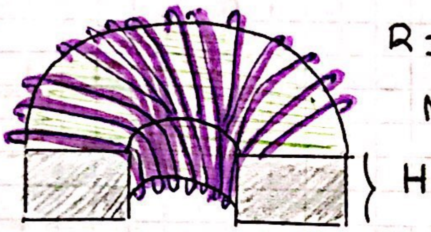
GUIA 6 – MAGNETISMO EN MEDIOS MATERIALES

1



R_I, R_E, H

MATERIAL FERROMAGNETICO BLANDO CON μ_R

N ESPIRAS CON I

A- CALCULAR $\bar{B}$ Y Φ

LEY DE AMPERE GENERALIZADA $\oint_{\mathcal{C}} \bar{H}\, dl = i_R$

$H(R)\, \check{\varphi} \rightarrow$ C. MAGNETICO

$$H \int_0^{2\pi} R\, d\varphi = IN$$

$$H\, 2\pi R = IN$$

$$\underline{\bar{H} = \frac{IN}{2\pi R}\, \check{\varphi}}$$

COMO ES UN MATERIAL LINEAL

$$\bar{B} = \mu_0 \mu_r \bar{H}$$

$$\underline{\bar{B} = \mu_0 \mu_r \frac{IN}{2\pi R}\, \check{\varphi}}$$

$$\Phi = \iint_S \bar{B}\, \bar{dS} = \int_0^H \int_{R_i}^{R_E} \mu_r \mu_0 \frac{IN}{2\pi R}\, dR\, dz =$$

$$\underline{\Phi = \mu_0 \mu_R \frac{INH}{2\pi} \ln\left(\frac{R_E}{R_i}\right)}$$

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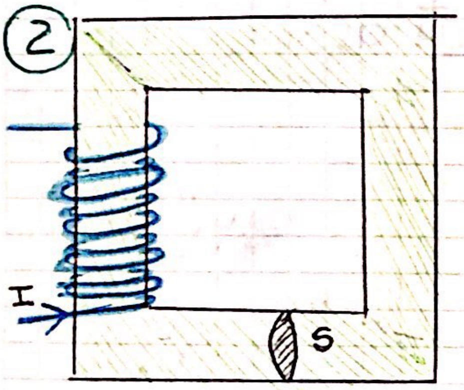
B) CALCULAR B Y Φ EN EL RADIO INTERMEDIO

$$R_M = \frac{R_E + R_i}{2}$$

$$\bar{B} = \mu_0 \mu_R \frac{IN}{2\pi R_M} = \mu_0 \mu_R \frac{I \cdot N}{2\pi \cdot \left(\frac{R_E + R_I}{2}\right)} \quad \varphi$$

CON Φ IDEM.

②



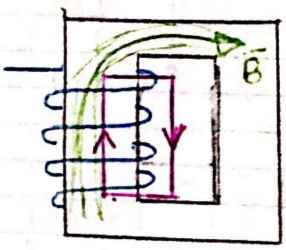
NÚCLEO = 40 cm LONG MEDIA → M.F

SECCIÓN = CTE = 1 cm^2 $\mu_r = 1000$

• NUCLEO INICIALMENTE DESMAGNETIZADO

COMO LA PERMEABILIDAD DEL NUCLEO ES $\overset{1000}{\uparrow}$ > A LA DEL MEDIO EXT LAS LINEAS DE CAMPO $\bar{B}$ SE MANTIENEN DENTRO DEL NUCLEO.

A- I NECESARIA PARA LAS ESPIRAS, PARA QUE B = 0,1 T



$$\oint H \, d\bar{L} = I^{CONC}$$

$$H \int_0^L dz + (-H) \cancel{\int_L^0 dz} = \quad H\,L = NI$$

(LAS OTRAS SON ⊥) B=0

$$H = \frac{NI}{L}$$

COMO ES UN M. LINEAL $\bar{B} = \mu_0 \mu_R H \rightarrow \mu_0 \mu_R \frac{NI}{L}$

$$0{,}1\,T = 4\pi \times 10^{-7} \cdot 1000 \cdot \frac{200 \cdot I}{0{,}4} \qquad I = 0{,}16\,A$$

