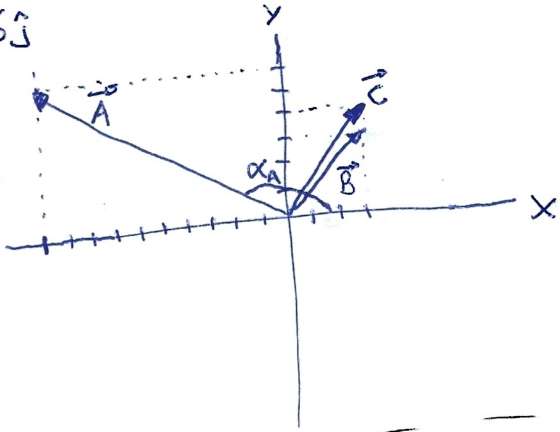
$A = -10\hat{\imath} + 6\hat{\jmath}$

$\vec{B} = 3\hat{\imath} + 3\hat{\jmath}$

$\vec{C} = 3\hat{\imath} + 4\hat{\jmath}$



¿α_A?

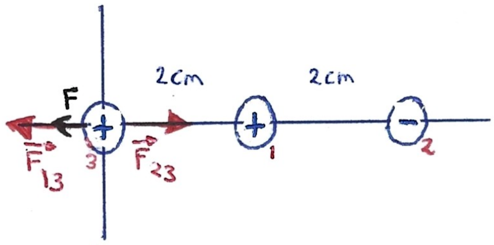
$$A \cdot \hat{\imath} = |\vec{A}||\vec{\imath}| \cdot \cos\alpha$$

$$\alpha_A = \cos^{-1}\left(\frac{A_x}{|A|}\right)$$

Opción 1

$$\boxed{tg\,\alpha_A = \frac{A_x}{A_y} \rightarrow \alpha = 31^\circ \rightarrow 180^\circ - 31^\circ = 139^\circ}$$

Opción 2



$$F_{13} = K\frac{q_1 q_3}{r_{13}^2} = 9 \cdot 10^9 \frac{N\cancel{m^2}}{\cancel{C^2}} \frac{10^{-9}\cancel{C} \cdot 5 \cdot 10^{-9}\cancel{C}}{(0{,}02\,\cancel{m})^2} = 1{,}125 \cdot 10^{-4}N$$

$$F_{23} = K\frac{q_2 q_3}{r_{23}^2} = 9 \cdot 10^9 \frac{N\cancel{m^2}}{\cancel{C^2}} \frac{3 \cdot 10^{-9}\cancel{C} \cdot 5 \cdot 10^{-9}\cancel{C}}{(0{,}04\,m)^2} = 8{,}4375 \cdot 10^{-5}N$$

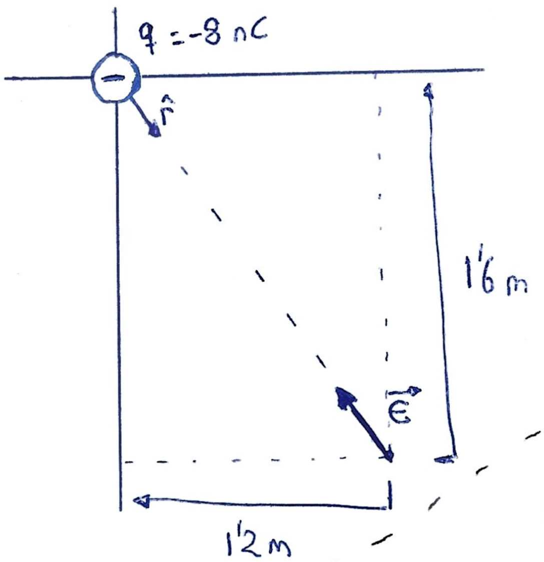
$q_1 = 1.0\,nC$

$q_2 = -3.0\,nC$

$q_3 = 5.0\,nC$

$$\vec{F} = \vec{F}_{13} + \vec{F}_{23} \rightarrow F = F_{13} - F_{23} = 1{,}125 \cdot 10^{-4}N - 8{,}4375 \cdot 10^{-5}N = \boxed{2{,}8125 \cdot 10^{-5}N}$$

$$\boxed{\vec{F}_3 = -2{,}8125 \cdot 10^{-5} N\,\hat{\imath}}$$

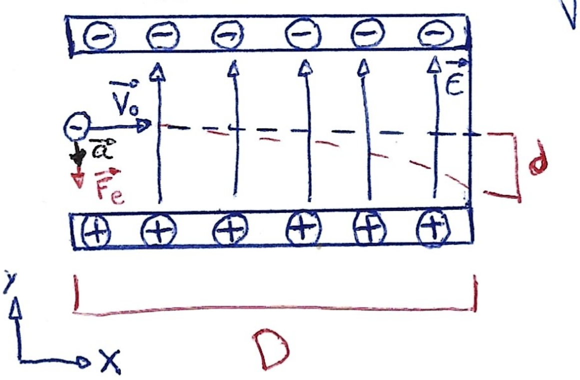


$$\vec{E} = K\frac{q}{r^2}\hat{r} = -9 \cdot 10^9 \frac{Nm^2}{C^{\cancel{2}}} \frac{8 \cdot 10^{-9}\cancel{C}}{(2\,m)^2}(0{,}6\hat{\imath} - 0{,}8\hat{\jmath}) = -18(0{,}6\hat{\imath} - 0{,}8\hat{\jmath})$$

$$= \boxed{-10{,}8\hat{\imath} + 14{,}4\hat{\jmath}\ \frac{N}{C}}$$

$$\hat{r} = \frac{1{,}2\hat{\imath} - 1'6\hat{\jmath}\ \cancel{m}}{\sqrt{1'2^2 + (-1'6)^2}\ \cancel{m}} = 0{,}6\hat{\imath} - 0{,}8\hat{\jmath}$$

$\sqrt{1'2^2 + (-1'6)^2} = 2$



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

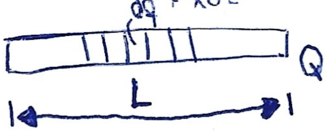
$V_x = V_0 \quad \vec{a}_x = 0 \qquad x = \cancel{x_0}^{\,0} + V_x t = D \rightarrow t = \frac{D}{V_x}$

$V_y = 0 \quad \vec{a}_y = \frac{-q\vec{E}}{m} \qquad y = \cancel{y_0}^{\,0} - \frac{1}{2}a_y t^2 = \frac{-q\vec{E}}{2m}\cdot\left(\frac{D}{V_x}\right)^2 = d$

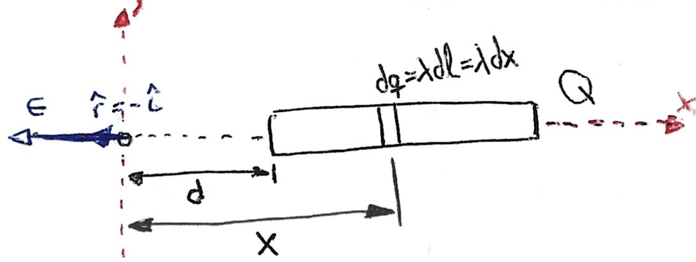
es un electrón

$$\boxed{d = \frac{-q|\vec{E}|}{2m} \cdot \frac{D^2}{V_x^2}}$$

$$\boxed{\vec{V} = V_0\,\hat{\imath} - \frac{q\vec{E} \cdot D}{m \cdot V_x}\,\hat{\jmath}}$$



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



$$\lambda (C/m) = \frac{Q}{L} = cte.$$

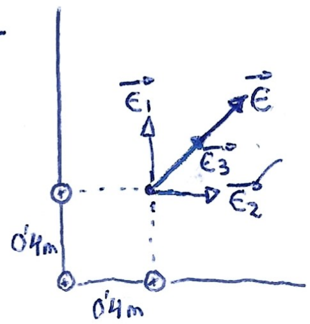
$$\boxed{E = k\lambda \int_d^{d+L} \frac{dx}{x^2}(-\hat{\imath}) = -k\lambda\left[\frac{-1}{x}\right]_d^{d+L}\hat{\imath} =}$$

$$= -k\lambda\frac{L}{d(d+L)}\hat{\imath} = \boxed{-k\frac{Q}{d(d+L)}\hat{\imath}}$$

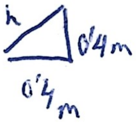
$$d\vec{E} = k\frac{dq}{r^2}\hat{r} = k\frac{\lambda dx}{x^2}(-\hat{\imath})$$

$$\boxed{\vec{E} = \int_{rod} d\vec{E} = \int_d^{d+L} k\frac{\lambda dx}{x^2}(-\hat{\imath})}$$

1



$q = 125\,\mu C = 125\cdot 10^{-6}\,C$



$h = \sqrt{0'4^2 + 0'4^2} = 0'4\sqrt{2}$

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

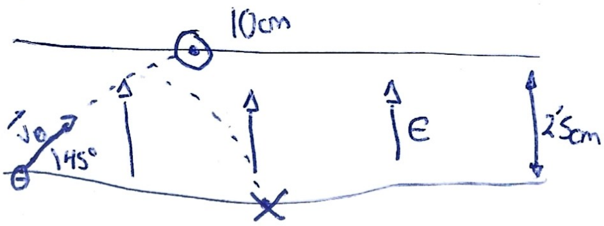
$$\vec{E}_1 = k\frac{q_1}{r^2}\vec{\jmath} = 9\cdot 10^9\frac{N\cdot m^2}{C^2}\cdot\frac{125\cdot 10^{-6}C}{(0'4m)^2}\vec{\jmath} = 7\cdot 10^6 N/C\,\vec{\jmath}$$

$$\vec{E}_2 = k\frac{q_2}{r^2}\vec{\imath} = 9\cdot 10^9\frac{N m^2}{C^2}\cdot\frac{125\cdot 10^{-6}C}{(0'4m)^2}\vec{\imath} = 7\cdot 10^6 N/C\,\vec{\imath}$$

$$\vec{E}_3 = k\frac{q_3}{r^2}\left(\frac{\sqrt{2}}{2}\vec{\imath} + \frac{\sqrt{2}}{2}\vec{\jmath}\right) = 9\cdot 10^9\frac{N m^2}{C^2}\cdot\frac{125\cdot 10^{-6}C}{(0'4\sqrt{2})m^2} = \frac{3'516\cdot 10^6}{\sqrt{2}}(\vec{\imath}+\vec{\jmath})\,N/C$$

$$E = 7\cdot 10^6\vec{\imath} + 7\cdot 10^6\vec{\jmath} + 2'486\cdot 10^6\vec{\jmath} + 2'486\cdot 10^6\vec{\imath}\; N/C = \boxed{9{,}49\cdot 10^6\vec{\imath} + 9{,}49\cdot 10^6\vec{\jmath}\; N/C}$$

4



$V_0 = 5\cdot 10^6\, m/s$

$\vec{E} = 3'5\cdot 10^3\,\vec{\jmath}$

$m_e = 9{,}11\cdot 10^{-31}\,kg$

$q_e = -1'6\cdot 10^{-19}\,C$

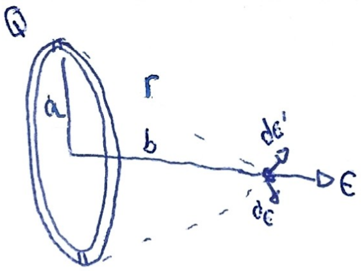
$$\vec{F} = q\vec{E} \qquad \vec{a} = \frac{\vec{F}}{m} = \frac{q\vec{E}}{m} = \frac{-1'6\cdot 10^{-19}C\cdot 3'55\cdot 10^3 N/C}{9'11\cdot 10^{-31}} = -6'15\cdot 10^{14}\vec{\jmath}\; m/s^2$$

$$x = x_0 + V_{ox}\cdot t = \frac{5\cdot 10^6}{\sqrt{2}}(m/s)\cdot t\;\vec{\imath}$$

$$y = y_0 + V_{oy}t + \frac{1}{2}at^2 = \frac{5\cdot 10^6}{\sqrt{2}}(m/s)\cdot t - \frac{1}{2}\,6'15\cdot 10^{14}(m/s^2)\,t^2\,\vec{\jmath}$$

$y(2'5cm) \rightarrow \cancel{t = 4'9\cdot 10^{-9}s}$

$\rightarrow t = 1'8\cdot 10^{-8}s \rightarrow x(1'8\cdot 10^{-8}s) = \boxed{5'8\,cm}$



$$\lambda = \frac{Q}{2\pi a} \qquad dE_x = |dE| \cos\theta = k\frac{dq}{r^2}\cos\theta \qquad dq = \lambda\, dl$$

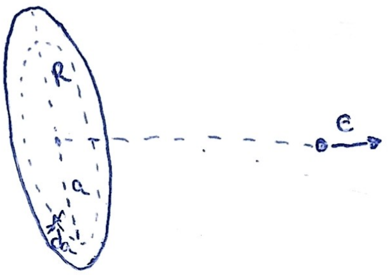
$$E = \int_{RING} dE_x = \int_{RING} k\frac{dq}{r^2}\cos\theta = \int_{RING} k\lambda\frac{dl}{r^2}\cos\theta = \frac{k\lambda}{r^2}\cos\theta\int_{RING} dl =$$

$$= \frac{k\lambda}{r^2}\cos\theta \cdot 2\pi a = \frac{k\lambda}{a^2+b^2}\cdot\frac{b}{(a^2+b^2)^{1/2}}\,2\pi a =$$

