Exam 3: Physics 2113 Fall 2014

6:00PM TUE 11 NOV 2014

Name (Last, First): _____

Section #_____

Instructor's name:_____

Answer all 3 problems & all 4 questions.

Be sure to write your name.   Please read the questions carefully.

You may use only scientific or graphing calculators. *In particular you may not use the calculator app on your phone or tablet!*

You may detach and use the formula sheet provided at the back of this test. No other reference materials are allowed.

You may not answer or use cell phones during the exam. Please note that the official departmental policy for exams is as follows: "During your test, the only electronic device you may have with you at your seat is a scientific or graphing calculator. You may not have your cell phone, tablet, smartphone, PDA, pager, digital camera, computer, or any other device capable of taking pictures or video, sending text messages, or accessing the Internet. This means not just on your person, but close enough to you that you could reach it during the test. Any student found with such a device during a test will be assumed to be violating the LSU Honor Code and will be referred to the Dean of Students for Judicial Affairs." The simplest remedy is to bring nothing to this test but the calculator, and leave your backpack or purse at home. *If you have brought your cell phone or tablet with you, please leave it at the front of the room under the watchful eye of your instructor.*

Some questions are multiple choice. You should work these problems starting with the basic equation listed on the formula sheet and write down all the steps. Although the work will not be graded, this will help you make the correct choice and to determine if your thinking is correct.

On problems that are not multiple choice, be sure to show all of your work since no credit will be given for an answer without explanation or work. These will be graded in full, and you are expected to show all relevant steps that lead to your answer.
Please use complete sentences where explanations are asked for. For numerical answers that require units you must give the correct units for full credit.

YOU GET 60 min (1 hr)

1. (Question) **[8 points]** The table (below left) gives four sets of values for the circuit elements in the figure (below right). When the switch S is closed on a, the capacitor is *charged* through the resistor. When the switch is afterward closed on b, the capacitor *discharges* through the resistor.

	1	2	3	4
$\mathscr{E}$ (V)	12	12	10	10
R (Ω)	2	3	10	5
C (μF)	3	2	0.5	2
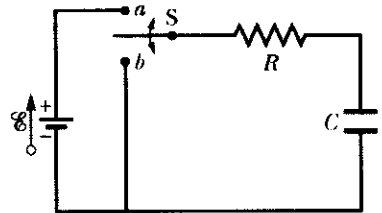
(i) **[4 points]** Rank the sets in decreasing order according to the initial current (as the switch is closed on a)

$$i = \frac{\mathscr{E}}{R} e^{-t/RC} \Big|_{t=0} = \frac{\mathscr{E}}{R}$$

So $\quad 1 > 2 > 4 > 3$

(ii) **[4 points]** Rank the sets in decreasing order according to the time required for the current to decrease to half its initial value after the switch is closed on b.

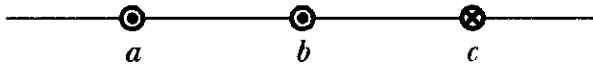Given that $\quad i = \left(\frac{-q_o}{RC}\right) e^{-t/RC}$

Solve for t such that

$e^{-t/RC} = 1/2$

$\Rightarrow \quad t = RC \log_e 2$

So $\quad 4 > 1 = 2 > 3$

2. (Question) **[6 points]** The figure shows three long straight, parallel, equally spaced wires with identical currents either going into or out of the page. Rank the wires according to the magnitude of the force on each due to the currents in the other two wires, greatest first.
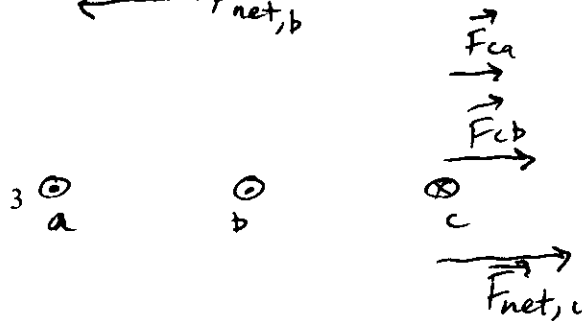
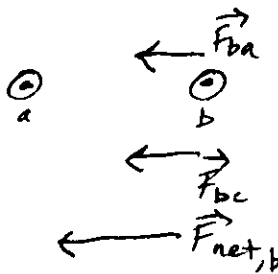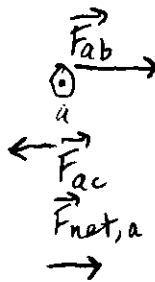a) $F_a > F_b > F_c$

