Physics 152 Roster No.:________________________

Score:_________<u>24 pts. possible</u>_______

FALL 2004 Midterm Exam #1, Part A

Exam time limit: 50 minutes. You may use a calculator and both sides of ONE sheet of notes, *handwritten only*. Closed book; no collaboration. For multiple choice questions, circle the letter of the one best answer (unless more than one answer is asked for). Ignore gravity and relativistic effects in all problems, unless told otherwise.

$k_e = 8.988 \times 10^9$ N·m^2/C^2 $e = 1.602 \times 10^{-19}$ C $m_e = 9.109 \times 10^{-31}$ kg

$\varepsilon_0 = 1/4\pi k_e = 8.854 \times 10^{-12}$ C^2/(N·m^2) $m_p = 1.673 \times 10^{-27}$ kg

1. a. (2 pts.) At what **distance** from a helium nucleus (2 protons and 2 neutrons, packed together like a "point charge") does the electric potential have a value of 109 V? (Assume that the electric potential is zero at $r = \infty$.)

A. 2.64×10^{-15} m D. 2.64×10^{-12} m
B. 2.64×10^{-14} m E. 2.64×10^{-11} m
C. 2.64×10^{-13} m F. 2.64×10^{-10} m

b. (1 pt.) The **direction** of the **electric field** at the location in part (a) is:

A. toward the nucleus
B. away from the nucleus
C. 90° to both *A* and *B*

c. (1 pt.) How much electric **potential energy** would be gained by an electron moved from a location very far away from the nucleus to the location in part (a)?

A. 54.3 eV D. 2.64 keV
B. 109 eV E. 5.28 keV
C. 217 eV F. 166 MeV

2. (2 pts.) Suppose that you were building a homemade capacitor out of two parallel sheets of metal foil. Which TWO of the following would **increase** its **capacitance**? ***Circle TWO:***

A. increasing the area of the sheets
B. increasing the spacing between the sheets
C. increasing the thickness of the sheets of foil
D. inserting a dielectric material
E. using a higher-voltage battery to charge up the capacitor

3. a. (2 pts.) While plugged into a standard 120.-volt-rms household circuit in Hawaii, how much **current** (rms) does a 100.-watt light bulb draw?

A. 0.667 A D. 1.00 A
B. 0.720 A E. 1.25 A
C. 0.833 A F. 1.44 A

b. (2 pts.) Suppose you take the same light bulb, fly to Tahiti (where the household voltage is 240. V rms), and screw the light bulb into a socket. Assuming that the bulb's resistance is the same in Tahiti as it was in Hawaii, how much average **power** does the light bulb dissipate in Tahiti?

A. 25.0 W D. 144 W
B. 50.0 W E. 200. W
C. 69.4 W F. 400. W

c. (2 pts.) The rms value of the AC voltage in Tahiti is 240. V. What is the **peak voltage** of every cycle?

A. 240 V D. 289 V
B. 267 V E. 318 V
C. 280. V F. 339 V

4. (6 pts.) **True or False (T or F):**

a. _______ Conductors have abundant charges that can move freely.

b. _______ An ideal insulator has a resistivity of zero.

c. _______ The net charge on any ideal conductor is always equal to zero.

d. _______ The electric field everywhere inside an ideal conductor is zero.

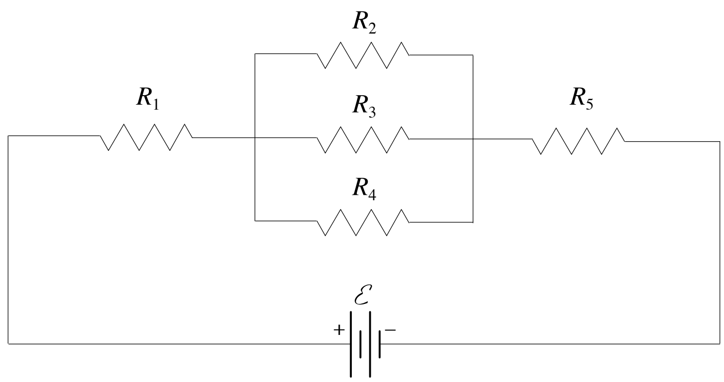
e. _______ The electric potential everywhere inside an ideal conductor is zero.

f. _______ Any closed Gaussian surface contained completely inside a conductor has a net electric flux of zero.

