Final Exam date: **Period Thirteen**—Friday May 2, 8:00–10:50 AM.

Final Exam location: **Howey L3 and L4** (our usual locations).

Physics 2212G Test form **556** Name _____

Spring 2014

Test 5 Recitation Section (see back of test):_____

A

1) Print your name, test form number (above), and nine-digit student number in the section of the answer card labeled "STUDENT IDENTIFICATION".

2) Bubble your test form number (**ABOVE**) in columns 1-3, skip column 4, then bubble in your student number in columns 5-13.

3) For each free-response question, show all relevant work supporting your answer. **Clearly box or underline your final answer.** "Correct" answers which are not supported by adequate calculations and/or reasoning will be counted wrong.

4) For each multiple-choice question, select the answer most nearly correct, **circle this answer on your test**, and bubble it in on your answer card. **Show all relevant work on your quiz.**

5) Be prepared to present your Buzzcard as you turn in your test. Scores will be posted to WebAssign after they have been been graded. **Quiz grades become final when the next quiz is given.**

6) You may use a simple scientific calculator capable of logarithms, exponentials, and trigonometric functions. **Programmable engineering calculators with text or graphical capabilities are not allowed. Wireless devices are prohibited.**

Numerical Constants:

$k = 8.99\times10^{9}\ \mathrm{N\cdot m^2/C^2}$

$\varepsilon_o = 8.85\times10^{-12}\ \mathrm{C^2/N\cdot m^2}$

$\mu_o = 4\pi\times10^{-7}\ \mathrm{T\cdot m/A}$

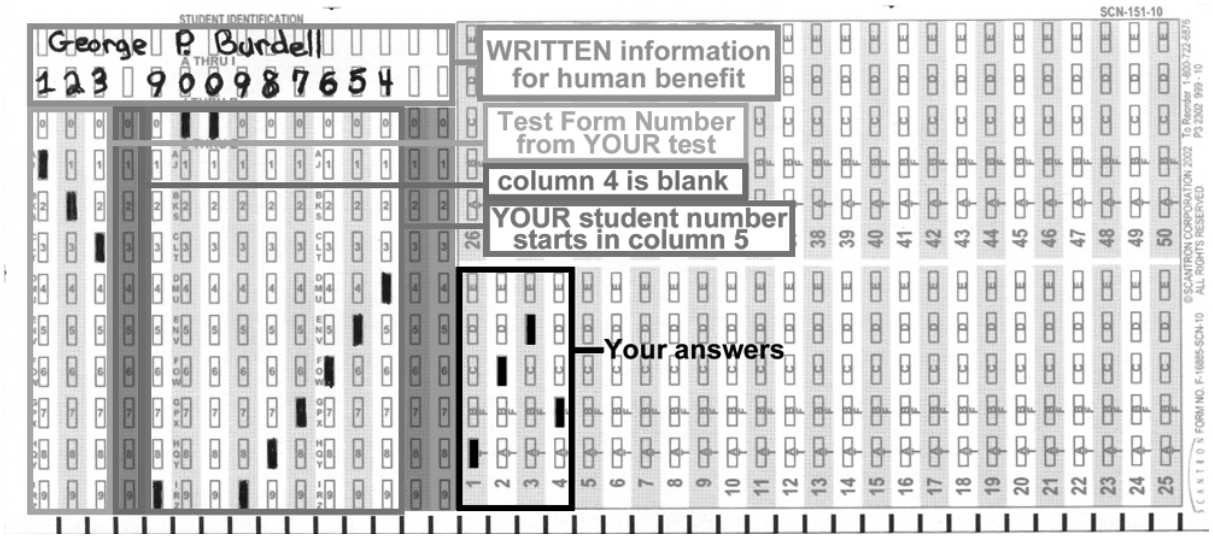
$e = 1.60\times10^{-19}\ \mathrm{C}$

$g = 9.81\ \mathrm{m/s^2}$

$m_e = 9.11\times10^{-31}\ \mathrm{kg}$

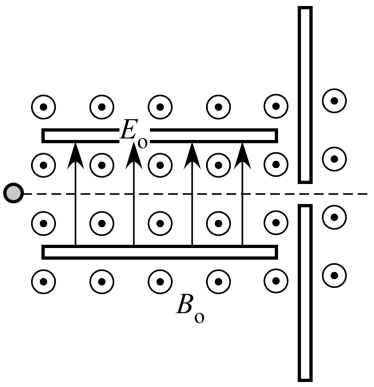
$m_p = 1.67\times10^{-27}\ \mathrm{kg}$

Your test form is: 556



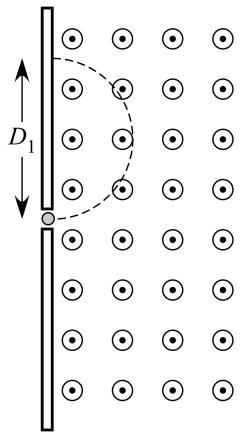
The following problem will be hand-graded. <u>*Show all your work for this problem*</u>*. Make no marks and leave no space on your answer card for it.*

