PHYS 122 A,B Spring 2012
MIDTERM I
April 12th 2012

NAME Coulomb C
Last First
Student #__________

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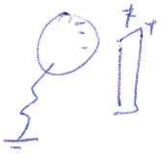
PART I Multiple Choice – **Each question is worth 5 points – total 55 points**

1. A positively charged rod is brought near one side of an (initially) neutral metal ball, the other side of which is connected to ground. The ground connection is then removed after which the rod is taken far away. Which one of the following statements is true?

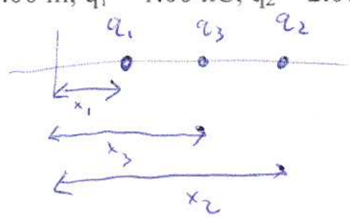


(a) Electrons were transferred from ball to ground and the ball is now positively charged.
(b) Electrons were transferred from ground to ball and the ball is now positively charged.
(c) Electrons were transferred from ball to ground and the ball is now negatively charged.
(d) Electrons were transferred from ground to ball and the ball is now negatively charged.
(e) None of the above

Questions 2 and 3 are connected

2. Point charges q_1 and q_2 are located on the x-axis at positions x_1 and x_2 respectively. Charge q_3 is then positioned on the x-axis at x_3 such that *each* charge feels no net electric force. If $x_1 = 1.00$ m, $x_2 = 2.00$ m, $q_1 = 1.00$ nC, $q_2 = 2.00$ nC, then the value of x_3 is

(a) 0.75 meters
(b) 1.28
(c) 1.41
(d) 1.78
(e) 2.33



F on $q_3 = 0 \Rightarrow$

$$\frac{q_1 \cancel{q_3}}{(x_3-x_1)^2} = \frac{q_2 \cancel{q_3}}{(x_3-x_2)^2}$$

$$(x_3-2)^2 \cdot 1nC = (x_3-1m)^2\, 2nC$$

$$x_3^2 - 4x_3 + 4 = 2x_3^2 - 4x_3 + 2$$

$$x_3^2 = 2m^2$$

3. (See question 3). The value of q_3 is

(a) -2.06 nC
(b) -1.51
(c) -1.08
(d) -0.72
(e) -0.34

F on $q_1 = 0 \Rightarrow$

$$\frac{q_3}{(x_3-x_1)^2} + \frac{q_2}{(x_2-x_1)^2} = 0$$

$$\frac{q_3}{(\sqrt{2}-1)^2} = \frac{-2}{(2-1)^2}$$

$$q_3 = -2 \cdot (0.41)^2$$

$$= -0.34 \text{ nC}$$

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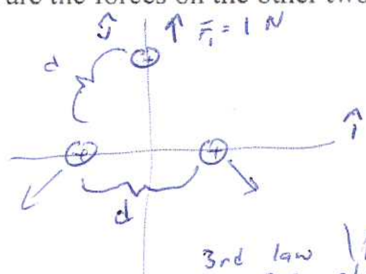
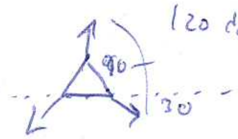
4. Three identical charges are placed equidistant from each other on the x-y plane. If the total electric force on one of the charges is $\hat{j}$ N, what are the forces on the other two?

120 degrees





(a) ~~0 and 0~~
(b) ~~$\hat{i}+\hat{j}$ and $\hat{i}-\hat{j}$~~
(c) $(\sqrt{3}/2)\hat{i}-\hat{j}/2$ and $(-\sqrt{3}/2)\hat{i}-\hat{j}/2$
(d) ~~$\hat{i}/\sqrt{2}-\hat{j}/\sqrt{2}$ and $-\hat{i}/\sqrt{2}-\hat{j}/\sqrt{2}$~~
(e) ~~$\hat{i}-\hat{j}/2$ and $-\hat{i}-\hat{j}/2$~~

