Physics 24 Midterm 1 — Feb 2, 2007

Name: Solutions

Perm: Avg was 54.4/60 = 90.6%

This exam in 50min long and closed book. You may use a single formula sheet and a calculator. You may not, of course, get any help from any other person. The test consists of three problems, of equal weight. Write your answers either in your blue book, or on this test itself; please show your work, and turn all your work in.

Good luck!

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1. (20 pt) *Cyclotron motion.* A proton (of mass $m_p = 1.67 \times 10^{-27}$kg) moves in a circle in a constant magnetic field, at a measured frequency of $f = 7.2$MHz. What is the strength B of the magnetic field?

$$f = \frac{qB}{2\pi m} \qquad (1\,MHz = 10^6\,Hz)$$

$$B = \frac{2\pi m}{q} f$$

$$= \frac{2\pi \times 1.67 \times 10^{-27}}{1.6 \times 10^{-19}} \times 7.2 \times 10^6$$

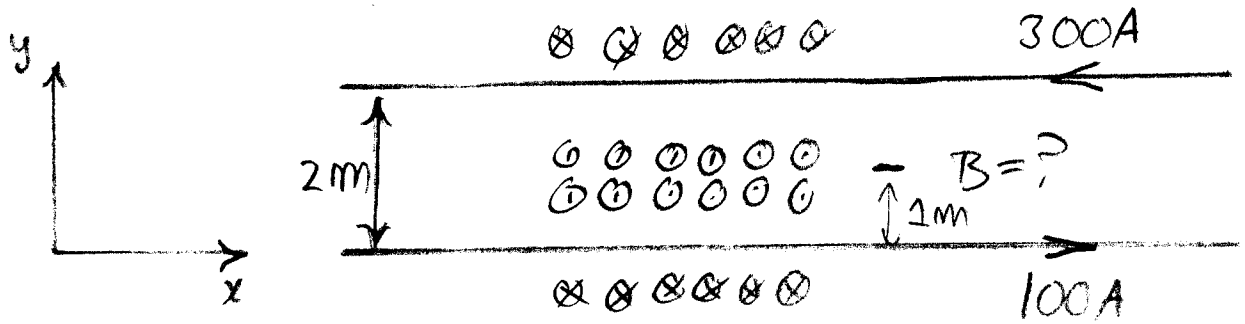
$$\boxed{B = 0.47 \text{ Tesla}}$$

2. (20 pt) *A pair of wires.*

Two straight wires run parallel to the x-axis, a distance $2m$ apart, in the xy plane. The first wire runs along $y = 0$ and carries a current of 100A in the $+x$ direction; the second wire runs along $y = 2$ and carries a current of 300A in the $-x$ direction; *i.e.,* the two currents run in opposite directions.

a) What is the force per unit length between the two wires?— is it attractive or repulsive?

b) What is the magnetic field $\vec{\mathbf{B}}$ at a point halfway between the two wires (magnitude and direction)?



