Fuentes de campo magnético

Física II

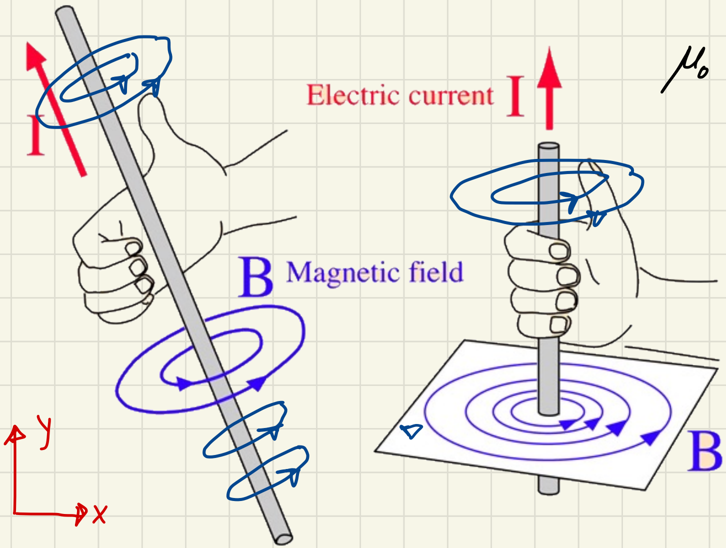
Ing. Claudia Contreras

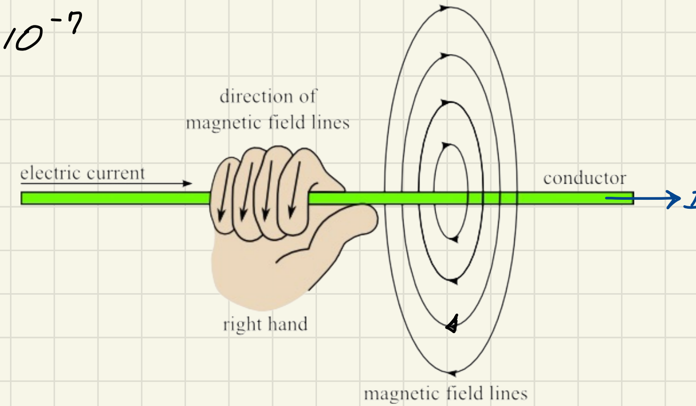
Campos Magnéticos de alambres largos que transportan corriente

