = dE \rightarrow E = \frac{\Delta V}{d}$

5) Energy stored in Cap? $\frac{1}{2} qV = \frac{1}{2} C V^2$

6) Energy density? $u = \frac{1}{2} \epsilon_0 E^2$.

→ Connection of Capacitors

توازي



• يوجد تفرع في الاسلاك ويكون لكل تفرع مواسعة واحدة فقط والفروع لها نفس البداية والنهاية .

• اللوح الموجب مع الموجب والسالب مع السالب

• الشحنة الكهربائية تتوزع

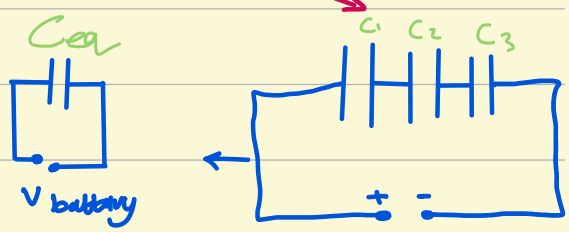
$q_{eq} = q_1 + q_2 + q_3 \cdots$

• الجهد متساوي

$V_{bat} = V_{eq} = V_1 = V_2 = V_3$

$C_{eq} = C_1 + C_2 + C_3 + \cdots$ • السعة مجموعة

توالي



- مافي تفرعات في الاسلاك

* اللوح الموجب متصل مع اللوح السالب

$q_{eq} = q_1 = q_2 = q_3 = \cdots$

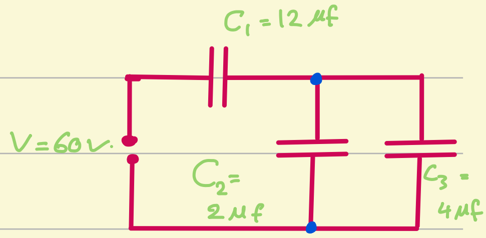
• يتوزع الجهد الكهربائي

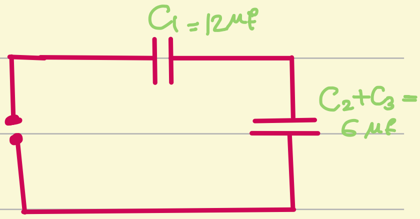
$V_{eq} = V_1 + V_2 + V_3$

• السعة مقلوبة

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

Ex: In the figure shown, Find:





A) C_{eq} ?

$C_{eq_4} = C_2 + C_3$

$= 4\times10^{-6} + 2\times10^{-6} = 6\times10^{-6}\ f.$

$$\frac{1}{C_{eq_5}} = \frac{1}{C_{eq_4}} + \frac{1}{C_1} = \frac{{}^{2}\times 1}{2\times 6\times10^{-6}} + \frac{1}{12\times10^{-6}} = \frac{3}{12\times10^{-6}}$$

$$C_{eq} = \frac{12\times10^{-6}}{3} = 4\ \mu f$$

B) q, v for all Capacitors?

$$C_5 = \frac{q_5}{v_5} = 4\times10^{-6} = \frac{q_5}{60} \rightarrow q_5 = 2.4\times10^{-4}$$

$q_4 = q_5 = q_1 = 2.4\times10^{-4}\ C$

$\frac{q_4}{C_4} = 40$ volt

$\frac{q_1}{C_1} = 20$ volt

$V_2 = V_3 = V_4 = 40$ volt

$q_2 = C_2 V_2 = 80\ \mu C$

$q_3 = C_3 V_3 = 160\ \mu C$

C) Energy stored in C_3? $U_3 = \frac{1}{2} q_3 v_3 = \frac{1}{2}(160\times10^{-6})(40) = 3200\ \mu J.$

Ex: Capacitor has $C_1 = 6\ \mu f$, Connected to voltage of 40 volt. then disconnected from battary, and the Conected to another capacitor $C_2 = 3\ \mu f$ initially Uncharged. Find q and v for C_1 and C_2 after Conected together?

