## PHY294 Exam #2

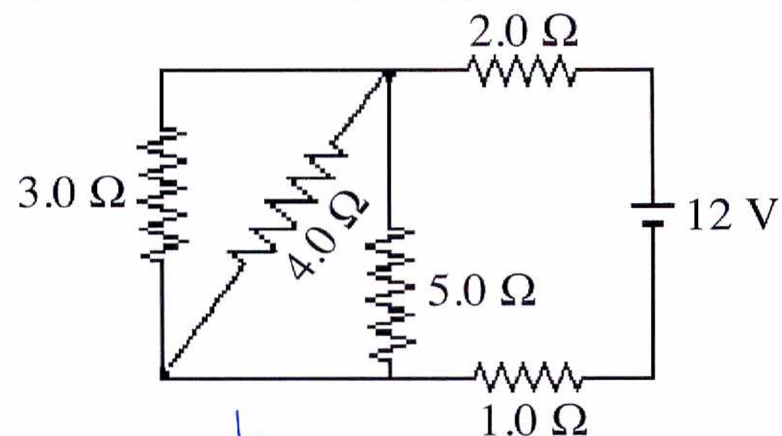
Name:_______________________ Student #:_________________

**Show work for problems. Include units in answer. For multiple choice problems, partial credit may be possible if work is provided.**

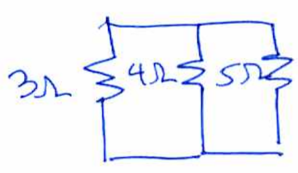
Some physical constants:

$e = 1.6 \times 10^{-19}$ C
$m_e = 9.1 \times 10^{-31}$ kg
$m_p = 1.67 \times 10^{-27}$ kg
$g = 9.83$ N/kg
$\varepsilon_o = 8.85 \times 10^{-12}$ C$^2$/N·m$^2$
$1/4\pi\varepsilon_o = 9 \times 10^9$ N·m$^2$/C$^2$
$\mu_o = 4\pi \times 10^{-7}$ T·m/A
$c = 3 \times 10^8$ m/s

1.) What is the current in the 4.0 Ω resistor? Show work.

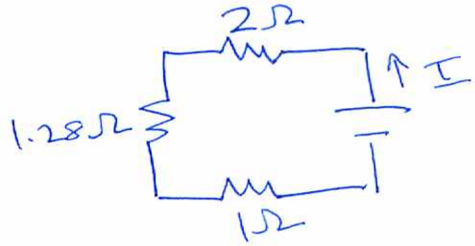



$\downarrow$




$\rightarrow \frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$

$R_{eq} = 1.28\,\Omega$

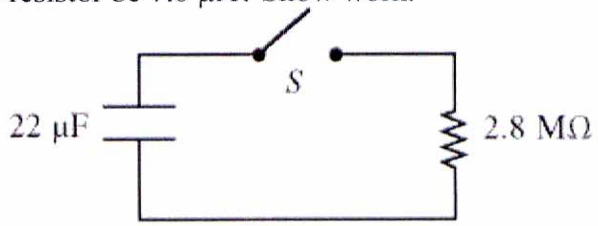



$I = \frac{12V}{4.28\Omega} = 2.8\,A$

$V_{1.28\Omega} = IR = (2.8A)(1.28\Omega)$
$= 3.59\,V$

$I_{4\Omega} = \frac{3.59V}{4\Omega} = 0.90\,A$

2.) For the circuit shown in the figure, the switch $S$ is initially open and the capacitor voltage is 80 V. The switch is then closed at time $t = 0$. How long after closing the switch will the current in the resistor be 7.0 μA? Show work.



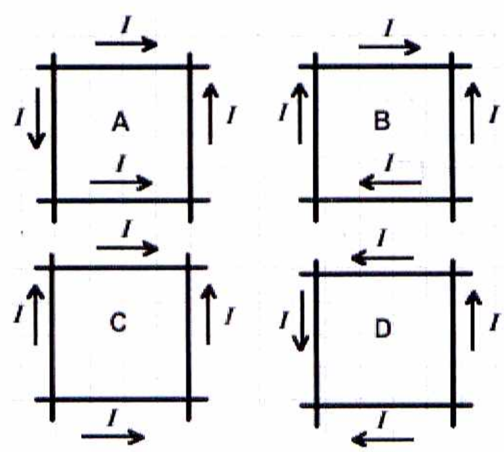

$\tau = RC = (2.8 \times 10^{6}\,\Omega)(22 \times 10^{-6}\,F) = 61.6\,s$

$I = I_0 e^{-t/\tau}$ $\quad I_0 = \frac{80\,V}{2.8 \times 10^{6}\,\Omega} = 2.86 \times 10^{-5}\,A$

