83/90

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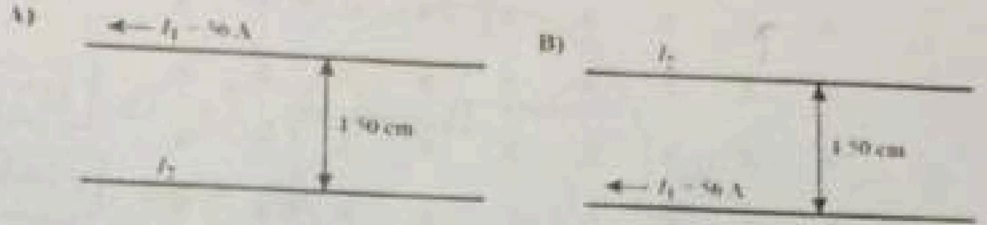
Physics 1C

Fall 2014

Midterm # 1

1) A long horizontal wire carries a current of 56 A. A second wire made of copper (density $8.90 \cdot 10^3$ kg/m^3) with a diameter of 2.0 mm is suspended magnetically 4.50 cm below the first wire as shown in Figure A.



$\frac{m}{V}$

$d = 2$mm

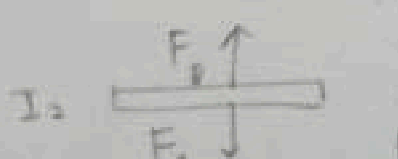
a) What is the direction of the current in the lower wire?
b) What is the magnitude of the current in the lower wire?
c) The second wire is now suspended magnetically 4.50 cm above the first wire (Figure B). What are the magnitude and direction of the current of the second wire in this situation?

a) wires attract, so same direction as I_1

$I_2 \leftarrow$ to the **left**

need force upward to balance out gravity ✓

b) $F_B = F_2 = I_2 L B_1 = F_g = mg$ = density × volume



$I_2 L B_1 =$ density $\times \left(\frac{d}{2}\right)^2 \pi \times L$

$I_2 = \frac{\text{density} \times \left(\frac{d}{2}\right)^2 \pi}{B_1}$

$B_1 = \frac{\mu_0 I_1}{2\pi x}$

$= \frac{\text{density} \times \left(\frac{d}{2}\right)^2 \pi (2\pi x)}{\mu_0 I_1}$

density $= 8.9 \cdot 10^3$ kg/m^3

$d = 2 \cdot 10^{-3}$ m

$x = 0.045$ m

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

$I_1 = 56$A

$= \frac{8.9 \cdot 10^3 \cdot \left(\frac{2 \cdot 10^{-3}}{2}\right)^2 \pi (2\pi \cdot 0.0\ldots}{4\pi \cdot 10^{-7} \cdot 56}$

$=$ **112 A**

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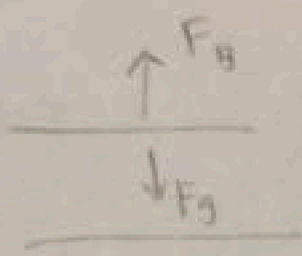
c)

top wire needs magnetic force upward to balance out gravity

I_2 points to right for F_B to point upward (RHR)

next page

c)



$F_B = F_2 = I_2 L B_1 = mg$ = density x volume

$$B_1 = \frac{\mu_0 I_1}{2\pi x}$$

⋮

(calculation same as part (a))

