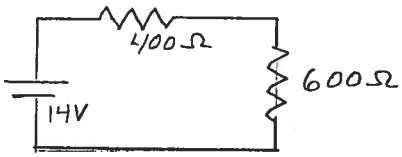
PHYSICS 203 **EXAM #1** NAME KEY
1 October 2013

General Instructions: For each problem your solution must be readable and your logic followable. Put a box around any numerical answers.

Constants: $\mu_0 = 1.26 \times 10^{-6}$ H/m $e = 1.60 \times 10^{-19}$ C $\varepsilon_0 = 8.85 \times 10^{-12}$ F/m
Prefixes: $c = 10^{-2}$ $m = 10^{-3}$ $\mu = 10^{-6}$ $n = 10^{-9}$ $p = 10^{-12}$

PART I - SHORT ANSWER QUESTIONS.
Do the 5 short questions/problems. Worth 8 points each.

1. For the circuit drawn below, find the power dissipated by the 600 Ω resistor.

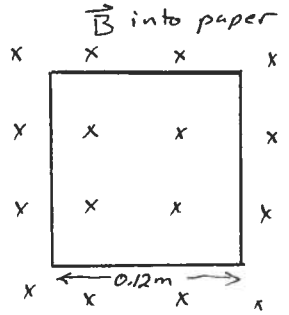


$P = i^2R$ & $i = \frac{\mathcal{E}}{R_{eq}} = \frac{14V}{1000\Omega} = 0.014A$

$P = (0.014A)^2(600\Omega) = \boxed{0.118W}$

2. A wire, of resistance 150 mΩ, is formed into a square of length 0.12 m on each side. It is placed with the plane of the square perpendicular to a spatially uniform magnetic field that is decreasing in strength at a rate of 0.024 T/s.

5 a) Find the magnitude of the current that flows.
3 b) Determine the direction of the current flow.



a) $i = \frac{\mathcal{E}}{R} = \frac{1}{R}\frac{d\Phi_B}{dt} = \frac{1}{R}\frac{d}{dt}BA = \frac{A}{R}\frac{dB}{dt}$

$i = \frac{(0.12m)^2}{0.150\Omega}\left(0.024\frac{T}{s}\right) = \boxed{2.30mA}$

b) since field is decreasing, need $i_{induced}$'s field to point into paper inside the square.
$\boxed{\text{Clockwise}}$ via RHR

3. Fischer described three dangers that should be avoided when discussing God and science. Give <u>one</u> of the three dangers and explain why it should be considered to be a danger.

One of:
1) Should not use science to deny God's work in creation
2) Should not assume rational thought gives proof for or against God's existance.
3) Should not assume science is complete.

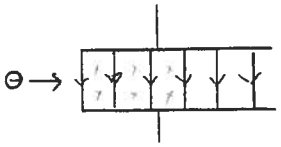
All are dangers in that they tend to define God in terms of our understanding ©

4. A 0.85 m long solenoid produced a field of 1.40 mT in its interior when a 2.10 A current flows through it. How many turns does the solenoid have?

$B = \mu_0 i n = \mu_0 i \frac{N}{L} \rightarrow N = \frac{BL}{\mu_0 i} = \frac{(1.40\times10^{-3}\,T)(0.85\,m)}{(1.26\times10^{-6}\,\frac{Tm}{A})(2.10\,A)}$

$N = 450$ turns

5. A parallel plate capacitor is charged such that it has an electric field of 1500 V/m between the plates. The field is directed from the top plate to the lower one, as shown.
a) What magnetic field (magnitude and direction) would be needed in the region between the plates so that an electron shot through the plates at a speed of 1.0×10^5 m/s would not be deflected?
b) What would happen to an electron shot through the plates at this speed if the field were higher than the value you found in a)?



a) Need $\vec{F}_{mag} = q\vec{v}\times\vec{B}$ to equal $-q\vec{E} = -\vec{F}_{elec}$

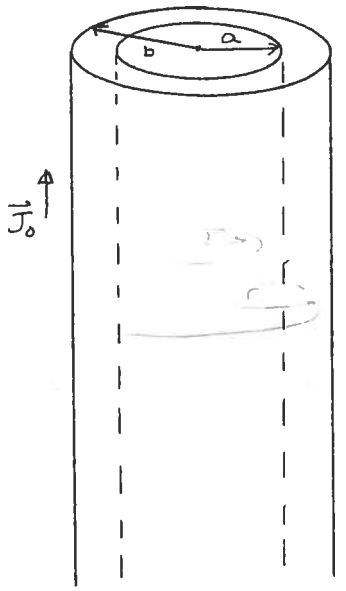
$qvB = qE \quad B = \frac{E}{v} = \frac{1500\,V/m}{1.0\times10^5\,m/s} = 0.015\,T$

Need $\vec{B}$ into page to have $\vec{F}_{mag} = -\vec{F}_{elec}$

b) If $\vec{B}$ increases $|\vec{F}_{mag}| > |\vec{F}_{elec}|$ so electron experiences a net force, deflecting it downward.

Part III - Problems.
Do all three. Worth 20 points each. Show and explain your work.

