

PHYS 272 Fall 2007  
Monday, December 10, 2007

Final Exam - A

There are two parts to the final exam, this machine-graded part and a separate portion that you will turn in to be graded by hand.

Machine Answer Sheet:

Using a pencil, fill in Last Name, First Name, & Middle Initial, plus your 10-digit Purdue University ID number. Enter Instructor (Hirsch), Course (PHYS 272), Date (12/10/07), and Test (3). **You must include your Signature. Fill in circle "A" for Test Form.**

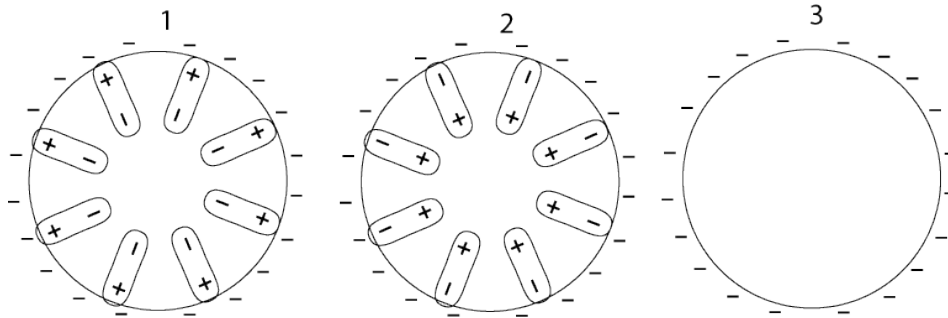
Hand-Graded Sheet:

Enter your Name, Signature, PUID, and circle your Recitation Section.

When finished with both parts, bring them to the front of the classroom, show your Purdue ID card to the Instructor, and turn in the machine-graded answer sheet and the hand-graded answer sheet at the same time. **These two parts together are worth 200 points total.** Your grades will appear in the CHIP grade book in a few days.

Problem 1 [6 points]

A solid plastic ball has been rubbed all over with a piece of wool so that negative charge is uniformly spread over its surface. Which diagram best shows the polarization of molecules inside the ball?



Problem 2 [6 points]

A capacitor with plates separated by 2 mm has one plate at a potential of 300 Volts and its other plate at a potential of 250 Volts. What is the magnitude of the electric field between the plates of the capacitor?

1. 550 N/C
2.  $2.5 \times 10^4$  N/C
3. 50 N/C
4.  $2.75 \times 10^3$  N/C
5. 0 N/C

Problem 3 [6 points]

A fully charged  $100 \mu\text{F}$  ( $=10^{-4}$  F) capacitor has a potential difference across it of 9 Volts. It is then connected to a resistor of  $10 \Omega$ . How long will it take for the current through the resistor to decrease to  $1/2$  of its initial value?

1.  $3.0 \times 10^{-4}$  seconds
2.  $6.9 \times 10^{-4}$  seconds
3.  $0.5 \times 10^{-3}$  seconds
4.  $5.0 \times 10^{-3}$  seconds

Problem 4 [6 points]

Referring to the circuit in Problem 3, what is the total energy dissipated by the resistor during the entire time the capacitor has been discharging, i.e., from  $t=0$  until that moment when the current through the resistor is  $1/2$  of its original value?

1.  $3.0 \times 10^{-3}$  J
2.  $8.1 \times 10^{-4}$  J
3.  $2.0 \times 10^{-3}$  J
4.  $4.1 \times 10^{-3}$  J

Problem 5 [6 points]

A certain 10-volt battery delivers 20 amperes when short-circuited by connecting one end of a conducting wire to the positive terminal and the other end of the wire to the negative terminal. How much current does the battery deliver when a 1.5-ohm resistor is added in series with the wire?

1. 5 A
2. 6.7 A
3. 20 A
4. 2.9 A
5. 26.7 A

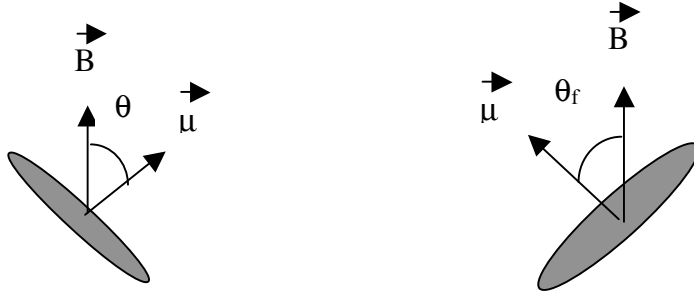
Problem 6 [6 points]

A 1.5 V AA battery is connected to two light bulbs of different resistances that are in series with one another. Bulb 1 has a resistance of  $10 \Omega$  and bulb 2 has a resistance of  $20 \Omega$ . The bulbs have filaments of the same length and conductivity. Through which filament is the drift speed of the conduction electrons the greater?