5. (1 pt.) Which one of the following is **NOT** a good **conductor**?

A. gold
B. iron
C. mercury
D. glass
E. plasma (entirely ionized gas)
F. salt water

6. Five identical resistors (R_1, R_2, R_3, R_4, R_5) of *equal* resistance R are connected to a DC battery of emf $\mathcal{E}$, as shown.



a. (2 pts.) The **equivalent resistance** of the combination of all 5 resistors is:

A. $\frac{1}{5}R$
B. $\frac{2}{5}R$
C. $\frac{5}{3}R$
D. $\frac{7}{3}R$
E. $3R$
F. $5R$

b. (1 pt.) Which one of the following is **TRUE**?

A. The currents through R_1, R_3, and R_5 are all equal.
B. The currents through R_2, R_3, and R_4 are all equal.
C. The currents through all 5 resistors are equal.

c. (1 pt.) Which one of the following is **TRUE**?

A. The voltage drops across R_1, R_3, and R_5 are all equal.
B. The voltage drops across R_2, R_3, and R_4 are all equal.
C. The voltage drops across all 5 resistors are equal.

d. (1 pt.) Which one of the following is **TRUE**?

A. The power dissipated by R_1 is greater than the power dissipated by R_2.
B. The power dissipated by R_1 is less than the power dissipated by R_2.
C. The power dissipated by R_1 is equal to the power dissipated by R_2.

BONUS: (2 pts.) The **voltage drop** across $\boldsymbol{R_2}$ is: *(This one is challenging… come back to it if you have time.)*

A. $\frac{1}{15}\mathcal{E}$
B. $\frac{1}{9}\mathcal{E}$
C. $\frac{1}{7}\mathcal{E}$
D. $\frac{1}{5}\mathcal{E}$
E. $\frac{1}{3}\mathcal{E}$
F. $\mathcal{E}$

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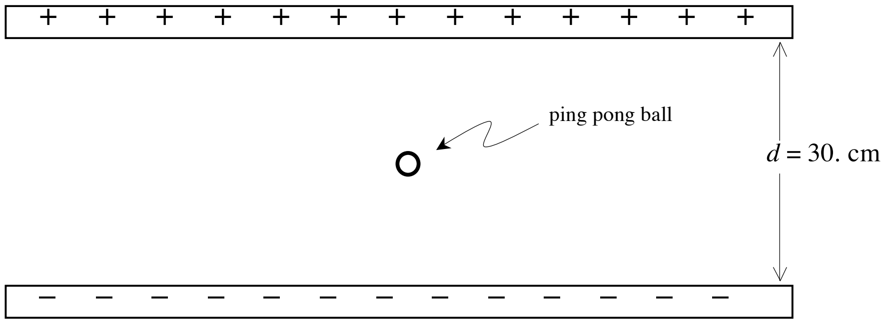
Score:______**26 pts. possible**______

FALL 2004 Midterm Exam #1, Part B

Show your work on all free-response questions. Be sure to use **proper units** and **significant figures** in your final answers. Ignore gravity and relativistic effects in all problems, unless told otherwise.



1. Above is an edge-on view of two charged parallel metal plates of infinite area, separated by 30. cm.

a. (2 pts.) On the above diagram, **sketch** the **electric field lines** between the plates. (Ignore "fringes.") Include directional **arrowheads**.

b. (3 pts.) Suppose that the plates are maintained at a potential difference of 45 kV. Calculate the magnitude of the **electric field** between the plates.