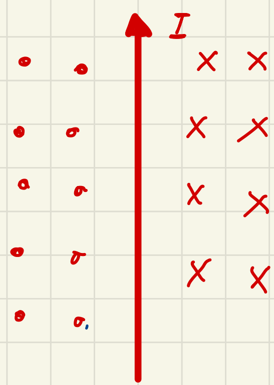
$$\boxed{B = \frac{\mu_0 I}{2\pi r}}$$

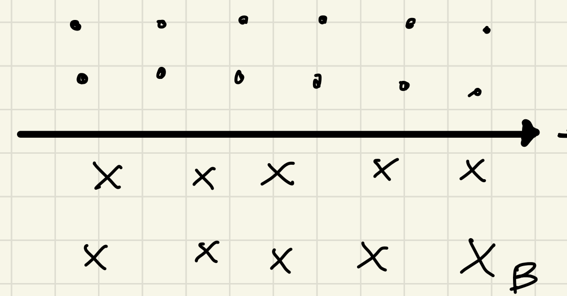
μ_0 = permeabilidad del espacio libre

$\mu_0 = 4\pi \times 10^{-7}$

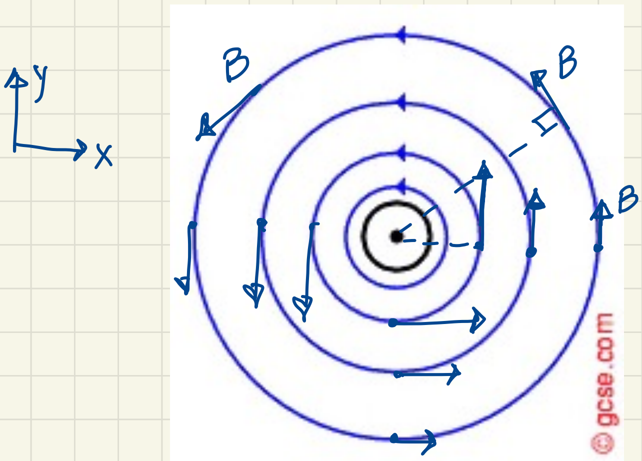




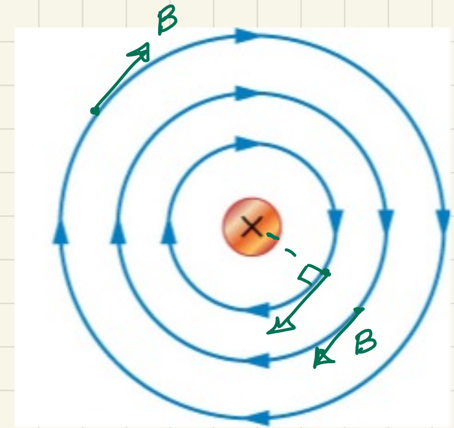




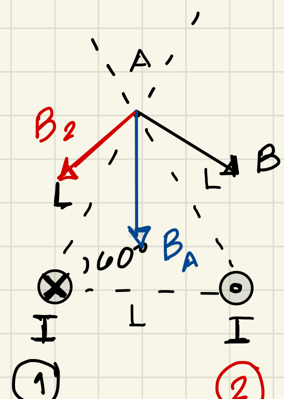
Campos Magnéticos de alambres largos que transportan corriente



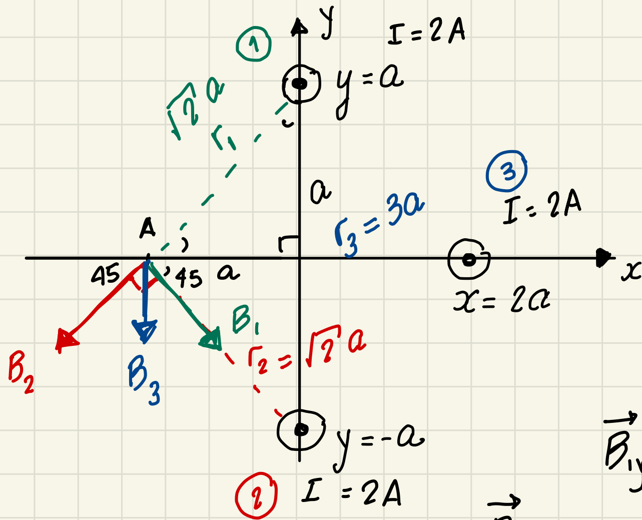
$$B = \frac{\mu_0 I}{2\pi r}$$



$$\vec{B}_A = \vec{B}_1 + \vec{B}_2$$



Problema 1. Tres largos conductores paralelos portan corrientes de 2A en las direcciones mostradas, si a=0.01m. Determine el campo magnético en el punto A.



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

$$\vec{B}_A = \vec{B}_1 + \vec{B}_2 + \vec{B}_3$$

$$\vec{B}_{1x} + \vec{B}_{2x} = \emptyset$$

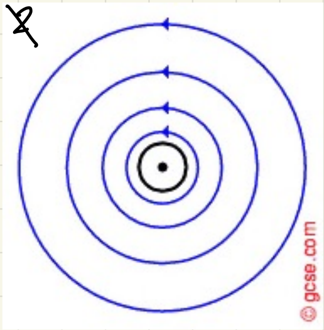
$$\vec{B}_{1y} + \vec{B}_{2y} = 2B_{1y}\,(-\hat{j})$$

$$\vec{B}_3 = \frac{\mu_0 I_3}{2\pi r_3}(-\hat{j}) = \frac{\cancel{4\pi}\times10^{-7}\cancel{(2)}}{\cancel{2\pi}[3*0.01]} = 13.\overline{33}\,\mu T\,(-\hat{j})$$

$$\vec{B}_{1y} = |B_1|\ \text{sen}\ 45\ (-\hat{j})$$

$$\vec{B}_{1y} = \frac{\mu_0 I_1}{2\pi r_1}\ \text{sen}\ 45\ (-\hat{j}) = \frac{\cancel{4}\pi\times10^{-7}(2)}{\cancel{2}\pi\cancel{\sqrt{2}}(0.01)} * \frac{\cancel{\sqrt{2}}}{\cancel{2}}$$

