Name _____KEY______

Physics 161 Lab Time ________________

Exam 3 - Electrostatics

April 14, 2011

- This is a closed book examination.
- You may use a 3x5 index card that you have made with any information on it that you would like. You must have your name, lab section and the date on your index card.
- There is extra scratch paper available.
- Please fill out the Scantron sheet completely
  - Include your test code.
  - Include your Dragon ID
  - Include your name
- Mark your exam and include explanations where needed. This will help you learn from your exam as well as provide any verification of your scantron sheet.
- Please make sure to fill out each "Problem Solving Sheet" completely
  - Include your test code
  - Include your Dragon ID
  - Include your name
  - Include your lab time
- Your explanation/work for the worked problems is worth ¾ of the points. You must use a separate "Problem Solving Sheet" for each problem.

A general reminder about problem solving:

1. Visualize - draw a picture
2. Pick a coordinate frame
3. Create a simplified picture – if appropriate
   a. Schematic with vectors and free body diagrams
   b. Energy level diagrams
   c. Wave pictures with multiple time frames (cartoon panels)
4. Write down what you know – create separate columns for different directions
5. Write down what you don't know and/or what you want to know
6. List mathematical relationships
7. Combine mathematical formulas, Simplify and Solve
8. Check your answer – Is it reasonable? Are the units correct?

- Show all work!

Unless otherwise specified, assume:

$k_o = 9 \cdot 10^9 \frac{Nm^2}{C^2}$

$q_e = -1.602 \cdot 10^{-19}\, C$

$m_e = 9.11 \cdot 10^{-31} kg$

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1. The voltage is doubled across a resistor. What happens to the current?
   A. The current increases by two times (doubles)
   B. The current decreases by one half
   C. The current does not change
   D. The current increases by four times
   E. The current decreases by one quarter

$V = IR$

2. The voltage is doubled across a resistor. What happens to the resistance?
   A. The resistance increases by two times (doubles)
   B. The resistances decreases by one half
   C. The resistance does not change
   D. The resistance increases by four times
   E. The resistance decreases by one quarter

Resistance is purely geometric... $R = \frac{\rho L}{A}$

3. What happens to the resistance of a wire if you double its radius but keep its length and resistivity constant?
   A. The resistance increases by two times (doubles)
   B. The resistances decreases by one half
   C. The resistance does not change
   D. The resistance increases by four times
   E. The resistance decreases by one quarter

$R = \frac{\rho L}{A}$

4. What happens to the resistance of a wire if you double its length but keep its area and resistivity constant?
   A. The resistance increases by two times (doubles)
   B. The resistances decreases by one half
   C. The resistance does not change
   D. The resistance increases by four times
   E. The resistance decreases by one quarter

$R = \frac{\rho L}{A}$

5. The voltage is doubled across a resistor. What happens to the power?
   A. The power increases by two times (doubles)
   B. The power decreases by one half
   C. The power does not change
   D. The power increases by four times
   E. The power decreases by one quarter

$P = IV = \frac{V^2}{R}$

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6. A positive charge is placed in front of a "goal". Where should a negative charge be placed if you want the positive charge forced "into" the net?
   A. Behind the positive charge.
   B. Between the goal and the net.
   C. Behind the net.
   D. Not possible to apply a force to the positive charge.
   E. Placement depends on the size of the two charges.

$$F = \frac{k\, q_2 q_1}{r^2}\hat{r}$$

7. A 15 pF capacitor is charged to 150 V. How much energy is stored in this capacitor?
   A. $1.69 \cdot 10^{-7}\ J$
   B. $1.69 \cdot 10^{-20}\ J$
   C. $8.45 \cdot 10^{-8}\ J$
   D. $3.38 \cdot 10^{-7}\ J$
   E. Can not be determined – you need the charge.

$$Energy = \tfrac{1}{2}QV = \tfrac{1}{2}CV^2$$

8. What is the capacitance of a large spherical conductor of diameter d = 15 cm?
   A. $1.67 \cdot 10^{-9}\ F$
   B. $8.33 \cdot 10^{-10}\ F$
   C. $1.67 \cdot 10^{-11}\ F$
   D. $8.33 \cdot 10^{-12}\ F$
   E. $4.17 \cdot 10^{-12}\ F$

$$C = \frac{r}{k}$$

9. How much work is done moving a charged object, q = -55.5 μC, from 15 volts to 55 volts?
   A. 2.22 mJ
   B. 0 mJ
   C. -2.22 mJ
   D. -3.05 mJ
   E. -0.83 mJ

$$PE = q\Delta V$$

10. What is the voltage when you are 15 cm away from a point charge q = 42.6 μC?
    A. 17.0 MV
    B. 2.56 MV
    C. 1.28 MV
    D. 109 V
    E. 284 μV

$$V = \frac{k\, q}{r}$$

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The next five questions involve two charges placed near each other. The first charge, $q_1 = 2.3\ \mu C$, is placed at the origin while the second charge, $q_2 = 7.2\ \eta C$, is placed at x = 10 cm and y = 0 cm.