b) $F_c > F_b > F_a$

c) $F_a > F_c > F_b$

d) $F_b > F_c > F_a$

e) $F_a = F_c > F_b$

Force is strength $\dfrac{\mu_0 L i_a i_b}{2\pi d}$

currents are the same, so focus on distance between them

$\vec{F}_{ab}$

a

$\vec{F}_{ac}$

$\vec{F}_{net,a}$

b

c

$\vec{F}_{ba}$

a   b   c

$\vec{F}_{bc}$

$\vec{F}_{net,b}$

$\vec{F}_{ca}$

$\vec{F}_{cb}$

3 a   b   c

$\vec{F}_{net,c}$

3. (Question) **[9 points]** The figure below shows three situations in which a charged particle, having positive or negative charge, and velocity $\vec{v}$ travels through a uniform magnetic field $\vec{B}$. The magnetic force $\vec{F}_B$ on the charged particle due to the external magnetic field is not drawn. (Recall that the $\hat{\imath}$ direction is in the direction of positive x, the $\hat{\jmath}$ direction is in the direction of positive y, and the $\hat{k}$ direction is in the direction of positive z.)
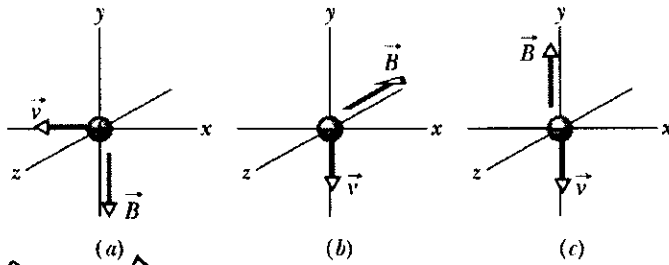
use Lorentz force law

$$\vec{F}_B = q\left(\vec{v} \times \vec{B}\right)$$

(a) (b) (c)

force → $\hat{k}$ direction $-\hat{\imath}$ force is zero

a) **[3 points]** In which situation is the magnetic force on the particle in the $-\hat{\imath}$ direction?

(i)   (a)

(ii)   (b)

(iii)   (c)

(iv)   None of them

b) **[3 points]** In which situation is the magnetic force on the particle equal to zero?

(i)   (a)

(ii)   (b)

(iii)   (c)

(iv)   None of them

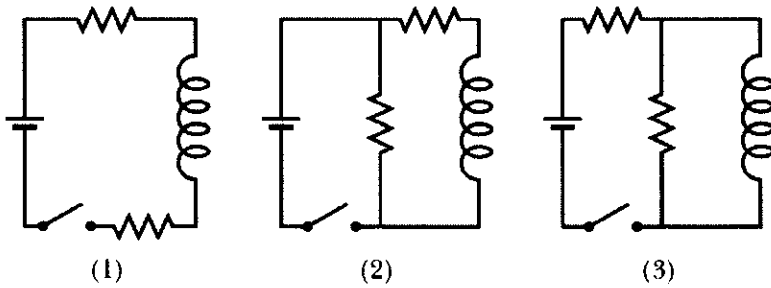c) **[3 points]** In which situation is the magnetic force on the particle in the $-\hat{k}$ direction?
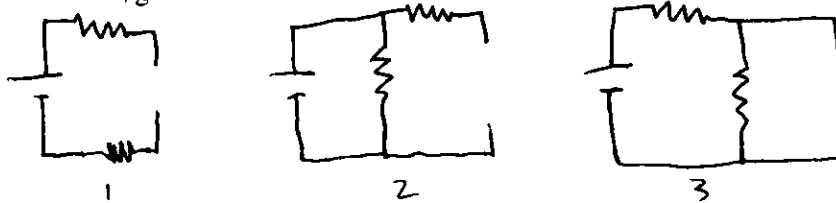
(i)   (a)

