Physics 2135 Exam 1

September 20, 2016

Exam Total

/ 200

Printed Name: _____

Rec. Sec. Letter: _____

Five multiple choice questions, 8 points each. Choose the **best** or **most nearly correct** answer.

_____1. Two positive charges Q are located a distance d from the origin. One of the charges lies along the positive x-axis, and the other lies along a line making a 30° angle with the positive x-axis, as shown in the diagram. What is the **y-component** of the total electric field at the origin?

      [A] $kQ/2d^2$ [B] $-2kQ/d^2$

      [C] $-kQ/2d^2$ [D] $-kQ/d^2$
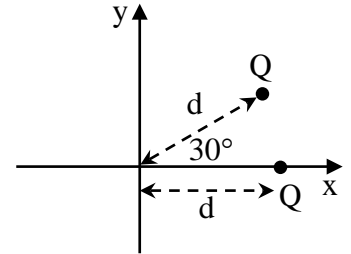
_____ 2. The figure shows an electric dipole with its dipole moment oriented perpendicular to a uniform electric field. For this orientation the torque on the dipole is _____ and the potential energy of the dipole is _____.

      [A] maximum, 0   [B] 0, maximum

      [C] minimum, 0   [D] 0, minimum
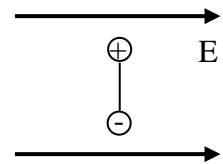
_____ 3. An electron is released from rest in a uniform electric field. The electron then moves under the influence of the electric field. Which of the following is true for the electron?

      [A] Its potential energy increases and it moves toward higher electric potential.

      [B] Its potential energy decreases and it moves toward higher electric potential.

      [C] Its potential energy increases and it moves toward lower electric potential.

      [D] Its potential energy decreases and it moves toward lower electric potential.

_____4. A parallel plate capacitor is fully charged and then disconnected from the battery which charged it. The separation between the plates is D and the electric potential difference between the plates is measured to be V_0. With the capacitor disconnected, the separation between the plates is then changed to $D/2$. What is the potential difference between the plates after their separation has been halved?

      [A] $4V_0$ [B] $2V_0$ [C] V_0 [D] $V_0/2$

_____5. If the Earth had a net positive charge, how could you make a Hoverdog™?

      [A] Feed it a bowl of protons.

      [B] Rub its fur with a rubber rod so it acquires a positive charge.

      [C] Praise it constantly, until it becomes more positive.

   [D] Stupid question, the Earth has a negative charge.

Note: no dogs were harmed in the making of this exam.

_____ /40 for page 1

6. (40 points total) A thin insulating semicircle of radius R is held in the vertical xy-plane with its center at the origin of the coordinate system. The semicircle carries a negative charge $-Q$ uniformly distributed over its length.

(a) (25 points) Determine the electric field produced by the semicircle at the origin of the coordinate system. Express your answer in unit vector notation.
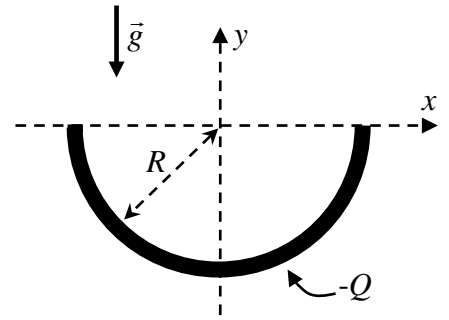
(b) (5 points) A small sphere of mass m and charge q is placed at the origin of the coordinate system and released from rest. You observe that it does not move. What is the sign of the charge q of the sphere (circle one below)?

<div align="center">Positive   Negative</div>

(c) (10 points) Find the magnitude of the charge q in terms of the system parameters.

_____ /40 for page 2

7. (40 points total) A solid **insulating** sphere of radius a carries a total net positive charge $2Q$ uniformly distributed throughout its interior. The insulating sphere is surrounded by a **conducting** spherical shell of inner radius a and outer radius b. The outer conducting layer carries a net charge of $-Q$.
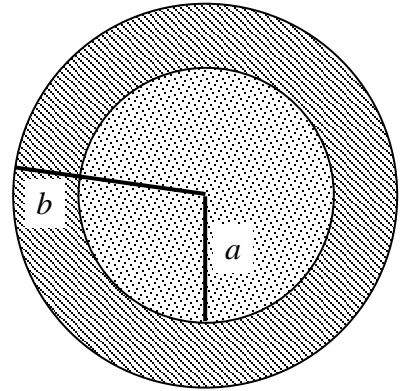
(a) (10 points) Compute the volume charge density ρ associated with the charge distributed throughout the inner **insulating** sphere in terms of variables introduced above.

(b) (10 points) Apply Gauss's law to obtain the magnitude $E(r)$ of the electric field in the region at a point located a distance $r < a$ from the center of the **insulating** sphere. In the figure, **draw the Gaussian surface** you will use for your computation. Express your answer in terms of a, Q, r, and ε_0. (If you get an expression involving ρ substitute in from above to re-express it in terms of the stated variables.) What direction is the electric field at this point?

(c) (10 points) What is the electric field at points in the region $b > r > a$? Briefly justify your answer (a few words will suffice).

(d) (10 points) Find the net charge Q_b residing on the outer surface of the conducting shell.

.

_____ /40 for page 3

8. (40 points total) A point charge $q_1 = 15$ µC is held stationary at the origin.

(a) (20 points) A second point charge $q_2 = 20$ µC is moved from the point $(x,y) = (3$ m, 4 m$)$ to the point $(x,y) = (1$ m, 0 m$)$ where it is held stationary. How much work was done by the electric force on q_2?
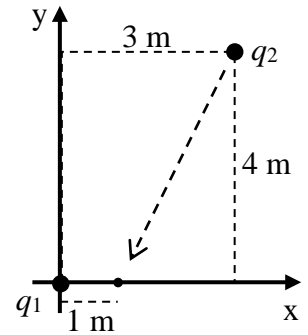
(b) (20 points) The mass of q_2 is 60 g. If q_2 is now released from rest at the point $(x,y) = (1$ m, 0 m$)$ and moves along the +x axis, what will its speed be when it passes through the point $(x,y) = (10$ m, 0 m$)$?

9. (40 points total) The capacitor network shown in the diagram stores a total charge of 600 nC.

(a) (10 points) If the equivalent capacitance of the network is 10 nF, what is the voltage ΔV?

C_1

C_2
18 nF

C_3
36 nF

C_4
18 nF

ΔV
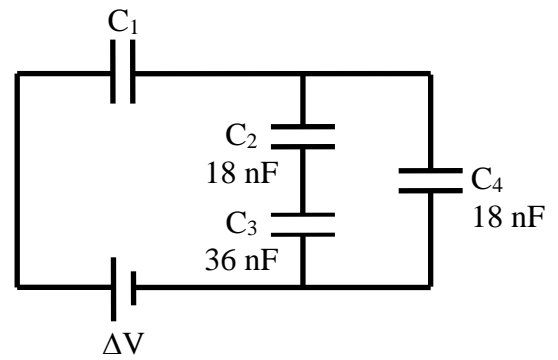
(b) (15 points) What is the unknown capacitance C_1?

(c) (15 points) What is the voltage across C_4?

_____ /40 for page 5