Physics 208: Electricity and Magnetism
Common Exam 3, November 14th 2016

Print your name **neatly**:

First name:																						
Last name:																						

Sign your name:____

Please fill in your Student ID number (UIN): _ _ _ -_ _ - _ _ _ _

Your classroom instructor:____________________ Your section:_________

IMPORTANT

Read these directions carefully:

• You have 75 minutes to complete the exam.

• Formulae are provided on a separate colored sheet. You may NOT use any other formula sheet. ***Please take the formula sheet with you. Do not turn it in.***

• You may use only an SAT approved calculator.

• When calculating numerical values, be sure to keep track of units. Results must include proper units.

• Be alert to the number of significant figures in the information given. Results must have the correct number of significant figures.

• You do not need to show work for the Multiple Choice questions.

• Show your work for Problems 1 to 3. Without supporting work, the answer alone is worth nothing.

• Mark your answers clearly by drawing boxes around them.

• Please write clearly. Neatness counts! You may gain marks for a partially correct calculation if your work can be deciphered.

• If you need additional space to answer a problem, indicate/ mark on the main page of the problem that you are continuing on another page. Staple together all the extra sheets that contain your work to be graded.

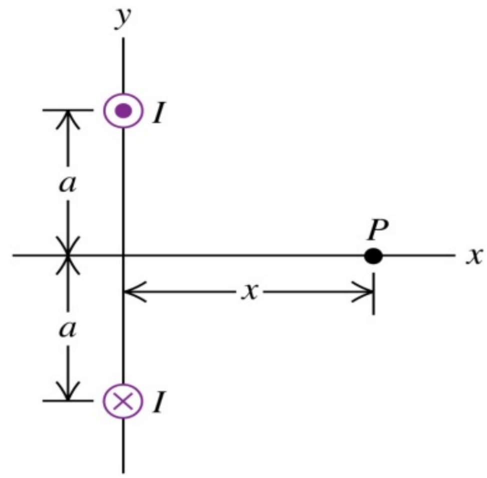
For grading only:

Problem	Score
Multiple Choice	
Problem 1	
Problem 2	
Problem 3	
TOTAL	

Multiple Choice Questions

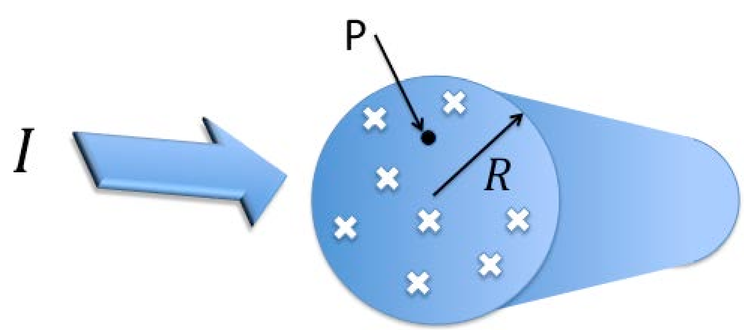
MC1. (5 pts) Two long, straight wires are oriented perpendicularly to the *xy*-plane. They carry currents of equal magnitude I in opposite directions as shown. At point P, the magnetic field due to these currents points in

A.) the positive x-direction.
B.) the negative x-direction.
C.) the positive y-direction.
D.) the negative y-direction.
E.) none of the above



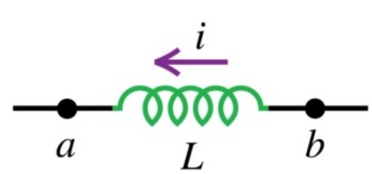
MC2. (5pts) A long, straight, solid wire has radius R. A cross-sectional view is shown here. Current I is flowing down the wire, that is, into the page, and the current is distributed uniformly throughout the cross-section of the wire. At the point P shown, which is **half way** between the centerline of the wire and the top edge, the magnitude of the magnetic field is:

A.) $3\mu_0 I/(4\pi R)$.
B.) $\mu_0 I/(2\pi R)$.
C.) $\mu_0 I/(4\pi R)$.
D.) $\mu_0 I/(8\pi R)$.
E.) 0 .



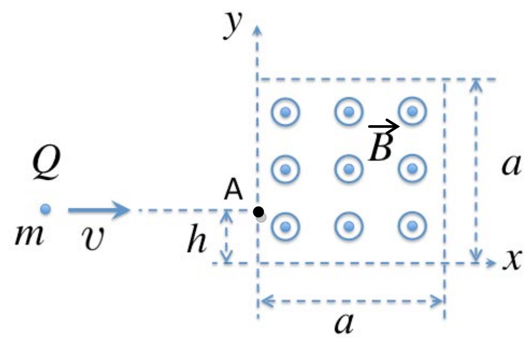
MC3. (5 pts) A current ***i*** flows through an inductor ***L*** in the direction from point ***b*** toward point ***a*** as shown in the figure. There is zero resistance in the wires of the inductor. **If the current is *decreasing*,**

A.) the electric potential is greater at point ***a*** than at point ***b***.
B.) the electric potential is less at point ***a*** than at point ***b***.
C.) the sign of the potential difference depends on the magnitude of ***di/dt*** .
D.) the sign of the potential difference depends on the value of the inductance ***L***.
E.) both C) and D) are correct.