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

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

$$\boxed{E = k\frac{Qb}{(a^2+b^2)^{3/2}}}$$



$$\sigma = \frac{Q}{\underbrace{\pi R^2}_{\text{Surface}}} \Rightarrow dq = \sigma\, dS = \sigma\, 2\pi a\cdot da$$

$$E = \int_{Disk} dE_{ring} = \int_0^R \lambda\frac{b}{(a^2+b^2)^{3/2}}\cdot\overbrace{(\sigma\, 2\pi a\, da)}^{dq} = \lambda b\cdot\sigma\pi\cdot\int_0^R \frac{2a}{\underbrace{(a^2+b^2)}_{u}{}^{3/2}}\,da =$$

$$du = 2a\,da$$

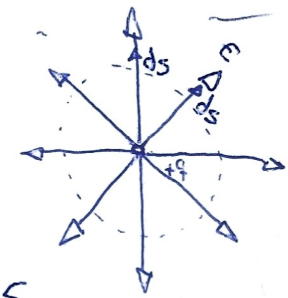
$$= 2\lambda b\,\sigma\pi\left[\frac{1}{b} - \frac{1}{(b^2+R^2)^{1/2}}\right] = 2\lambda\sigma\pi\left[1 - \frac{b}{(b^2+R^2)^{1/2}}\right]$$

$$\boxed{E = 2\lambda\pi\sigma\left[1 - \frac{b}{(b^2+R^2)^{1/2}}\right]\vec{i}}$$

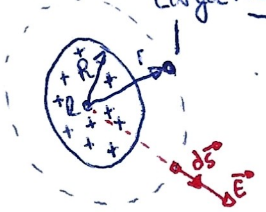
$R \approx \infty$

$$E_{plane} = 2\lambda\pi\sigma\vec{i} = \frac{\sigma}{2\varepsilon_0}\vec{i}$$

$$\boxed{\lambda = \frac{1}{4\pi\varepsilon_0}\vec{i}}$$



$$\phi = \oint_{sphere} \vec{E}\cdot d\vec{S} \underset{\vec{E}\parallel d\vec{S}}{=} \oint_{Sphere} E\,dS\overbrace{\cos 0}^{1} \underset{E = cte.}{=} E\int_{Sphere} dS = E\underbrace{4\pi r^2}_{S} = \overset{\frac{1}{4\pi\varepsilon_0}}{k}\frac{q}{\cancel{r^2}}\cdot 4\pi\cancel{r^2} = \frac{1}{\cancel{4\pi}\varepsilon_0}\cdot q\cdot\cancel{4\pi} = \frac{q}{\varepsilon_0}$$

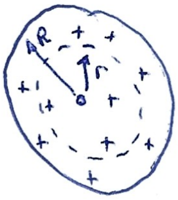


carga fuera

$$\rightarrow \phi = \oint_{\substack{\text{Spherical}\\ \text{radius } r}} \vec{E}\cdot d\vec{S} \underset{\vec{E}\parallel d\vec{S}}{=} \oint_{sph} E\,dS\overbrace{\cos 0}^{1} = E\,4\pi r^2 = \frac{Q}{\varepsilon_0} \Rightarrow \vec{E} = \frac{Q}{4\pi\varepsilon_0 r^2}\hat{r}$$

↳ cambia con el punto

$$\rho = \frac{Q}{\underbrace{4/3\,\pi R^3}_{\text{V of a sphere}}}$$



Inside of the sphere

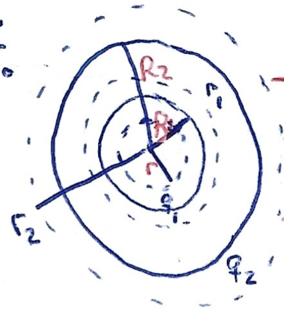
$Q_{enc} = \rho \cdot V$

$$\phi = \oint_{sph} \vec{E} \cdot d\vec{S} = E\, 4\pi r^2 = \frac{Q_{enc}}{\varepsilon_0} = \frac{\rho \cdot 4/3\,\pi r^3}{\varepsilon_0}$$

$$\rho = \frac{Q}{4/3\,\pi R^3}$$

$$E = \frac{\rho \cdot 4/3\,\pi r^3}{\varepsilon_0 \cdot 4\pi r^2} = \frac{\rho r}{3\varepsilon_0} = \boxed{\frac{Q r}{4\pi \varepsilon_0 R^3} \left(N/C\right)}$$

7.



$\underline{r < R_1}$ $\quad \phi = \oint \vec{E}\, d\vec{S} = \frac{\overset{=0}{q_{enc}}}{\varepsilon_0} = 0 \rightarrow \vec{E} = 0$

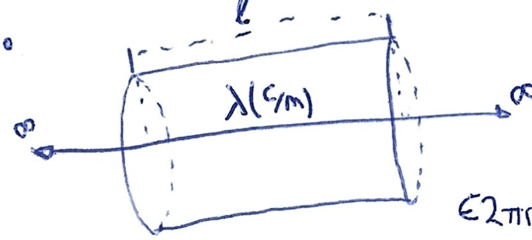
$\underline{R_1 < r_1 < R_2}$ $\quad \phi = \oint \vec{E}\, d\vec{S} = \frac{\overset{=q_1}{q_{enc}}}{\varepsilon_0} = \frac{q_1}{\varepsilon_0} = \boxed{\vec{E} \parallel d\vec{S}}$

$= E \oint dS = E\, 4\pi r^2$

$$E\, 4\pi r^2 = \frac{q_1}{\varepsilon_0} \rightarrow \vec{E} = \frac{q_1}{4\pi r^2 \varepsilon_0}\,\hat{r}$$

$\underline{R_2 < r_2}$ $\quad \phi = \oint \vec{E}\, d\vec{S} = \frac{\overset{=q_1+q_2}{q_{enc}}}{\varepsilon_0} = E\, 4\pi r^2 \rightarrow \vec{E} = \frac{q_1 + q_2}{4\pi r^2 \varepsilon_0}\,\hat{r}$

8.

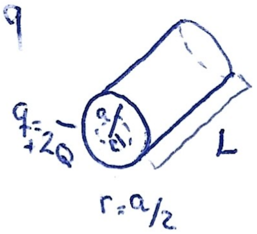


$$\phi = \frac{q_{enc}}{\varepsilon_0} = \frac{l \cdot \lambda}{\varepsilon_0} = \oint \vec{E}\, d\vec{S} = \int_{lat} E\, dS + 2\cancel{\int_{lat} E\, dS \cdot 0} = E \int dS = E\, 2\pi r L$$

$E \parallel dS$ $\qquad E \perp dS$

$$E\, 2\pi r \cancel{L} = \frac{\cancel{L}\lambda}{\varepsilon_0}$$

9



$$\rho\,(C/m^3) = \frac{Q_{TOTAL}}{V_{TOTAL}}$$

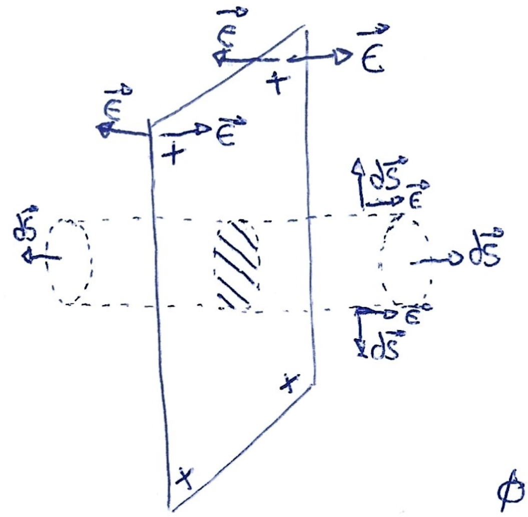
$$q_{enc} = \rho \cdot V_{cylinder\ a/2} = \frac{+2Q}{\pi a^2 \cancel{L}} \cdot \pi \left(\frac{a}{2}\right)^2 \cancel{L} = \frac{Q}{2}$$

$\vec{E} \perp \vec{S}$ $\qquad \vec{E} \parallel d\vec{S}$

$$\oint \vec{E}\, d\vec{S} = \cancel{\int_{Tapa 1} \vec{E}\, d\vec{S}}^{\,0} + \cancel{\int_{tapa 2} \vec{E}\, d\vec{S}}^{\,0} + \int_{lateral} \vec{E}\, d\vec{S} = E \int_{lat.} dS = E\, \cancel{2}\pi \frac{a}{\cancel{2}} L$$

$$\oint \vec{E}\, d\vec{S} = \frac{q_{enc}}{\varepsilon_0}$$

$$\frac{Q}{2} \cdot \frac{1}{\varepsilon_0} = E \pi a L \qquad \vec{E} = \frac{Q}{2\pi \varepsilon_0 a L}\,\hat{r}$$



$\sigma = \left(C/m^2\right)$

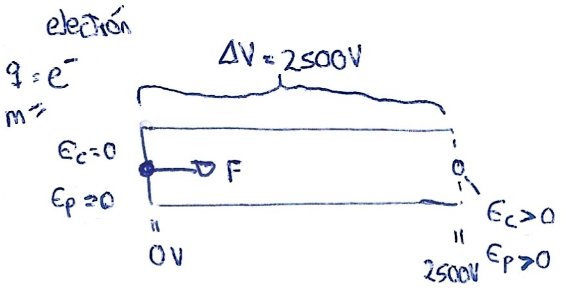
$\epsilon = cte$

$$\phi = \oint \vec{\epsilon}\, d\vec{S} = \int_{Flat1} \epsilon\, dS + \int_{Flat2} \epsilon\, dS + \int_{lat} \cancel{\vec{\epsilon}\, d\vec{S}}^{\,0} =$$

Flat1: $\vec{\epsilon} \parallel d\vec{S}$ — Flat2: $\vec{\epsilon} \parallel d\vec{S}$ — lat: $\vec{\epsilon} \perp d\vec{S}$

$= 2\epsilon S$ ~ Surface of Flat

$$\phi = \frac{\overset{q_{enc}}{\overset{\shortparallel}{\sigma S}}}{\varepsilon_0} = 2\epsilon S \rightarrow \epsilon = \frac{\sigma}{2\varepsilon_0} \begin{cases} \vec{\epsilon}_+ = \frac{\sigma}{2\varepsilon_0}\hat{i} \\ \vec{\epsilon}_- = \frac{\sigma}{2\varepsilon_0}\hat{i} \end{cases}$$

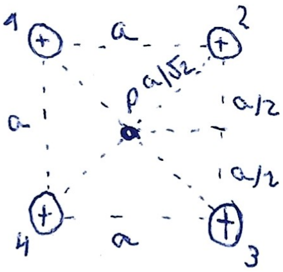


$$\epsilon_{m0} = 0 = \epsilon_{mF} = \epsilon_c + \epsilon_p$$

$$\epsilon_c = \frac{1}{2} m \cdot V^2 = -\epsilon_p = -(q \cdot V) \Rightarrow 2500\,eV = 4 \cdot 10^{-16}\,J$$

$$\boxed{V = 2{,}9634 \cdot 10^7\ m/s}$$

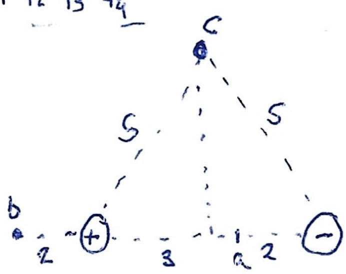
$\epsilon_{m0} = \epsilon_{mF}$



$\vec{\epsilon} = 0$

$$V = 4\,V_1 = 4k\frac{q}{r} = 4\sqrt{2}\,k\frac{q}{a}\ \overset{J/C}{\overset{\shortparallel}{(V)}}$$

$q_1 = q_2 = q_3 = q_4$



$$V_c = V_+ + V_- = k\left(\frac{q}{r} + \frac{q}{r}\right) = \frac{k}{r}\left(q_+ + q_-\right) = \frac{9 \cdot 10^9\ \frac{N \cdot m^2}{C^2}}{5 \cdot 10^{-2}\,m} \cdot \left((15-8) \cdot 10^{-9}\,C\right) = 1260\,V$$

$V_b = 5720\,V$

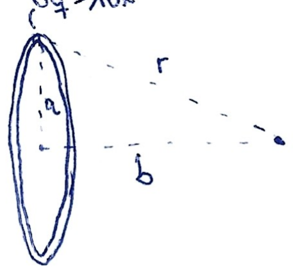
$V_a = 900\,V$

$$W_{c\to a} = -\Delta V \cdot \overset{+3nC}{\overset{\shortparallel}{q_0}} = -(V_A - V_c) \cdot q_0 = +(V_c - V_a)\,q_0 = 1'1 \cdot 10^{-6}\,J > 0 \rightarrow \text{Espontáneo}$$

$$W_{a\to b} = -\Delta V \cdot q_0 = -(V_b - V_a) \cdot q_0 = +(V_a - V_b) \cdot q_0 = -1'4 \cdot 10^{-5}\,J < 0 \rightarrow \text{No espontáneo}$$

Ex3

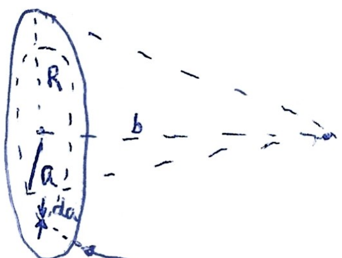
Ring $dq = \lambda dl$ $\quad r = \sqrt{a^2+b^2}$



$$V = \int_{ring} k\frac{dq}{r} = k\int_{ring}\frac{\lambda dl}{\sqrt{a^2+b^2}} = \frac{k\lambda}{\sqrt{a^2+b^2}}\underbrace{l}_{2\pi a} = \frac{kQ}{\sqrt{a^2+b^2}}$$

$$\lambda = \frac{Q}{2\pi a}\ (C/m)$$

Disk

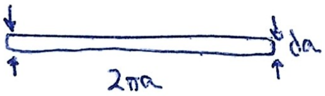


$$V = \int_{Disk} dV = \int_0^R \frac{k\,\overbrace{dq}^{\sigma dS = \sigma 2\pi a da}}{\sqrt{a^2+b^2}} = \int_0^R \frac{k\sigma 2\pi a da}{\sqrt{a^2+b^2}}$$