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B- CALCULAR $\bar{H}$ Y $\bar{M}$

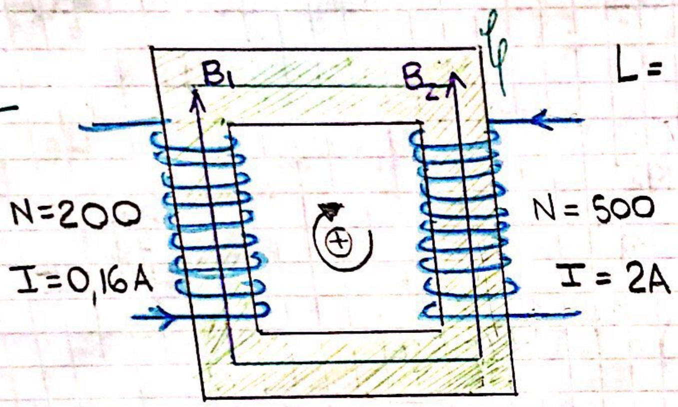
$$\bar{H} = \frac{NI}{L}\,\check{\varphi} \qquad \bar{B} = \mu_0 \mu_R \frac{NI}{L}$$

$$\bar{M} = \frac{B}{\mu_0} - \bar{H} \rightarrow \bar{M} = \mu_R \frac{NI}{L} - \frac{NI}{L}$$

$$\bar{M} = \frac{NI}{L}(\mu_R - 1)\,\check{\varphi}$$

3

2-



L = 0,4 m

$$\oint H\, dL = I^{CONC}$$

φ $\quad H \cdot L = N_1 I_1 - N_2 I_2$

$$H \cdot 0{,}4\,m = 200 \cdot 0{,}16 - 500 \cdot 2$$

$$\underline{H = -2420\ A/m}$$

$$\bar{B} = \mu_0 \mu_r H \longrightarrow 4\pi \times 10^{-7} \cdot 1000 \cdot -2420$$

$$\underline{B = -3{,}0409\ T}$$

$$\bar{M} = \frac{B}{\mu_0} - \bar{H} = \frac{-3{,}0409}{12{,}566 \times 10^{-7}} + 2420$$

$$\underline{\bar{M} = -2418\ A/m}$$

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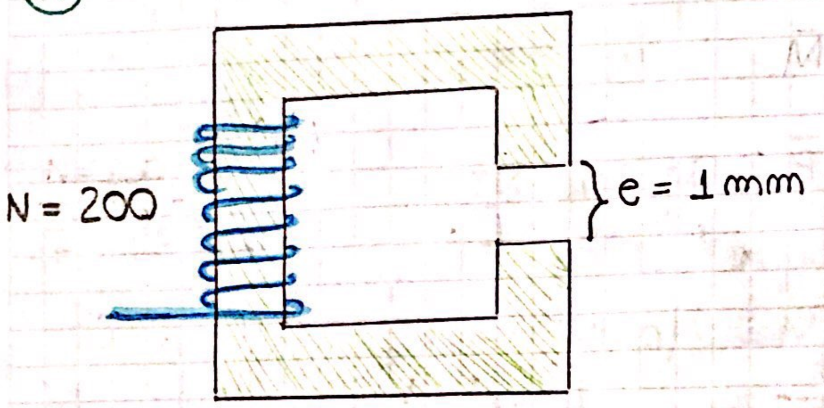


- COMO $\mu_R >> \mu_0$ LAS LINEAS DE CAMPO QUEDAN DENTRO Y SIGUEN LA FORMA DEL MATERIAL
  ↳ DIREC y S.
- $e << L$ LAS L C NO SE DESVIAN.

