Physics 152 Roster No.:________________________

Score: ________25 pts. possible________

FALL 2003 Midterm Exam #1, Part A

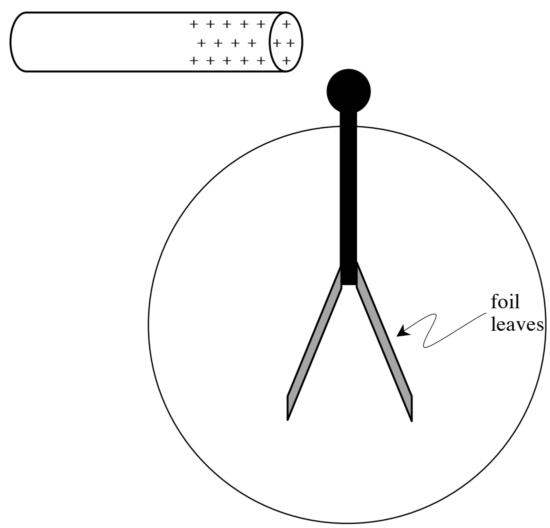
Exam time limit: 50 minutes. You may use a calculator and both sides of ONE sheet of notes, *handwritten only*. Closed book; no collaboration. For multiple choice questions, circle the letter of the one best answer (unless more than one answer is asked for). Ignore gravity and relativistic effects in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

1. An electroscope, like the one shown at right, is initially neutral before a positively-charged rod is brought near its top.



a. What is the **net charge** on **the foil leaves only** while a positively-charged rod is held nearby *without touching* the electroscope's top?

A. positive
B. negative
C. neutral

b. What is the **net charge** on the **foil leaves** after the positively-charged rod is *touched* to the top of the electroscope and then removed?

A. positive
B. negative
C. neutral

c. Which one of the following is normally TRUE for an electroscope?

A. Spread-out leaves have net *positive* charge; leaves together have net *negative* charge.
B. Spread-out leaves have net *negative* charge; leaves together have net *positive* charge.
C. Spread-out leaves have net *positive or negative* charge; leaves together have net *neutral* charge.
D. Spread-out leaves have net *neutral* charge; leaves together have net *positive or negative* charge.
E. Spread-out leaves have net *neutral* charge; leaves together are net *oppositely*-charged leaves.

2. All of the following are TRUE about **conductors** EXCEPT:

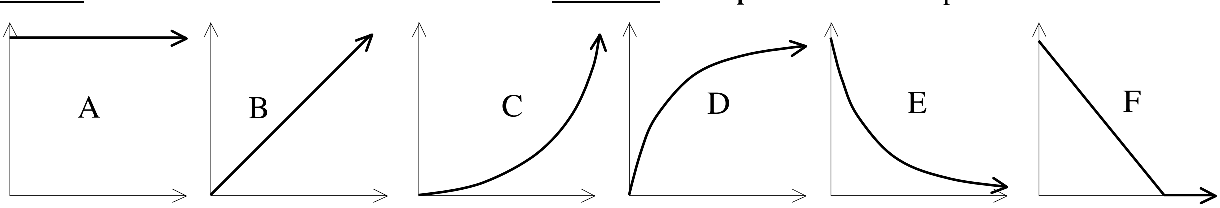
A. Most metals are good conductors.
B. No work is required for charges (usually electrons) to move throughout an ideal conductor.
C. **E** (electric field) is always zero inside any conductor.
D. Net charge on a charged conductor always moves to the center of the conductor's interior.

3. An initially uncharged capacitor C is connected in series with a resistor R and a battery V_0. At the instant that the circuit is completed ($t = 0$), the capacitor begins to charge.

a. (4 pts.) **Which graph** best represents how each quantity varies with time as the capacitor charges? (You may use each graph *more than once*, or *not at all*.)

________ the **charge** on one capacitor plate ________ the **potential difference** across the capacitor

________ the **current** in the circuit ________ the **capacitance** of the capacitor



b. (2 pts.) Suppose a different capacitor C_d is used in part (a) *instead* of C. C_d is identical to C in every way except that its dielectric constant κ is 5 times greater than C's. Which **TWO** of the following are **greater** for C_d than for C?

A. the final ($t = \infty$) charge on each plate
B. the initial ($t = 0$) current in the circuit
C. the final potential difference across the capacitor
D. the final energy stored in the capacitor

4. For a recent demonstration in class, your instructor connected a 30.-millifarad capacitor to a 6.0-volt battery. After the capacitor was fully charged, your instructor disconnected the capacitor from the battery.

a. (2 pts.) When fully charged, how much **charge** was present on each plate of the capacitor?

A. 20. μC D. 9.2 mC
B. 38 μC E. 45 mC
C. 420 μC F. 180 mC

b. (2 pts.) Then your instructor (unwisely) touched the wire from one side of the capacitor to the other, creating a big spark. How much **energy** was released in the spark? (Assume that all of the energy stored in the capacitor just prior to the spark was released.)

A. 760 μJ D. 0.54 J
B. 8.8 mJ E. 42 J
C. 92 mJ F. 1.8 kJ

5. Two *unequal* point charges, Q_A and Q_B, are fixed in space. The electrostatic force felt by Q_A is exactly 100 N, pointing to the left.

a. What is the electrostatic **force** on Q_B?

A. 100 N to the left
B. 100 N to the right
C. 100 N, but cannot determine direction from information given
D. to the right, but cannot determine magnitude from information given
E. cannot determine magnitude *or* direction from information given

b. What is the **sign** of the charge Q_B?