[I] A negatively-charged hydrogen ion (mass m, charge $-e$) is travelling through a *velocity selector* that consists of: (1) a uniform magnetic field directed out of the page (magnitude B_o), and (2) a charged capacitor generating an upward-directed electric field (magnitude E_o). When the hydrogen ion enters the apparatus from the left with a horizontally-directed speed v_1, it passes straight through without deflection.



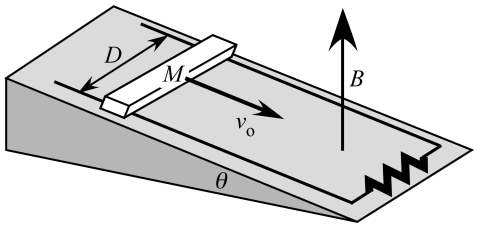
(A) *(8 points)* A doubly-positive helium ion (mass $4m$, charge $+2e$) is fired horizontally through the same apparatus with unknown speed v_2, and *also* experiences no deflection. Determine v_2, expressed as a fraction or multiple of v_1.

(B) *(8 points)* After emerging from the capacitor, both charges continue to travel through the uniform magnetic field. The trajectory of the first ion is displayed; it strikes the screen at a distance D_1 above its entry point, after an elapsed time Δt_1. Where and when will the second ion strike the screen (relative to D_1 and Δt_1)?



The following problem will be hand-graded. <u>*Show all your work for this problem*</u>*. Make no marks and leave no space on your answer card for it.*

[II] A ramp lies in a vertically upward magnetic field of magnitude B. The surface of the ramp is inclined at an angle θ relative to the horizontal. A bar of mass M slides down frictionless conducting rails that are separated by a distance D. The rails are connected at the bottom of the ramp by a load resistance R.

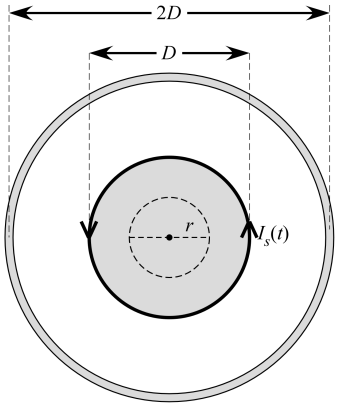


(A) *(8 points)* Find an expression for the induced emf in the bar, when it is sliding down the rails with a speed v_o. Express your answer entirely in terms of the parameters listed above.

(B) *(12 points)* Find an expression for the *terminal speed* with which the bar will slide down the rails. (That is, if released from rest, what maximum speed will it attain?) Express your answer in terms of the parameters listed above, as well as the <u>symbols</u> for any necessary physical constants (such as e, g, μ_o or ε_o).

The following problem will be hand-graded. *Show all your work for this problem.* *Make no marks and leave no space on your answer card for it.*

[III] The figure at right displays an end-on view of a solenoid of diameter *D*. The solenoid has *N* turns of wire, extending over a length *L*. It is surrounded by a copper ring of diameter 2*D*, having resistance *R*. There is a time-dependent, counterclockwise current in the solenoid given by the expression:



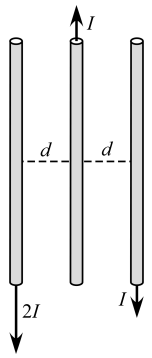
$$I_s(t) = I_1\left(\frac{t}{T} - \frac{t^2}{T^2}\right) \quad \text{for} \quad 0 \le t \le T$$

(A) *(8 points)* Determine the direction of the induced current in the copper ring, at all times during the interval $t \in [0, T]$. Specifically, when (if ever) the induced current is clockwise? Counterclockwise? *Zero*?

(B) *(12 points)* Consider a point inside the solenoid, at a distance $r = D/4$ from the axis. What is the maximum induced electric field at point *r* (magnitude only; ignore direction) during the interval $t \in [0, T]$?

Question value 8 points

(1) Three long wires are aligned parallel to one another, with a uniform spacing d between each wire. Each wire carries the current indicated in the figure. Which (if any) of the wires experiences a net magnetic force to the left?



(a) Only the wire in the center.

(b) None of the wires.