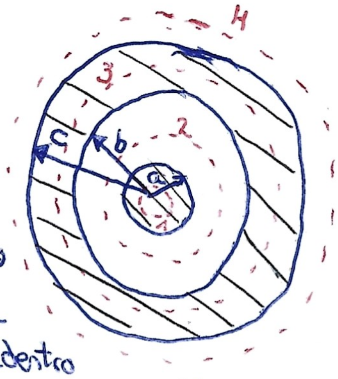
$$\sigma = \frac{Q}{\pi R^2}\ (C/m^2)$$

$$dq = \sigma dS$$

$$dS = 2\pi a \cdot da$$



11.



a → insulating, solid
c → conductive, hollow (hueco)

$a = 2cm$ $\quad \rho_a (C/m^3) = 4'5 \cdot 10^{-6}$
$b = 5cm$
$c = 8cm \rightarrow Q = 2\cdot 10^{-9} C$

Es una esfera dentro de otra, no un cable

$r_1 = 1cm$, $r < a$

$$Q_{enc} = \int_V \rho\, dV = \int_0^{r_1 = 1cm} \rho\, 4\pi r^2 dr = \left[\rho \frac{4\pi}{3} r^3\right]_0^{0{,}01m} = 1'88\cdot 10^{-11} C = 18'8\ pC$$

esfera → $V = \frac{4}{3}\pi r^3 \rightarrow dV = 4\pi r^2$
no cilindro

$$\emptyset = \oint_S \vec{E}\cdot d\vec{S} = \frac{Q_{enc}}{\varepsilon_0} \rightarrow \underbrace{E\cdot S \cdot \cos 0}_{E \parallel S} = \frac{1'88\cdot 10^{-11} C}{8'85\cdot 10^{-12}\frac{C^2}{Nm^2}} \Rightarrow \vec{E}_1 = \frac{\frac{1'88\cdot 10^{-11}}{8'85\cdot 10^{-12}}}{4\pi (0{,}01m)^2} = 1'695\cdot 10^3 \vec{u}_r \frac{N}{C}$$

$r_2 = 3cm$ $\quad a < r_2 < b$

a → hasta donde llega la carga

$$Q_{enc} = \int_V \rho\, dV = \int_0^a \rho\, 4\pi r^2 dr = 1'51\cdot 10^{-10} C$$

$$\emptyset = \oint \vec{E}\cdot d\vec{S} = E\cdot S = \frac{Q_{enc}}{\varepsilon_0} \rightarrow \vec{E} = \frac{Q_{enc}}{4\pi r_2^2 \varepsilon_0} = 1'507\cdot 10^3 \vec{u}_r \frac{N}{C}$$

queremos calcular

Continue ex 11.

$r_3 = 7\,cm$ inside a conductor

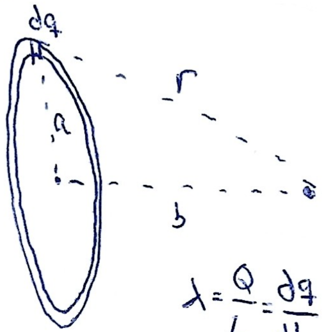
$Q_{enc} = 0 \quad \vec{E}_3 = 0$

$r_4 = 10\,cm \qquad r_4 > C$

$Q_{enc} = Q_c + Q_a = 2\cdot 10^{-9}C + 1'51\cdot 10^{-10}C = 2'151\cdot 10^{-9}C$

$\oint \vec{E}\,d\vec{S} = \frac{Q_{enc}}{\varepsilon_0} \qquad \vec{E} = \frac{2'151\cdot 10^{-9}}{\varepsilon_0 \cdot 4\pi r^2}\vec{U}_r \ \frac{N}{C}$

Ex:



$$V = \int dV = \int k\frac{dq}{r} = \frac{k}{r}\cdot\int \underset{\lambda\cdot dL}{\underset{\parallel}{dq}} = \frac{k\lambda}{r}\int_0^L dL = \frac{\overset{Q}{\overbrace{\lambda L}}}{4\pi\varepsilon_0\sqrt{a^2+b^2}}$$

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

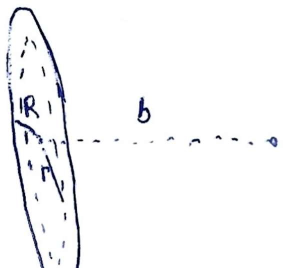
Uniform

$d = \frac{m}{V}$

$\rho = \frac{Q}{V}$ (3D)

$\sigma = \frac{Q}{S}$ (2D)

$\lambda = \frac{Q}{L}$ (1D)



$$V = \int_{Disk} dV = \int_0^R \frac{dq}{4\pi\varepsilon_0\sqrt{r^2+b^2}} = \int_0^R \frac{\sigma\cdot \overset{2\pi r dr}{\overset{\parallel}{dS}}}{4\pi\varepsilon_0\sqrt{r^2+b^2}} = \int_0^R \frac{\sigma\cdot \cancel{2}\pi r dr}{\cancel{4}\pi\varepsilon_0\sqrt{r^2+b^2}} = \frac{\sigma}{2\varepsilon_0}\int_0^R \frac{r dr}{\sqrt{r^2+b^2}} =$$

$U = r^2+b^2$

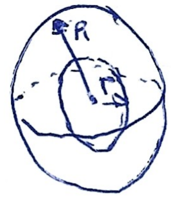
$du = 2r\,dr$

$$= \frac{\sigma}{2\varepsilon_0}\int \frac{\frac{1}{2}du}{\sqrt{U}} = \frac{\sigma}{4\varepsilon_0}\cdot\frac{\sqrt{U}}{1/2} = \frac{\sigma}{2\varepsilon_0}\sqrt{r^2+b^2}\Big|_0^R =$$

$\sigma = \frac{Q}{S} = \frac{dq}{dS} = \frac{Q}{\pi R^2}$

$$= \frac{\sigma}{2\varepsilon_0}\left(\sqrt{R^2+b^2} - b\right) = \frac{Q}{2\pi\varepsilon_0 R^2}\left(\sqrt{R^2+b^2} - b\right)$$

13 Non-conductive Solid-sphere $\left[\rho_0 \left(\frac{r}{R}\right) \right.$ → constant → Varía según $\underline{r}$



a) $\underline{Q} = \int_V \rho \cdot dV = \int_0^R \rho \cdot 4\pi r^2 dr = \int_0^R \rho_0 \frac{r}{R} 4\pi r^2 dr = \frac{\rho_0 4\pi}{R} \int_0^R r^3 dr = \boxed{\rho_0 \pi R^3}$

$V = \frac{4}{3}\pi r^3$

$dV = \frac{4}{\cancel{3}}\pi \cancel{3} r^2$

$\boxed{Q = \rho_0 \pi R^3}$

b) $(r<R) \rightarrow q_{enc} = \int_0^r \rho_0 \frac{r}{R} 4\pi r^2 dr = \frac{\rho_0 4\pi}{R} \cdot \frac{r^4}{4}\Big|_0^r = \frac{\rho_0 \pi}{R} r^4 = \frac{Q}{\cancel{\pi} R^3} \cdot \frac{\cancel{\pi} r^4}{R} = \boxed{Q\left(\frac{r^4}{R^4}\right)}$

c) $\underline{r<R}$

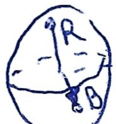
$\phi = \oint_S \vec{E} \cdot d\vec{S} = \frac{Q_{enc.}}{\varepsilon_0} = E \underbrace{4\pi r^2}_{S} = \frac{Q\left(\frac{r^4}{R^4}\right)}{\varepsilon_0} \rightarrow E = \frac{Q r^4}{4\pi\varepsilon_0 r^2 R^4} \rightarrow \boxed{\vec{E} = \frac{Q r^2}{4\pi\varepsilon_0 R^4} \hat{U}_r}$

$\underline{r>R}$

$\phi = \oint \vec{E} d\vec{S} = \frac{Q_{enc.}}{\varepsilon_0} = E 4\pi r^2 = \frac{\pi R^3 \rho_0}{\varepsilon_0} \rightarrow \boxed{\vec{E}_{out} = \frac{\rho_0 R^3}{4\varepsilon_0 r^2} \hat{u}_r}$

(ex a) above $Q_{enc.}$)

d) $r>R$ $\quad \Delta V = V_A - V_\infty = V_A = -\int_\infty^r \vec{E} d\vec{r} = -\int_\infty^r \frac{\rho_0 R^3}{4\varepsilon_0 r^2} dr = \frac{\rho_0 R^3}{4\varepsilon_0}\left[\frac{1}{r}\right]_\infty^r = \boxed{\frac{\rho_0 R^3}{4\varepsilon_0 r} = V_{out}}$



$- \overset{r}{\triangleright} A$

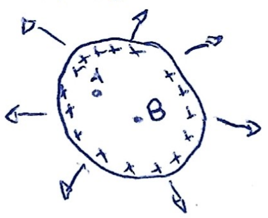
$\vec{E}_{out}$, $\vec{E}_{in}$ – se puede poner en función de ρ_0 o de Q

$r<R$

$\Delta V = V_B - V_\infty = V_B = -\int_\infty^r \vec{E} d\vec{r} = -\int_\infty^R \frac{Q}{4\pi\varepsilon_0 r^2} dr - \int_R^r \frac{Q r^2}{4\pi\varepsilon_0 R^4} dr = \underbrace{\frac{Q}{4\pi\varepsilon_0 R}}_{\text{Outside}} - \frac{Q}{4\pi\varepsilon_0 R^4} \cdot \frac{r^3}{3}\Big]_R^r =$

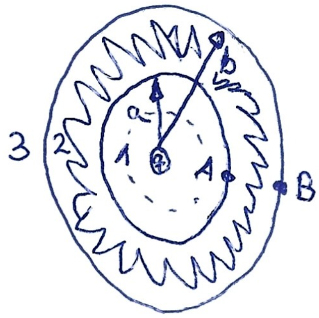
$V_B = \frac{Q}{12\pi\varepsilon_0 R^4}(4R^3 - r^3)$

Inside a conductor:



$V_A = 0 = V_B$

$\vec{E}_{inside} = 0$



Uncharged $\rightarrow Q_{total} = Q_A + Q_B = 0$

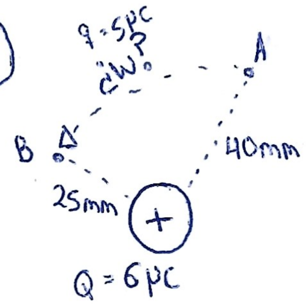
Conductor $\rightarrow$ charges on the surface

① $Q_{enc} = q$

$$\phi = \oint_S \vec{E}\,d\vec{S} = ES = \frac{Q_{enc}}{\varepsilon_0} = E\cdot 4\pi r^2 \rightarrow \vec{E} = \frac{q}{4\pi\varepsilon_0 r^2}\vec{U_r}$$

...

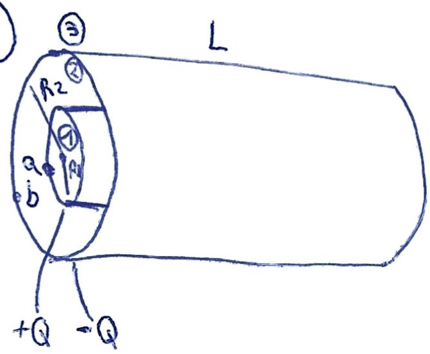
(14)



$$\boxed{W_{A\to B} = -q\cdot\Delta V} = -q(V_B - V_A) = q(V_A - V_B) = q\cdot k\left(\overbrace{\frac{6\mu C}{40mm}}^{\frac{Q}{r_A}} - \frac{6\mu C}{25mm}\right) =$$

$$= \underbrace{6\cdot10^{-6}C}_{Q}\cdot\underbrace{8'99\cdot10^{9}\frac{N\cdot m^2}{C^2}}_{k}\cdot\underbrace{5\cdot10^{-6}C}_{q}\cdot\left(\frac{1}{0{,}04m} - \frac{1}{0'025m}\right) = \boxed{-4{,}05\,J}$$

(17)

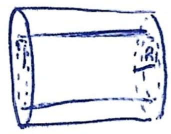


$L = 50\,cm$

$R_1 = 2cm \quad R_2 = 4cm$

$Q = 10^{-9}C$

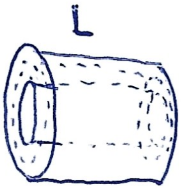
①



$\underline{r < R_1}$

$Q_{enc} = 0 \qquad \underline{\vec{E_1} = 0}$

②



$\underline{R_1 < r < R_2}$

$Q_{enc} = +Q \qquad \phi = \oint_V \vec{E}\,d\vec{S} = \frac{Q_{enc}}{\varepsilon_0}$

$$\oint_V \vec{E}\,d\vec{S} = \underbrace{\cancel{\int \vec{E}\,d\vec{S}}}_{base1}{}^{0} + \underbrace{\cancel{\int \vec{E}\,d\vec{S}}}_{base2}{}^{0} + \underbrace{\int \vec{E}\,d\vec{S}}_{lateral} = E\overset{2\pi r\cdot L}{S} = \frac{Q_{enc}}{\varepsilon_0}$$

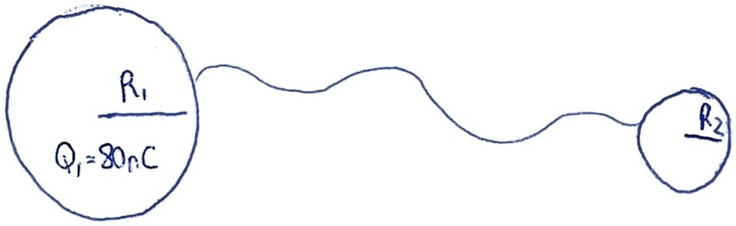
$$\underline{\vec{E_2} = \frac{Q}{2\pi r L\varepsilon_0}\hat{U_r}}$$

③ $Q_{enc} = +Q - Q = 0$

$\underline{\vec{E} = 0}$

$$\boxed{\Delta V} = V_A - V_B = -\int_b^a \vec{E_2}\,d\vec{r} = -\int_{b=R_2}^{a=R_1} \frac{Q}{2\pi\varepsilon_0 rL}dr = \frac{Q}{2\pi\varepsilon_0 L}\ln r\Big]_{R_1}^{R_2} = \frac{Q}{2\pi\varepsilon_0 L}\ln\frac{R_2}{R_1} = \boxed{24{,}93V}$$

CxS



$R_1 = 6cm$

$R_2 = 2cm$

$$V_{sphere} = k \frac{Q_{sphere}}{r_{sphere}}$$

Wait some time.