A. positive
B. negative
C. cannot determine from the information given

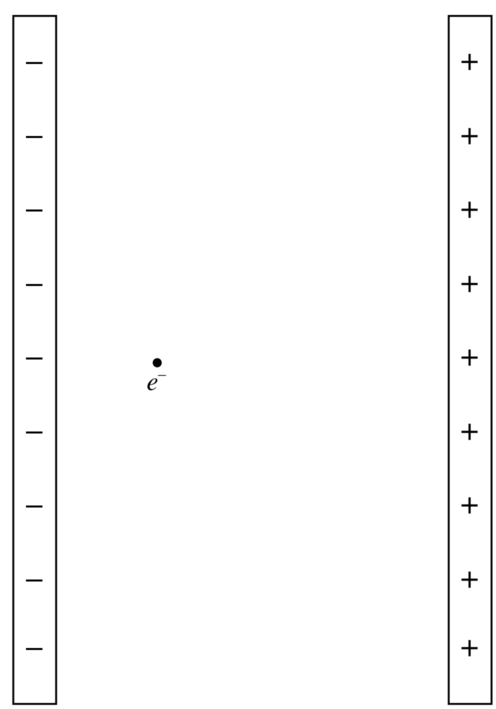
c. If *both* Q_A and Q_B are *doubled* in charge, what is the new electrostatic **force** on Q_A?

A. 141 N C. 283 N E. 1600 N
B. 200 N D. 400 N F. 10,000 N

d. If INSTEAD of part (c), Q_A and Q_B are separated to *five times* their original distance, what is the new electrostatic **force** on Q_A?

A. 4 N C. 20 N E. 50 N
B. 6.25 N D. 25 N F. 71 N

6. Two oppositely-charged, parallel plates are located 20. cm apart. (Assume that the **E**-field between the plates is ideally uniform — ignore "fringes.") The negatively-charged plate is at a potential of 0 V, while the positive plate is at 3200 V.



a. (2 pts.) What is the **electric field strength** between the plates?

A. zero D. 8.0×10^3 N/C
B. 2.4×10^2 N/C E. 1.6×10^4 N/C
C. 3.6×10^3 N/C F. 3.2×10^4 N/C

b. The **direction** of the **E field** between the plates is…

A. to the left D. toward bottom of page
B. to the right E. into the page
C. toward top of page F. out of the page

c. (2 pts.) An electron is released from rest, 5.0 cm away from the negative plate. When the electron finally strikes the positive plate, how much **kinetic energy** does it possess?

A. 800 eV D. 2.4 keV
B. 1.2 keV E. 3.2 keV
C. 1.6 keV F. 3.6 keV

d. (2 pts.) **Sketch and label equipotential lines** for **800 V, 1600 V,** and **2400 V** on the diagram at right.

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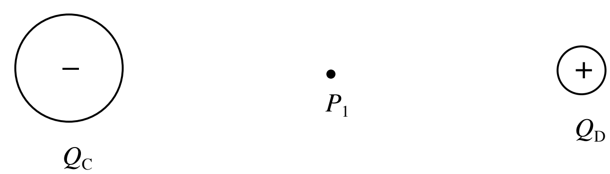
FALL 2003 Midterm Exam #1, Part B

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. Q_C and Q_D are two point charges, –16.0 nC and +4.0 nC, respectively, fixed 1.0 meter apart. Point P_1 is located exactly halfway between them.

a. (3 pts.) Sketch **E-field lines** surrounding the charges below. Include **arrowheads** to indicate direction.



(8 pts.) You may solve (b) and (c) in whichever order you wish, but *show your work* clearly:

b. Calculate the **magnitude and direction** of the **total E-field** at point P_1.

c. If an electron were placed at point P_1, what would be the **magnitude and direction** of the electrostatic **force** on it?

d. (1 pt.) Imagine a line passing through the centers of Q_C and Q_D and extending outward to either side. Find the ONE position along this line where an electron would feel a **net electrostatic force** of **zero**. Do NOT solve for the exact position; just **mark its approximate location on the page with a point labeled "P_2"**. (*Hint*: P_2 is not necessarily located between Q_C and Q_D.)

2. Household appliances can be represented simply as *resistors*, all connected in *parallel* across the same 120.-volt-rms AC source when they are all plugged into the same circuit.

a. (2 pts.) **Draw a schematic circuit diagram, at right**, of 3 appliances labeled R_1, R_2, and R_3, all connected to the same AC voltage source.

b. (4 pts.) Suppose that the appliances have the following average power consumptions:

R_1: halogen lamp $P_1 = 500.$ W
R_2: fan $P_2 = 250.$ W
R_3: toaster oven $P_3 = 1350$ W

Calculate the **total rms current** drawn by all 3 appliances from the voltage source at the same time. (There is a quick way to do this, and a slow way… whichever you choose, show your work clearly.)

c. (1 pt.) Based on what you have learned about household appliances and circuits, would you consider your answer to part (b) to be **a safe amount of current**? **Why or why not**?

d. (3 pts.) Which one appliance has the **lowest resistance**? Show your work/justify your answer.

e. (3 pts.) As accurately as possible, **graph** what household 60-Hz, 120.-volt-rms **AC voltage** looks like as a function of time. **Label the vertical axis** numerically with volts [V]. (The heavy tick marks on the horizontal axis are positioned 1/120th of a second apart.)