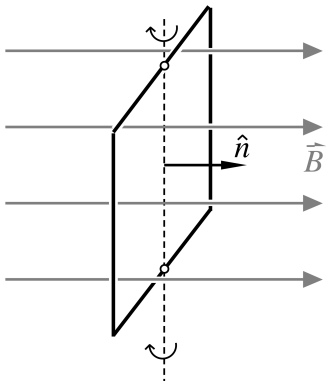
(c) Both the wires on the left and right.

(d) Only the wire on the left.

(e) Only the wire on the right.

Question value 8 points

(2) A simple electrical generator consists of a square loop of wire rotating in a uniform magnetic field. The loop begins with its normal aligned parallel to the field, and rotates about a vertical axis with period T. At what time during the rotation will you detect the maximum induced current flowing clockwise around $\hat{n}$ (i.e. clockwise when viewed from a perspective where $\hat{n}$ points directly at you)?



(a) At time $T/4$.

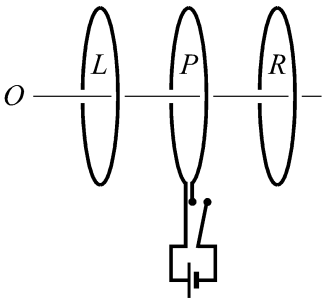
(b) At time $T/2$.

(c) At time $t = 0$.

(d) At time T.

(e) At time $3T/4$.

The next two questionsboth involve the following situation:
Primary loop *P* is coaxial with nearby loops *L* (on the left) and *R* (on the right). If the switch in the primary circuit closed, current will flow clockwise around loop P, as seen by an observer at position *O*.



Question value 4 points

(3) If the initially *closed* switch is opened, what will be the nature of the induced current in loop *R* (as seen by an onbserver at *O*)?

(a) There will be a steady, clockwise current in loop *R*, for as long as the switch remains closed.

(b) There will be a brief, counterclockwise current in loop *R*, at the moment the switch closes.

(c) There will be a brief, clockwise current in loop *R*, at the moment the switch closes.

(d) There will be a steady, counterclockwise current in loop *R*, for as long as the switch remains closed.

(e) There will be no current in loop *R*.

Question value 4 points

(4) If the initially *open* switch is closed, what will be the nature of the induced current in loop *L* (as seen by an observer at *O*)?

(a) There will be a steady, clockwise current in loop *L*, for as long as the switch remains closed.

(b) There will be a brief, counterclockwise current in loop *L*, at the moment the switch closes.

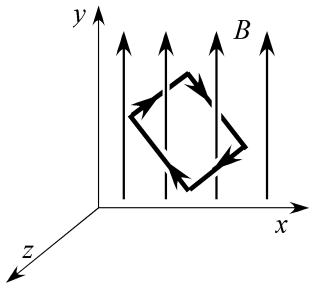
(c) There will be a steady, counterclockwise current in loop *L*, for as long as the switch remains closed.

(d) There will be a brief, clockwise current in loop *L*, at the moment the switch closes.

(e) There will be no current in loop *L*.

Question value 8 points

(5) The loop of wire placed in the uniform magnetic field shown at right will experience



(a) a torque about the negative *x*-axis.

(b) a torque about the positive *x*-axis.

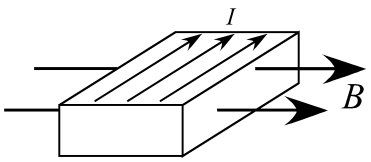
(c) *zero* torque, because the field is uniform.

(d) a torque about the negative *z*-axis.

(e) a torque about the positive *z*-axis.

Question value 8 points

(6) A slab of conducting material lies in a rightward-directed magnetic field, and carries a current directed into the page. Which two faces of the slab will develop a Hall voltage across them, and in particular, which of those two faces will be at the higher Hall potential?



(a) The front face will be at a higher Hall potential than the back.

(b) There will be no Hall potential, in this conficguration.

(c) The bottom face will be at a higher Hall potential than the top.

(d) The top face will be at a higher Hall potential than the bottom.

(e) The right face will be at a higher Hall potential than the left.

PHYS 2212 GHJ Recitation TA and Room Assignments

Tests will be returned in recitation, in the week *after* the test. In order to ensure that you receive your test back as soon as possible, please enter your recitation section from the table above (G01–G10) on the front of this test.

	Clough 123	Clough 125	Clough 127	Clough 131
WEDNESDAY				
2:05 pm			G01 Sharma, Kamal	G06 Roveto, Jonathan
3:05 pm	G05 Barrow, Kirk			
4:05 pm			G02 Sharma, Kamal	
5:05 pm			G09 Sharma, Kamal	
THURSDAY				
2:05 pm	G03 Barrow, Kirk			
3:05 pm				G07 Barrow, Kirk
4:05 pm		G10 Sharma, Kamal	G04 Barrow, Kirk	
5:05 pm	G08 Sharma, Kamal			