PROBLEM 1

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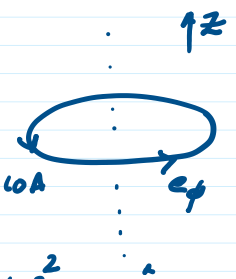
A CIRCULAR LOOP LOCATED ON $x^2+y^2=9$, $z=0$ CARRIES A CURRENT OF 10A ALONG $\hat{e}_\phi$. FIND $\bar{H}$ AT $(0,0,4)$ AND $(0,0,-4)$.

FROM NOTES:

$\bar{B}(z) = \frac{1}{2}\frac{\mu I a^2}{(a^2+z^2)^{3/2}}\hat{e}_z$



FOR THE FIG. SHOWN. $I = 10A$

$a = 3$

$\Rightarrow \bar{H}(0,0,4) = \frac{1}{2}\frac{10\times 3^2}{(9+16)^{3/2}}\hat{e}_z$

$= 0.36\,\hat{e}_z$ A/m

$\bar{H}(0,0,-4) = 0.36\,\hat{e}_z$ A/m.

PROBLEM 2

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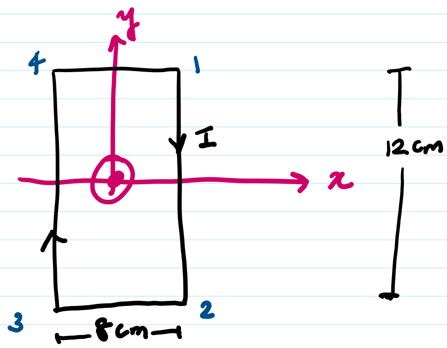
AN 8cm X 12 cm RECTANGULAR LOOP OF WIRE IS SITUATED IN THE x-y PLANE AS SHOWN IN THE FIGURE WITH CURRENT OF 50A. FIND THE TOTAL MAGNETIC FIELD INTENSITY AT THE ORIGIN.



$\bar{H}_{34} = \bar{H}_{12}$ AND $\bar{H}_{32} = \bar{H}_{41}$

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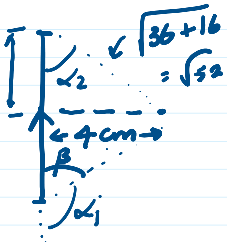
$\bar{H}_{34}$:



$\cos\alpha_2 = \frac{6}{\sqrt{52}} = \cos\beta$

$= 0.832$

$\Rightarrow \beta = 0.588$

$\Rightarrow \alpha_1 = \pi - 0.588 = 2.553$ rad

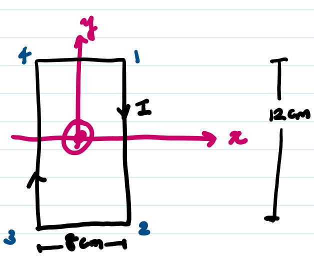
$\Rightarrow \cos\alpha_1 = -0.832$

$\Rightarrow \bar{H}_{34} = \frac{I}{4\pi\rho}(\cos\alpha_2 - \cos\alpha_1)(-\hat{e}_z)$

$= \frac{50}{4\pi\times 0.04}(2\times 0.832)(-\hat{e}_z)$

$= -165.52\,\hat{e}_z\left(\frac{A}{m}\right)$

$= \bar{H}_{12}$



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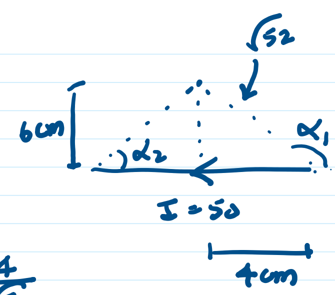
$\bar{H}_{32}$:



$\cos\alpha_2 = \frac{4}{\sqrt{52}}$

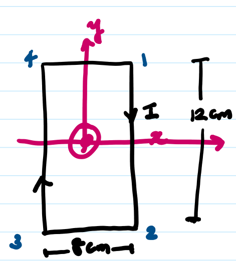
AND $\cos\alpha_1 = \frac{-4}{\sqrt{52}}$

$\Rightarrow \bar{H}_{32} = \frac{50}{4\pi\times 0.06}(2\times 0.555)(-\hat{e}_z)$

