PH2200 Practice Exam II — *Summer 2003*

INSTRUCTIONS

1. Write your name and student identification number on the answer sheet and mark your recitation section.

2. Please cover your answer sheet at all times.

3. This is a closed book exam. You may use the PH2200 formula sheet that is included with the exam.

4. Equations may not be stored in calculators, nor may calculators be exchanged.

5. Record your answers in the form A, B, C, etc, on the answer sheet.

6. This exam consists of 10 concept questions worth four points each and four problems having a total of 15 parts. The problem parts are equally weighted: each is worth four points. The total number of points on the exam is 100.

7. If you have any questions during the exam, please raise your hand and wait for assistance.

Concept Questions: Each question has a single correct answer and is worth four points.

1. Many computer keyboard buttons are constructed of parallel-plate capacitors. When a key is pushed down, the soft insulator between the movable plate and the fixed plate is compressed. When a key is pressed down, the capacitance

   (A) increases.
   (B) decreases.
   (C) remains the same.
   (D) changes in a way that we cannot determine because the complicated electric circuit connected to the keyboard may cause a change in ΔV .

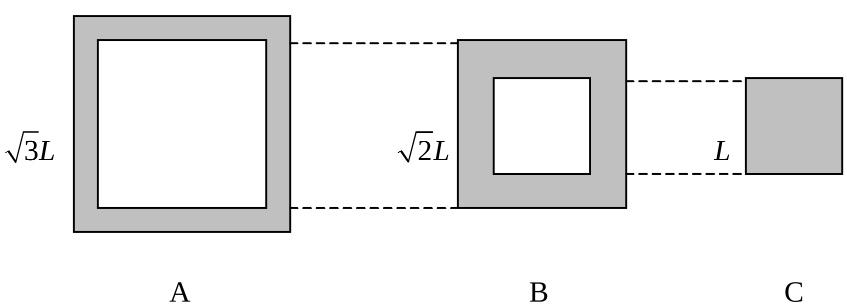
2. A dielectric is inserted between the plates of a fully charged capacitor that is connected to a battery. The dielectric completely fills the space between the plates. Compared to what it was before the dielectric was inserted, the electric field between the plates is

   (A) larger in magnitude.
   (B) the same.
   (C) smaller in magnitude.
   (D) the same in magnitude, but opposite in direction.

3. Which of the following represents the emf of a battery?

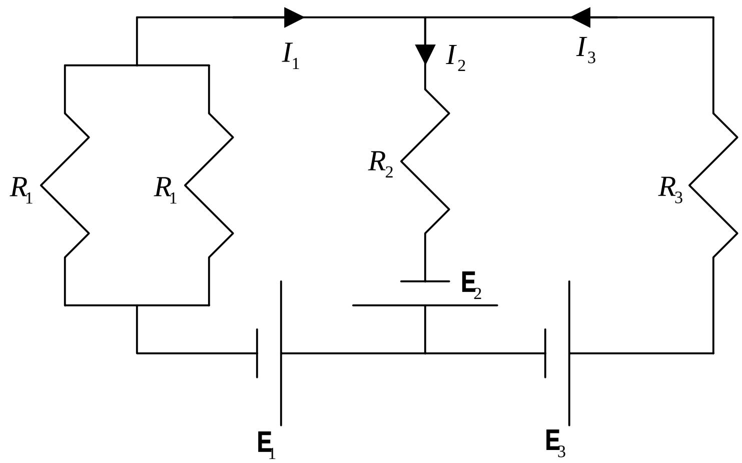
   (A) the chemical energy stored in the battery
   (B) the terminal voltage of the battery when no current flows
   (C) the maximum current that the battery can supply
   (D) the amount of charge the battery can deliver
   (E) the chemical energy of the battery divided by the net charge of the battery

4. The figure below shows cross sections through three long conductors of the same length and material, with square cross-sections of edge as shown. Conductor B will fit snugly within conductor A, and conductor C will fit snugly within conductor B. Rank the three conductors according to their end-to-end resistance, greatest first.



   (A) A - B - C (Conductor A has the greatest resistance, and conductor C has the least resistance.)
   (B) A - C - B
   (C) B - A - C
   (D) B - C - A
   (E) C - A - B
   (F) C - B - A
   (G) All three have the same resistance.