$Q_1' + Q_2' = 80nC \rightarrow V_1' = V_2'$:

$$V_1' = k \frac{Q_1'}{R_1}$$

$$V_2' = k \frac{Q_2'}{R_2}$$

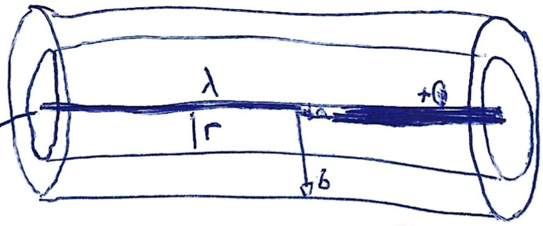
$$\rightarrow \frac{Q_1'}{R_1} = \frac{Q_2'}{R_2}$$

$$\boxed{\begin{aligned} Q_1' &= 60nC \\ Q_2' &= 20nC \end{aligned}}$$

$$\boxed{V_1' = V_2' = 8{,}99\ kV}$$

Coaxial Capacitor example

$$E = \frac{1}{2\pi\varepsilon_0}\frac{\lambda}{r}$$



$$C = \frac{Q}{V_{ab}} = \frac{Q}{\frac{Q}{2\pi\varepsilon_0 L}\ln\left(\frac{b}{a}\right)} = \frac{2\pi\varepsilon_0 L}{\ln\left(\frac{b}{a}\right)}$$

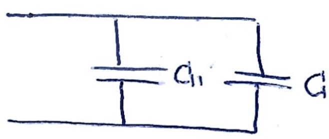
$$\Delta V = -\int \vec{E}\, d\vec{l}$$

$$Q_{enc} = +Q = \int \lambda\, dl = \lambda L$$

$$\phi = \oint \vec{E}\, d\vec{S} = \frac{Q_{enc}}{\varepsilon_0} = \int_{\text{round}} E\cdot dS = E\cdot 2\pi r L = \frac{Q}{\varepsilon_0} \rightarrow \vec{E} = \frac{Q}{2\pi\varepsilon_0 r L}\vec{U}_r$$

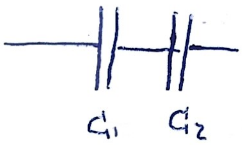
$$V_a - V_b = \Delta V = -\int_b^a \vec{E}\, d\vec{l} = \int_a^b \vec{E}\, d\vec{l} = \int_a^b \frac{Q}{2\pi\varepsilon_0 r L} = \frac{Q}{2\pi\varepsilon_0 L}\ln\left(\frac{b}{a}\right) = V$$

Examples capacitance:



$\approx$

$C_{eq} = 1\,\mu F = C_1 + C_2$

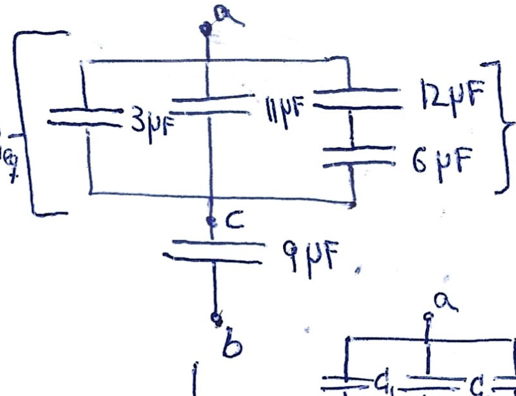


$\approx$

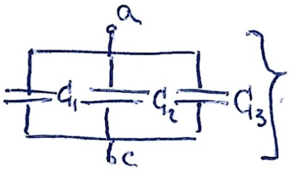
$C_{eq} = 0{,}09\,\mu F = \frac{1}{C_1} + \frac{1}{C_2}$

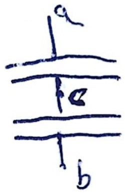
$C_1 = 0{,}9\,\mu F$

$C_2 = 0{,}1\,\mu F$




$C_{eq} \Rightarrow \frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2}$ $\quad C_{eq} = 4\,\mu F$



$C_{eq} = C_1 + C_2 + C_3 = 18\,\mu F \rightarrow$


$18\,\mu F = C_1$

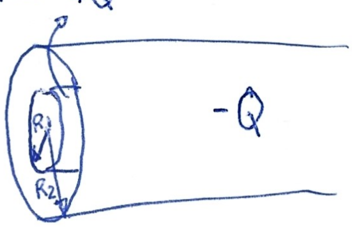
$9\,\mu F = C_2$

$C_{eq}^{-1} = \frac{1}{18} + \frac{1}{9}$

$\boxed{C_{eq} = 6\,\mu F}$

Semminar:

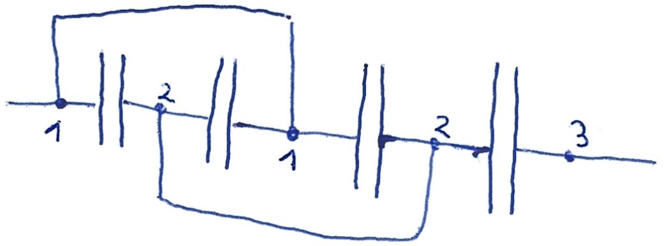
Ex 17: $+Q = 10^{-9} C$



$$C = \frac{Q}{V_{12}} = \frac{10^{-9} C}{24'93 V} = 4{,}01 \cdot 10^{-11} F = \boxed{0{,}401 \ pF}$$

$$V_{12} = 24'93 V$$

Capacitors ex:



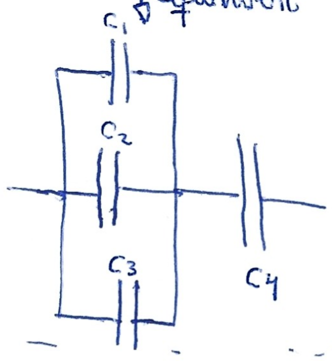
$C_1 \to 1 \ \& \ 2$

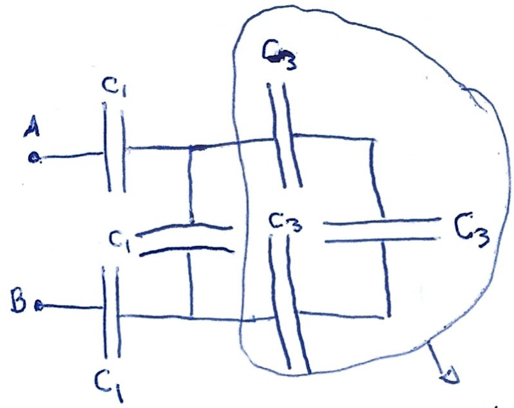
$C_2 \to 2 \ \& \ 1$

$C_3 \to 1 \ \& \ 2$

$C_4 \to 2 \ \& \ 3$

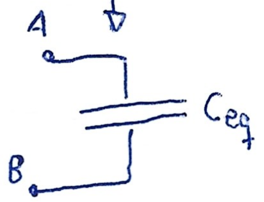
equivalent





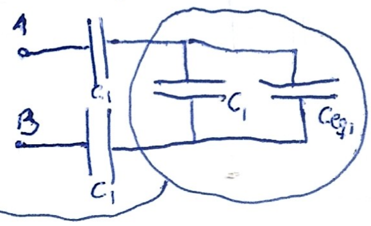
$C_1 = 1 \mu F$

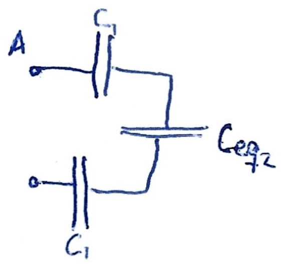
$C_3 = 3 \mu F$



$$C_{eq1} \Rightarrow \frac{1}{C_{eq}} = \frac{1}{C_3} + \frac{1}{C_3} + \frac{1}{C_3} = 1$$

$$\boxed{C_{eq1} = 1 \ \mu F}$$





$$C_{eq2} \Rightarrow C_{eq2} = C_1 + C_{eq1} = 1 + 1 = \boxed{2 \ \mu F}$$

$$\boxed{C_{eq}} \Rightarrow \frac{1}{C_{eq}} = \frac{1}{1} + \frac{1}{2} + \frac{1}{1} = \frac{5}{2} \to C_{eq} = \frac{2}{5} = \boxed{0{,}4 \mu F}$$

$$\Delta V = V_{AB} = 10V$$

$$C_{eq} = \frac{Q}{V_{AB}} \to Q_{total} = C_{eq} \cdot V_{AB} = 0{,}4 \mu F \cdot 10V = \boxed{4 \mu C}$$

Continue.

Álvaro Puebla Ruisánchez

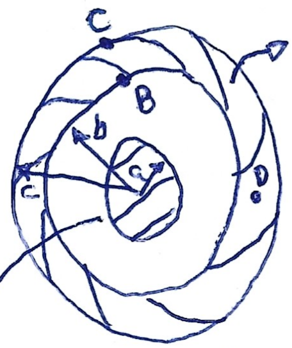
UO299874

Task 1.1:

$$Q_a = \int_V \rho \, dV = \int_0^a r \cdot 4\pi r^2 = \pi \left[r^4 \right]_0^a = \pi a^4$$

$$V = \frac{4}{3}\pi r^3$$

$$dV = 4\pi r^2$$



conductive

Q inside = 0

non-conductive sphere

$$\rho = r \left(\frac{Q}{m^3} \right)$$

1.
$$\left. \begin{array}{l} 0 = Q_B + Q_C \\ 0 = Q_D = Q_a + Q_B \end{array} \right\} \quad \begin{array}{l} Q_a = Q_C = \pi a^4 \\ Q_a = -Q_B = -\pi a^4 \end{array}$$

$$\boxed{\begin{array}{l} \sigma_C = \frac{Q_C}{S_C} = \frac{\cancel{\pi} a^4}{4\cancel{\pi} c^2} = \frac{a^4}{4c^2} \\ \sigma_B = \frac{Q_B}{S_B} = \frac{-\cancel{\pi} a^4}{4\cancel{\pi} b^2} = \frac{-a^4}{4b^2} \end{array}}$$

✓

2. $\boxed{r < a}$

$$\phi = \oint_V \vec{E} \, d\vec{S} = ES = E \, 4\pi r^2 = \frac{Q_{enc}}{\varepsilon_0} \rightarrow E = \frac{\cancel{\pi} r^{\cancel{4}\,2}}{4\cancel{\pi} \cancel{r^2} \varepsilon_0} \Rightarrow \boxed{\vec{E} = \frac{r^2}{4\varepsilon_0} \left(\frac{N}{C} \right)} \vec{u_r}$$

$\vec{E} \parallel \vec{S}$

✓

$$Q_{enc} = \int_V \rho \, dV = \int_0^r r \, 4\pi r^2 = \pi r^4$$

$\boxed{a < r < b}$

$$\phi = ES = E 4\pi r^2 = \frac{Q_a}{\varepsilon_0} \rightarrow E = \frac{\cancel{\pi} a^4}{4\cancel{\pi} r^2 \varepsilon_0} \rightarrow \boxed{\vec{E} = \frac{a^4}{4 r^2 \varepsilon_0} \left(\frac{N}{C} \right)} \vec{u_r}$$

✓

$\boxed{b < r < c}$

$$\phi = 0 \rightarrow \boxed{\vec{E} = 0}$$

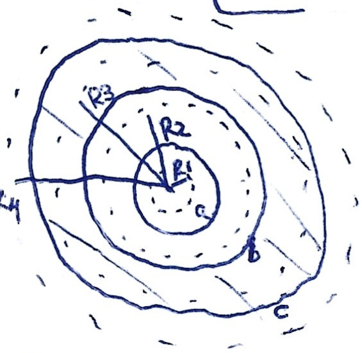
$Q_{enc} = 0$

✓

$\boxed{c < r}$

$$\phi = ES = E 4\pi r^2 = \frac{Q_a + 0}{\varepsilon_0} \rightarrow E = \frac{\cancel{\pi} a^4}{4\cancel{\pi} r^2} \rightarrow \boxed{\vec{E} = \frac{a^4}{4 r^2 \varepsilon_0} \left(\frac{N}{C} \right)} \vec{u_r}$$

3. A) $\boxed{\Delta V} = V_{R1} - \cancel{V_\infty}^{\,0} = -\int_\infty^{R_1} \vec{E}\,d\vec{r} = -\int_\infty^{c} \frac{a^4}{4r^2\varepsilon_0}dr - \int_c^{b} 0\,dr - \int_b^{a} \frac{a^4}{4r^2\varepsilon_0}dr - \int_a^{a/2} \frac{r^2}{4\varepsilon_0}dr =$



$$= \frac{a^4}{4\varepsilon_0}\left(\left[\frac{1}{r}\right]_\infty^{c} + \left[\frac{1}{r}\right]_b^{a}\right) - \frac{1}{12\varepsilon_0}\left[r^3\right]_a^{a/2} = \frac{a^3(ab+cb-ac)}{4\varepsilon_0 bc} + \frac{7a^3}{96\varepsilon_0} =$$

$$= \boxed{\frac{a^3}{4\varepsilon_0}\left(\frac{ab+cb-ac}{bc} + \frac{7}{24}\right)(V)}$$ ✓