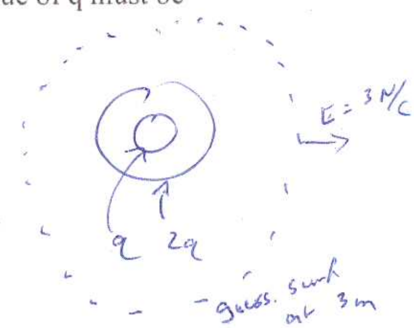
90 degrees so no

3rd law cross out $|F_1| = |F_2| = |F_3|$ wrong magnitude

5. Two spherical metallic shells with total charges q and 2q are both centered at (x, y, z) = (0, 0, 0), and have radii 1m and 2m respectively. If the electric field at (0, 0, 3m) is measured to be 3 N/C in the +z-direction, the value of q must be

$\Phi = \frac{q_{tot}}{\varepsilon}$

(a) 1 nano-Coulomb
(b) 2
(c) 3
(d) 4
(e) 5



$4\pi(3m)^2 \cdot (3\,N/C) = \frac{3q}{\varepsilon}$

$= 10^{-9}$ C

6. When the electric field magnitude in dry air exceeds 3 x 10^6 N/C, the air ionizes and an electric discharge can occur. A 100μC charge is placed on a uniform conducting sphere in air. How small can the radius of this sphere be, before an electric discharge may occur?

(a) .75 meters
(b) .55
(c) .97
(d) .12
(e) .37

$4\pi r^2 \cdot 3\cdot 10^6\ N/C = \frac{100\cdot 10^{-6}\ C}{\varepsilon}$

$r = \left(\frac{100\cdot 10^{-6}\ C}{\varepsilon}\ \frac{1}{4\pi\cdot 3\cdot 10^6\ N/C}\right)^{1/2}$

$= 0.55$ m

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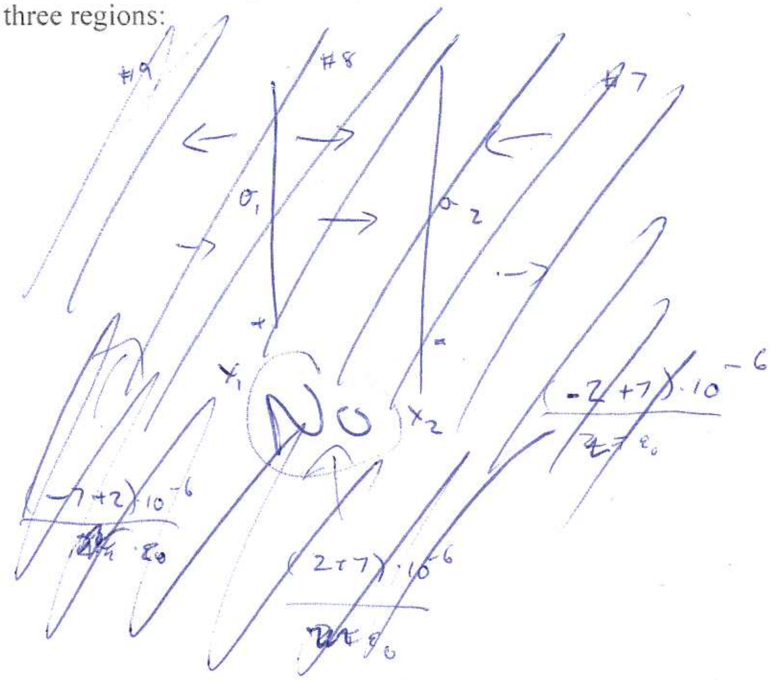
Two infinite non-conducting uniformly charged planes lie parallel to each other and parallel to the *yz* plane. One is at x_1=+2 m and has a surface charge density of σ_1= +7.0 μC/m^2. The other is at x_2=−2m and has a surface charge density of σ_2=−2.0 μC/m^2. Find the electric fields in the following three regions:

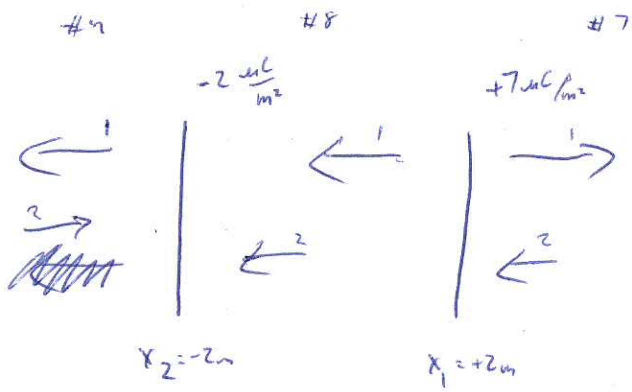


7. $x > 2.00$ m

   A. 0.00
   B. $+2.82 \times 10^5 \ \frac{N}{C}\ \hat{\imath}$
   C. -2.82×10^5
   D. $+5.08 \times 10^5$
   E. -5.08×10^5

8. $-2.00 < x < +2.00$ m

   A. 0.00
   B. $+2.82 \times 10^5 \ \frac{N}{C}\ \hat{\imath}$
   C. -2.82×10^5
   D. $+5.08 \times 10^5$
   E. -5.08×10^5



9. $x < -2.00$ m

   A. 0.00
   B. $+2.82 \times 10^5 \ \frac{N}{C}\ \hat{\imath}$
   C. -2.82×10^5
   D. $+5.08 \times 10^5$
   E. -5.08×10^5

$\frac{1}{\varepsilon_0}(+2-7)\cdot 10^{-6}$ $\frac{1}{\varepsilon_0}(-7-2)\cdot 10^{-6}$ $\frac{1}{\varepsilon_0}(7-2)\cdot 10^{-6}$

$-2.8\cdot 10^5$ $-5.0\cdot 10^5$ $+2.8\cdot 10^5$

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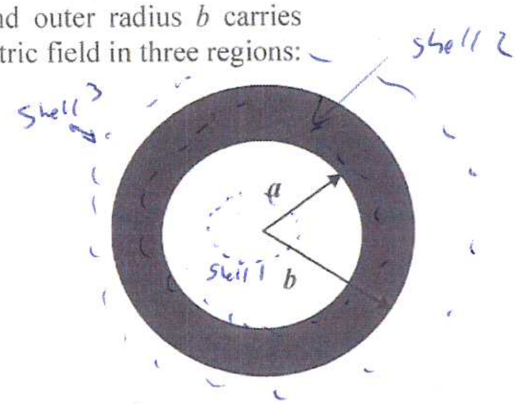
PART II Long handwritten lecture question - **total 25 points**

A hollow spherical non-conducting shell of inner radius a and outer radius b carries charge density $\rho = C/r^2$ in the region $a \leq r \leq b$. Find the electric field in three regions: [SHOW YOUR WORK!]



(i) (5 points) $r<a$

use shell 1

$\oint E\,dA = Q_{net} = 0$

$E \oint dA = 0$

$E \cdot 4\pi r^2 = 0 \Rightarrow E = 0$

(ii) (10 points) $a<r<b$

use shell 2

$\oint E\,dA = Q_{net}$

$E \cdot 4\pi r^2 = \int \rho\, dV$

make dV a shell of thickness dr

$\rightarrow \int \rho\, dV = \int \rho\, A\,dr = \int \rho\, 4\pi r^2\, dr$

this part outside shell

this part inside shell

Integrate from "a" to "r"

$\rightarrow E \cdot \cancel{4\pi} r^2 = C \cancel{4\pi} (r-a)$

$E = \dfrac{C(r-a)}{r^2}$

(iii) (10 points) $r>b$

Q inside = Q total = $C\,4\pi(b-a)$

So

$E = \dfrac{C\cancel{4\pi}(b-a)}{\cancel{4\pi} r^2} = \dfrac{C(b-a)}{r^2}$