$$\oint \bar{H} d\bar{L} = I$$

DESPRECIANDO EFECTOS DE BORDE

$$e << L_M$$

$$\oint_{\mathcal{C}} \bar{H}_e d\bar{L} + \oint_{\mathcal{C}} H_M d\bar{L} = NI$$

$$(B_M - B_e)\check{N} = 0$$

$$B_M \check{N} = B_e \check{N}$$

$$\int_0^e H_e dL + \int_0^{L-e} H_M dL = NI$$

$$\cancel{\mu_0} \mu_R H_M = \cancel{\mu_0} H_e$$

$$\boxed{H_M = \frac{H_e}{\mu_r}}$$

$$H_e \cdot e + H_M (L - e) = NI$$

$$H_e \cdot e + \frac{H_e}{\mu_R}(L-e) = NI$$

$$H_e (\overset{e + L - e}{e + (L-e)}) = NI$$

$$H_e L = NI \rightarrow \underline{H_e = \frac{NI}{L} \check{\varphi}}$$

COMO EL FLUJO SE MANTIENE CTE → (NO HAY DISPERSIÓN DE Φ)

$$\phi_e = \phi_M \rightarrow B_e S_e = B_M S_M \rightarrow \underline{B_e = B_M} \rightarrow \text{XQ EL ENTREHIERRO ES DELGADO}$$

$$B_e = B_M$$

$$\mu_0 \mu_R H_e = \mu_0 \mu_r H_M$$

$$\underline{H_e = \mu_r H_M}$$

$$H_e = \frac{B}{\mu_0}$$

$$H_M = \frac{B}{\mu_0 \mu_r}$$

$$\frac{B}{\mu_0} \cdot e + \frac{B}{\mu_0 \mu_R}(L-e) = 200 I$$

$$B\left(\frac{e}{\mu_0} + \frac{(L-e)}{\mu_0 \mu_R}\right) = 200 I \rightarrow \underbrace{I = 0{,}556\ A}$$

EL e HACE QUE $\uparrow I$ PARA GENERAR EL MISMO $\overline{B}$.

B –

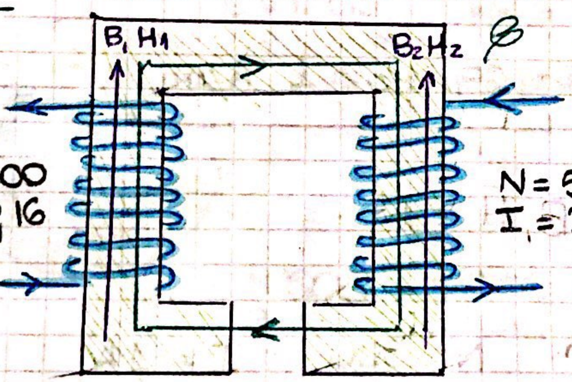
$\overline{H}e = 79579$ A/M A/M

$\overline{H}_M = 79{,}579$ A/M

$\underbrace{B = 0{,}1\ T}$

$$\overline{M} = \frac{B}{\mu_0} - H_M = \begin{cases} 79500{,}23\ A/M & \text{EN MM} \\ 0 & \text{EN VACIO} \end{cases}$$

3 –



$e = 1mm = 0{,}001\ m$

$$\oint_{\mathcal{C}} H\,dL = I$$

$$\int_0^e He\,dL + \int_0^{L-e} H_M\,dL = N_1 I_1 - N_2 I_2$$

$$He \cdot e + H_M(L-e) = N_1 I_1 - N_2 I_2$$

$$0{,}001\,He + 0{,}399\,H_M = 200 \cdot 0{,}16 - 500 \cdot 2$$

$$0{,}001\,He + 0{,}399\,H_M = -968\ A$$

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COMO VIMOS, NO HAY DISPERSIÓN DE Φ ENTONCES ($e << L$)

$$\Phi_e = \Phi_M \rightarrow B_e S_e = B_e \cancel{S_M} \qquad B_e = B_M$$

$$\left.\right\} \quad B = \mu_0 \mu_R H \qquad B_e = \mu_0 H_e \qquad B_M = \mu_0 \mu_R H_M$$