The following two questions pertain to the circuit to the right.



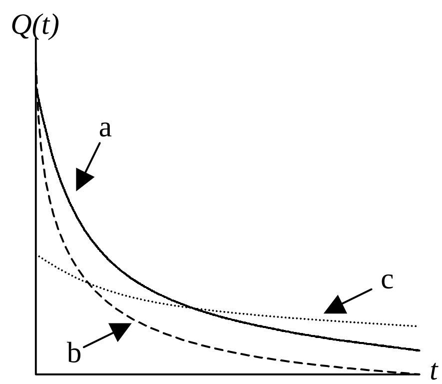
5. Which of the following equations is a valid Kirchhoff current equation for the circuit?

   (A) $I_1 + I_2 + I_3 = 0$
   (B) $I_1 + I_2 = I_3$
   (C) $I_1 + I_3 = I_2$
   (D) $I_2 + I_3 = I_1$
   (E) none of the above

6. Which of the following equations is **not** a valid Kirchhoff voltage equation for the circuit?

   (A) $+\mathcal{E}_1 - \mathcal{E}_2 + I_2R_2 + I_1R_1 = 0$
   (B) $+\mathcal{E}_1 + \mathcal{E}_3 - I_3R_3 + \frac{1}{2}I_1R_1 = 0$
   (C) $+\mathcal{E}_2 + \mathcal{E}_3 - I_3R_3 - I_2R_2 = 0$

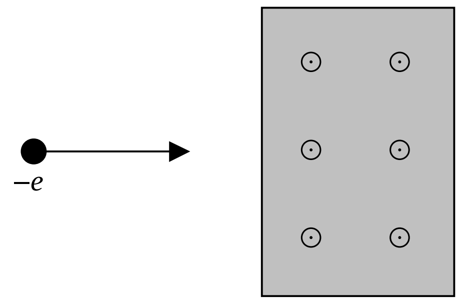
7. The figure below shows plots of charge on the plates of a capacitor as a function of time for three capacitors that discharge (separately) through the same resistor.



   Rank the plots according to the capacitances of the capacitors, greatest first.

   (A) a - b - c (Circuit a has the greatest capacitance, and circuit c has the least capacitance.)
   (B) (a = b) - c
   (C) c - (a = b)
   (D) c - a - b

8. An electron moving to the right enters a region of uniform magnetic field that points out of the paper. Upon entering the magnetic field, the electron will initially be



(A) deflected out of the plane of the paper.
(B) deflected into the plane of the paper.
(C) deflected upward.
(D) deflected downward.
(E) undeflected in its motion.

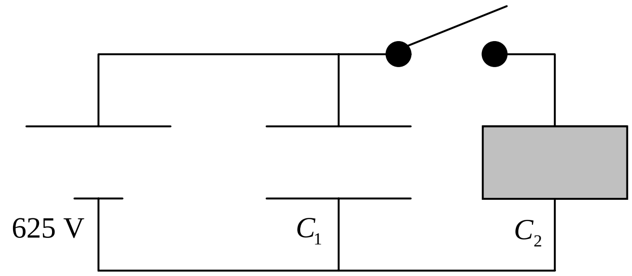
9. A proton, projected perpendicularly into a magnetic field with a certain velocity, follows a circular path. An electron is then projected into the same region with the same initial velocity as the proton. If the electron is to follow the exact same circular path as the proton, should the direction of the magnetic field be kept the same or reversed, and should the magnitude of the magnetic field be increased or decreased?

(A) keep the same field direction and increase its magnitude
(B) keep the same field direction and decrease its magnitude
(C) reverse the field direction and increase its magnitude
(D) reverse the field direction and decrease its magnitude
(E) none of the above

10. In a velocity selector, electric and magnetic fields are perpendicular to one another, and the electric and magnetic forces on a charged particle cancel if $\vec{E} + \vec{v} \times \vec{B} = 0$. Which of the following conditions on the direction of the particle's velocity $\vec{v}$ can result in no net electromagnetic force on the particle, assuming the electric and magnetic fields are both non-zero?

