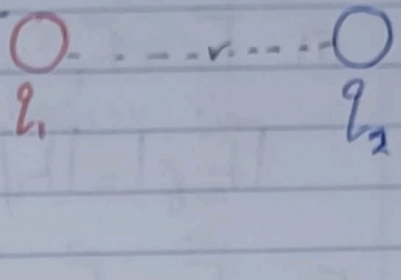
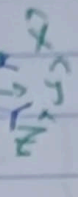
Coulomb's law



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



- K : Constant $\frac{1}{4\pi\epsilon_0}$ ثابتية المادة للتوصيل الكهربائي

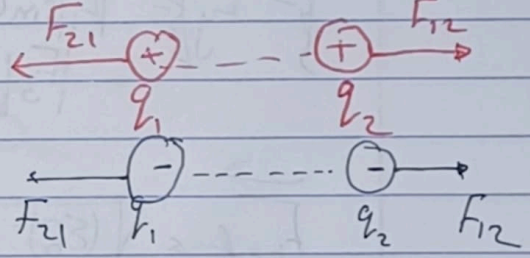
$K = 9 \times 10^9$

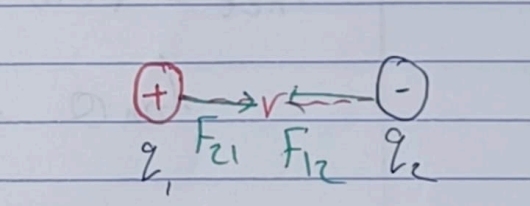
- q_1, q_2 : Magnitude of charges. (C)
- r : distance between Charges. (m)
- $\hat{r}$: متجه وحدة يعبر عن اتجاه $\vec{F}$

1×10^{-2} Centi
1×10^{-3} milli
1×10^{-6} / μ Micro.
1×10^{-9} nano

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

- Direction نفس المقدار عكس الإتجاه بين أي شحنتين $|F_{12}| = |F_{21}|$





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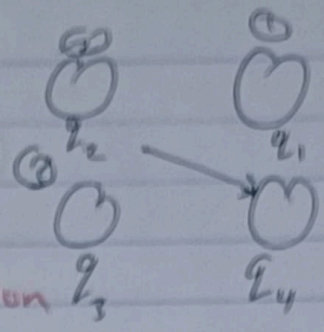
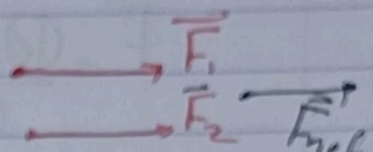
$\vec{F}_{net}$ محصلة



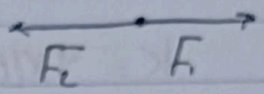
① $\vec{F}_1$, $\vec{F}_2$ in the Same direction

$$|\vec{F}_{net}| = |\vec{F}_1| + |\vec{F}_2|$$



② $\vec{F}_1$, $\vec{F}_2$ in Opposite direction

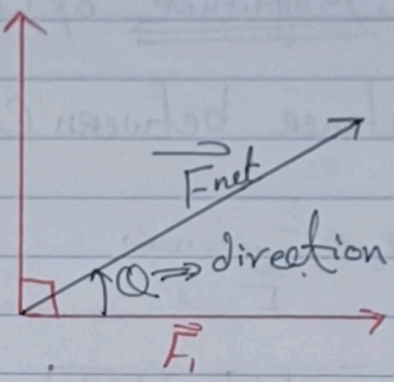
$$|\vec{F}_{net}| = |\vec{F}_{\text{الأكبر}} - \vec{F}_{\text{الأصغر}}| \Rightarrow \text{باتجاه الأكبر}$$



③ $\vec{F}_1 \perp \vec{F}_2$

$$|\vec{F}_{net}| = \sqrt{|F_1|^2 + |F_2|^2}$$

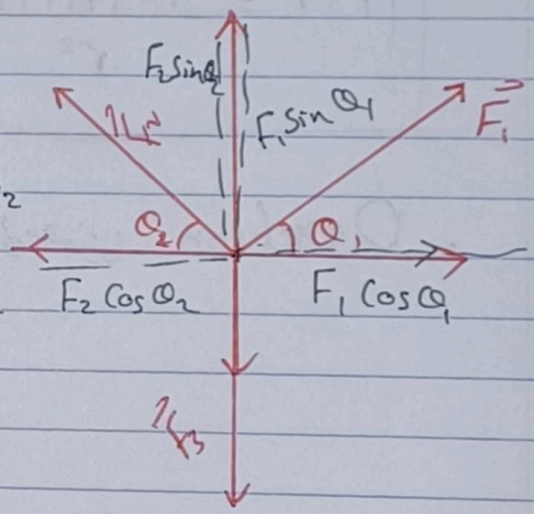
$$\tan\theta = \frac{|F_1|}{|F_2|}$$



④

$$\sum F_x = |F_1|\cos\theta_1 - |F_2|\cos\theta_2$$

$$\sum F_y = |F_1|\sin\theta_1 + |F_2|\sin\theta_2 - |F_3|$$



$$\vec{F}_{net} = \sqrt{(\Sigma F_x)^2 + (\Sigma F_y)^2}$$

$$\tan\theta = \frac{\Sigma F_y}{\Sigma F_x}$$

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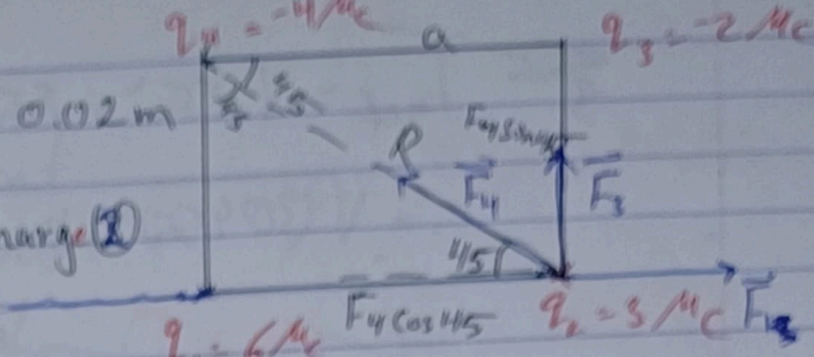
Exp: $a = 2cm = 0.02m$

Find $\vec{F}_{net}$ on charge ②



① $\Sigma F_x = F_1 + -F_4 \cos 45$

$= \frac{Kq_1q_2}{a^2} - \frac{Kq_4q_2}{2a^2} \cos 45$

$= \frac{9\times10^9 \times 6\times10^{-6} \times 3\times10^{-6}}{(0.02)^2} - \frac{9\times10^9 \times 4\times10^{-6} \times 3\times10^{-6}}{2(0.02)^2} \cos 45$

$R = \sqrt{a^2+a^2}$

$= \sqrt{2}\,a^2$

$R^2 = 2a^2$

$= \frac{0.162}{4\times10^{-4}} - \frac{0.108}{8\times10^{-4}} \times \frac{1}{\sqrt{2}}$

$= 405 - 95.45$

$\Sigma F_x = 309.55\ C/m^2$

$\Sigma F_y = F_3 + |F_4| \cos 45$

$= \frac{Kq_3q_2}{a^2} + \frac{Kq_4q_2}{2a^2} \times \sin 45$

$= \frac{9\times10^9 \times 3\times10^{-6} \times 2\times10^{-6}}{(0.02)^2} + 95.45$

$= 135 + 95.45$

$\Sigma F_y = 230.45$

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$$\vec{F}_{net} = \sqrt{\Sigma F_x^2 + \Sigma F_y^2}$$

$$= \sqrt{(309.55)^2 + (230.45)^2}$$

$$\vec{F}_{net} = 385.9 \ C/m^2$$

$$\theta = \tan^{-1}\left(\frac{230.45}{309.55}\right)$$

$$\theta = 36.66^\circ$$

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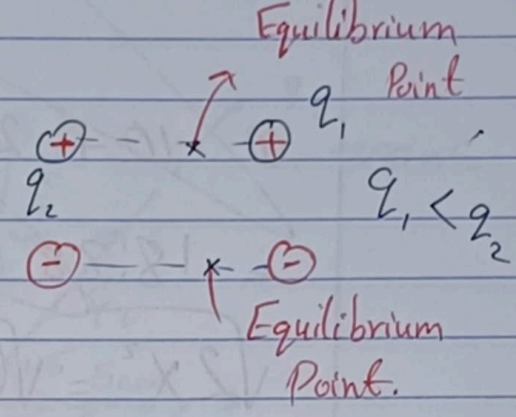
Equilibrium Point نقطة الإتزان

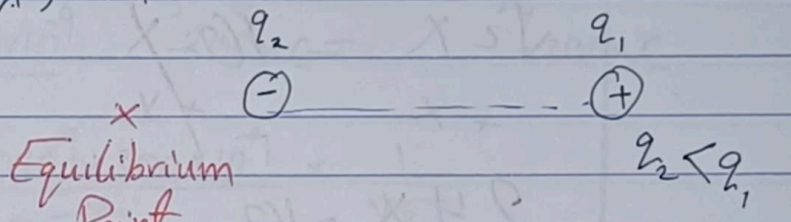
$$\Sigma F_{net} = 0$$

* $\Sigma F_x = 0$, $\Sigma F_y = 0$

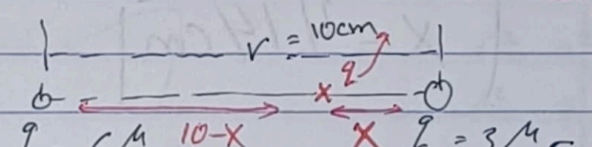
* Location

* نقرب الإشارة بينهما وأقرب ذي الشحنة الصغيرة ⇓ مقدار ⇑ * خارجها وأقرب ذي الشحنة الصغيرة





Exp: Find Equilibrium Point.



Asume

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

$$\frac{k q_1 q}{(10-x)^2} = \frac{k q_2 q}{x^2}$$

$$\frac{q_1}{(10-x)^2} = \frac{q_2}{x^2} \longrightarrow \frac{6\times10^{-6}}{(10-x)^2} = \frac{3\times10^{-6}}{x^2}$$

$$2x^2 = 100 - 20x + x^2$$

$$-100 + 20x - x^2$$

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$$X^2 + 20X - 100 = 0$$

$$(\quad)(\quad)$$

$$\frac{-20 \pm \sqrt{400 - 4 \times 1 \times -100}}{2 \times 1}$$

$$= -10 \pm \sqrt{800}$$

① $-10 + 28.28$ or ② $-10 - 28.28$

$= 18.28$

$$\sqrt{2X^2} = \sqrt{(10-X)^2}$$

$$\sqrt{2}X = 10 - X$$

$+X \qquad +X$

$$2.4X = 10$$

$$\boxed{X = 4.14\,cm}$$

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Quantized Charge

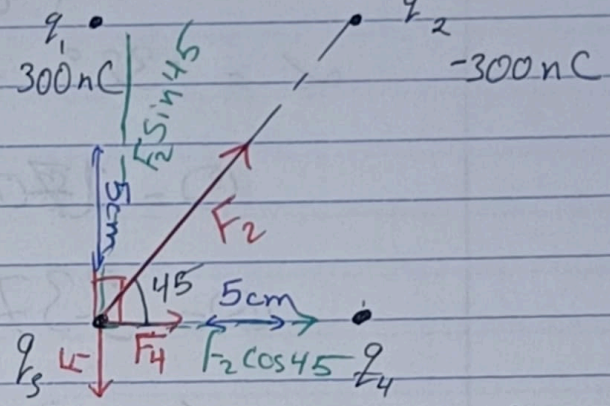
$$q = \pm n e$$

$n = 1, 2, 3, \ldots$

e ← electric charge

electrons.

Problem 3



A. $\Sigma F_x = F_4 + F_2 \cos 45$

$$= \frac{K q_4 q_3}{r^2} + \frac{K q_2 q_3}{r^2} \cos 45$$

$$= \frac{9 \times 10^{9} \times 200 \times 10^{-9} \times 200 \times 10^{-9}}{(0.05)^2} + \frac{9 \times 10^{9} \times 200 \times 10^{-9} \times 300 \times 10^{-9}}{2 \times (0.05)^2} \times \frac{1}{\sqrt{2}}$$

$= 0.144 + 0.076$

$= 0.22\ N \quad x+$

$r^2 = a^2 + a^2$

$r^2 = 2a^2$

$$\Sigma F_y = F_2 \sin 45 - F_1$$

$$= \frac{K q_2 q_3}{r^2} \sin 45 - \frac{K q_1 q_3}{r^2}$$

$$= 0.076 - \frac{9 \times 10^{9} \times 300 \times 10^{-9} \times 200 \times 10^{-9}}{(0.05)^2}$$

$= 0.076 - 0.216$

$\Sigma F_y = -0.14 \quad y-$

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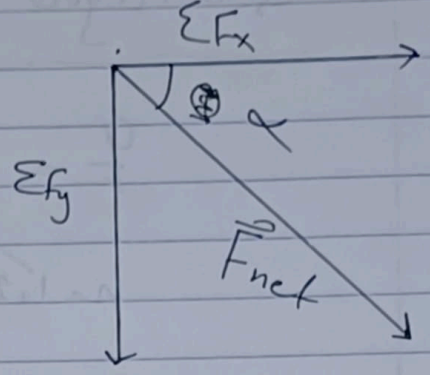
$$|\vec{F}_{net}| = \sqrt{\Sigma F_x^2 + \Sigma F_y^2}$$

$$= \sqrt{(0.22)^2 + (0.14)^2}$$

$$\vec{F}_{net} = 0.26\ N$$



$$\alpha = \tan^{-1}\left(\frac{\Sigma F_y}{\Sigma F_x}\right)$$

$$= \tan^{-1}\left(\frac{-0.14}{0.22}\right)$$

$\alpha = -32^\circ = 32$ Clockwise.

$\theta = 270 + (90 - 32)$

$\theta = 337.5^\circ$ with x^+ Counter clockwise

$\alpha = 32^\circ$ clockwise with $x+$.

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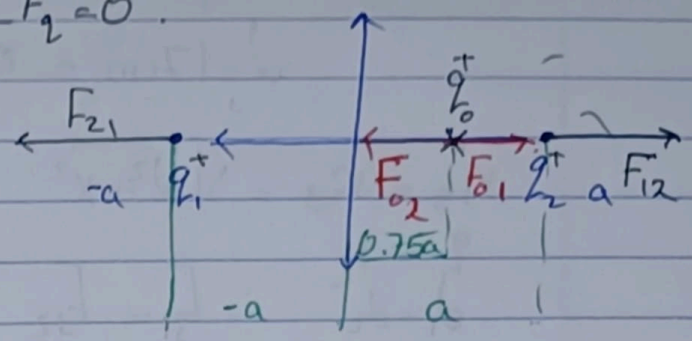
Problem $\frac{6}{5}$

$\Sigma F_2 = 0$.



a) $F_{o1} = F_{o2}$

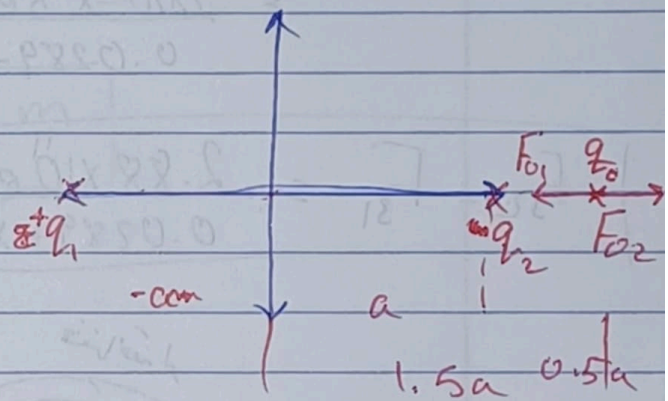
$$\frac{K q_o q_1}{(1.75a)^2} = \frac{K q_o q_2}{(0.25a)^2}$$

$$\frac{K q_o q_1}{3.0625a^2} = \frac{K q_o q_2}{0.0625a^2}$$

$$\frac{0.0625}{0.0625}\frac{q_1}{q_2} = \frac{3.0625}{0.0625}\frac{q_2}{q_2}$$

$$\boxed{q_1/q_2 = 49}$$

(b)



$F_{o_1} = F_{o2}$

$$\frac{K q_o q_1}{(2.5a)^2} = \frac{K q_o q_2}{(0.5a)^2}$$

$$\frac{K q_o q_1}{6.25a^2} = \frac{K q_o q_2}{0.25a^2}$$

$0.25 q_1 = 6.25\, q_2$

$$\boxed{\frac{q_1}{q_2} = -25}$$

Must $\frac{q_1}{q_2}$ = - Negative due to E.q points outside

$q_1/q_2 = -25$

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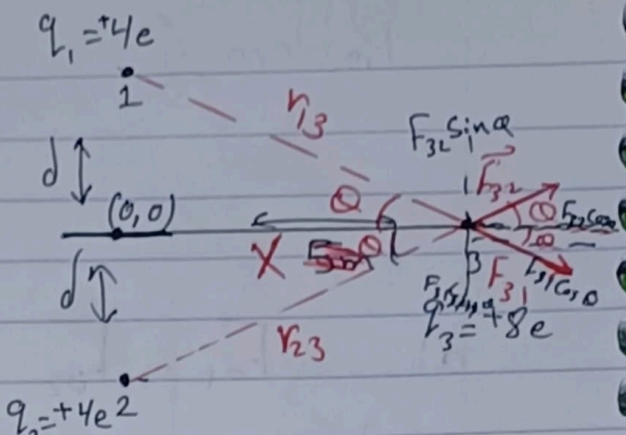
Problem 31 (Min , Max)

$d = 17cm = 0.17m$



$r_{13} = r_{23} = \sqrt{d^2 + x^2}$

$q_1 = q_2$

$d_1 = d_2 \quad \therefore F_{31} = F_{32}$

$r^2 = (0.17)^2 + x^2$

$r^2 = 0.0289 + x^2$ ——— (1)

$\cos\theta = \frac{x}{r_{23}}$

$= \frac{x}{\sqrt{0.0289 + x^2}}$

~~$F_{31} = F_{32}$~~

~~$Kq_3q_1 = Kq_3q_1$~~

$F_{31} = F_{32} = \frac{Kq_3q_1}{(0.0289 + x^2)}$

$= \frac{9\times10^9 \times 8e \times 4e}{0.0289 + x^2}$

$\boxed{F_{32} = F_{31} = \frac{2.88\times10^{11}e^2}{0.0289 + x^2}}$

$\Sigma F_{8x} = \cos\theta\,(F_{31} + F_{32})$

$= \cos\theta \times 2F_{31}$

~~$= 5.76\,F_{31}$~~

$= \frac{5.76\times10^{11}e^2}{(0.0289 + x^2)} = \Sigma F_{3x}$

$\Sigma F_{3x} = \frac{5.76\times10^{11}e^2 \times x}{(\sqrt{0.0289 + x^2})(0.0289 + x^2)}$ $\cos\theta$

$\Sigma F_{3x} = \frac{5.76\times10^{11}e^2\,x}{(0.0289 + x^2)^{\frac{3}{2}}}$

$\Sigma F_y = F_{32}\sin\theta - F_{31}\sin\theta$ (تتغير العقد)

$\Sigma F_y = 0$

$\therefore \Sigma F_3 = \Sigma F_{3x} = \frac{5.76\times10^{11}e^2\,x}{(0.0289 + x^2)^{\frac{3}{2}}}$

$\Sigma F_3 = 0$

Must

For Calculate Min , Max.

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$$\sum F_3' = \frac{(0.0289+x^2)^{\frac{3}{2}} \times (5.76\times10^{11}e^2) - 5.76\times10^{11}e^2 \times \left(\frac{3}{2}\times(0.0289+x^2)^{\frac{1}{2}}\times 2x\right)}{(0.0289+x^2)^3}$$

Numerator = 0.

$$(0.0289)^{\frac{3}{2}}(5.76\times10^{11}e^2)$$

$$\frac{(0.0289+x^2)^{\frac{3}{2}} \times 5.76\times10^{11}e^2}{(0.0289+x^2)^{\frac{1}{2}}} = +\left(5.76\times10^{11}e^2 \times 3x\right)$$

$$0.0289 + x^2 = +3x^2$$

$$-x^2 \quad -x^2$$

$$\frac{2x^2}{2} = \frac{0.0289}{2}$$

$$x^2 = 0.01445$$

$$\boxed{x = 0.12\ m}$$

F_{3Min} at $x=0$ $= 0$

$$F_{3Max}(0.12m) = \frac{5.76\times10^{11}\times(1.6\times10^{-19})^2 \times 0.12}{(0.0289+0.01445)^{\frac{3}{2}}}$$

$$= \frac{1.769\times10^{-27}}{9.025\times10^{-3}} = 1.96\times10^{-25}\ N\ x+$$

$\theta = 0°$.

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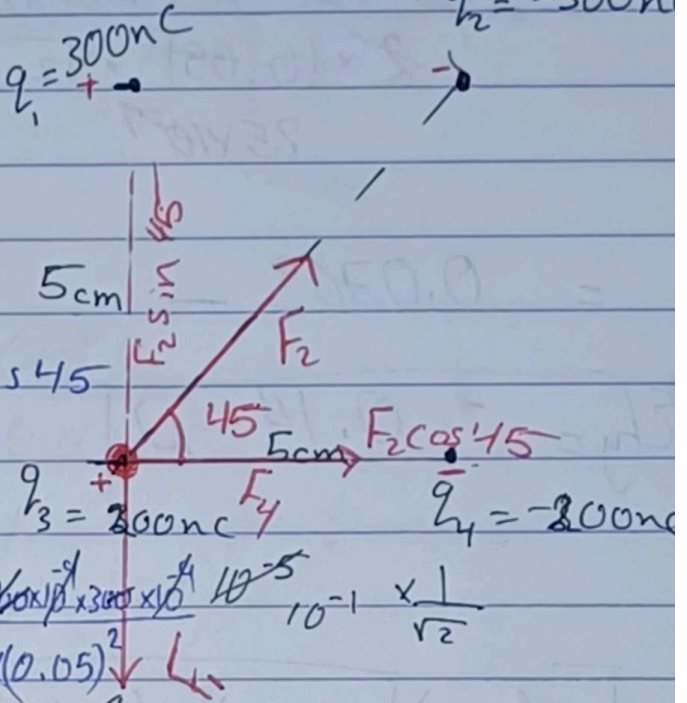
Chapter 1

Problem 3

$r^2 = a^2 + a^2$
$= 2a^2$

$r = \sqrt{25+25}$
$= \sqrt{50}$

$\Sigma F_x =$



$F_4 + F_2 \cos 45$

$= \frac{K q_3 q_4}{r^2} + \frac{K q_3 q_2}{r^2} \cos 45$

$= \frac{9\times10^9 \times 200\times10^{-9} \times 200\times10^{-9}}{(0.05)^2} + \frac{9\times10^9 \times 300\times10^{-9} \times 200\times10^{-9}}{2\times(0.05)^2} \times \frac{1}{\sqrt{2}}$

$= \frac{0.324}{25\times10^{-4}} + \frac{0.162}{25\times10^{-4}} \times \frac{1}{\sqrt{2}}$

$= 0.144 + 0.108 \times \frac{1}{\sqrt{2}}$

$\boxed{\Sigma F_x = 0.22\ N}$

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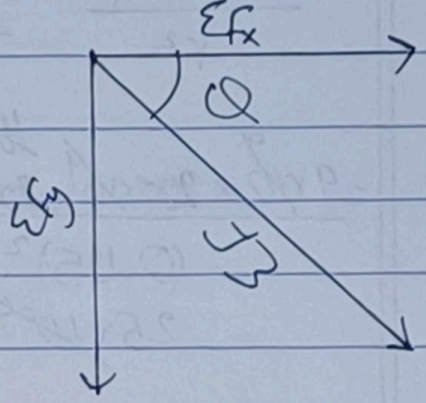
$$\Sigma F_y = F_2 \cos 45 - F_1$$

$$= \frac{K q_3 q_2}{r^2} \times \frac{1}{\sqrt{2}} - \frac{K q_3 q_1}{r^2}$$

$$= \frac{9\times10^{9} \times 200\times10^{-9} \times 300\times10^{-9}}{2 \times (0.05)^2 \times \sqrt{2}} - \frac{9\times10^{9} \times 200\times10^{-9} \times 300\times10^{-9}}{25\times10^{-4}}$$

$$= 0.0763 - 0.216$$

$$\boxed{\Sigma F_y = -0.14\ N}$$



$$F_{net} = \sqrt{(0.22)^2 + (0.14)^2}$$

$$\boxed{F_{net} = 0.26\ N}$$

$$\theta = \tan^{-1}\left(\frac{0.14}{0.22}\right)$$

$$\boxed{\theta = 32.47 \text{ clockwise } X+}$$

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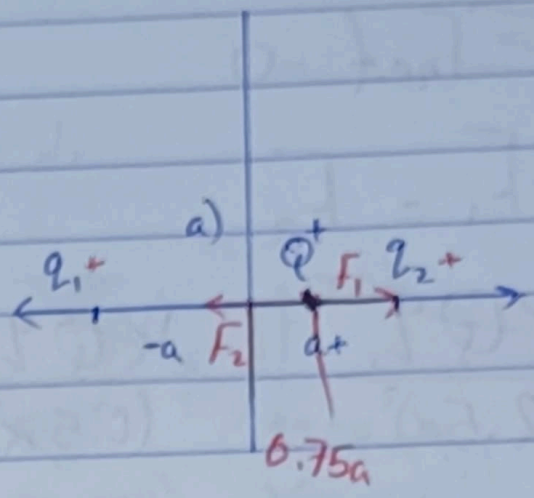
Problem 6

a)

$$\sum_{Q} F_{net} = 0$$



$$\therefore F_1 = F_2$$

$$\frac{KQq_1}{(1.75a)^2} = \frac{KQq_2}{(0.25a)^2}$$

$$(0.25)^2 a^2 \frac{q_1}{q_2} = \frac{q_2}{q_2}(1.75)^2 a^2$$

$$q_1/q_2 = \left(\frac{1.75}{0.25}\right)^2 = +49$$

$$\boxed{q_1/q_2 = 49}$$

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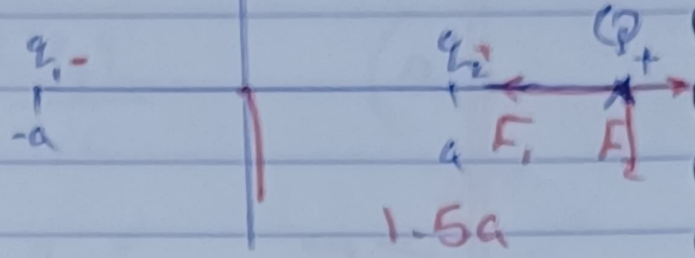
b) q_1/q_2 Must be Negative

$\Sigma F_{net} = 0$

$F_1 = F_2$



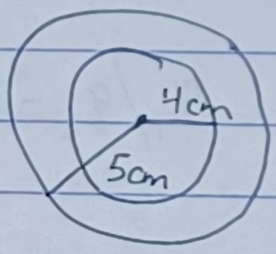
$$\frac{KQq_1}{(2.5a)^2} = \frac{KQq_2}{(0.5a)^2}$$

$$q_1/q_2 = \left(\frac{2.5}{0.5}\right)^2 = 25$$

$$q_1/q_2 = -25$$

Problem 13

$\rho = b/r$ non uniform $b = 3 \times 10^{-6} C/m^2$



$$\rho = \frac{b}{r}$$

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

$$dq = \rho\, dV$$

$$q_{tot} = \int_4^5 \frac{b}{r}\, dV$$

$$= \int_4^5 \frac{b}{r} \times \frac{4}{3}\pi r^3\, dr$$

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$$q_{tot} = \int_{0.04}^{0.05} 4\pi r^2 dr \times \frac{b}{r}$$

$$q_{tot} = 4\pi b \int_{0.04}^{0.05} r\, dr$$

$$= 4\pi \times 3\times10^{-6} \times \left(\frac{r^2}{2}\right)\Big|_{0.04}^{0.05}$$

$$= 4\pi \times 3\times10^{-6} \times \left(\frac{(0.05)^2}{2} - \frac{(0.04)^2}{2}\right)$$

$$= \frac{2}{4}\pi \times 3\times10^{-6} \times \frac{25\times10^{-4} - 16\times10^{-4}}{2}$$

$$= \pi \times 6\times10^{-6} \times 9\times10^{-4}$$

$$\boxed{q_{tot} = 1.69\times10^{-8}}$$

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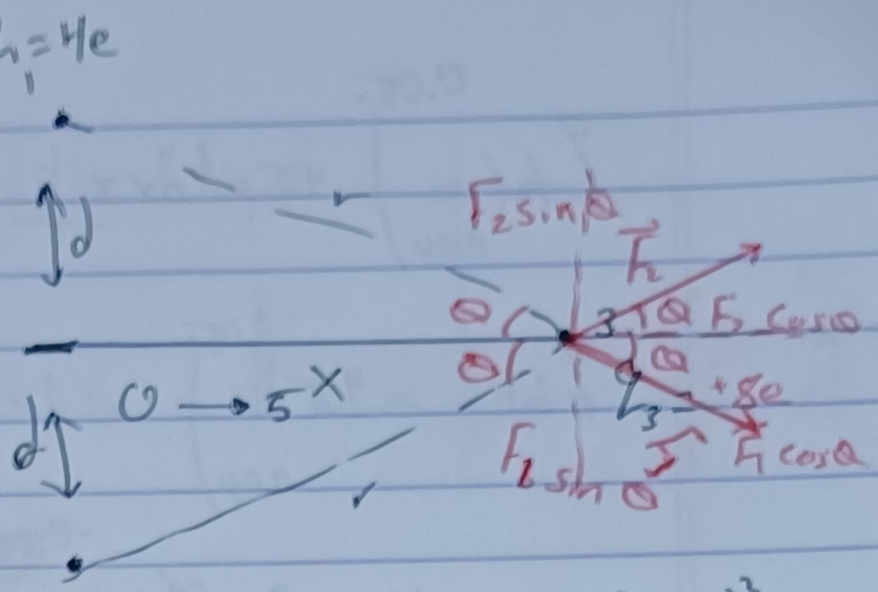
Problem 31

$d = 17\,cm$

$= 0.017\,cm$



$F_2 = F_1$

$r_1 = r_2$

$d_1 = d_2$

$q_1 = q_2$

$r^2 = x^2 + d^2$

$r = \sqrt{x^2 + d^2}$

$r^3 = (x^2 + d^2)^{\frac{3}{2}}$

$\cos\theta = \frac{x}{r}$

$$\sum F_y = 0$$

$$\sum F_x = F_{3net} = 2F\cos\theta$$

$$= 2 \times \frac{K q_2 q_3}{r^2} \times \frac{x}{r}$$

$$= \frac{2Kqe \times 8e}{(x^2 + d^2)^{\frac{3}{2}}} \times x$$

Minimum at $x = 0$

Maximum at $F_3' = 0$

$$F_3' = \frac{(x^2+d^2)^{\frac{3}{2}} \times 64e^2K - \left(64e^2Kx \times \frac{3}{2} \times (x^2+d^2)^{\frac{1}{2}} \times 2x\right)}{(x^2 + d^2)^3}$$

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$F_{(3)} = 0$ Numerator $= 0$

$(x^2 + d^2)^{\frac{3}{2}} \times 64kQ^2 = 64kQ^2x \times \frac{3}{2}(x^2+d^2)^{\frac{1}{2}} \times 2x$

$x^2 + d^2 = 3x^2$

$-x^2 \quad -x^2$

$2x^2 = d^2$

$x = \sqrt{\frac{d^2}{2}}$

$= \sqrt{\frac{(0.17)^2}{2}}$

$x = \sqrt{0.01445}$

$\boxed{x = 0.12\ m}$

$F_{3\,Minimum}$ at $x = 0 \quad = 0$

$r^3 = (x^2+d^2)^{\frac{3}{2}}$

$= \sqrt{((0.12)^2 + (0.17)^2)^3}$

F_3 Maximum at $x = 0.12$

$F_{3\,Max} = \frac{64 \times 10^9 \times 9 \times (1.6 \times 10^{-19})^2 \times 0.12}{9.01 \times 10^{-3}}$

$\boxed{F_{3\,Max} = 1.963 \times 10^{-25}\ N}$

$\theta = \tan^{-1}\left(\frac{F_y}{F_x}\right)$

$= \tan^{-1}(0)$

$\theta = 0^\circ \quad x^+$

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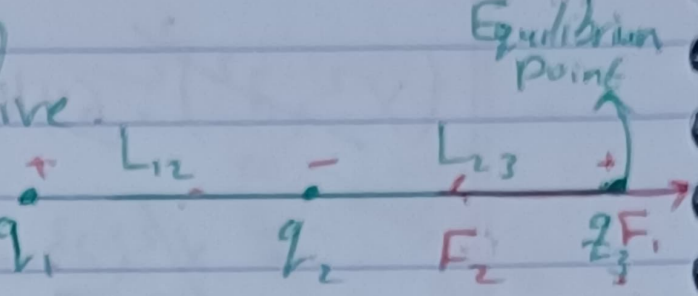
Problem 35

q_1/q_2 Must be Negative.

$2L_{23} = L_{12}$



$r_{13} = L_{12} + L_{23}$

$= 2L_{23} + L_{23}$

$= 3L_{23}$

$$F_1 = F_2$$

$$\frac{Kq_1q_3}{r^2} = \frac{Kq_2q_3}{r^2}$$

$$\frac{Kq_1q_3}{(3L_{23})^2} = \frac{Kq_2q_3}{(1L_{23})^2}$$

$$qq_{r_2} = q_{r_1}$$

$$\frac{q_1}{q_2} = -9$$

$q_1 = +$, $q_2 = -$

OR

$q_1 -$, $q_2 -$

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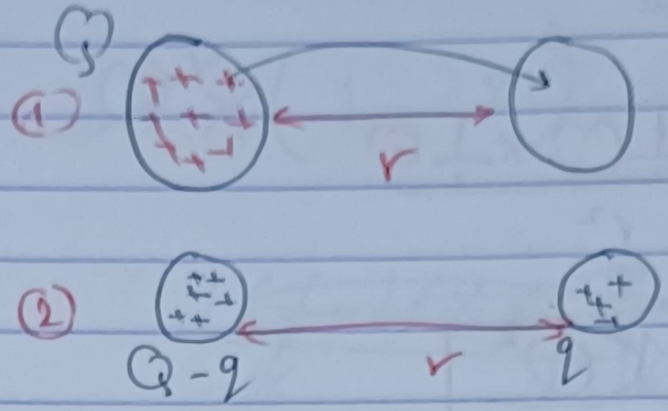
Problem 37



$\frac{q}{Q}$ maximized F

$$F = \frac{K(Q-q)\cdot q}{r^2} = \frac{KQq - q^2}{r^2}$$

Maximum $\frac{dF}{dq} = 0$ ← F′ derivative

$$\frac{dF}{dq} = \frac{K}{r^2} \times (Q - 2q)$$

$$\frac{dF}{dq} = 0$$

$$\frac{K}{r^2} \times (Q - 2q) = 0$$

$$Q - 2q = 0$$

$$Q = 2q$$

$$q = \frac{1}{2}Q \Rightarrow \text{For Maximum F}$$

$$F_{max} = \frac{K\left(Q - \frac{1}{2}Q\right)\frac{1}{2}Q}{r^2}$$

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$$F_{max} = \frac{kq_1q_2}{r^2}$$

$$= \frac{k \frac{1}{2}Q \times \frac{1}{2}Q}{r^2}$$

$$\boxed{F_{max} = \frac{kQ^2}{4r^2}}$$

q/Q larger smaller

$$F_{new} = 0.75 F_{max}$$

$$\frac{k(Q-q)q}{r^2} = 0.75 \times \frac{kQ^2}{4r}$$

$$\frac{k(Q-q)q}{r^2} = \frac{3kQ^2}{16r^2}$$

$$(Q-q)q = \frac{3Q^2}{16}$$

$$x = \frac{q}{Q} \qquad q = Qx$$

$$(Q - Qx)Q = \frac{3Q^2}{16}$$

$$(Q - Qx) \cdot Qx = \frac{3Q^2}{16}$$

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$$CQ^2x - CQ^2x^2 = \frac{3CQ^2}{16}$$

$$CQ^2x(1 - x) = \frac{3CQ^2}{16}$$

$$16 - 16x = 3$$

$$-16 \qquad -16$$

$$16x = -13$$

$$x - x^2 = \frac{3}{16} \implies \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$x^2 - x + \frac{3}{16} = 0$$

$$-1 \pm \sqrt{(1)^2 - 4 \times 1 \times \frac{3}{16}}$$

$$16x - 16x^2 = 3$$

$$16x^2 - 16x + 3 = 0$$

$$\frac{\pm 16 \pm \sqrt{(-16)^2 - 4 \times 16 \times 3}}{2 \times 16}$$

$$= \frac{16 + \sqrt{256 - 192}}{32} \text{ or } \frac{16 - \sqrt{256 - 192}}{32}$$

$$= x = \frac{24}{32} \text{ or } x = \frac{8}{32}$$

$$x = \frac{3}{4} \qquad x = \frac{1}{4}$$

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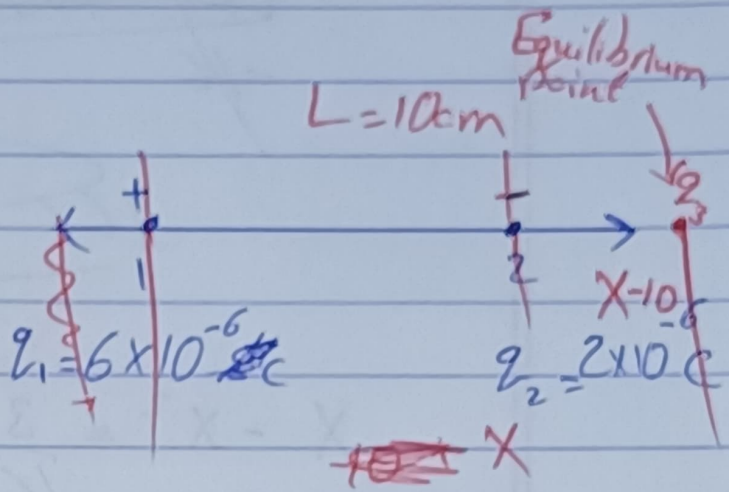
a) $q/Q \longrightarrow F_{max} = \frac{1}{2}$

b) $q/Q \longrightarrow$ Smaller $F = 0.75F_{max} = \frac{1}{4}$

$q/Q \longrightarrow$ Larger $F = 0.25F_{max} = \frac{3}{4}$

Problem 5



$F_{13} = F_{23}$

$$\frac{K q_1 q_3}{r^2} = \frac{K q_2 q_3}{r^2}$$

$$\frac{K q_1 q_3}{x^2} = \frac{K q_2 q_3}{(x-10)^2}$$

$$\frac{3 \times 10^{-6}}{x^2} = \frac{2 \times 10^{-6}}{(x-10)^2}$$

$$\sqrt{x^2} = \sqrt{3(x-10)^2}$$

$$x = \sqrt{3}(x-10)$$

$$x = \sqrt{3}x - 10\sqrt{3}$$

$$-\sqrt{3}x \quad -\sqrt{3}x$$

$$-0.732x = -10\sqrt{3}$$

$$-0.732 \quad -0.732$$

$$x = 17.32$$

$x = 23.6$cm

$y = 0$

$\boxed{x = 23.66\text{m}}$

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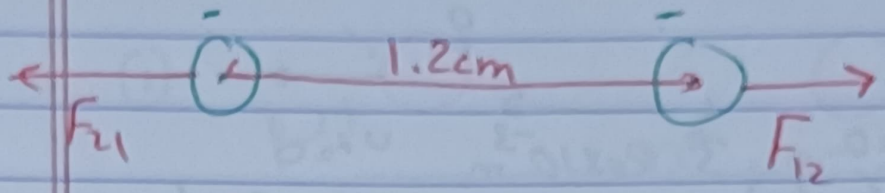
Problem 18 $q = 1 \times 10^{-16} C$



$$F_{12} = F_{21} = \frac{K q_1 q_2}{r^2}$$

$$= \frac{9 \times 10^{9} \times 1 \times 10^{-16} \times 10^{-16}}{(1.2)^2 \times 10^{-2}} = \frac{10^{-19}}{1.44}$$

$$F = 6.25 \times 10^{-19} \text{ N}$$

$$q = ne$$

$$n = \frac{q}{e} = \frac{1 \times 10^{-16}}{1.6 \times 10^{-19}}$$

$$n = 625.$$

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Problem 22

$m = 6.3 \times 10^{-7}$

~~$F = ma$~~

~~$K F_1 = F_2$~~ $F_1 = F_2$

~~$\frac{K q q}{r^2} =$~~

$F_1 = m_1 a_1$

$= 6.3 \times 10^{-7} \times 6$

$= 3.78 \times 10^{-6}$ west

$F_2 = 3.78 \times 10^{-6}$ east

$F_2 = m_2 a_2$

$\frac{3.78 \times 10^{-6}}{q} = \frac{m_2 \times q}{q}$

$m_2 = 4.2 \times 10^{-7}$ kg

$F = \frac{K q^2}{r^2}$

$3.78 \times 10^{-6} = \frac{9 \times 10^9 \, q^2}{(3.2 \times 10^{-3})^2}$

$q = 6.558 \times 10^{-11}$ C

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Problem 30

(1)

$$p^+ \longrightarrow n^0 + e^- + \nu_e$$

Positron ←

← Neutrino

$$n^0 \longrightarrow p^+ + e^- + \bar{\nu}_e$$

- When Proton transformed to neutron electron and Positron Produced
- When Neutron transformed to Proton electron ~~and p~~ is produced.

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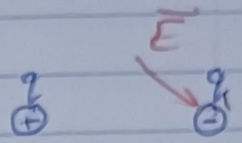
Electric Field

Electric field for pointed charges.

$$\vec{E} = \frac{\vec{F}}{|q_1|} \quad , \quad F = \frac{K q q_1}{r^2}$$

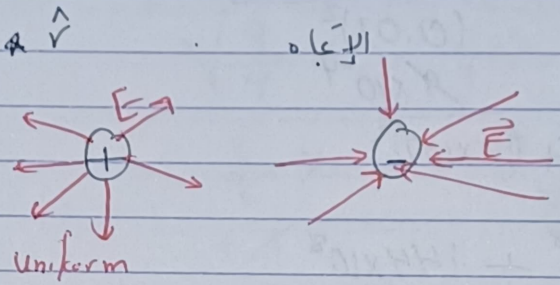
$|q_1|$ الشحنة التي اريد أحسب عليها المجال الكهربائي



$$\vec{E} = \frac{K q q_1}{r^2 q_1}$$

الشحنة المسببة للمجال.