$$0{,}001\, H_e + 0{,}399\, H_M = -968\ A$$

$$0{,}001 \frac{B}{\mu_0} + 0{,}399 \frac{B}{\mu_0 \mu_R} = -968\ A$$

$$795{,}8\, B + 317{,}5\, B = -968$$

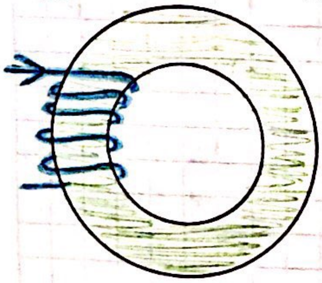
$$\underline{B = 0{,}87\ T}$$

COMO ES UN MATERIAL LINEAL $\rightarrow$ RELACIÓN LINEAL

$$\underline{H_e = 692344{,}4\ A/m} \qquad \underline{H_M = 692{,}3\ A/m}$$

$$\bar{M} = \frac{B}{\mu_0} - H_M = H_e - H_M = \underline{691652{,}1\ A/m}$$

(5) A- CALCULAR $\bar{B}$, $\bar{H}$ Y $\bar{M}$

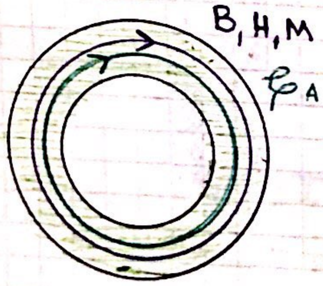


$R_1 = 0{,}02\ m$ $\quad \mu_R = 800$

$R_2 = 0{,}03\ m$ $\quad N = 300 \quad I = 1A$

$H(R)\check{\varphi}$ AL IGUAL QUE $\bar{B}$ y $\bar{M}$

$$\oint H\, dl = I^{conc}$$



$$\varphi_A \quad H(R)\check{\varphi} \int_0^{2\pi} R\, d\varphi\, \check{\varphi} = NI$$

$$H\, 2\pi R = NI$$

$$\underline{\bar{H} = \frac{NI}{2\pi R}\, \check{\varphi}}$$

COMO EL MAT ES LINEAL $\underline{\bar{B} = \mu_0 \mu_R \frac{NI}{2\pi R} \check{\varphi}}$

$$\bar{M} = \frac{B}{\mu_0} - H \rightarrow M = \frac{\cancel{\mu_0}\mu_R \frac{NI}{2\pi R}}{\cancel{\mu_0}} - \frac{NI}{2\pi R}$$

$$\bar{M} = \frac{NI}{2\pi R}(\mu_R - 1)\check{\varphi}$$

B- VALOR MAXIMO DE B?

COMO SUPONEMOS QUE $B=0$ CON $R>R_i$, EL V. MAX QUE PUEDE TOMAR ES: $\bar{B}_{MAX} = \mu_0\mu_R \frac{NI}{2\pi R_i}\check{\varphi}$

XQ CUANTO ↑R ↓B
EL MIN $R \rightarrow R_i$

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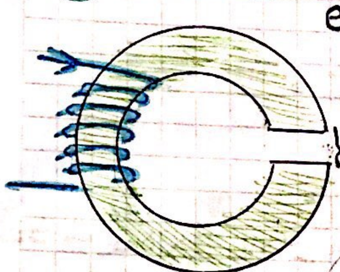


$e = 0{,}001$ $R_1 = 0{,}02\ m$ $R_2 = 0{,}03\ mm$

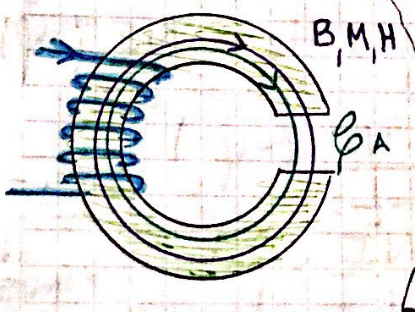
$N = 300$ $I = 1A$ $\mu_R = 800$

$$R_M = \frac{0{,}02 + 0{,}03}{2} = 0{,}025\ m$$

ACA DEBERIA EVALUAR MIS CAMPOS

$\oint \bar{H} \cdot d\bar{l} =$

HAY 2 CAMPOS H, PERO B ES EL MISMO



$$\oint_{C_A} \bar{H}_e\, d\bar{L} + \oint_{C_A} \bar{H}_M\, d\bar{L} = N_1 I_1$$

AMBOS $H(R)\check{\varphi}$

COMO SON LOS LIMITES DE $\int$?