$R_1 = a/2$
$R_2 = 2a$
$R_3 = 2b$
$R_4 = 2c$

B) $\boxed{\Delta V} = V_{R1} - V_{R4} = -\int_\infty^{R1=a/2} \vec{E}\,d\vec{r} + \left(\int_\infty^{R4=2c} \vec{E}\,d\vec{r}\right) = \frac{a^3}{4\varepsilon_0}\left(\frac{ab+cb-ac}{bc} + \frac{7}{24}\right) + \int_\infty^{2c} \frac{a^4\,dr}{4r^2\varepsilon_0} =$

$$= \frac{a^3}{4\varepsilon_0}\left(\frac{ab+cb-ac}{bc} + \frac{7}{24} - \frac{a}{2c}\right) = \boxed{\frac{a^3}{4\varepsilon_0}\cdot\frac{\cancel{36}^{\,12}ab + 31bc - 24ac}{24bc}(V)}$$

C) $\boxed{\Delta V} = V_{R1} - V_{R3} = -\int_\infty^{R1} \vec{E}\,d\vec{r} + \int_\infty^{R3} \vec{E}\,d\vec{r} = \frac{a^3}{4\varepsilon_0}\left(\frac{ab+cb-ac}{bc} + \frac{7}{24}\right) - \frac{a^4}{4c\varepsilon_0} =$

because From c to R3 $\Delta V = 0$

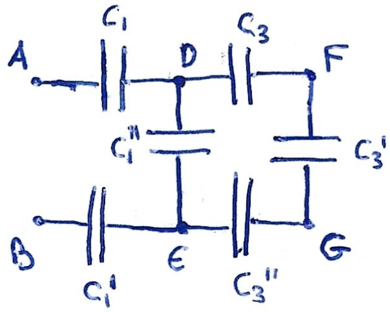
$$= \boxed{\frac{a^3}{4\varepsilon_0}\cdot\frac{\cancel{48}ab + 31bc - 24ac}{24bc}(V)}$$

D) $\boxed{\Delta V} = V_{R1} - V_{R2} = -\int_\infty^{R1} \vec{E}\,d\vec{r} + \int_\infty^{R2} \vec{E}\,d\vec{r} = -\int_\infty^{R1} \vec{E}\,d\vec{r} + \frac{a^4}{4\varepsilon_0}\left(\left[\frac{1}{r}\right]_\infty^{c} + \left[\frac{1}{r}\right]_b^{2a}\right) =$

$$= \frac{a^3}{4\varepsilon_0}\left(\frac{24ab+31bc-24ac}{24bc} + \frac{2ab+bc-2ac}{2bc}\right) = \boxed{\frac{a^3}{4\varepsilon_0}\cdot\frac{\cancel{48}ab + 43bc - 48ac}{24bc}(V)}$$

Continue

Q, V in each capacitor?



$V_{TOTAL} = 10V$

$Q_{TOTAL} = 0'4\mu F \cdot 10V = 4\mu C$

$$\boxed{C_{eq} = \frac{Q}{V_{eq}}}$$

$\underline{Q_{C1}} = \underbrace{Q_{eq_2}}_{E-D} = \underline{Q_{C1'}} = Q_{TOTAL} = \underline{4\mu C}$

$V_{AB} = V_{AD} + V_{DE} + V_{EB} = 10V$

$V_{EB} \to \frac{Q_{C1'}}{C_{C1'}} = \underline{4V}$

$V_{DE} \to \frac{Q_{eq2}}{C_{eq2}} = 2V$

$V_{AD} \to \frac{Q_{C1}}{V_{C1}} = \underline{4V}$

$V_{DE} = \underline{V_{C1''}} = \underline{V_{Ceq1}} = \underline{2V}$

$\to \underline{Q_{C1''}} = C_1'' \cdot V_{C1''} = \underline{2\mu C}$

$Q_{ceq1} = C_{eq1} \cdot V_{eq1} = 2\mu C$

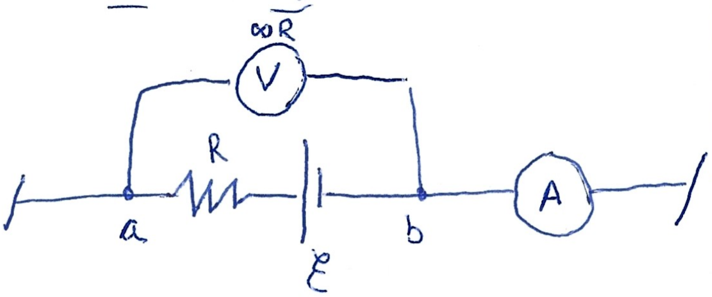
$\underline{Q_{C3}} = \underline{Q_{C3'}} = \underline{Q_{C3''}} = Q_{ceq1} = \underline{2\mu C}$

$\underline{V_{C3}} = V_{DF} = \frac{Q_{C3}}{C_3} = \underline{\frac{2}{3}V}$

$\underline{V_{C3'}} = V_{FG} = \underline{\frac{2}{3}V}$

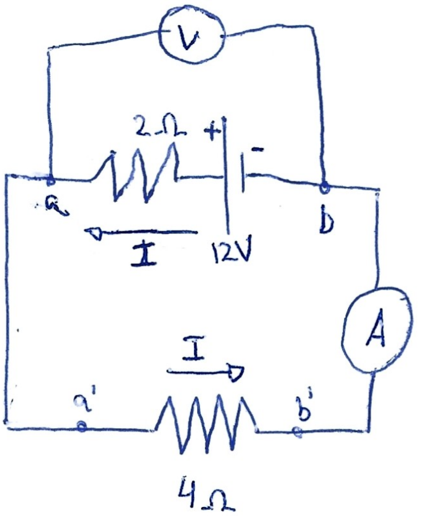
$\underline{V_{C3''}} = V_{GE} = \underline{\frac{2}{3}V}$

C_3, C_3', C_3'' are equivalent as they have the same Q, V and C



$I = 0 \to$ Open circuit

$V_{ab} = \mathcal{E} - \cancel{IR} = \mathcal{E}$



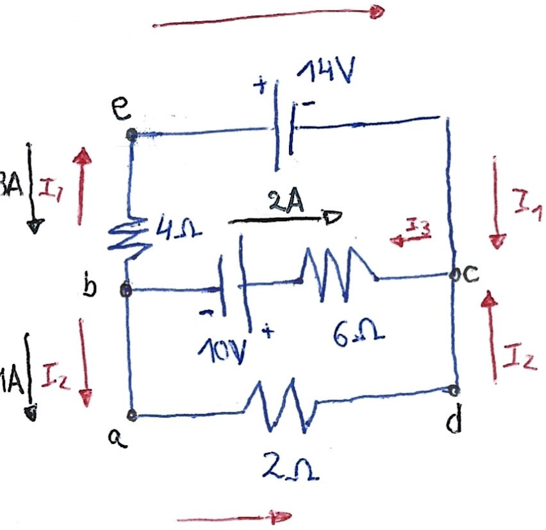
$V_{ab} = V_{a'b'} = RI = 4I \to \underline{V_{ab} = 4I = 8V}$

$12 - 2I - 4I = 0$

$12 = 6I \to \boxed{I = 2}$

$\underline{V_{ab} = 12V - I \cdot R = 12 - 2 \cdot 2 = 8V}$

$\underline{V = I \cdot R}$



Junctions: 2 → ⓑ $I_3 = I_1 + I_2$

~~ⓒ $I_1 + I_2 = I_3$~~

Loops: 3 → Upper loop from b: $= -I_1 \cdot 4 \overbrace{-14}^{\text{Battery}} - I_3 \cdot 6 - 10 = 0$

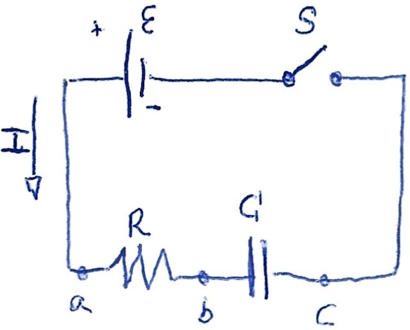
↘ Lower loop from b: $= +10 + I_3 \cdot 6 + I_2 \cdot 2 = 0$

3 unknowns → 3 equations
(I_1, I_2, I_3) (1 → Junction, 2 → Loop)

$$\begin{cases} I_3 = I_1 + I_2 \\ -4I_1 - 6I_3 = 24 \\ 2I_2 + 6I_3 = -10 \end{cases} \rightarrow \begin{matrix} I_1 = -3A \\ I_2 = 1A \\ I_3 = -2A \end{matrix}$$

$\left.\begin{matrix} V \\ Q \\ I \end{matrix}\right\}$ Steady constants $\left.\begin{matrix} v \\ q \\ i \end{matrix}\right\}$ time-dependent magnitudes

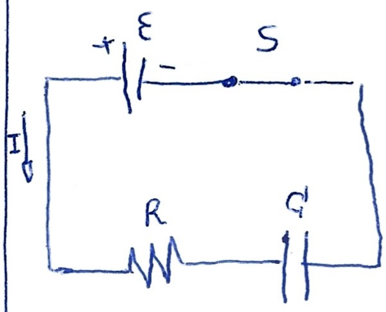
At $t < 0$:



switch open: $i = 0$

No charges in C → $q = 0$

At $t = 0$

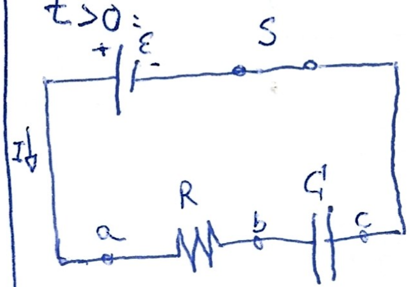


switch close $i \neq 0$ (I_0)

Not enought time to arrive to C → $q = 0$

$\varepsilon = i \cdot R \rightarrow \boxed{I_0 = \frac{\varepsilon}{R}}$

$t > 0$:



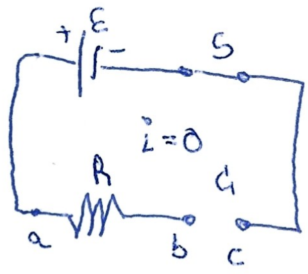
$\varepsilon - V_{ab} - V_{bc} = 0$

$\varepsilon - iR - \frac{q}{C} = 0$

constant

$t\uparrow \rightarrow q\uparrow \rightarrow i\downarrow$

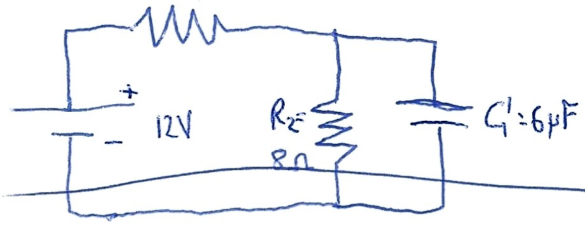
$t = \infty$ C Fully charged

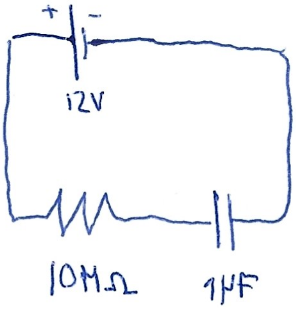


$\varepsilon - V_{ab} - V_{bc} = 0$

$\varepsilon - iR - \frac{q}{C} = 0 \rightarrow q = \boxed{Q_F = \varepsilon \cdot C}$

$t=0 \rightarrow 12 - i\cdot 4 = 0 \rightarrow \boxed{I_0 = 3A}$





a) Time constant $\Rightarrow \tau = R\cdot C_1 = 10\cdot 10^{6}\Omega \cdot 1\cdot 10^{-6}F = \boxed{10s}$

b) $q(t) = Q_F\left(1-e^{-\frac{t}{\tau}}\right) \quad t=46s$

$$\frac{q(t)}{Q_F} = 1 - e^{-\frac{46}{10}} = 0'99 \rightarrow \underline{99\%}$$

c) $i(t) = I_0\cdot e^{-t/\tau} \Rightarrow \frac{i(t)}{I_0} = e^{-t/\tau} = 0'01 \rightarrow \underline{1\%}$

...

a) $Q_0 = 5\mu C$

$q(t) = 0{,}5\mu C$

$0{,}5\mu C = 5\mu C \cdot e^{-t/10}$

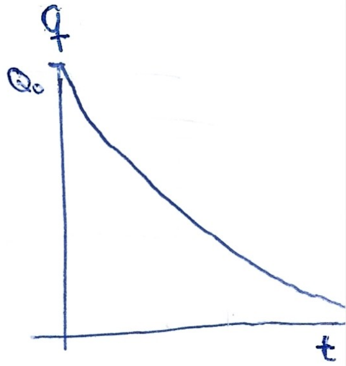
$\ln(0{,}1) = -\frac{t}{10} \rightarrow \underline{t = 23\,s}$

$q(t) = Q_0\cdot e^{-t/\tau}$

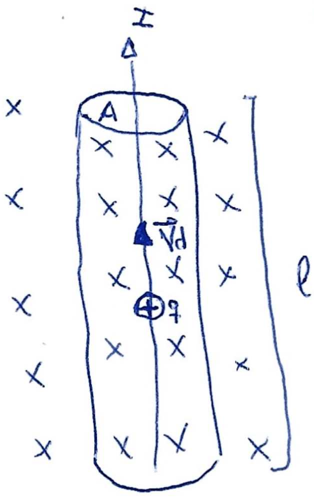
b) $i(t=23) = \frac{5\cdot 10^{-6}C}{10s}\, e^{-\frac{23}{10}} = 5\cdot 10^{-8}A$

$\tau = R\cdot C_1 = 10s$

$i(t) = I_0 e^{-t/\tau} = \frac{Q_0}{RC_1} e^{-t/\tau}$



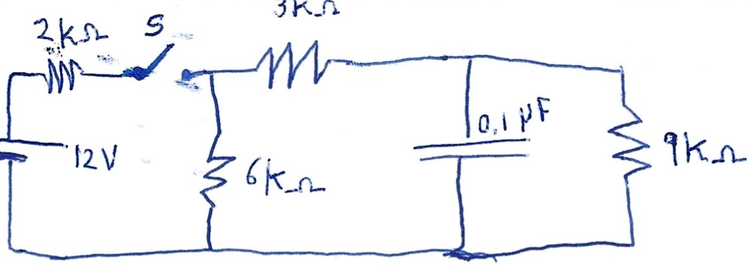
Magnetic forces



$\boxed{\begin{matrix} F = I\ell B \\ \vec{I} \perp \vec{B} \end{matrix}}$ $\boxed{\vec{F} = I\,\vec{\ell}\times\vec{B}}$

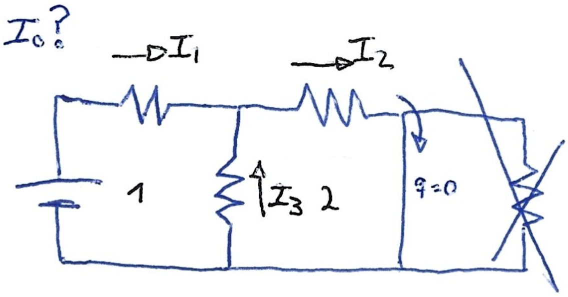
$$\vec{F} = \int d\vec{F} = \int_L \left(I\cdot d\vec{\ell}\times\vec{B}\right)$$

6



a) At t = 0 , i ≠ 0 , q = 0

I_0?