1. Bulb 1
2. Bulb 2
3. Neither, because the length and conductivity of the filaments is the same so that the drift speed is the same.
4. Not enough information

Problem 7 [6 points]

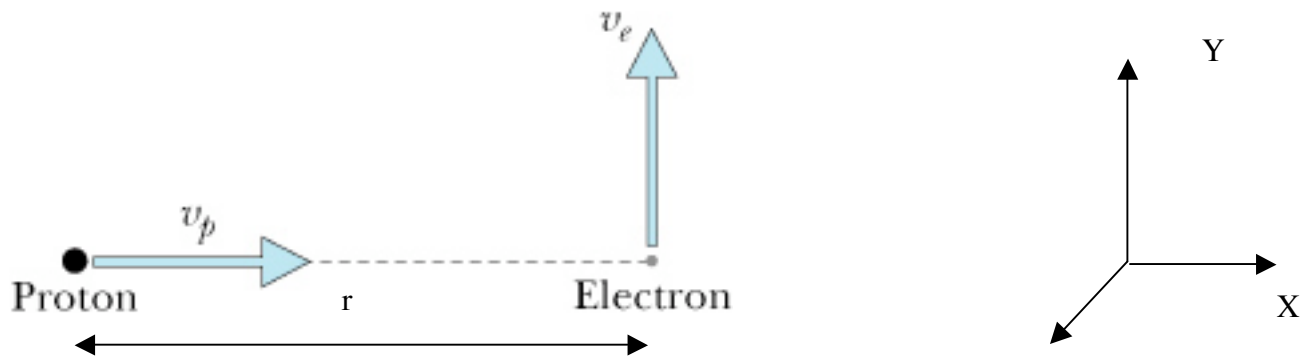
A magnetic dipole with  $\mu=2 \text{ A}\cdot\text{meter}^2$  is initially oriented as shown in the figure below in a uniform magnetic field  $B = 0.5 \text{ T}$ ,  $\theta_i = 30$  degrees. An external agent exerts a torque on the dipole, changing its orientation to the final configuration where the angle between the magnetic field and the dipole moment is now  $\theta_f = 45$  degrees. The change in magnetic potential energy,  $U_f - U_i$  is



1. 0.259 Joules
2. -0.259 Joules
3. 1.57 Joules
4. -1.57 Joules
5. 0.159 Joules
6. -0.159 Joules

Problem 8 [6 points]

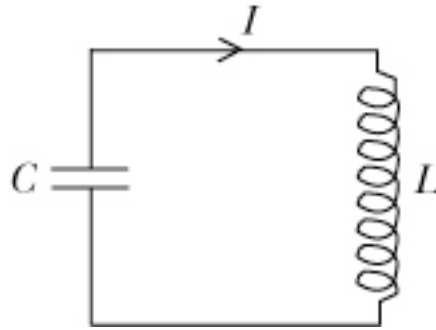
A proton and an electron are moving at a particular instant as shown in the figure below. What is the magnetic force on the proton due to the electron when the proton is at the location shown in the diagram below?



1.  $(\frac{\mu_0 v_e v_p e^2}{4\pi r^2})\hat{z}$
2.  $-(\frac{\mu_0 v_e v_p e^2}{4\pi r^2})\hat{z}$
3.  $(\frac{\mu_0 v_e v_p e^2}{4\pi r^2})\hat{y}$
4.  $-(\frac{\mu_0 v_e v_p e^2}{4\pi r^2})\hat{y}$
5.  $(\frac{\mu_0 v_e v_p e^2}{4\pi r^2})\hat{x}$
6.  $-(\frac{\mu_0 v_e v_p e^2}{4\pi r^2})\hat{x}$

Problem 9 [6 points]