$= 73.61(-\hat{e}_z)$ (A/m) $= \bar{H}_{41}$

$\therefore \bar{H}(@\ z=0)$

$= \bar{H}_{34} + \bar{H}_{41} + \bar{H}_{12} + \bar{H}_{32} = -478.26\,\hat{e}_z\left(\frac{A}{m}\right)$



PROBLEM -3

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A CIRCULAR LOOP CONDUCTOR LIES IN THE PLANE $z = 0$ AND HAS A RADIUS OF 0.1m. IF THE LOOP IS PLACED IN A MAGNETIC FIELD DEFINED BY

$$\bar{B} = 0.2\sin(10^3 t)\,\hat{e}_z \quad (T),$$

FIND THE INDUCED emf IN THE LOOP.

$$\bar{B} = 0.2\sin(10^3 t)\,\hat{e}_z \quad (T)$$

$$V_{emf} = -N\frac{d\psi_{mag}}{dt} \quad (N = 1)$$

$$\psi_{mag} = \iint \bar{B}\cdot d\bar{s}$$

$$d\bar{s} = \rho\, d\rho\, d\phi\; \hat{e}_z$$

$$\Rightarrow \psi_{mag} = \int_{\phi=0}^{2\pi}\int_{\rho=0}^{0.1} 0.2\sin(10^3 t)\,\hat{e}_z \cdot \rho\, d\rho\, d\phi\;\hat{e}_z$$

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$$\Rightarrow \psi_{mag} = 0.2\sin(10^3 t)\, 2\pi \times \left(\frac{0.1}{2}\right)^2 \quad (Wb)$$

$$\Rightarrow emf = -\frac{d}{dt}\left(0.2\sin(10^3 t)\, 2\pi \times \frac{(0.1)^2}{2}\right)$$

$$= -0.2 \times 2\pi \times \frac{(0.1)^2}{2} \times 10^3 \cos(10^3 t)$$

$$= -6.283\cos(10^3 t) \text{ V}$$

PROBLEM

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The electric field of a plane wave propagating in a nonmagnetic material is given by $\bar{E} = 3\sin(\pi \times 10^7 t - 0.2\pi x)\,\hat{e}_y$ (V/m). Find the wavelength, dielectric constant of the medium, and $\bar{H}$.

$$\bar{E} = 3\sin(\pi \times 10^7 t - 0.2\pi x)\,\hat{e}_y \;(\text{V/m})$$

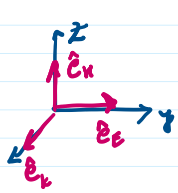
$$\beta = 0.2\pi = \frac{2\pi}{\lambda} \Rightarrow \lambda = \frac{2\pi}{\beta} = 10\text{ m}$$

$$v_p = \frac{c}{\sqrt{\varepsilon_r}} = \frac{\omega}{\beta} \Rightarrow \sqrt{\varepsilon_r} = \frac{c \times \beta}{\omega}$$

$$= \frac{3\times 10^8 \times 0.2\pi}{\pi \times 10^7} \Rightarrow \varepsilon_r = 36.$$

$$\hat{e}_n = -\hat{e}_z$$

$$\eta = \frac{120\pi}{\sqrt{\varepsilon_r}} = \frac{120\pi}{6} = 20\pi$$



$$\Rightarrow H_0^+ = \frac{E_0^+}{\eta} = \frac{3}{20\pi}$$

$$\Rightarrow \bar{H} = \frac{3}{20\pi}\sin(\pi \times 10^7 t - 0.2\pi x)(\hat{e}_z) \;(\text{A/m})$$

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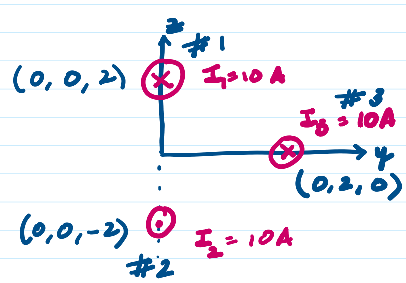
Three infinitely long parallel wires are arranged parallel to the x-axis and pass through #1(0,0,2m), #2(0,0,-2m), and #3(0,2,0m) and respectively. The corresponding currents in the wires are $I_1 = 10A$ in $-\hat{e}_x$ direction, $I_2 = 10A$ in $\hat{e}_x$ direction, and $I_3 = 10A$ in $-\hat{e}_x$ direction.

a) Find the force per unit length on wire #3.

b) Find the net magnetic field intensity at the origin.