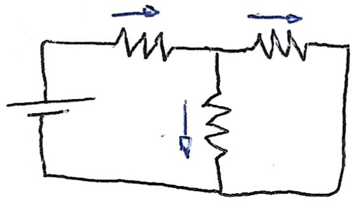
Junctions → $I_1 + I_3 = I_2$

Loops → 1: $2000 I_1 - 6000 I_3 = 12$

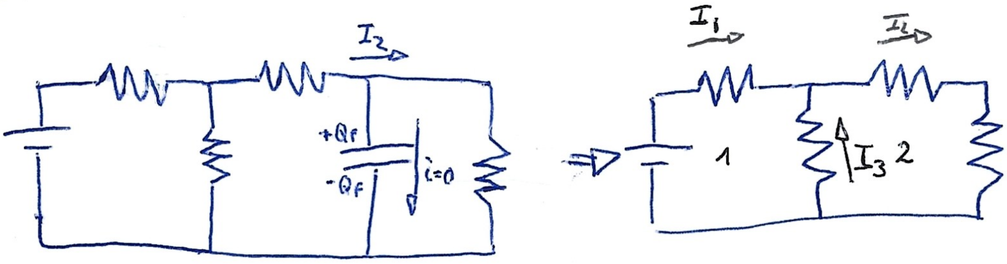
2: $3000 I_2 + 6000 I_3 = 0$

$$\left.\begin{array}{l} \\ \end{array}\right\} \quad I_1 = 3\,mA \quad I_2 = 2\,mA \quad I_3 = -10^{-3} A = -1\,mA$$

wrong direction



b) $t = \infty$



Junctions → $I_1 + I_3 = I_2$

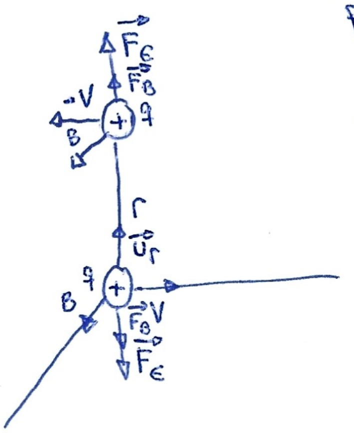
Loops: 1: $2000 I_1 - 6000 I_3 = 12$

2: $12000 I_2 + 6000 I_3 = 0$

$I_1 = 1'5\,mA$

$I_2 = 0'67\,mA$

$I_3 = -1'33\,mA$



$$\vec{F}_{E_{up}} = \vec{E}_{bot} \cdot q_{up}$$

$$\vec{E}_{bot} = \frac{1}{4\pi\varepsilon_0} \cdot \frac{|q|}{r^2}\vec{j}$$

$$\vec{F}_{E\,up} = \frac{1}{4\pi\varepsilon_0}\frac{q^2}{r^2}\vec{j}$$

$$\vec{F}_{B,up} = q_{up}\,\vec{V}_{up} \times \vec{B}_{bot}$$

$$\vec{B}_{bot} = \frac{\mu_0}{4\pi}\frac{q_{bot}\vec{V}_{bot} \times \vec{U}_r}{r^2} = \frac{\mu_0}{4\pi}\frac{q\,v\,\vec{i} \times \vec{j}}{r^2} = \frac{\mu_0 q V}{4\pi r^2}(\vec{i} \times \vec{j})$$

$$\frac{F_E}{F_B} = \frac{\frac{1}{4\pi\varepsilon_0}\cancel{\frac{q^2}{r^2}}}{\frac{\cancel{q^2}\mu_0 V^2}{\cancel{4\pi r^2}}} = \frac{1}{\underbrace{\varepsilon_0\mu_0}_{c^2} V^2} = \boxed{\frac{c^2}{V^2}}$$

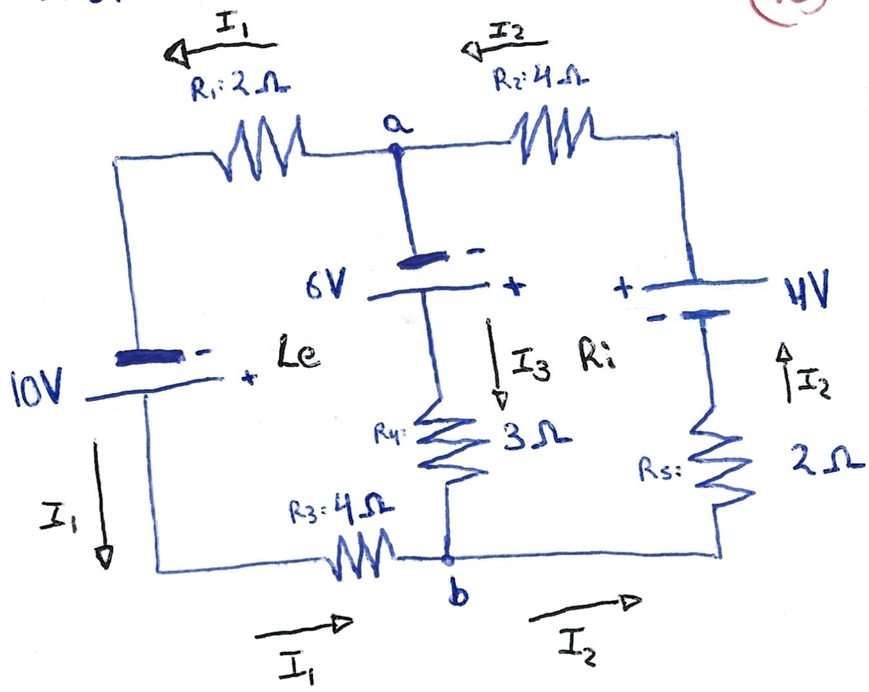
$$\begin{vmatrix} \vec{i} & \vec{j} & \vec{k} \\ 1 & 0 & 0 \\ 0 & 1 & 0 \end{vmatrix} = \vec{k}$$

$$\vec{B}_{bot} = \frac{\mu_0 q V}{4\pi r^2}\vec{k}$$

Task 2: kirchhoff rules

10

Álvaro Puebla Ruisánchez



Junctions (2) → a: $I_2 = I_1 + I_3$

→ b: $\cancel{I_2 = I_3 + I_1}$

Loops (2) → Le: $6 - 3 \cdot I_3 + 4I_1 - 10 + 2I_1 = 0$

→ Ri: $4 \cdot I_2 - 4 + 2I_2 + 3I_3 - 6 = 0$

$$\begin{cases} I_2 = I_1 + I_3 \\ 6I_1 - 3I_3 - 4 = 0 \\ 6I_2 + 3I_3 - 10 = 0 \end{cases} \rightarrow \begin{matrix} 6I_1 - 3I_3 = 4 \\ 6I_1 + 9I_3 = 10 \end{matrix} \rightarrow \boxed{\begin{matrix} I_2 = \frac{17}{12}\,A \\ I_3 = \frac{1}{2}\,A \\ I_1 = \frac{11}{12}\,A \end{matrix}}$$

The current was well oriented

The current through R_1 and R_3 is $\frac{11}{12}A \approx 0'92A$

The current through R_2 and R_5 is $\frac{17}{12}A \approx 1'42A$

The current through R_4 is $\frac{1}{2}A = 0'5A$

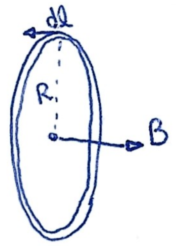
$$\vec{B} = \frac{\mu_0}{4\pi}\frac{q\cdot\vec{v}\times\vec{U_r}}{r^2} = \frac{\mu_0}{4\pi}\frac{I\,\vec{dl}\times\vec{U_r}}{r^2}$$

$$I = \frac{dq}{dt} \rightarrow dq = I\,dt \rightarrow \vec{v}\,dq = I\,\underbrace{\vec{v}\,dt}_{\vec{dl}}$$

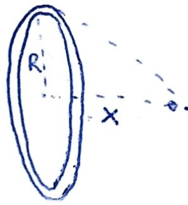
$\otimes P$ $$\boxed{\vec{B} = \int d\vec{B} = \int \frac{\mu_0}{4\pi}\frac{dq\cdot\vec{v}\times\vec{U_r}}{r^2} = \int_L \frac{\mu_0}{4\pi}\frac{I\cdot\vec{dl}\times\vec{U_r}}{r^2} = \int_L \frac{\mu_0}{4\pi}\frac{I\,\vec{U_l}\times U_r}{r^2}\,dl}$$

$\vec{dl} = dl\cdot\vec{U_l}$

LAW OF BIOT & SAVART

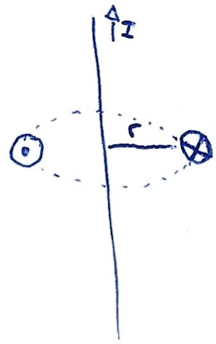


$$\vec{B} = \frac{\mu_0 N I}{2R}$$



$$\rightarrow B_x = \frac{\mu_0}{4\pi}\cdot\frac{2\pi R^2 I}{(x^2+R^2)^{3/2}}$$

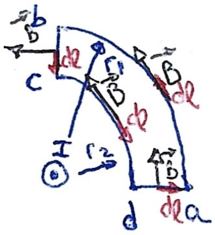
Circulation of $\vec{B}$ through a curve : $\int_L \vec{B}\cdot\vec{dl}$



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

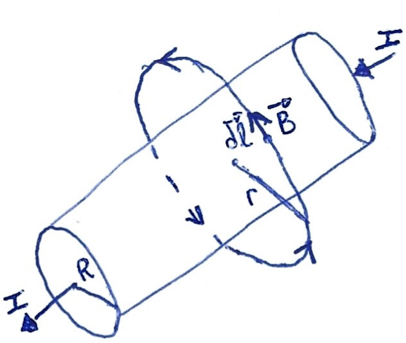
$$\boxed{\oint_C \vec{B}\,\vec{dl}} = \oint_C B\,dl = \int \frac{\mu_0 I}{2\pi r}\,dl = \frac{\mu_0 I}{2\pi r}\oint dl = \frac{\mu_0 I}{2\pi r}\cdot 2\pi r = \mu_0 I_{enc}$$

Ampère's law



$$\oint_C \vec{B}\,\vec{dl} = \int_a^b \vec{B}\cdot\vec{dl} + \underbrace{\cancel{\int_b^c \vec{B}\,\vec{dl}}}_{0\ \vec{B}\perp\vec{dl}} + \int_c^d \vec{B}\,\vec{dl} + \underbrace{\cancel{\int_d^a \vec{B}\,\vec{dl}}}_{0\ \vec{B}\perp\vec{dl}} = \int_a^b \frac{\mu_0 I}{2\pi r_1}\,dl + \int_c \frac{\mu_0 I}{2\pi r_2}\,dl =$$

$$= \frac{\mu_0 I}{2\pi \cancel{r_1}}\cdot\theta \cancel{r_1} - \frac{\mu_0 I}{2\pi r_2}\cdot\theta \cancel{r_2} = 0$$



$$\oint_C \vec{B}\cdot\vec{dl} = \underset{\vec{B}\,//\,\vec{dl}}{\oint B\,dl} = B\oint dl = B\,2\pi r = \mu_0 I_{enc} = \mu_0 I$$

Ampère's law

$\Downarrow$

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

- On the surface

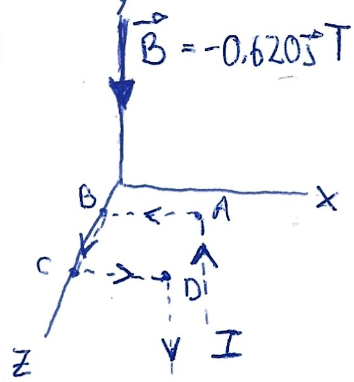
$r = R$ $\quad \boxed{B = \frac{\mu_0 I}{2\pi R}}$

- Inside $r < R$

$$\oint_C \vec{B}\,\vec{dl} = B\,2\pi r = \mu_0 I_{enc} = \mu_0 I\frac{r^2}{R^2} \rightarrow \boxed{B = \frac{\mu_0 I r}{2\pi R^2}}$$

$\vec{B}\,//\,\vec{dl}$

4



$I = 19\,A$

$\overline{AB} = \overline{CD} = 38\ cm$

$\overline{BC} = 76\ cm$

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

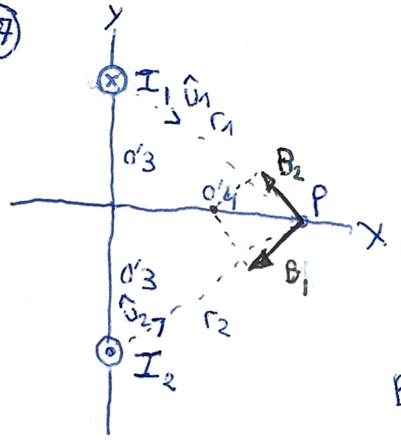
$\vec{F}_{AB} = 19A \cdot 0'38(+\vec{i})m \times (+0'620\vec{j})T = +4'48\ \vec{k}N$