a) $F = \frac{\mu_0 i_1 i_2}{2\pi d} = \frac{\mu_0}{2\pi} \frac{(100)(300)}{2}$

$F = 3 \times 10^{-3}$ N

repulsive

because currents are opposite

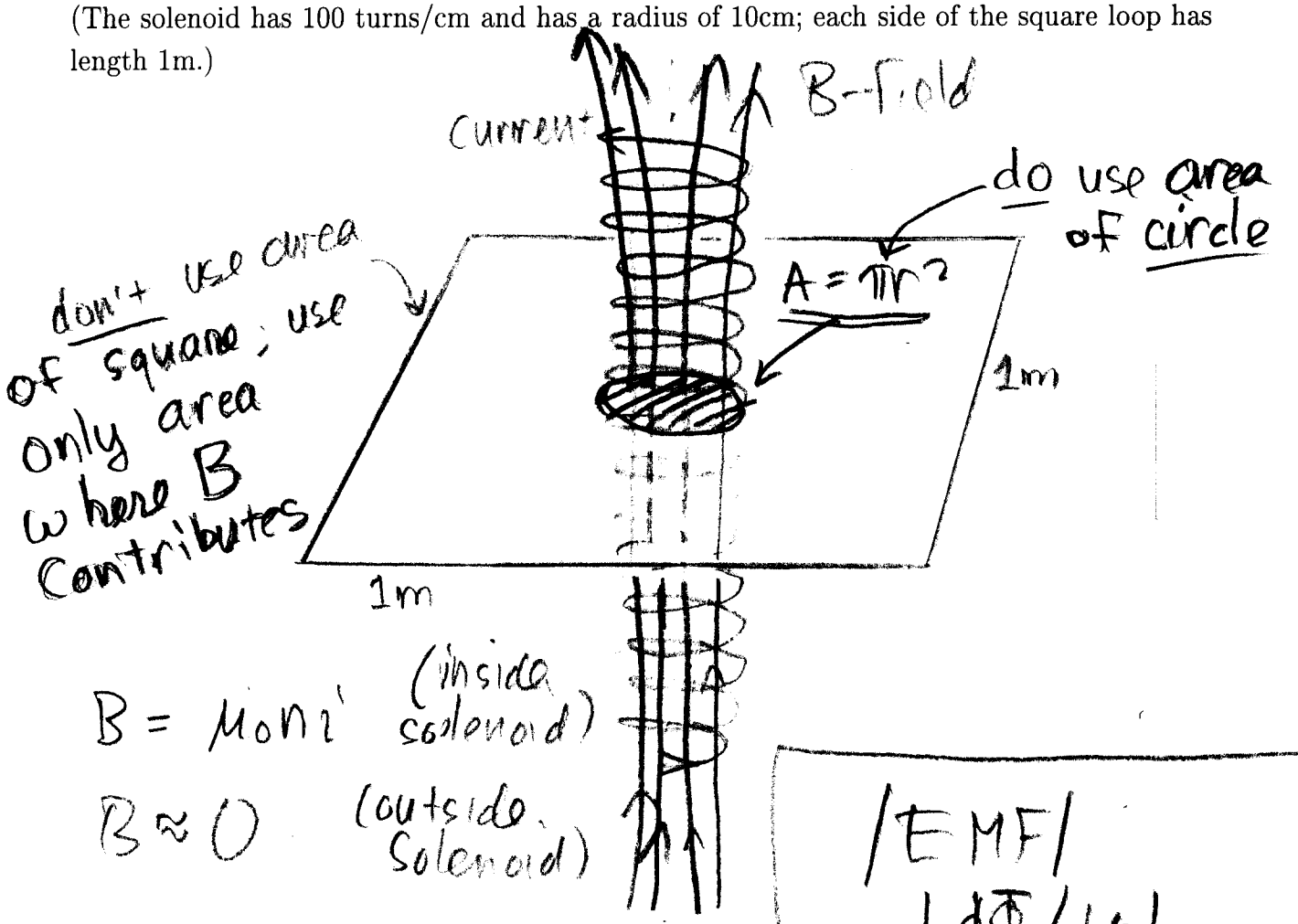
b) By right hand rule, $\vec{B}$ field points out of page $(+\hat{k})$ for both wires. Therefore magnitudes add.

$B = \frac{\mu_0 i_1}{2\pi d_1} + \frac{\mu_0 i_2}{2\pi d_2} = \frac{\mu_0}{2\pi}\left(\frac{100}{1} + \frac{300}{1}\right)$

$B = 8 \times 10^{-5}$ T out of page $(+\hat{k})$

3. (20 pt) *Induction.*

A long solenoid runs through the center of a large square loop of wire. The current in the solenoid increases at a rate $10A$ per second. What is the EMF $\mathcal{E}$ around the square loop? (The solenoid has 100 turns/cm and has a radius of 10cm; each side of the square loop has length 1m.)



$B = \mu_0 n i$ (inside solenoid)

$B \approx 0$ (outside solenoid)

$\Phi = BA$

$= \mu_0 n i \cdot \pi r^2$

$\frac{d\Phi}{dt} = \mu_0 n \frac{di}{dt} \cdot \pi r^2$

$= \mu_0 (10000 \text{ turn/m}) \cdot 10 \cdot \pi (0.1\text{m})^2$

$|EMF| = |d\Phi/dt| = 3.95 \times 10^{-3} V$

End of Test