$$\vec{B}_{1y} = 20\,\mu T\,(-\hat{j})$$

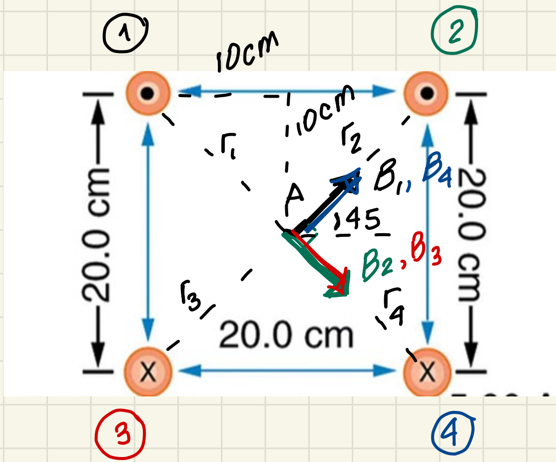


$$\vec{B}_A = 2\vec{B}_{1y} + \vec{B}_3 = 40\,\mu T\,(-\hat{j}) + 13.33\,\mu T\,(-\hat{j})$$

$$\vec{B}_A = -53{,}33\,\mu T\,(\hat{j})$$

Problema 2.

En la figura se muestra cuatro conductores largos paralelos que transportan una corriente de 10 Amperios en la dirección mostrada si el cuadrado tiene lado de 20 cm, ¿Cuál es la magnitud y dirección del campo resultante en el centro del cuadrado?



$$r_1 = r_2 = r_3 = r_4 = \sqrt{2}\,(0.1)\ m$$

$$I_1 = I_2 = I_3 = I_4 = 10A$$

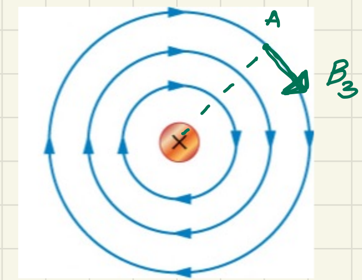
$$B_{1y} + B_{2y} + B_3 + B_{4y} = \emptyset$$

$$\sum B_{iy} = \emptyset$$

$$B_{1x} = B_{2x} = B_{3x} = B_{4x}$$

$$\vec{B}_A = 4B_{1x}\ \hat{i}$$

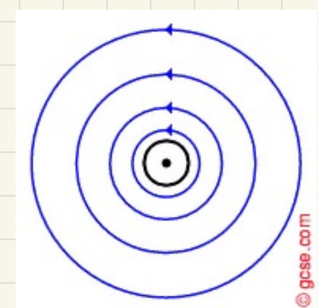
$$\vec{B}_{1x} = |B_1| \cos 45\ \hat{i}$$



$$\vec{B}_A = 4B_{1x}\hat{i}$$

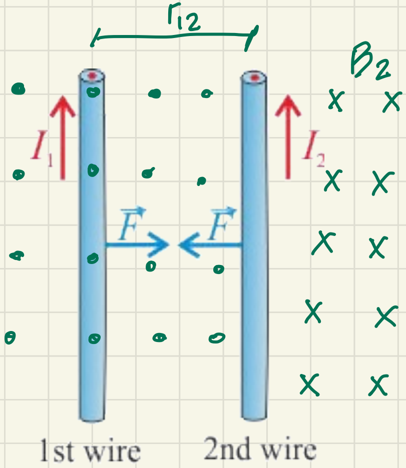
$$= 4\,\frac{\mu_0 I_1}{2\pi r_1} \cos 45\ \hat{i}$$

$$= 4\left[\frac{\cancel{4}\cancel{\pi}\times 10^{-7}(10)}{\cancel{2}\cancel{\pi}\cancel{\sqrt{2}}(0.1)} \times \frac{\cancel{\sqrt{2}}}{\cancel{2}}\right] T\ \hat{i}$$



$$\boxed{B_A = 40\mu T\ (\hat{i})}$$

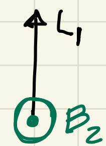
Fuerza Magnética entre alambres paralelos