Problem 1 (25 points).

A negatively charged ionized particle of dust of mass m and charge Q (where Q is a negative number) is moving at constant velocity v parallel to the x-axis. The particle enters a rectangular shaped detector which contains a uniform magnetic field B pointing out of the page (that is, along the positive z-axis) and extends between $0 \leq x \leq a$ and $0 \leq y \leq a$ as shown. There is no detectable gravitational effect inside the detector.



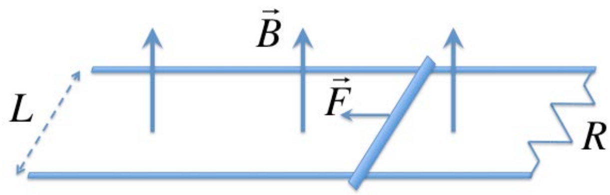
(a) Write an equation for the force acting on the charged particle at the moment when it reaches the point A (x=0, y=h) shown on the diagram. Express your answer in symbols, in terms of m, Q, B, and v. Remember that force is a vector, so give the components, or the magnitude and direction.

(b) Evaluate the coordinates of the point P where the charged particle leaves the magnetic field for the following set of values: m = 20 μg, Q = -1.0 mC, $\vec{v} = \left(1.0\,\frac{\mathrm{km}}{\mathrm{s}}\right)\hat{\imath}$, $\vec{B} = (1.0\ \mathrm{T})\hat{k}$, $a = 10$ cm, $h = 1.0$ cm. *Note:* Be careful with units: 1 cm = 10^{-2} m and 1 micro-gram = 10^{-9} kg.

(c) Sketch the path of this particle inside the magnetic field, and also after it leaves the magnetic field. Justify in few sentences why the path has that shape.

Problem 2 (30 pts)

A metal bar of length ***L*** is pulled to the left by a constant external force ***F***. The bar rides on parallel metal rails connected through a resistance ***R*** as shown in the Figure. The bar and rails have practically no resistance and there is no friction between them. The circuit is in a uniform magnetic field ***B*** that is perpendicular to the plane formed by the rails and bar as shown. The external force causes the bar to move with a velocity ***v*** to the left that is not necessarily constant. The rails and the bar lie in a horizontal plane; this means gravity plays no role here.



(a) Evaluate the induced current through the resistor in terms of some or all given parameters ***L, F, R, B***, and ***v***. Make sure to indicate the direction of this current on the diagram.

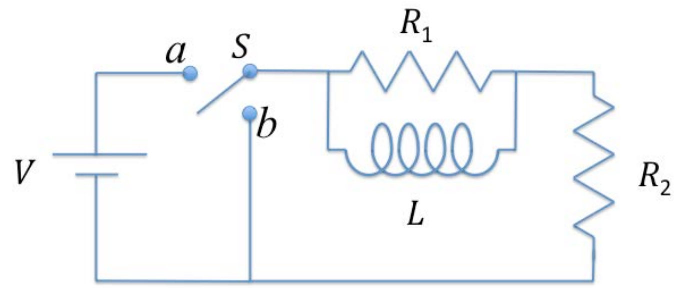
(b) Evaluate the ***magnetic force*** on the bar in terms of some or all given parameters ***L, F, R, B***, and ***v***. Make sure to indicate the direction of this force on the diagram.

(c) Evaluate the ***net force*** on the bar in terms of some or all given parameters ***L, F, R, B***, and ***v***. What is the direction of the ***net force***?

(d) Now assume that the value of the external force is not given but that the bar has a known constant velocity ***v***. Evaluate the rate at which work is done by the external force for this case. Express your answer in terms of the parameters ***L, R, B***, and ***v*** (***F*** is not given here).

Problem 3 (30 pts).

Consider the circuit shown:



a) Write expressions for the currents I_1, I_2, and I_L through the elements R_1, R_2, and L, respectively, at the following three moments in time. In your expression, label the current through resistor R_1 as I_1, the current through resistor R_2 as I_2, and the current through the inductor L as I_L, for each case below. Express all your answers in terms of V, R_1, R_2, L, and numerical factors.

i. Immediately after the switch S is moved to position **a**. Note: The switch was in position **b** for a very long time before being moved to position **a**.

ii. A very long time after the switch is moved to position **a**.

iii. Just after the switch **S** is moved back to position **b**. *Note:* The switch was in position **a** for a very long time before being moved to position **b**.

b) What is the numerical value of the time constant of the circuit with the switch in position **b**? For this question, use the set of numerical values: $V = 9$ V, $R_1 = 100\ \Omega$, $R_2 = 100\ \Omega$, and $L = 10.0$ mH.

Work *neatly*.