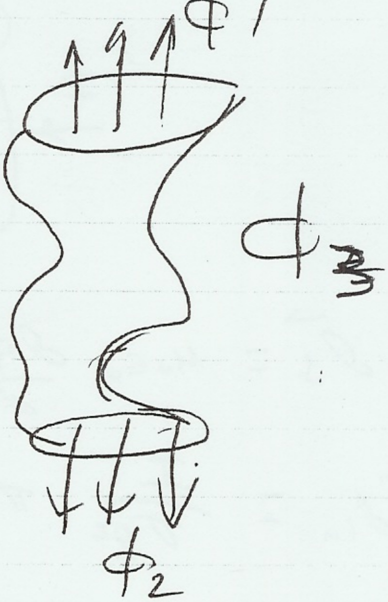
CH # 32

H.W. Solution



$$\oint \vec{B} \cdot d\vec{s} = 0$$

$$\Phi_1 = \int \vec{B} \cdot d\vec{s}$$

$$= 0.3 \times \pi (.2 \times 10^{-2})^2$$

$$= 3.7 \times 10^{-4} \text{ web.}$$

$$\Phi_2 = 0.7 \times 10^{-3} \text{ web} = 7 \times 10^{-4} \text{ web}$$

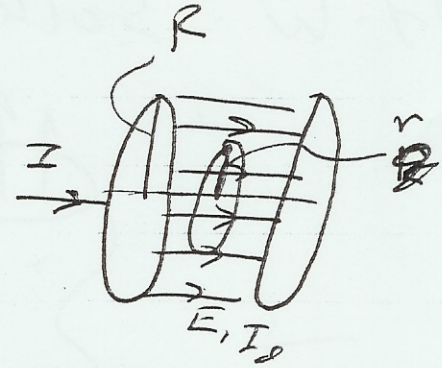
$$\Phi_1 + \Phi_2 + \Phi_3 = 0$$

$$\Phi_3 = -(\Phi_1 + \Phi_2)$$

$$= -10.7 \times 10^{-4} \text{ web}$$

Inward

#6



$$\oint \vec{B}\cdot d\vec{s} = \mu_0 \epsilon_0 \frac{d\Phi_E}{dt} = \mu_0 I_{d_{in}}$$

$$I_{d_{in}} = \frac{I}{\pi R^2}\cdot \pi r^2 \quad , \quad r \in R$$

$$I_{d_{in}} = I \quad \text{for} \quad r > R$$

$\Rightarrow$ for $r < R$

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

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

$\cancel{B_{max}}$

B is maximum when $r = R$

$$B_{max} = \frac{\mu_0 I}{2\pi R}$$

$$\frac{B}{B_{max}} = \frac{I}{2\pi R^2}\cdot r \times \frac{2\pi R}{I} = \frac{r}{R}$$

$$r = R\cdot \frac{B}{B_{max}} = 0.75\,R$$

b. For $r > R$

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

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

$$\frac{B}{B_{max}} = \frac{\mu_0 I}{2\pi r} \times \frac{2\pi R}{\mu_0 I}$$

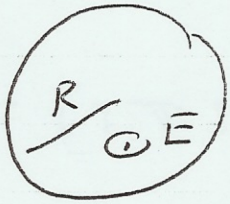
$$= \frac{R}{r}$$

$$r = R \cdot \frac{B_{max}}{B}$$

$$= R \cdot \frac{1}{0.75}$$

or $\boxed{r = 1.33 R}$

#9.



a. $\Phi_E = 6\left(\frac{r}{R}\right)t \qquad r \le R$

$$\oint \vec{B}\cdot d\vec{s} = \mu_0\epsilon_0 \frac{d\Phi_E}{dt}$$

$$B(2\pi r) = \mu_0\epsilon_0 \cdot \frac{d}{dt}\left(6\,\frac{r}{R}\,t\right)$$

$$B(2\pi r) = 6\mu_0\epsilon_0\,\frac{r}{R}$$

$$B = 3\,\frac{\mu_0\epsilon_0}{\pi R} = \frac{3\times4\pi\times10^{-7}\times8.85\times10^{-12}}{\pi\, 3\times10^{-2}}$$