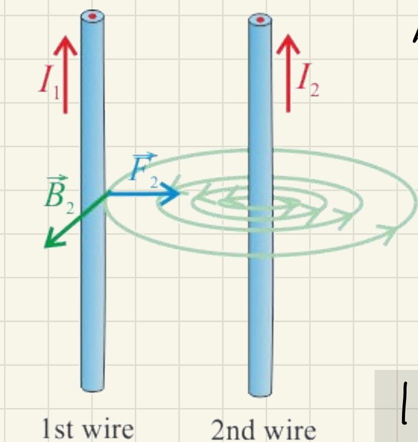


$$\vec{B}_2 = \frac{\mu_0 I_2}{2\pi r_{12}} \odot$$

$\vec{F}_{12} \rightarrow$ fuerza q' siente ① debido a $\vec{B}_2$

$$\vec{F}_{12} = I_1 \vec{L}_1 \times \vec{B}_2$$



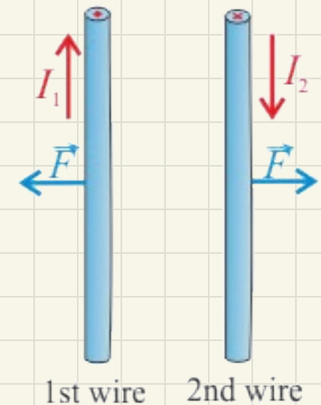


$$F_{12} = I_1 L_1 B_2 \operatorname{sen} 90 \longrightarrow$$

$$\vec{F}_{12} = I_1 L_1 \frac{\mu_0 I_2}{2\pi r_{12}} \longrightarrow$$

$$|F_{12}| = \frac{\mu_0 I_1 I_2 L_1}{2\pi r_{12}}$$

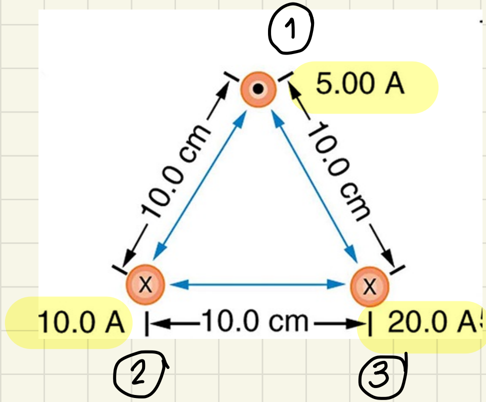
$$|F_{21}| = \frac{\mu_0 I_1 I_2 L_2}{2\pi r_{12}}$$



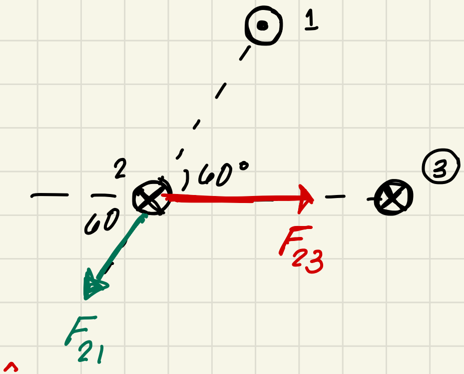
$$\boxed{F_{parallel\,wires} = \frac{\mu_0 l I_1 I_2}{2\pi d}}$$

Problema 3. a)Calcule la fuerza magnética por unidad de longitud que experimenta el conductor que se encuentra en el vértice inferior izquierdo. b) Calcule el campo magnético en el punto medio de la base del triángulo.

$$F_{parallel\,wires} = \frac{\mu_0 l I_1 I_2}{2\pi d}$$



$$\vec{F}_2 = \vec{F}_{21} + \vec{F}_{23}$$



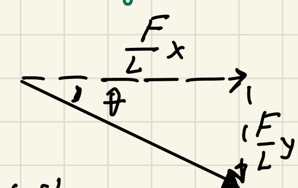
$$\vec{F}_{23} = \frac{\mu_0 I_2 I_3 L_2}{2\pi r_{23}}\hat{i} \Rightarrow \frac{\vec{F}_2}{L_2} = \frac{\overset{2}{\cancel{4\pi}}\times 10^{-7}(10)(20)}{\cancel{2\pi}(0.1)}(\hat{i}) = 400\,\frac{\mu N}{m}\hat{i}$$

$$\frac{\vec{F}_{21}}{L_2} = \frac{\mu_0 I_2 I_1}{2\pi r_{12}}\left(\cos 60(-\hat{i}) + \operatorname{sen} 60(-\hat{j})\right) = \frac{4\pi\times 10^{-7}(10)(5)}{2\pi(0.1)}\left(-\cos 60\,\hat{i} - \operatorname{sen} 60\,\hat{j}\right)$$

$$\frac{\vec{F}_{21}}{L_2} = -50\times 10^{-6}\frac{N}{m}\hat{i} - 86.6\times 10^{-6}\frac{N}{m}\hat{j}$$