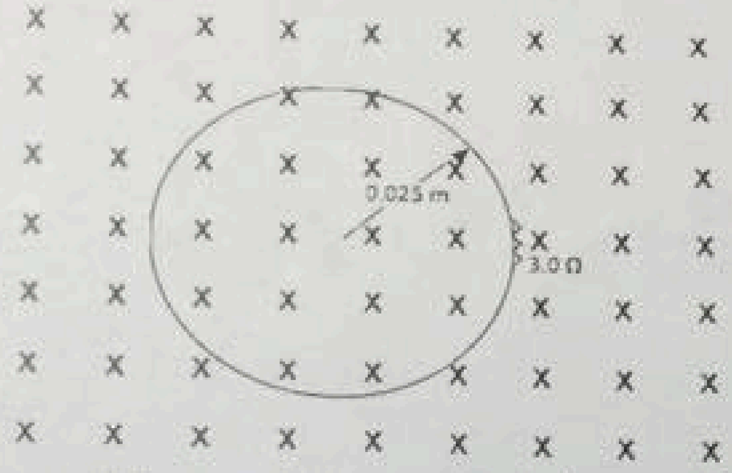
· Therefore, I_2 is **112 A** pointing to the **right**

2) A circular coil of wire with N = 10 loops has a radius of 0.025 m and a resistance of 3.0 Ω. It is placed in a 1.6 T magnetic field which is directed in through the loop as shown and then turned off uniformly over a period of 0.10 s.

a) What is the current in the wire during the time that the magnetic field changes from 1.6 T to zero?

b) What direction is the current flowing?

c) What is the energy dissipated in the loop?



in

$V = IR$

$I = \frac{V}{R}$

a) N, r, R, B, t, I =

$\mathcal{E} = -\frac{d\Phi_B}{dt} = -\frac{BA}{t} = -\left(\frac{-1.6\,(0.025)^2\pi}{0.1}\right)$

$= +0.0314\ V$

$I = \frac{|\mathcal{E}|}{R} = \frac{0.0314}{3} = \boxed{1.05 \cdot 10^{-2}\ A}$ -3

b) Lenz' law

$\Phi_B \downarrow$ Φ_B into field is decreasing b/c magnetic field is decreasing, so induced current goes the same way (CW)

clockwise

B ⊗ I RHR

c) $P = I\mathcal{E}$

$|\mathcal{E}| = 0.0314\ V$

from (a): $|I| = 1.05 \cdot 10^{-2}\ A$

$P = I\mathcal{E} = 1.05 \cdot 10^{-2} \cdot 0.0314 = \boxed{3.30 \cdot 10^{-4}\ W}$

$E = P\Delta t$

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3) An alpha particle (m = 6.64 x 10^{-27} kg) which has charge $q = 3.2 \cdot 10^{-19}$ C (twice the charge of a proton) is moving in a circle of radius 0.75 m perpendicular to a magnetic field of magnitude 0.75 T. Calculate the alpha particle's

a) Angular frequency and period of motion
b) Speed
c) Kinetic energy
d) What would be the radius of curvature if the alpha particle kinetic energy is doubled?

a) given: m, q, r, B

$$\omega = \frac{v}{R} = v\frac{qB}{mv} = \frac{qB}{m} = \frac{3.2 \cdot 10^{-19} \cdot 0.75}{6.64 \cdot 10^{-27}}$$

$$= 3.61 \cdot 10^{7} \text{ rad/s}$$

$$T = \frac{2\pi}{\omega} = \frac{2\pi}{3.61 \cdot 10^{7}} = 1.74 \cdot 10^{-7} \text{ sec}$$

b) $v = R\omega = 0.75 \cdot 3.61 \cdot 10^{7} = 2.71 \cdot 10^{7}$ m/s

→ There are awful 7's.

c) $KE = \frac{1}{2}mv^2 = \frac{1}{2} \cdot 6.64 \cdot 10^{-27} \cdot (2.71 \cdot 10^{7} \text{ m/s})^2$

$$= 2.44 \cdot 10^{-12} \text{ J}$$

d) $KE' = 2KE$

$$\frac{1}{2}mv'^2 = 2(\frac{1}{2}mv^2)$$

$$v'^2 = 2v^2 \qquad v' = \sqrt{2}\,v$$

$$r' = \frac{mv'}{qB} = \frac{m\sqrt{2}\,v}{qB} = \sqrt{2}\,r = \sqrt{2} \cdot 0.75$$

$$= 1.06 \text{ m}$$

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