Just prior to  $t = 0$ , the capacitor ( $C = 1 \times 10^{-3} F$ ) in the circuit below has a charge of  $1 \mu C$ . The inductor has inductance,  $L = 1 \times 10^{-6} H$ . At  $t=0$ , a switch (not shown) is closed, allowing current to flow around the circuit. What is the magnitude of the current when the charge on the capacitor has fallen to  $0.5 \mu C$ ? [Hint:  $Q(t) = Q_0 \cos(\frac{1}{\sqrt{LC}}t)$ ]



1.  $2.7 \times 10^{-2} A$
2.  $1.0 \times 10^{-3} A$
3.  $5.5 \times 10^{-2} A$
4.  $7.4 \times 10^{-3} A$
5.  $7.5 \times 10^{-4} A$

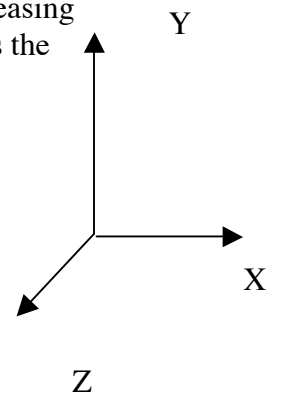
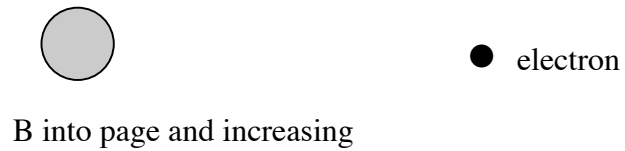
Problem 10 [6 points]

Referring to the above circuit, at the instant when the charge on the capacitor has fallen to  $0.5 \mu C$ , what is the magnitude of the rate of change in current?

1.  $5 A/s$
2.  $50 A/s$
3.  $100 A/s$
4.  $10 A/s$
5.  $500 A/s$
6. Not enough information

Problem 11 [6 points]

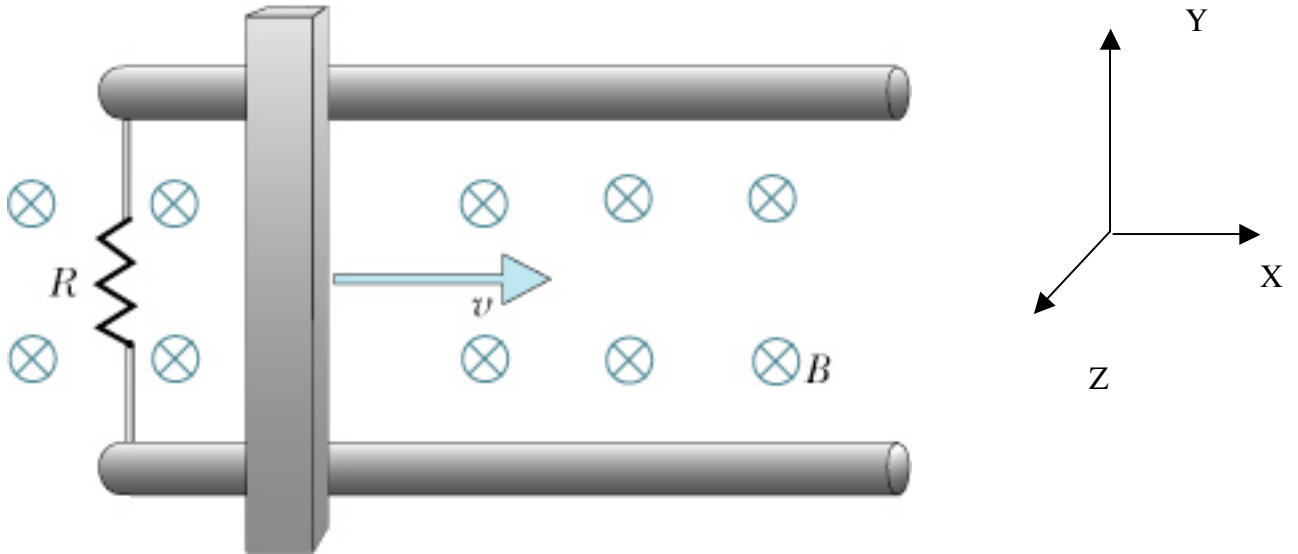
In the grey area there is a magnetic field into the page ( $-z$ -direction) that is increasing with time. There is negligible magnetic field elsewhere in this diagram. What is the direction of the force on the electron?



1.  $+x$
2.  $-x$
3.  $+y$
4.  $-y$
5.  $+z$
6.  $-z$
7. There is no force on the electron.