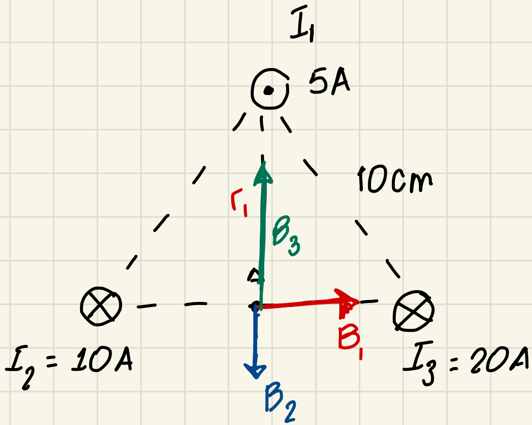
$$\frac{\vec{F}_2}{L_2} = 350\frac{\mu N}{m}\hat{i} - 86.6\frac{\mu N}{m}\hat{j}$$

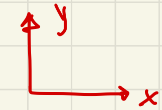
$$\left|\frac{\vec{F}_2}{L_2}\right| = 360.55\frac{\mu N}{m}$$



$$\theta = \tan^{-1}\frac{-86.6}{350} = -13.9°$$

Continúa **Problema 3.**





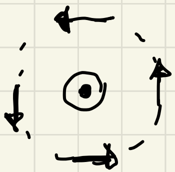
b)

$$\vec{B}_A = \vec{B}_1 + \vec{B}_2 + \vec{B}_3$$

$$\vec{B}_1 = \frac{\mu_0 I_1}{2\pi r_1}\,\hat{\imath} = \frac{\cancel{4}^{2}\cancel{\pi}\times10^{-7}(5)}{\cancel{2}\cancel{\pi}\sqrt{0.1^2-0.05^2}} = 11.55\,\mu T\,\hat{\imath}$$

$$\vec{B}_2 = \frac{\mu_0 I_2}{2\pi r_2}(-\hat{\jmath}) = -\frac{\cancel{4}^{2}\cancel{\pi}\times10^{-7}(10)}{\cancel{2}\cancel{\pi}(0.05)}\,\hat{\jmath} = -40\,\mu T\,\hat{\jmath}$$

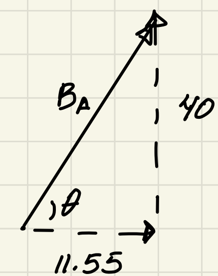
$$\vec{B}_3 = +80\,\mu T\,\hat{\jmath}$$

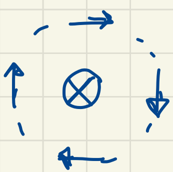


$$r_1 = \sqrt{0.1^2-0.05^2}$$

$$r_2 = 0.05m$$

$$\boxed{\vec{B}_A = 11.55\,\mu T\,\hat{\imath} + 40\,\mu T\,\hat{\jmath}}$$

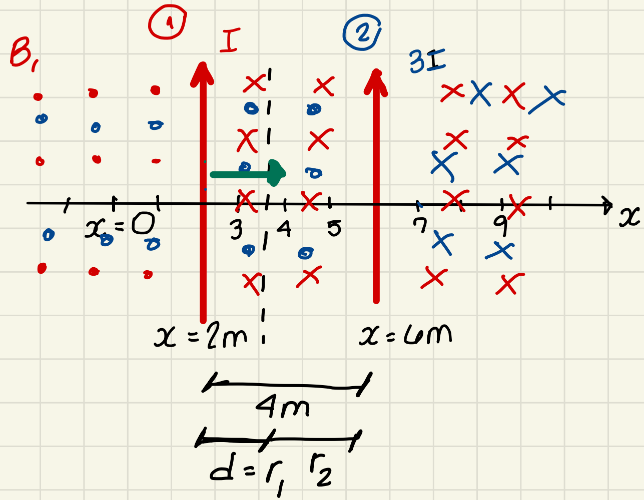




$$|B_A| = 41.6\,\mu T$$

$$\theta = \tan^{-1}\frac{40}{11.55} = 73.9°$$

Problema 4. Dos alambres rectos y largos llevan corrientes de I y 3I en la dirección mostrada y se encuentran como se muestra en la figura. ¿En qué valor de x en metros el campo magnético es cero? ¿Si I=10A, cuál es la magnitud y dirección de la fuerza por unidad de longitud en el alambre que lleva una corriente I?



a) $\vec{B}_1 + \vec{B}_2 = \emptyset$

$|B_1| = |B_2|$

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

$$\frac{\cancel{I}}{d} = \frac{3\cancel{I}}{4-d} \rightarrow 4-d = 3d$$

$4d = 4$

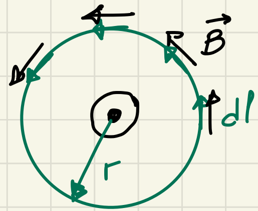
$d = 1m$

En $\boxed{x = 3m}$ el $\vec{B} = \emptyset$

b) $I_1 = 10$ $\quad I_2 = 30A$

$$\frac{\vec{F}_1}{L_1} = \frac{\mu_0 I_1 I_2}{2\pi r_{12}} \hat{i} = \frac{\overset{2}{\cancel{4}}\pi \times 10^{-7}(10)(30)}{\cancel{2}\pi\,(4)} \frac{N}{m} \hat{i} = \underline{15 \frac{\mu N}{m} \hat{i}}$$