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



* Equilibrium point

$$\sum F_{net} = 0 \longrightarrow \sum E_{net} = 0$$

$$|\vec{E}_1| = |\vec{E}_2|$$

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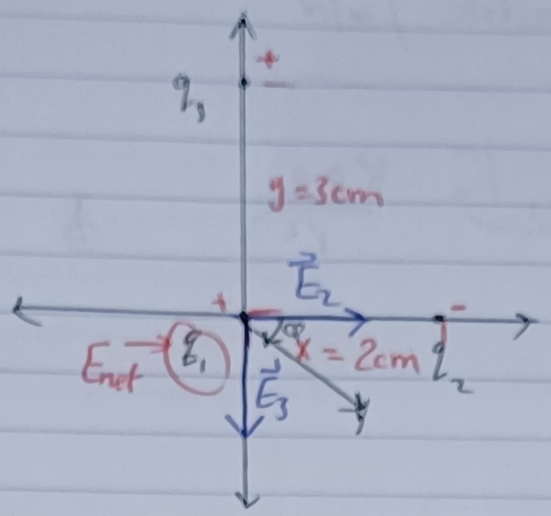
Exp: $q_1 = 1nc$, $q_2 = -4nc$, $q_3 = 12nc$



$$\vec{E}_2 = \frac{Kq_2}{x^2} = \frac{9\times10^9 \times 4\times10^{-4}}{(0.02)^2} = 9\times10^4 \ N/C$$

$$\vec{E}_3 = \frac{Kq_3}{y^2} = \frac{9\times10^9 \times 12\times10^{-4}}{(0.03)^2} = 12\times10^4 \ N/C$$

$$E_{net} = \sqrt{(9\times10^4)^2 + (12\times10^4)^2}$$

$$= \sqrt{81\times10^8 + 144\times10^8}$$

$$= \sqrt{225\times10^8}$$

$$\vec{E}_{net} = 15\times10^4 \ N/C$$

$$\therefore \theta = \tan^{-1}\left(\frac{E_3}{E_2}\right)$$

$$\theta = \tan^{-1}\left(\frac{12\times10^4}{9\times10^4}\right)$$

$\theta = 53^\circ$ Clockwise. X^+

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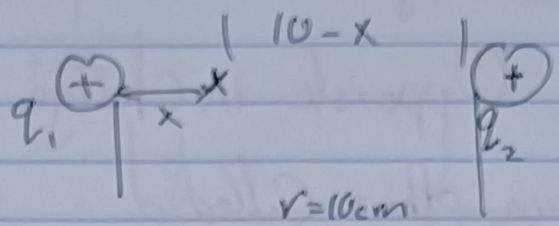
Exp: $q_1 = 4\mu c$ $q_2 = 9\mu c$



$E_{net} = 0$

$$E_1 = E_2$$

$$\frac{K q_1}{x^2} = \frac{K q_2}{(10-x)^2}$$

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

$$\sqrt{\frac{9}{4}x^2} = \sqrt{(10-x)^2}$$

$$\frac{3}{2}x = 10 - x$$

$$+x \qquad +x$$

$$\frac{5}{2}x = 10$$

$$5x = 20$$

$$\boxed{x = 4\,cm}$$

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Electrical dipole:

Two charges have the Same Magnitude But Opposite in charge have a distance Between others Called d

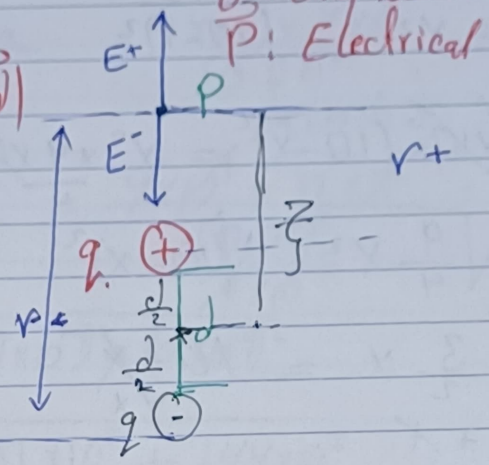
(+) ---d--- (-)

* Electrical dipole moment ($\vec{P}$)

$\vec{P} = q\vec{d}$ $\vec{d}$: displacement

$|\vec{P}| = q|\vec{d}|$ $\vec{P}$: Electrical dipole = from + ⟶ -

باتجاه الإزاحة



$E_{net} = |E^+| - |E^-|$

$E_{net} = \frac{Kq_+}{(r_+)^2} - \frac{Kq_-}{(r_-)^2}$

نكتب المجال الكهربائي بدالة P دايبول عوضت

$|\vec{P}| = q|\vec{d}|$

$r_+ = z - \frac{d}{2}$

$E_{dipole} = Kq\left(\frac{1}{(z-\frac{d}{2})^2} - \frac{1}{(z+\frac{d}{2})^2}\right)$ $r_- = z + \frac{d}{2}$

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

$$E_{dipole} = \frac{q}{2\pi\varepsilon_0 r^3} * \frac{d}{\left(1-\left(\frac{d}{2r}\right)^2\right)^2}$$

$$\vec{P} = q\vec{d}$$

$$E_{dipole} = \frac{P}{2\pi\varepsilon_0 r^3 \left(\left(1-\left(\frac{d}{2r}\right)^2\right)^2\right)}$$

Special Case

Assume

$$\left(1-\left(\frac{d}{2r}\right)^2\right)^2 \approx 1$$

$$\frac{d}{2r} << 1$$

$$\Downarrow$$

$$d << 2r$$

$$\therefore \boxed{E_{dipole} = \frac{P}{2\pi\varepsilon_0 r^3}}$$

Special Case.

$$r_- = r_+ + d$$

$$\left(r + \frac{d}{2}\right) = r - \frac{d}{2} + d$$

$$+\frac{d}{2} \qquad + \frac{d}{2}$$

$$r + d = r + d.$$

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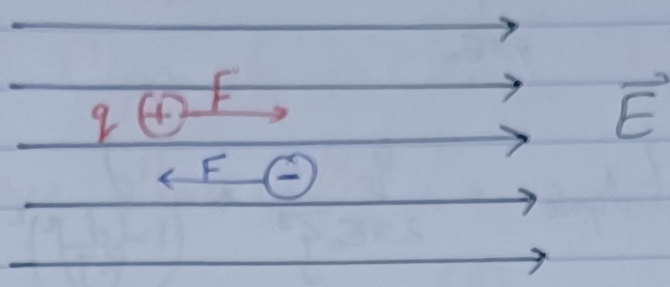
* Point Charge inferior External, Electric Field. (Uniform)

Uniform Electric Field



$$|\vec{F}| = q|\vec{E}| \longleftarrow \vec{E} = \frac{\vec{F}}{q}$$

$$v_f = v_i + at$$
$$v_f^2 = v_i^2 + 2a\Delta x$$
$$\Delta x = v_i t + \frac{1}{2}at^2$$

motion بتعجيل ثابت ينطبق

على الشحنة معادلات الحركة

[2] * حسب قانون نيوتن الثاني

$$\vec{F}_{net} = m\vec{a}$$

وزن الشحنة — تسارع الشحنة

$$\boxed{q\vec{E} = m\vec{a}} \qquad \vec{F} = q\vec{E}$$

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

* $Work = \vec{F}.\vec{d} = |\vec{F}||\vec{d}|\cos\theta$ → شغل

$$W = q(\vec{E}.\vec{d})$$

الشغل الذي يكون موجب أو سالب

* $W_{net} = \Delta K$

$$= \frac{1}{2}m(v_f^2 - v_i^2)$$

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Exp: mass of charge $= 2 \times 10^{-4}$ Kg

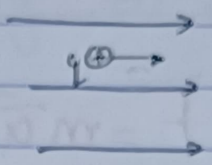
charg $= 6 \times 10^{-8}$ C

$\vec{E} = 4000$ N/C

$V_i = 2 \times 10^4$ m/s

$t = 10^3$ sec

① Find acceleration
② V_f
③ Displacement
④ Force.
⑤ Work
⑥ Change in Kinatic Energ



① $\vec{F}_{net} = m\vec{a}$

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

$\frac{6 \times 10^{-8}}{10^{-4}} \times 4000 = 2 \times 10^{-4} a$

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

② $V_f = V_i + at$

$V_f = 2 \times 10^4 + 1.2 \times 10^3$

$= 20000 + 1200$

$$\boxed{V_f = 21200 \text{ m/s}}$$

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(3) $\Delta x = v_i t + \frac{1}{2} a t^2$

$= 2 \times 10^4 \times 10^3 + \frac{1}{2} \times 1.2 \times (10^3)^2$

$= 2 \times 10^7 + 6 \times 10^5$

$\boxed{\Delta x = 20.6 \times 10^6 \text{ m}}$

(4) $\vec{F} = m\vec{a}$

$= 2 \times 10^{-4} \times 1.2$

$\boxed{\vec{F} = 24 \times 10^{-5} \text{ N}}$

(5) $W = \vec{F} \cdot \vec{d}$

$= Fd \cos\theta$

$= 24 \times 10^{-5} \times 20.6 \times 10^6 \times \cos 0$

$\boxed{W = 4944 \text{ J}}$

(6) $W = \Delta K$

$= 4944 \text{ J} = \frac{1}{2} m (v_f^2 - v_i^2)$

* Point charge with Electric field straight,

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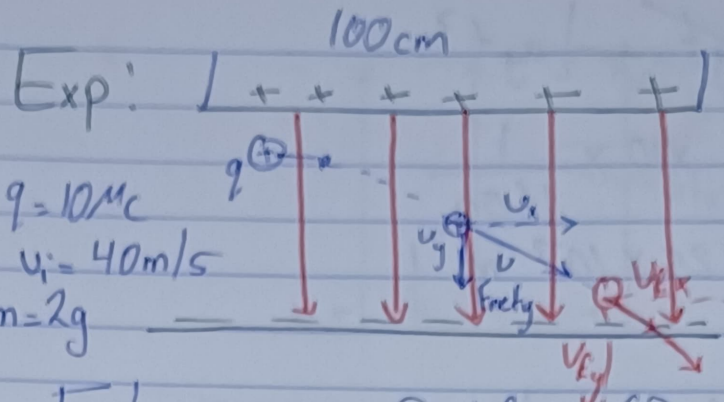
Exp:



$q = 10\mu C$

$v_i = 40 m/s$

$m = 2g$

$E = 2000 N/C$

Find : ① a_y ② V_f ③ Δy ④ t

$v_{ix} = 40 m/s$ ⟸ ثابتة خلال المقذوفات

$v_{iy} = 0$

$\vec{F}_{net_y} = m\vec{a}_y$

$qE = m\vec{a}_y$

$\vec{a}_y = \frac{10 \times 10^{-6} \times 2000}{2 \times 10^{-3}}$

$\boxed{\vec{a}_y = 10 m/s^2}$

② V_f

* $v_{fx} = v_{fy} = 40 m/s$

$v_{fy} = v_{oy} + a_y t$

$v_{fy} = 10 \times \frac{1}{40}$

$\boxed{v_{fy} = 0.25 m/s}$

$V_f = 40\hat{j} - 0.25\hat{j}$

④ المعادلة الوحيدة بالـ x

$\boxed{x = v_{ox} t}$

$t = \frac{1}{40}$ sec

Note المقذوفات

$x = v_{ox} t$ — ①

$v_{fy} = v_{iy} + a_y t$

$v_{fy}^2 = v_{iy}^2 + 2 a_y \Delta y$

$\Delta y = v_{iy} t + \frac{1}{2} a_y t^2$

$\boxed{v_{ox} = v_{fx} = v_x}$

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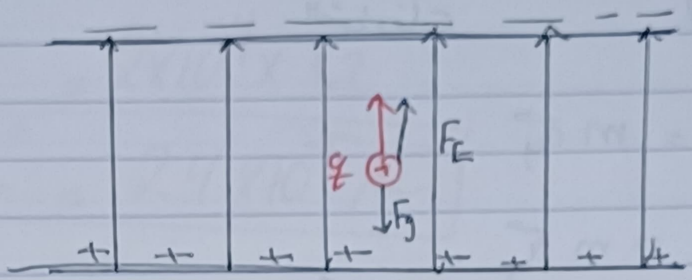
③ $\Delta y = \cancel{v_{oy}^{0} t} + \frac{1}{2} a_y t^2$

$= \frac{1}{2} \times 10 \times \frac{1}{1600}$

$\boxed{\Delta y = 3.125 \times 10^{-3} \text{ m}}$

④ $\boxed{t = \frac{1}{40} \text{ sec.}}$

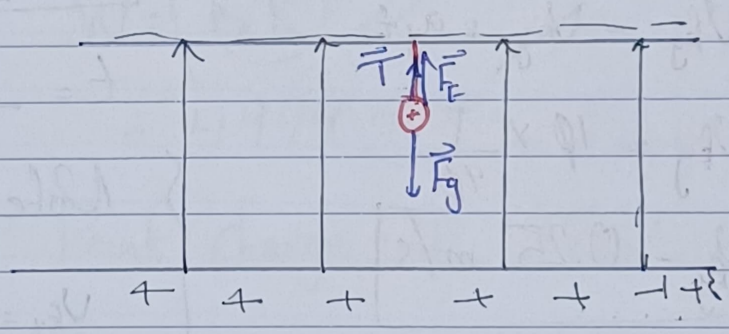


$\vec{F}_{net} = \vec{F}_E + \vec{F}_g$

* Equilibrium: $\vec{F}_{net} = 0$

$|\vec{F}_E| = |\vec{F}_g|$

$qE = mg$



حيث

$\vec{F}_{net} = \vec{F}_E + \vec{T} + \vec{F}_g$ بما أن

$= (\vec{F}_E + \vec{T}) - \vec{F}_g$ ⟸

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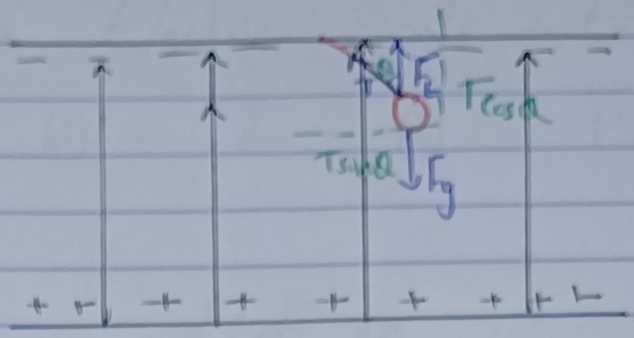

$T\sin\theta = ma$ ، $F_e + T\cos\theta = mg$ ، $\Sigma F = 0$

بالوزن الطبيعي

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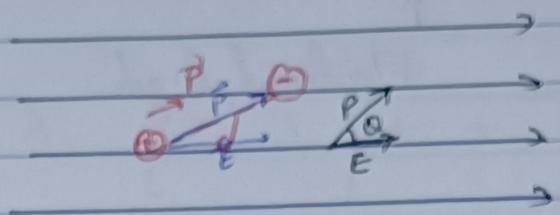
Electric dipole in $\vec{E}$:

$(+)$ —— d —— $(-)$ $\quad \vec{P} = q\vec{d}$



[1] Potential Energy "U"

$U = -\vec{P} \cdot \vec{E}$ علاقة الزاوية

U ⟨ $+ \quad \theta = 180°$ ⟨ $U = -PE\cos\theta$ → between P, E
$0 \quad \theta = 90$
$- \quad \theta = 0$

* $\vec{P} = 2\hat{i} + 3\hat{j}$

$E = 3\hat{i}$

$U = -(6 + 0)$

$U = -6$ J

θ = Unknown ← ؟

$\vec{P} = \sqrt{(2\hat{i})^2 + (3\hat{j})^2}$ $\quad U = -$؟$|P||E|\cos\theta$

$E = \sqrt{(3\hat{i})^2}$ المقدار داخل الجذر

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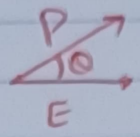
Torque ($\vec{\tau}$)

$$\vec{\tau} = \vec{P} \times \vec{E} = |\vec{P}||\vec{E}| \sin\theta$$

↑ Electrical dipole.



Exp $\vec{P} = 2\hat{i} + 3\hat{j}$

$\vec{E} = 2\hat{i} + \hat{j}$

$$\vec{\tau} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 2 & 3 & 0 \\ 2 & 1 & 0 \end{vmatrix}$$

$\vec{\tau} = (\text{Zero})\hat{i} + (\text{Zero})\hat{j} + (2\times1 - 2\times3)\hat{k}$

$\vec{\tau} = -4\hat{k}$ N.m

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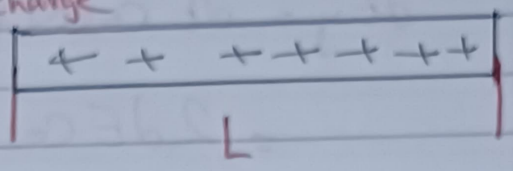
* Electric field due to distribution of charge

① linear charge density "λ"

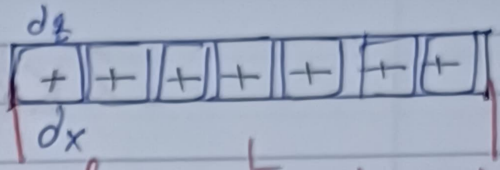
$$\lambda = \frac{q}{L}$$ ← total charge



or

$$\lambda = \frac{dq}{dx}$$

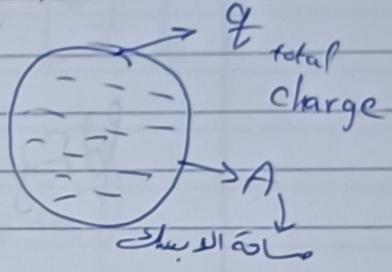
$$\boxed{dq = \lambda\, dx}$$



Uniform linear charge density

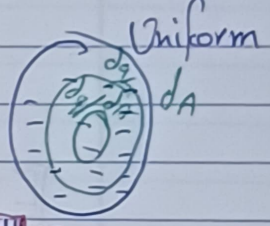
② Surface charge density (σ)

$$\boxed{\sigma = \frac{q_{tot}}{A}}$$

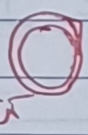


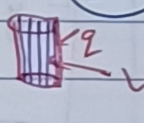
$$\sigma = \frac{q}{A} = \frac{dq}{dA}$$

$$dq = \sigma\, dA$$



③ Volume charge density (ρ)





~~Uniform~~

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

Uniform $\rho = \frac{dq}{dV}$ → كثافة حجمية منتظمة

$$\boxed{dq = \rho\, dV}$$

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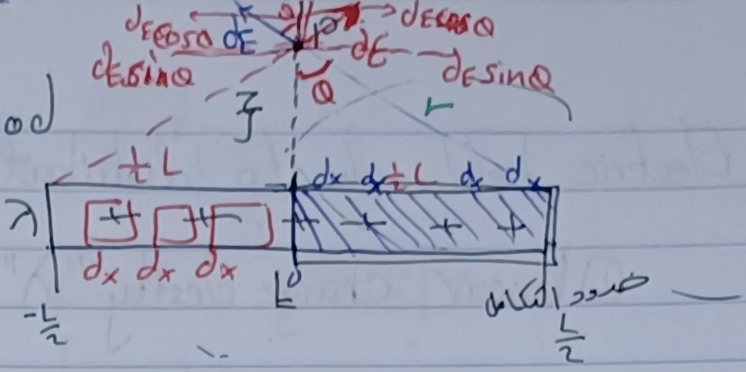
Explo Rod



$$dE_y = dE\cos\theta + dE\cos\theta$$

$$= 2dE\cos\theta$$

$$= 2\frac{K dq}{r^2} \times \frac{y}{r}$$

~~$= 2K dq$~~

$$dE_y = \frac{2Ky}{r^3}\,dq$$

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

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

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

$$dq = \lambda\, dx$$

$$r = \sqrt{y^2 + \left(\frac{1}{2}L\right)^2} \to x$$

$$= \sqrt{y^2 + x^2}$$

$$r^3 = (y^2 + x^2)^{\frac{3}{2}}$$

$$\int dE_y = \int_0^{L/2} \frac{2Ky}{(y^2+x^2)^{\frac{3}{2}}}\lambda\, dx$$

$$= 2K\lambda \int_0^{L/2} \frac{y}{(x^2+y^2)^{\frac{3}{2}}}\,dx$$

$$\boxed{E_y = \frac{K\lambda L}{y\sqrt{y^2 + \frac{L^2}{4}}}}$$

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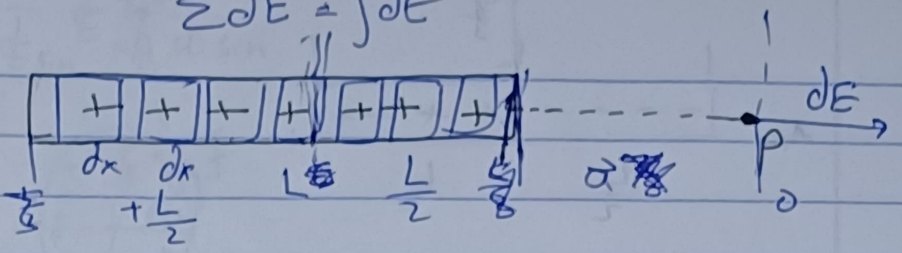
$\Sigma dE = \int dE$



$$dE = \frac{K dq}{r^2} \qquad dq = \lambda dx$$

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

$$\int dE = \int \frac{K \lambda dx}{x^2}$$

$$E = \int_{a}^{\frac{L}{2}+a} \frac{K \lambda dx}{x^2}$$

$$= K\lambda \int_{a}^{\frac{L}{2}+a} \frac{1}{x^2} = K\lambda \left[-\frac{1}{x} \right]_{a}^{\frac{L}{2}+a}$$

$$= K\lambda \left(\frac{1}{a} - \frac{1}{\frac{L}{2}+a} \right)$$

$$E = K(\lambda L) \Rightarrow q$$

$$E = Kq$$

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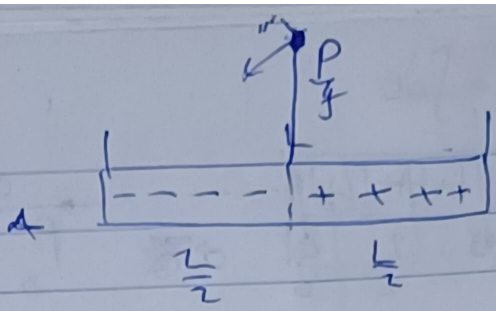

finite rod ↗

یعنی infinite rod کی طرح $-\frac{L}{2} \longrightarrow \infty$

یعنی

$$L \gg\gg\gg \rho$$

$$E = \frac{K\lambda L}{\rho\sqrt{\underset{\approx 0}{\rho^2} + \frac{L^2}{4}}}$$

$\rho = 0.01$

$\rho^2 = 0.0001$

$$= \frac{K\lambda L}{\rho \frac{L}{2}}$$

$$\boxed{E = \frac{2K\lambda}{\rho}}$$ (infinite rod.

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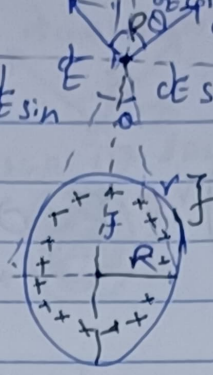

$dq = \lambda ds$

المحيط

$ds = 2\pi R$

$r = \sqrt{R^2 + z^2}$

$r^3 = (R^2 + z^2)^{\frac{3}{2}}$

$$dE = 2dE\cos\theta$$

$$= \frac{2K\,dq}{r^2}\cos\theta$$

$$= \frac{2K\lambda ds}{r^2} \times \frac{z}{r}$$

$$\int dE = \int \frac{2K\lambda ds\, z}{(R^2+z^2)^{\frac{3}{2}}}$$

$$E = \int_0^{2\pi R} \frac{2K\lambda z\, ds}{(R^2+z^2)^{\frac{3}{2}}}$$

$$= \frac{2K\lambda z}{(R^2+z^2)^{\frac{3}{2}}} \int_0^{2\pi R} ds$$

$$= \frac{4\pi K\lambda z R}{(R^2+z^2)^{\frac{3}{2}}}$$

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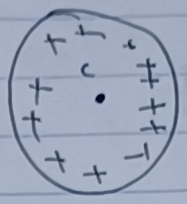
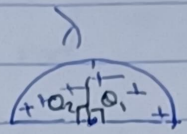


$E = 0$ in Centre

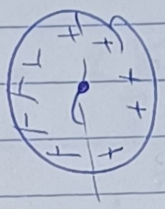


$$E_{centre} = \frac{1}{R}\left(\sin\theta_1 + \sin\theta_2\right)$$

$$E_{centre} = \frac{2\lambda}{R}$$

$$E_{centre} = \frac{\lambda}{R}\left(\sin 90 + \sin 0\right)$$

$$= \frac{\lambda}{R}$$



$\theta_1 = 180 \quad \theta_2 = 180$

$$E_{centre} = \frac{\lambda}{R}\left(\sin 0 + \sin 0\right)$$

$$= 0$$

$$E_{centre} = \frac{\lambda}{R}\left(\sin\theta_1 + \sin\theta_2\right)$$

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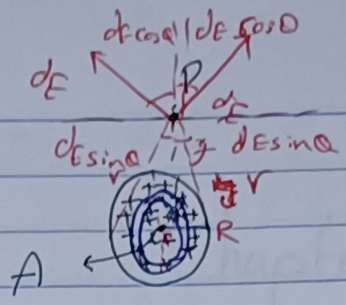
* Disk



$$dE = 2dE\cos\theta$$

$$= \frac{2K\,dq}{r^2}\cos\theta$$

$$dE = \frac{2K\sigma\,dA}{(x^2+y^2)^{\frac{3}{2}}} \times y$$

$$\int dE = \int \frac{2K\sigma 2\pi x\,dx\,y}{(x^2+y^2)^{\frac{3}{2}}}$$

$$E = K y \sigma \pi \int_0^R \frac{x\,dx}{(x^2+y^2)^{\frac{3}{2}}}$$

$$\boxed{E = \frac{\sigma}{2\epsilon_0}\left(1 - \frac{y}{\sqrt{y^2+R^2}}\right)}$$

$dq = \sigma dA$

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

$r^3 = \left(x^2+y^2\right)^{\frac{3}{2}}$

$A = 2\pi x^2$

$\boxed{dA = 2\pi x\,dx}$

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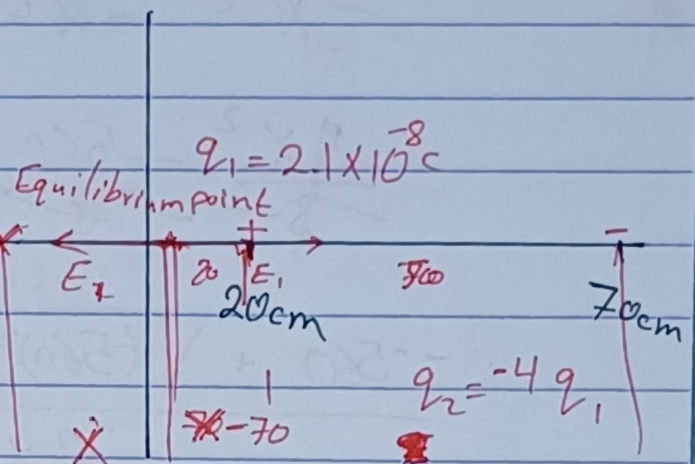
Chapter 2
Problems.

Problem 1



$$\frac{K|4q_1|}{(70+x)^2} = \frac{K|q_1|}{(x+20)^2}$$

$$\sqrt{4(x+20)^2} = \sqrt{(70+x)^2}$$

$$2x + 40 = 70 + x$$

$$-40 \quad -40 \quad -x$$

$$\sum E_{net} = 0$$

$$E_1 = E_2$$

$$\frac{Kq_1}{r^2} = \frac{Kq_2}{r^2}$$

$$\frac{Kq_1}{(x-70)^2} = \frac{K4q_2}{x^2}$$

$$\sqrt{x^2} = \sqrt{4(x-70)^2}$$

$$x = 2(x-70)$$

$$x = 2x - 140$$

$$-2x \quad -2x$$

$$-x = -140$$

$$x = 140cm = 1.4m$$

$$\frac{K4q_1}{(x2)} = \frac{Kq_1}{70+x}$$

$$\sqrt{4x^2} = \sqrt{(70+x)^2}$$

$$2x = 70 + x$$

$$-x \quad -x$$

$$x = 70.$$

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$$dE = \frac{K q_2 dx}{x^2}$$

$$x^2 = 4\left(x^2 - 140x + 4900\right)$$

$$x^2 = 4x^2 - 560x + 19600$$

$$-x^2 \quad -x^2$$

$$\frac{3x^2}{3} - \frac{560}{3} + \frac{19600}{3} = 0$$

$$x = \frac{-(-560) \pm \sqrt{(560)^2 - 4 \times 3 \times 19600}}{2 \times 3}$$

$$\frac{560 + 280}{6} \quad \Big| \quad \frac{560 - 280}{6}$$

$x = 140\text{cm}$ Or $x = 46.67\text{cm}$

Not valid

q_2 is west 140cm ,,

q_1 is west 70cm ,,

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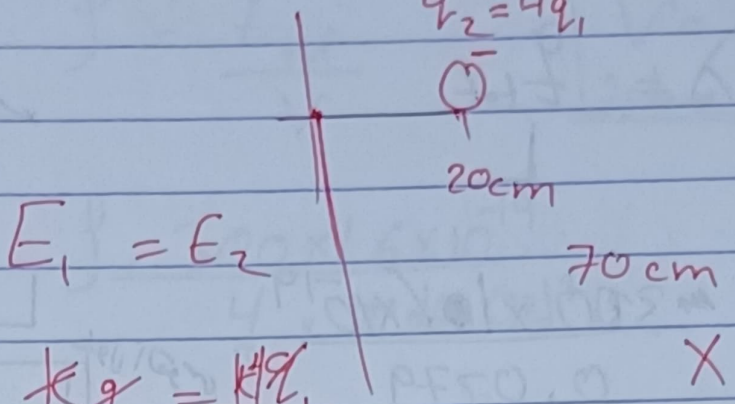
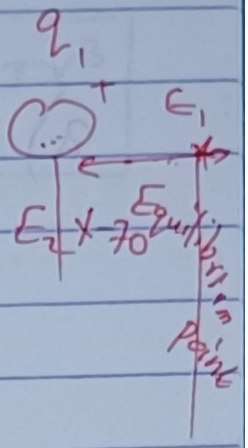
if changed





$$E_1 = E_2$$

$$\frac{kq_1}{r^2} = \frac{k4q_1}{r^2}$$

$$\sqrt{\frac{1}{(X-70)^2}} = \sqrt{\frac{4}{(X-20)^2}}$$

$$\frac{1}{X-70} = \frac{2}{X-20}$$

$$2X - 140 = X - 20$$

$$-X \quad +140 \qquad -X \quad +140$$

$$\boxed{X = 120 \text{ cm}}$$

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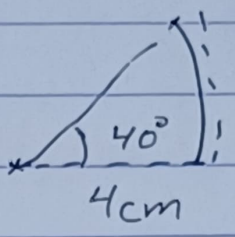
Problem 4 :

$q = -300e$

a) $\lambda = \frac{q_{tot}}{L}$



$= \frac{300 \times 1.6 \times 10^{-19}}{0.0279}$

$L = \theta r$

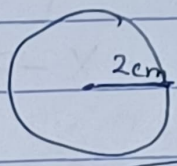
$L = \theta$ in radian

$\lambda = 1.71 \times 10^{-15} C/m$

$L = \frac{\pi}{180} \times 40 \times 0.04$

$L = 0.0279 m$

b) $\sigma = \frac{q_{tot}}{A}$



$q = -300e^-$

$= \frac{300 \times 10^{-19} \times 1.6}{\pi \times (0.02)^2}$

$A = \pi r^2$ disk

$\sigma = 3.82 \times 10^{-14} C/m^2$

c) $q = -300e^-$ $r = 4 cm$

Sphere Surface $A = 4\pi r^2$

$\sigma = \frac{q_{tot}}{A} = \frac{300 \times 1.6 \times 10^{-19}}{4\pi \times (0.04)^2}$

$\sigma = 2.38 \times 10^{-15} C/m^2$

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d) $q = 300e^-$ $r = 0.02\,m$

$$\rho = \frac{q_{tot}}{V}$$

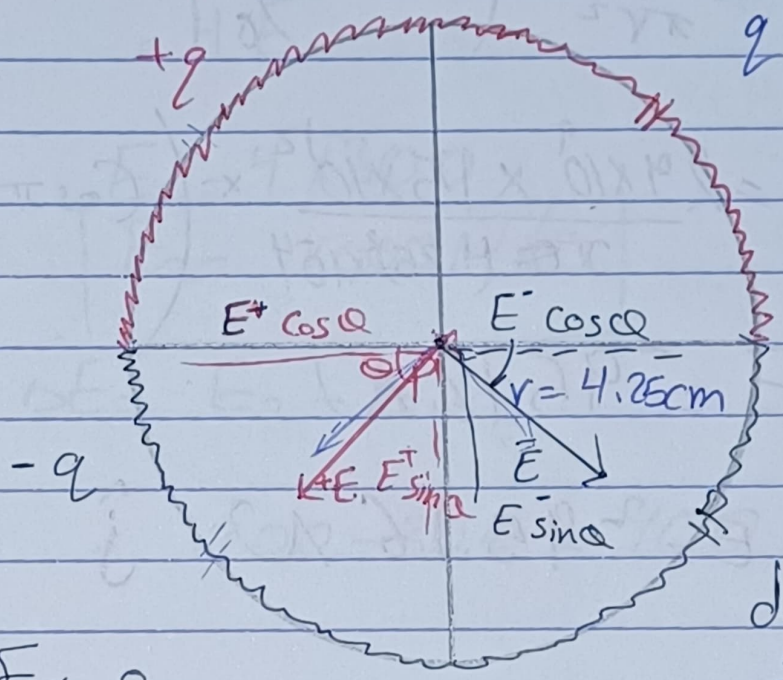
$$\boxed{V_{sphere} = \frac{4}{3}\pi r^3}$$

$$\rho = \frac{300 \times 1.6 \times 10^{-19}}{\frac{4}{3} \times \pi \times (0.02)^3}$$

$$= 1.432 \times 10^{-12}\ C/m^3$$

Problem 11:

$q = 15\,pC$



$\Sigma E_x = 0$

$dq = \lambda dx$

$q = \lambda \theta r$

~~$dq = \lambda d\theta r$~~

$\lambda r d\theta$

$$\Sigma dE = dE^+ \sin\theta + dE^- \sin\theta$$

$$= 2\,dE \sin\theta$$

$$dE = 2\frac{K dq}{r^2} \sin\theta$$

$dq = \lambda r d\theta$

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$$dE = \frac{2k\lambda r\, d\theta \sin\theta}{r^2}$$

$$\int dE = \int_0^{\pi} \frac{2k(\lambda)}{r} \sin\theta\, d\theta$$

$$\lambda = \frac{q}{\pi r}$$

$$E = \frac{2k(\lambda)}{\pi r}\left(\cos\theta\right)\Big|_0^{\pi}$$

~~$= 9\times10^{-9} \times$~~

$$E = \frac{2kq}{\pi r^2}\left(\cos\theta\right)_0^{\pi}$$

$$= \frac{2\times9\times10^{9}\times15\times10^{-12}}{\pi\,(1.25)^2\times10^{-4}} \times \left(\cos\pi - \cos 0\right)$$

$$E = -95.16\,\Omega$$

$$E = -95.16\,\Omega\,\hat{j}$$

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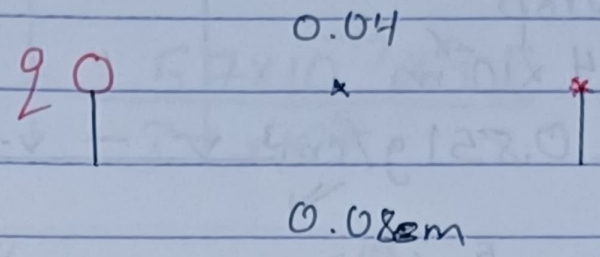
Problem 12

$\vec{E}_1 = 300\ N/C$



A

$E_2 = \frac{kq}{r_2^2}$ $\qquad r_2 = \frac{1}{2} r_1 = 0.04$

$= \frac{kq}{\frac{1}{4} r_1^2} E_1$

$= 4 E_1$

$E_2 = 4 \times 300$

$\boxed{E_2 = 1200\ N/C}$

$\Delta E = E_2 - E_1$

$= 1200 - 300 = 900\ N/C$

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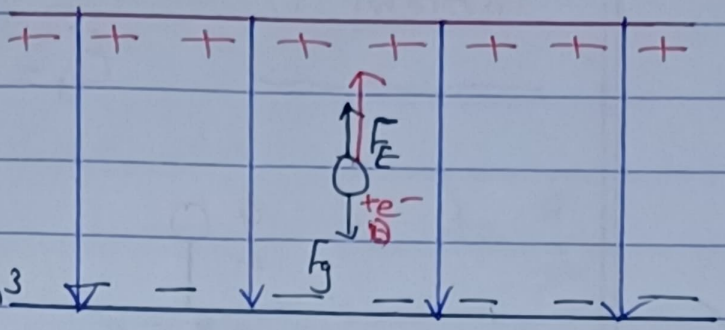
Problem 33



Oil Drop

$r = 1.64 \times 10^{-6}\ m$

$d = 0.851\ g/cm^3$

$E = 3.2 \times 10^5\ N/C$

$\Sigma F_{net} = 0$

$$\text{density} = \frac{\text{Mass}}{\text{Volume}}$$

$$851 = \frac{\text{Mass}}{\frac{4}{3}\pi r^3}$$

$$\text{Mass} = 851 \times \frac{4}{3} \times \pi \times (1.64 \times 10^{-6})^3$$

$$m = 1.57 \times 10^{-14}$$

a) $F_E = F_g$

$qE = mg$

$$q = \frac{mg}{E}$$

$$q = \frac{1.58 \times 10^{-9} \times 9.8}{3.2 \times 10^5}$$

$$q = 2.93 \times 10^{-13}\ C$$

$q = ne$

$$n = \frac{q}{e} = \frac{2.93 \times 10^{-13}}{1.6 \times 10^{-19}}$$

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$$q = \frac{mg}{E}$$

$$q = \frac{1.57 \times 10^{-14} \times 9.8}{3.2 \times 10^{5}}$$

$$\boxed{q = 4.81 \times 10^{-19}\ C}$$

$$\#n = \frac{q}{e} = \frac{4.81 \times 10^{-19}}{1.6 \times 10^{-19}}$$

$$\boxed{\#n = 3.009 \times 10^{0}\ e^-}$$

b) $eE = E \times e^-$

$= 3.2 \times 10^{5} \times 1.6 \times 10^{-19}$

$eE = 5.12 \times 10^{-14}\ N/C$

$mg_{e^-} = 9.1 \times 10^{-31} \times 9.8 = 8.918 \times 10^{-30}\ N$

$F_E = F_{E_e} + F_E - F_g^{\,0} - F_{g_{e^-}}$

$F_E = qE - mg_{e^-}$

$= (5.12 \times 10^{-14} \times 4.81 \times 10^{-19}) - (8.918 \times 10^{-30})$

$\boxed{F_{E_{net}} = \ominus 8.8 \times 10^{-30}\ N}$

$\therefore$ Upward.

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$$F_{E_{net}} = 2.46 \times 10^{-23} N \quad \text{Upward.}$$

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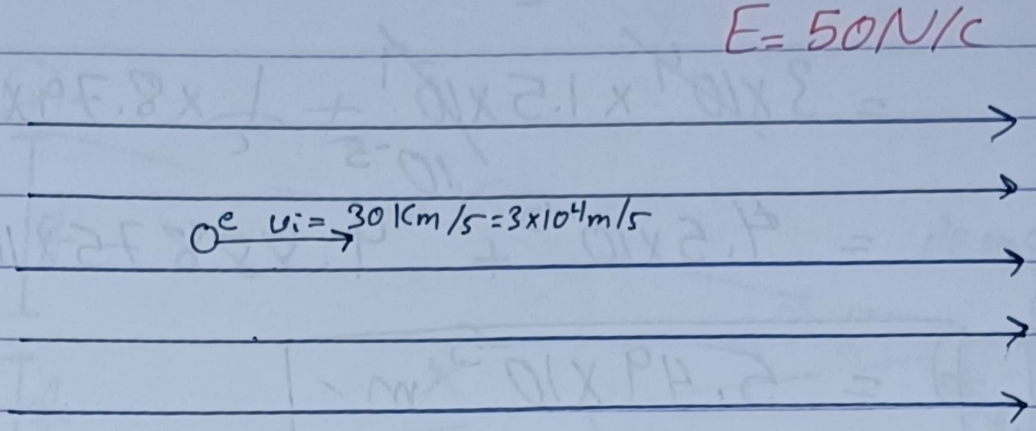
Problem 38



① v_f after $1.5 \text{ ns} = 1.5\times10^{-9}$ sec

$$qE = ma$$

$$\frac{1.6\times10^{-19}\times 50}{9.1\times10^{-31}} = \frac{9.1\times10^{-31}\,\vec{a}}{9.1\times10^{-31}}$$

$$\boxed{\vec{a} = 8.79\times10^{12}}$$

$$v_f = v_i + \vec{a}t$$

$$= 3\times10^{4} + 8.79\times10^{12}\times10^{-9}\times1.5$$

$$= 3\times10^{4} + 1.3185\times10^{4}$$

$$\boxed{v_f = 4.185\times10^{4} \text{ m/s}}$$

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$$d = v_i t + \frac{1}{2} a t^2$$

$$= 3\times10^{4} \times 1.5\times10^{-9} + \frac{1}{2} \times 8.79\times10^{12} \times (1.5\times10^{-9})^2$$

$$= 4.5\times10^{-5} + 9.888\,75\times10^{-6}$$

$$\boxed{d = 5.49\times10^{-5}\ m}$$

Problem 41

$E = 46\ N/C$

$P = 3.02\times10^{-25}$

$\theta_1 = 23^\circ$

$\theta_2 = \theta_1 + \pi$

$$W_a = \Delta U$$

$$= U_f - U_i$$

$$= \left((-PE\cos\theta_2) - (-PE\cos\theta_1) \right)$$

$$= -PE\left(\cos\theta_2 - \cos\theta_1\right)$$

$$= \ominus PE\left(\cos(\theta_1+\pi) - \cos(\theta_1+\pi)\right)$$

$$= +3.02\times10^{-25} \times 46 \left(\cos 23 - \left(-\cos 23\right)\right)$$

$$= +2\times3.02\times10^{-25}\times46\times0.92$$

$$\boxed{W_a = +2.557\times10^{-23}\ J}$$

$\cos(\theta_1+\pi) = \cos\theta_1\cos\pi - \sin\theta_1\sin\pi = -\cos\theta_1$

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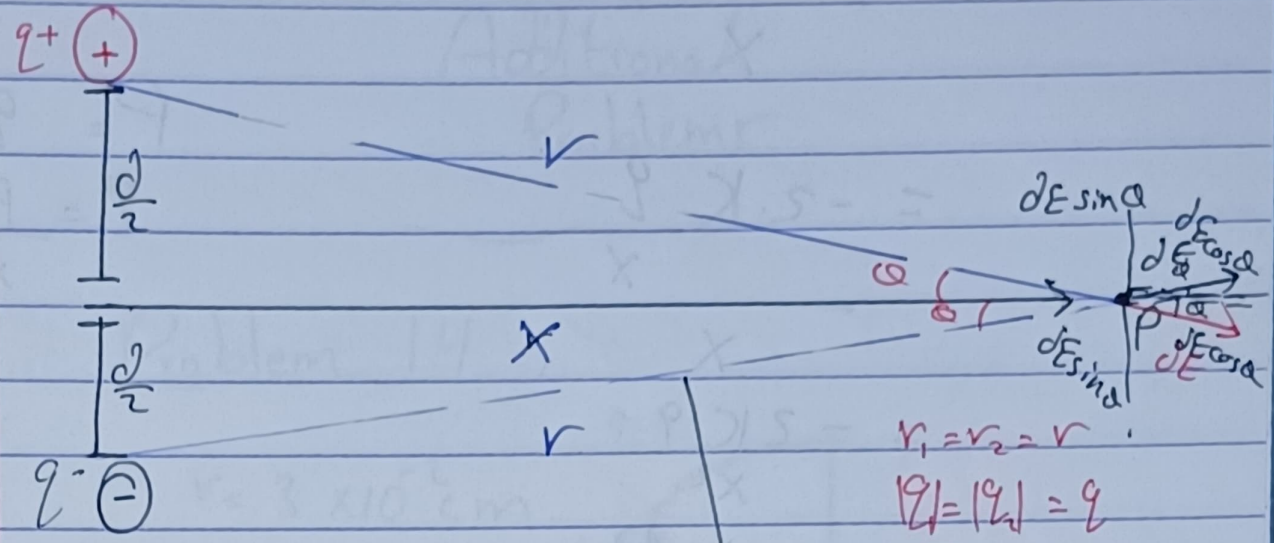
Problem 55



$r_1 = r_2 = r$

$|q_1| = |q_2| = q$

$E_1 = E_2 = E$

$\cos\theta = \frac{x}{r}$

$r^2 = x^2 + \left(\frac{d}{2}\right)^2$

$r^3 = \left(x^2 + \left(\frac{d}{2}\right)^2\right)^{\frac{3}{2}}$

$\sum E_y = 0$

$\sum E_x = E$

$dE = 2dE\cos\theta$

$dq = \lambda\, dx$

$dE = \frac{2K\,dq}{r^2}\cos\theta$

$r >>> d$

$dE = \frac{2K\,dq\,x}{r^3}$

$\int dE = \int \frac{2K\lambda x\,dx}{\left(x^2 + \left(\frac{d}{2}\right)^2\right)^{\frac{3}{2}}}$

$E = 2K\lambda \int \frac{x}{\left(x^2 + \left(\frac{d}{2}\right)^2\right)^{\frac{3}{2}}}\,dx \quad \left(\frac{d}{2}\right) \approx 0$