Problem 12 [6 points]

A slidewire generator is made with a wire that makes good contact with conducting rails as shown below. The rails are connected to a resistor. There is a uniform magnetic field into the page ( $-z$  direction) throughout the region of the apparatus. You pull the wire towards the right with a constant force, and the wire moves with a constant speed in the direction shown. What is the direction of the magnetic force on the slidewire?

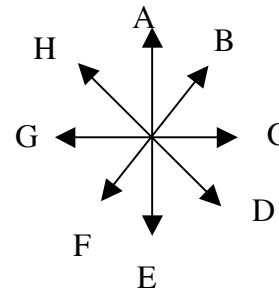
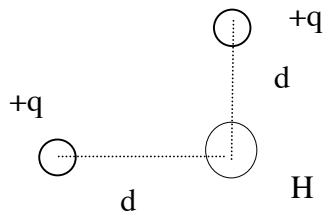


1.  $+x$
2.  $-x$
3.  $+y$
4.  $-y$
5.  $+z$
6.  $-z$
7. There is no magnetic force on the slidewire.



Problem 13 [6 points]

A neutral hydrogen atom is near two charged particles as shown. What is the direction of the net force on the hydrogen atom?



1. A
2. B
3. C
4. D
5. E
6. F
7. G
8. H
9. There is no force on the hydrogen atom

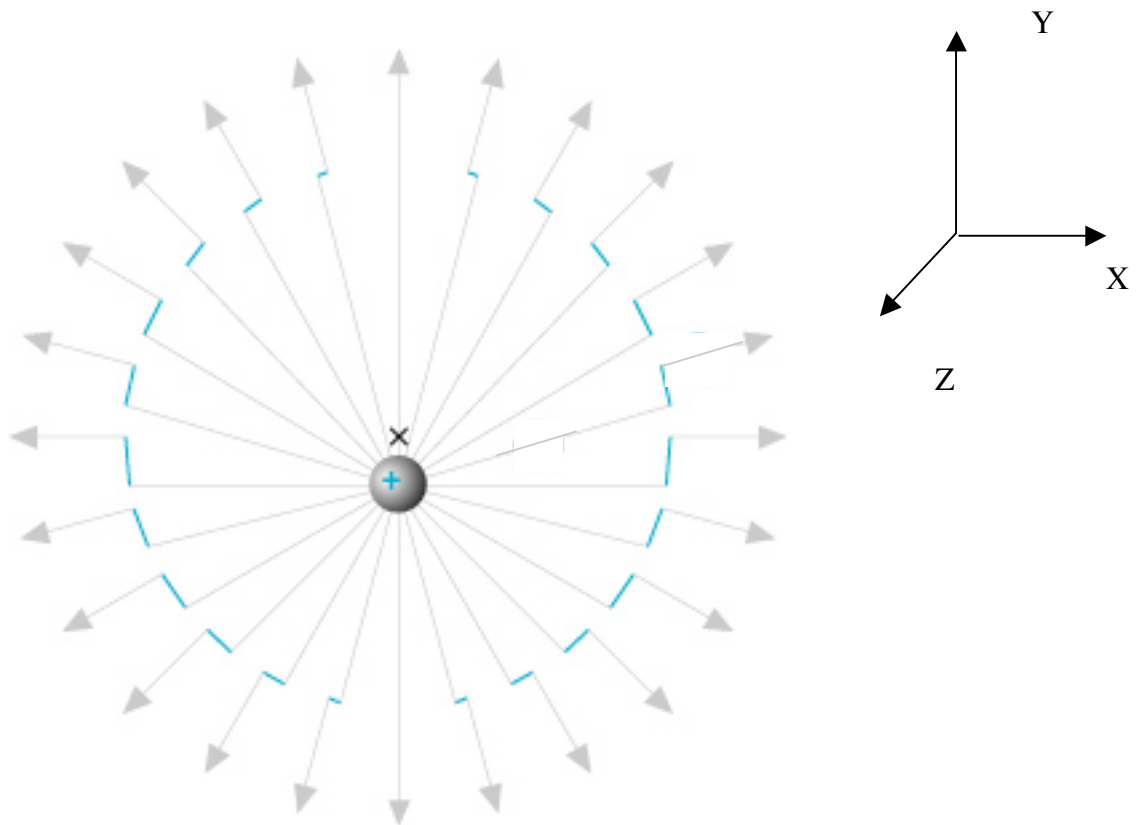
Problem 14 [6 points]

In the problem above, what is the direction of the induced dipole moment of the hydrogen atom?