Ley de Ampere



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

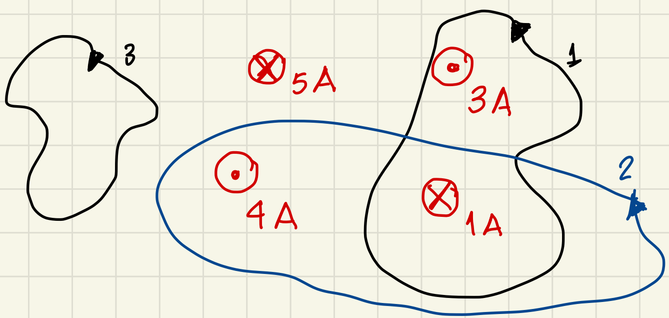
$$\oint \vec{B} \cdot d\vec{l} = \oint B \, dl \cos 0^\circ = B \oint dl = B(2\pi r)$$

$$\oint \vec{B} \cdot d\vec{l} = \frac{\mu_0 I}{\cancel{2\pi} r} (\cancel{2\pi} r)$$

$$\boxed{\oint \vec{B} \cdot d\vec{l} = \mu_0 I_{enc}}$$

Si se evalúa la integral del lado izquierdo en sentido anti-horario, entonces considere positivas las corrientes que salen de la pizarra. $\odot$ +

Si se evalúa la integral del lado izquierdo en sentido horario, entonces considere positivas las corrientes que entran a la pizarra. $\otimes$ +

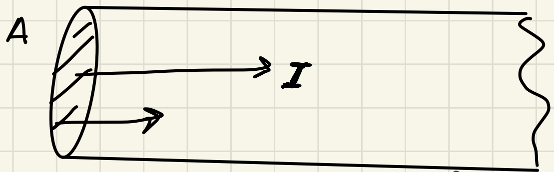


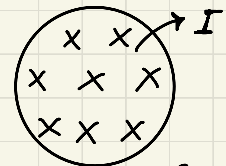
1) $\oint \vec{B} \cdot d\vec{l} = \mu_0 (3 - 1) = \underline{2\mu_0}$

2) $\oint \vec{B} \cdot d\vec{l} = \mu_0 (4 - 1) = \underline{3\mu_0}$

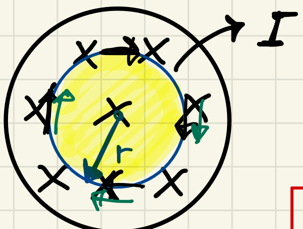
3) $\oint \vec{B} \cdot d\vec{l} = \varnothing$

Problema 5. Un conductor cilíndrico largo, de radio R, transporta una corriente I. La corriente se distribuye uniformemente en toda el área de la sección transversal del conductor. Encuentre el campo magnético para r<R y para r > R





a) $B(r<R)$



$$\oint \vec{B}\cdot d\vec{l} = \mu_0 I_{enc}$$

$$B(2\pi r) = \mu_0 I_{enc}$$

$$B(2\pi \cancel{r}) = \mu_0 \frac{I r^{\cancel{2}}}{R^2}$$

$$\boxed{\vec{B}(r<R) = \frac{\mu_0 I r}{2\pi R^2}}$$

$$\pi R^2 \rightarrow I$$

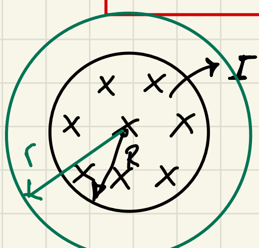
$$\pi r^2 \rightarrow I_{enc} = ?$$

$$I_{enc} = \frac{\cancel{\pi} r^2 I}{\cancel{\pi} R^2} = \frac{I r^2}{R^2}$$

$$J = \frac{I}{\pi R^2}$$

$$I_{enc} = J \, Area = J \pi r^2 = \frac{I r^2}{R^2}$$

b) $B(r>R)$

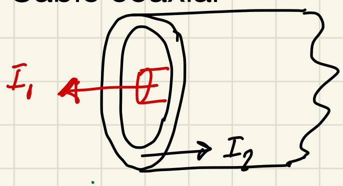


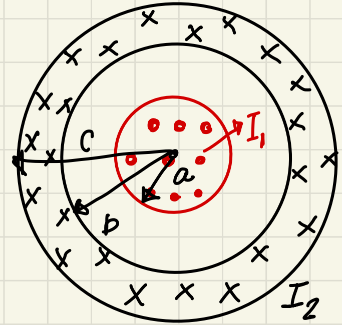
$$\oint \vec{B}\cdot d\vec{l} = \mu_0 I_{enc}$$