$E = 2K\lambda \int \frac{x}{(x^2)^{\frac{3}{2}}}\,dx$

$E = 2K\lambda \int \frac{1}{x^2}\,dx$

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$$E = \frac{-2K\lambda}{x}$$

$$= \frac{-2K\frac{q}{x}}{x}$$

$$= \frac{-2Kq}{x^2}$$

$$= \frac{-2KP}{x^3}$$

$$= -\frac{1}{2} \times \frac{1}{4\pi\epsilon_0} \cdot \frac{P}{x^3}$$

$$\boxed{E = \frac{-P}{2\pi\epsilon_0 x^3}}$$

$$\vec{P} = q(-\hat{j})x$$

$$P = qx$$

$$q = \frac{P}{x}$$

$$\frac{P}{2\pi\epsilon_0 x^3}\hat{j}$$

بالرمز كامل بهذه الطريقة

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Additional Problems

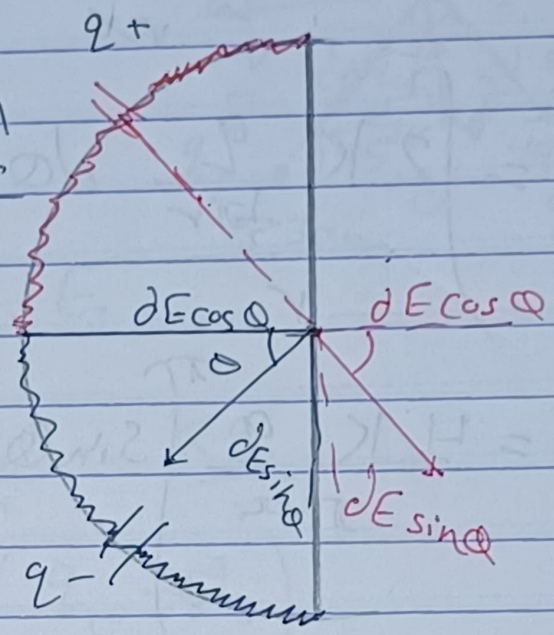
Problem 14

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

$q = 4.5 \times 10^{-12}\ C$

$\theta_1 = 0$

$\theta = 180$



$\Sigma E_x = 0$

$\Sigma E_y = E$

~~$E = \frac{kq}{r^2}$~~ $E_{net} = 2\,dE \sin\theta$

$dE = 2 \times \frac{k\,dq}{r^2} \sin\theta\, d\theta$

$\int dE = \int \frac{2 \times k \times \lambda S}{r^2} \sin\theta\, d\theta$

$E = \frac{2k\lambda S}{r^2} \int_0^{\frac{1}{4}\pi r} \sin\theta\, d\theta$

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$$E = \frac{2\times9\times10^{9} \times 4.5\times10^{-12}}{(0.03)^2} \times \left(\cancel{\cos 180 - \cos 0}\right) = \frac{q}{L}$$

$$\lambda = \frac{4.5\times10^{-12}}{\frac{1}{2}\pi \times 0.03}$$

$$E = -180\ N/C$$

$$dE = \frac{2K\lambda \cancel{dx}\, d\theta \sin\theta}{r\cancel{x}} \quad \Big| \; S = \theta r$$

$$\int dE = \int \frac{2K \frac{q}{\frac{1}{2}\pi r}\, d\theta \sin\theta}{r}$$

$$= \frac{4Kq}{\pi r^2} \int_{\frac{\pi}{2}}^{\pi} \sin\theta \, d\theta$$

$$= \frac{4\times9\times10^{9} \times 4.5\times10^{-12}}{\pi \times 9\times10^{-4}} \times \left(\cancel{\cos\pi} - \cancel{\cos\frac{\pi}{2}}\right)$$

$$\boxed{E = -4426\ N/C}$$

$$\boxed{E = -57.29\ N/C}$$

Can use

$$E = \frac{K\lambda}{R}\left(\sin\theta_1 + \sin\theta_2\right)$$

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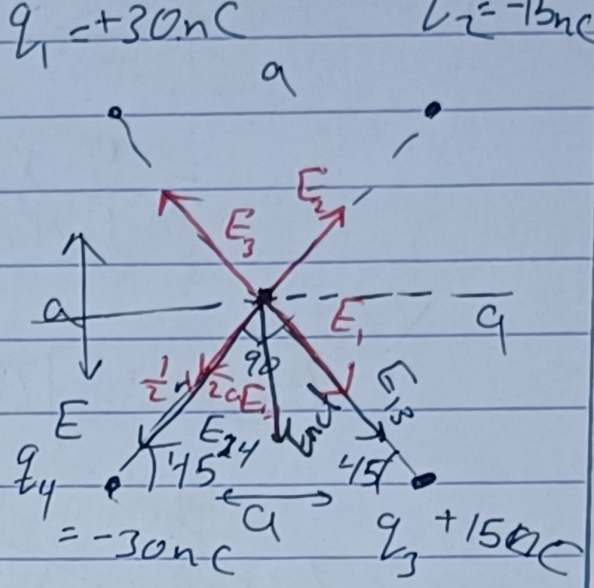
Problem 19

$r = \sqrt{a^2 + a^2}$

$a = 5\text{cm}$

$= \sqrt{2}a$

$\frac{1}{2}r = \frac{1}{2}\sqrt{2}a$



$\therefore E_{13} = E_1 - E_3$

$= \frac{Kq_1}{r^2} - \frac{Kq_3}{r^2}$

$= \frac{K}{r^2}(q_1 - q_3)$

$= \frac{9 \times 10^9}{(\frac{1}{2}\sqrt{2}a)^2}\left(30 \times 10^{-9} - 15 \times 10^{-9}\right)$

$= \frac{9 \times 10^{9} \times 15 \times 10^{-9}}{\frac{1}{4} \times 2 \times (0.05)^2}$

25×10^{-4}

$E_{13} = 108000\ N/C$

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$$E_{24} = E_4 - E_2$$

$$= \frac{K}{r^2}\left(q_4 - q_2\right)$$

$$= \frac{9 \times 10^9}{\left(\frac{1}{2}\sqrt{2} \times 0.05\right)^2}\left(30 - 15\right) \times 10^{-9}$$

$$E_{24} = 108000 \ N/C$$

$$E_{net} = \sqrt{(E_{13})^2 + (E_{24})^2}$$

$$= 152.7 \times 10^3 \ N/C$$

45° with x+

$$\Sigma E_x = E_{13}\cos 45 - E_{24}\cos 45$$

$$= 0$$

$$\Sigma E_y = E_{13}\sin 45 + E_{24}\sin 45$$

$$= 2 \times 108000\left(\frac{1}{\sqrt{2}}\right)$$

$$= 1.52 \times 10^5 \ -\hat{j}$$

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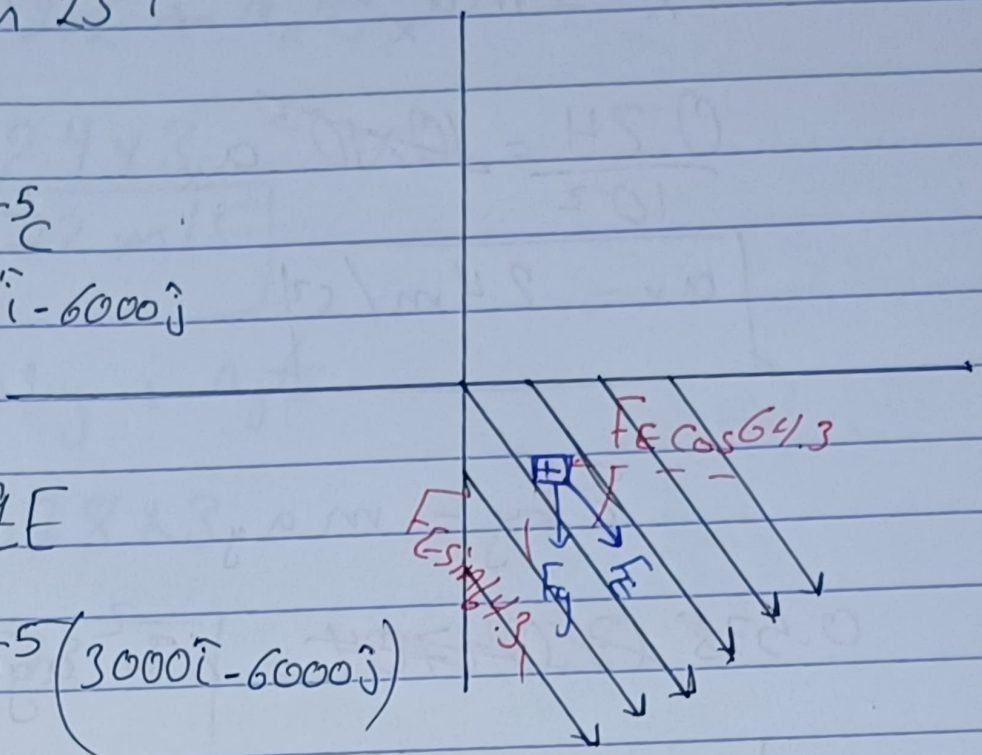
Problem 23 :

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

$+q = 8 \times 10^{-5} C$

$E = 3000\hat{i} - 6000\hat{j}$



① $F_E = qE$

$= 8 \times 10^{-5} (3000\hat{i} - 6000\hat{j})$

$F_E = 0.24\hat{i} - 0.48\hat{j}$

$F_E = \sqrt{(0.24)^2 + (0.48)^2}$

$\boxed{F_E = 0.536\ N}$

$\theta = \tan^{-1}\left(\frac{0.48}{0.24}\right)$

$\theta = \tan^{-1}(2)$

$t_1 = 0 \quad v_i = 0 \quad t_2 = 3\ sec$

$\boxed{\Sigma F_x = +0.24\ N}$

$\boxed{\theta = 63.4^\circ \text{ with } X^+ \text{ clockwise.}}$

$\Sigma F_y = F_{Ey} + F_g$

$= 0.48 + 10^{-2} \times 9.8$

$\boxed{\Sigma F_y = \cancel{-0.0470.4} \; 0.578}$

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$$\Sigma F_x = m a_x$$

$$\frac{0.24}{10^{-2}} = 10 \times 10^{-3} a_x$$

$$\boxed{a_x = 24 \text{ m/s}^2}$$

$$\Sigma F_y = m a_y$$

$$0.578 = 10^{-2} a_y$$

$$\boxed{a_y = 57.8 \text{ m/s}^2}$$

(2) $$X = v_{ix}^{0} t + \frac{1}{2} a_x t^2$$

$$= \frac{1}{2} \times 24 \times 9$$

$$\boxed{X = 108 \text{ m}}$$

(3) $$y = v_{iy}^{0} t + \frac{1}{2} a_y t^2$$

$$= \frac{1}{2} 57.8 \times 9$$

$$\boxed{y = 260.1 \text{ m}}$$

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$$v_{fx} = \cancel{v_{ix}^{0}} + a_x t$$

$$= 24 \times 3$$

$$\boxed{v_{fx} = 72 \text{ m/s}}$$

$$v_{yx} = v_{iy} + a_y t$$

$$= 57.8 \times 3$$

$$\boxed{v_{fy} = 173.4}$$

$$v_f = 72\hat{i} - 173.4\hat{j}$$

$$v_f = \sqrt{(72)^2 + (173.4)^2}$$

$$\boxed{v_f = 187.7 \text{ m/s}}$$

$$\theta = \tan^{-1}\left(\frac{173.4}{72}\right)$$

$$\theta = 67.45 \text{ clockwise } x+$$

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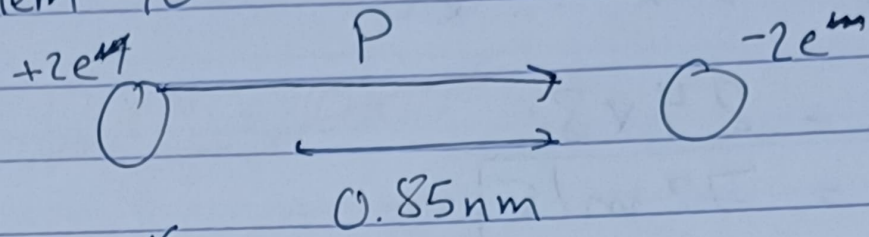
Problem 40



$E = 3.4 \times 10^{6}$

$\vec{P} = q\vec{d}$

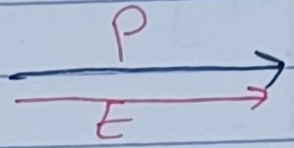
↗ from - to positive

① Parallel

$\vec{\tau} = P \times E$

$= PE \sin\theta$

$\theta_1 = 0$

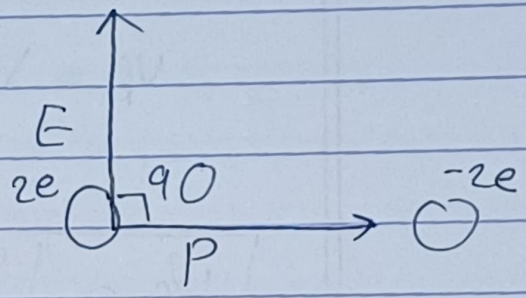


$\tau = 0$

②

$\tau = PE \sin 90$

$= qdE$



$= 2 \times 1.6 \times 10^{-19} \times 0.85 \times 10^{-9} \times 3.4 \times 10^{6}$

$\vec{\tau} = 9.25 \times 10^{-22}\ N.m$

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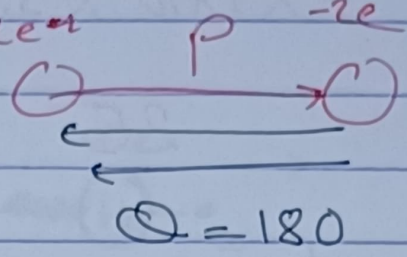
(c)

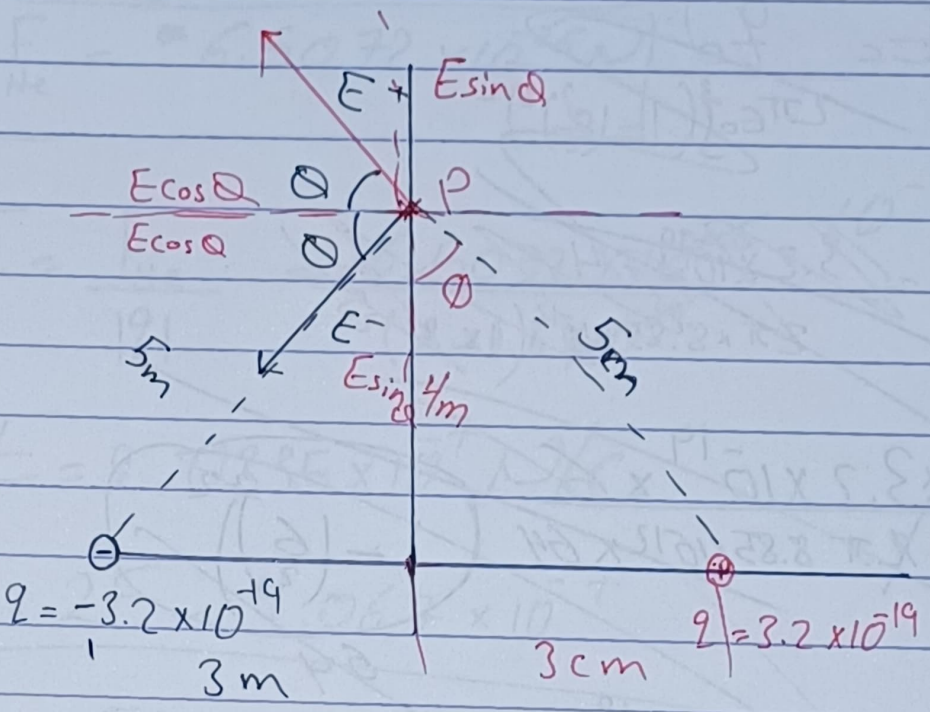
$\tau = PE\sin\theta$

$\theta = 180$



$= 0$

Problem 49



$r_1 = r_2 = r = 5\ m$

$E_1 = E_2 = E$

$\theta_1 = \theta_2$

$|q_1| = |q_2| = q = 3.2 \times 10^{-19}\ C$

(1) $\Sigma E_y = 0$

$\Sigma E_x = E = 2E\cos\theta$

$= \frac{2kq}{r^2} \times \cos\theta$

$\Rightarrow$

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$$\frac{2\times 9\times 10^{9}\times 3.2\times 10^{-19}}{25}\times\frac{4}{5}$$

$E = 1.8432\times 10^{-10}\ N/C$ (x⁻)

$\theta = 180°$ with x^+

$E = -1.8432\times 10^{-19}\hat{i}$

$$E=\frac{q}{2\pi\epsilon_0 z^2\left(1-\left(\frac{a}{2}\right)^2\right)^2}$$

$$=\frac{3.2\times 10^{-19}\times 4}{2\pi\times 8.85\times 10^{-12}\left(1-\frac{4}{4}\right)^2}\times\frac{4}{5}$$

$$E=\frac{2\times 3.2\times 10^{-19}\times 6}{2\pi\ 8.85\times 10^{-12}\times 64}\left(1-\left(\frac{6}{2}\right)^{-2}\right)$$

64

$$\frac{3.2\times 10^{-19}\times 6}{3.62\times 10^{-8}}$$

② if y is doubled $y=8$ $\therefore r=\sqrt{9+64}$

$= 8.54$

$$E=\frac{2\times 9\times 10^{9}\times 3.2\times 10^{-19}}{(8.54)^2}\times\frac{8}{8.54}$$

72

x^- $\theta = 180°$

7.38×10^{-11}

Energy

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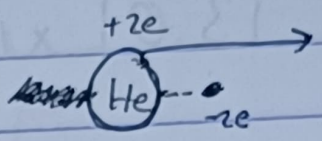
Problem 60

$m = 6.64 \times 10^{-27}\ kg$

$q = +2e$



$$F_{E_{He}} = mg$$

$$= 6.64 \times 10^{-27} \times 9.8$$

$$\boxed{F_{He} = 6.5072 \times 10^{-26}\ N}$$

$$E = \frac{F_{He}}{|2|} = \frac{6.5072 \times 10^{-26}}{2 \times 1.6 \times 10^{-19}}$$

10^{-7}

$$E = 2.0335 \times 10^{-7}\ N/C$$

$$E_2 = 2E = 4.067 \times 10^{-7}$$

$$F_2 = 2Eq$$

$$= 2 \times 4.067 \times 10^{-7} \times 2 \times 1.6 \times 10^{-19}$$

$$\boxed{F_2 = 13.01 \times 10^{-26}\ N}$$

$$\Sigma F_{net} = ma$$

$$F_2 - F_g = ma$$

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$$13.01 \times 10^{-26} - 6.64 \times 10^{-27} \times 9.8 = ma$$

$$13.01 \times 10^{-26} - 6.5 \times 10^{-26} = 6.64 \times 10^{-27} a$$

$$6.5 \times 10^{-26} = 6.64 \times 10^{-27} a$$

$$a = \frac{6.5 \times 10}{6.64}$$

$$\boxed{a = 9.8\ m/s^2}$$

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Chapter 23

Electrical flux:

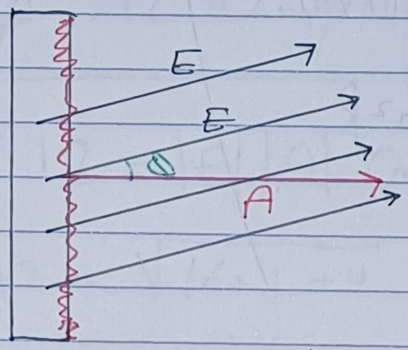
* Flux * # of electric field lines through a normal area

* How we can find the flux?

Case : 1 Uniform electric field $\Rightarrow \phi = \vec{E} \cdot \vec{A}$

يعبر عن المساحة بعمودي على السطح

$$\phi = |E||A| \cos\theta .$$



ϕ_{max} $\theta = 0$.

$\phi_{min} = 0 \Rightarrow E \perp A$ $\theta = 90^\circ$

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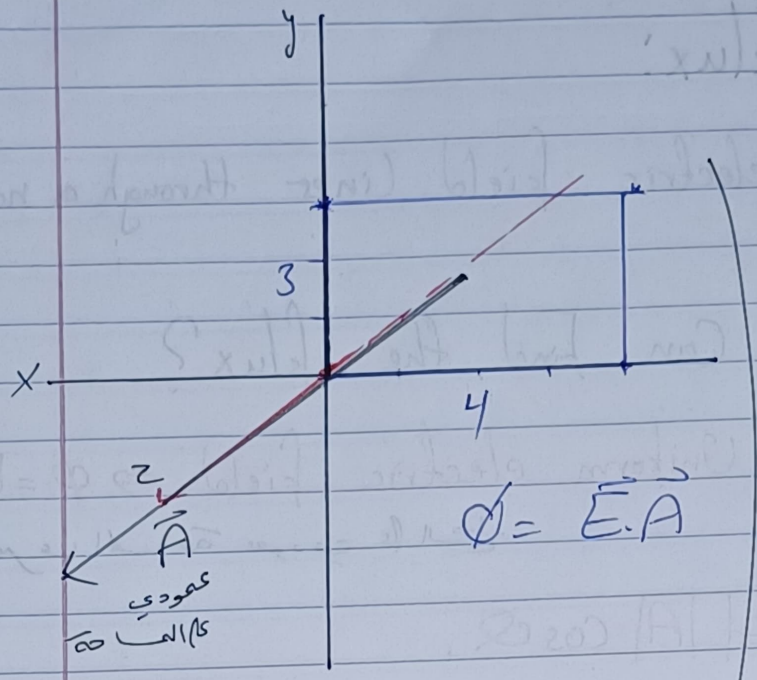
Exp

if $\vec{E} = 4i + 2j + 5k$ Area is rectangular with dimension 4 x 3 cm Lieing on the x-y plane find ϕ



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

$\phi = 5 \times 12 \times 10^{-4}\ N.m^2/C$

$\phi = 60 \times 10^{-4}\ N.m^2/C$

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

$|\vec{A}| = 4 \times 3 \times 10^{-2} \times 10^{-2}$

$= 12 \times 10^{-4}\ m^2 \hat{k}$

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Exp: $\vec{E} = 4\hat{i} + \hat{j} - 2\hat{k}$

$\vec{A} = 3\hat{i} + 2\hat{j} + \hat{k}$

① Find Net Flux
② Angle between $\vec{E}$ and $\vec{A}$

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

~~$\phi = 12\hat{i} + 2\hat{j} - 2\hat{k}$~~

~~$\phi = \sqrt{(12)^2 + (2)^2 + (2)^2}$~~

~~$= \sqrt{144 + 4 + 4}$~~

Scaler $\leftarrow$ ~~$\phi = 12 + 2 - 2$~~

$\phi = 12\ N.m^2/C$

$12 = |E||A| \cos\theta$

$12 = \sqrt{16+1+4} * \sqrt{9+4+1} \cos\theta$

$12 = \sqrt{21} * \sqrt{14} \cos\theta$

$\cos\theta = \frac{12}{17.14}$

$\theta = \cos^{-1}(0.699)$

$\theta = 45.58°$

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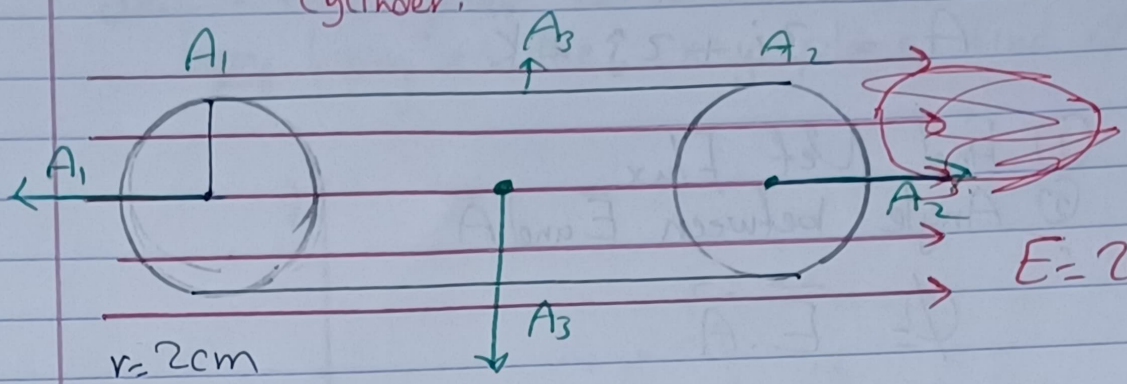
Ex: find the Net Flux through the below cylinder.



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

$$\phi_{net} = \phi_1 + \phi_2 + \phi_3$$

$A = \pi r^2$

$$= E A_1 \cos 180 + E A_2 \cos 0 + E A_3 \cos 90$$

$$= 2000 \times \pi \times (0.02)^2 \times -1 + 2000 \times \pi \times (0.02)^2 \times 1 + 0$$

$$= -0.8\pi + 0.8\pi + 0$$

$$\boxed{\phi_{net} = \text{zero}}$$

* Note:

the Net flux through any closed and Isolated uniformed shape equal zero.

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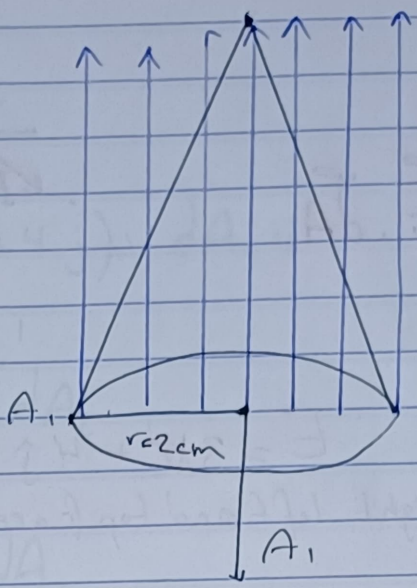
Expl

Find ϕ through each surface.



$A_1 = \pi r^2$

$\phi = E A_1 \cos\theta$

$= 400 \times \pi \times (0.02)^2 \cos^{-1} \cos 180$

$\boxed{\phi_1 = -0.5 \ N.m^2/C}$

Uniform closed shape.

ϕ_2 $\quad \phi_{net} = 0$

$\phi_{net} = \phi_1 + \phi_2 = 0$

$\boxed{\phi_2 = 0.5 N.m^2/C}$

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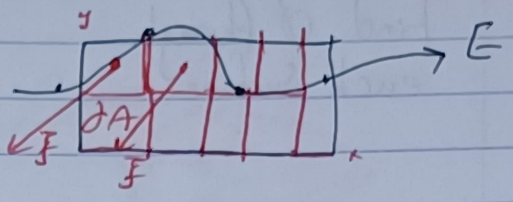
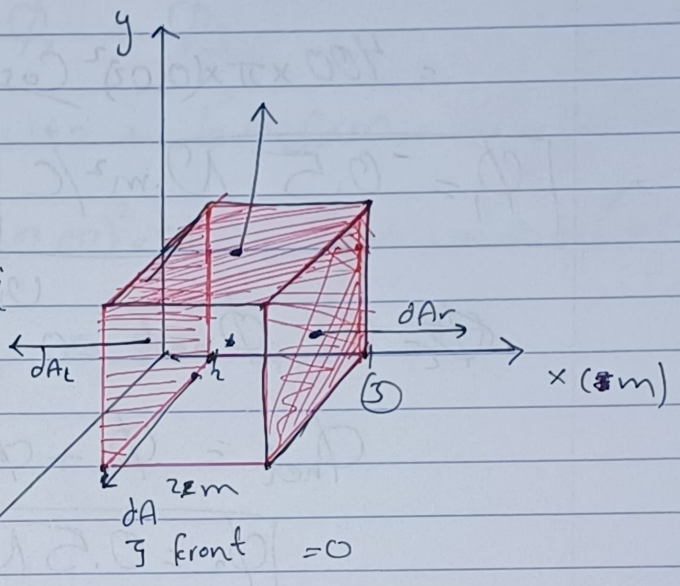
Case II: Non Uniform Electric Field.



$$\phi = \int \vec{E} \cdot \vec{dA}$$

Exp: $\vec{E} = 3x\hat{i} + 4\hat{j}$, what is the ϕ through the right, left and top face of a cube.



① Right face

$$\phi = \int \vec{E} \cdot \vec{dA_r}$$

$$= \int (3x\hat{i} + 4\hat{j})(dA_r)\hat{i}$$

$$= \int 3x\, dA_r$$

$$= 3\int x\, dA_r \quad (x = 2)$$

$$= 9 \int dA_r$$

$$= 9A$$

$$= 9 \times (2)^2$$

$$= 9 \times 4 = 36\ N.m^2/C$$

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② Left face.

$$\Phi_L = \int \vec{E} \cdot d\vec{A}_L$$

$$= \int (3x\hat{i} + 4\hat{j}) \; dA_L (-\hat{i})$$

$$\Phi_L = \int -3x \, dA_L$$

$$= -3 \int dA_L$$

$$= -3 \; A_L$$

$$= -3 \times 4 = -12 \, N.m^2/C$$

③ Top face.

$$\Phi_T = \int \vec{E} \cdot d\vec{A}_{top}$$

$$= \int (3x\hat{i} + 4\hat{j}) \; (dA) \, \hat{j}$$

$$= \int 4 \, dA_{top}$$

$$= 4 \; A_t$$

$$= 4 \times (2)^2 = 16 \, N.m^2/C$$

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Exp: $E = 4x\hat{i} + 4\hat{j} + 5y\hat{k}$

$d\vec{A} = 3\hat{i} + 4\hat{j}$ find ϕ

$\phi = \int E \cdot dA$

$x = [-1, 2]$

$y = [0, 3]$

$= \int (4x\hat{i} + 4\hat{j} + 5y\hat{k}) \cdot (3\hat{i} + 4\hat{j})$

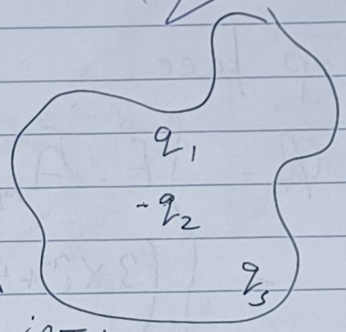
$= \int_{-1}^{2} 12x\hat{i} + 16\hat{j} + 0 \, dx$

$= (6x + 16)\Big|_{-1}^{2}$

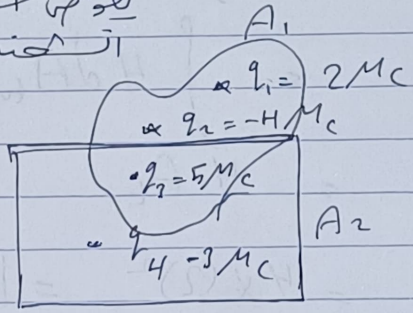
$= (18 + 16) - (-9 + 16)$

Case III

$\phi_{net} = \frac{\sum q_{enc}}{\epsilon_0}$



$\epsilon_0 = 8.85 \times 10^{-12}$



Exp:

$\phi_1 = \frac{\sum q_{enc}}{\epsilon_0} \times 10^6$

$= \frac{(2 - 4 + 5) \times 10^{-6}}{8.85 \times 10^{-12}}$

$= 3.38 \times 10^5 \, N \cdot m^2/C$

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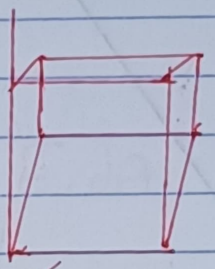
$$\Phi_2 = \frac{\Sigma q_{enc}}{\epsilon_0}$$

$$= \frac{(5-3)\times 10^{-6}\times 10^{6}}{8.85\times 10^{-12}}$$

$$= \$\ 2.25\times 10^{6}\ N.m^2/C$$

Exp: Cube of Side 10cm



(a) $q = 12\mu c$

(1) Net flux

$$\Phi = \frac{\Sigma q_{enc}}{\epsilon_0} = \frac{12\times 10^{-6}}{\epsilon_0} = 1.4\times 10^{6}$$

(2) Flux through each Surface.

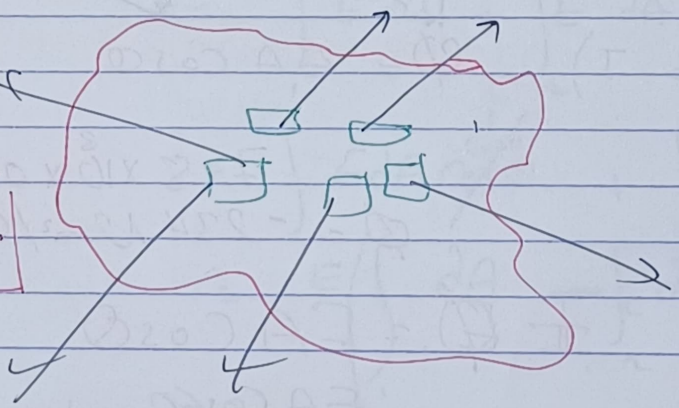
$$\Phi_{surface} = \frac{1}{6}\cdot \Phi_{net} \text{ for each Surface.}$$

Conducting shaps $E=0$ inside

Non Conducting the Charge distribute inside.

$$\Phi = \int E \cdot dA$$

$$\boxed{\Phi = \int E \cdot dA.}$$



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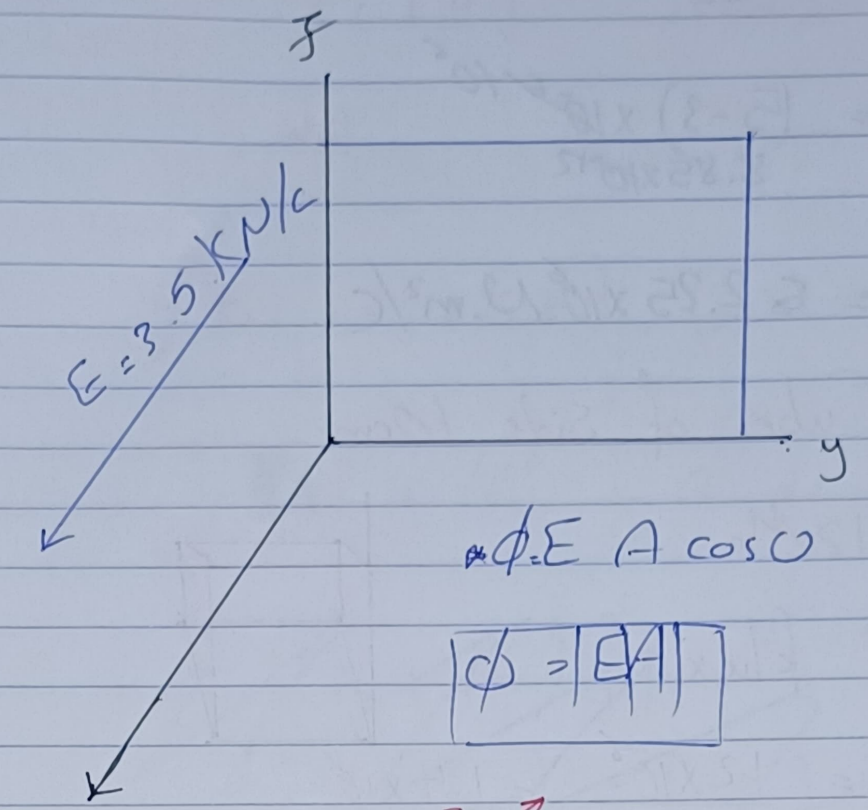
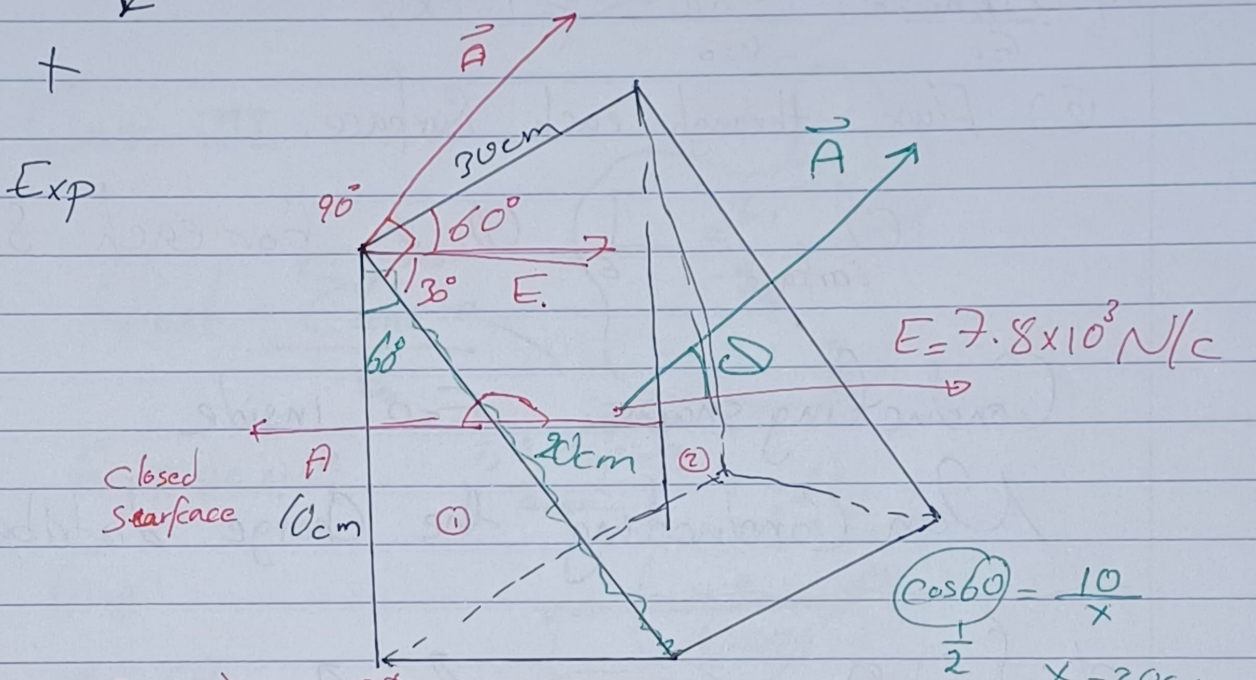
Exp:



$\phi = E A \cos\theta$

$\boxed{\phi = |E||A|}$

Exp



$\cos 60 = \frac{10}{x}$

$\frac{1}{2}$

$x = 20cm$

i) I) $\phi = EA\cos\theta$

$= 7.8 \times 10^3 \times 0.1 \times 0.3 \times \cos 180$

$\phi = -234\ N.m^2/C$

II $\phi = EA\cos\theta$

$= EA\cos 60 \quad 0.1$

$= 7.8 \times 10^3 \times 0.2 \times 0.3 \times \cos 60$

$= -234\ N.m^2/C$

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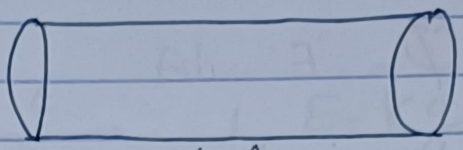
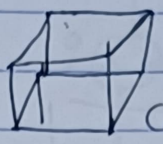
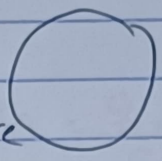


Cylinder.

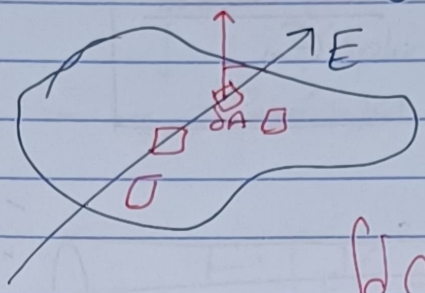


Cube



sphere

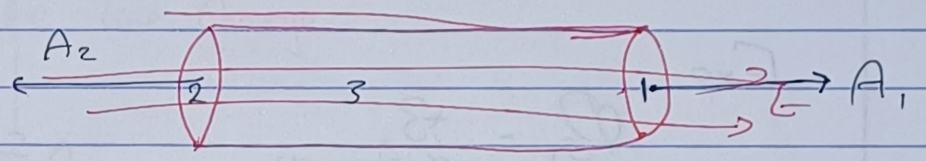
Guassain's Surface.



$$\int d\phi = \int E \cdot dA$$

$$\phi = \oint E \cdot dA$$

Integration on Closed Surface.



$$\phi = \oint E \cdot dA \quad \text{---} (1)$$

$$= \int_1 E \cdot dA + \int_2 E \cdot dA + \int_3 E \cdot dA \quad (\theta = 90)$$

$$= \int_1 E dA \cos 0 + \int_2 E dA \cos 180$$

$$= E\left(\int_1 dA - \int_2 dA\right)$$

$$= E\left(\pi R^2 - \pi R^2\right)$$

$$\phi_{net} = 0$$

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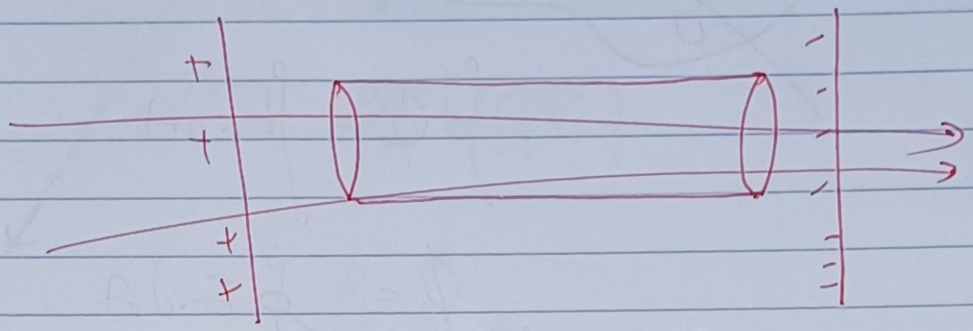
Guass. ⟶

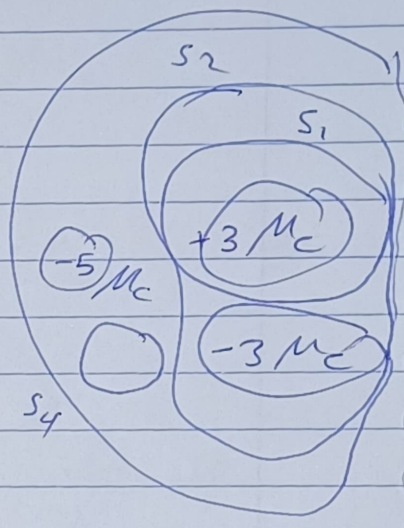
$$\Phi = E \cdot dA$$

$$\Phi = \frac{\sum Q_{enclosed}}{\epsilon_0}$$



$$\Phi = \frac{0}{\epsilon_0} = 0$$

Exp



$$\Phi_{S_1} = \frac{+3}{8.85\times10^{-12}}$$

$$= 3.39\times10^{11}\ N.m^2/C$$

$$\Phi_{S_2} = \frac{+3-3}{8.85\times10^{-12}} = 0$$

$$\Phi_{S_3} = \frac{+3-3-5}{8.85\times10^{-12}} = -5.6\times10^{11}\ N.m^2/C$$

$$\Phi_{S_4} = 0$$

صافي الشحنات داخل السطح

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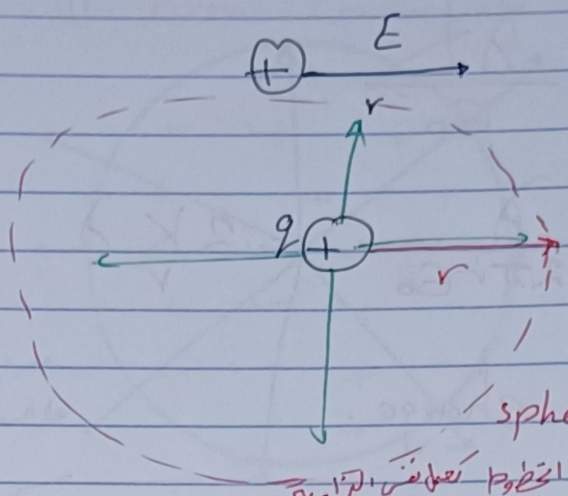
① Guass on point charge



$E = \frac{Kq}{r^2}$ → Columb

$\oint E \cdot dA = \frac{q_{en}}{\epsilon_0}$

$\int E dA \cos\theta = \frac{q}{\epsilon_0}$

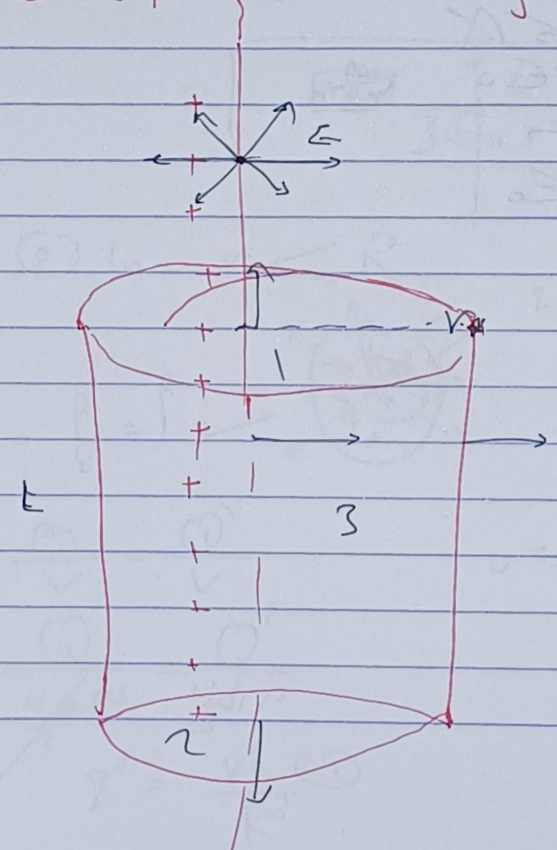
- يجب صحيح الخطوط تعامد الزاوية

$E \int dA = \frac{Q}{\epsilon_0}$

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

$\boxed{E = \frac{q}{4\pi\epsilon r^2}}$ اثبات قانون كولوم من قانون جاوس

② Infinate line Charge



$\int E \cdot dA = \frac{q_{en}}{\epsilon_0}$

$\int_1 E dA + \int_2 E dA + \int_3 E dA = \frac{q_{en}}{\epsilon_0}$

$\int_3 E dA = \frac{q_{en}}{\epsilon_0}$

$E \int dA \cos\theta = \frac{q_{en}}{\epsilon_0}$

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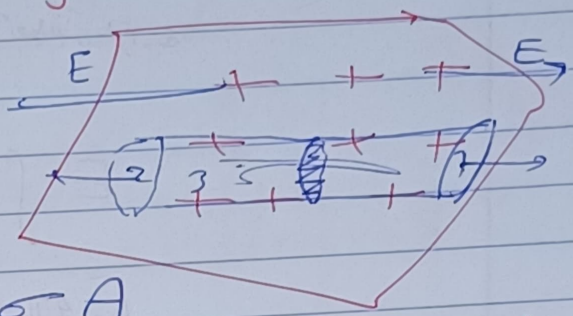
$$E \int dA = \frac{\lambda L}{\epsilon_0} \qquad \lambda = \frac{q}{L}$$

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

هيخ قاعدة الاسطوانة x الارتفاع

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

③ Infinate Surface charge.



$$\oint E.dA = \frac{q_{en}}{\epsilon_0}$$

$$\int_{\cos 0} E.dA + \int_{2} E.dA_{\cos 90} + 0 = \sigma A$$

$$\sigma = \frac{q}{A} \ C/m^2$$

$$EA_1 + EA_2 = \sigma A$$

$$2EA = \frac{\sigma A}{\epsilon_0}$$ Plain

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

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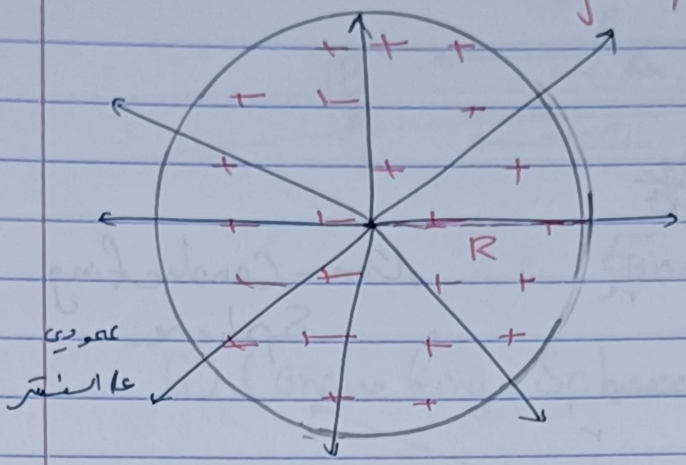
② Volume charge.