6. A long copper pipe has an inner radius of "a" and an outer radius of "b." A current flows with a uniform current density of $\vec{J}_0$. Starting from Ampere's law derive (i.e. show/explain intermediate steps) an expression or expressions for the magnetic field as a function of r, where r is measured from the central axis of the pipe.



Ampere's law is $\oint \vec{B} \cdot d\vec{s} = \mu_0 i_{enc}$

From symmetry $\oint \vec{B} \cdot d\vec{s} = \oint B\, ds$

$= B \oint ds = B 2\pi r$

in each case.

For $r < a$, $i_{enc} = 0$ so $B 2\pi r = 0$

$B = 0$

For $a < r < b$, $i_{enc} = J_0 (\pi r^2 - \pi a^2)$

so $B 2\pi r = \mu_0 J_0 \pi (r^2 - a^2)$

$$B = \frac{\mu_0 J_0 (r^2 - a^2)}{2r} \qquad a < r < b$$

$r > b$ $\quad i_{enc} = J_0 \pi (b^2 - a^2)$

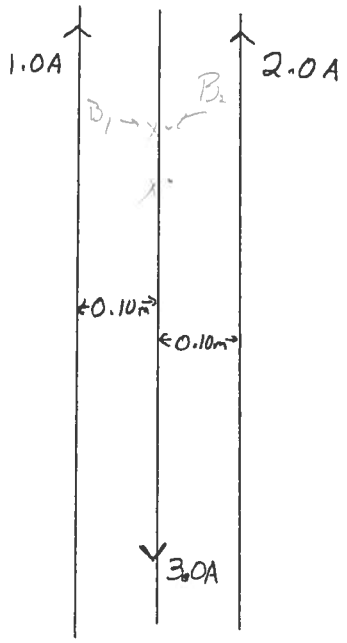
so $B 2\pi r = \mu_0 J_0 \pi (b^2 - a^2)$

$$B = \frac{\mu_0 J_0 (b^2 - a^2)}{2r} \qquad r > b$$

12 pts if a<r<b or r>b correct

8 pts other 2

7. Three long parallel wires carry currents as shown below.
a) What is the magnitude and direction of the magnetic field produced by the outer two wires at the location of the central wire?
b) What is the magnitude and direction of the force per unit length on the central wire?



a) $B = \frac{\mu_0 i}{2\pi r}$ for a long straight wire

From RHR B_1 (= field from 1A wire) points into the paper & B_2 is out at center position.

$$B_{net} = B_2 - B_1 = \frac{\mu_0 (2A)}{2\pi (0.10m)} - \frac{\mu_0 (1A)}{2\pi (0.10m)}$$

$$= \frac{(1.26\times10^{-6}\frac{Tm}{A})(1A)}{2\pi (0.10m)} = 2.00\,\mu T$$ directed up out of the paper

b) $\vec{F} = I\vec{L}\times\vec{B}$

$$\frac{F}{L} = I B = 3.0A\,(2.00\,\mu T) = 6.00\,\mu\frac{N}{m}$$

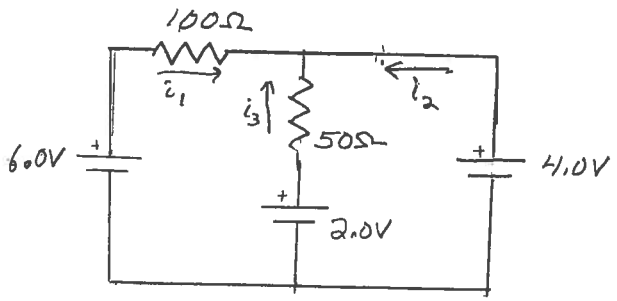
directed **left** via RHR

8. Consider the circuit below.

12 a) Find each of the currents i_1, i_2, and i_3.

4 b) Are the directions of each of the currents that are drawn on the diagram correct? How do you know? (Explain for each current separately)

4 c) Suppose the 2.0 V seat of emf in the center leg of the circuit is removed and replaced with a 2.0 μF capacitor. After a 'long time' what are the values of the currents i_1, i_2, and i_3?



a) node rule: $i_1 + i_2 + i_3 = 0$

loop rule around outside of circuit:

$6.0\,V - i_1(100\,\Omega) - 4.0\,V = 0 \rightarrow i_1 = \frac{2.0\,V}{100\,\Omega} = 0.020\,A$

loop rule around right loop:

$2.0\,V - i_3(50\,\Omega) - 4.0\,V = 0 \qquad -i_3 = \frac{2.0\,V}{50\,\Omega}$

$i_3 = -0.040\,A$

$i_1 + i_2 + i_3 = 0$ so $i_2 = -i_1 - i_3 = -0.020\,A + 0.040\,A =$

$i_2 = 0.020\,A$

b) Since i_1 + i_2 are positive both currents flow as drawn on the circuit.

i_3 is negative, meaning it flows down, not up as drawn.

c) After a long time the capacitor is charged and no current flows in the center leg. $i_3 = 0$

loop rule around outside is (again):

$6.0\,V - i_1(100\,\Omega) - 4.0\,V = 0$ $\quad i_1 = 0.020\,A$

$i_2 = -0.020\,A$ since it must have the same mag. as i_1 + same direction (opp to dir. it is drawn).