$$H_e \int_0^{e} R\, d\varphi + H_M \int_0^{2\pi - e} R\, d\varphi = NI$$

$$(2\pi R - e) H_M + H_e\, e = NI$$

$$(2\pi R - e)\frac{B}{\mu_0\mu_R} + \frac{B}{\mu_0} e = NI$$

$$\bar{B} = NI \Big/ \left(\frac{2\pi R - e}{\mu_0\mu_R} + \frac{e}{\mu_0}\right) \rightarrow$$ DESPEJO LOS OTROS

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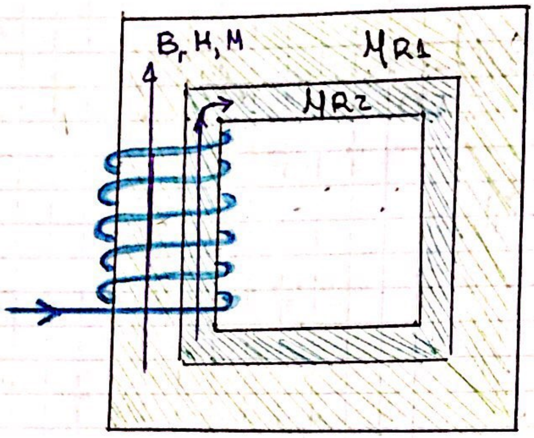
(7)



NUCLEO = 0,5 m

↳ (2) MATERIALES

1) $S_1 = 1\,cm^2$ $\mu_{R_1} = 1000$

2) $S_2 = 1,5\,cm^2$ $\mu_{R_2} = 2000$

$N = 350$ $I = 1A$

CADA MATERIAL TIENE UN Φ DI

COMO HAY DOS MATERIALES, SE DEBEN CUMPLIR LAS CONDICIONES DE BORDE:

- $B_{1\check{N}} = B_{2\check{N}}$ → ?
- $H_{1\check{T}} = H_{2\check{T}}$
- $B_i = \mu_i H_i$

- H VA A SER EL MISMO PORQUE ?
- B VA A SER DISTINTO. → PORQUE CADA MATERIAL TIENE ≠ SECCIÓN

$$\oint_{\mathcal{C}_A} H\,dL = NI \rightarrow H_1 L = NI \rightarrow H_1 = \frac{NI}{L_1}(-\check{\varphi})$$

$$H_2 = \frac{NI}{L_2}(-\check{\varphi})$$

AHORA YO SE QUE $\bar{B} = \mu_0 \mu_R H$

$$B_1 = \mu_0 \mu_{R_1} H_1 \longrightarrow B_1 = \mu_0 \mu_{R_1} \frac{NI}{L_1}(-\check{\varphi})$$

$$B_2 = \mu_0 \mu_{R_2} H_2 \longrightarrow B_2 = \mu_0 \mu_{R_2} \frac{NI}{L_2}(\check{\varphi})$$

$L_1 = L_2$
↓
MISMO NUCLEO

$$\bar{M}_1 = \frac{B_1}{\mu_0} - H_1 = \frac{NI}{L}(\mu_{R_1} - 1)(-\check{\varphi})$$

$$M_2 = \frac{B_2}{\mu_0} - H_2 = \frac{NI}{L}(\mu_{R_2} - 1)(-\check{\varphi})$$

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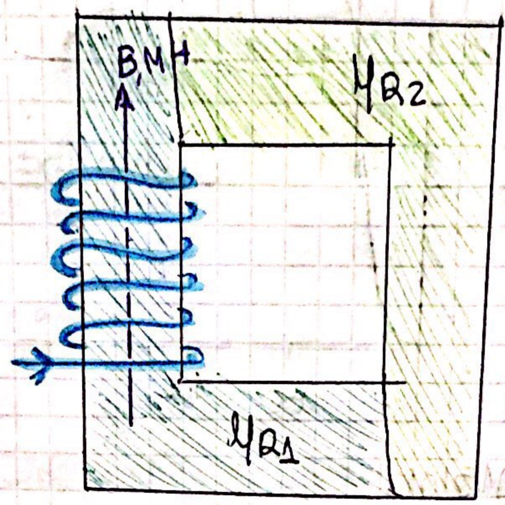