(1) Non Conducting sphere.

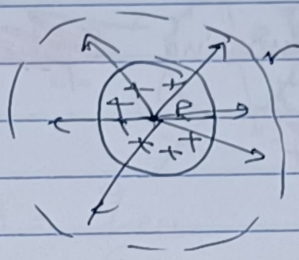


$$\rho = \frac{q}{V} \quad c/m^3$$

Volume charge density.

* $E_{out\ side}$
* E_{in}
* $E_{surface}$

① out



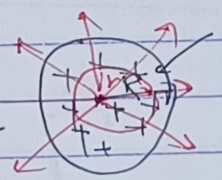
$$\int E \cdot dA = \frac{q_{en}}{\epsilon_0}$$

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

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

$$\star\ \boxed{E = \frac{q}{4\pi\epsilon_0 r^2}}$$

② In $r < R$



$$\int_1 = \int_2 = \int_s$$

$$\int E \cdot dA = \frac{q_{enc}}{\epsilon_0}$$

$$E\,4\pi r^2 = \frac{q'}{\epsilon_0}$$

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

$$\frac{Q}{\frac{4}{3}\pi R^3} = \frac{Q'}{\frac{4}{3}\pi r^3}$$

$$q' = \frac{r^3}{R^3}\,Q$$

$$E\,4\pi r^2 = \frac{r^3 q}{R^3 \epsilon_0}$$

$$\boxed{E = \frac{q r}{4\pi\epsilon_0 R^3}} = \frac{1}{4\pi\epsilon_0}\frac{q r}{R^3}$$

or $q = \rho\,\frac{4}{3}\pi R^3$

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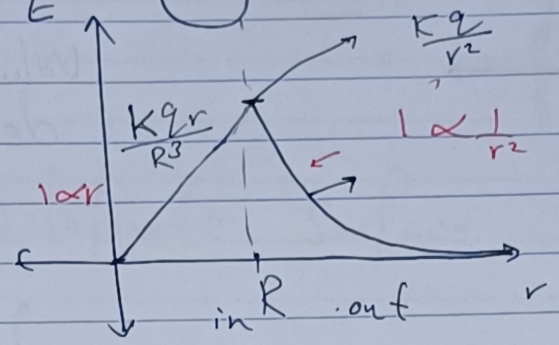
OR $E = \frac{\rho \cancel{\frac{4}{3}\pi} \cancel{R^3} r}{\cancel{4\pi\epsilon_0} \cancel{R^3}}$

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



Non-Conducting Sphere

(2) Conducting ~~Sphere~~.

~~$E_{in} = 0$~~

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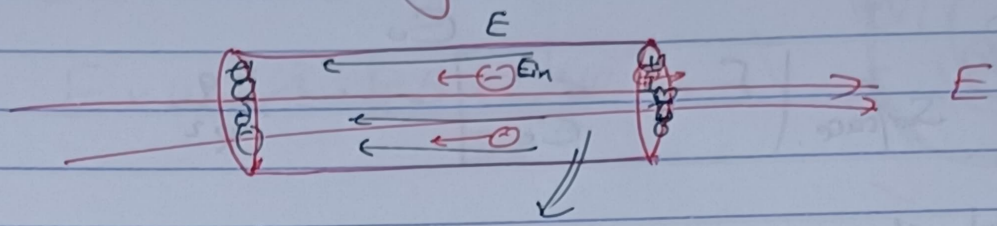
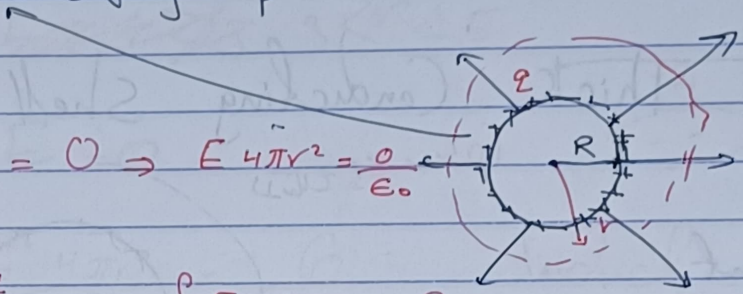
Conducting



$E_{in} = 0$

① Conducting Sphere.



$E_{in} = 0 \Rightarrow E\,4\pi r^2 = \frac{0}{\epsilon_0}$

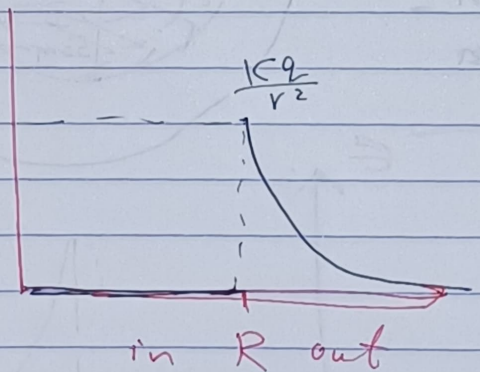
① E_{out} $\int E.dA = \frac{q_{en}}{\epsilon_0}$

$E \times 4\pi r^2 = \frac{q}{\epsilon_0}$

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

$$= \frac{1}{4\pi\epsilon} \times \frac{\sigma\, 4\pi R^2}{r^2}$$

$$E = \frac{\sigma R^2}{\epsilon r^2}$$



Conducting sphere.

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② $\oint E \cdot dA = \frac{q_{enc}}{\epsilon_0}$ $\quad r = R$

$E \times 4\pi r^2 = \frac{\sigma \times 4\pi R^2}{\epsilon_0}$

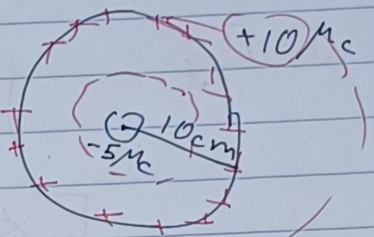
Surface. $\boxed{E = \frac{\sigma}{\epsilon_0}} = \frac{kq}{R^2}$

Shell $\Longrightarrow$ $E_{out} = \frac{kq}{r^2}$

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

* Thick Conducting Shell

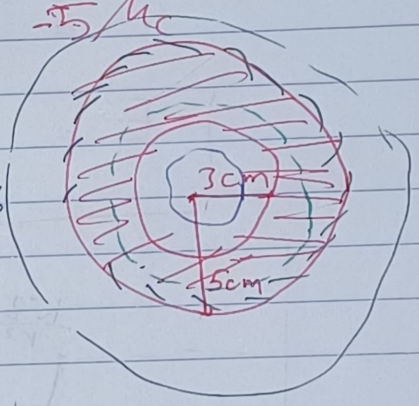
E_{out}



① $E \times 4\pi r^2 = \frac{+5 \times 10^{-6}}{\epsilon_0}$

② E_{in} $\quad E \times 4\pi r^2 = \frac{5 \times 10^{-6}}{\epsilon_0}$

Exp Conducting material



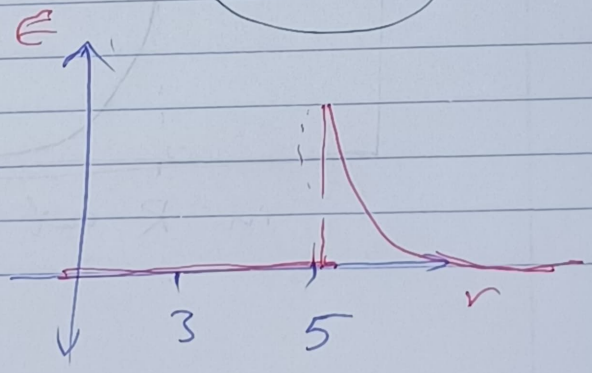
① $r > 5$

$|E| \times 4\pi r^2 = \frac{q_{en} = +5 \times 10^{-6}}{\epsilon_{or}}$

② $5 > r > 3$

$E_{in} = 0$

③ $r < 3 = 0$



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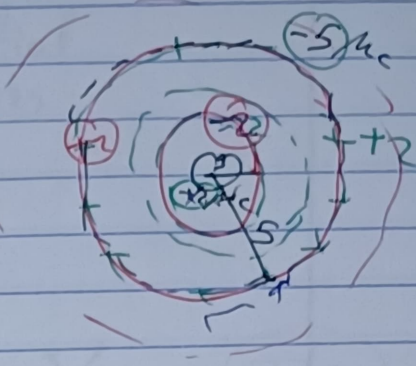
Conducting

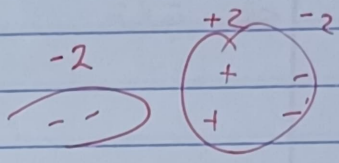


Eat $r > 5$

$$E \times 4\pi r^2 \quad \frac{|(-5+2)| \times 10^{-6}}{\epsilon_0}$$

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

E ~~5~~ $3 < r < 5$



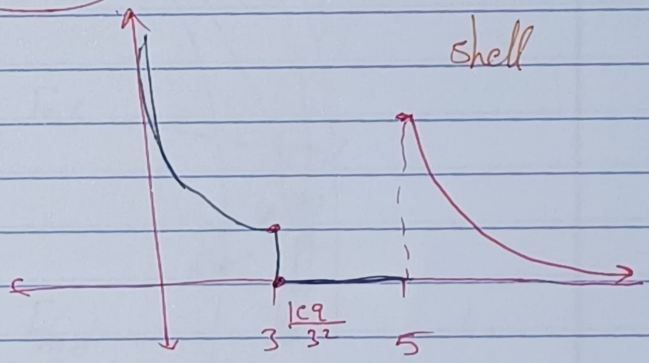
$E = 0$

$E\, 4\pi r^2 = \frac{Q}{\epsilon_0}$ Induction

$r < 3$

$$E \times 4\pi r^2 = \frac{+2}{\epsilon_0}$$

$$= \frac{1c\,q}{r^2}$$



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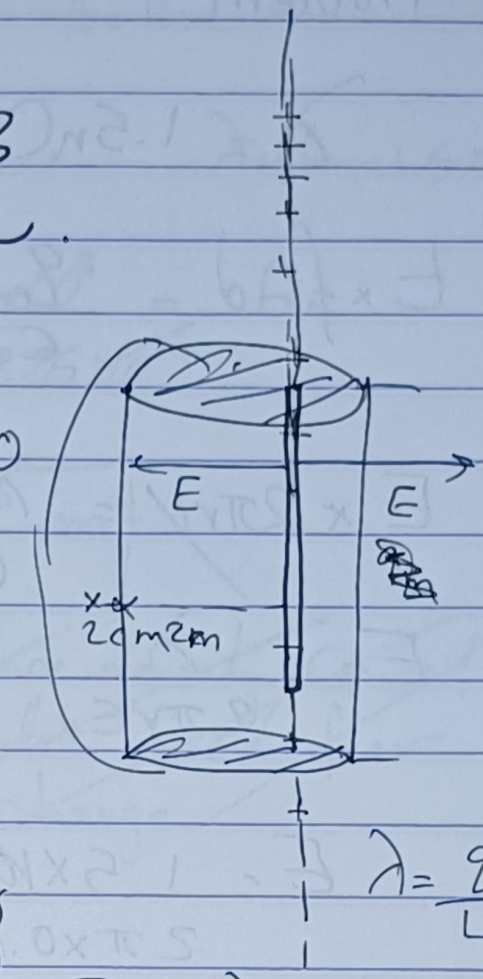
Problems Chapter 3

Problem 1

$E = 1.7 \times 10^4 N/C$



$$E \int dA = \frac{q_{en}}{\epsilon_0}$$

q_{en}

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

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

$$= \frac{8.5 \times 10^{-6}}{2\pi \times 2 \epsilon_0}$$

$$\boxed{E = 7.6 \times 10^4 N/C}$$

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

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

$$1.7 \times 10^4 = \frac{\lambda}{2\pi \times 9 \times 8.85 \times 10^{-12}}$$

$$\lambda = 8.5 \times 10^{-6}$$

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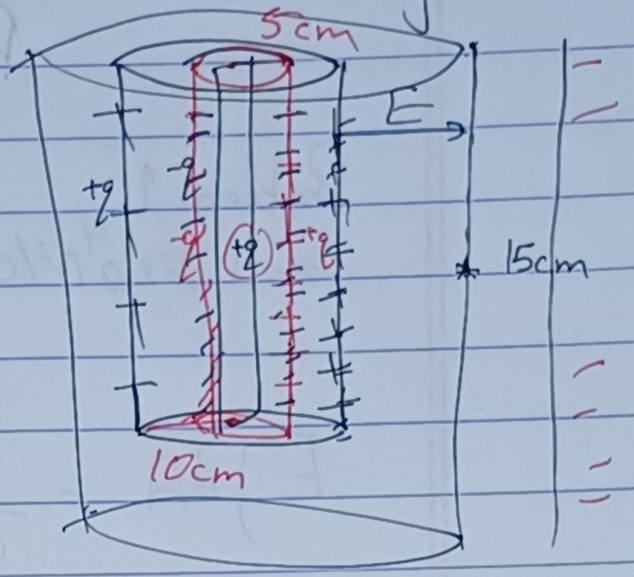
Problem 4

Non Conducting rod.

$\lambda = 1.5 nC/m$



a)

$$E \times \oint A\,d = \frac{q_{en}}{\epsilon_0}$$

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

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

$q = \lambda L$

$$E = \frac{1.5 \times 10^{-9} \times 10^{3}}{2\pi \times 0.15 \times 885 \times 10^{-12}}$$

$$\boxed{E = 179.8\ N/C}$$

b) $\sigma = \frac{q}{A}$

the inner surface Must Carry charge equal to and negative of the rod

$\lambda_{inner} = -1.5 \times 10^{-9}$

for Cancelling the E_{inner}

$$\sigma_{inner} = \frac{-\lambda L}{A} = \frac{\lambda L}{2\pi r L} = \frac{1.5 \times 10^{-9}}{2\pi \times 0.05}$$

$$\boxed{\sigma_{inner} = -4.77 \times 10^{-9}\ C/m^2}$$

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c) must be negative σ_o be 0

$$\sigma_{outer} = \frac{\lambda}{2\pi r \epsilon_0} \qquad \lambda_{outer} = 1.5 \times 10^{-9}$$

$$= \frac{1.5 \times 10^{-9} \quad 10^3}{2\pi \times 0.1 \times 8.85 \times 10^{-12}}$$

$$\boxed{\sigma_{outer} = 2.4 \times 10^{-9} \ C/m^2}$$

the remain Surface density Cancel out the Electric field for Net Zero charge.

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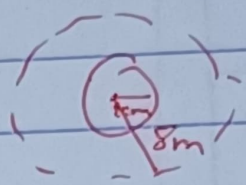
Problem 6

$E_{sphere} = 10 \times 10^7 \, N/C$

r = 2cm



(a) $E\, 4\pi r^2 = \frac{q_{enc}}{\epsilon_0}$

$10 \times 10^7 \times 4\pi \times (0.02)^2 = \frac{q_{enc}}{\epsilon_0 \, 8.85 \times 10^{-12}}$

$q_{enc} = 4.4 \times 10^{-6} \, C$

(b) Non Conducting sphere. r = 8m

$E \times 4\pi r^2 = \frac{q_{enc}}{\epsilon_0}$

Guass

$E \times 4\pi \times (8)^2 = \frac{4.4 \times 10^{-6}}{8.85 \times 10^{-12}}$

$E = 625 \, N/C$

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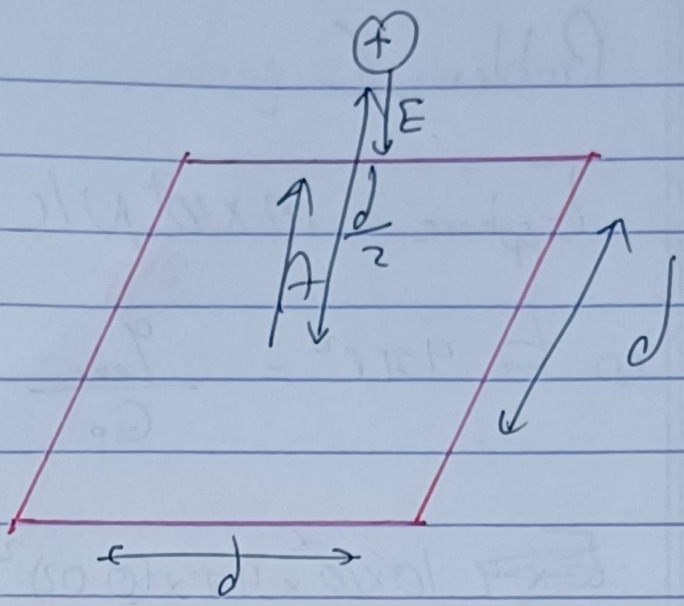
Proton $= 1.6 \times 10^{-19} C$



$$\Phi_{Surface} = \frac{1}{6} \Phi_{net}$$

$$= \frac{1}{6} \times EA \cos 180$$

$$\Phi_{net} = \frac{-1Kq}{\frac{d^2}{4}} \times$$

$$= -4Kq$$

$$\Phi_{net} = \frac{\sum Q_{enc}}{\epsilon_0}$$

$$\Phi_{Surface} = \frac{1}{6} \times \frac{1.6 \times 10^{-19}}{8.85 \times 10^{-12}} \times 10^{-7}$$

$$\boxed{\Phi_{Surface} = 3.01 \times 10^{-9} \, N.m^2/C}$$

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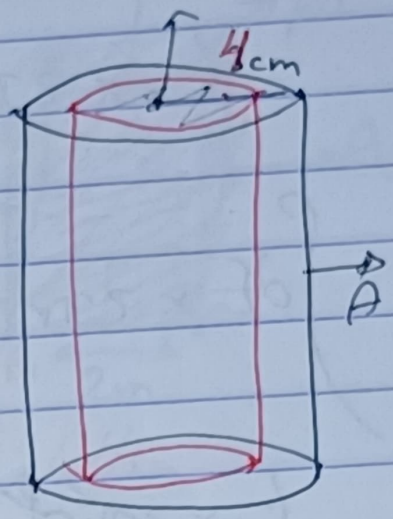
Problem 18



$\rho = Ar^2$

$A = 6.3 \times 10^{-6}\ C/m^2$

(1) $r = 3$

$r \leq R$

$$E \times 2\pi r l = \frac{\rho dV}{\epsilon_0}$$

$$\int E \times 2\pi r l = \int \frac{Ar^2\ 2\pi r l \times dr}{\epsilon_0}$$

$$E \times 2\pi r l = \int_0^{0.03} \frac{A r^2\ 2\pi r l\ dr}{\epsilon_0}$$

$$E \times \cancel{2\pi r} l = \frac{A \cdot \cancel{2\pi} l}{\epsilon_0} \int_0^{0.03} r^3 dr$$

$$E \times r = \frac{6.3 \times 10^{-6}}{8.85 \times 10^{-12}} \times \left(\frac{r^4}{4}\right) \Big|_0^{0.03}$$

$$E \times (0.03) = \frac{6.3 \times 10^{-6}}{8.85 \times 10^{-12}} \times \frac{(0.03)^{\cancel{4}\,3}}{4}$$

$$\boxed{E = 4.81\ N/C}$$

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$r = 5\,cm$

$$E \times 2\pi r l = \frac{\rho \, dV}{\epsilon_0}$$

$$\int dE \times 2\pi r l = \int \frac{AR^2 \times 2\pi R l \times dr}{\epsilon_0}$$

$$E \times 2\pi r l = \frac{A}{\epsilon_0} \times 2\pi l \int_0^{0.04} r^3 \, dr$$

$$E \times r = \frac{6.3 \times 10^{-6}}{8.85 \times 10^{-12}} \times \int_0^{0.05} \left(\frac{r^4}{4}\right)_0^{0.05}$$

$$E \times (0.05) = 7.1 \times 10^5 \times \frac{(0.05)^4}{4}$$

$$E = 1.42 \times 10^7 \times \frac{(0.04)^4}{4}$$

$$\boxed{E = 9.1 \; N/C}$$

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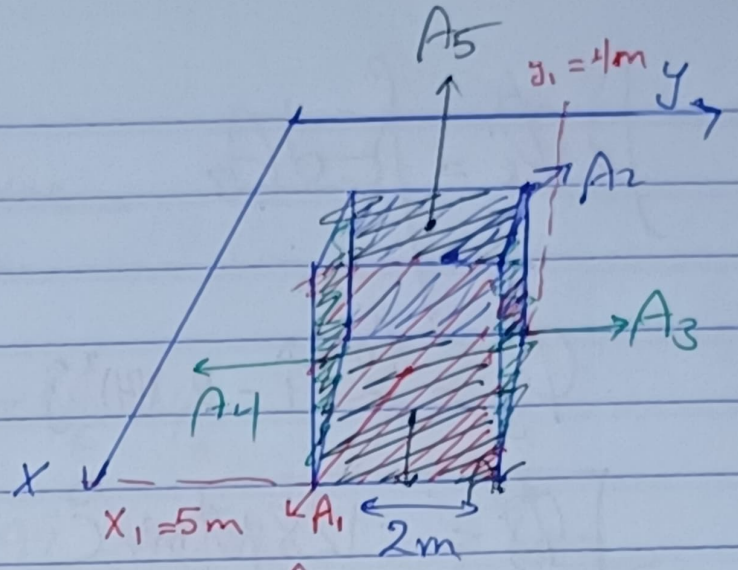
Problem 23



A_3, A_4 Variables

$A_5 \mid A_6 = 0$

$A_1 / A_2 = 0$

$$\vec{E} = +23.0\,i - 2y^2\,\hat{j} - 16\,\hat{k}\ N/C$$

$$\phi_{net} = \frac{\sum Q_{net\,enc}}{\epsilon_0}$$

$$d\phi_1 = E \times dA_1$$

$$\phi_1 = E \int dA_1\,\hat{i}$$

$$= (23i - 2x(y)^2\,\hat{j} - 16\hat{k}) \times -4\,\hat{i}$$

$$\boxed{\phi_1 = -92\,i}$$

$$d\phi_2 = \int E\,dA_2$$

$$\phi_2 = (23i - 2x(y)^2\,\hat{j} - 16\hat{k}) \times 4i$$

$$\boxed{\phi_2 = 92\,\hat{i}}$$

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$$\int d\phi_3 = \int E\, dA_3$$

$$\phi_3 = (28\hat{i} - 2x(4)^2\hat{j} - 16\hat{k}) \cdot 4\hat{j}$$

$$\boxed{\phi_3 = -128\ N.m^2/C}$$

$$\phi_4 = E\int dA_4 \quad \Rightarrow \text{at left Surface } y=2m$$

Surface 2m with Corner of K

$$= (28\hat{i} - 2x(2)^2\hat{j} - 16k)\, x(2)^2\hat{j}$$

$$\boxed{\phi_4 = 32\ N.m^2/C}$$

$$\phi_5 = E\int dA_5$$

$$= (28\hat{i} - 2xy^2\hat{j} - 16\hat{k}) \cdot (2)^2\hat{k}$$

$$\boxed{\phi_5 = -64\ N.m^2/C}$$

$$\boxed{\phi_6} = E\int dA_6$$

$$= (28\hat{i} - 2xy^2\hat{j} - 16k) \cdot -4\hat{k}$$

$$\boxed{\phi_6 = 64\ N.m^2/C}$$

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$$\phi_{net} = \frac{\sum q_{enc}}{\epsilon_0}$$

$$\phi_1 + \phi_2 + \phi_3 + \phi_4 + \phi_5 + \phi_6$$

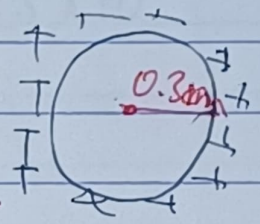
$$-128 + 64 - 64 + 92 - 92 + 32 = \frac{q_{en}}{8.85\times10^{-12}}$$

$$\boxed{q_{en} = -8.496\times10^{-10}\,C}$$

Problem 39

Uniform $\sigma = 5.7\times10^{-6}\,C/m^2$ Conducting Sphere.

ϕ (1) = 0.6m



(1) $E \times 4\pi r^2 = \frac{6 * 4\pi r^2}{\epsilon_0}$

$$E = \frac{\sigma}{\epsilon_0} = \frac{5.7\times10^{-6}\times10^{6}}{8.85\times10^{-12}}$$

$$\boxed{E = 6.4\times10^{5}\,N/C}$$

$$q_{enc} = \frac{E \times 4\pi \times (0.3)^2}{9\times10^{9}} \times \epsilon_0$$

$$= 6.4\times10^{5} \times 4\pi \times (0.3) \times 8.85\times10^{-12}$$

$$\boxed{q_{en} = 6.4\times10^{-8}\,C}$$

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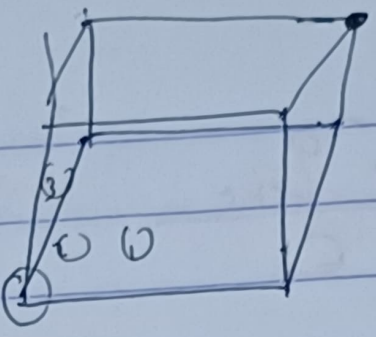

Note.

$\frac{1}{8}$ الحصة داخل المكعب

$$\phi_{123} = 0$$

$$\phi_{4,5,6} = \frac{Q}{\epsilon_0 \, 8 \times 3}$$

b) $\phi = \frac{Q_{en}}{\epsilon_0} \cdot A$

$$\phi = \frac{Q_{en}}{\epsilon_0} = \frac{6.4 \times 10^{-8} \times 10^4}{8.85 \times 10^{-12}}$$

$$\phi = 7.2 \times 10^3 \; N.m^2/C$$

$$\boxed{\phi = 723 \; N.m^2/C}$$

c) at $a = 2m$

ϕ the same $= 723 \; N.m^2/C$

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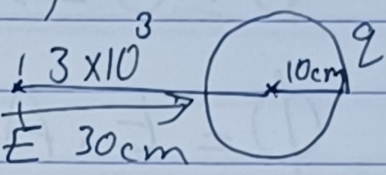
Additional Problems

Problem 3

$E = 3 \times 10^3 N/C$

$Q = -q$



a)

$$E \times 4\pi r^2 = \frac{Q_{enc}}{\epsilon_0}$$

$$Q_{enc} = 4\pi \times (0.3)^2 \times 8.85 \times 10^{-12} \times 3 \times 10^3$$

$$= 1 \times 10^{-11} \times 3 \times 10^3$$

$$\boxed{Q_{en} = 3 \times 10^{-8} C}$$

(b) $$\sigma = \frac{Q}{A} = \frac{3 \times 10^{-8}}{4\pi \times (0.11)^2}$$

1×10

$$\sigma = 2.38 \times 10^{-7} C/m^2$$

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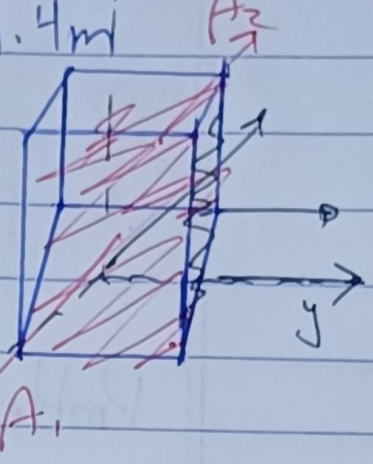
Problem 13

edge Length = 1.4m



$A_{right\ face} = (1.4)^2 = 1.96\,\hat{j}$

a) $\phi = 0 \Rightarrow -2\hat{j} \times 0\hat{j}$

b) $\phi = E \cdot A$

$= -2\hat{j} \times 1.96\hat{j}$

$\boxed{\phi = -3.92\ N.m^2/C}$

c) $\phi = E \cdot A$

$= (-20\hat{i} + 0\hat{j} + 4\hat{k}) \cdot 1.96\hat{j}$

$\phi = 0$

d) a) $\phi_{tot} = -1.96E + 1.96E$ A_1, A_2

$= 0$

b) for all Magnitude for E

$\phi = 0$ Closed Cube.

c) $= 0$

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(c) $E = -20i + 4k$ = ~~4400 N/C~~

Right, Left $\phi = 0$

$\phi_{Top} = EA\cos\theta = E.A$

$= (-20i + 4k)\ 1.96\hat{k}$

$$\boxed{\phi_{Top} = 7.84\ N.m^2/C}$$

$\phi_{bottom} = (-20i + 4k) * -1.96\hat{k}$

$$\boxed{\phi_{bottom} = -7.84\ N.m^2/C}$$

$\phi_{back} = (-20i + 4k) * -1.96\ i$

$$\boxed{\phi_{back} = 39.2\ N.m^2/C}$$

$\phi_{front} = (-20i + 4k) * 1.96\ i$

$= -39.2\ N.m^2/C$

$$\boxed{\phi_{net} = 0}$$

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e) Dont Matter

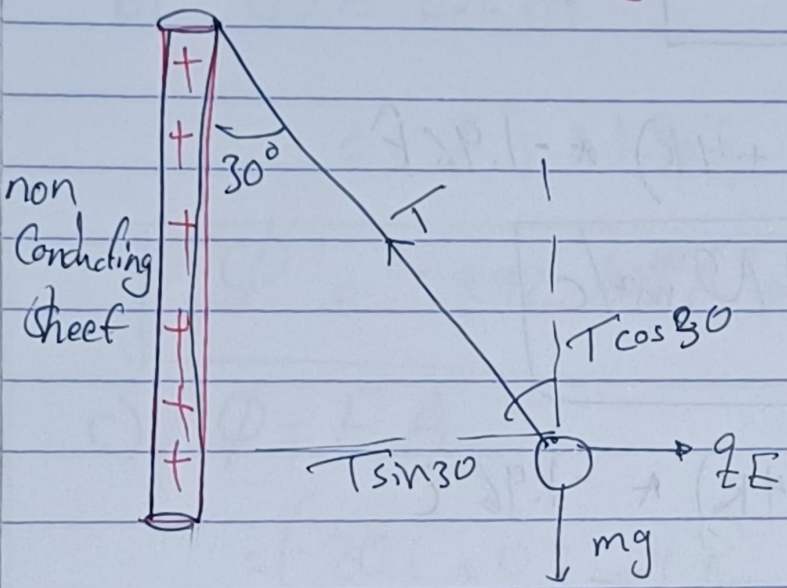
$\Phi_{total} = 0 \Rightarrow \frac{q_{enc}}{\epsilon_0} = 0$

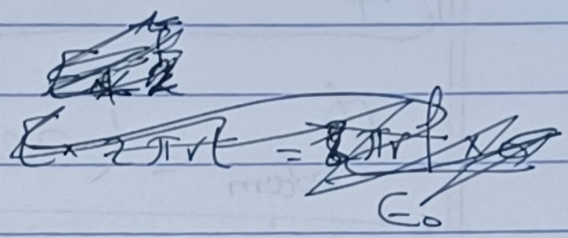
Closed Isolated Shape

Problem 21

- Non Conducting ball

$m = 7.3\,mg$ / $q = 2 \times 10^{-8}\,C$ Uniformely.





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

$\frac{qE}{mg} = \frac{T \sin 30}{T \cos 30}$ ÷

$\tan 30 = \frac{q \times \sigma}{2\epsilon_0 \, mg}$

$0.577 = \frac{2 \times 10^{-8} \times \sigma}{2 \times 8.85 \times 10^{-12} \times 7.3 \times 10^{-3} \times 10^{-5} \times 9.8}$

10^{-18}

10^{-10}

$\sigma = 365.5 \times 10^{-10}\ C/m^2$

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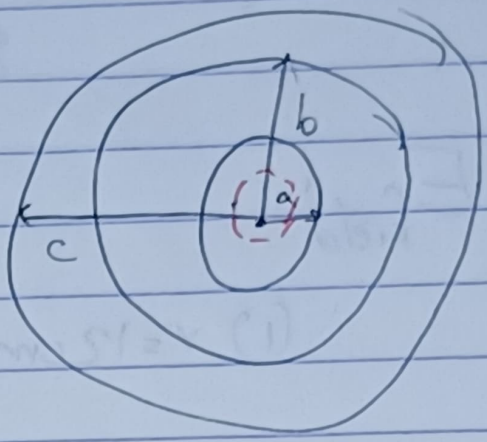
Problem 29



$a = 2\,cm$

$b = 4\,cm$

$c = 4 \times 2.4\,cm$

$Q_{1,\,sphere} = 2 \times 10^{-15}\,C$

Shell $Q_2 = -2 \times 10^{-15}\,C$

a) $r = 0 \Longrightarrow E = 0$.

b) $r = \frac{a}{2} = 1\,cm$

$E \times 4\pi r^2 = \frac{Q_{en}}{\epsilon_0}$

$E \times 4\pi r^2 = \int \frac{4\pi r^2 \times dr}{\epsilon_0}$

$E \times 4\pi \left(\frac{a}{2}\right)^2 = \int_0^{\frac{a}{2}} \frac{4\pi r^2\, dr}{\epsilon_0}$

$E \times 4\pi \frac{a^2}{4} = \int \frac{4\pi}{\epsilon_0} \int_0^{\frac{a}{2}} r^2 dr$

$E \times a^2 = \frac{1.19 \times 10^{-12} \times 4 \times \left(\frac{a}{2}\right)^3}{8.85 \times 10^{-12} \times 3}$

$E \times 4 \times 10^{-4} = \frac{1.19 \times 4 \times 8 \times 10^{-6} \times 10^{-2}}{8.85 \times 3 \times 8}$

$dE = \int \frac{4\pi r^2}{3}$

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

$= \frac{2 \times 10^{-15}}{\frac{4}{3}\pi \times 4 \times 10^{-11}}$

$\int = 1.19 \times 10^{-12}$

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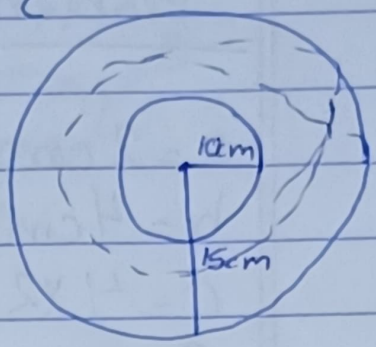
Problem 25

$q_{inner} = 7.5 \times 10^{-8} C$

$q_{outer} = 6.33 \times 10^{-8}$



E_{field}

(1) $r = 12cm$

$$E * 4\pi r^2 = \frac{q_{enc}}{\epsilon_0}$$

$$E \times 4\pi \times (0.12)^2 = \frac{q_1}{\epsilon_0}$$

$$E \times 4\pi \times 0.0144 = \frac{7.5 \times 10^{-8}}{8.85 \times 10^{-12}}$$

$$\boxed{E = 4.68 \times 10^{4} N/C}$$

(2) $r = 20cm$

$$E * 4\pi r^2 = \frac{q_1 + q_2}{\epsilon_0}$$

$$E = \frac{K q_{net}}{r^2} = \frac{9 \times 10^{9} \times 13.83 \times 10^{-8}}{(0.2)^2}$$

$$\boxed{E = 31.11 \times 10^{3} N/C}$$

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Problem 29

2) $r = \frac{a}{2}$

$$E \times 4\pi r^2 = \frac{q_{en}}{\epsilon_0}$$

$$E \times 4\pi r^2 = \int \frac{4\pi r^2 dr}{\epsilon_0}$$

$$E \times 4\pi r^2 = \int_0^{\frac{a}{2}} \frac{4\pi r^2 dr}{\epsilon_0}$$

$$E \times 4\pi r^2 = \frac{4\pi}{\epsilon_0}\left(\frac{r^3}{3}\right)_0^{\frac{a}{2}}$$

$$E \times 4\pi \frac{a^2}{4} = \frac{q}{3V\epsilon_0} * \frac{a^3}{8}$$

$$E = \frac{2\times10^{-15}\ 2\times10^{-2}}{\frac{6}{2} \times \frac{4}{3}\pi \times 8\times10^{-6} \times 8.85\times10^{-12}}$$

$$= \frac{10^{-17}}{16\pi \times 8.85\times10^{-18}} \qquad 10^{1}$$

$$\boxed{E = 2.25\times10^{-2}\ N/C \text{ outward}}$$

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(c) $r = a$

$$E \times 4\pi r^2 = \frac{\int \frac{4}{3}\pi r^3}{\epsilon_0}$$

$$E = \frac{\int r}{3\epsilon_0}$$

$$= \frac{q\,r}{3 \times \frac{4}{3}\pi r_2^3 \epsilon_0} = \frac{q}{3 \times 4\pi\epsilon_0 \times \frac{(2\times10^{-2})^2}{3}}$$

$$= \frac{2\times10^{-15} \times 3 \times 9\times10^{9}}{4\times10^{-4} \times 3}$$

$$= 4.5\times10^{-2} \text{ outward.}$$

(d) $r = 1.5a$

$$E \times 4\pi r^2 = \frac{q_{enc}}{\epsilon_0}$$

$$E = \frac{9\times10^{9} \times 2\times10^{-15}}{2\times10^{-4}}$$

$$E = \frac{9\times10^{9} \times 2\times10^{-15}}{9\times10^{-9}}$$

$$\boxed{E = 2\times10^{-2} N/C}$$

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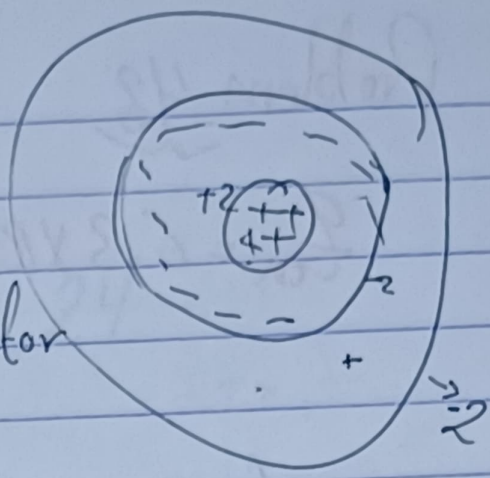
(e) $r = 2.3a$



$E = 0$ inside Conductor

(f) $r = 3.5a$

$$E\,4\pi r^2 = \frac{\sum q_{en}}{\epsilon_0} \qquad \sum q_{enc} = (-2+2)\times 10^{-15} = 0$$

$E = 0$

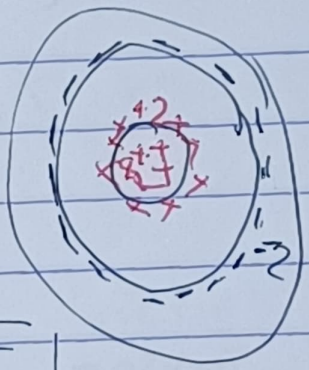
$$E = \frac{9\times10^{9}\times 2\times10^{-15}\times 2\times10^{-15}}{(2\times 3.5\times10^{-2})^2}$$

$$= \frac{9\times4\times10^{-19}}{.49\times10^{-4}}$$

(f) $E = 7.34\times10^{-17}\ N/C$

(g) $\oint E\cdot dA = \frac{q_{en}}{\epsilon_0}$

$0 = q_1 + q_{inner}$



$q_{inner} = -q_1 = -2\times10^{-15}\ C$

Net shell $= -2\times10^{-15}\ C$

(h) outer shell charge $= 0$

$q_{net} = q_{inner} + q_{outer}$

$-2 = -2 + 0$

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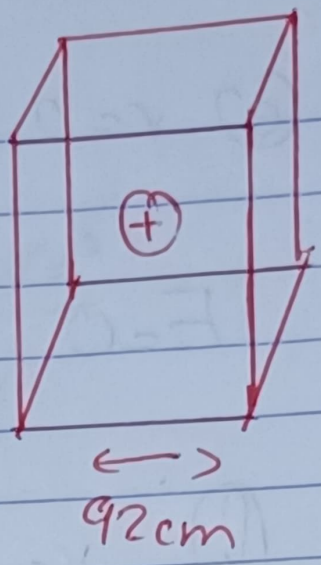
Problem 43

$q_{en} = 6.3 \times 10^{-6} C$



$$\Phi_{net} = \frac{\Sigma q_{enc}}{\epsilon_0}$$

$$= \frac{6.3 \times 10^{-6} \times 10^{6}}{8.85 \times 10^{-12}}$$

$$\boxed{\Phi_{net} = 7.1 \times 10^{5} \, N \cdot m^2/C}$$

(b) $\Phi_{net\ double} = \Phi_{net\ original}$

Because flux ↑ont relation
Net flux
↑ inside
with edge length.