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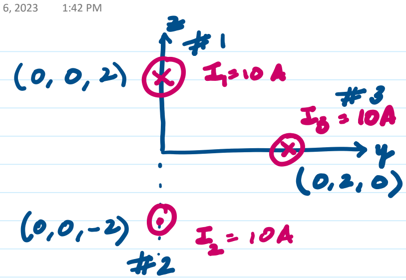
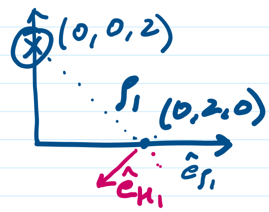


FIELD AT #3 DUE TO #1

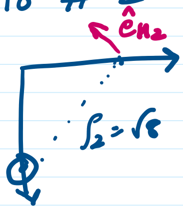
$$\bar{B}_1 = \frac{\mu_0 I}{2\pi \rho_1}\,\hat{e}_{\phi 1}$$



$$\rho_1 = \sqrt{4+4} = \sqrt{8}$$

FIELD AT #3 DUE TO #2

$$\bar{B}_2 = \frac{\mu_0 I}{2\pi \rho_2}\,\hat{e}_{\phi 2}$$



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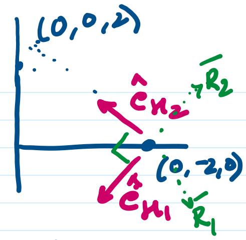
FOR THE GEOMETRY IN THE PROBLEM,



THE NET $\bar{B}$ AT #3 WILL NOT HAVE $\hat{e}_z$ COMPONENTS

AND

$$\hat{e}_{\phi_2} = \frac{2\hat{e}_z + (-2\hat{e}_y)}{\sqrt{8}} = \frac{2\hat{e}_z - 2\hat{e}_y}{\sqrt{8}}$$

$$\hat{e}_{\phi_2, y} = \frac{-2}{\sqrt{8}}\hat{e}_y$$

$$\therefore\ \bar{B} = \bar{B}_1 + \bar{B}_2 = \cancel{2}\times \frac{\mu_0 10}{\cancel{2}\pi\sqrt{8}} \times \left(\frac{-2}{\sqrt{8}}\right)\hat{e}_y$$

$$= -\frac{20\mu_0}{8\pi}\,\hat{e}_y$$

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$$\bar{F} = \int I\,d\bar{l} \times \bar{B}$$

$$d\bar{l}\ (\text{FOR } \#3) = -dx\,\hat{e}_x$$

$$\Rightarrow \bar{F} = \int 10(-dx\,\hat{e}_x) \times -\frac{20\mu_0}{8\pi}\,\hat{e}_y$$

$$= \frac{200\mu_0}{8\pi}\int \hat{e}_x \times \hat{e}_y\,dx$$

$$= \frac{200\mu_0}{8\pi}\,\hat{e}_z \int_l dx$$

$\Rightarrow$ FORCE PER UNIT LENGTH $= \dfrac{\bar{F}}{\int_l dx}$

$$= \frac{200\mu_0}{8\pi}\,\hat{e}_z = 1\times 10^{-5}\,\hat{e}_z \left(\frac{N}{m}\right)$$

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(b) NET MAGNETIC FIELD AT THE ORIGIN :

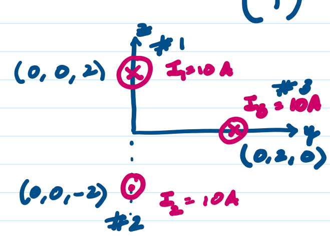
$$\bar{B}_1 = \frac{\mu_0 \times 10}{2\pi \times 2}(-\hat{e}_y)$$

$$\bar{B}_2 = \frac{\mu_0 \times 10}{4\pi}(-\hat{e}_y)$$

$$\bar{B}_3 = \frac{\mu_0 10}{4\pi}(\hat{e}_z)$$

$$\Rightarrow \bar{B} = \frac{20\mu_0}{4\pi}(-\hat{e}_y) + \frac{\mu_0 10}{4\pi}(\hat{e}_z)\ (T)$$

$$\Rightarrow \bar{H} = \frac{-20}{4\pi}\hat{e}_y + \frac{10}{4\pi}\hat{e}_z\ \left(\frac{A}{m}\right)$$