$\frac{I}{I_0} = \frac{7\,\mu A}{28.6\,\mu A} = 0.248 = e^{-t/\tau}$

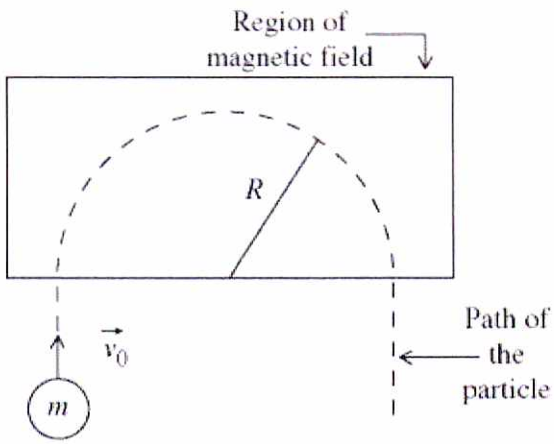
$t = 1.41\,\tau = 86.7\,s$

3.) The figure shows four different sets of insulated wires that cross each other at right angles without actually making electrical contact. The magnitude of the current is the same in all the wires, and the directions of current flow are as indicated. For which (if any) configuration will the magnetic field at the center of the square formed by the wires be equal to zero?




A) A
B) B
C) C
D) D
E) The field is not equal to zero in any of these cases.

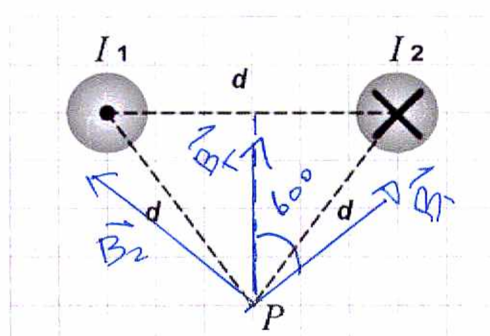
4.) As shown in the figure, a small particle of charge $q = -7.0 \times 10^{-6}$ C and mass $m = 3.1 \times 10^{-12}$ kg has velocity $v_0 = 9.4 \times 10^3$ m/s as it enters a region of uniform magnetic field. The particle is observed to travel in the semicircular path shown, with radius $R = 5.0$ cm. Calculate the magnitude and direction of the magnetic field in the region. Show work.




$$R = \frac{mv}{qB} \quad = \frac{(3.1 \times 10^{-12}\,kg)(9.4 \times 10^{3}\,m/s)}{(7 \times 10^{-6}\,C)(0.05\,m)} = 0.083\,T$$

into page because of negative charge

5.) The figure shows two long, parallel current-carrying wires. The wires carry equal currents $I_1 = I_2 = 20$ A in the directions indicated and are located a distance $d = 0.5$ m apart. Calculate the magnitude and direction of the magnetic field at the point $P$ that is located an equal distance $d$ from each wire. Show work.



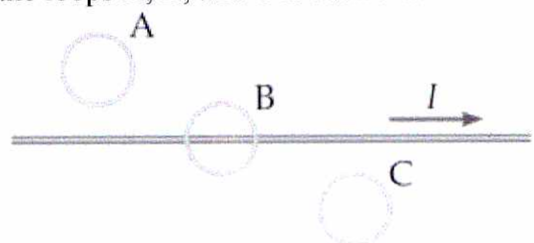

$$|B_1| = |B_2| = \frac{\mu_0 I}{2\pi d} = (2 \times 10^{-7}\,T \cdot m/A)\frac{20\,A}{0.5\,m}$$

$$= 8 \times 10^{-6}\,T$$

$$B_T = B_1 \cos 60^\circ + B_2 \cos 60^\circ$$

$= 8 \times 10^{-6}\,T$ upwards

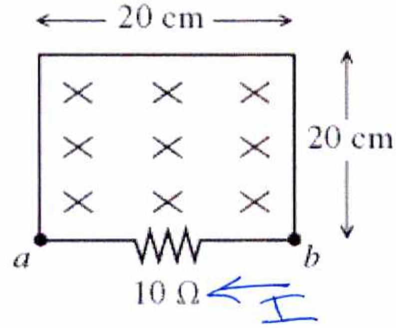
6.) The long straight wire in the figure carries a current $I$ that is decreasing with time at a constant rate. The circular loops A, B, and C all lie in a plane containing the wire. The induced emf in each of the loops A, B, and C is such that




A) no emf is induced in any of the loops.
B) a counterclockwise emf is induced in all the loops.
C) loop A has a clockwise emf, loop B has no induced emf, and loop C has a counterclockwise emf.
D) loop A has a counter-clockwise emf, loop B has no induced emf, and loop C has a clockwise emf.
E) loop A has a counter-clockwise emf, loops B and C have clockwise emfs.