NUCLEO = 0,5 m

SECCIÓN ES CTE = $1\,cm^2$

$N = 350 \quad I = 1$

• COMO LA SECCIÓN ES LA MISMA EN AMBOS MATERIALES EL B, ES EL MISMO.

$$\left.\begin{aligned} B_1 &= \mu_0 \mu_{R_1} H_1 \\ B_2 &= \mu_0 \mu_{R_2} H_2 \end{aligned}\right\} B_1 = B_2 \rightarrow \mu_{R_1} H_1 = \mu_{R_2} H_2$$

$$H_1 = \frac{\mu_{R_2}}{\mu_{R_1}} H_2$$

LOS H SON $\neq$

$$\oint_C \bar{H}\, dL = I$$

$$\int H_1\, dL + \int H_2\, dL = NI$$

$$H_1 L_1 + H_2 L_2 = NI$$

$$\frac{B}{\mu_0 \mu_{r_1}} L_1 + \frac{B}{\mu_0 \mu_{r_2}} L_2 = NI \qquad L_1 = L_2 = \frac{L_m}{2}$$

$$B \frac{L_m}{2} \left(\frac{1}{\mu_0 \mu_{r_1}} + \frac{1}{\mu_0 \mu_{r_2}} \right) = 350$$

$$B = 1,17\,T$$

ENTONCES $B_1 = \mu_0 \mu_{R_1} H_1 \rightarrow H_1 = 931$ A/m

$B_2 = \mu_0 \mu_{R_2} H_2 \rightarrow H_2 = 465$ A/m

$M_1 = 930125$ A/m, $M_2 = 930590$ A/m

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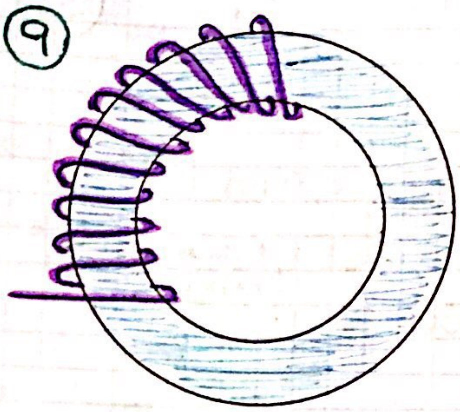

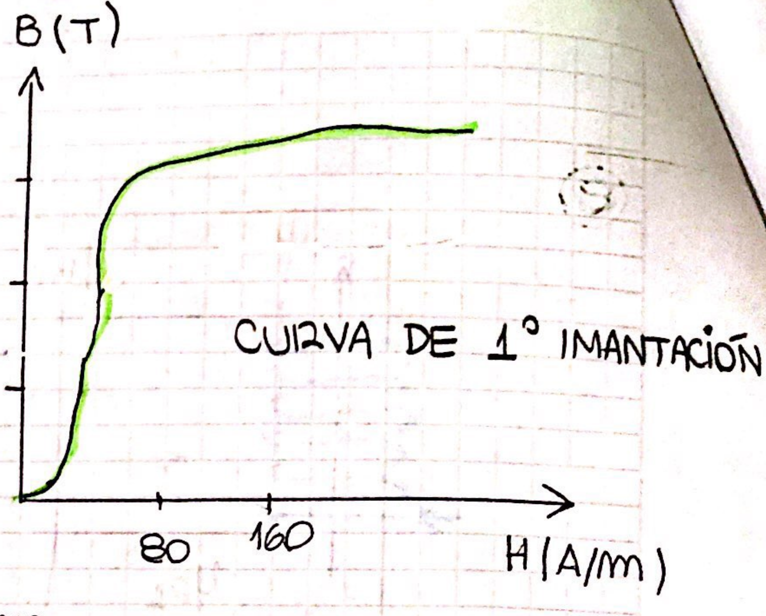

$R_1 = 0{,}11\ m$
$R_2 = 0{,}12\ m$ } TORO FINO → $R_M = 0{,}115\ m$
$N = 2000$

A- CALCULAR I PARA QUE B = 1T

DEL GRAFICO PUEDO OBTENER QUE $B = 1T \rightarrow H = 80\ A/m$

$$\oint_{\mathcal{C}_A} H\, dL = I^{conc}$$

$$H(R)\check{\varphi}\int_0^{2\pi} R\, d\varphi = NI \longrightarrow \bar{H} = \frac{NI}{2\pi R}(-\check{\varphi})$$