(ii)   (b)

(iii)   (c)

(iv)   None of them

4

4. (Question) **[8 points]** The figure shows three circuits with identical batteries, inductors, and resistors.
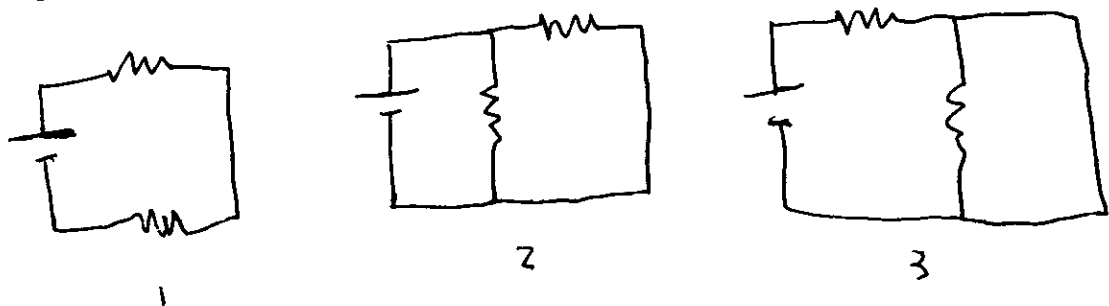

(1)   (2)   (3)

just use that initially an inductor acts like a broken wire + later acts like an ordinary one

a) **[4 points]** Rank the circuits according to the current through the battery just after the switch is closed, greatest first.

1   2   3

$$\Rightarrow \quad 2 > 3 > 1$$

b) **[4 points]** Rank the circuits according to the current through the battery a long time later, greatest first.
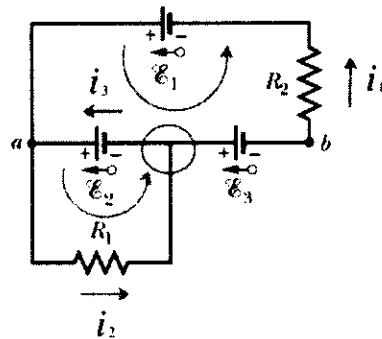

1   2   3

2R resistance $\frac{R}{2}$ resistance   R resistance

$$\Rightarrow \quad 2 > 3 > 1$$

5. (Problem) [23 points] In the figure to the right, $R_1 = 150\ \Omega$, $R_2 = 50\ \Omega$, and the ideal batteries have EMFs $\mathcal{E}_1 = 6.0$ V, $\mathcal{E}_2 = 4.5$ V, and $\mathcal{E}_3 = 4.0$ V. Directions for the currents are indicated.

(a) [7 points] Write down the junction rule formula for the currents at the circled junction.

$$i_1 + i_3 = i_2$$

(b) [8 points] Write down the two loop rule equations for the indicated loops.

$$-i_2 R_1 + \mathcal{E}_2 = 0$$

$$-\mathcal{E}_2 - \mathcal{E}_3 - i_1 R_2 + \mathcal{E}_1 = 0$$

(c) [8 points] Find the current in resistor 1, the current in resistor 2, and the potential difference between points a and b.
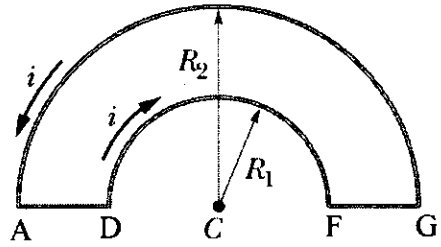
From b, $\dfrac{\mathcal{E}_2}{R_1} = i_2 = \dfrac{4.5\,V}{150\,\Omega} = 0.03\,A$