11. Where would you place a negative charge so it would have a zero net force on it?
   A. Not possible since it would always be attracted towards the positive charges.
   B. Place to the left of the first charge (x < 0 cm).
   C. Place between the two charges.
   D. Place to the right of the second charge (x > 10cm).
   E. Place anywhere since it is attracted to both charges.

$\boxed{\text{Balance the forces from each charge on the new charge…}}$

12. What is the force exerted on the first charge, q_1?
   A. $F = 0.015\ N\ \hat{x}$
   B. $F = -0.015\ N\ \hat{x}$
   C. $F = 6480\ N\ \hat{x}$
   D. $F = -2.07 \cdot 10^{6}\ N\ \hat{x}$
   E. $F = -1.07 \cdot 10^{-10}\ N\ \hat{x}$

$$\boxed{F = \frac{k\, q_2 q_1}{r^2}\hat{r}}$$

13. What is the force exerted on the second charge, q_2?
   A. $F = 0.015\ N\ \hat{x}$
   B. $F = -0.015\ N\ \hat{x}$
   C. $F = -6480\ N\ \hat{x}$
   D. $F = 2.07 \cdot 10^{6}\ N\ \hat{x}$
   E. $F = 1.07 \cdot 10^{-10}\ N\ \hat{x}$

$$\boxed{F = \frac{k\, q_2 q_1}{r^2}\hat{r}}$$

14. If you double the first charge, $q_1 = 4.6\ \mu C$, what happens to the force exerted on it from the second charge?
   A. The force decreases by 4.
   B. The force decreases by 2.
   C. The force increases by 2.
   D. The force increases by 4.
   E. The force does not change (q_2 is unchanged).

$$\boxed{F = \frac{k\, q_2 q_1}{r^2}\hat{r}}$$

15. If you move the first charge to x = 20 cm, what happens to the force exerted on it from the second charge?
   A. The force decreases by 4.
   B. The force decreases by 2.
   C. The force increases by 2.
   D. The force increases by 4.
   E. The force does not change (q_2 does not move).

$$\boxed{F = \frac{k\, q_2 q_1}{r^2}\hat{r} \quad \text{r is still 10 cm}}$$

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The next three questions involve two charged parallel plates. One plate is connected to -30 V while the other plate is connected to 60V. The aluminum plates are separated by 2 cm.

16. What is the magnitude of the electric field between the plates – right in the middle?
   A. 45 N/C
   B. 0 N/C
   C. 4500 N/C
   D. 3000 N/C
   E. 1500 N/C

$$E = \frac{\Delta V}{\Delta x}$$

17. What is the magnitude of the electric field between the plates – right next to the -30V plate?
   A. 45 N/C
   B. 0 N/C
   C. 4500 N/C
   D. 3000 N/C
   E. 1500 N/C

$$E = \frac{\Delta V}{\Delta x}$$

18. What is the direction of the electric field between the plates – right in the middle?
   A. The electric field points toward the 60 V plate.
   B. There is no electric field between the plates (the plates are conductors)
   C. The electric field points away from both plates.
   D. The electric field points towards both plates.
   E. The electric field points toward the -30 V plate.

Electric field is uniform and points toward the lower voltage.

19. You hook 3 resistors (20 Ω, 55 Ω and 333 Ω) in series in a circuit. What is the effective resistance of your circuit?
   A. 408 Ω
   B. 71 mΩ
   C. 14 Ω
   D. 2.5 mΩ
   E. 348 Ω

$$R_{eff} = \sum_i R_i$$

20. An empty aluminum can (probably a Dr. Pepper) is connected to a 10 V battery. The can is 7 cm in diameter and 13 cm tall. What is the magnitude of the electric field inside the can?
   A. 143 V/m
   B. 71.5 V/m
   C. 286 V/m
   D. 154 V/m
   E. 0 V/m

The electric field is zero inside a conductor.

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Do the next two problems using separate problem solving sheets. There are extra problems solving sheets available if you need one.

21. [10 PTS] An electron is placed between two large parallel plates that are separated by 10 cm. One plate is connected to -20V while the other is connected to -70V. The electron is placed 2 cm from the -20 V plate and given an initial velocity of 100 m/s towards the -70 V plate.
    A. Which plate does the electron hit?
    B. Draw the electrons approximate position as a function of time.
    C. How fast is the electron traveling when it hits the plate?

22. [10 PTS] You have purchased a 20 W and a 60 W light bulb from the store. These are labeled for the power that they normally consume when used in your house, which is wired in parallel. You decide to hook these two light bulbs up in series. Assume that the wall outlet is 120 V.
    A. Draw both circuit diagrams.
    B. Which light bulb is brightest (i.e. uses the most power)?