Name: _____ Instructor:_____

Louisiana State University Physics 2102, Exam 1,

September 16, 2010.

• Please be sure to write your name and class instructor above.

• The test consists of 3 questions (multiple choice), and 4 problems (numerical). All numerical quantities must have appropriate units. *Points will be deducted if units are absent.*

• For the problems: Show your reasoning and your work – *no credit will be given for an answer without explanation or work*. Note that in many of the problems, you can do parts (b) or (c) even if you get stuck on (a) or (b).

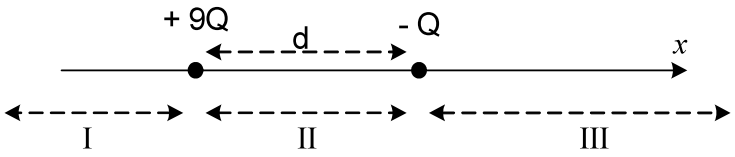
• You may use scientific or graphing calculators. Cell phones cannot be used as calculators.

• Feel free to detach, use, and keep the formula sheet pages. No other reference material is allowed during the exam.

• **Good Luck!**

Question 1 [10 points]

Two point charges, a positive charge of +9Q and a negative charge of –Q, are fixed in place on an *x*-axis, separated by a distance d. The axis is divided into three regions: I, II, and III, as shown.



(a) [6 points] In which region (or regions) along the axis could you place a third point charge, in such a way that the third charge would be in equilibrium? (circle the right answer)

I II III I and II I and III

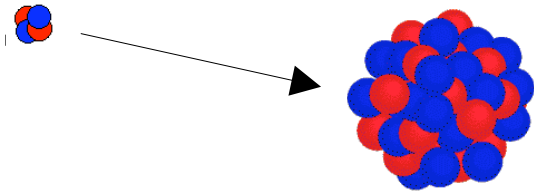
(b) [4 points] If equilibrium is possible, should this third charge be positive or negative, or does it matter at all?

positive negative doesn't matter

Problem 1 [15 points]

An alpha particle is a helium nucleus, composed of 2 protons and 2 neutrons. Thus it possesses a mass of approximately 6.7×10^{-27} kg, and a charge of +2e. By comparison, the nucleus of an atom of gold has 79 protons and 118 neutrons, giving a mass of 3.3×10^{-25} kg, and a charge of +79e.

The figure shows and alpha particle is moving towards a gold nucleus.



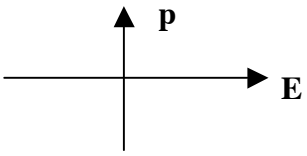
(a) [6 points] How close would the alpha particle have to approach the gold nucleus in order to experience a force of 1 N due to the presence of the gold nucleus?

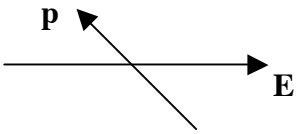
(b) [5 points] What is the magnitude and direction of the acceleration experienced by the alpha particle when it is at the position found above in part (a)? Indicate the direction of **a** in the figure or with words.

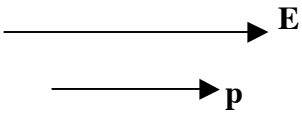
(c) [4 points] When the alpha particle is at the position found in (a), calculate the magnitude of the electrostatic force exerted **on the gold nucleus**?

Question 2 [10 points]

The figure shows three different orientation of an electric dipole (with dipole moment **p**) in a uniform electric field **E**, which points in the positive x-direction.

(1) 

(2) 

(3) 

(a) [4 pts] Rank the scenarios according to the potential energy of the dipole in the electric field, greatest first (circle the right answer):

$U_1 > U_2 > U_3$ $U_2 > U_1 > U_3$ $U_2 > U_1 = U_3$

$U_1 > U_2 = U_3$ All tie

(b) [3 pts] Rank the scenarios according to the magnitude of the torque on the dipole in the electric field, greatest first (circle the right answer):

$\tau_1 > \tau_2 > \tau_3$ $\tau_2 > \tau_1 > \tau_3$ $\tau_2 > \tau_1 = \tau_3$

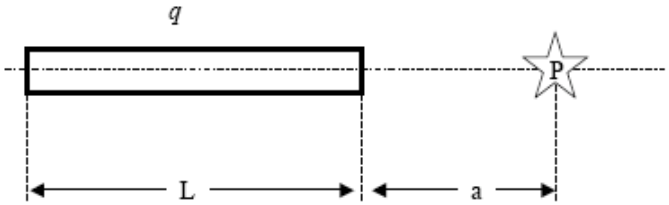
$\tau_1 > \tau_2 = \tau_3$ All tie

(c) [3 pts] In which scenario (or scenarios) is the dipole in equilibrium? Circle the right answer.

1 2 3 1 and 2 2 and 3

Problem 2 [20 points]

The figure shows a one-dimensional insulating rod of length L = 8.0 cm. It has charge q = -2.0 nC deposited uniformly along its length, with a constant linear charge density. The point P is located distance a = 5.0 cm from the end of the rod.