$C_1 = 6\ \mu f$, $V_1 = 40$ volt $\rightarrow q_1 = 240\ \mu C.$

$C_2 = 3\ \mu f$, $V_2 = 0$ $\;\; q_2 = 0$

$\therefore V_1' = \frac{160\ \mu}{6\ \mu} = 26.7\ V$

بعد التوصيل $V_1 = V_2$

$$\frac{q_1'}{\cancel{6\mu}} = \frac{q_2'}{\cancel{3\mu}}$$

$q_1' = 2q_2'$

$\Sigma q = \Sigma q'$

$q_1 + q_2 = q_1' + q_2' = 240_\mu + 0 = q_1' + q_2$

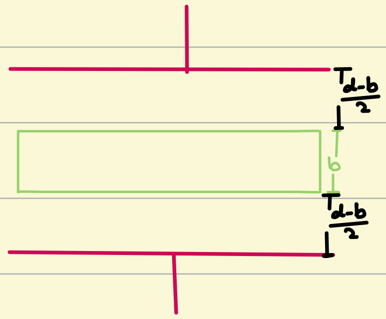
$240_\mu = 2q_2' + q_2'$ $\quad q_2' = 80\ \mu C$

$q_1' = 160\ \mu C.$

→ metalic slap inside $\underline{C}$

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

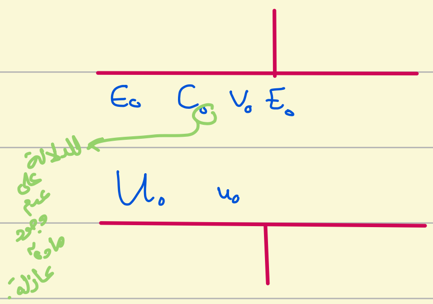
$\Downarrow$



$\rightarrow C = \frac{\epsilon_0 A}{(d-b)}$

→ Insulatic material (Dielectric material)

k:dielectric Constant (k = 1 air)



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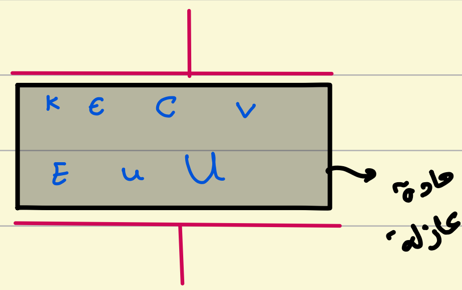
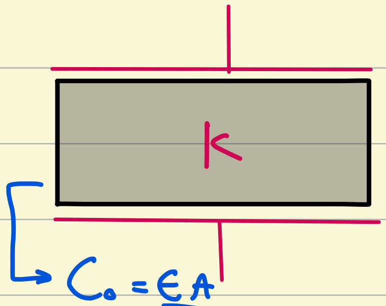


$\epsilon = k\epsilon_0$ $\qquad$ $C = kC_0$

$V = \frac{V_0}{k}$ $\qquad$ $E = \frac{E_0}{k}$ $\qquad$ $U = \frac{U_0}{k}$ $\qquad$ $u = \frac{u_0}{k}$

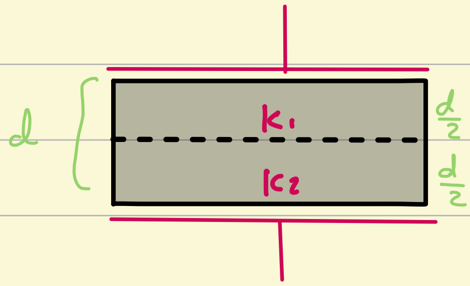
Ex :-



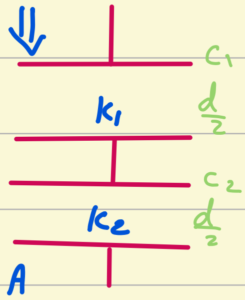
$C_0 = \frac{\epsilon A}{d}$

$\therefore \; C = \frac{k\epsilon_0 A}{d} = kC_0$

Ex



$\Downarrow$



$C_1 = \frac{2k_1\epsilon_0 A}{d}$

$C_2 = \frac{2k_2\epsilon_0 A}{d}$

$\therefore \frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2}$

$\frac{d}{2k_1\epsilon_0 A} + \frac{d}{2k_2\epsilon_0 A}$

$C_{eq} = \frac{2k_1 k_2}{(k_1+k_2)} \underbrace{\frac{\epsilon_0 A}{d}}_{C_0}$

$= \frac{2k_1 k_2}{(k_1+k_2)} C_0$