$$B(2\pi r) = \mu_0 I$$

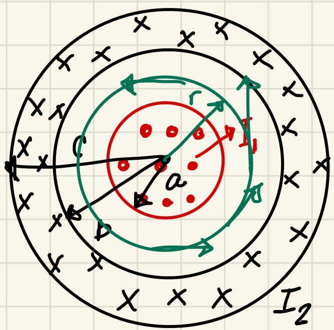
$$\vec{B} = \frac{\mu_0 I}{2\pi r}$$

Cable coaxial





$\vec{B}\ (a<r<b)$

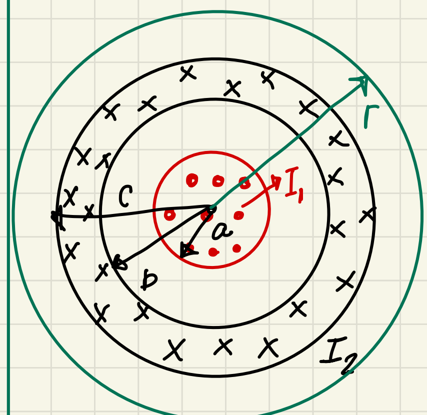


$$\oint \vec{B}\cdot d\vec{l} = \mu_0 I_{enc}$$

$$B(2\pi r) = \mu_0 I_1$$

$$\vec{B} = \frac{\mu_0 I_1}{2\pi r_1}$$

$B\ (r>c)$



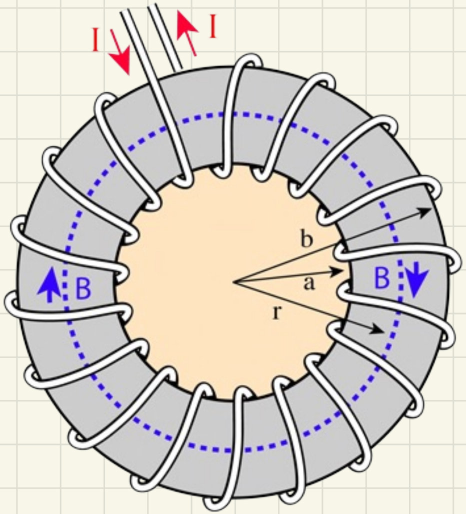
$$\oint \vec{B}\cdot d\vec{l} = \mu_0 I_{enc}$$