7.) A capacitor is charging in a simple $RC$ circuit with a dc battery. Which one of the following statements about this capacitor is accurate?
A) There is a magnetic field between the capacitor plates because charge travels between the plates by jumping from one plate to the other.
B) There is no magnetic field between the capacitor plates because no charge travels between the plates.
C) There is a magnetic field between the capacitor plates, even though no charge travels between them, because the magnetic flux between the plates is changing.
D) There is a magnetic field between the capacitor plates, even though no charge travels between them, because the electric flux between the plates is changing.
E) The magnetic field between the capacitor plates is increasing with time because the charge on the plates is increasing.

8.) As shown in the figure, a wire and a 10-Ω resistor are used to form a circuit in the shape of a square, 20 cm by 20 cm. A uniform but nonsteady magnetic field is directed into the plane of the circuit. The magnitude of the magnetic field is decreased from 1.50 T to 0.50 T in a time interval of 63 ms. The average induced current and its direction through the resistor, in this time interval, are? Show work.




$$\mathcal{E} = -\frac{d\phi}{dt} = -A\frac{dB}{dt}$$

$$= (0.2m \times 0.2m)\frac{1T}{0.063s} = 0.63V$$

$$I = \frac{\mathcal{E}}{R} = \frac{0.63V}{10\Omega} = 0.063\ A$$

9.) ) Unpolarized light is incident upon two polarization filters that do not have their transmission axes aligned. If 18% of the light passes through this combination of filters, what is the angle between the transmission axes of the filters?

A) 53°
B) 73°
C) 85°
D) 80°
E) 90°

50% of light makes it through first filter

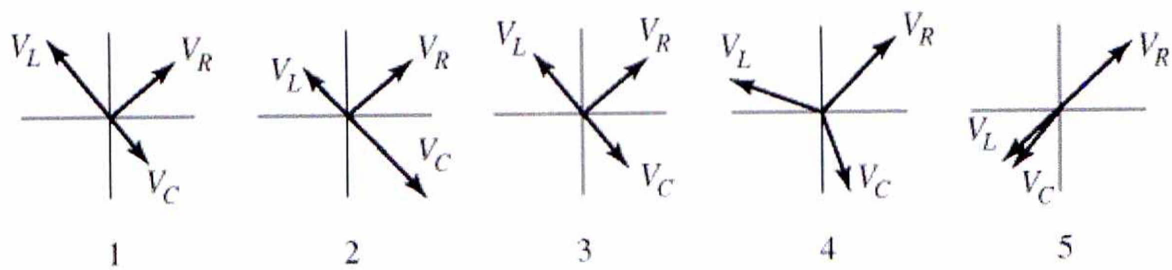
for 2nd filter

$$\frac{I}{I_0/2} = 0.18 = \cos^2\theta$$

$$\cos^2\theta = 0.36$$

$$\theta = 53°$$

10.) Which one of the phasor diagrams shown below best represents a series *LRC* circuit driven at resonance?



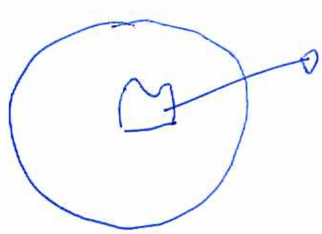

$V_L = V_C$ at resonance

A) 1
B) 2
C) 3
D) 4
E) 5

11.) Experimenter A creates a magnetic field in the laboratory. Experimenter B moves relative to A. Experimenter B sees

a) just the same magnetic field
b) a magnetic field in the opposite direction
c) a magnetic field of different strength
d) just an electric field
e) both a magnetic and an electric field

12.) The state of Michigan has an area of 253,793 km$^2$. Suppose you are told that the magnetic flux through the state due to the Earth's magnetic field is $-7.6\text{X}10^7$ T.m$^2$, i.e. the magnetic field lines are pointing into the surface of Michigan. What is the magnetic flux through the rest of the surface of the Earth? Show work.



$\phi_{MI} = -7.6 \times 10^7 \ T \cdot m^2$

$\phi_{MI} + \phi_{not-MI} = 0$

$\phi_{not-MI} = +7.6 \times 10^7 \ T \cdot m^2$