$$= 3.54\times10^{-16}\ \text{T}$$

b for $r > R$

$$\Phi_E = 6t$$

$$B(2\pi r) = 6\mu_0\epsilon_0$$

$$B = \frac{3\mu_0\epsilon_0}{\pi r} = \frac{3\times4\pi\times10^{-7}\times8.85\times10^{-12}}{\pi\times5\times10^{-2}}$$

$$= 2.12\times10^{-16}\ \text{T}$$

#17

$$\oint \vec{B} \cdot \vec{ds} = \mu_0 I_{d\,in}$$

for $r < R$

$$I_{d\,in} = 20 \cdot \pi r^2$$

$$\therefore B(2\pi r) = \mu_0 \times 20 \pi r^2$$

$$B = 10 \mu_0 r$$

$$B = 10 \times 4\pi \times 10^{-7} \times 5 \times 10^{-3}$$

$$= 6.28 \times 10^{-8}\ T$$

$$= 0.628\ \mu T.$$

b. $I_d = \epsilon_0 \frac{d\phi_E}{dt} = \epsilon_0 A \frac{dE}{dt}$

for $r > R$

$I_d = 20 \pi R^2$, $A = \pi R^2$

$$\therefore 20 = \epsilon_0 \frac{dE}{dt}$$

or $\frac{dE}{dt} = \frac{20}{\epsilon_0} = 2.25 \times 10^{12}$ V/m.s

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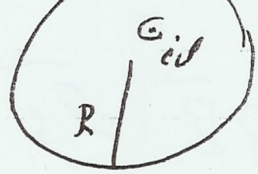
$i_d = 0.50$ (uniform)



$$\oint \vec{B}\cdot d\vec{s} = \mu_0 (i_d)_{enclosed}$$

for $r < R$,

$$(i_d)_{enclosed} = \frac{\mu_0 \bar{i}_d}{\pi R^2}\cdot \pi r^2$$

or $B(2\pi r) = i_d \left(\frac{r}{R}\right)^2$.

or $B = \frac{i_d\, r}{2\pi R^2}$

or $B = \frac{0.5 \times 3\times 10^{-2}}{2\pi \times (3\times 10^{-2})^2} \times 4\pi \times 10^{-7}$

$= \cancel{0.44} = 5.5\times 10^{-7}$ T.

b. for $r > R$

$(i_d)_{enclosed} = i_d$

$\therefore B(2\pi r) = \mu_0 i_d$

$B = \frac{\mu_0 i_d}{2\pi r} = \cancel{4\pi\times10^{-7}\times 0.5}$

$= \frac{4\pi\times 10^{-7}\times 0.5}{2\pi\times 5\times 10^{-2}} = 2\times 10^{-6}$ T

#30

$$u_s = m_s \frac{eh}{2\pi m} \quad , \quad \text{where } m_s = \pm \frac{1}{2}$$

$$u_s = \pm \frac{eh}{4\pi m}$$

$$U_+ = u_s B = \frac{eh}{4\pi m} B$$

$$U_- = -u_s B = -\frac{eh}{4\pi m} B$$

$$\Delta U = U_+ - U_-$$

$$\Delta U = \frac{eh}{2\pi m} B$$

$$= 2\, u_B\, B$$

$$= 2 \times 9.27 \times 10^{-24} \times 0.25$$

$$= 4.6 \times 10^{-24}\ \text{J}.$$

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$U = \mu_{orb} B$

$= - m_\ell \mu_B B \quad , \quad m_\ell = 0, \pm 1, \pm 2 \ldots$

a. Since E_1 does not splite when the magnetic field was turn on, this means that $m_\ell = 0$

b. Since E_2 was splite into 3 levels, when B was turn on, it means ~~$m_\ell = 0, \pm$~~