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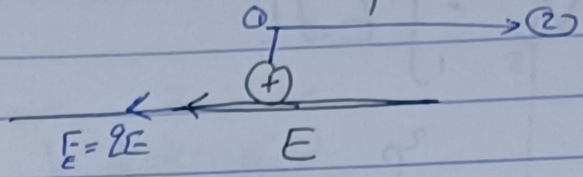
Electric potential



$$\frac{W_{12\ applied}}{q} = \Delta V_{12} = V_f - V_i$$

J/C
Volt
V

* $V_2 - V_\infty = \frac{W_{\infty 2}}{q}$ حيث نقطة

$$V_2 = \frac{W_{\infty 2}}{q}$$

* الشغل لا يعتمد على المسار على النقطة البداية والنهاية
Conservative force (work)

* Definition
* $E \longrightarrow V$
* $V \longrightarrow E$

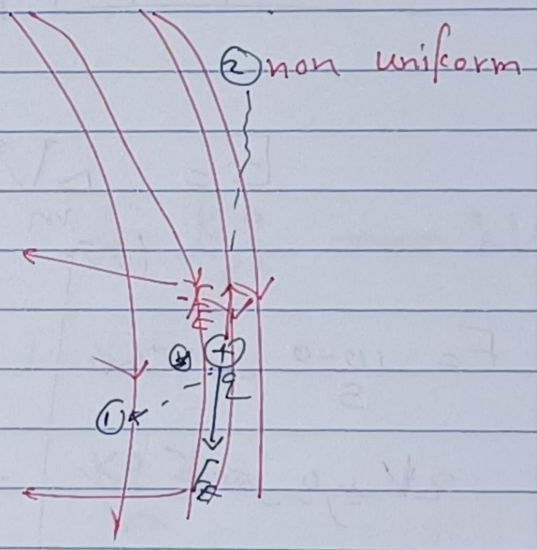
*

$$W = \vec{F} \cdot \vec{l}$$

$$W_{12} = \int_1^2 F \cdot dl$$

$$W_{12} = -\int_1^2 qE \cdot dl$$

$$\frac{W_{12}}{q} = -\int_1^2 E \cdot dl = \Delta V$$



$$\Delta V = \frac{W_{12}}{q} = -\int_1^2 E \cdot dl$$

$V_2 - V_1$

General

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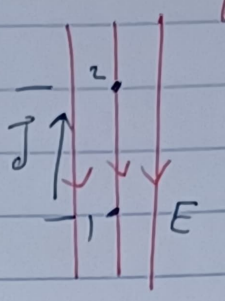
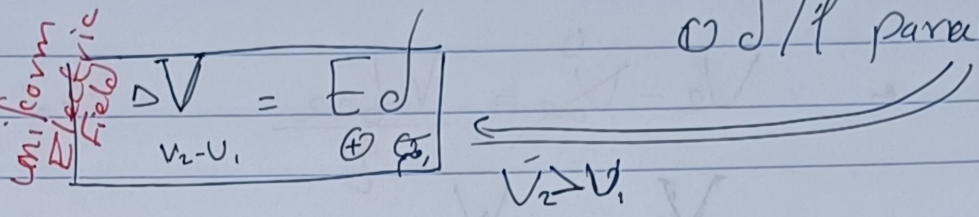
E uniform



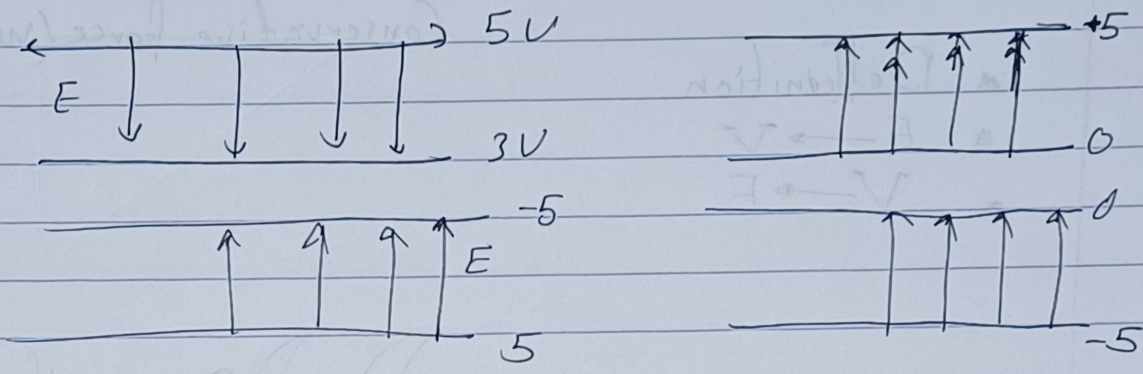
$$\Delta V = V_2 - V_1 = -\int_1^2 E \cdot dL$$

$$= -\int_1^2 E\,dl\cos 180 \qquad \cos 180 = -1$$

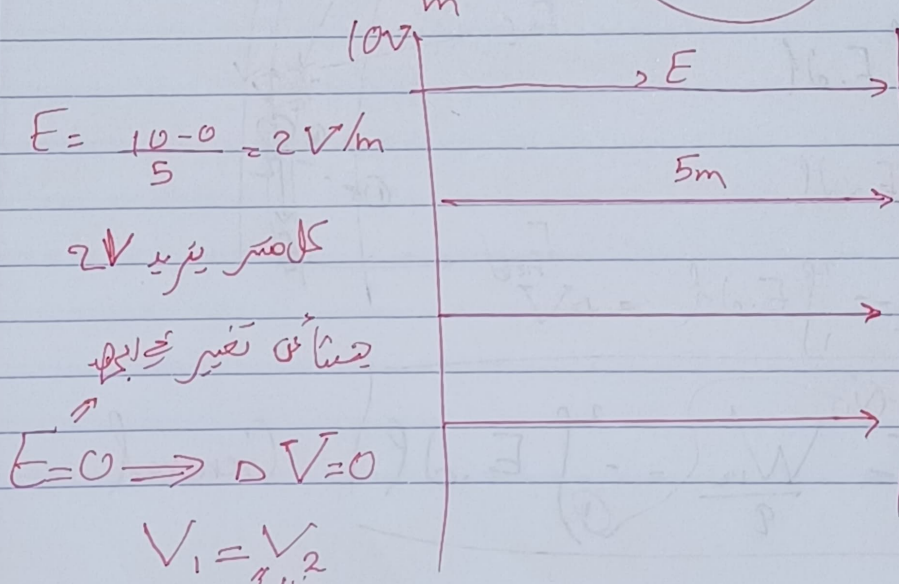
$$= +E\int_1^2 dl$$



المجال الكهربائي من V_2 إلى V_1 أيضا هو من الكبير العالي إلى الأقل



$$E = \frac{\Delta V}{m} \qquad V/m$$



$$E = \frac{10-0}{5} = 2\,V/m$$

كل متر يزيد 2V

حيثما لن تغير فجأة

$$E = 0 \Rightarrow \Delta V = 0$$

$$V_1 = V_2$$

غالبا

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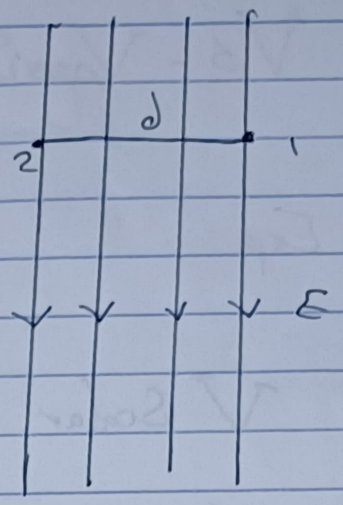
$\Delta V \neq Ed$ ← هذه العلاقة لما يكون Parallel فقط

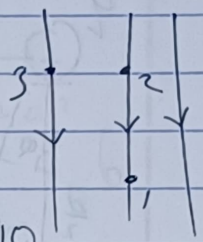


$$\Delta V = -\int E \cdot dl$$

$$= -\int E\, dl \cos 90$$

$$\Delta V = 0 \Longrightarrow V_2 = V_1$$

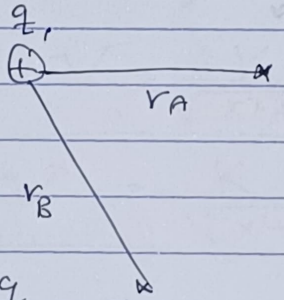
* أي خط عمودي على المجال $\Delta V = 0$



$V_2 = 10$

$\therefore V_3 = 10$

Point Charge



$$E = \frac{Kq}{r^2} \Longrightarrow \Delta V$$

$$V = E \cdot d$$

$$V_B = \frac{Kq}{r_B}$$

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

$$\boxed{V_A = \frac{Kq}{r_A}}$$

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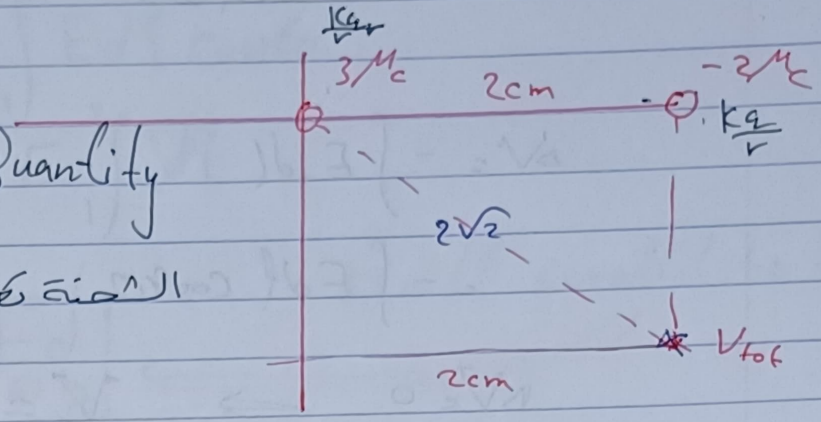
$$V_B - V_A = Kq\left(\frac{1}{r_B} - \frac{1}{r_A}\right)$$

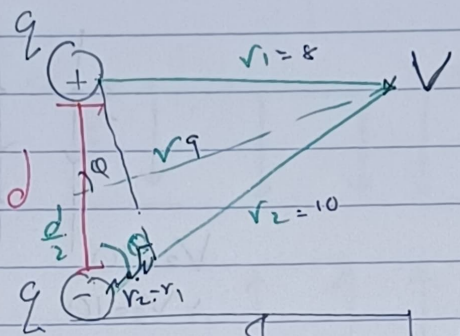
Exp



V Scalar Quantity

. ليس لها اتجاه وهي كمية قياسية

Electric Potential Due to dipole



$$V_+ = \frac{Kq_+}{r_1}$$

$$V_- = \frac{Kq_-}{r_2}$$

$$\cos\theta = \frac{r_2 - r_1}{d} \qquad V_{tot} = Kq\left(\frac{1}{r_1} - \frac{1}{r_2}\right)$$

$r_2 - r_1 = d\cos\theta$

$r_1 r_2 \approx r^2$

$8 \times 10 = 80$

$9^2 = 81 \approx$

$r \gg\gg d$

$$V = Kq\,\frac{r_2 - r_1}{r_1 r_2}$$

$$V = \frac{Kq \times d\cos\theta}{r^2}$$

$$\boxed{V = \frac{KP\cos\theta}{r^2}}$$ Special Case.

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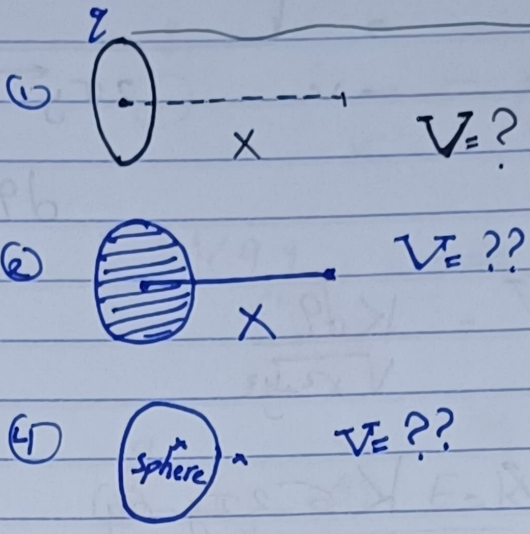
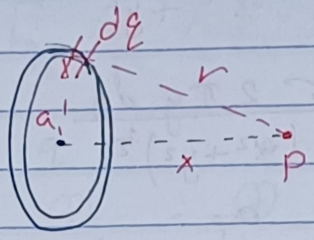
Potential to Ring



(1)



$r = \sqrt{x^2 + a^2}$

$$dV = \frac{K\,dq}{r}$$

$$\int dV = \int \frac{K\,dq}{\sqrt{x^2+a^2}}$$

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

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

$$\boxed{V = \frac{K}{\sqrt{x^2+a^2}}\, q}$$

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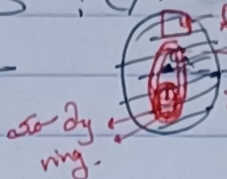
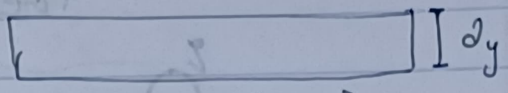
V due to a disk.

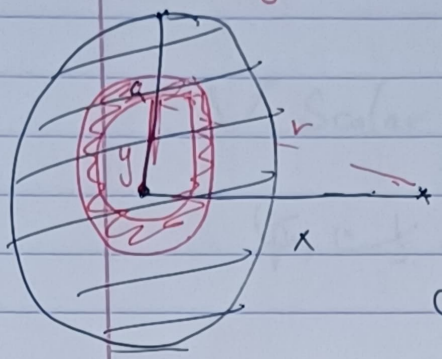
σ : C/m²

$\sigma = \frac{q}{A}$





$dq = \sigma * 2\pi y\, dy$



$$dV = \frac{K\,dq}{\sqrt{x^2+y^2}}$$

$$dV = \frac{K\sigma 2\pi y\, dy}{\sqrt{x^2+y^2}}$$

$$V = K\int \frac{\sigma 2\pi y\, dy}{(x^2+y^2)^{\frac{1}{2}}}$$

$$= K\sigma \times 2\pi \int_0^a \frac{y\, dy}{(x^2+y^2)^{\frac{1}{2}}}$$

$$= 2\pi K\sigma \left((x^2+y^2)^{\frac{1}{2}} \right)_0^a$$

$$= \frac{1}{2\pi\epsilon_0} \times 2\pi\sigma \left((x^2+a^2)^{\frac{1}{2}} - x \right)$$

$$\boxed{V = \frac{\sigma}{2\epsilon_0} * \left((x^2+a^2)^{\frac{1}{2}} - x \right)}$$

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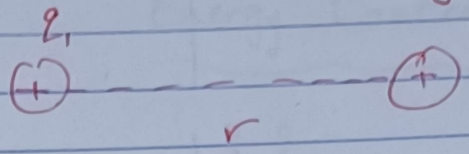
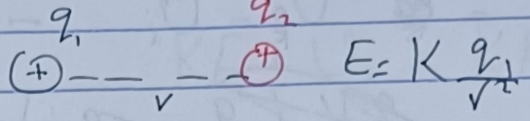
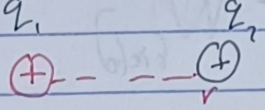
Potential Energy and Work



$$F = \frac{K q_1 q_2}{r^2} \Rightarrow q_2 E_1 \;/\; q_1 E_2$$



$$F_{q_2} = q_2 E_1 = \frac{K q_1 q_2}{r^2}$$

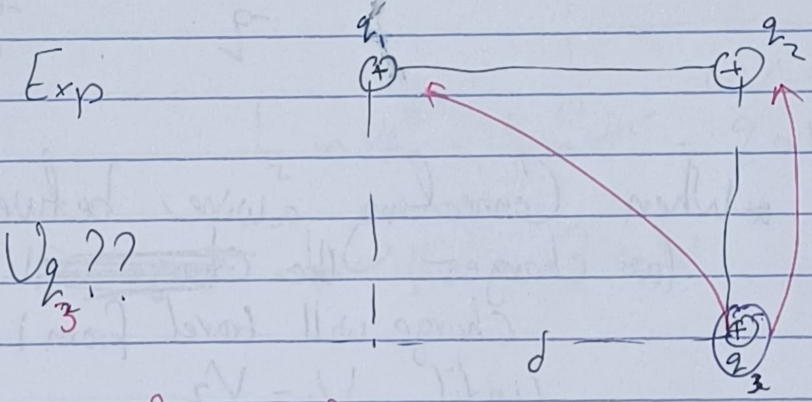


$$V = \frac{Kq}{r}$$

$$U_{q_2} = q_2 V_1$$

$$\boxed{U_{q_2} = \frac{K q_1 q_2}{r}}$$

Exp



U_{q_3} ??

$$U_{q_3} = U_{31} + U_{32}$$

$$= q_3 V_1 + q_3 V_2$$

$$= \frac{K q_1 q_3}{r_{31}} + \frac{K q_3 q_2}{r_{32}}$$

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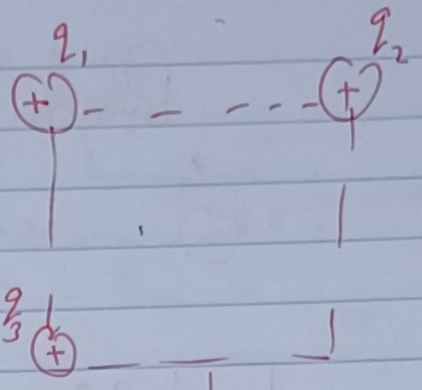
$U_{q_3 f} \longrightarrow$



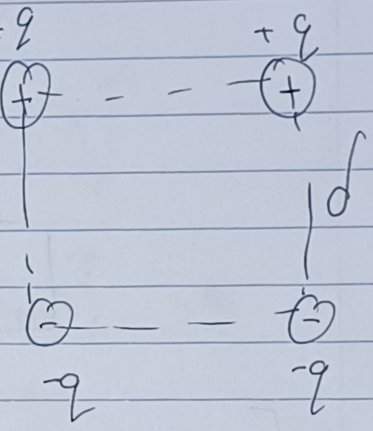
$$U_{q_3 f} = \frac{k q_1 q_3}{r_{13}} + \frac{k q_3 q_2}{d\sqrt{2}}$$

$$\Delta U_{q_3} = U_f - U_i = W_{ext}$$

~~$q_3 k \left(\frac{q_1}{r_{13}} + \frac{q_2}{d\sqrt{2}} \right) = W_{ext}$~~

$$W_{ext} = -W_{field}$$

$$U_{system} = U_{12} + U_{13} + U_{14} + U_{23} + U_{24} + U_{34}$$



* When Connecting a wire between two charges the ~~Charge will~~ Charge will travel from 1 to 2 until $V_1 = V_2$

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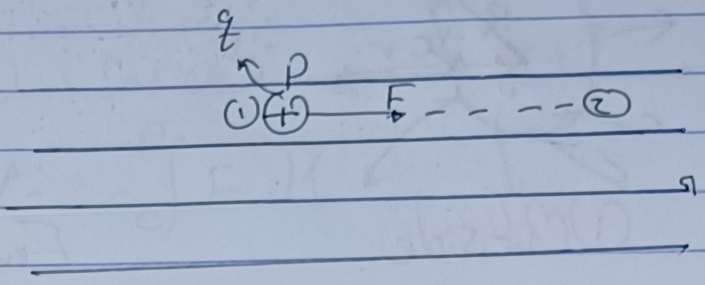
Energy Conservation

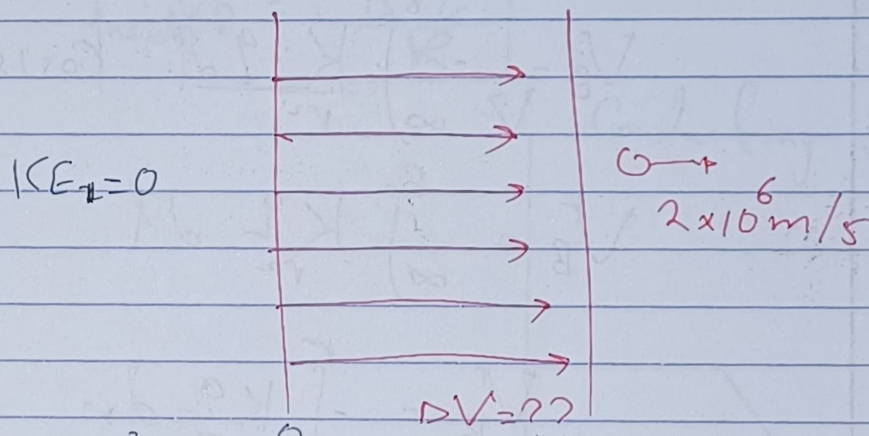


$$KE_1 + U_1 = KE_2 + U_2$$

$$KE_2 - KE_1 = U_1 - U_2$$

$$KE_2 - KE_1 = qV_1 - qV_2$$

$$\Delta KE = q(\Delta V)$$



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

$$\frac{1}{2}mv_f^2 = q\Delta V$$

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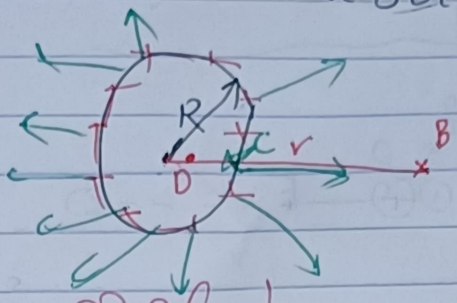
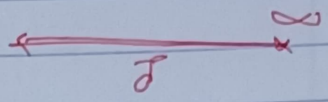
Electric Potential due to a Solid Conducting Sphere.





① Outside

$E_{in} = 0$

$E_{out} = \frac{Kq}{r^2}$

$V_f - V_i = \Delta V = -\int_i^f E.dl$

$V_B - V_\infty = \Delta V = -\int_\infty^B E.dl$ $\quad V_\infty = 0$ i.e.

$V_B = -\int_\infty^B \frac{Kq\,dl}{r^2} \cos 180$

$V_B = \int_\infty^B \frac{Kq}{r^2} dl$ $\quad dl = dr$

$V_B = -\int_\infty^r \frac{Kq}{r^2} dr$

$V_B = -Kq \int_\infty^r \frac{dr}{r^2}$

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

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On Surface

(2) $\boxed{V_c = \frac{Kq}{R}}$

(3) On D inside $r < R$

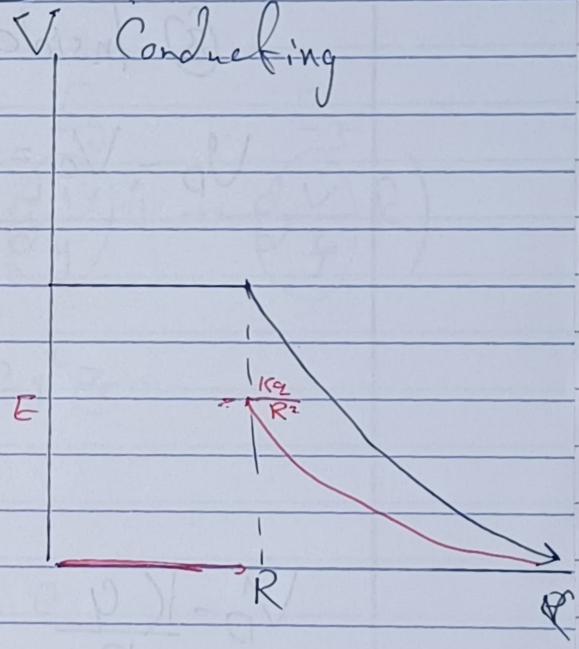
$$\Delta V = -\int_c^D E.dl$$

$$V_D - V_c = -\int_c^D E.dl$$

$$V_D - V_c = 0$$

$$V_D = V_c$$

$$\boxed{\text{inside } V_D = \frac{Kq}{R}}$$



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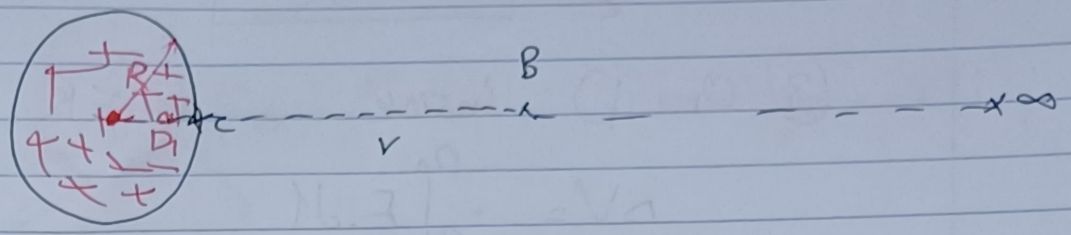
Non Conducting sphere.



$\frac{Kqr}{R^3}$ ① Out Side $r > R$

the Same as Conducting

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

② Surface $\boxed{V_C = \frac{Kq}{R}}$

③ Inside

$$V_D - V_C = \Delta V = -\int_D^C E \cdot dy$$

$$= -\int_D^C \frac{Kq}{R^3} r \, -dr$$

$$= +\int_D^C \frac{Kqr}{R^3} \, dr$$

$$V_D - \frac{Kq}{R} = \frac{Kq}{2R^3} \left(r^2\right)\Big|_R^r$$

$$V_D = \frac{Kq}{2R}\left(\frac{3 - r^2}{R^2}\right)$$

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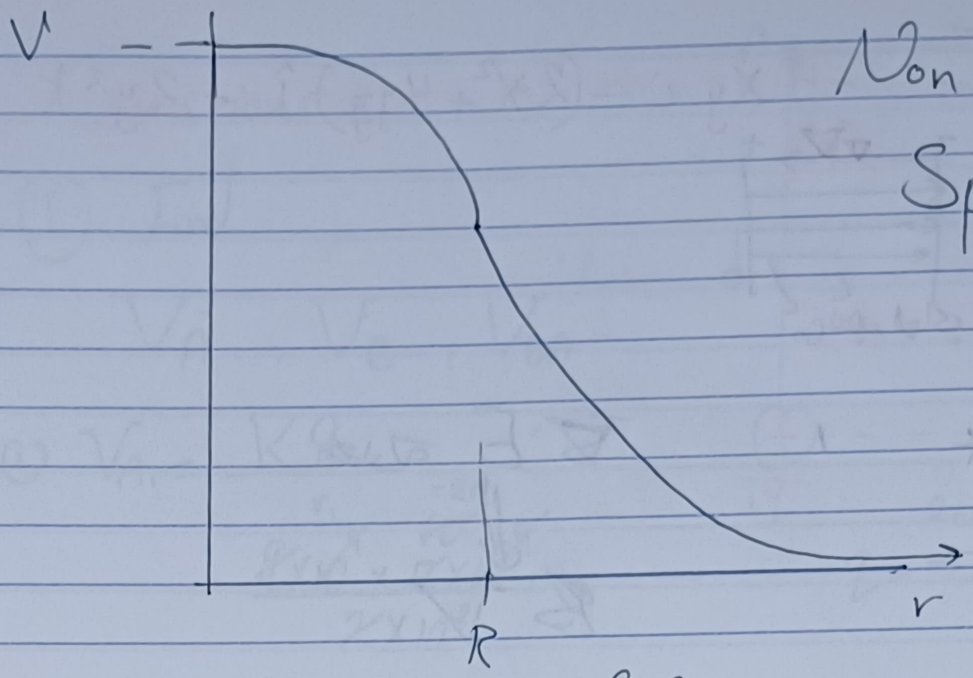

Non Conducting Sphere.

* Electric field Calculation from E.Potential.

$$\Delta V = -\int E \cdot dl$$

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

↳ Del Nebla, Gradiant.

$$-\left(\frac{dV}{dx}\,i + \frac{dV}{dy}\,\hat{j} + \frac{dV}{dz}\,\hat{k}\right)$$

(E_x, E_y, E_z)

* Ex) $V = 2x^2y + 2y^2z$

$$E = -\nabla V$$

$$E_x = -\frac{dV}{dx} = -4xy + 0$$

$$E_y = -\frac{dV}{dy} = -\left(2x^2 + 4yz\right)$$

$$E_z = \frac{dV}{dz} = 2y^2$$

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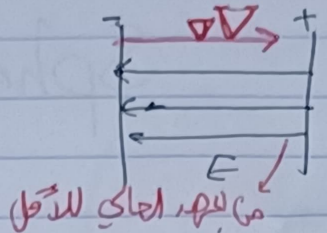
$$\vec{E} = -4xy\,i - (2x^2 + 4yz)\,\hat{j} - 2y^2 k$$



من الموجب الحاكي للأقل

* I $\vec{E}$ معلوم

$\Downarrow$

V

$$V = \int E\,dx - \int E\,dy - \int E\,dz$$

$$\Delta U = W = q\Delta V = -\Delta K$$

Semi Circle

$$dV = \frac{k\,dq}{r} \qquad dq = \lambda \pi r$$

$$V = \frac{k\lambda\pi r}{r}$$

$$V = k\lambda\pi$$

Quarter $dq = \lambda \frac{\pi}{2} r$

$$V = \frac{k\lambda\frac{\pi}{2}}{}$$

$$= \frac{k\lambda\pi}{2}$$

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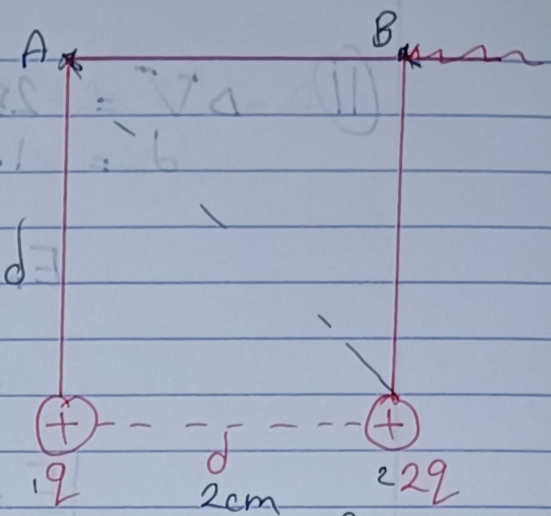
Questions

(I) Find

V_A , V_B , V_{BA}



① $V_{A_1} = \frac{Kq_1}{r_1} = \frac{9\times10^{9}\times5\times10^{-9}}{2\times10^{-2}}$

$$\boxed{V_{A_1} = 2\times10^{3}\ \text{Volts}}$$

$$V_{A_2} = \frac{Kq_2}{r_2} = \frac{9\times10^{9}\times2\times5\times10^{-9}}{2\sqrt{2}\times10^{-2}}$$

$$\boxed{V_{A_2} = 2.82\times10^{3}\ \text{Volts}}$$

$$V_A = \sum_{1}^{2} V_A = (2.82+2)\times10^{3}$$

$$= 4.82\times10^{3}\ \text{Volts}$$

② $V_{B_1} = \frac{Kq_1}{r_1} = \frac{9\times10^{9}\times5\times10^{-9}}{2\sqrt{2}\times10^{-2}}$

$$= 0.14\times10^{3}\ \text{Volts}$$

$$V_{B_2} = \frac{Kq_2}{r_2} = \frac{9\times10^{9}\times2\times5\times10^{-9}}{2\times10^{-2}}$$

$$= 4\times10^{3}$$

$$V_B = \sum_{1}^{2} V_{B_n} = 4.14\times10^{3}$$

③ $V_{BA} = V_B - V_A = (4.14 - 4.82)\times10^{3} = -680\ \text{Volts}$

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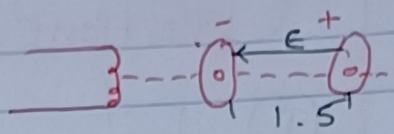
(11) $\Delta V = 25000\ V$

$d = 1.5\,cm$



$$E = \frac{\Delta V}{d}$$

$$= \frac{25000}{1.5 \times 10^{-2}}$$

$$\boxed{E = 1.6 \times 10^{6}\ V/m}$$

III $V = 5x - 3x^2y + 2yz^2$

① Find E

② E at $(1, 0, -2)\,m$

$$E = -\nabla V$$

① $E_x = -\frac{\partial V}{\partial x} = -(5 - 6yx + 0)$

$$E_x = (6xy - 5)\,i$$

② $E_y = -\frac{\partial V}{\partial y} = -(0 - 3x^2 + 2z^2)$

$$= (3x^2 - 2z^2)\,j$$

③ $E_z = -\frac{\partial V}{\partial z} = -(0 - 0 + 4yz)$

$$= -4yz$$

$$E = (6xy - 5)\,i + (3x^2 - 2z^2)\,j - (4yz)\,k$$

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$$E\Big|_{(4,0,-2)} = -5\hat{i} + (3 - 2x - 2) - 0$$

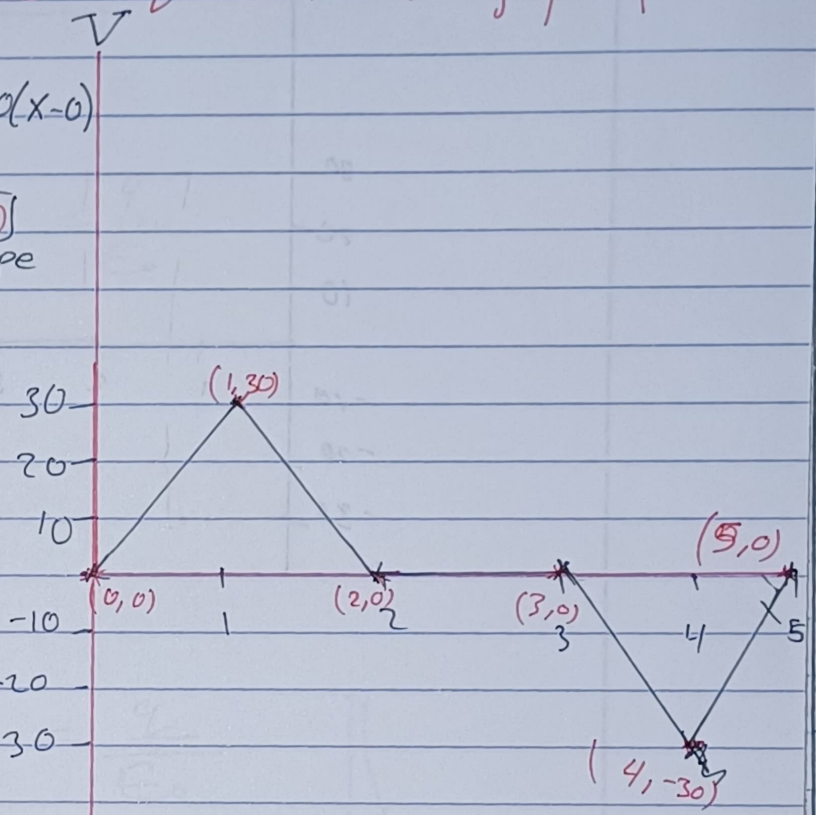
$$= -5i + 7\hat{j}$$

$$E = \sqrt{5^2 + 7^2}$$

$$= \sqrt{25 + 49}$$

$$= 8.6 \ V/m$$

III Question. Find Equation and graph of E



1) $0 \longrightarrow 1$ $\quad V - 0 = 30(x - 0)$

$$\frac{\Delta V}{\Delta X} = \frac{30 - 0}{1 - 0} = \boxed{30} \text{ Slope}$$

$$V = 30x \quad \text{——} ①$$

$$E = -30i \quad \text{——} ①$$

2) $1 \longrightarrow 2$

$$\frac{\Delta V}{\Delta X} = \frac{0 - 30}{2 - 1} = -30$$

$$V - 30 = -30(x - 1)$$

$$V - 30 = -30x + 30$$

$$+30 \qquad +30$$

$$V = -30x + 60 \quad \text{——} ②$$

$$E = -(-30i) = 30\hat{i} \quad \text{——} ②$$

3) $2 \longrightarrow 3$

$$\frac{\Delta V}{\Delta X} = \frac{0 - 0}{3 - 2} = 0$$

$$E = 0i$$

4) $3 \longrightarrow 4$

$$\frac{\Delta V}{\Delta X} = \frac{-30 - 0}{4 - 3} = -30$$

$$V - 0 = -30(x - 3)$$

$$V = -30x + 90$$

$$E = -(-30\hat{i})$$

$$\boxed{E = 30i}$$

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(5) 4 → 5

$$\frac{\Delta V}{\Delta X} = \frac{0 - -30}{5 - 4} = 30$$

$$V - 4 = 30(X - 30)$$

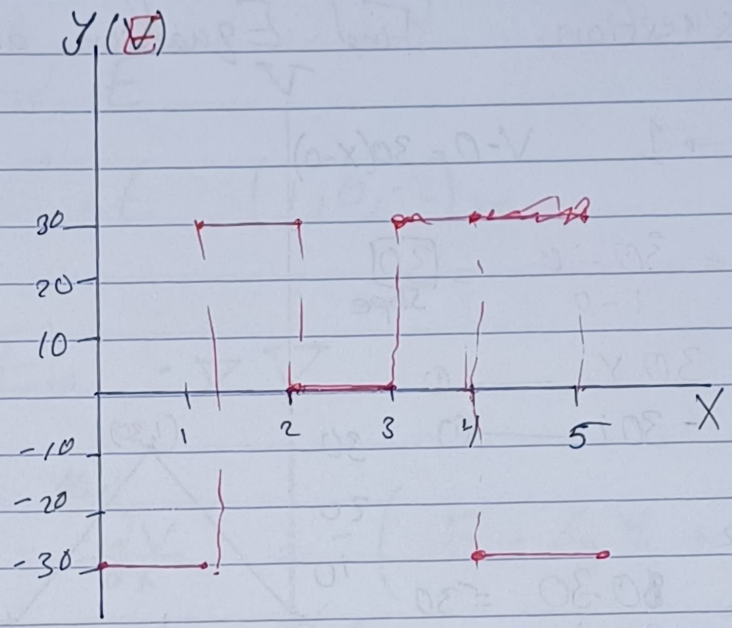
$$+4$$

$$V = 30X + 900 + 4$$

$$= 30X + 904$$

$$E = --30i$$

$$= 30i$$



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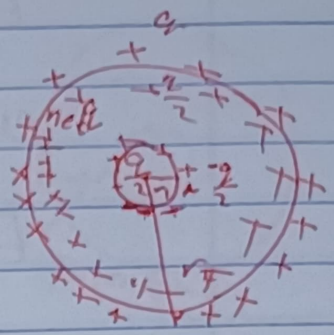
V

E and V
in, out, between



$r > r_2$

① outside

$$E \times 4\pi r^2 = \frac{q_{enc}}{\epsilon_0}$$

$$E \times 4\pi r^2 = \frac{3q}{\epsilon_0}$$

$$E = \frac{3q}{4\pi\epsilon_0 r^2}$$

$r > r_2$ $\quad \boxed{E = \frac{3}{2}\frac{kq}{r^2}}$

$r_2 > r > r_1$

②
$$E \times 4\pi r^2 = \frac{q_{en}}{\epsilon_0}$$

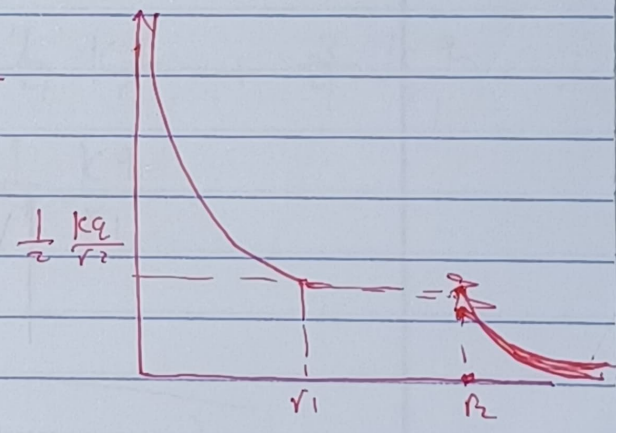
$$E = \frac{0}{4\pi\epsilon_0 r^2}$$

$$\boxed{E = 0}$$

③ $r < r_1$

$$E \times 4\pi r^2 = \frac{q}{2\epsilon_0}$$

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



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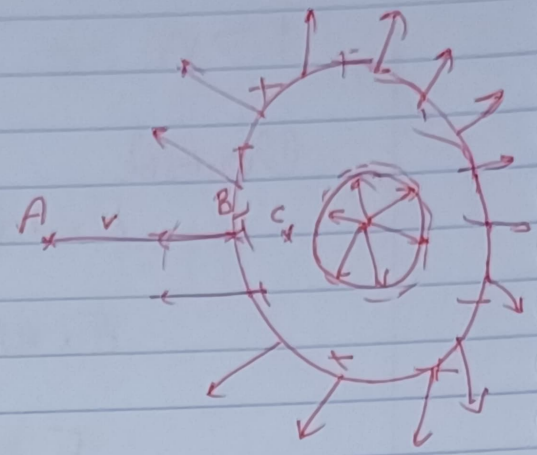
Electric potential

out side. $r > r_2$

$$E = \frac{3}{2}\frac{kq}{r^2}$$



$$V = -\int E.dl$$

$$V_2 - V_\infty = -\int_\infty^A E.dl$$

$$V_2 = -\int_\infty^A E\,dl \cos 180^{-1}$$

$$V_2 = \int_\infty^A E\,dl \qquad dl = dr$$

$$= -\int_\infty^r E\,dr$$

$$V_A = -\int_\infty^r \frac{3}{2}\frac{kq}{r^2} \times dr$$

$$= -\frac{3}{2} kq \int_\infty^r \frac{1}{r^2} dr$$

$$= -\frac{3}{2} kq \left(-\frac{1}{r}\right)_\infty^r$$

$$\boxed{V_A = \frac{3}{2}\frac{kq}{r}}$$

$$\boxed{V_B = \frac{3}{2}\frac{kq}{r_2}} \quad \text{①}$$

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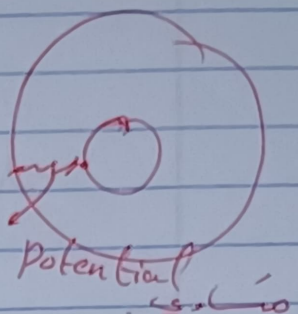
$$V_C - V_B = -\int_B^C \vec{E} \cdot d\vec{l}$$



$$V_C - V_B = 0$$

$$\boxed{V_C = V_B = \frac{3}{2}\frac{kq}{r_2}}$$

$$\boxed{V_D = \frac{3}{2}k\frac{q}{r_2}}$$

inside $r < r_1$

$$V_e - V_D = -\int_D^e \vec{E} \cdot d\vec{l}$$

$$= -\int_D^e \frac{1}{2}\frac{kq}{r^2}\, dr$$

$$= +\frac{1}{2}\frac{kq}{r}\Big|_{r_1}^{r}$$

$$V_e - V_D = \frac{1}{2}(kq)\times\left(\frac{1}{r} - \frac{1}{r_1}\right) + V_D$$

$$V_e = \frac{1}{2}\frac{kq}{r} - \frac{1}{2}\frac{kq}{r_1} + \frac{3}{2}\frac{ke\,q}{2r_1}$$

$$= \frac{1}{2}\frac{kq}{r} - \frac{2}{4}\frac{kq}{r_1} + \frac{3}{4}\frac{kq}{r_1}$$

$$= \frac{1}{2}\frac{kq}{r} + \frac{1}{4}\frac{kq}{r_1}$$

$$\boxed{V_e = \frac{1}{2}kq\left(\frac{1}{r} + \frac{1}{2r_1}\right)}$$

$r < r_1$

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uniformly $-256 \times 10^{12} C$

$R = 3.71$

$P = 120°$

$$dV_p = \frac{k\,dq}{r}$$

$$V_p = \frac{K}{R} \int \lambda\, ds$$

$$= \frac{k}{R} \lambda \int ds \; q$$

$$= \frac{Kq}{R} = \frac{9 \times 10^9 \times -25.6 \times 10^{-12}}{3.71 \times 10^{-2}}$$

$$V_p = 6.2 \text{ Volts.}$$

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Disscusion
Problems 24

Problem 3

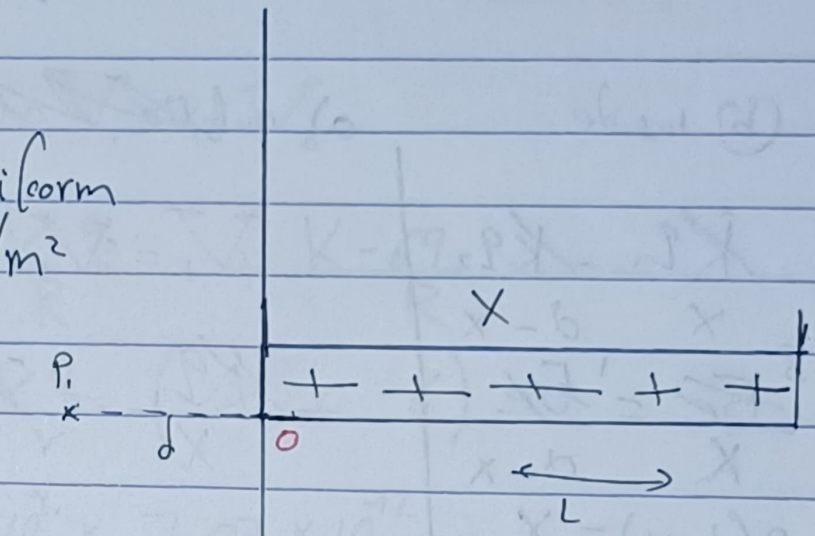
$L = 24cm$

$\lambda = cx$ nonuniform

$C = 28.9 \times 10^{-12} C/m^2$

$V_\infty = 0$

$d = 3cm$



$$\int dV = \int \frac{K\,dq}{r}$$

$dq = \lambda\,dx$

$$V = \int_0^x \frac{K\,\lambda\,dx}{d}$$

$$= \frac{K}{d}\int_0^x c\,x\,dx$$

$$= \frac{Kc}{d}\int_0^x x\,dx$$

$$= \frac{9\times10^{9}\times28.9\times10^{-12}}{3\times10^{-2}} \times \frac{x^2}{2}\Big|_0^{24\times10^{-2}}$$

$$= 3\times10^{11}\times28.9\times10^{-12}\times\frac{(24)^2\times10^{-4}}{2}$$

$$= 0.25\ Volts.$$

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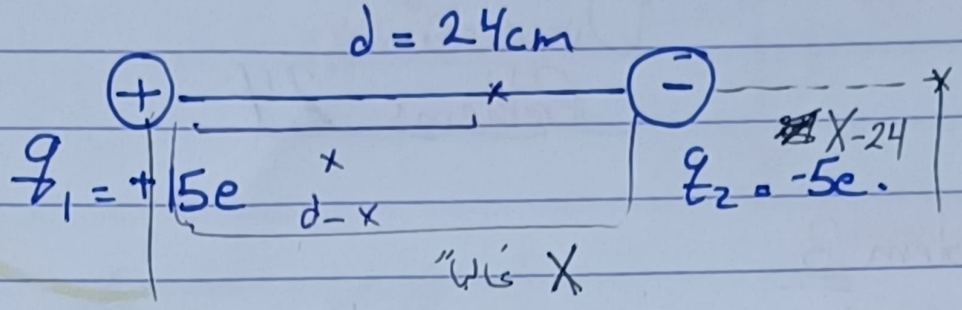
Problem 7