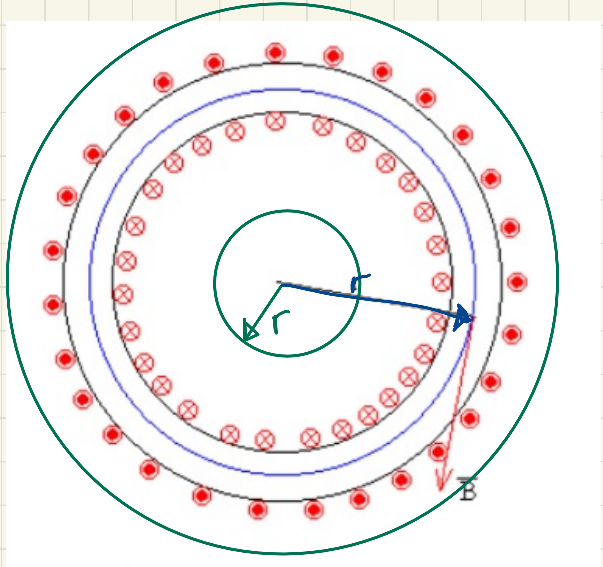
$$B(2\pi r) = \mu_0 (I_1 - I_2)$$

$$B = \frac{\mu_0 (I_1 - I_2)}{2\pi r}$$

Campo Magnético de un Solenoide Toroidal

$N \rightarrow$ # vueltas





$a < r < b$

$$\oint \vec{B} \cdot d\vec{l} = \mu_0 I_{enc}$$

$$B(2\pi r) = \mu_0 N I$$

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

$B(r < a) \rightarrow I_{enc} = 0 \rightarrow B = \emptyset$

$B(a < r < b) = \boxed{\frac{\mu_0 N I}{2\pi r}}$

$B(r > b) \rightarrow I_{enc} = NI - NI = 0 \Rightarrow B(r > b) = \emptyset$

Campo Magnético de un Solenoide ideal

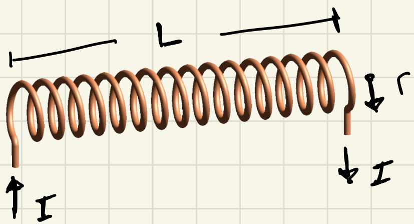
N : # vueltas

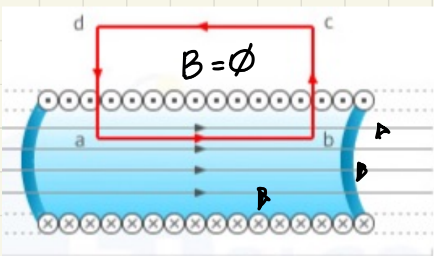
L : longitud

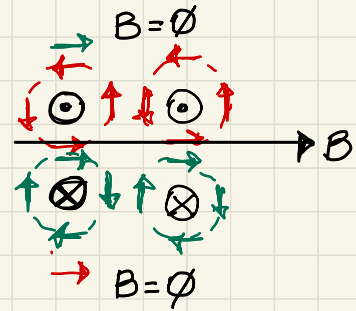
$n = \frac{N}{L}$ $\frac{\text{vueltas}}{m}$

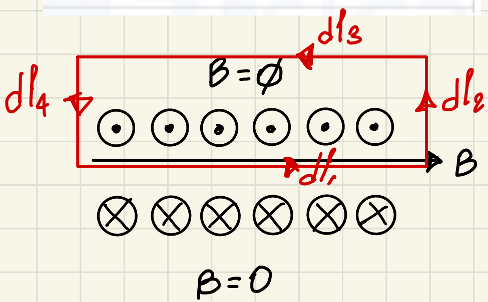
radio → r

$r <<< L$









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

$$\int \vec{B}\cdot d\vec{l}_1 + \cancel{\int \vec{B}\cdot d\vec{l}_2} + \cancel{\int \vec{B}\cdot d\vec{l}_3} + \cancel{\int \vec{B}\cdot d\vec{l}_4} = \mu_0 N I$$

$$BL = \mu_0 N I$$

$$\boxed{B = \mu_0 \frac{N}{L} I}$$

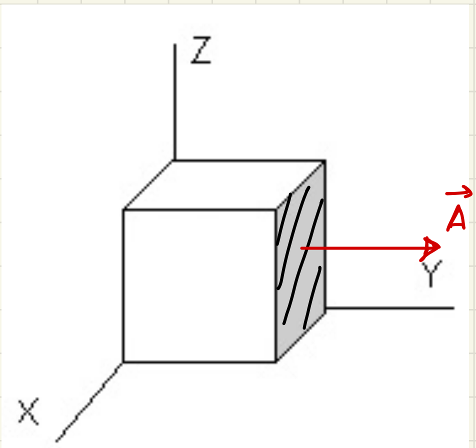
$$\boxed{B = \mu_0 n I}$$

Flujo Magnético

$$\Phi_B = \vec{B} \cdot \vec{A} \qquad T \cdot m^2 = 1\,Webber \qquad d\Phi_B = \vec{B} \cdot d\vec{A}$$

$$\Phi_B = |B||A| \cos\theta \qquad \Phi_B = B_x A_x + B_y A_y + B_z A_z$$

Un cubo de aristas de longitud 2.5 cm se coloca en una región donde existe un campo magnético dado por B = (5i +4j +3k) Teslas. Calcule el flujo magnético a través de la cara sombreada del cubo.



$$\vec{B} = (5\hat{i} + 4\hat{j} + 3\hat{k})\,T$$

$$\vec{A} = 0{,}025^2\,m^2\,\hat{j}$$

$$\Phi_B = \cancel{B_x A_x} + B_y A_y + \cancel{B_z A_z}$$

$$\Phi_B = 4(0{,}025^2) = \underline{2{,}5\,mWb.}$$

$$\Phi_{CUBO} = \oint \vec{B} \cdot d\vec{A} = \varnothing$$

$$\oint \vec{B} \cdot d\vec{A} = \varnothing$$