$$80 = \frac{2000\, I}{2\pi \cdot 0{,}115\, m}$$

$$\underline{I = 0{,}029\ A}$$

B- CALCULAR I PARA QUE B = 1T PERO AHORA EL TOROIDE TIENE ENTREHIERRO

$$\oint H\, dL = I$$

$$He \cdot e + H_M(2\pi R - e) = NI \longrightarrow$$

$$\frac{B}{\mu_0} \cdot e + \frac{B}{\mu_0 \mu_R}(2\pi R - e) = NI$$

LOS B SON IGUALES ASI QUE

$\bar{B}e = \mu_0 He$

$B_M = \mu_0 \mu_r H_M$

$$\underline{I = 0{,}4267\ A}$$

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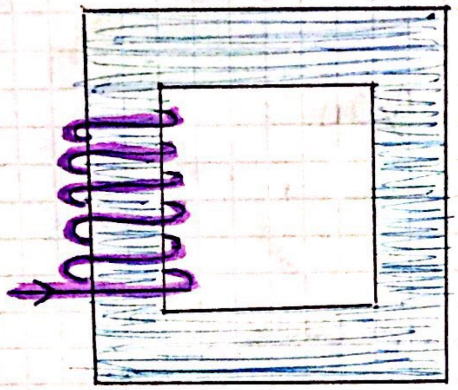

MATERIAL HIPERNIK

$L = 0,4\,m$

$S = CTE = 1\,cm^2$

$N = 200$

4- CALCULAR I PARA QUE $B = 0,1\,T$

COMO ES UN MATERIAL NO LINEAL, BUSCO H EN TABLA

COMO $B = 0,1\,T$ NO ESTA, HAGO INTERPOLACIÓN

$$y = \frac{y_2 - y_1}{x_2 - x_1}(x - x_1) + y_1$$

$$H = \frac{H_2 - H_1}{B_2 - B_1}(B - B_1) + H_2$$

USO LOS VALORES ENTRE 0,1 – (0,06 – 0,150)

$$H = \frac{2,4 - 1,6}{0,15 - 0,06}(0,1 - 0,06) + 2,4$$

$$\bar{H} = 1,96\ A/m$$

$$\oint H\,dL = I$$

$$H \cdot L = NI$$

$$1,96\ A/m \cdot 0,4\,m = 200\,I$$

$$I = 3,92 \times 10^{-3}\ A$$

B- $\boxed{B = 0{,}1\ T}$

$\boxed{H = 1{,}96\ A/m}$

$$\vec{M} = \frac{B}{\mu_0} - H = 79575{,}5\ A/m$$

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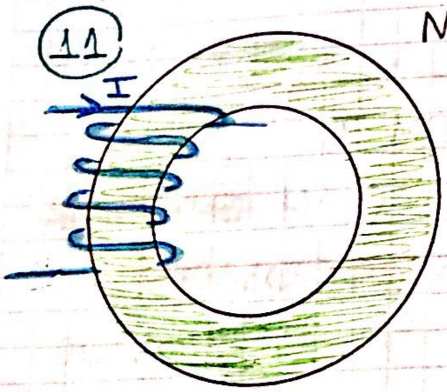

MATERIAL HIPERNIK

$R_1 = 0{,}02\ m \quad R_2 = 0{,}03\ m$

$N = 300 \quad I = 1A \quad \hookrightarrow R_m = 0{,}025\ m$

$H(R)\ \check{\varphi}$

$$\oint H\, dL = I^{CONC}$$

$$H \oint_0^{2\pi} R\, d\varphi = I \longrightarrow H\, 2\pi R = NI$$

$$H = \frac{NI}{2\pi R}$$

$$\boxed{H = 1909{,}86\ A/m}$$

$\downarrow$

NO SE PUEDE
RESOLVER
NO ALCANZA LA
TABLA !