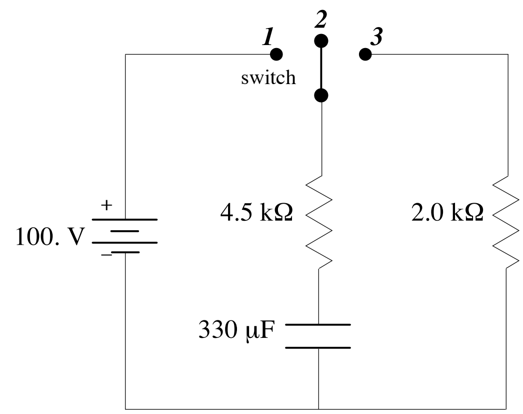
c. (5 pts.) A 1.0-gram ping pong ball carrying some net charge is released at rest at a point exactly halfway between the plates. Suppose that the electric field is exactly strong enough to counteract the ball's weight, so that the ball remains stationary after release. (*Recall:* weight = $m \cdot g$, and $g = 9.8\ \mathrm{m/s^2}$.) Calculate the **net charge** on the ball, and determine the **charge's sign**.

d. (2 pts.) What is the number of excess or missing **electrons** on the ping pong ball?

e. (1 pt.) Suppose the 45-kV difference between the plates is created by a DC voltage supply, which has a dial that allows you to adjust the voltage. As you **increase** the **voltage**…

A. The ball accelerates upward. B. The ball accelerates downward. C. The ball remains at rest.

2. Consider the circuit shown at right. The capacitor is initially uncharged. First, the switch is moved to position (1), and is left there for a long period of time. Then, the switch is moved to position (3).

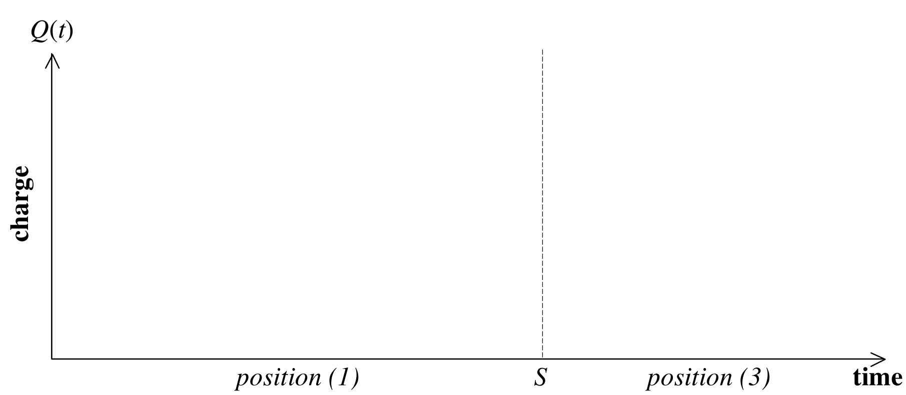


a. (5 pts.) What is the **potential difference across the capacitor** 5.0 seconds after the switch is moved to position (1)? Show your work.

b. (1 pt.) What is the **potential difference across the capacitor** after the switch has been in position (1) for a very long period of time? (You do NOT need to show your work.)

c. (4 pts.) What is the **current** through the 2.0-kΩ resistor immediately after the switch touches position (3)? Show your work.

d. (2 pts.) Qualitatively graph the magnitude of the **charge on the capacitor**, starting at the moment when the switch touches position (1). "*S*" corresponds to the time when the switch is quickly moved from position (1) to position (3). (You do NOT need to label the axes with numerical values.)



e. (1 pt.) Which one of the following best describes the **direction** of the **current** through the 4.5-kΩ resistor?

A. Upward while switch is in position (1), and upward while switch is in position (3).
B. Upward while switch is in position (1), and downward while switch is in position (3).
C. Downward while switch is in position (1), and upward while switch is in position (3).
D. Downward while switch is in position (1), and downward while switch is in position (3).