$V_\infty = 0$



(b) Inside

$\frac{kq_1}{x} = \frac{kq_2}{d-x}$

$\frac{5e}{x} = \frac{5e}{d-x}$

$3(d-x) = X$

$3(24-X) = X$

$72 - 3X = X$

$-4X = 72$

$X = 18\text{cm}$

a) outside ~~$V = 0$~~ $V_{net} = 0$

$V_1 = -V_2$

$\frac{kq_1}{X} = -\frac{kq_2}{X-24}$

$\frac{5e}{X} = +\frac{5e}{X-24}$

$X = \frac{3X}{-3X} - 72$

$-2X = -72$

$X = 36\text{cm}$

~~$-5X = -72$~~

~~$-X = -3X - 72$~~

~~$-3X \quad -3X$~~

~~$-4X = -72$~~

~~$X = 18\text{cm}$~~

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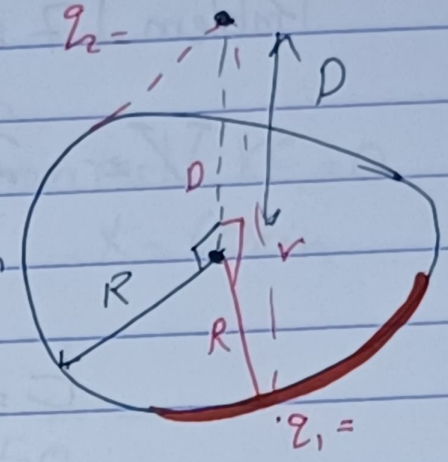
Problem 9



$R = 8.20\,cm$

$q_1 = +7.07 \times 10^{-12} C$ uniform

$q_2 = -6 \times 7.07 \times 10^{-12} C$

$V_0 = 0$, $D = 2.05\,cm$

① $V_{center} = V_1 + V_2$

$$= \frac{Kq}{R} + \frac{K-6q}{R}$$

$$= \frac{Kq}{r}\left(1 + -6\right)$$

$$= \frac{9 \times 10^{9} \times 7.07 \times 10^{-12}}{8.2 \times 10^{-2}} \times -5$$

$$\boxed{V_{centre} = -3.88 \text{ Volts}}$$

② at P

$$r = \sqrt{R^2 + D^2}$$

$$= \sqrt{(8.2)^2 + (2.05)^2}$$

$$= 8.45\,cm$$

$$V_P = \frac{Kq}{r} + \frac{K-6q}{r}$$

$$= \frac{Kq}{r}\left(1 + -6\right)$$

$$= \frac{9 \times 10^{9} \times 7.07 \times 10^{-12}}{8.45 \times 10^{-2}} \times -5$$

$$\boxed{V_P = -3.76 \text{ Volts}}$$

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Problem 17: $(-1,-2,4)$ $E|$

$$V = 2xyz^2$$

$$E = -\nabla V$$

$$E_x = -\frac{dV}{dx} = -2yz^2$$

$$E_y = -\frac{dV}{dy} = -2xz^2$$

$$E_z = -\frac{dV}{dz} = -4xyz$$

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

$$E|_{(-1,-2,4)} = -2\times-2\times16\,\hat{i} - 2\times-1\times16 - 4\times-1\times-2\times4$$

$$= 64\hat{i} + 32\hat{j} - 32\hat{k}$$

$$E = \sqrt{64^2 + 32^2 + 32^2}$$

$$\boxed{E = 78.38\ V/m}$$

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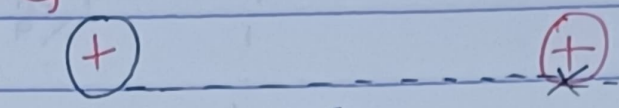
Problem 25

$q = +7.5 \times 10^{-6}\ C$ | from rest $KE_1 = 0$

① $Q = +20 \times 10^{-6}\ C$ | $x = 60\,cm$



$$KE_2 = -q\,\Delta V$$

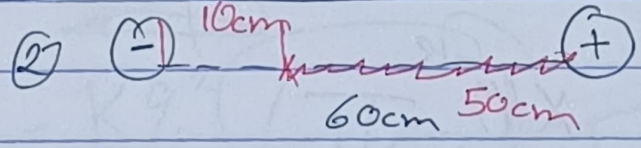
$$= -Q\left(\frac{kq}{r_2} - \frac{kq}{r_1}\right)$$

$$= -Qkq\left(\frac{1}{r_2} - \frac{1}{r_1}\right)$$

$$= -20\times10^{-6} \times 9\times10^{9} \times 7.5\times10^{-6} \times \left(\frac{1}{110} - \frac{1}{60}\right)$$

$$= \left(-20 \times 9 \times 7.5 \times -0.75\right) \times 10^{-3} \times 10^{9} \times 10^{-6} \times 10^{2}$$

$$\boxed{KE_2 = +1.022\ J}$$

② 

$$KE = -Qkq\left(\frac{1}{r_2} - \frac{1}{r_1}\right)$$

$$= -20\times10^{-6} \times 9\times10^{9} \times 7.5\times10^{-6} \times \left(\frac{1}{10} - \frac{1}{60}\right) \times 10^{2}$$

$$\boxed{KE_2 = 11.25\ J}$$

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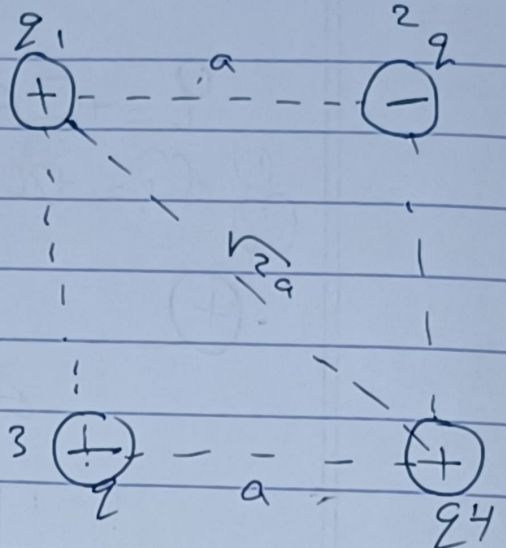
Problem 33

$q = 5 \times 10^{-12}\ C$

$a = 64\ cm$



a) $V_\infty = 0$

$W_{net} = U_{12} + U_{13} + U_{23} + U_{14} + U_{34} + U_{24}$

$\frac{kq_1q_2}{} = \frac{-kq^2}{a} + \frac{-kq^2}{a} + \frac{kq^2}{\sqrt{2}a} + \frac{kq^2}{\sqrt{2}a} + \frac{-kq^2}{a} = \frac{-kq^2}{a}$

$\frac{kq^2}{a}\left(-1-1+\frac{1}{\sqrt{2}}+\frac{1}{\sqrt{2}}-1-1\right)$

$10^{9} \quad 25\times10^{-24} \quad 10^{13} \quad -4$

$= \frac{9\times10^{9}\times(5\times10^{-12})^2}{64\times10^{-2}} \times -2.58$

$= -9.09 \times 10^{-13}\ J$

a) $W_{Ext} = 9.09 \times 10^{-13}\ J$

W

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b) $W_{FE} = -W_{ext}$

$= -9.07 \times 10^{-13}$ J

c)

c) $U_{system} = U_{12} + U_{13} + U_{14} + U_{23} + U_{24} + U_{34}$

$= \frac{Kq_1q_2}{a} + \frac{Kq_1q_3}{a} + \frac{Kq_1q_4}{a\sqrt{2}} + \frac{Kq_2q_3}{a\sqrt{2}} + \frac{Kq_2q_4}{a} + \frac{Kq_3q_4}{a}$

$= \frac{Kq^2}{a}\left(-1 + -1 + \frac{1}{\sqrt{2}} + \frac{1}{\sqrt{2}} + -1 + -1\right)$

$= -2 \quad \sqrt{2} \quad \sqrt{2} \quad -2$

$= \frac{-2.58\,Kq^2}{a}$

$= \frac{-2.58 \times 9 \times 10^{9} \times (5 \times 10^{-12})^2}{64 \times 10^{-2}}$ 10^{-13}

$= -9.07 \times 10^{-13}$ J.

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Problem 3

$dV = \frac{K\,dq}{r}$

$\lambda = cx$

$dq = \lambda\,dx$

$= cx\,dx$

$\int dV = \int \frac{K c x\,dx}{d+x}$

$V = Kc \int \frac{x}{d+x}\,dx$

$u = d + x$

$du = dx$

$= Kc \int \frac{u-d}{u}\,du$

$= Kc \int_0^L \left(1 - \frac{d}{u}\right) du$

$= Kc \left(u - d\ln u\right)\Big|_0^L$

$= Kc \left((d+x) - d\ln(d+x)\right)\Big|_0^L$

$= 9\times10^9 * 28.9\times10^{-12} \left((3\times10^{-2} + 24\times10^{-2}) - 3\times10^{-2}\ln(3+24)^{\times10^{-2}}\right)$

$= 0.2601 * \left(27\times10^{-2} - 0.0392\right)$

$= 0.08$ volt.

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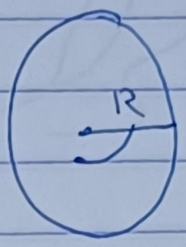
Additional Problems.

Q1) Conducting Sphere.

$R = 5.5\,cm$



a) $V = 75\,V$ at $2.2\,m$

$V_\infty = 0$

$V_{2.2} = \frac{kq}{r}$

$75 = \frac{9\times10^9 \times q}{2.2}$

$q = 18.3\times10^{-9}\,C$

$= 1.83\times10^{-8}\,C$

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

$= \frac{9\times10^9 \times 18.3\times10^{-9}}{5.5\times10^{-2}}$

$= 30\times10^2$

$\boxed{V_s = 3000\,V}$

b) $\sigma = \frac{q}{A} = \frac{1.83\times10^{-8}}{4\pi(5.5\times10^{-2})^2}$

$= 4.82\times10^{-7}\,C/m^2$.

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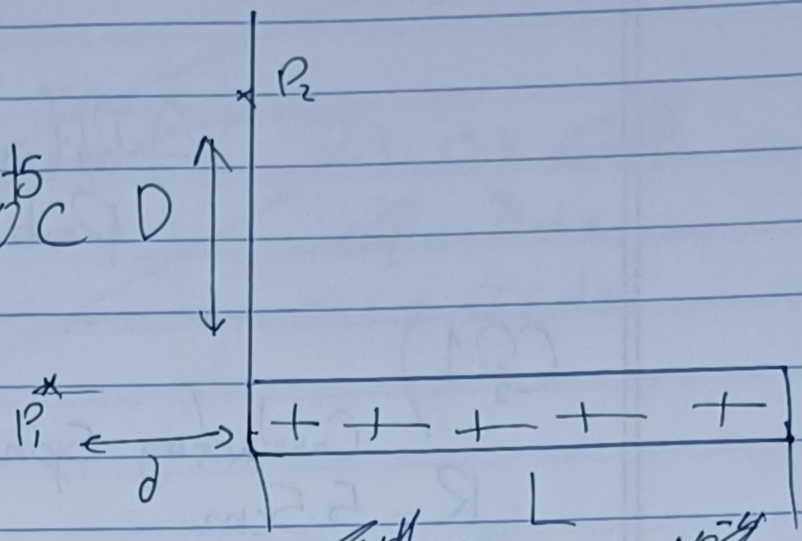
(Q2)



$L = 12\,cm$

uniform $Q = 47.9 \times 10^{-15}\,C$

$V_\infty = 0$

$d = 2.5\,cm$

$V = \frac{kq}{r} = \frac{9\times10^{9}\times47.9\times10^{-15}}{2.5\times10^{-2}}$

$= 0.01724\,V$

$\int dV = \int \frac{k\,dq}{d} = \int_0^L \frac{k\,\lambda\,dx}{d+x}$

$= k\lambda \int_0^L \frac{dx}{(d+x)}$

$= k\lambda \ln(d+x)\Big|_0^L$

$= \frac{kq}{L}\left(\ln(d+L) - \ln d\right)$

$= \frac{9\times10^{9}\times47.9\times10^{-15}}{12\times10^{-2}}\left(\ln 14.5\times10^{-2} - \ln 2.5\times10^{-2}\right)$

$= 3.6\times10^{-3}\left(-1.93 - -3.68\right)$

$= 1.75$

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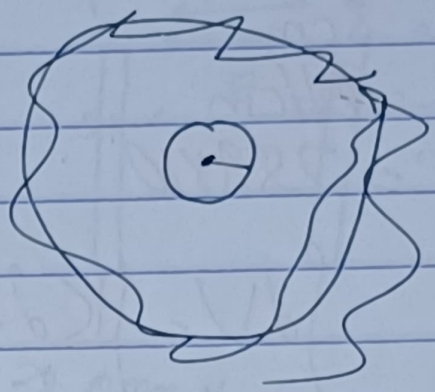
$V = 6.28 \times 10^{-3}$ Volts.

(c) 10

$V = -170\,V$

$r \geq R$



$\Delta KE = -qV$

$\frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2 = +qV$ ($v_f = 0$)

$v_i^2 = \frac{2qV}{m}$

$v_i^2 = \frac{2 \times 1.6 \times 10^{-19} \times 170}{9.1 \times 10^{-31}}$

$v_i = \sqrt{59.7 \times 10^{12}}$

$\boxed{v_i = 7.73 \times 10^6\ m/sec}$

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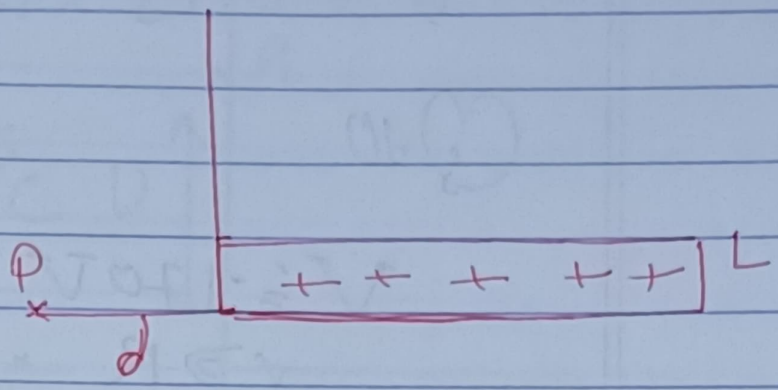
Problem 3

$\lambda = cx$

$d = 3\,cm$

$L = 24\,cm$

$c = 28.9 \times 10^{-12}$



$$\int dV = \int \frac{K\,dq}{r} = \int \frac{K\,c\,x\,dx}{d+x} \qquad dq = \lambda dx = c\,x\,dx$$

$$V = \int_0^L \frac{Kc\,x\,dx}{d+x} = Kc \int \frac{x}{x+d}\,dx$$

$$V = \int_d^{d+L} Kc\,\frac{r-d}{r}\,dr$$

$r = x + d$

$dr = dx$

$x = 0 \Rightarrow r = d$

$x = L \Rightarrow r = L + d$

$$= Kc\,\left[r - d \ln r \right]_d^{d+L}$$

$$= Kc\,\left[r \Big|_d^{d+L} - d \ln r \Big|_d^{d+L} \right]$$

$$= Kc\left(L - \left((d \ln d + L) - (d \ln d) \right) \right)$$

$$= Kc\left(L - d \ln \left(\frac{d+L}{d} \right) \right)$$

$$= 9 \times 10^9 \times 28.9 \times 10^{-12} \left(0.24 - 0.03 \ln \left(\frac{0.3}{0.03} \right) \right)$$

$$= 4.5 \times 10^{-2}\ \text{Volts}$$

$$= 45\ \text{m Volts}$$

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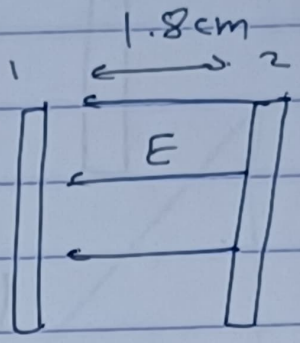
(Q12)

$V = 1500x^2$



$E = -\nabla V$

$E_x = -\frac{dV}{dx} = -3000x\,i$

$E_y = -\frac{dV}{dy} = 0$

$E_z = -\frac{dV}{dz} = 0$

$E = -3000x\,i$

$E\downarrow_{1.8cm} = -3000 * 1.8\times10^{-2}$

$= -54\ N/C$ / toward plate 1

$\boxed{E(1.8) = -54\ V/m}$

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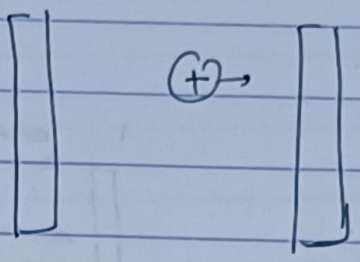
$\Delta V = 4.5\,kV$



$U = q\Delta V$

$= 1.6 \times 10^{-19} * 4.5 \times 10^{3}$

$U = 7.2 \times 10^{-16}\ J$

$1ev = 1.602 \times 10^{-19}\ J$

$$U = \frac{7.2 \times 10^{-16}}{1.602 \times 10^{-19}}$$

$$\boxed{U = 4.5\ kev}$$

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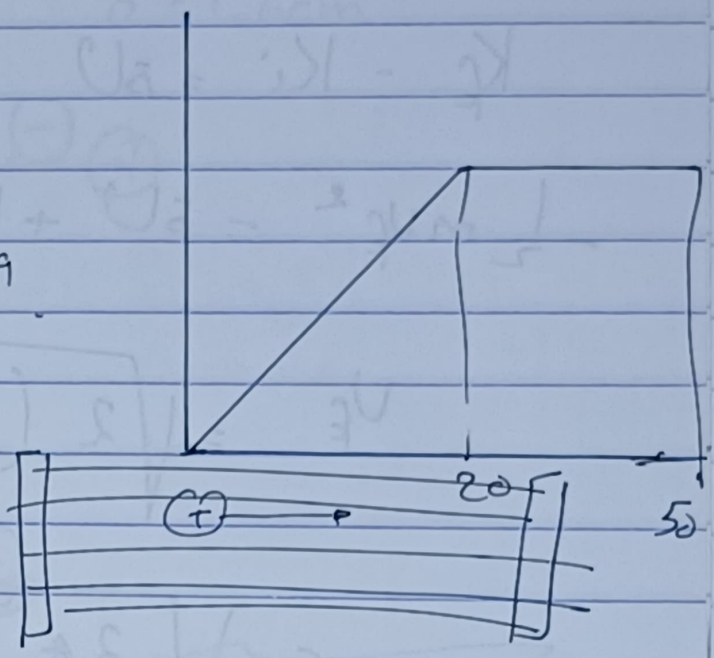
Q28

$v_i = 1.5 \times 10^7 \text{ m/sec}$

$m_{Positron} = 9.11 \times 10^{-31}$

$q_{Positron} = 1.6 \times 10^{-19}$

$V_{max} = 500\ V$



$$K_i = \frac{1}{2} m v_i^2$$

$$= \frac{1}{2} * 9.11 \times 10^{-31} * (1.5 \times 10^7)^2$$

$$K_i = 1.02 \times 10^{-16}\ J \quad \text{---(1)}$$

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

$$= 1.6 \times 10^{-19} \times 500$$

$$\boxed{\Delta U = 8 \times 10^{-17}}$$

$K_i > U$

$\therefore$ Positron have enough energy to continue moving without reversing

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b) $\Delta KE = \Delta U$

$$K_f - K_i = \Delta U$$

$$\frac{1}{2} m v_f^2 = \Delta U + K_i$$

$$v_f = \sqrt{2\left(\frac{U + K_i}{m}\right)}$$

$$= \sqrt{\frac{2 (0.8 \times 1.02) \times 10^{-16} \; 10^{15}}{9.11 \times 10^{-31}}}$$

$$v_f = 7 \times 10^6 \text{ m/sec}$$

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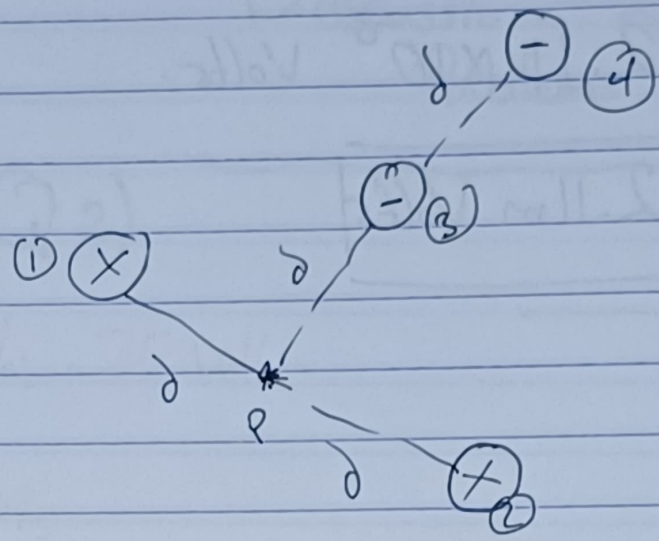
(Q31) $V_\infty = 0$ $\quad q = 7.5\text{fC}$
$d = 1.6\text{cm}$



$$V_1 = \frac{Kq}{d_8} = \text{~~} q \times 10^{+9} \times 7.5 \times 10^{-15} \text{~~}$$

$$V_2 = \frac{Kq}{d}$$

$$V_3 = \frac{K(-q)}{d}$$

$$V_4 = \frac{K(-q)}{2d}$$

$$V_{tot\ at\ P} = \sum V = V_1 + V_2 + V_3 + V_4$$

$$= \frac{Kq}{d} + \frac{Kq}{d} + \frac{-Kq}{d} + \frac{-Kq}{2d}$$

$$= \frac{Kq}{d}\left(1 + 1 - 1 - \frac{1}{2}\right)$$

$$V_{tot} = \frac{Kq}{2d}$$

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$$V_{tot} = \frac{9 \times 10^{9} \times 7.5 \times 10^{-15}}{2 \times 1.6 \times 10^{-4}}$$

$$V_{tot} = 2.11 \times 10^{-3} \text{ Volts.}$$

$$\boxed{V_{tot} = 2.11\text{m Volts}}$$

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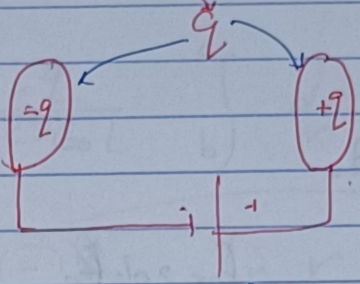
Capacitors

Capacitance : C

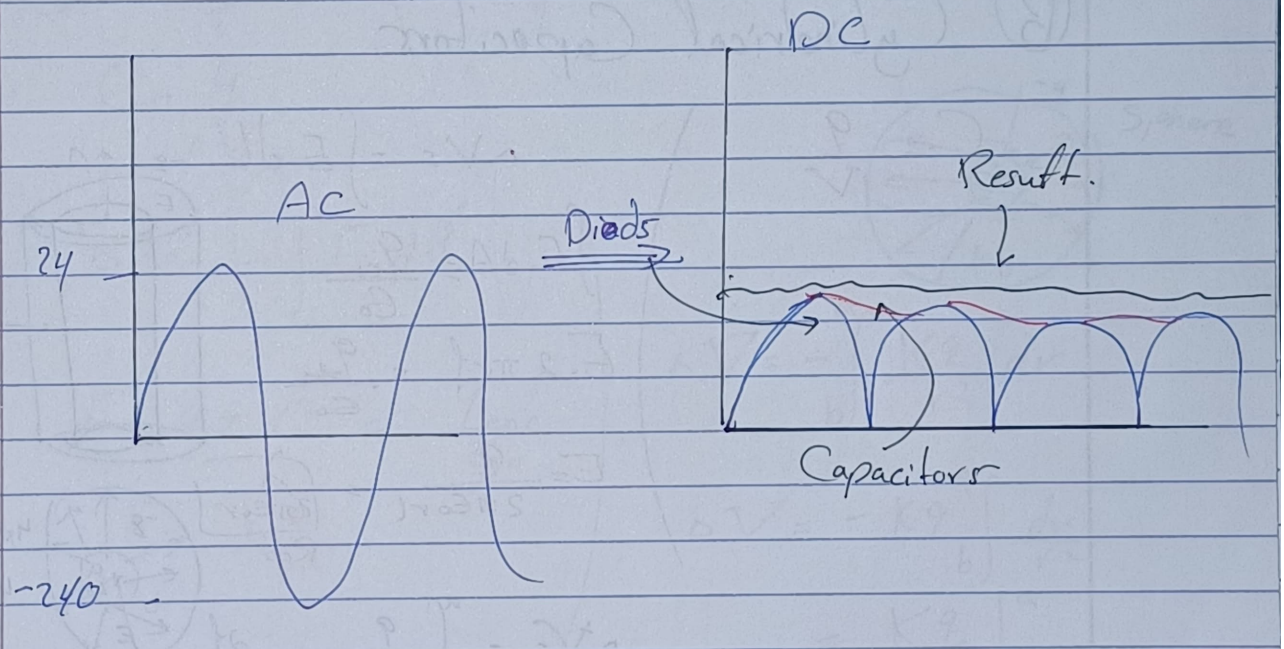


$$C = \frac{q}{V} \Longrightarrow \quad q = CV$$

Unit C/Volt $\Longrightarrow$ F (Farad)

$\mu F, nF, pF, fF$

femto



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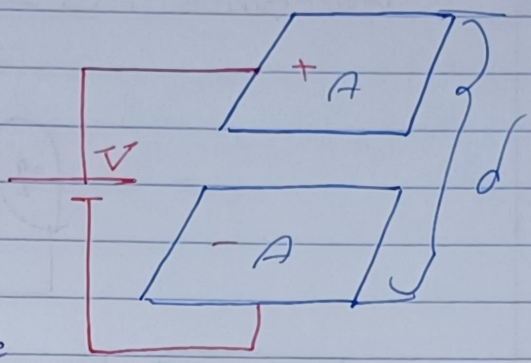
Types of Capacitors:

(A) Parallel plate Capacitor.

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

$C = \frac{\sigma A}{E d}$



for 2 plates have same charge

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

$E = \frac{\sigma}{\epsilon_0}$ ②

$q = \sigma A$ ③

$E = \frac{V}{d}$ ← parallel Uniform

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

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

Special plate parallel Capacitor.

(B) Cylindrical Capacitors.

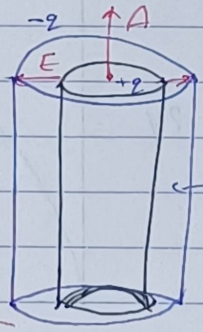
$C = \frac{q}{V}$

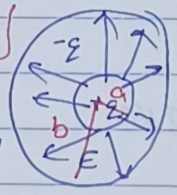
$\Delta V = -\int E \cdot dl$

$\int E \cdot dA = \frac{q_{en}}{\epsilon_0}$

$E \cdot 2\pi r l = \frac{q_{en}}{\epsilon_0}$

$E = \frac{q}{2\pi \epsilon_0 r l} = \frac{2\pi \epsilon_0 r}{\text{Rod}}$





$\Delta V = -\int_b^a \frac{q}{2\pi \epsilon_0 r l} \cdot dl$

$V_b - V_a = -\int_b^a \frac{q}{2\pi \epsilon_0 r l} |dl| \cos 180$

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$$V_a - V_b = \int_b^a \frac{q}{2\pi r \ell} \, dl$$

$$V_a - V_b = -\int_b^a \frac{q}{2\pi r \ell} \, dr$$

$$= \frac{-q}{2\pi \epsilon_0 L} \int_b^a \frac{dr}{r}$$

$$V_a - V_b = \frac{-q}{2\pi \epsilon_0 L} \ln r \Big|_b^a \quad (\ln a - \ln b)$$

$$\times \frac{1}{q} \quad \Delta V = \frac{q}{2\pi \epsilon_0 \ell} \ln \frac{b}{a} \quad \times \frac{1}{q}$$

$$\boxed{C = \frac{2\pi \epsilon_0 \ell}{\ln \frac{b}{a}} = \frac{\ell}{2k \ln \frac{b}{a}}}$$

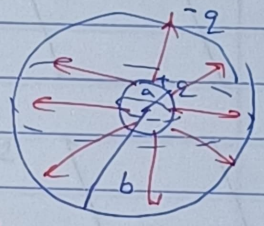
(c) Spherical Capacitor

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

$$\Delta V = -\int E \cdot dl$$

$$E \, 4\pi r^2 = \frac{q_{enc}}{\epsilon_0}$$

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



$$\Delta V = -\int_b^a \frac{kq}{r^2} \, dr$$

$$\Delta V = -kq \int_b^a \frac{dr}{r^2}$$

$$= \frac{kq}{r} \Big|_b^a$$

$$\Delta V = \frac{kq\left(\frac{b-a}{ab}\right)}{}$$

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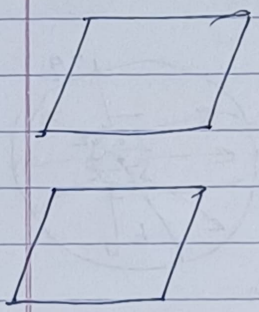
$$C = \frac{q}{\Delta V} = \frac{q}{\frac{kq}{}\left(\frac{b-a}{ab}\right)}$$

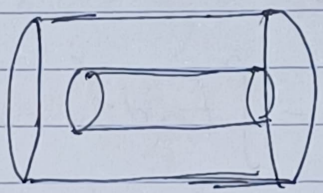
$$\boxed{C = \frac{ab}{k(b-a)}}$$

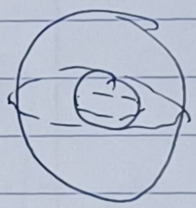
Summary

$C = \frac{q}{\Delta V}$ → Capacitor

Parallel plate	Cylindrical	Spherical
$\frac{\epsilon_0 A}{d}$	$\frac{2\pi\epsilon_0 L}{\ln\frac{b}{a}}$	$\frac{4\pi\epsilon_0 ab}{b-a}$
	$\frac{L}{2k\ln\frac{b}{a}}$	$\frac{ab}{k(b-a)}$







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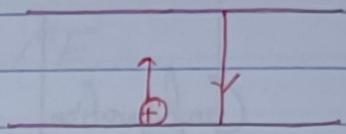
Energy in Capacitors

$$dU = dq \cdot V$$

$$U = \int dq \cdot V$$



$$U = \int \frac{q}{C}\, dq$$

$$U = \frac{q^2}{2C}$$

الطاقة تخزن على شكل
طاقة وضع كهربائية

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

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

Energy density (u)

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

$$= \frac{\epsilon_0 A}{d} \cdot \frac{V^2}{2dA}$$

$$= \frac{\epsilon_0 V^2}{2d^2}$$

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

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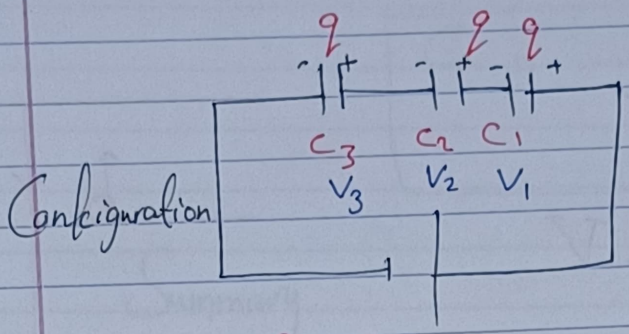
Capacitors Connection

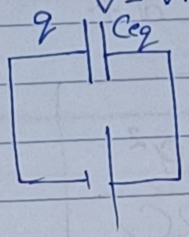
Series



Configuration

$q_1 = q_2 = q_3 = q$

$V = V_1 + V_2 + V_3$



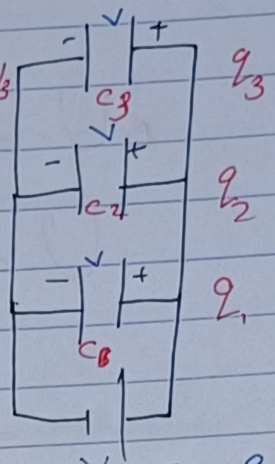
$V = V_1 + V_2 + V_3$

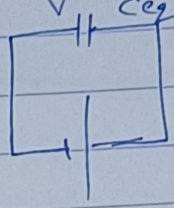
$$\frac{q}{C_{eq}} = \frac{q}{C_1} + \frac{q}{C_2} + \frac{q}{C_3}$$

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

Parallel

$V_1 = V_2 = V_3 = V$





$q = q_1 + q_2 + q_3$

$C_{eq}V = C_1V + C_2V + C_3V$

$$\boxed{C_{eq_3} = C_1 + C_2 + C_3}$$

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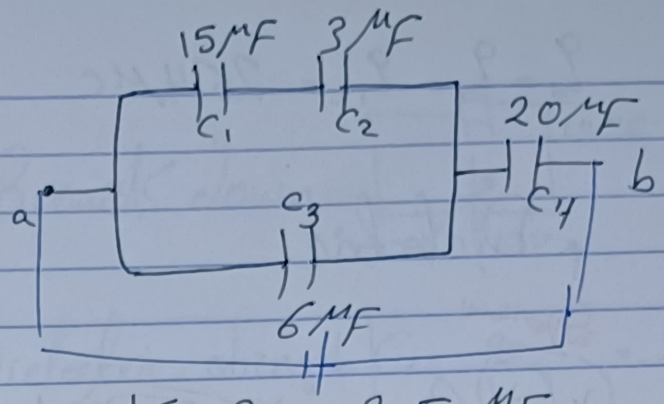
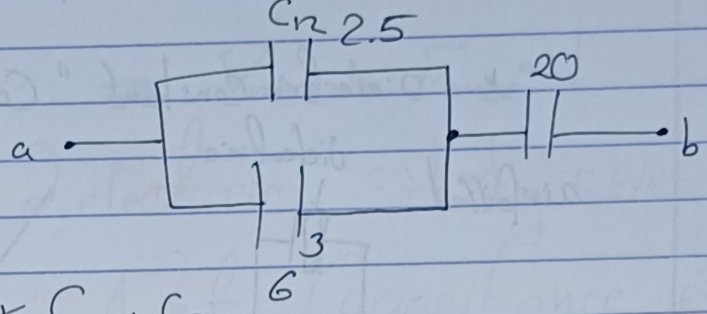
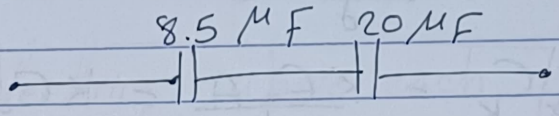
Exp



$$C_{12} = \frac{C_1 C_2}{C_1 + C_2} = \frac{15 \times 3}{15+3} = 2.5\ \mu F$$

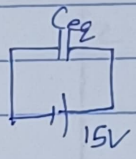


$$C_{123} = \cancel{2.5} + C_{12} + C_3$$
$$= 8.5\ \mu F$$



$$C_{eq} = \frac{8.5 * 20}{20 + 8.5} = 5.96\ \mu F$$

$V_{ab} = 15V$



$$C_{eq} = \frac{Q_{eq}}{V_{ab}}$$

$$Q_{eq} = 5.96 \times 15 = 89.4 \text{ Volts}$$

$$Q_{eq} = q_4 = q_{123}$$

$$C_{123} = \frac{q}{V}$$

$$8.5 = \frac{89.46}{V_{123}}$$

$$V_{123} = 10.5 \text{ Volts}$$

$$q_3 = C_3 V$$
$$= 6 * 10.5$$
$$= 63\ \mu C$$

$$q_{eq} = q_{12} + q_3$$

$$89.4 = 63 + q_{12}$$

$$q_{12} = 26.4\ \mu C$$

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$Q_1 = Q_2 = Q_{12} = 26.4\,\mu C$

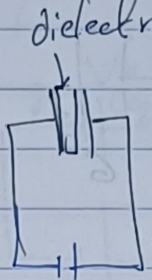
Dielectric

للمادة العازلة

$\frac{k\epsilon_0 A}{d}$ $\frac{k 2\pi\epsilon_0 L}{\ln(\frac{b}{a})}$ $\frac{k 4\pi\epsilon_0 (ab)}{(b-a)}$

k : Dielectric Constant "Capa". $k > 1$

airfilled



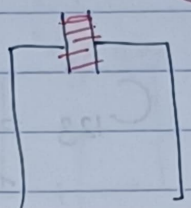
$C_0 = \frac{\epsilon_0 A}{d}$

$C_k = k\frac{\epsilon_0 A}{d} = kC_0$

$C = \frac{Q}{V}$ ↓ اذا دخل مادة العازلة تنقص

$C_0 = \frac{Q_0}{V_0}$ $C_k = \frac{kQ_0}{V_0}$

$C_0 = \frac{\epsilon_0 A}{d} = \frac{Q_0}{V_0}$



the battery disconnected

$C = kC_0$

$= \frac{C_0}{V_0/k}$

$= \frac{kQ_0}{V_0}$

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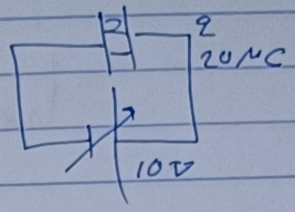
Dielectric Breakdown.



E_{max} = Dielectric strength (طاقة الكهرباء)

$C = \frac{q}{V} = \frac{20}{10} = 2\mu F$

$E_{max} = \frac{V_{max}}{d} \Rightarrow V_{max} = E_{max} * d$

* When dielectric side by side to each other Net Capacitance equal.

$$C_{net} = C_1 + C_2 \quad \text{---------- (1)}$$

* When dielectrics above each other Net Capacitance equal

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

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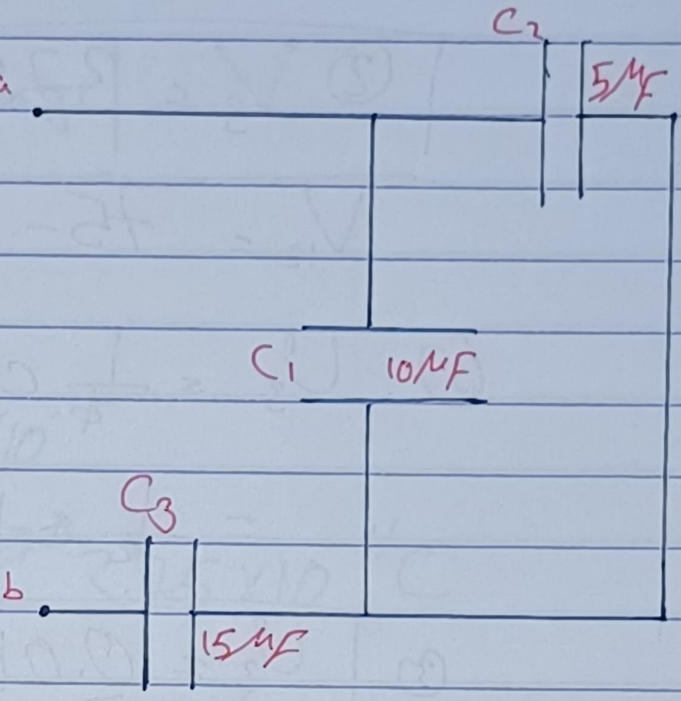
Disscussion 25
Problems.

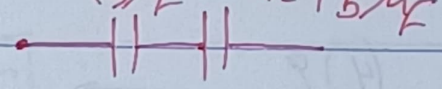
(Q 2)



$V_{ab} = 75$ Volts

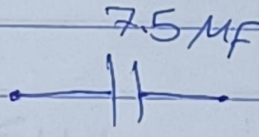
① q_3

[1] ~~$C_{12} = \frac{10 \times 15}{25} = 6\,\mu F$~~



$C_{12} = 10 + 5 = 15\,\mu F$

$C_{eq} = \frac{15 \times 15}{30} = 7.5\,\mu F$



$q_{tot} = C_{eq} * V = 7.5 * 75$

$= 562.5\,\mu C$

$= 5.6 \times 10^{-4}\,C$

$q_{tot} = q_3 = q_{12}$

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① $q_3 = 5.625 \times 10^{-4}\ C$

$q = CV$

$V_3 = \frac{q_3}{C_3} = \frac{5.625 \times 10^{-4} \times 10^{2}}{15 \times 10^{-6}}$

② $V_3 = 37.5$ Volts

$V_{12} = 75 - 37.5 = 37.5$ Volts

③ $U_3 = \frac{1}{2} C_3 V_3^2$

$= \frac{1}{2} * 15 \times 10^{-6} * (375)^2$

③ $U_3 = 0.01$ J

④ $q_1 \Longrightarrow q_{12} = 5.625 \times 10^{-4} C$

$V_{12} = 37.5$ Volts

$V_1 = 37.5$ Volts

$V_2 = 37.5$ Volts.

$q_1 = \frac{q_{12}}{V_{12}} = \frac{10 \times 10^{-6}}{37.5}$

$q_1 = 2.67 \times 10^{-7}\ C$

$q_1 = C_1 V_1 = 10 \times 10^{-6} * 37.5$

$q_1 = 3.75 \times 10^{-4}\ C$

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(f) $U_1 = \frac{1}{2} C_1 V_1^2$

$= \frac{1}{2} \times 10 \times 10^{-6} * (37.5)^2$

$= 7 \times 10^{-3} J = 7mJ$

$\boxed{U_1 = 7mJ}$

g) q_2

$q_{12} = 5.625 \times 10^{-4}$

$q_1 = ~~2.67 \times 10^{-4}~~ 3.75 \times 10^{-4} C$

$q_2 = C_2 V_2 = 5 \times 10^{-6} * 37.5$

$\boxed{q_2 = 1.875 \times 10^{-4} C}$

h) $V_2 = V_1 = V_{12} = 37.5 Volts.$

i) $U_2 = \frac{1}{2} C_2 V_2^2$

$= \frac{1}{2} * 5 \times 10^{-6} * (37.5)^2$

$\boxed{U_2 = 3.5 \times 10^{-3} J} \Rightarrow 3.5 mJ$

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10) Parallel air filled Capacitor.

a) $A = 40\,cm^2$

$d = 1\,mm \quad 0.1\,cm \quad 1\times10^{-3}$

$\Delta V = 500\,Volts$

$$C = \frac{\epsilon_0 A}{d} = \frac{8.85\times10^{-12} * 40\times10^{-4}}{1\times10^{-3}}$$

$$* \boxed{C = 35.4\,PF} *$$

b) $Q_{tot} = CV$

$$= 35.4\times10^{-12} * 500 = 17.700\times10^{-10}$$

$$* = 17.7\times10^{-9} = 17.7\,nC$$

$$* \; Q_1 = +17.7\,nC \;, \; Q_2 = -17.7\,nC$$

c) $$U = \frac{1}{2} CV^2 = \frac{1}{2} * 35.4\times10^{-12} * (500)^2$$

$$\boxed{U = 4.425\times10^{-6}\,J = 4.425\,\mu J}$$

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b) $E = \frac{\Delta V}{d}$

$= \frac{500}{10^{-3}} = 5 \times 10^5 \ V/m$

$E = 5 \times 10^5 \ V/m$

c) $u = \frac{1}{2} \epsilon_0 E^2$

$= \frac{1}{2} \times 10^{-12} \times 8.85 \times (5 \times 10^5)^2$

$u = 1.10625 \ J/m^3$

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Q (7) Parallel plates.

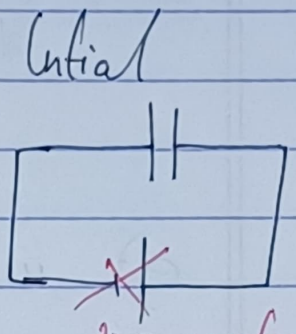
Area = $8.5 cm^2 = 8.5 \times 10^{-4} m^2$

air filled $\Longrightarrow \epsilon_o = 8.85 \times 10^{-12}$

$d_i = 8mm = 8 \times 10^{-3} m$

$d_f = 3mm = 3 \times 10^{-3} m$

Battary = 16V



① ~~$C = \frac{Q}{V} =$~~

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

$$= \frac{8.85 \times 10^{-12} \times 8.5 \times 10^{-4}}{8 \times 10^{-3}}$$

$$C_o = 0.94 \, PF$$

$$C_f = \frac{8.85 \times 10^{-12} \times 8.5 \times 10^{-4}}{3 \times 10^{-3}}$$

$$C_f = 2.5 \, PF$$

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$$q_c = C_o V_o$$

$$= 0.94 \times 10^{-12} \times 16$$

$$\boxed{q_c = 15\ pC}$$

حفظ الشحنة $q = C_1 V_1 = C_2 V_2$

@ $V_f = \frac{q_c}{C_f} = \frac{15 \times 10^{-12}}{2.5 \times 10^{-12}} = 6\ V$

* ΔV after disconnecting the battery is 6 V

b)

$$U_o = \frac{1}{2} C_o V_o^2$$

$$= \frac{1}{2} * 0.94 \times 10^{-12} * 16^2$$

$$U_o = 120.32 \times 10^{-12}\ J$$

$$\boxed{U_o = 1.2 \times 10^{-10}\ J}$$

c) $U_f = \frac{1}{2} C_f V_f^2$

$$= \frac{1}{2} \times 2.5 \times 10^{-12} * 6^2$$

18

$$\boxed{U_f = 45 \times 10^{-12}\ J}$$

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W_{ext} = ΔU

Pushing

$= U_f - U_o$

$= (45 - 120) \times 10^{-12}$

$W = -75 \times 10^{-12}$ J

(-) that's indicates that the system done the work to push the plates into each other.