1. A
2. B
3. C
4. D
5. E
6. F
7. G
8. H

Problem 15 [6 points]

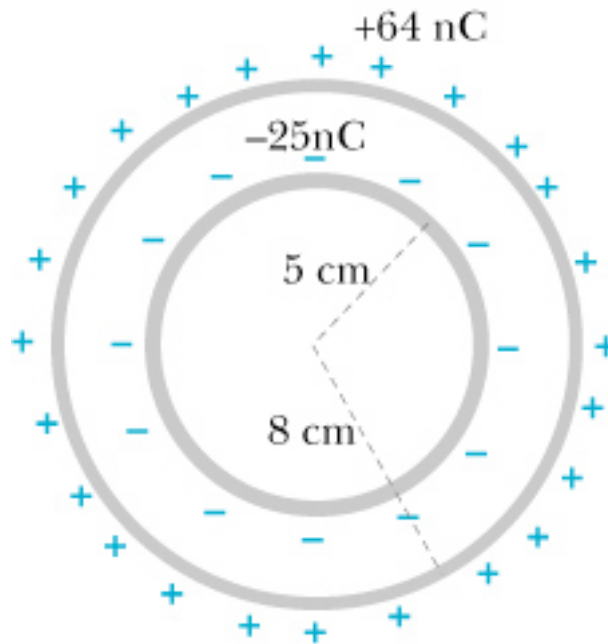
The figure below shows a proton initially at rest that is briefly accelerated in the  $-y$  direction and then moves at a constant velocity. Suppose that “electric field detectors” are placed around this proton in a sphere of radius  $r$  when the electromagnetic pulse is emitted. Which detector would measure the largest radiative electric field as the pulse passes the detector?



1. The detector on the x-axis
2. The detector on the y-axis
3. The detector on the z-axis
4. Detectors on the x and z axes would both measure the largest radiative field.
5. All of the detectors would measure the same magnitude of radiative electric field.

Problem 16 [6 points]

A thin plastic spherical shell of radius 5 cm has a uniformly distributed charge of  $-25 \text{ nC}$  on its outer surface. A concentric thin plastic spherical shell of radius 8 cm has a uniformly distributed charge of  $+64 \text{ nC}$  on its outer surface. What is the magnitude of the electric field 10 cm from the center?



1.  $3.51 \times 10^4 \text{ V/m}$
2.  $3.51 \text{ V/m}$
3.  $0 \text{ V/m}$
4.  $0.351 \text{ V/m}$
5.  $3.51 \times 10^{-2} \text{ V/m}$

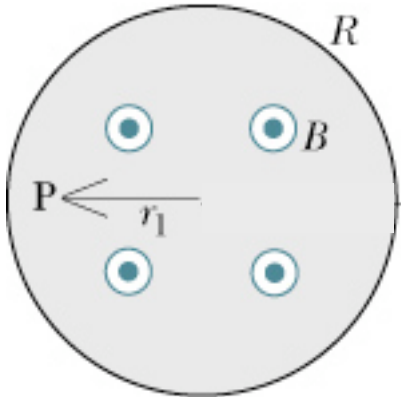
Problem 17 [6 points]

Referring to problem 16, what is the electric potential a distance 10 cm from the center of the spheres? (Assume that the potential at infinity is zero.)

1.  $3.51 \text{ V}$
2.  $35.1 \text{ V}$
3.  $351 \text{ V}$
4.  $3510 \text{ V}$
5.  $3.51 \times 10^4 \text{ V}$

Problem 18 [6 points]

The magnetic field is uniform and out of the page inside a circle of radius  $R$ . The magnetic field is essentially zero outside the circular region. The magnitude of the field as a function of time is  $(B_0 + bt^3)$ .  $B_0$  and  $b$  are positive constants and  $t = \text{time}$ . What is the magnitude of the induced electric field at location P, a distance  $r_1$  to the left of the center ( $r_1 < R$ )?



1.  $\pi r_1^2 b t^2$
2.  $\frac{3}{2} \pi r_1^2 b t^2$
3.  $\frac{3}{2} r_1 b t^2$
4.  $\frac{(B_0 + b t^3) R^2}{2 r_1}$
5.  $\frac{3 r_1^2 b t^2}{2 R}$