$\vec{F}_{BC} = 19A \cdot 0'76(\vec{k})m \times (-0'620\vec{j})T = +8'95\ \vec{i}N$

$\vec{F}_{CD} = 19A \cdot 0'38(\vec{i})m \times (-0'620\vec{j})T = -4'48\ \vec{k}N$

$\vec{F}_B = \vec{F}_{AB} + \vec{F}_{BC} + \vec{F}_{CD} = \cancel{+4'48 - 4'48}\ \vec{k}N + 8'95\vec{i}N = \boxed{8'95\,\vec{i}N}$

7



$r_1 = r_2 = 0'5\,m$

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

$B_1 = \dfrac{\mu_0 I}{2\pi r_1} = \dfrac{4\pi\cdot 10^{-7}\cdot 9}{2\pi \cdot 0'5} = 36\cdot 10^{-7}T = B_2$

$U_1 = \dfrac{\vec{r}_1}{|\vec{r}_1|} = \dfrac{0'4\vec{i} - 0'3\vec{j}}{0'5} = 0'8\vec{i} - 0'6\vec{j} \quad \perp -0'6\vec{i} - 0'8\vec{j}$

$\vec{B}_1 = 36\cdot 10^{-7}T(-0'6\vec{i} - 0'8\vec{j})$

$B_2 = \dfrac{\mu_0 I}{2\pi r_2} = 36\cdot 10^{-7}T$

$U_2 = \dfrac{\vec{r}_2}{|\vec{r}_2|} = \dfrac{0'4\vec{i} + 0'3\vec{j}}{0'5} = 0{,}8\vec{i} + 0'6\vec{j} \quad \perp -0'6\vec{i} + 0'8\vec{j}$

$\vec{B}_2 = 36\cdot 10^{-7}T(-0'6\vec{i} + 0'8\vec{j})$

$\boxed{\vec{B} = \vec{B}_1 + \vec{B}_2} = \boxed{2\cdot(-21'6\vec{i})\cdot 10^{-7}T = -43{,}2\cdot 10^{-7}\vec{i}T}$

Coil in a magnetic field

$\dfrac{\Delta B}{\Delta t} = +0'020\dfrac{T}{S} \approx \dfrac{dB}{dt}$

$N = 1$

$S = 120\,cm^2$

$R = 5\,\Omega$

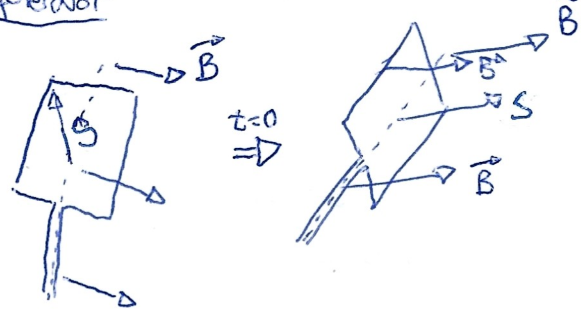
$\mathcal{E}$?

i ? $\rightarrow \boxed{i = \dfrac{\mathcal{E}}{R}} = -\dfrac{2'4\cdot 10^{-4}}{5} = -48\cdot 10^{-6}A = \boxed{-48\,\mu A}$

$\boxed{\mathcal{E} = -\dfrac{d\phi_B}{dt} = \dfrac{-d(A\cdot B)}{dt}\Big|_{A\ \text{constant}} = -A\dfrac{dB}{dt} = -\overbrace{1'20\cdot 10^{-2}}^{1'2\cdot 10^{-2}m^2}\cdot 0'020 = -2'4\cdot 10^{-4}V}$

$\phi_B = \int \vec{B}\,d\vec{S} = \int B\,dS\cdot \overbrace{\cos\theta}^{1} = \int B\,dS \underset{B\ \text{uniform}}{=} B\int dA = BA$

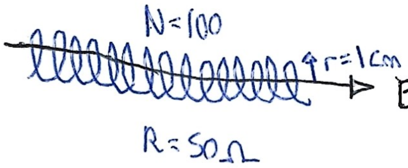
AC generator



$\phi_B = \int \vec{B}\,d\vec{S} = \int B\,dS\cdot\cos\theta = B S\cdot\cos(wt)$

$\mathcal{E} = -\dfrac{d(BS\cos(wt))}{dt} = BS\,w\cdot\sin(wt)$

$i = \dfrac{\mathcal{E}}{R} = \dfrac{B\cdot S\cdot \overset{\text{omega}}{w}\cdot\sin(wt)}{R}$



$i = \frac{dq}{dt} \approx \frac{\Delta q}{\Delta t}$

induced ↑ induced $\mathcal{E}$ ↑ $\frac{d\phi_B}{dt} \neq 0$

$\phi_B = \int \vec{B}\, d\vec{S} =$

$\phi_{B\,initial} = B \cdot S \cdot \cos\overset{0^\circ}{\theta} = B \cdot S$

$\phi_{B\,Final} = B \cdot S \cdot \cos\overset{180^\circ}{\theta} = -B \cdot S$

$\Delta \phi_B = \phi_{B\,Final} - \phi_{B\,inicial} =$

$= -B S - B \cdot S = -2 B \cdot S$

$i = \frac{\mathcal{E}}{R} = -\frac{1}{R} \cdot \frac{\Delta \phi_B}{\Delta t} = \frac{dq}{dt} \approx \frac{\Delta q}{\Delta t} \rightarrow \frac{-1}{R} \cdot \frac{\Delta \phi}{\cancel{\Delta t}} \approx \frac{\Delta q}{\cancel{\Delta t}} \rightarrow \boxed{\Delta q = +\frac{1}{50} \cdot (+2 \cdot 1 \cdot \pi \cdot 0'01^2) = 1'26 \cdot 10^{-3} C}$

$t = 0'1 s$

$\boxed{i = +\frac{1}{50} \cdot \frac{(+2 \cdot 1 \pi \cdot 0'01^2)}{0'1} = 12'6 \text{ mA}}$ $\quad \boxed{\mathcal{E} = iR = 0'63 V}$

Ex: Induced emf by movement

F_B ↑ ↓ F_e

$F_B = F_e$

$q v B = q E$

$\boxed{E = vB}$

$V_{ab} = E \cdot l = \boxed{vB \cdot l = \mathcal{E}}$

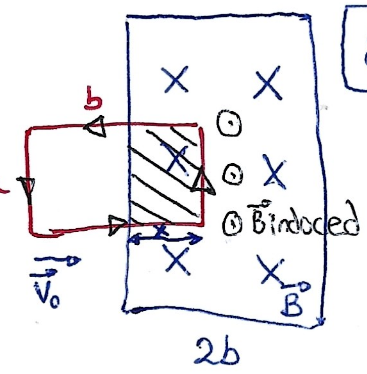
If the cables have resistance: r

$V_{ab} = \mathcal{E} - Ir = \underset{\vec{v} \perp \vec{B}}{vBl} - Ir$

In general:

$V_{ab} = \oint_C \vec{v} \times \vec{B}\, dl - Ir$

Example:



$\boxed{\mathcal{E} = -\frac{d\phi_m}{dt} = -B v_0 a}$

$\phi_m = \int \vec{B} \cdot d\vec{A} = B\underset{\text{Inside}}{A} = B \cdot \overset{v_0 \cdot t}{x} \cdot a = B \cdot v_0 \cdot t \cdot a \cdot \cancel{(-1)}$

crece
si decrece (−1)

$i = \frac{\mathcal{E}}{R} = -\frac{B v_0 a}{R}$ $\quad \vec{F}_B = I \cdot \vec{L} \times \vec{B}$

Si $\frac{\Delta \phi_m}{\Delta t}$ crece, $\frac{\Delta \phi_m}{\Delta t} > 0$

Si $\frac{\Delta \phi_m}{\Delta t}$ decrece, $\frac{\Delta \phi_m}{\Delta t} < 0$

Ex 10

Waves

$$X(t) = A \cdot \cos(wt + \delta)$$

$$V(t) = \frac{dx}{dt} = -Aw \sin(wt + \delta)$$

$$w^2 = \frac{K}{m}$$

$$a(t) = \frac{dx^2}{dt^2} = -A w^2 \cos(wt + \delta)$$

Ex:

$A = 1m$

$w = \pi$ rads/s

a) $\left[T = \frac{2\pi}{w} = \frac{2\cancel{\pi}}{\cancel{\pi}} = 2s\right]$ $\boxed{F = \frac{1}{T} = 0{,}5 \text{ Hz}}$

b) $\delta = 0$ $\boxed{x(t) = 1 \cdot \cos(\pi t) \text{ m}}$

c) $v(t) = -\pi \cdot \sin(\pi t)$ m/s

$a(t) = -\pi^2 \cos(\pi t)$ m/s²

d) $x(t = \frac{1}{6}s) = \cos\left(\frac{\pi}{6}\right) m = 0'866 m$

$v(t = \frac{1}{6}s) = -\pi \sin\left(\frac{\pi}{6}\right) \frac{m}{s} = -1'571$ m/s

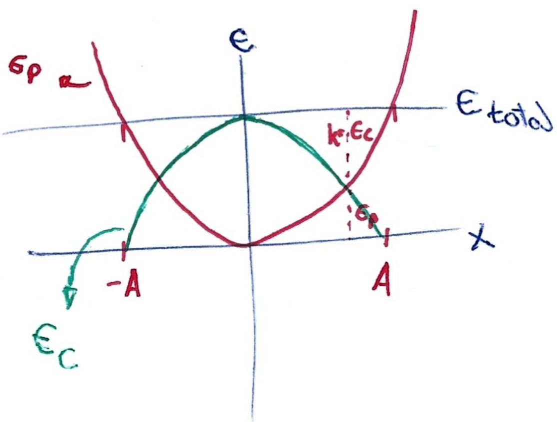
$a(t = \frac{1}{6}s) = -\pi^2 \cdot \cos\left(\frac{\pi}{6}\right) \frac{m}{s^2} = -8{,}55 \frac{m}{s^2}$

e) $x(t) = -0'5 m = \cos(\pi t)$

$t = \arccos(-0'5) = \boxed{0'67 s}$

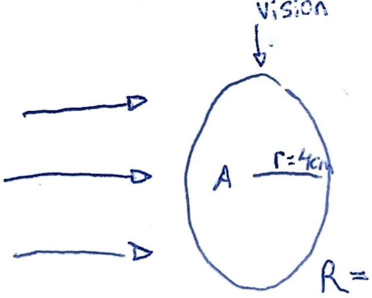
Energy of the SHM.

$$\boxed{\frac{1}{2} K A^2 = cte}$$



③ $B = 2T$

ϕ_m

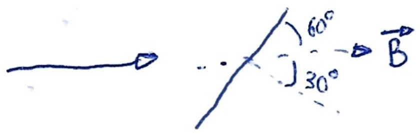


a)

$R = 8,5\,\Omega$

$$\phi_m = \int \vec{B}\,d\vec{A} = B\int dA = B\cdot A = 2\,\pi\cdot 0'04^2 = 0'01\cdot T\cdot m^2 = \underline{0'01\ Wb}$$

b)



$$\phi_m = \int \vec{B}\,d\vec{A} = \int B\,dA\cdot\cos\underset{\vec{B},\,d\vec{A}}{\theta} = B\cdot A\cdot\cos 30^\circ = 2\,\pi\cdot 0'04^2\cdot\cos 30^\circ = 0'00867\ Wb = 8'67\ mWb$$

c) first case $\boxed{\theta = 0^\circ}$

$$\Delta\phi_m = \phi_{m\,Final} - \phi_{m\,inicial} = B_{Final}\cdot A_f\cdot\cos\theta - B_{ini}\cdot A\cdot\cos$$

$$\frac{\Delta B}{\Delta t} = -\frac{1T}{8s} = -0'125\,\frac{T}{s}$$

$$i = \frac{\varepsilon}{R} = -\frac{1}{R}\cdot\frac{\Delta\phi_m}{\Delta t} = -\frac{1}{8'5}\cdot\pi\cdot 0'04^2\cdot(-0'125) = \underline{74\ \mu A}$$

second case $\boxed{\theta = 30^\circ}$

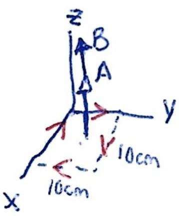
$$\frac{\Delta B}{\Delta t} = +\frac{2T}{8s} = 0'25\,\frac{T}{s}$$

$$i = \frac{\varepsilon}{R} = -\frac{1}{R}\cdot\frac{\Delta\phi_m}{\Delta t} = -\frac{1}{8'5}\,\frac{\pi\cdot 0'04^2\cdot\cos 30^\circ\cdot(4-2)}{8} = \boxed{-12\ \mu A}$$

⑤ $R = 2\,\Omega$

$B = 0'3 + 2t^2\ T$

$\vec{B} = (0'3 + 2t^2)\,\vec{k}\ T$



a) $\phi_m\,(t = 1s)$

$$\phi_m(t) = \int \vec{B}\,d\vec{A}\cdot B\cdot A = (0'3 + 2t^2)\cdot\underset{0'1\cdot 0'1}{0'01} =$$

$$= (3\cdot 10^{-3} + 2\cdot 10^{-2}t^2)\ Wb$$

$$\boxed{\phi_m(1) = 0'023\ Wb}$$

b) $$\varepsilon = \frac{d\phi_m}{dt} = -\frac{d}{dt}\left(3\cdot 10^{-3} + 2\cdot 10^{-2}t^2\right) = -0'04t\ V$$

c) $t = 0'2s$

i, direction?

$$i = \frac{\varepsilon}{R} = \frac{-0'04\cdot 0'2}{2} = -0'004\,A = -4\,mA$$

clockwise

d) $\vec{F}_B = I\vec{L}\times\vec{B}$

$$\vec{F}_{AB} = 0'004\cdot(-0'1\vec{j})\times(0'3 + 2t^2)\,\vec{k} = -1'52\cdot 10^{-4}\,\vec{i}\ N$$