Q18) Parallel plate. $A = 5.56\ cm^2 = 5.56 \times 10^{-4}\ m^2$

$d = 5.56\ mm = 5.56 \times 10^{-3}\ m$

$K_1 = 7$

$K_2 = 10$

$C_{K_1} = K_1 C_o$

$= K_1 \frac{\varepsilon_o A}{d}$

$= \frac{7 \times 8.85 \times 10^{-12} \times 5.56 \times 10^{-4}}{5.56 \times 10^{-3} \times 2}$ (10^{-1})

$C_{K_1} = 3.1\ PF$

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$$C_{K_2} = K_2 C_{O2}$$

$$= \frac{5 \times 8.85 \times 10^{-12} \times 5.56 \times 10^{-1}}{5.56 \times 10^{-3} \times x}$$

$$= 4.425 \times 10^{-12} F = 4.425 PF$$

$$C_{net} = 4.425 PF + 3.1 PF$$

$$\boxed{C_{net} = 7.525 PF}$$

Question 37:

$K = 5.6$) diedectric strength = 18M V/m

if used in parallel plate Capacitance.

Minimum Area ?? $\longrightarrow$ $C = 3.9 \times 10^{-2} \mu F$

$\Delta V_{max} = 4KV$

$$E_{max} = \frac{V_{max}}{d} \Rightarrow 18 \times 10^6 = \frac{4000}{d}$$

$$d = 2.22 \times 10^{-4} m$$

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

$$A = \frac{Cd}{K\epsilon_o} = \frac{3.9 \times 10^{-2} \times 2.22 \times 10^{-4}}{5.6 \times 8.85}$$

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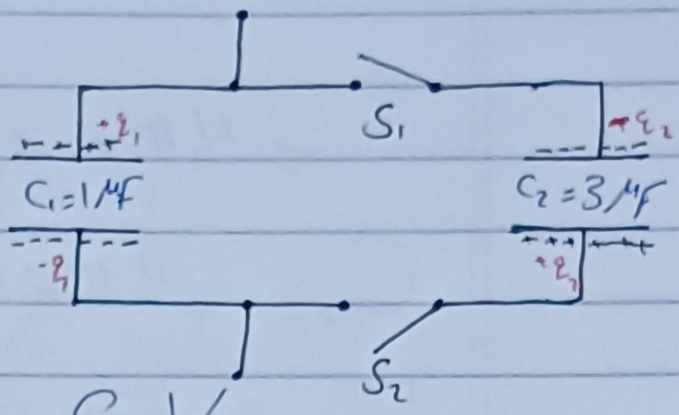
$A = 0.174\ m^2$

Question 39)

Parallel

$V_1 = V_2 = V = 200V$



$q_1 = C_1 V$

$= 1 \times 10^{-6} * 200$

$q_1 = 2 \times 10^{-4} C$

$q_2 = C_2 V$

$= 3 \times 10^{-6} * 200$

$q_2 = 6 \times 10^{-4} C$

$V_{ab} = q_{tot} / C_{eq}$

$= \frac{8 \times 10^{-4}}{0.75 \times 10^{-6}}$

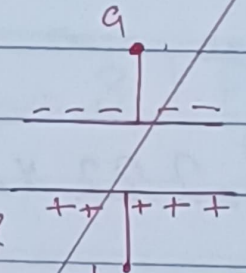
$= 10.7 \times 10^2$

$C_{eq} = \frac{(1*3) \times 10^{-6} \times 10^{-6}}{(1+3) \times 10^{-6}}$

$= \frac{3}{4} \times 10^{-6}$

$= 0.75 \times 10^{-6}$

$C_{eq} = 0.75 \times 10^{-6}$



$q_{tot_a} = (2 - 6) \times 10^{-4}$

$= -4 \times 10^{-4}$

$q_{tot_b} = (6 + -2) \times 10^{-4}$

$= 4 \times 10^{-4}$

$V_{ab} = \frac{q_{tot}}{C_{eq}} = \frac{4 \times 10^{-4}}{0.75 \times 10^{-6}}$

$= 533.3\ Volt.$

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(Question 53)

$C_1 = 100pF$

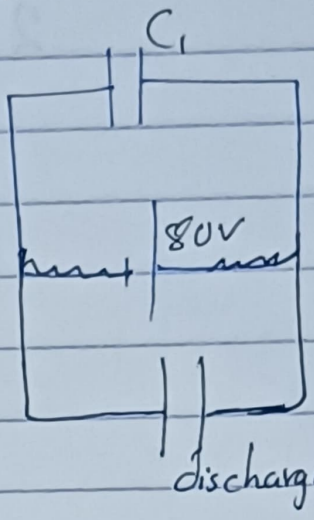
$\Delta V_i = 80$ Volts.

$\Delta V_f = 35V$

$q_{i1} = C_{i1} V_{i1}$

$= 100 \times 10^{-12} \times 80$

$\boxed{q_{i1} = 8nC}$



$q_{f1} = C_{f1} V_{f1}$

$= 100 \times 10^{-12} \times 35$

$\boxed{q_{f1} = 3.5nC}$

$q_i = C_i V$

$= 100 \times 10^{-12} \times 80$

$= 8 \times 10^{-9} C$

$q_i = 8nC$

$q_i = q_{tot}$

$q_2 = q_{i1} - q_{f1}$

$= (8 - 3.5) \times 10^{-9}$

$= 5 \times 10^{-9} C = 5nC$

$\boxed{q_2 = 5nC}$

$q_{tot} = C_{eq} V$

$\frac{8 \times 10^{-9}}{35} = (C_1 + C_2)$

$C_2 = \frac{8 \times 10^{-9}}{35} - C_1$

$C_2 = \frac{q_2}{V} = \frac{8 \times 10^{-9}}{35}$

$= 1.142 \times 10^{-10} F$

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$$Q_{tot} = (C_1 + C_2)V$$

$$\frac{8 \times 10^{-9}}{35} = \frac{((100 \times 10^{-12}) + C_2)}{35} \times 35$$

$$2.28 \times 10^{-10} = 10^{-10} + C_2$$

$$C_2 = 1.28 \times 10^{-10}$$

$$= 128 \times 10^{-12}$$

$$\boxed{C_2 = 128.5\,PF}$$

Question 39) Assuming.

$V_1 = V_2 = 200$ Volts.

$$q_1 + q_2 = 4 \times 10^{-4}\,C \quad \text{——(1)}$$

$q_{tot} = C_{eq} V$

$V = \frac{q_{tot}}{C_{eq}}$

$= \frac{4 \times 10^{-4}}{4 \times 10^{-6}}$

$= 100$ Volts.

$q_1' = C_1' V$

$= 1 \times 10^{-6} \times 100$

$= 10^{-4}\,C$

$q_2 = 3 \times 10^{-6} \times 100$

$= 3 \times 10^{-4}\,C$

New charge.

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$$q_1 = C_1 V_1$$

$$= 1 \times 10^{-6} * 100$$

$$\boxed{q_1 = 100 \mu C}$$

$$q_2 = C_2 V_2$$

$$= 3 \times 10^{-6} \times 100$$

$$\boxed{q_1 = 300 \mu C}$$

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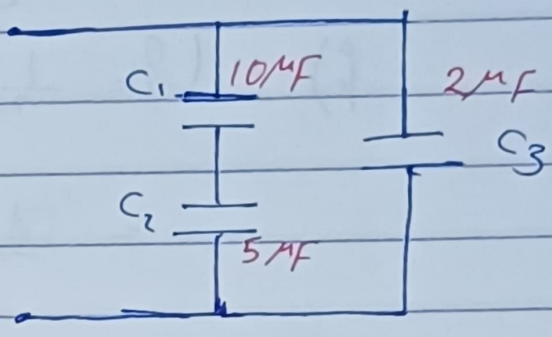
Additional Problems

Question 6:

$V_{ab} = 100 \text{ volts} = V_3 = V_{12}$



a) $q_3 = C_3 V_3$

$= 2 \times 10^{-6} * 100$

$\boxed{q_3 = 200 \mu C}$

b) $V_3 = V_{ab} = V_{12} = 100 \text{ volts}$.

c) $U_3 = \frac{1}{2} C_3 V_3^2$

$= \frac{1}{2} * 2 \times 10^{-6} * (100)^2 \times 10^{-2}$

$\boxed{U_3 = 1 \times 10^{-2} \text{ J}}$

d) $q_1 = C_1 V_1 = q_2 = q_{12}$

$q_{tot_{12}} = q_1 = C_{12} V$

$= \frac{10 \times 100 \times 10^{-6}}{3}$

$\boxed{q_{12} = q_1 = \frac{16}{3} \times 10^{-4}}$

$C_{12} = \frac{C_1 C_2}{C_1 + C_2}$

~~$10 + 5 = 15 \mu F$~~

$C_{12} = \frac{10 * 5}{10 + 5} = \frac{50}{15} = \frac{10}{3} \mu F$

$q_{tot_{12}} = C_{12} V_{12}$

$= 15 \times 10^{-6} * 100$

$q_{tot_{12}} = 15 \times 10^{-4} \text{ C}$

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e) $V_1 = \frac{q_1}{C_1} = \frac{\frac{10}{3} \times 10^{-4}}{10 \times 10^{-6}}$

$= \frac{1}{3} \times 10^{2}$

$$\boxed{V_1 \approx 33.3 \text{ Volts}}$$

f) $U_1 = \frac{1}{2} C_1 V_1^2$

$= \frac{1}{2} * 5 \times 10^{-6} * \left(\frac{1}{3} \times 10^{2}\right)^2$

$= 5 \times 10^{-6} * \frac{10^{-2}}{9} * 10^{4}$

$$\boxed{U_1 = \frac{5}{9} \times 10^{-2} \text{ J}} \quad \approx 5.6 \times 10^{-3} \text{ J}$$

g) $q_2 = C_2 V_2$ $\quad V_2 = 100 - \frac{1}{3} \times 10^{2}$

$= 5 \times 10^{-6} \times \frac{2}{3} \times 10^{2}$ $\quad = \frac{2}{3} \times 10^{2}$

$$\boxed{q_{tot} = q_1 = q_2 = \frac{10}{3} \times 10^{-4} \text{ C}}$$

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Question 11

Dielectric:

C_i air

$C_{i_{air}} = 8PF = 8 \times 10^{-12} F$

$V_{max} = 350.8$ Volts.

$U = 3.2 \mu J$

$Q = CV$

a) $U = \frac{1}{2} C_K V^2 =$

$3.2 \times 10^{-6} = \frac{1}{2} C_K (350.8)^2$

$6.4 \times 10^{-6} = C_{IC} * 123060.64$

$C_K = 52 PF = 52 \times 10^{-12} F$

$C_K = K C_i$ *

$52 \times 10^{-12} = K 8 \times 10^{-12}$

b) $\boxed{K = 6.5}$

b) the Material is Porcelain

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Q12) Air filled parallel Capacitor.

$C_i = 2.1 \times 10^{-12} F$ $\quad d_2 = 2d_1$

- Wax ⟶ ⟹ dielectric Material

$C_f = 2.6 \times 10^{-12} F$

~~$C_f = KC_i$~~

~~$K = \frac{2.6 \times 10^{-12}}{2.1 \times 10^{-12}} = 1.238$~~

$C_f = KC_i$

$\frac{\epsilon_0 A}{2d} = K \frac{\epsilon_0 A}{d}$

$\frac{C_i}{2} = KC_i$

$C_f = K \frac{\epsilon_0 A}{2d} C_i$

$2C_f = KC_i$

$K = \frac{2 \times 2.6 \times 10^{-12}}{2.1 \times 10^{-12}}$

$K = 2.47 \approx 2.5$

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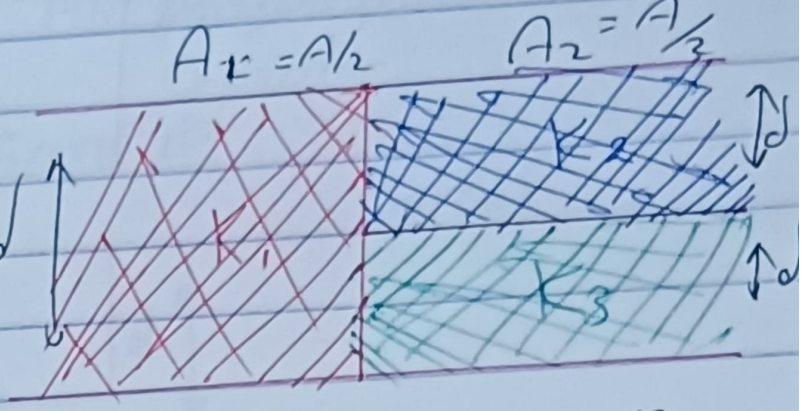
Question: 22.



$A = 12.5 cm^2$

$2d = 7.12 mm$

$K_1 = 21$

$K_2 = 42$

$K_3 = 58$

$$C_1 = \frac{K_1 \varepsilon_0 A_1}{2d} = \frac{21 \times 8.85 \times 10^{-12} \times 12.5 \times 10^{-4} \times \frac{1}{2}}{7.12 \times 10^{-3}}$$

$$C_1 = \frac{32.6}{2} \times 10^{-12} F$$

$$C_1 = \frac{32.6}{2} PF \Rightarrow C_1 = 16.3 PF$$

$$C_2 = \frac{K_2 \varepsilon_0 A/2}{d}$$

$$= \frac{42 * 8.85 \times 10^{-12} * 12.5 \times 10^{-4}}{2d = 7.12 \times 10^{-3}}$$

$$C_2 = 65.25 \times 10^{-12} = 65.25 PF$$

$$C_2 = 65.25 PF$$

$$C_3 = \frac{K_3 \varepsilon_0 A}{2d} = \frac{58 * 8.85 \times 10^{-12} * 12.5 \times 10^{-4}}{7.12 \times 10^{-3}}$$

$$= 90.1 \times 10^{-12}$$

$$= 90.1 PF$$

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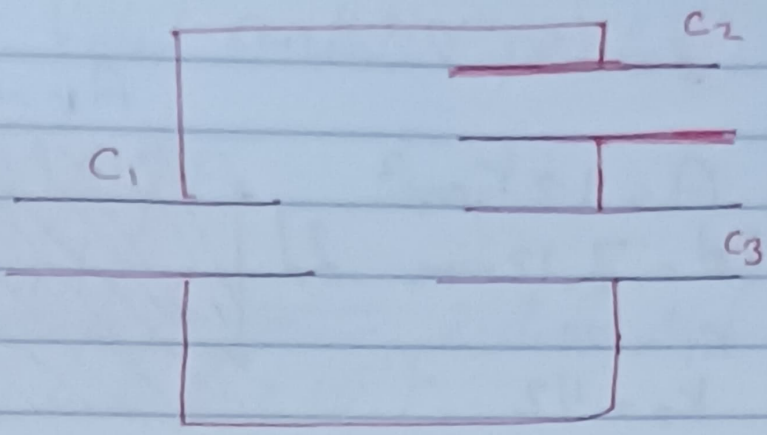
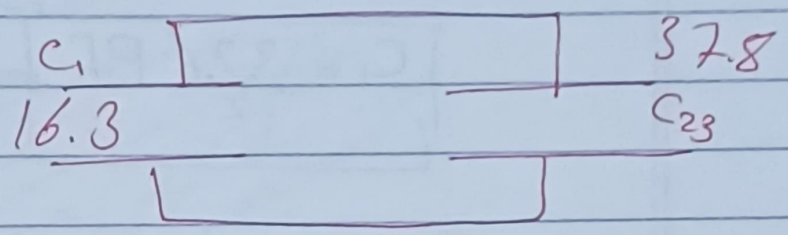


$$C_{23} = \frac{C_2 C_3}{C_2 + C_3} = \frac{96.1 * 65.25}{96.1 + 65.25}$$

$$C_{23} = 37.8 \text{ PF}$$



$$C_{net} = C_1 + C_{23} = 16.3 + 37.8$$

$$= 54.14 \text{ PF}.$$

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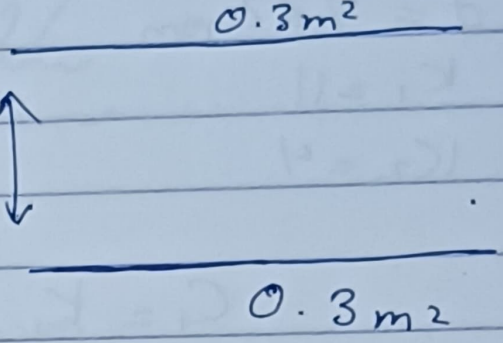
(Question 28) Air ~~parallel~~ Paralleled Capacitor.

$C_i = 50PF = 50 \times 10^{-12} F$



~~$C_f = KC_i$~~

① $C_i = \frac{\epsilon_0 A}{d}$

$50 \times 10^{-12} = \frac{8.85 \times 10^{-12} \times 0.3}{d}$

$d = \frac{8.85 \times 0.3}{50}$

$d = 0.0531 m$

$\boxed{d = 5.31 cm}$

② $C_f = KC_i$

$= 5.6 \times 50 \times 10^{-12}$

$\boxed{C_f = 280 PF}$

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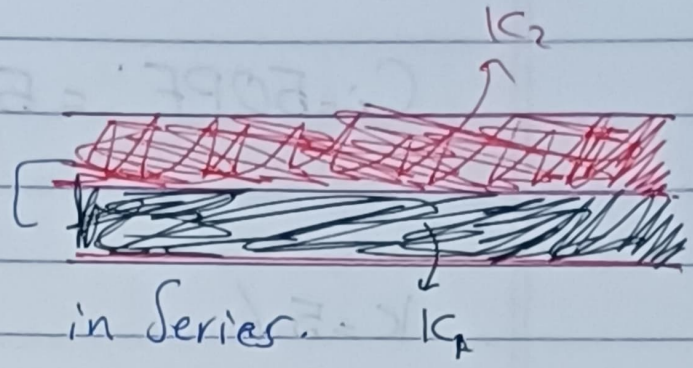
Question 31)

$A = 7.89 cm^2$

$d = 4.62 mm$

$K_1 = 11$

$K_2 = 4$



$$C_1 = \frac{K_1 \epsilon_0 A}{\frac{1}{2}d}$$

$$= \frac{11 \times 2 \times 8.85 \times 10^{-12} \times 7.89 \times 10^{-4}}{4.62 \times 10^{-3}}$$

$$C_1 = 33.25 \text{ PF}$$

$$C_2 = \frac{2 K_2 \epsilon_0 A}{d} = \frac{2 \times 4 \times 8.85 \times 10^{-12} \times 7.89 \times 10^{-4}}{4.62 \times 10^{-3}}$$

$$C_2 = 12.1 \times 10^{-12} F$$

$$12.1 \text{ PF}$$

$$C_{net} = \frac{C_1 C_2}{C_1 + C_2} = \frac{12.1 \times 33.25}{12.1 + 33.25} = \frac{402.325}{45.35}$$

$$C_{net} = 8.87 \text{ PF}$$

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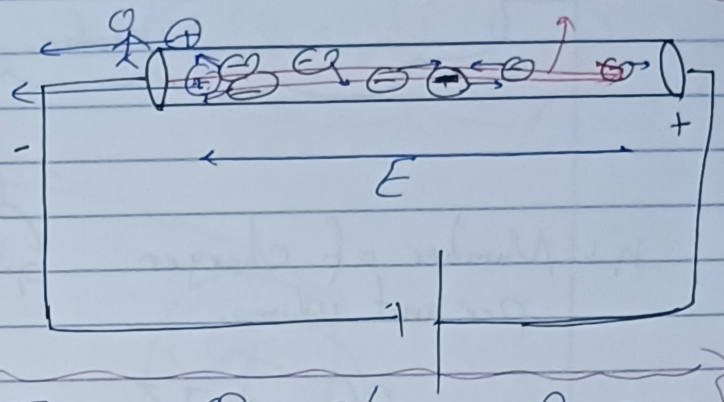
Direct Current and Resistance.

* I = Current.

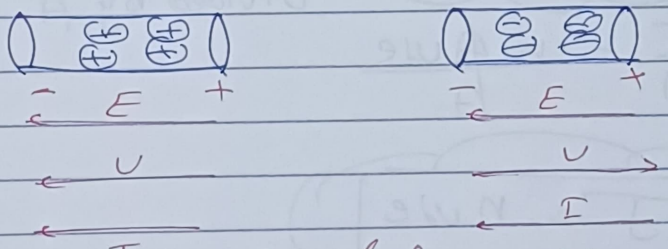
Electric Current.



$$I_{avg} = \frac{\Delta Q}{\Delta t} = C/sec = Ampere\ (A)$$

$$I_{Instantenous} = \frac{dq}{dt}$$

$$I_{Instantenous} = \frac{dq}{dt}$$



Current from V_2 to V_1

$V_2 > V_1$

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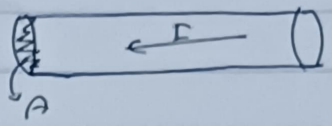
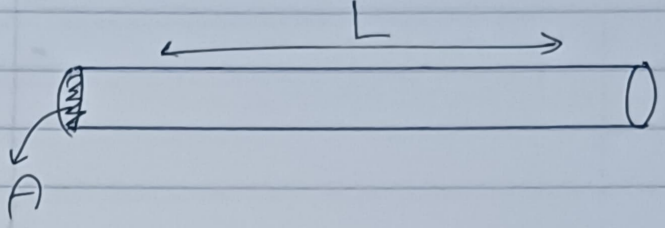
* Current density ($\vec{J}$)

$$\vec{J} = \frac{I}{A} = A/m^2$$



* $I = \int \vec{J} \cdot d\vec{A}$

Scaler. ← I ; $\vec{J}$ ↑ Vector



n: Number of charges per unit volume

$$Q = nVe$$

$$\frac{q}{t} = \frac{nAle}{t}$$

$$I = nAv_d e$$

v_d: Drift Velocity

Divided by A

$$\frac{I}{A} = \frac{nAv_d e}{A}$$

$$J = nv_d e$$

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

ρ → Resistivity $\quad \rho = \frac{1}{\sigma}$

$$J = \sigma E$$

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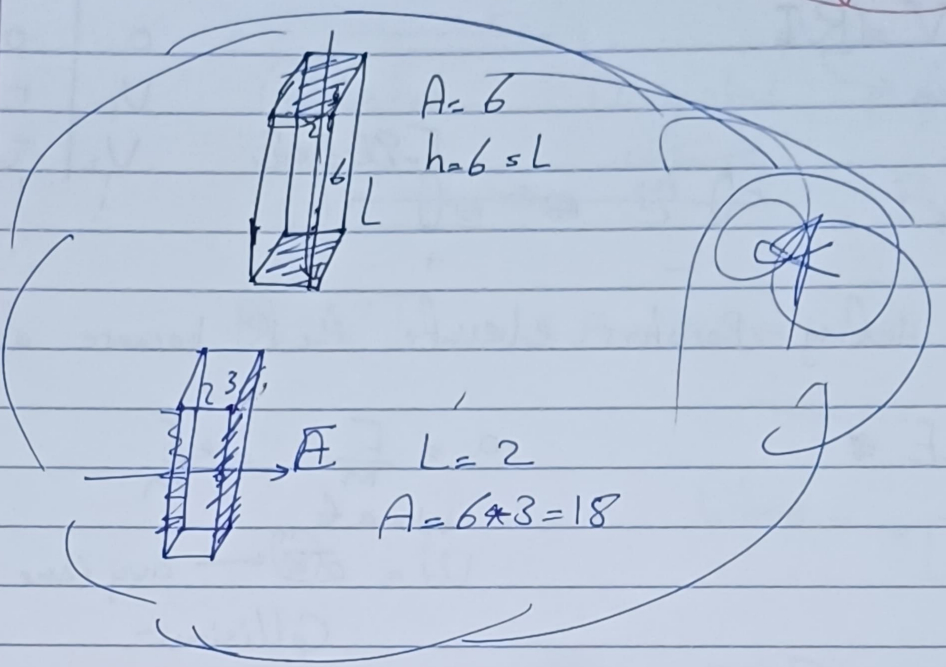
$$\rho = \frac{E}{J} = \frac{\Delta V / L}{I / A}$$

$$\rho = \frac{\Delta V A}{I L} \quad (R)$$

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



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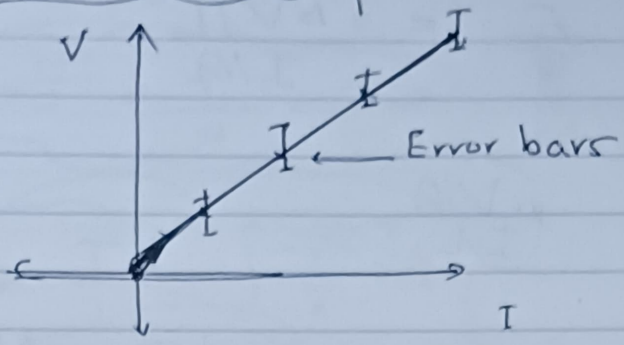
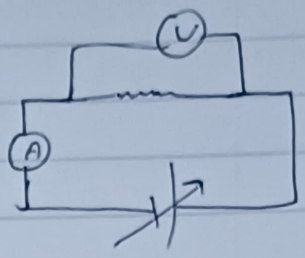
Ohms Law?



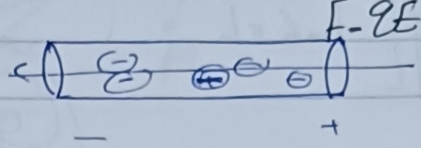


$y = ax$ → Linear Curve.

I	U
0	0
I_1	V_1
I_2	V_2

$V = RI$

slope



Heating Resistors elevate the R because of Collision

$F = eE$ ✱ $\qquad a = \frac{F}{m} = \frac{eE}{m}$

$v_d = at$

$v_d = a\tau$ ← avg time between Collisions.

$$v_d = \frac{eE\tau}{m} \quad \text{——} (1)$$

$$J = nev_d$$

$$v_d = \frac{J}{ne} \quad \text{——} (2)$$

$$\frac{eE\tau}{m} = \frac{J}{ne}$$

$$ne^2E\tau = mJ$$

$$\frac{E}{J} = \rho = \frac{m}{ne^2\tau} \quad \text{——} (3)$$

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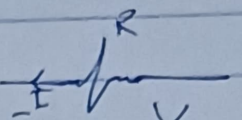
Power

* rate of change of energy ← Power = Energy / time J/s = Watt.

* KWh = Energy = KW h

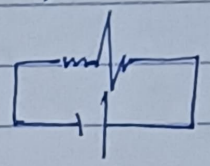
Power
- Generated (مولدة)
- Disipated (مستهلك)



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

* $P = VI$ Volt.A = J/s = Watt

When →



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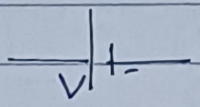
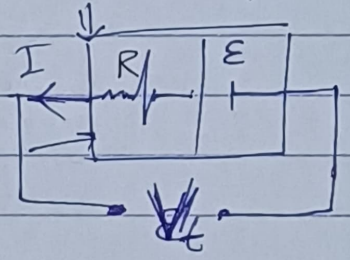


emf = Electromotive force. = $\mathcal{E}$ (دفع الكهربائي في البطارية)



Ture battery

Terminal Voltage $< \mathcal{E}$

قبل توصيل الدائرة $V_t = \mathcal{E}$

* التفريغ $V_t = \mathcal{E} - IR$

* الشحن $\mathcal{E} = V_t - IR$
اذا شحن

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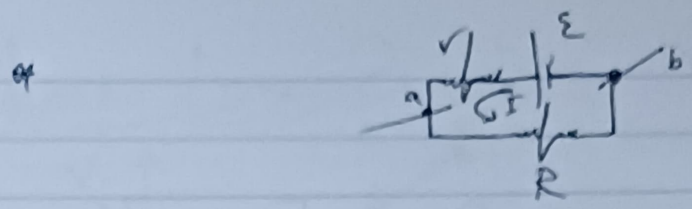
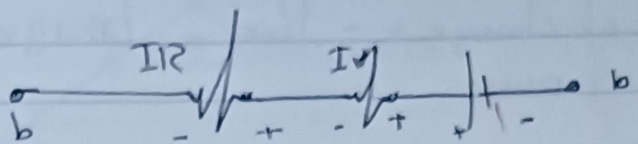
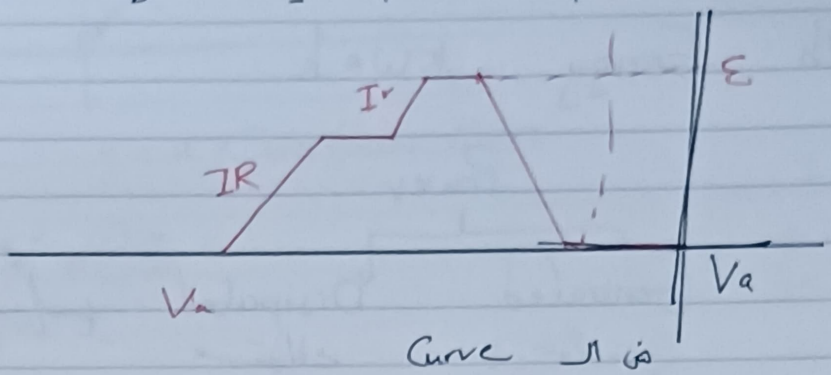






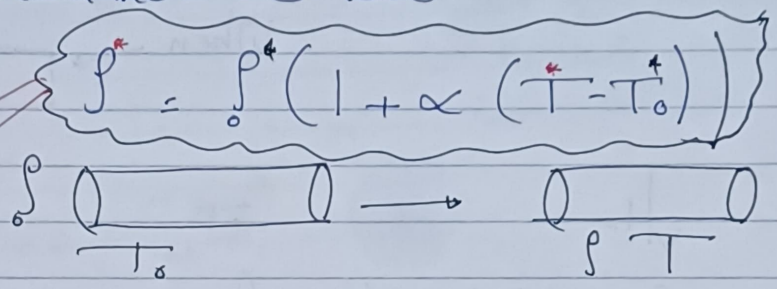
Curve ل ؤ

$\mathcal{E} = Ir + IR$

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

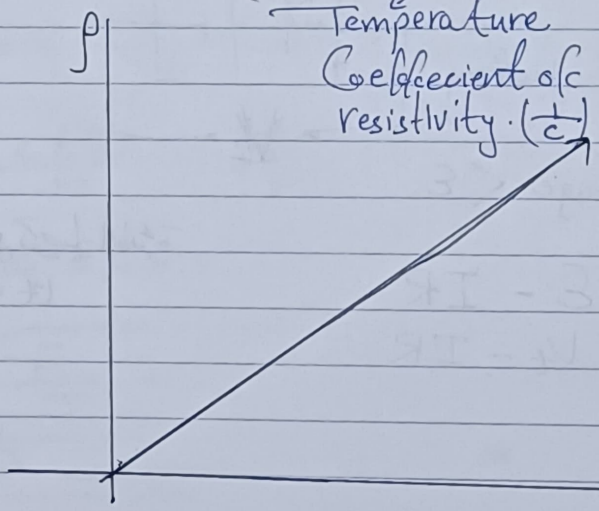
* Resistance ∝ heat.

$\rho = \rho_0 (1 + \alpha (T - T_0))$



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

Temperature Coefficient of resistivity $(\frac{1}{C})$



$R_0 = 10\ \Omega$

$T_0 = 20^\circ$

$T_f = 120^\circ$

$R = ??$

$I = ??$

$I = \frac{V}{R_0} = \frac{220}{10} = 22$

$I_2 = \frac{V}{R} = \frac{220}{R_0 (1 + \alpha (T - T'}$

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$$F = \frac{K|q_1||q_2|}{r^2} \quad , \quad F = \frac{|E|}{|q|} \quad , \text{ Newton}$$

$$E = \frac{Kq}{r^2} \quad , \quad N/C \quad \longleftarrow \text{ Point charge.}$$

$$\Sigma F = ma \implies qE = ma$$

$$v_f = v_i + at$$
$$v_f^2 = v_i^2 + 2a\Delta x$$
$$\Delta x = v_i t + \frac{1}{2}at^2$$

$$E_{\substack{\text{dipole} \\ \text{Point charges}}} = \frac{P}{2\pi\epsilon_0 y^3 \left(1 - \left(\frac{d}{2y}\right)^2\right)^2}$$

$$U = -P.E = -PE\cos\theta \equiv J$$

$$\vec{\tau} = P \times E = PE\sin\theta \equiv N.m$$

$$E_{disk} = \frac{\sigma}{2\epsilon_0}\left(1 - \frac{y}{\sqrt{R^2+y^2}}\right) \longrightarrow \text{Disk.}$$

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

$$E = \frac{2k\lambda}{y} \longleftarrow \text{Infinate Rod}$$

$$E = \frac{k\lambda}{R}\left(\sin\theta_1 + \sin\theta_2\right) \text{ Centre Ring.}$$

$$E = \frac{k\lambda}{R} \longrightarrow \frac{1}{4} \text{ Circle.}$$

$$E = \frac{2k\lambda}{R} \longrightarrow \text{Hemi circle.}$$

$$E = \frac{\sigma}{2\epsilon_0} \longrightarrow \text{Sheet.}$$

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* $V = \frac{Kq}{r}$ ⟶ Uniform q → sphere, ring, disk, ...

* Rod $dV = \frac{K\,dq}{r} \Rightarrow V = \int_0^L \frac{K\,dq}{r}$

* E in Conducting $= 0$

* $V_{\text{in non Conducting}} = \frac{KQ}{2R}\left(\frac{3 - r^2}{R^2}\right)$

* $V_{\text{dipole}} = \frac{KP\cos\theta}{r^2}$

* $\Delta V = -\int E.d \Rightarrow$ Uniform $E \Rightarrow \Delta V = E.d$

* $W_{ext} = \Delta U = -q\Delta V = \Delta KE$

* $U_1 = q_1 V_2 = \frac{Kq_1q_2}{r_{12}}$

* $E = -\nabla V \Rightarrow = -\frac{dV}{dx} - \frac{dV}{dy} - \frac{dV}{dz}$

* $V = \int E\,dx - \int E\,dy - \int E\,dz$

* $V_{\text{semi Circle}} = K\lambda\pi \Rightarrow$ Qurter $\Rightarrow \frac{K\lambda\pi}{2}$

* $\Sigma V_{net} = V_1 + V_2 + V_3 - - - -$

* $W = F.d \Rightarrow = qE.d$

* $\Phi_{net} = \frac{q_{en}}{\epsilon_0}$, $\Phi = E.A$

* $\Phi = \int E.A \Leftarrow$ nonuniform

* $C = \frac{\epsilon_0 A}{d} \Rightarrow$ Parallel Plate Capacitor.

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* $C = \frac{2\pi\epsilon_0 L}{\ln\frac{b}{a}}$ ← Cylindrical Capacitor.

* $C = \frac{4\pi\epsilon_0 ab}{b-a}$ ← spherical Capacitor

* $U = \frac{1}{2}CV^2 = \frac{q^2}{2C} = \frac{1}{2}qV \equiv J$

* $C_{eq} = C_1 + C_2$ ⟶ Parallel

* $C_{eq} = \frac{C_1 C_2}{C_1 + C_2}$ ⟶ Series.

* $Q = CV$

* $I = \frac{dQ}{dt}$

* $I = neAv_d$

* $I = \int \vec{J} \cdot d\vec{A}$

* $\vec{J} = nev_d = \frac{I}{A}$ $\quad v_d = a\tau = \frac{qE}{m}\tau$

* $\vec{J} = \frac{ne^2 E}{m}$

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

* $V = RI$

* $\rho = \rho_0(1 + \alpha(T - T_0))$

* $\vec{J} = \sigma E = \frac{E}{\rho}$

* $P = VI = \frac{V^2}{R} = RI^2 = E/t$

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Discussion Problems 26

(Question 2)

$L = 8m \qquad \phi = 6mm$

$R = 30m\Omega \qquad \Delta V = 23V$

$I = \frac{V}{R} \qquad V = RI$

$= \frac{23}{30 \times 10^{-3}}$

a) $I = 766.67\,A$

$J = \frac{I}{A} = \frac{766.67}{\pi (3 \times 10^{-3})^2}$

b) $J = 2.71 \times 10^{7}\ A/m^2$

$R = \frac{\rho L}{A} \Rightarrow \frac{\rho L}{\pi R^2} = \frac{R \pi R^2}{L} = \rho$

$\rho = \frac{30 \times 10^{-3} * \pi * (3 \times 10^{-3})^2}{8}$

c) $\rho = 1.06 \times 10^{-7} \approx 10.6 \times 10^{-8}$

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Material is Platinium

Question 3

63 Strands fine wire. $R_{\text{each one}} = 2.65\ \mu\Omega$

$I_{tot} = 0.75\ A$

$V = RI$

a) Assume that every strand have resistance R and its Connection are paralled
So the Current will distribute equally

$I_{tot} = \#\text{Strands} \times I_0$ or ~~$I_{tot} = I_0$~~

~~$I_{tot} = I_0$~~

$I_0 = \frac{0.75}{63} = 0.0119$

$I = 11.9 \times 10^{-3} = 11.9\ mA$

$V_{tot} = R_{tot} I_{tot}$

$= \frac{R}{63} \times 0.75 = \frac{2.65 \times 10^{-6}}{63} \times 0.75$

$V_{tot} = 31.5 \times 10^{-8}$ Volts $\Rightarrow$ $V_{tot} = 31.5$ nVolts

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(c) R_{net} =

$$\frac{1}{R_{net}} = \frac{1}{R} + \frac{1}{R} + \frac{1}{R} \cdots \frac{1}{R}^{63}$$

$$\frac{1}{R_{net}} = \frac{63}{R}$$

$$R_{net} = \frac{R}{63} = \frac{2.65 \times 10^{-6}}{63}$$

$$R_{net} = 42.06 \times 10^{-9} = 42.06 \text{ n}\Omega$$

* Question 11

$V = 230$ volts

$L = 14.1$ m

$R = 0.3$ mm

$J = 1.98 \times 10^{8}$ A/m²

$E = \frac{\Delta V}{L}$

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

$$\rho = \frac{E}{J} = \frac{\Delta V}{JL}$$

$$= \frac{230}{1.98 \times 10^{8} * 14.1}$$

$$\rho = 8.23 \times 10^{-8} \ \Omega \cdot m$$

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Q) 15

Nichrome wire

$\rho = 5.0 \times 10^{-7}\ \Omega.m$

$L = 5.85\ m$

$\Delta V = 112$ volts.

$P_{dissipation} = 4000\ W$ ① $A = ??$

$$P_{dissipation} = \frac{V^2}{R}$$

$$4000 = \frac{(112)^2}{R} \Rightarrow R = \frac{12544}{4000}$$

$$\boxed{R = 3.136\ \Omega}$$

$$R = \frac{\rho L}{A} \Rightarrow A = \frac{\rho L}{R} = \frac{5 \times 10^{-7} \times 5.85}{3.136}$$

(a) $A = 9.32 \times 10^{-7}\ m^2$

(b) $P = \frac{V^2}{R} \Rightarrow P = \frac{V^2}{\frac{\rho L}{A}}$

$P = \frac{V^2 A}{\rho L} \Rightarrow L = \frac{V^2 A}{\rho P} = \frac{(100)^2 \times 9.32 \times 10^{-7}}{5 \times 10^{-7} \times 4000}$

$L = 4.66\ m$

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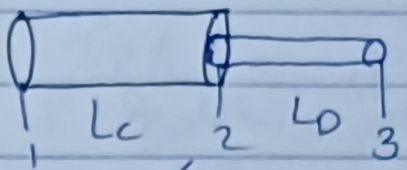
(Q 25)

$L_C = L_D = 1m$



$\rho_C = 2 \times 10^{-6}\ \Omega.m$ | $\rho_D = 1 \times 10^{-6}\ \Omega.m$

$R_C = 1mm$ | $R_D = 0.5mm$

$I_{tot} = 2A$

(a) $V_{12} = R_{12} I$

$= \frac{\rho_C L_C}{A_C} I$

$= \frac{2 \times 10^{-6} * 1}{\pi (1 \times 10^{-3})^2} * 2$

$V_{12} = 1.273$ volts.

(b) $V_{23} = R_{23} I$

$= \frac{\rho_D L_D}{A_D} * I = \frac{1 \times 10^{-6} * 1}{\pi * ((0.5) \times 10^{-3})^2} * 2$

$V_{23} = 2.54$ volts

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© Energy dispated.

$P_{12} = \frac{V_{12}^2}{R}$ $\quad V = RI$

$P_{12} = V_{12} I$

$= 1.273 * 2$

$P_{12} = 2.54$ Watt

$P_{23} = V_{23} I = 2.54 \times 2$

$P_{23} = 5.1$ Watt

43) $I = 285A$, Copper wire

$\rho = 1.69 \times 10^{-8} \Omega.m$ $\quad A = 0.17 cm^2$

$L = 0.43$

~~$I = nAvde$~~ $\quad \# = 8.49 \times 10^{28} m^{-3}$

$\Sigma F = ma$

$I = nAvde$

$v_d = a\tau$

$= nA \frac{e\tau}{m} * e \frac{J}{A}$ $\quad = \frac{eE\tau}{m}$

$I = \frac{nAe^2\tau}{m} * \frac{I}{A}$

$\tau = \frac{mA}{e^2} = \frac{9.1 \times 10^{-31} * 0.17 \times 10^{-4}}{(1.6 \times 10^{-19})^2 * 10^{-38} * 8.49 \times 10^{28}}$

$\tau = 6043$ sec

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$$I = nAv_d e$$

$$v_d = \frac{I}{nAe} = \frac{285}{8.49\times10^{28}\times1.6\times10^{-19}\times0.17\times10^{-4}}$$

$$v_d = 1.234\times10^{-3}\ m/sec$$

$$v_d = \frac{L}{t}$$

$$t = \frac{L}{v_d} = \frac{0.43}{1.234\times10^{-3}}$$

$$t = 348.41\ sec$$

$$t = \frac{348.41}{60} = 5.8\ min$$

$t = 5.8 min$

(Q) 45 $R = 2.67mm$

$$J_a = \frac{J_o r}{R}, \quad J_b = J_o\left(1 - \frac{r}{R}\right)$$

$$J_o = 5.5\times10^{4}\ A/m^2$$

$$I = \int_0^R J.dA$$

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a) $I = \int_0^R J_a 2\pi r\,dr$ $\qquad A = \pi r^2$, $dA = 2\pi r\,dr$

$= \int_0^R \frac{J_0 r}{R} * 2\pi r\,dr$

$= 2\pi J_0 \int_0^R \frac{r^2}{R}\,dr$

$= \frac{2\pi J_0}{R} \frac{r^3}{3}\Big|_0^{2.67\times10^{-3}}$

$= \frac{2\pi * 5.5\times10^{4}\,10^{7}}{2.67\times10^{-3}}\,A\,\frac{(2.67\times10^{-3})^3}{3}$

$12.942\times10^{7} * 6.344\times10^{-9}$

$\boxed{I_a = 0.821A}$

b) $I_b = \int_0^R J_b\,2\pi r\,dr = \int_0^R J_0\left(1-\frac{r}{R}\right)2\pi r\,dr$

$= 2\pi J_0 \int_0^R \left(1-\frac{r}{R}\right) r\,dr = 2\pi J_0 \int_0^R \left(r - \frac{r^2}{R}\right)dr$

$= 2\pi J_0 * \left(\frac{r^2}{2} - \frac{r^3}{3R}\right)\Big|_0^R = 2\pi J_0 * \left(\frac{R^2}{2} - \frac{R^3}{3R}\right)$

$= 2\pi J_0 \frac{R^2}{6} = 2\pi * 5.5\times10^{4} * \frac{(2.67\times10^{-3})^2}{6}$

$\boxed{I_b = 0.4105\,A}$

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c) Maximage Current ~~near~~ density near Surface.

Substitute R in r

$$J_a = J_0 \frac{R}{R} = J_0$$

$$J_b = 1 - \frac{R}{R} = 0$$

Hence J_a Maximage the Current density near the Surface.

53) $n = 4.5 \times 10^{8}$ $e = 2e = 2 \times 1.6 \times 10^{-19}$

$v_d = 300 m/s$

a) $\frac{I}{A} = \frac{nevdA}{A}$

$n = \frac{4.5 \times 10^{8}}{(100)^3 \, 10^{-6}}$

$J = nevd = 4.5 \times 10^{14} \times 2 \times 1.6 \times 10^{-19} \times 300$

$= 43.2 \times 10^{-3} A/m^2$

$n = 4.5 \times 10^{8} ions/m^3 = 43.2 mA/m^2$

$= \frac{4.5 \times 10^{8}}{10^{-6}} = 4.5 \times 10^{14}$ ion/m^3

b) South because ⊕ charge with I, these are negative ∴ Opposite direction.