(A) $\vec{v}$ parallel to $\vec{E}$.
(B) $\vec{v}$ parallel to $\vec{B}$.
(C) $\vec{v}$ parallel to $\vec{E} \times \vec{B}$.
(D) All of the above.
(E) None of the above.

Problems: Each part of each problem is worth four points.



1. As shown in the circuit to the right, a potential difference of 625 V is applied across an air-filled parallel plate capacitor having capacitance $C_1 = 2.36\times10^{-11}$ F and plate area $A = 4.00\times10^{-3}$ m^2. The dielectric constant of air is 1.00. Consider the switch in the circuit to be open as shown for parts (a) and (b).

(a) Find the charge on capacitor C_1.

(A) 1.25×10^{-8} C
(B) 1.48×10^{-8} C
(C) 1.68×10^{-8} C
(D) 1.79×10^{-8} C
(E) 1.93×10^{-8} C

(b) Determine the separation between of the plates of capacitor C_1.

(A) 1.20×10^{-3} m
(B) 1.35×10^{-3} m
(C) 1.50×10^{-3} m
(D) 1.65×10^{-3} m
(E) 1.90×10^{-3} m

Capacitor C_2 is uncharged when the switch is closed. Capacitor C_2 is a parallel-plate capacitor having the same plate area and plate separation as capacitor C_1, and it is completely filled with polystyrene having a dielectric constant of 2.56.

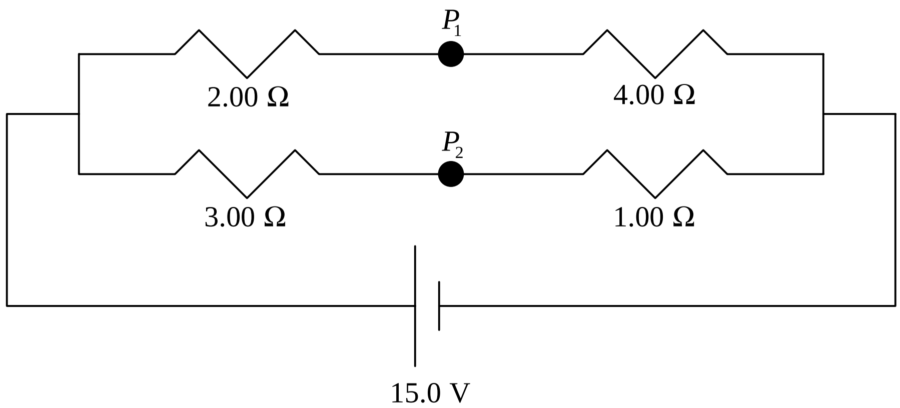
(c) How much charge passes through the switch after it is closed??

(A) 3.17×10^{-8} C
(B) 3.31×10^{-8} C
(C) 3.43×10^{-8} C
(D) 3.64×10^{-8} C
(E) 3.78×10^{-8} C

(d) What is the equivalent capacitance of the two capacitors in the circuit?

(A) 5.90×10^{-11} F
(B) 6.60×10^{-11} F
(C) 7.30×10^{-11} F
(D) 8.40×10^{-11} F
(E) 9.60×10^{-11} F

2. Consider the circuit shown below.



(a) Calculate the equivalent resistance of the circuit.

(A) 2.00 Ω
(B) 2.20 Ω
(C) 2.40 Ω
(D) 2.60 Ω
(E) 2.80 Ω

(b) Calculate the current through the 4.00 Ω resistor.

(A) 2.00 A
(B) 2.50 A
(C) 3.00 A
(D) 3.50 A
(E) 4.00 A

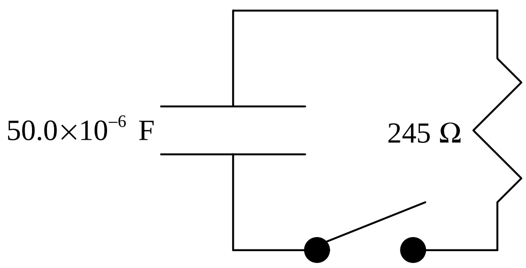
(c) What is the power delivered by the source of emf?