PROBLEM

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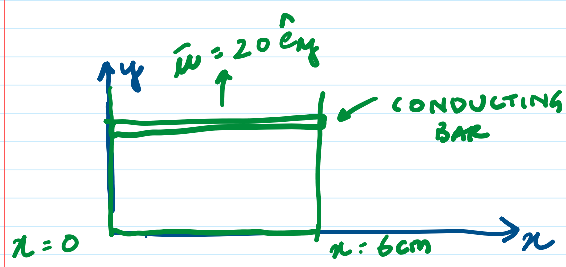
A conducting bar slides at velocity $\bar{u} = 20\,\hat{e}_y$ m/s over a rail that starts at y=0, is parallel to the y–axis, and extends to infinity. One side of the rail passes through *x* = 0 while the other passes through *x* = 6cm. The two rails are connected at y=0 to form a closed loop along with the conducting bar. If a magnetic field of $\bar{B} = 4\cos(10^6 t - y)\,\hat{e}_z$ mT exists at the rails, find the emf induced in the conducting bar using magnetic flux approach (not motional emf).



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$\bar{u} = 20\,\hat{e}_y \quad (m/s)$

$\bar{B} = 4\cos(10^6 t - y)\,\hat{e}_z$ mT

$= 4\times10^{-3}\cos(10^6 t - y)\,\hat{e}_z \; (T)$

$V_{emf} = -\frac{d}{dt}\iint \bar{B}\cdot d\bar{s}$ ← $dx\,dy\,\hat{e}_z$

$$= -\frac{d}{dt}\int_{y=0}^{y'}\int_{x=0}^{0.06} 4\times10^{-3}\cos(10^6 t - y)\,\hat{e}_z \cdot dx\,dy\,\hat{e}_z$$

$$\Rightarrow V_{emf} = -\frac{d}{dt}\int_{y=0}^{y'}\int_{x=0}^{0.06} 4\times10^{-3}\cos(10^6 t - y)\,dx\,dy$$

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$$= -4\times10^{-3}\, x\Big|_0^{0.06}\frac{d}{dt}\left(-\sin(10^6 t - y)\right)\Big|_{y=0}^{y'}$$

$$= 4\times10^{-3}\times0.06\,\frac{d}{dt}\left[\sin(10^6 t - y') - \sin(10^6 t)\right]$$

BUT $y' = ut = 20t$

$$\Rightarrow V_{emf} = 4\times10^{3}\times0.06\,\frac{d}{dt}\left(\sin(10^6 t - 20t) - \sin(10^6 t)\right)$$

$$= 4\times10^{-3}\times0.06\left[(10^6 - 20)\cos(10^6 t - 20t) - 10^6\cos(10^6 t)\right]$$

$$V_{emf} = 0.24\times10^{-3}\left[(10^6 - 20)\cos(10^6 t - 20t) - 10^6\cos(10^6 t)\right] \text{ V}$$

PROBLEM

Thursday, March 28, 2024 10:09 PM

A long solenoid is created by winding 100 turns of wire over a manganese-zinc ferrite core with relative permeability of 700. If the diameter of the wire used to create the solenoid is 0.2 mm and the cross-sectional area of the solenoid is 10 mm^2, find its inductance.

$\mu_r = 700$

S = AREA = 10 mm^2

$N = 100$

WIRE DIAMETER = 0.2mm = d

⇒ LENGTH = Nd = 0.02 m

$$\Rightarrow L = \frac{\mu N^2 S}{l} = \frac{\mu_0 \mu_r N^2 S}{l}$$

$$= \frac{4\pi\times10^{-7}\times700\times100^2\times10\times10^{-3}\times10^{-3}}{0.02}$$

≈ 4.4 mH