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$$I = J * A$$

$$= 43.2 \times 10^{-3} * 2.5 \times 10^{-6}$$

$I = 108\ nA$ $= 0.108\ \mu A$

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Additional Problems 26

Q) 13

Nichrome wire

$\sigma = 2 \times 10^{6} (\Omega.m)^{-1}$

$A = 2.3 mm^2$

$I = 5.5 A$

$\Delta V = 1.4$ volts.

$$V = RI \Rightarrow R = \frac{1.4}{5.5} = 0.25\ \Omega$$

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

$$L = R \sigma A$$

$$= 0.25 \times 2 \times 10^{6} \times 2.3 \times 10^{-6}$$

$$L = 1.17 m$$

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14) $P = 90W$

$I = 3A$

$$P = RI^2 \Rightarrow R = \frac{P}{I^2}$$

$$R = \frac{90}{9} = 10\ \Omega$$

(Q17) $\mathcal{E}_1 = 3$ Volts. $\quad P_{dissipated} = 0.707$ Watt

$\mathcal{E}_2 = 12$ Volts.

$(V_2 = 4V_1)$

$\mathcal{E}_2 = 4\mathcal{E}_1 \qquad P_1 = V_1 I_1$

$R_1 = R_2$

$$\frac{V_1}{I_1} = \frac{V_2}{I_2} \Rightarrow \frac{3}{I_1} = \frac{12}{I_2}$$

$$I_2 = 4 I_1$$

$P_1 = V_1 I_1 = 0.707$ watt

$P_2 = V_2 I_2$

$= 4V_1 \cdot 4I_1 = 16 \times 0.707$ watt

$= 11.312$ J/s

$P_2 = 11.312$ watt

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(Q20) $V(x)$, Copper wire

$V_{max} = 12\mu V$ at $x = 0$

$V = 0$, at $x = 3m$

$R = 2.20mm$

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

$E = J\rho$ $\quad\quad$ $\Delta V = E\,\Delta x$

$E = \frac{I\rho}{A}$

$\frac{\Delta V}{\Delta x} = \frac{I\rho}{A}$

$\frac{0 - 12\times10^{-6}}{3-0} = \frac{I}{\pi(2.2)^2 * 10^{-6}} * 1.69\times10^{-8}$

$\pi(2.2)^2 * -4\times10^{-6} = I * 1.69\times10^{-2}$

$I = 3.6\times10^{-3} A$

$I = 3.6mA$

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(Q 32) $J = (2.75 \times 10^{10} A/m^4) r^2$

$R = 3\ mm$

$\therefore V = 80V$

Energy $= P * t = IV * t$

$$I = \int J\, dA$$

$$= \int_0^{2R} 2.75 \times 10^{10} r^2 * 2\pi r\, dr$$

$$= 2.75 \times 10^{10} * 2\pi \int_0^R r^3\, dr$$

$$= 2.75 \times 10^{10} * 2\pi \quad \frac{R^4}{4}$$

$$= \frac{2.75 \times 10^{10} * 2\pi}{4} * (3)^4 * (10^{-3})^4$$

$$I = 3.5A$$

$* P = VI = 80 \times 3.5$

$= 280$ Watt

Energy (kwh) $= \frac{280}{1000} * 1h$

$= 0.28$ kwh $= 280 \times 3500$

$= 1.008 \times 10^6$ J

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(Q5) $\rho = 731\ \Omega.m$

$a = 1.7mm$

$b = 2.3\ mm$

$L = 3.5\ cm$ Juniform

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

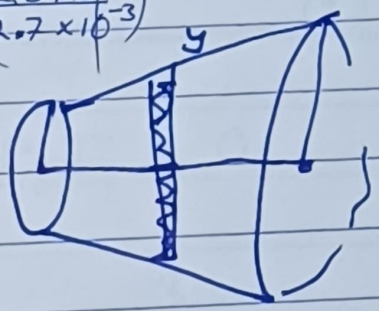
$$\int dR = \int \frac{\rho L}{dA}$$

$$R = \frac{\rho L}{2\pi} \int_a^b \frac{1}{R\,dR}$$

$$= \frac{\rho L}{2\pi} \ln R \Big|_a^b$$

$$= \frac{731 * 3.5\times10^{-2}}{2\pi} * \left(\ln 2.3\times10^{-3} - \ln 1.7\times10^{-3}\right)$$

$$= 1.07 * \left(\ln\left(\frac{2.3\times10^{-3}}{1.7\times10^{-3}}\right)\right)$$



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

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

$$R = \frac{\rho}{\pi} \int \frac{dx}{\left(\frac{b-a}{L}x + a\right)^2}$$

at $x = 0$, $y = a$

at $x = L$, $y = b$

$y = mx + a$

$b = mL + a$

$$m = \frac{b-a}{L}$$

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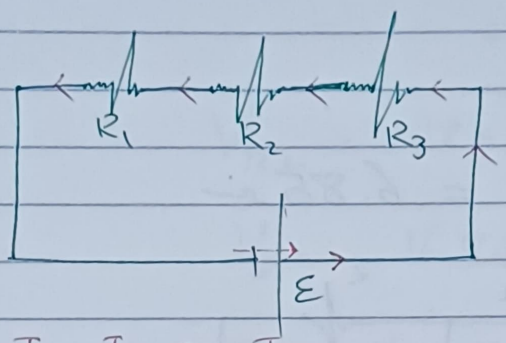
Chapter 27
Circuits

★ Resistors Connection

1. Configuration
2. Current
3. Potential

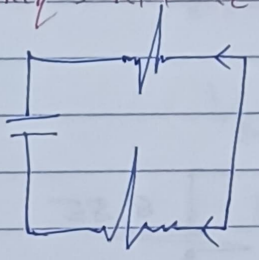
Series



$I = I_1 = I_2 = I_3$ ⟸ the same

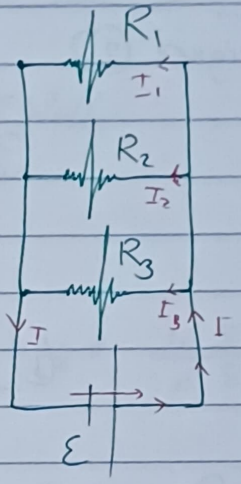
$V_{tot} = V_1 + V_2 + V_3$

$R_{eq} = R_1 + R_2 + R_3$



Not Series
Not Parallel

Parallel



$I = I_1 + I_2 + I_3$

$V = V_1 = V_2 = V_3$

$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$

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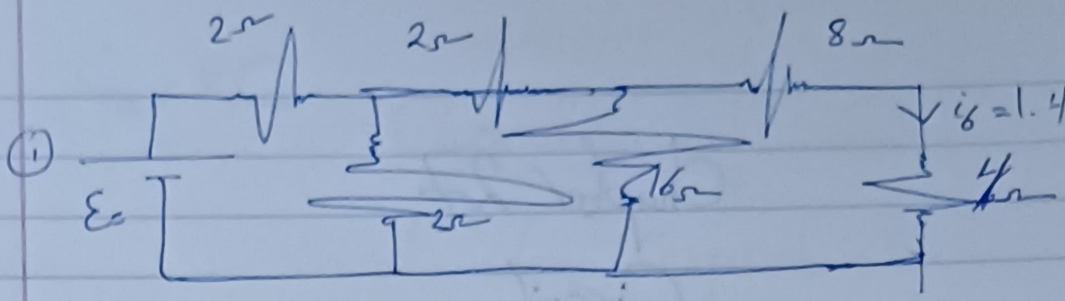
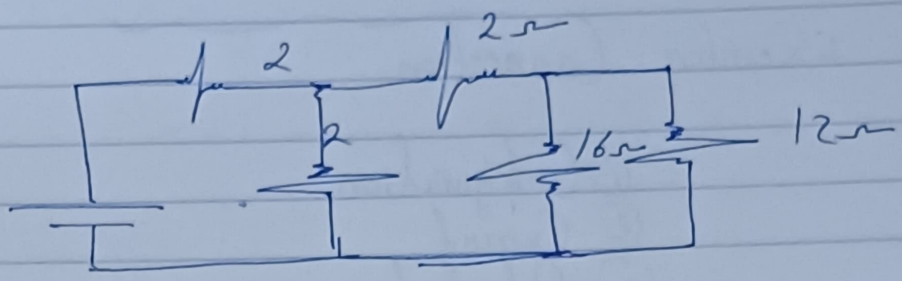


②



In Fig ① ~~8 − 4~~

$R_{s_1} = 8 + 4 = 12\Omega$

---

in Figure ② . $16 // 12$

$$R_{eq} = \frac{12 \times 16}{28} = \frac{6 * 8}{28} = 6.85\Omega$$

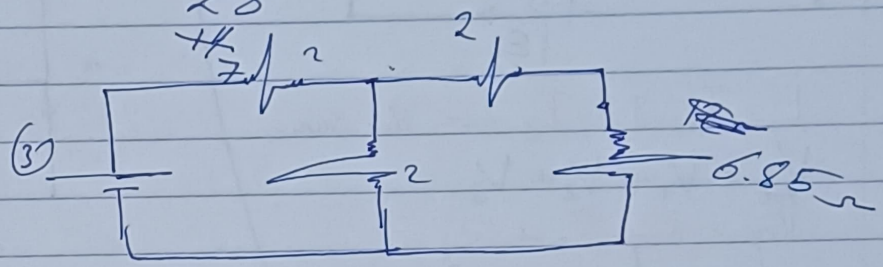


Fig ③ $2 - 6.85$

$R_{s_2} = 8.85$

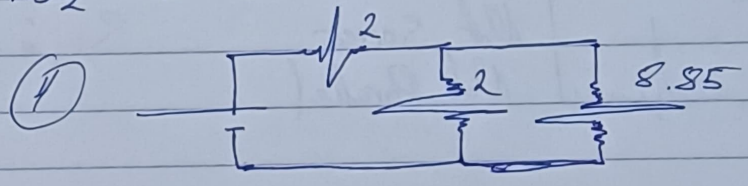


Fig ④ $2 // 8.85$

$$R_{p_2} = \frac{2 * 8.85}{2 + 8.85} = 1.6\Omega$$

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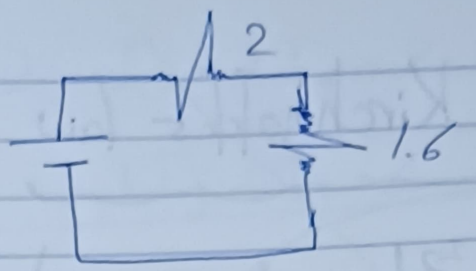
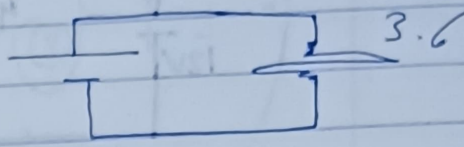


$2 - 1.6$



$R_{5_3} = 3.6\ \Omega$

$R_{eq} = 3.6\ \Omega$

(2) ε??

$V_{4\Omega} = RI = 4 * 1.4$
$= 5.6$ volts.

$V_{12\Omega} = 12 * 1.4 = 16.8$ volts.

$V_{16} = 16.8$ volts.

$V_{6.8} = 16.8$ volts. $\Rightarrow I_{6.8} = \frac{16.8}{6.8} = 2.47\ A$

~~$V_{8.85}$~~ ~~$=$~~

$V_{8.85} = RI = 8.85 * 2.47 = 21.86$ volts.

$V_{1.6} = 21.86 \Rightarrow I_{1.6} = \frac{V}{R} = \frac{21.86}{1.6} = 13.66A$

$V_{3.6} = 3.6 * 13.665 = 49.19$

$\varepsilon = 49.2$ Volts

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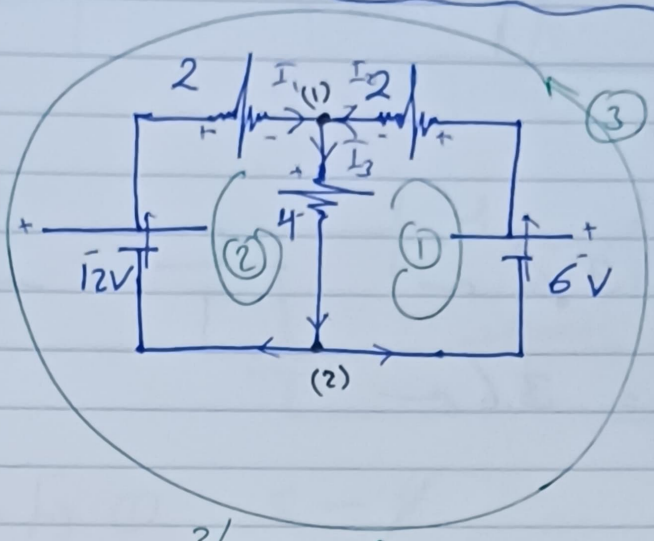
Kirchhoff's law



$\Sigma I = 0$ at any node (junction) (3 points)

$\Sigma V = 0$ (loop) ~~3 loops~~

at node (1) Node Equation

3 loops

2 nods

$$I_1 + I_2 = I_3 \quad \text{——} (1)$$

Loop (1) $\quad -4I_3 + 6 - 2I_2 = 0$

$$2I_2 + 4I_3 = 6$$

$$I_2 + 2I_3 = 3 \quad \text{——} (2)$$

loop (2) $\quad +2I_1 - 12 + 4I_3$

$$I_1 + 2I_3 = 6 \quad \text{——} (3)$$

3 - 1

$$I_1 + 2I_3 = 6$$
$$I_1 + I_2 = I_3$$

$$2I_3 - I_2 = 6 - I_3$$
$$+I_3 \quad +I_3$$
$$3I_3 + I_2 = 6 \quad \text{——} (4)$$

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(4) - (2) $I_2 + 2I_3 = 3$

$3I_3 + I_2 = 6$

$-I_3 = -3$

$\boxed{I_3 = 3A}$

$I_2 + 6 = 3$
$-6 \quad -6$

$\boxed{I_2 = -3A}$ اتجاهه عكس الفرض

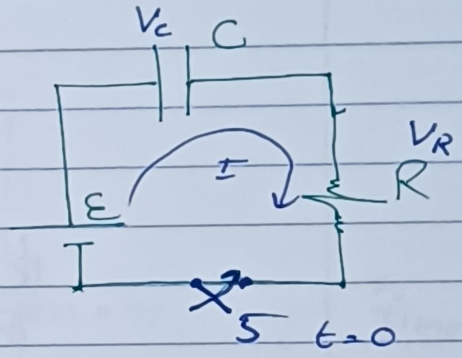
$I_2 + I_1 = I_3$

$-3 + I_1 = 3$
$+3 \quad +3$

$\boxed{I_1 = 6A}$

RC Circuits

Series.



(1) Charging

(2) Discharging

~~t=0~~ Charging

* $V_R = IR$
* $V_c = \frac{q}{C}$
* $\mathcal{E} = V_R + V_C$

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① $t=0$ Switch قفل

$q_c=0$ ~~$V_R=\mathcal{E}$~~

$V_c=0 \quad =\frac{q}{C}$

$V_{R_{max}}=\mathcal{E} \longrightarrow I_{max}=\frac{\mathcal{E}}{R}$

② $t\uparrow\uparrow$

$q\uparrow \quad V_c\uparrow \quad V_R\downarrow$

$t=\infty$

$q_{max}=C\mathcal{E}$

$V_{c\,max}=\mathcal{E} \Rightarrow V_R=0 \quad I_R=0 \Rightarrow I=0$

Eq

$\mathcal{E}=V_c+V_R \quad \text{——①}$

$\mathcal{E}=\frac{q}{C}+RI$

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

$\frac{R}{R}\frac{dq}{dt}+\frac{q}{CR}-\frac{\mathcal{E}}{R}=\frac{0}{R}$

Differential Equation.

$\frac{dq}{dt}+\frac{q}{RC}-\frac{\mathcal{E}}{R}=0 \quad \text{——②}$

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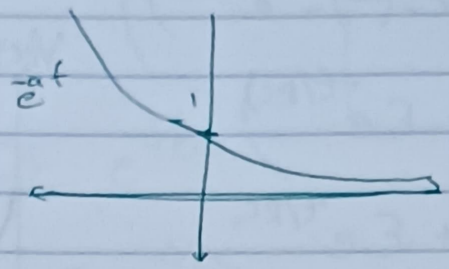
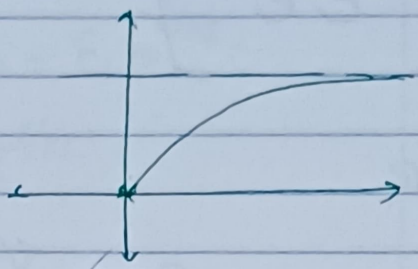
CE

$$q(t) = q_{max}\left(1 - e^{-t/RC}\right) \quad \text{(charging)}$$



e^{-at}



$1 - e^{-t}$

$q(t)$ $Q(t)$

(y) Q	(x) t
0	0
q_{max}	∞

Q_{max}

%63

1

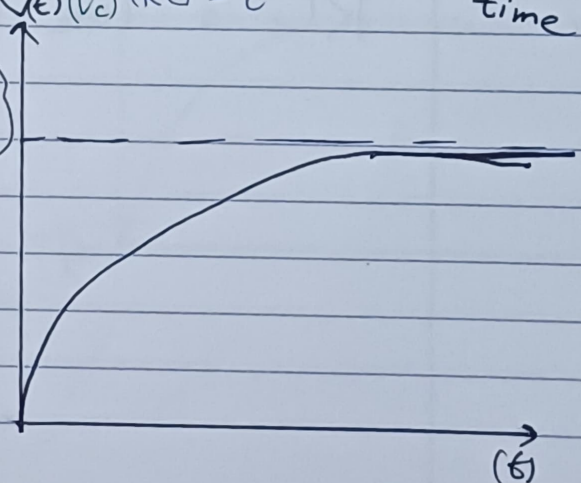
$$\frac{q(t)}{C} = \frac{\mathcal{E}}{C}\left(1 - e^{-t/RC}\right)$$

$$V_C = \underset{max}{\mathcal{E}}\left(1 - e^{-t/RC}\right)$$

$$V_C = V_{max}\left(1 - e^{-t/RC}\right)$$

0 $(RC) = \tau$ time

$V(t)$ (V_C)



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$$V_R = \mathcal{E} - V_c$$

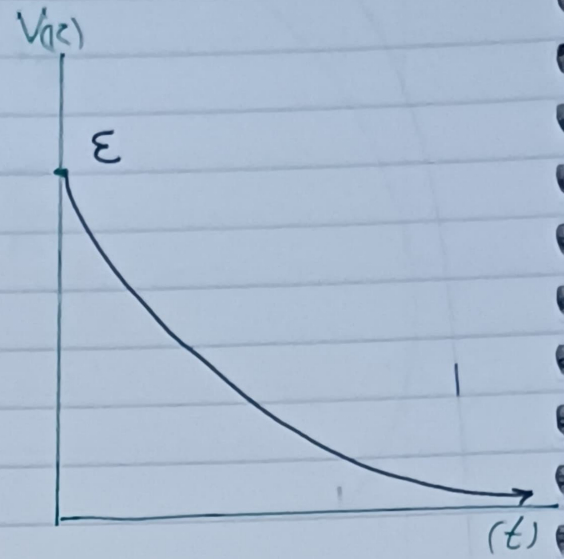
$$= \mathcal{E} - \left(\mathcal{E}\left(1 - e^{-t/RC}\right)\right)$$

$$= \mathcal{E} - \left(\mathcal{E} - \mathcal{E}e^{-t/RC}\right)$$

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

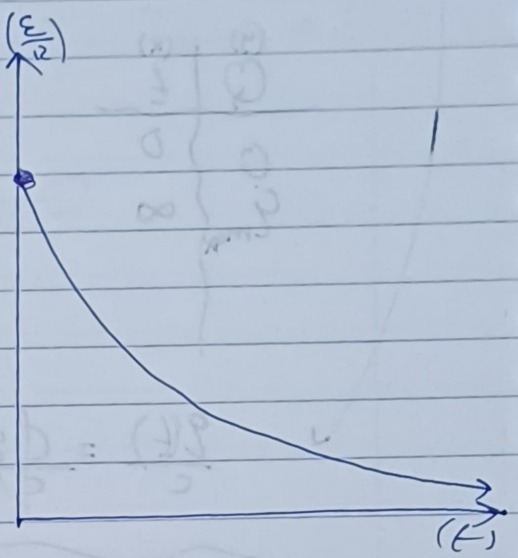
$$\boxed{V_R = \mathcal{E}e^{-t/RC}}$$

V_R/R



$$\frac{V_R}{R} = \frac{\mathcal{E}}{R}e^{-t/RC}$$

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



RC = Time Constant τ at τ : $Q = 63\% Q_{max}$

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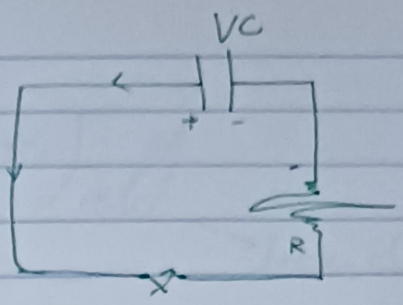
② Discharging



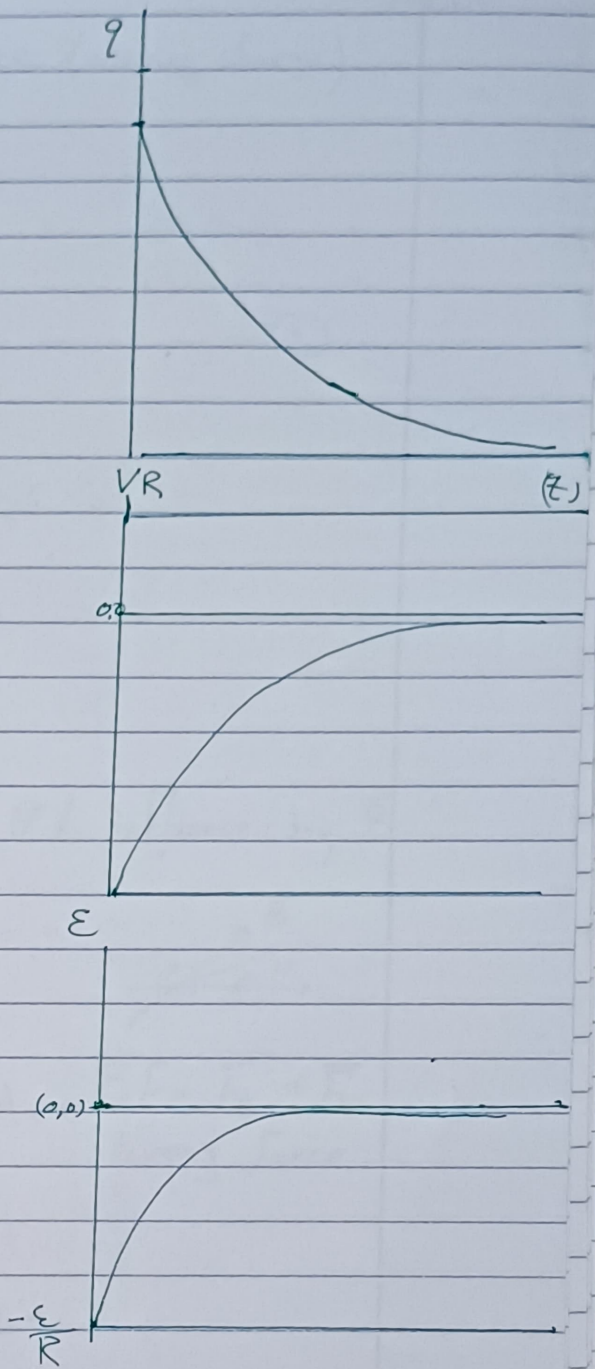
$$q(t) = C\mathcal{E}\, e^{-t/RC}$$

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

$$V_R = V_C = -\mathcal{E}\, e^{-t/RC}$$

$$I = -\frac{\mathcal{E}}{R}\, e^{-t/RC}$$

$$V(\tau) = \mathcal{E}e^{-1}$$
$$= 0.37\,\mathcal{E}$$



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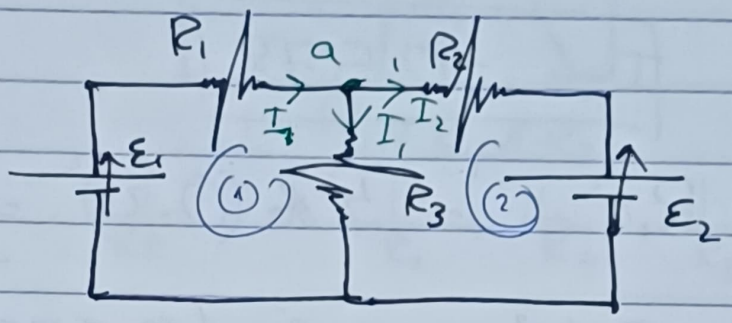
Problems 27

(Q3) $\mathcal{E}_1 = 1$ Volts

$\mathcal{E}_2 = 3$ Volts.

$R_1 = \frac{1}{4}\Omega$ $R_2 = 2\Omega$ $R_3 = 5\Omega$



$$I = I_1 + I_2 \quad \text{——— (1)}$$

$$-R_3 I_1 + \mathcal{E}_1 - R_1 I = 0$$

$$\frac{1}{4} I + 5 I_1 = 1 \quad \text{——— (2)}$$

$$-R_2 I_2 - \mathcal{E}_2 + R_3 I_1 = 0$$

$$-2 I_2 + 5 I_1 = 3 \quad \text{——— (3)}$$

$$2 I_2 + 2 I_1 = 2I \quad + \quad \text{——— (1)}$$

$$7 I_1 = 3 + 2I$$

$$2 * (7 I_1 - 2I = 3) \quad \text{——— (4)}$$

$$14 I_1 - 4I = 6 \quad \text{——— (5)}$$

$$4I + 5 I_1 = 1 \quad + \quad (2)$$

$$19 I_1 = 7$$

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$$7 * 0.368 = 3 + 2I$$

$$\boxed{I = -0.21\ A}$$

$$I = I_1 + I_2$$

$$I_2 = I - I_1 = -0.21 - 0.368$$

$$\boxed{I_2 = -0.578}$$

(a) $P_1 = R_1 i^2 = 4 * (0.21)^2 = \boxed{0.177\ W}$

(b) $P_2 = R_2 I_2^2 = 2 * (0.578)^2$

$$\boxed{P_2 = 0.670\ Watt}$$

(c) $P_3 = R_3 I_1^2 = (0.368)^2 * 5$

$$\boxed{P_3 = 0.679\ Watt}$$

(d) $P_{\varepsilon_1} = \varepsilon_1 I = 1 * -0.21 = -0.211\ watt$ (انبار يمر داخله)

(e) $P_{\varepsilon_2} = \varepsilon_2 I_2 = 3 * 0.578 = 1.74\ watt$

f) absorbed

g) provided.

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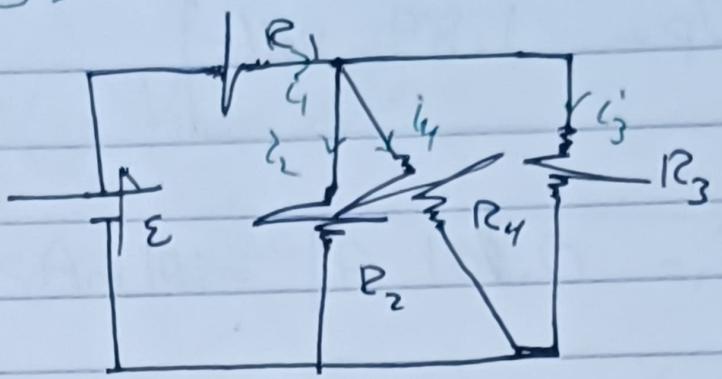
Problem 8)

$R_1 = 100\,\Omega$, $R_2 = R_3 = 50\,\Omega$

$R_4 = 75\,\Omega$

$\mathcal{E} = 12$ Volts.



$R_2 // R_4 // R_3$

$$\frac{1}{R_P} = \frac{1}{R_2} + \frac{1}{R_4} + \frac{1}{R_3}$$

$$= \frac{1}{50} + \frac{1}{75} + \frac{1}{50}$$

$$\frac{1}{R_P} = \frac{1}{25} + \frac{1}{75} = \frac{100}{1875}$$

$$\boxed{R_p = 18.75\,\Omega}$$

$$R_{eq} = R_p + R_1 = 18.75 + 100$$

a) $\boxed{R_{eq} = 118.75\,\Omega}$

$$V = R_{eq} I_{tot}$$

$$12 = 118.75\, I_{tot}$$

$$\boxed{I_{tot} = 0.101\,A}$$

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$V_p = R_p I_{tot}$

$= 18.754 * 0.101$

$\boxed{V_p = 1.89 \text{ volts}}$

b) $\boxed{i_1 = 0.101 \text{ A}} = 101 \text{ mA}$

c) $i_2 = \frac{V_p}{R_2} = \frac{1.89}{50} = 0.03789 \text{ A}$

$= 37.9 \times 10^{-3} \text{ A}$

$= 37.9 \text{ mA}$

d) $i_3 = \frac{V_p}{R_3} = 37.9 \text{ mA}$

e) $i_4 = \frac{V_p}{R_4} = \frac{1.89}{75} = 25.2 \text{ mA}$

Problem 15) $t = \square \tau$??

$q = .1899 q_{max}$

$q = q_{max}(1 - e^{\frac{-t}{RC}})$

$89\% q_{max} = q_{max}(1 - e^{\frac{-t}{RC}})$

$\frac{89}{100} - 1 \therefore e^{\frac{-t}{\tau}}$

$0.11 = e^{\frac{-t}{\tau}} \Rightarrow \ln 0.11 = \ln e^{\frac{-t}{\tau}}$

$\ln 0.11 = -\frac{t}{\tau} \ln e^1$

$t = -\tau \ln 0.11 \Rightarrow \boxed{t = 2.207\tau}$

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Problem 18)

a) $V_i = 80$ volts. $t = 0$

$V_f = 1$ volts $t = 16$ sec

$$V_1 = V_{max}\, e^{\frac{-t}{RC}}$$

$$1 = 80\, e^{\frac{-t}{RC}}$$

$$-\ln 80 = \frac{-t}{\tau}$$

$$\Rightarrow \tau = \frac{10}{\ln 80} = 2.28 \text{ sec}$$

$$\boxed{\Rightarrow \tau = 2.28 \text{ sec}}$$

b)

$$V = V_{max}\, e^{\frac{-17}{2.28}} = 80\, e^{\frac{-17}{2.28}}$$

$$V = 0.0462$$

$$\boxed{V_{(17)} = 46.2 \text{ mVolts}}$$

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30) q_0

a) 25% ⟹ 75% Remain

$$q = q_{max}\left(1 - e^{\frac{-t}{RC}}\right)$$

$$75\%\, q_{max} = q_{max}\left(1 - e^{\frac{-t}{RC}}\right)$$

$$-1 \qquad -1$$

$$-25\% = -e^{\frac{-t}{RC}}$$

$$\ln 0.25 = \ln e^{\frac{-t}{\tau}}$$

$$\ln 0.25 = \frac{-t}{\tau} \ln e \quad (\ln e = 1)$$

$$t = -\ln 0.25\, \tau$$

$$\boxed{t = 1.386\, \tau}$$

a) $q = q_0\left(e^{\frac{-t}{RC}}\right)$

$$0.75\%\, q_0 = q_0\, e^{\frac{-t}{RC}}$$

$$t = -\ln 0.75\, \tau$$

$$\boxed{t = 0.287\, \tau}$$

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b) 50%

$$q = q_0 e^{-\frac{t}{RC}}$$

$$50\%\, q_0 = e^{-\frac{t}{RC}} q_0$$

$$t = \tau \times -\ln\frac{50}{100}$$

$$t = -\ln 0.5\, \tau$$

$$\boxed{t = 0.69\tau}$$

62) 1 MF Capacitor $U_0 = 0.6\,J$
discharged through 1 M.Ω

a) $$U = \frac{q^2}{2C}$$

$$q = \sqrt{2CU}$$

$$q_{max} = \sqrt{2 \times 1\times10^{-6} \times 0.6} = 1.095\times10^{-3}\,C$$

b) $$q_{max} = C \cdot V_{max}$$

$$V_{max} = \frac{1.095\times10^{-3}}{1\times10^{-6}} = 1095\ \text{volts}$$

$$i = \frac{V}{R} = \frac{1095}{1\times10^{6}} = 1.095\times10^{-3}\,A$$

$$= 1.095\,mA$$

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c) ~~$\Delta V_C = V_{C_A} - V_{C_B}$~~

~~$V_C = V_0 e^{\frac{t}{RC}}$~~

$= 1095 * e^{x}$

~~$V_C = V_{max} = 1095$ volts~~

$V_R = RI$

$= 1 \times 10^{+6} * 1.095 \times 10^{3}$

$= 1.095 \times 10^{6}$ volts.

c) $V_C = V_0 e^{\frac{t}{RC}}$

$= 1095 e^{-t/1}$ $\boxed{V_C = 1095 e^{-t}}$

d) $V_R = RI$

$= R i e^{-t} = 10^{6} * 1.095 \times 10^{-6} e^{-t}$

$\boxed{V_R = 1095 e^{-t}}$

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e) $P(t) = (I(t))^2 R$

$= (1095 \times 10^{-3})^2 (e^{-t})^2 * 1 \times 10^6$

$= 1.2 \times 10^6 e^{-2t}$

(Q64)

$V = 12$ Volts $\quad Q = 120 A.h$

$P = 75$ Watt

~~Energy = P/t~~

$P = \varepsilon i = 12 * i = 75$

$i = 6.25 A$

$t = \frac{120}{6.25} = 19.2 h$ OR

~~$E = \frac{P}{t} = \frac{q}{t} V$~~

~~$\frac{75}{t} = 120 * 12$~~

~~$t =$~~

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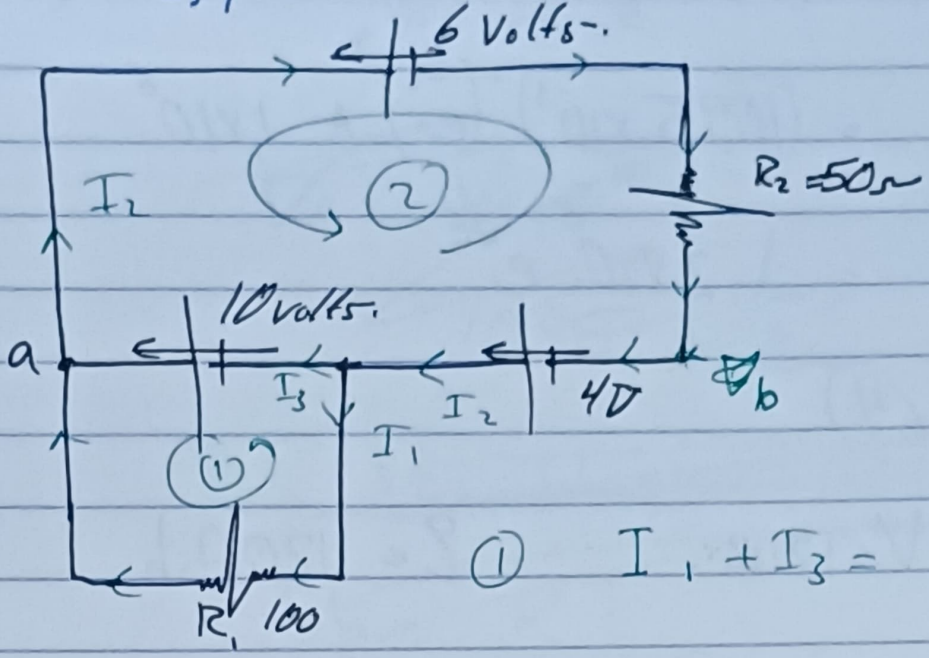
Q) 69)



① $I_1 + I_3 = I_2$ ——— ①

Loop (1)

$100 I_1 + 10 = 0$

$I_1 = \frac{-10}{100} = -0.1\,A$

a) $\boxed{I_1 = 0.1\,A}$ opposite direction
(R1)

Loop (2)

c) $-6 - 50 I_2 + 4 + 10 = 0$

$Vab = -10 - 4$

$\boxed{Vab = -14 \text{ Volts}}$

$-50 I_2 = -8$

b) $\boxed{I_2 = 0.16\,A}$ in same direction
(R2)

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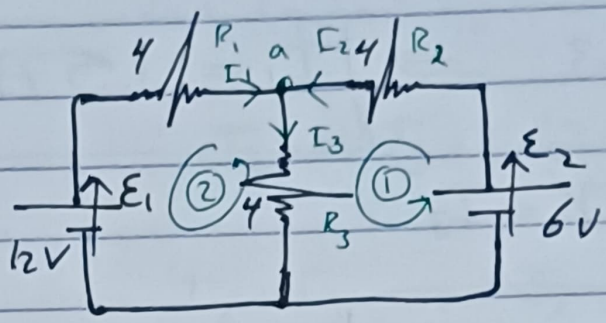
Additional Problems.

(Q2) $\mathcal{E}_1 = 12V$ $\mathcal{E}_2 = 0.5\,\mathcal{E}_1 = 6$ Volts.

$R_1 = R_2 = R_3 = 4\,\Omega$



$$I_1 + I_2 = I_3 \quad \text{——} (1)$$

Loop (1)

$$-4I_3 + 6 - 4I_2 = 0$$

$$I_2 + I_3 = \frac{6}{4} = \frac{3}{2} \quad \text{——} (2)$$

Loop (2)

$$4I_1 - 12 + 4I_3 = 0$$

$$I_1 + I_3 = 3 \quad \text{——} (3)$$

3 ~~(1)~~ in (2) and (3)

$$2I_2 + I_1 = \frac{3}{2} \quad \text{——} (4)$$

$$I_2 + 2I_1 = 3 \quad \text{——} (5)$$

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$4I_2 + 2I_1 = 3$

$I_2 + 2I_1 = 3$ —

$5I_2 = 0$

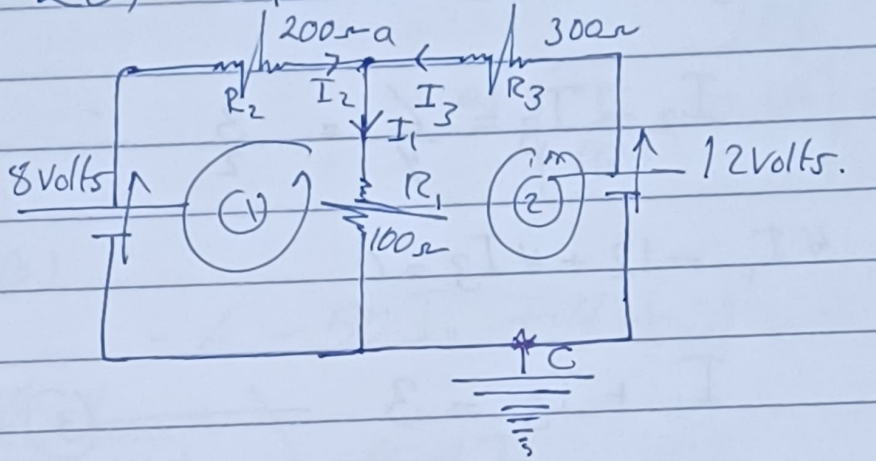
$\boxed{I_2 = 0}$

$2I_1 = 3 \Rightarrow \boxed{I_1 = 1.5\,A}$

$I_1 + I_2 = I_3$

$\boxed{I_3 = 1.5\,A}$

Q 20) ~~$\mathcal{E}_1 = 8$ Volts.~~



$I_2 + I_3 = I_1$ ——— (1)

Loop (1)

$-100I_1 + 8 - 200I_2 = 0$

$I_1 + 2I_2 = 0.08$ ——— (2)

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Loop (2)

$$-100 I_1 + 12 - 300 I_3 = 0$$

$$I_1 + 3 I_3 = 0.12 \quad \text{---(3)}$$

3 in (3)

$$I_2 + I_3 + 3 I_3 = 0.12$$

$$I_2 + 4 I_3 = 0.12 \quad \text{---(4)}$$

1 in (2)

$$I_2 + I_3 + 2 I_2 = 0.08$$

$$I_3 + 3 I_2 = 0.08 \quad \text{---(5)}$$

$$4 I_3 + 12 I_2 = 0.32 \quad \text{---(6)}$$

$$4 I_3 + I_2 = 0.12 \quad \text{---(4)}$$

$$11 I_2 = 0.2$$

$$I_2 = \frac{0.2}{11} = 18.18\,mA \text{ Right}$$

$$4 I_3 + 18.18 \times 10^{-3} = 0.12$$

$$I_3 = \frac{0.12 - 18.18 \times 10^{-3}}{4}$$

$$I_3 = 34.5\,mA \text{ Left.}$$

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$I_1 = I_2 + I_3$

$= 18.18 + 34.5$

$\boxed{I_1 = 52.56 \text{ mA}}$ down

Direction as in the main figure.

(V_A) ~~$V_A + 300 I_3 - 12 + V_c = 0$~~

$V_{ac} = 300 I_3 - 12$

$V_a - V_c = 300 I_3 - 12$

$V_a = 300 * 34.5^{\times 10^{-3}} - 12$

$\boxed{V_a = -1.65 \text{ Volts.}}$

Q21) $t=0$ swith closed. $C = 4\mu F$

$R = 32\ \Omega$

$V_R = V_C = 50\% V_{max}$

$V(t) = V_{max}(1 - e^{-t/RC})$

~~V_{max}~~ $50\% = $ ~~V_{max}~~ $(1 - e^{-t/1.568\times10^{-3}})$

$-1 \qquad -1$

$-50\% = -e^{-t/1.568\times10^{-3}}$

$\ln 0.5 = \frac{-t}{1.568\times10^{-3}} \ln e^1$

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$t = \frac{-\ln 0.5}{1.568 \times 10^{-3}}$

~~$t = 442.05$ sec~~

$t = -\ln 0.5 * 1.568 \times 10^{-3}$

$t = 1.086 \times 10^{-3}$ sec

$\boxed{t = 1.09 \text{ msec.}}$

(Q59) Ideal Battery = 20 V

a) $W = -q\Delta V$ $\quad 1J = \frac{1}{1.6 \times 10^{-19}} eV$

$= -1.6 \times 10^{-19} * 20$ J

$= -1.6 \times 10^{-19} * 20 * \frac{1}{1.6 \times 10^{-19}}$

$\boxed{W = -20 \text{ evolts}}$

b) $P = VI$

$= 20 * 0.8272$

$\boxed{P = 16.5 \text{ Watt in 1sec.}}$

$I = \frac{q}{t}$ $\quad q = ne$

$= 5.17 \times 10^{18} \times 1.6 \times 10^{-19}$

$I = \frac{0.8272 \text{ A}}{1 \text{ in 1sec.}}$

$\boxed{I = 0.8272 \text{ A}}$

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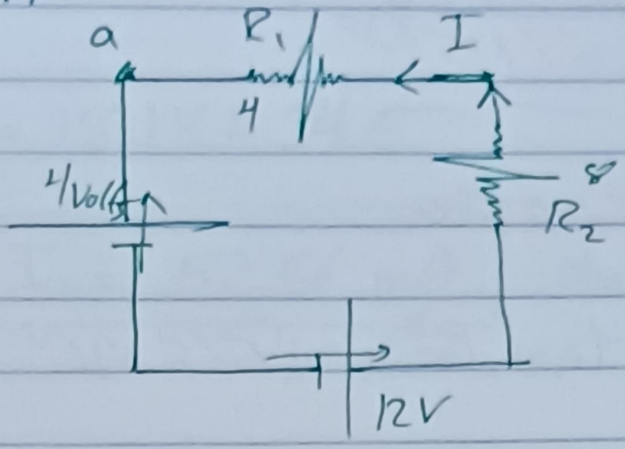
(8) 61)



a)

$$-4 + 12 - 8I - 4I = 0$$

$$+12I = 8 \Rightarrow \boxed{I = 0.67}$$

b) $P_{R_1} = i^2 R_1 = (0.67)^2 * 4$

$$\boxed{P_{R_1} = 1.8 \text{ Watt}}$$

c) $P_{R_2} = i^2 R_2 = (0.67)^2 * 8$

$$\boxed{P_{R_2} = 3.6 \text{ Watt}}$$

d) $P_{\mathcal{E}_1} = VI = \mathcal{E}_1 I = 12 * 0.67$

$$\boxed{P_{\mathcal{E}_1} = 8 \text{ Watt}}$$

e) $P_{\mathcal{E}_2} = \mathcal{E}_2 I = 4 * 0.67 = 2.68$

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f) $\mathcal{E}_1$ Supplying g) $\mathcal{E}_2$ absorbing

Q64) $\mathcal{E} = 12$ Volts.
$q = 120$ A.h
$P = 75$ Watt.

① $P = VI$

$$I = \frac{75}{12} = 6.25\ A$$

② $$t = \frac{120\ A.h}{6.25\ A}$$

$$\boxed{t = 19.2\ h}$$

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