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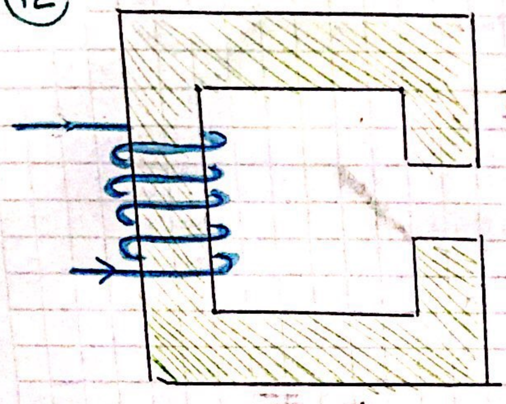

NUCLEO ACERO AL SILICIO

75 cm × 25 cm

$N = 500 \quad e = 1 mm$

$B = 1T$

• COMO LA SECCION ES CONSTANTE, EL MATERIAL Y EL ENTREHIERRO TIENEN EL MISMO B

$$\oint H\,dL = I$$

$$H_M \cdot (L - e) + H_e \cdot e = NI$$

COMO EN EL ENTREHIERRO SE CUMPLE LA CONDICIÓN LINEAL $B_E = \mu_0 H_E$

$$H_M (L - e) + \frac{B}{\mu_0} \cdot e = NI$$

DESPEJO B EN FUNCION DE H PARA FORMAR UNA RE...

$$B \cdot \frac{e}{\mu_0} = NI - H_M L' \qquad L - e = L' = 1{,}999\ m$$

$$L = 2(0{,}75) + 2(0{,}25)$$

$$B = -\frac{L'}{e/\mu_0} H_M + \frac{NI}{e/\mu_0}$$

$$B = -3{,}1 \times 10^{-3} H + 0{,}63 I$$

COMO $B = 1T \rightarrow H = 200\ A/m$ (POR GRAFICO)

$$1T = -3{,}1 \times 10^{-3} \cdot 200 + 0{,}63 I$$

$$I = 2{,}57\ A$$

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(13) IDEM QUE 12) CALCULAR B
CUANDO $I = 1,5\ A$

$$\oint H\, dL = I$$

$$H_M (L - e) + H_e \cdot e = NI$$

$$1,999\ H_M + \frac{B}{\mu_0} e = 750\ A$$

$$1,999 H_M + 796\ B = 750\ A$$

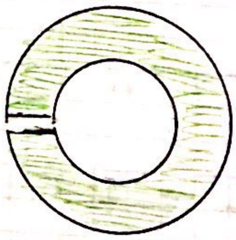
$$\underbrace{B = -2,5 \times 10^{-3}\ H + 0,94}$$

DIBUJO LA RECTA ↳ CUANDO NO TENGO NI B NP H

$$\underbrace{B \cong 0,7\ T} \quad Y \quad \underbrace{H = 100\ A/m}$$

$$\underbrace{\bar{M} = \frac{B}{\mu_0} - H = 556958,8\ A/m}$$

(14)



TOROIDE ALNICO
$R_i = 0,05\ m$
CAMPO REMANENTE $\rightarrow B = 1,2\ T$
↳ $I = 0$

A-

$$\oint H\, dL = I$$

$$H_M (2\pi R - e) + H_e \cdot e = \overset{0}{\widehat{NI}}$$

$$H_M\, 2\pi R - H_M e + \frac{B}{\mu_0} e = 0 \quad \text{CUANDO } B = 1,2 \quad H = -40\ KA/m$$

$$-12566,4 - 40\,000\, e + 954957,8 = 0$$

$$914957,8\ e = 12566,4$$

$$\boxed{e_{MAX} = 0,0137\ m}$$

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B- $B = 1{,}2\,T$

$H_M = -40\,000\ A/m$

$H_e = \frac{B}{\mu_0} = 954957{,}8\ A/m$

$\overline{M} = 914957{,}8\ A/m$

C- DEPENDENCIA LINEAL

$-12566{,}4 - 40\,000\,e + \frac{1}{\mu_0} B \cdot e = 0$

$$\frac{12566{,}4 + 40\,000\,e}{795798{,}2\,e} = B$$

$$\boxed{B = \frac{0{,}016}{e} + 0.05}$$

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