⑥ $R = 6\,cm$

$r = 2\,cm$

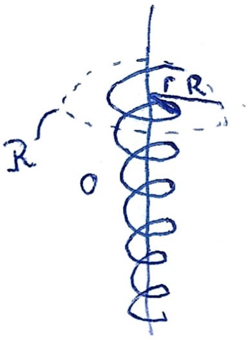
$\mathcal{R} = 1\,m\Omega$

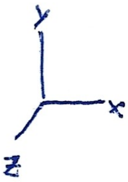
$n = 8000\ \frac{turns}{m}$

$I = 0'5t\ \frac{A}{s}$

a) $\phi_m = \int \vec{B}\,d\vec{A} = \int \mu_0 n I \cdot dA =$

$=$

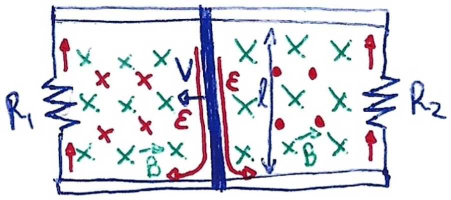




⑨ $\ell = 35\,cm$

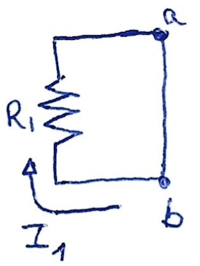
$R_1 = 2\,\Omega$

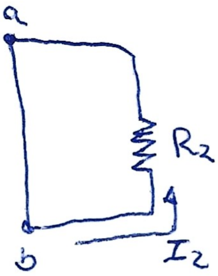
$R_2 = 5\,\Omega$



a) $\mathcal{E} = vB\ell = 8 \cdot 2{,}5 \cdot 0'35 = 7V$ $\quad \boxed{i = \frac{\mathcal{E}}{R}}$

b) $V_{ab} = \mathcal{E} = 7V = I_1 R_1 = I_2 \cdot R_2$





$I_1 = \frac{7}{2} = 3{,}5A$ $\qquad I_2 = \frac{7}{5} = 1'4A$

c) $\vec{F}_B = I\vec{L} \times \vec{B}$

$I_1 + I_2 = 3'5 + 1'4\ A = 4'9\ A = I$

$\vec{L} = 0'35(-\vec{j})\,m$

$\vec{B} = 2'5(-\vec{k})\,T$

$\vec{F}_B = 4'9\,(+0'35\vec{j}) \times (+2'5\vec{k}) = 4'29\,\vec{i}\,N$

① PS#5

$y(t) = 1'2 \cdot \cos\left(\frac{1}{2}t + \frac{\pi}{6}\right)$ (S.I.)

$A = 1'2\ m$

$w = \frac{1}{2}\ rad/s = 2\pi F$

$\delta = \frac{\pi}{6}\ rad$

$F = \frac{1}{4\pi} = 0'08\ Hz$

$T = \frac{1}{F} = 12'575$

$y(t = 1s) = 1'2\cos\left(0'5 \cdot 1 + \frac{\pi}{6}\right) m = 0'624\ m$

$v(t) = 1'2 \cdot \frac{1}{2}\left(-\sin\left(0'5t + \frac{\pi}{6}\right)\right) = -0'6\ \sin\left(\frac{1}{2}t + \frac{\pi}{6}\right)\ m/s$

$a(t) = -0'6 \cdot \frac{1}{2}\cos\left(\cancel{0'5}t + \frac{\pi}{6}\right) = -0'3\cos\left(\frac{1}{2}t + \frac{\pi}{6}\right)\ m/s^2$

④ $m = 0'5\,kg$

$k = 450\,\frac{N}{m}$

$A = 0'04\,m$ amplitud

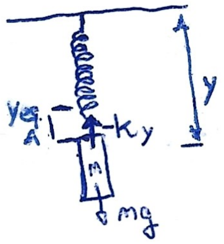
a) v_{max}

b) v? $x = -0{,}015\,m$

c) a_{max}?

d) a? $x = -0{,}015\,m$

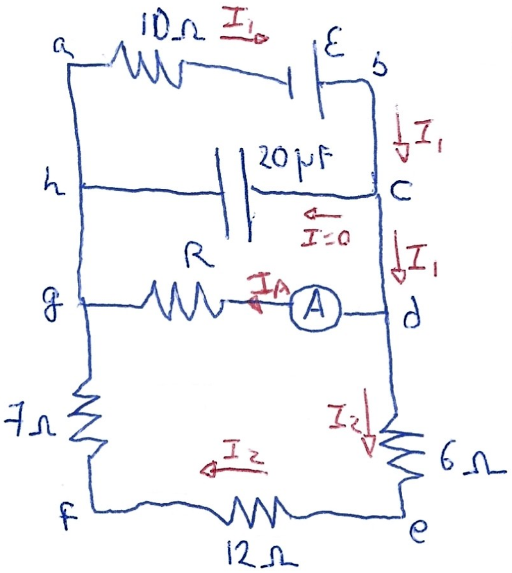
e) E_{mech}?



$$\Sigma F_y = mg - ky = m a_y$$

$$E_{mech} = E_c + E_p = \frac{1}{2} k A^2 = 0'36\,J$$

①



Datos:

$I_A = 1'5\,A$

$U = 526{,}5\,\mu J$

Fully charged

a) Q, V_{hc}

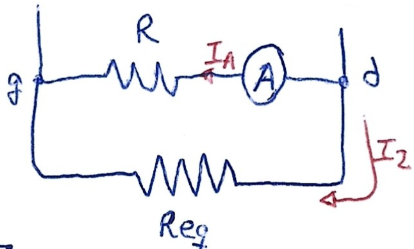
$$C = \frac{Q}{V_{hc}} \quad \Big| \quad U = \frac{1}{2} C V_{hc}^2 \rightarrow V_{hc} = \sqrt{\frac{2U}{C}} = 7'26$$

$$Q = C \cdot V_{hc} = 20 \cdot 10^{-6} \cdot 7'26 = \underline{1'45 \cdot 10^{-8}\,C}$$

b) $V_{hc} = V_{ab} = \varepsilon - I_1 \cdot R_1 = \boxed{\varepsilon - 10 I_1 = 7'26}$

$R_{eq} = 6 + 12 + 7 = 25\,\Omega$

serie



$V_{gd} = V_{hc} = 7'26 = I_2 R_{eq} = I_2 \cdot 25$

$$\boxed{I_2 = \frac{7'26}{25} = 0'29\,A}$$

En d: $I_1 = I_A + I_2 = 1'5 + 0'29 = \boxed{1'79\,A}$

c) $\varepsilon = 7'26 + 10 I_1 = 7'26 + 17'9 = \boxed{25{,}16\,V}$

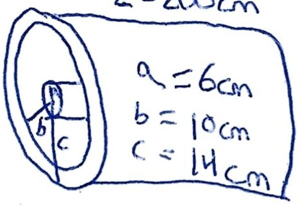
$$V_{gd} = V_{hc} = 7'26 = I_A \cdot R = 1'5 \cdot R \Rightarrow R = \frac{7'26}{1'5} = \boxed{4'84\,\Omega}$$

d) $P_{net} = P_{battery} - P_R = \varepsilon \cdot I_1 - I_1^2 \cdot R_1 = 25'16 \cdot 1'79 - 1'79^2 \cdot 10 =$ ......

Ex 12

(2)

$L = 200\,cm$



$a = 6\,cm$
$b = 10\,cm$
$c = 14\,cm$

a) $r_1 = 4\,cm$
$r_2 = 8\,cm$
$r_3 = 12\,cm$
$r_4 = 16\,cm$

solid cylinder → insulator → Q uniformly distributed

$Q_1 = 2\cdot10^{-9}\,C$

cylindrical crust → conductor → Q go to the surfaces

$Q_2 = -4\cdot10^{-9}\,C$

a) $$Q_{enc} = \int_V \rho \cdot dV = \int \rho\cdot 2\pi r L\, dr =$$

$V = \pi r^2 \cdot L$

$dV = 2\pi r L\, dr$

$$= \rho 2\pi L \int r\,dr = \frac{\rho \cancel{2}\pi L r^2}{\cancel{2}}\Bigg]_0^{0'04} = \rho\pi L\cdot 0'04^2 = \boxed{0'89\cdot10^{-9}\,C}$$

$$\rho = \frac{Q_1}{V} = \frac{2\cdot10^{-9}}{\pi\cdot 0'06^2\cdot 2}$$

uniforme, r_a, $200\,cm = L$

Gauss' law:

$$\oint \vec{E}\cdot d\vec{S} = \frac{Q_{enc}}{\varepsilon_0}$$

$$\cancel{\int_{base\ izq} \vec{E}\, d\vec{S}} + \cancel{\int_{base\ der} \vec{E}\, d\vec{S}} + \int_{curva} \vec{E}\, d\vec{S} = \frac{Q_{enc}}{\varepsilon_0}$$

$$E\cdot\int dS = E\cdot S = E\cdot 2\pi r L = \frac{Q_{enc}}{\varepsilon_0} = \frac{0'89\cdot10^{-9}}{8'85\cdot10^{-12}}$$

$$E = \frac{0'89\cdot10^{-9}}{2\pi\cdot 8'85\cdot10^{-12}\cdot 0'04\cdot 2} = 9991\,\frac{N}{C} \rightarrow \boxed{\vec{E} = 9991\,\vec{u}_r\,\frac{N}{C}}$$

b) $Q_{enc} = Q_1 = 2\cdot10^{-9}\,C$

$$E = \frac{Q_{enc}}{2\pi\varepsilon_0 r L}$$

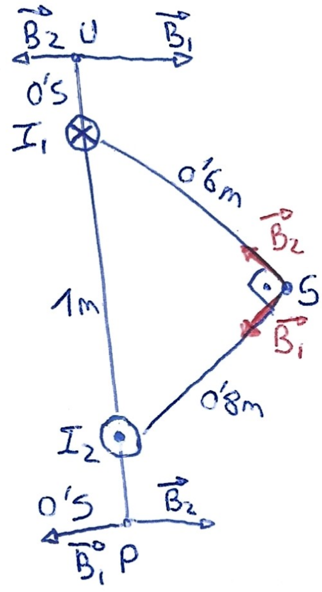
$$E = \frac{2\cdot10^{-9}}{2\pi\cdot 8'85\cdot10^{-12}\cdot 0'08\cdot 2} \rightarrow \boxed{\vec{E} = 5620\,\vec{u}_r\,\frac{N}{C}}$$

c) $Q_{enc} = 0$ (cond.) → $\boxed{\vec{E} = 0}$

d) $Q_{enc} = Q_1 + Q_2 = -2\cdot10^{-9}\,C$

$$E = \frac{-2\cdot10^{-9}}{2\pi\cdot 8'85\cdot10^{-12}\cdot 0'16\cdot 2} \Rightarrow \boxed{\vec{E} = -1405\,\vec{u}_r\,\frac{N}{C}}$$

(3)



$I_1 = 6A$

a) Principio Superposición

$$\vec{B_P} = \vec{B_1} + \vec{B_2}$$

$$B_1 = B_2$$

$$\frac{\mu_0 I_1}{2\pi r_1} = \frac{\mu_0 I_2}{2\pi r_2}$$

$$\frac{I_1}{1'5} = \frac{I_2}{0'5}$$

$$\boxed{I_2 = \frac{0'5 I_1}{1'5} = 2A}$$

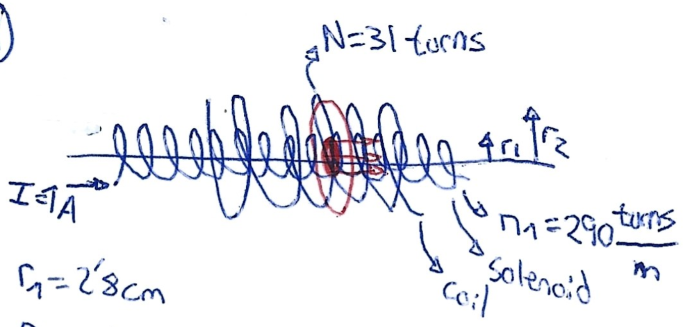
b) $B_1 = \frac{\mu_0 I_1}{2\pi \cdot r_1} = \frac{4\pi \cdot 10^{-7} \cdot 6}{2\pi \cdot 0'5} = \ldots$

$B_2 = \frac{\mu_0 I_2}{2\pi r_2} = \frac{4\pi \cdot 10^{-7} \cdot 2}{2\pi \cdot 1'5} = \ldots$

$B_1 > B_2$

$\vec{B_0} = (B_1 - B_2)\,\vec{i}\ T = \boxed{21'33 \cdot 10^{-7}\,\vec{i}\,T}$

(4)



$r_1 = 2'8cm$

$r_2 = 4'9cm$

a) $B_{solenoid} = \mu_0 n \overset{1}{I} = \mu_0 n_1 I = \boxed{3'644 \cdot 10^{-4} T}$

b) $\phi_m = \int \vec{B} \cdot d\vec{S} = BS = 3'644 \cdot 10^{-4} T \cdot \pi r_1^2 = \boxed{9 \cdot 10^{-7} Wb}$

c) $I = 1A \rightarrow I = 3'2A$

$t = 48\,ms$

$\frac{\Delta I}{\Delta t} = \frac{3'2 - 1}{48 \cdot 10^{-3} s} = 45,83 \frac{A}{s}$

$\boxed{\varepsilon} = -N \frac{d\phi_m}{dt} = -N \frac{\Delta \phi_m}{\Delta t} = -N \cdot \mu_0 n_1 \frac{\Delta I}{\Delta t} \cdot \pi r_1^2 =$

$= \boxed{-4'11 \cdot 10^{-5} V}$

d) $I = 6t^2 - 2A \rightarrow \varepsilon = -1'1 \cdot 10^{-4} V$