$\dfrac{\mathcal{E}_1 - \mathcal{E}_2 - \mathcal{E}_3}{R_2} = i_1 = \dfrac{(6 - 4.5 - 4)\,V}{50\,\Omega}$

$= \dfrac{-2.5}{50} = -0.05\,A$

$V_a - \mathcal{E}_2 - \mathcal{E}_3 = V_b{}^6$

$\Rightarrow\ V_a - V_b = \mathcal{E}_2 + \mathcal{E}_3 = 8.5\,V$

6. (Problem) [23 points] As shown in the figure to the right, two semicircular arcs of radii R_1 and R_2 form part of the circuit $ADFGA$ carrying current i.

use Biot-Savart law:
$$d\vec{B} = \frac{\mu_0}{4\pi r^2} i\, d\vec{s} \times \hat{r}$$

a) [7 points] Find an expression for the magnetic field at point C, which is the common center of the semicircular arcs, due to the two straight segments AD and FG. Explain your answer.

so total contribution is zero

For AD, direction of current is $\rightarrow$ + direction of $\hat{r}$ is $\rightarrow$ so the contribution is zero b/c they're aligned

For FG, direction of current is $\rightarrow$ + direction of $\hat{r}$ is $\leftarrow$ so the contribution is zero b/c anti aligned

b) [8 points] Derive an expression for the magnitude of the magnetic field at point C due to the complete circuit $ADFGA$. Express your answers in terms of R_1, R_2, i, and any constants as needed.

contribution of AD & FG is zero, so focus on DF & GA

For DF, going into page + equal to $\dfrac{\mu_0 i \pi}{4\pi R_1} = \dfrac{\mu_0 i}{4 R_1}$

For GA, going out of page + equal to $\dfrac{\mu_0 i \pi}{4\pi R_2} = \dfrac{\mu_0 i}{4 R_2}$

So total is

$$\frac{\mu_0 i}{4}\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

c) [8 points] What is the direction of the net magnetic field at point C?

direction is into the page

7

7. (Problem) [23 points] In the figure, a charged particle moves into a region of uniform magnetic field $\vec{B}$, goes through a half cycle, and then exits that region. The particle is either a proton or an electron (you must determine this). It spends 200 ns in the region.
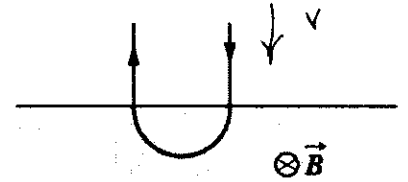
a) [7 points] Is the particle a proton or an electron? Show the work that leads you to the answer.

velocity is $\downarrow$ at beginning

so $\vec{v} \times \vec{B}$ is to the right.

But force is to the left, so it must be an electron $\ominus$

b) [8 points] Calculate the magnitude of the magnetic field $\vec{B}$.

Period for a full circle is $T = \dfrac{2\pi m}{qB}$

but this is a half cycle,

So $\dfrac{T}{2} = \dfrac{\pi m}{qB} = 200\,ns$

So $B = \dfrac{\pi m}{q\,200\,ns} = \dfrac{\pi\left(9.11 \times 10^{-31}\,kg\right)}{\left(1.60 \times 10^{-19}C\right)\left(200\times10^{-9}s\right)} = 8.94 \times 10^{-5}\,T$

c) [8 points] If the particle is sent back through the magnetic field (along the same initial path) but with 3.00 times its previous kinetic energy, how much time does it spend in the field during this trip?

the time spent in the region does not depend on velocity of kinetic energy $= \frac{1}{2}mv^2$,

So time is the same as before

8

$\left(\text{equal to } 200\,ns\right)$