(A) 87.9 W
(B) 93.8 W
(C) 99.2 W
(D) 103.0 W
(E) 111.4 W

(d) What is the magnitude of the electric potential difference between points P_1 and P_2 in the circuit?

(A) 0 V
(B) 3.50 V
(C) 6.25 V
(D) 9.75 V
(E) 15.0 V

3. A defibrillator passes a brief burst of current through the heart to restore normal beating. In one such defibrillator, a 50.0×10^{-6} F capacitor is charged to 6.00×10^{3} V. Paddles are used to make an electrical connection to the patient's chest. The electrical resistance of the patient (from paddle to paddle) is $245\ \Omega$. A pulse of current lasting 1.00×10^{-3} s partially discharges the capacitor, *i.e.*, the switch is closed for 1.00×10^{-3} s and then opened.



(a) What is the time constant of this circuit?

(A) 1.23×10^{-2} s
(B) 1.59×10^{-2} s
(C) 1.81×10^{-2} s
(D) 2.01×10^{-2} s
(E) 2.34×10^{-2} s

(b) What is the energy initially stored in the capacitor?

(A) 500 J
(B) 600 J
(C) 700 J
(D) 800 J
(E) 900 J

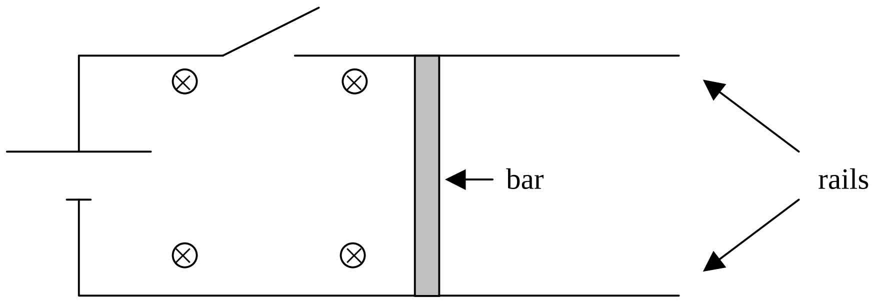
(c) What is the initial current through the patient (resistor)?

(A) 19.2 A
(B) 24.5 A
(C) 29.9 A
(D) 33.2 A
(E) 37.0 A

(d) How much energy is dissipated in the patient (resistor) during the 1.00×10^{-3} s that the switch is closed?

(A) 91.0 J
(B) 106 J
(C) 121 J
(D) 136 J
(E) 151 J

4. A type of projectile launcher is shown in the figure below. A large current moves in a closed loop composed of fixed rails, a battery and a very light bar touching the rails. The loop lies in a horizontal plane. A magnetic field of 1.70 T is perpendicular to the plane of the circuit. The bar has a length of 0.200 m, a mass of 1.52×10^{-3} kg, and a resistance of $4.00\times10^{-3}\ \Omega$. The bar is made of copper which has a resistivity of $1.70\times10^{-8}\ \Omega\cdot$m. When the switch is closed, the bar experiences an acceleration of 4.50×10^{2} m/s^2.



(a) What is the cross-sectional area of the bar?

(A) 6.72×10^{-7} m^2
(B) 7.13×10^{-7} m^2
(C) 7.96×10^{-7} m^2
(D) 8.50×10^{-7} m^2
(E) 9.43×10^{-7} m^2

(b) In which direction does the bar move when the switch is closed?

(A) to the right
(B) to the left
(C) out of the page, *i.e.*, the bar jumps off the fixed rails

(c) When the switch is closed, what is the current through the bar?

(A) 1.00 A
(B) 2.01 A
(C) 3.02 A
(D) 4.03 A
(E) 5.04 A

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Name: KEY ID# ____

Concept Questions

1. A
2. B
3. B
4. G
5. C
6. A
7. D
8. C
9. D
10. C

Subtotal 1: 10

Problems

1. (a) B
   (b) C
   (c) E
   (d) D
2. (a) C
   (b) B
   (c) B
   (d) C

Subtotal 2: 8

3. (a) A
   (b) E
   (c) B
   (d) D
4. (a) D
   (b) A
   (c) B

Subtotal 3: 7

Exam Score: 25