$m_\ell = -1, 0, 1$

c. ΔU = Energy spacing between to adjacent levels

$= U_0 - U_{-1} = -U_0 + U_1$

$= \mu_B B = 9.27 \times 10^{-24} \times 0.5$

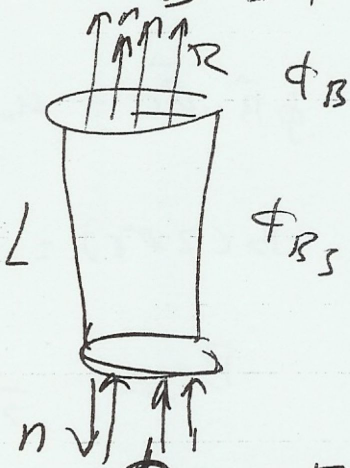
$= 4.63 \times 10^{-24}$ Joules

Ch #32, Example,

$B = 1.6\,mT$

#3 $R = 12\,cm$

$L = 80\,cm$



$\Phi_{B1} = -25\times10^{-6}\,Wb$

$A = \pi R^2 = \pi(.12)^2$

$\Phi_{B1} + \Phi_{B2} + \Phi_{B3} = 0$

$\Phi_{B3} = -(\Phi_{B1} + \Phi_{B2})$

$= -(-25\times10^{-6} + 1.6\times\pi(.12)^2)$

$\cancel{= -7.25\times10^{-2}\,wb.}$

~~inward.~~

$= -(-25\times10^{-6} + 1.6\times10^{-3}\pi(.12)^2)$

$\cancel{= -4.7}$

$= 47\,\mu Wb$

~~out of surface.~~

<u>Inward</u>

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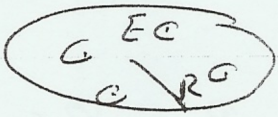

$$\oint \vec{B}\cdot d\vec{s} = \mu_0 \frac{d\Phi_E}{dt}$$

$$B(2\pi r) = \mu_0 \frac{d\Phi_E}{dt}$$

$$B = \frac{1}{2\pi r}\mu_0 \frac{d\Phi_E}{dt}$$

$$= \frac{1}{2\pi r}\mu_0 \frac{d}{dt}(3\times10^{-3} t)$$

$$= \frac{1}{2\pi r}\mu_0 \times 3\times10^{-3}$$

a. ~~A~~ $r = 2\,cm$

$$B = \cancel{\frac{1}{2\pi\times 10^{2}}} \times \overset{2}{\cancel{4\pi}}\times10^{-7}\times3\times10^{-3}$$

$$= 3.\times10^{-8}\ T$$

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~~$i_d = \epsilon_0 \frac{d\Phi_E}{dt}$~~

Current density $= \frac{2}{L^2}$

a. 2 A

b. $i_d = \epsilon_0 \frac{d\Phi_E}{dt}$

$$= \epsilon_0 L^2 \cdot \frac{dE}{dt}$$

$$\frac{dE}{dt} = \frac{i_d}{\epsilon_0 L^2}.$$

c. $i = \frac{2}{L^2}\cdot d^2.$

d. $\oint \vec{B}\cdot d\vec{s} = \mu_0 i$

#26 $i_d = 3 \frac{r}{R}$

$\oint \vec{B} \cdot ds = \mu_0 \left(3\frac{r}{R}\right)$

$r < R$

$B(2\pi r) = \mu_0 \frac{3r}{R}$

$B = \frac{3\mu_0}{2\pi R}$

for $r > R$

$B(2\pi r) = 3\mu_0$

$\boxed{B = \frac{3\mu_0}{2\pi r}}$

#31 $L_{orb\,z} = m_\ell \frac{h}{2\pi}$, $U = -\mu_{or} B_e$

$= \left(m_\ell \frac{eh}{4\pi m}\right) B_e$.

a. for $m_\ell = 0$ $L = 0$, $U = 0$, $\mu_{orb} = 0$

b. $U_{orb} = 0$, $\mu_{orb} = 0$.

d $U_s = \mu_B = -\mu_{sz} B = \pm \mu_B B$

$U_{s+} = \mu_B B = 9.27\times10^{-24} \times 35\times10^{-3}$

e. $L_{orb} = \cancel{3\times\mu_B B}\ 3\frac{h}{2\pi}$, $\mu_{orb} = -m_\ell\left(\frac{eh}{4\pi m}\right)$

g $U_{orb} = \mu_{or} B = -m_\ell \mu_B B$, $U_{spin} = -m_\ell \mu_B$