(a) [4 pts] Calculate the linear charge density of the rod

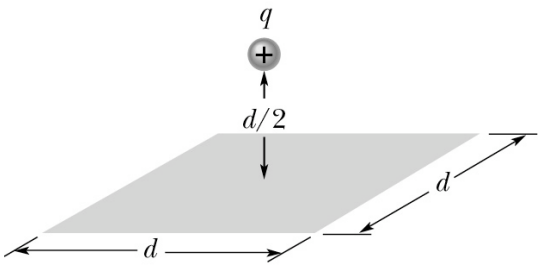
(b) [3 pts] What is the direction of the electric field at point P, due to the charged rod? Indicate your answer on the figure.

(c) [5 pts] Pick a charge element dq along the rod and write down an expression for the magnitude of the electric field dE at point P due to charge dq. Indicate the location of dq on the figure.

(d) [8 pts] Calculate the magnitude of the electric field at point P. Useful integral: $\int 1/x^2 \, dx = [-1/x]$

Question 3 [10 points]

The figure shows a charge $+q$ which is located at a distance $d/2$ directly above the center of a surface which is a square with sides d.



(a) [7 pts] What is the magnitude of the electric flux through the square surface? (Hint 1: Think of the square as one face of a cube with edges d. Hint 2: no calculus involved). Circle the correct answer.

q/ε_0 $\quad$ $q/2\varepsilon_0$ $\quad$ $q/4\varepsilon_0$

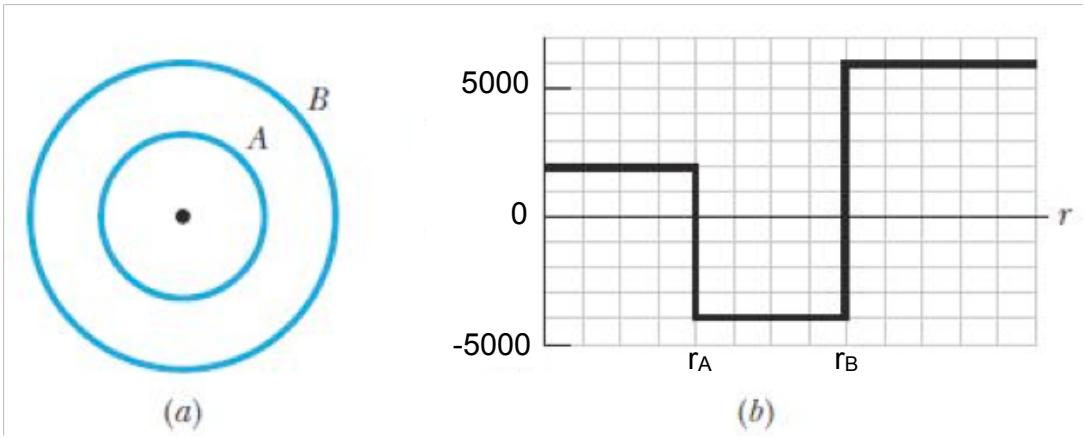
$q/6\varepsilon_0$ $\quad$ $q/(4\pi\varepsilon_0 d^2)$ $\quad$ $q/(\pi\varepsilon_0 d^2)$

(b) [3 pts] If you were to move the charge closer to the square, so that it would be located at distance $d/4$ above the square, would the magnitude of the flux through the square be the same or different? Circle the correct answer:

Larger $\quad$ The same $\quad$ Smaller

Problem 3 [20 points]

A charged particle is suspended at the center of two concentric spherical shells that are very thin and made of non-conducting material. The figure (a) below shows a cross section. Figure (b) shows the net electric flux through a Gaussian sphere centered on the particle, as a function of the radius r of the sphere. The scale on the vertical axis is given in units of Nm^2/C



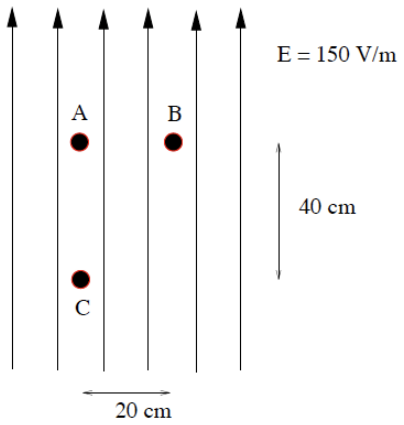
(a) [7 pts] Calculate the charge of the particle at the center of the shell (magnitude and sign):

(b) [7 pts] Calculate the net charge on shell A:

(d) [6 pts] Indicate on the figure the direction of the electric field lines outside of shell B: Explain your choice briefly.

Problem 4 [15 points]

The figure shows a uniform electric field with magnitude $E = 150$ V/m. Three different locations in the electric field are marked with A, B, and C.



(a) [4 pts] Circle the correct statement about the electric potential at points A, B, and C:

$V_C < V_A < V_B$ $V_C < V_A = V_B$ $V_C > V_A = V_B$ $V_C > V_A > V_B$

(b) [6 pts] Calculate the work needed by an external force to move a point charge q = -2.0 μC (at rest) from point C to point A. Specify both magnitude and sign of the work:

(c) [5 pts] Calculate the work (magnitude and sign) needed by an external force to move a point charge q = -2.0 μC (at rest)

(i) from point C to point B:

(ii) from point C to point A, then from A to B, then from B to C: