PHYSICS 231 – TEST # 1

NAME:

STUDENT ID #:

USEFUL CONSTANTS

$$\epsilon_0 = 8.85 \times 10^{-12} C^2/(N \cdot m^2)$$

$$k = \frac{1}{4\pi\epsilon_0} = 8.988 \times 10^9 \; N \cdot m^2/C^2$$

$$e = 1.6 \times 10^{-19} C$$

$$m_e = 9.1 \times 10^{-31} kg$$

USEFUL FORMULAS

Coulomb's law:

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

Electric field:

$$\vec{E} = \frac{\vec{F}}{q}$$

due to point charge:

$$\vec{E} = k\frac{q}{r^2}\,\hat{\mathbf{r}}$$

Electric dipole:

- dipole moment: $p = qd$
- torque: $\vec{\tau} = \vec{p} \times \vec{E}$
- energy: $U = -\vec{p} \cdot \vec{E}$

Electric flux:

$$\Phi_E = \int \vec{E} \cdot d\vec{A}$$

Gauss's law:

$$\Phi_E = \frac{Q_{enc}}{\epsilon_0}$$

Electric field

- due to infinite wire:

$$E = \frac{1}{2\pi\epsilon_0}\frac{\lambda}{r}$$

- inside uniformly charged sphere:

$$E = k\frac{Qr}{R^3}$$

- due to infinite sheet:

$$E = \frac{\sigma}{2\epsilon_0}$$

Potential energy of two point charges:

$$U = k\frac{q_1 q_2}{r}$$

Potential:

$$V = \frac{U}{q}$$

Potential difference:

$$V_a - V_b = \int_a^b \vec{E} \cdot d\vec{l}$$

Electric field: $\vec{E} = -\vec{\nabla} V$

There are three (3) problems in this test. Make sure you answer all questions in each problem for full credit. Show as much of your work as possible to receive partial credit, in case you don't come up with the right answer. Good luck!

George Siopsis - 2/7/06

Problem 1

(a) A proton is placed in a uniform electric field and then released. Then an electron is placed at this same point and released. Do these two particles experience the same force? The same acceleration? Do they move in the same direction when released?

(b) You find a sealed box on your doorstep. You suspect that the box contains several charged metal spheres packed in insulating material. How can you determine the total net charge inside the box without opening the box? Or is this not possible?

(c) Is it possible to have an arrangement of two point charges separated by a finite distance such that the electric potential energy of the arrangement is the same as if the two charges were infinitely far apart? Why or why not?

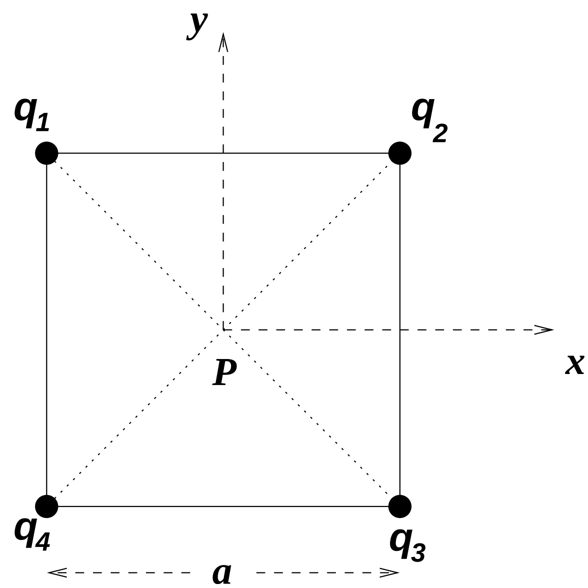
Problem 2

Three positive charges $q_1 = +7.5\ \mu C$, $q_2 = +9.0\ \mu C$, $q_3 = +7.5\ \mu C$ and one negative charge $q_4 = -9.0\ \mu C$ are placed at the corners of a square as shown. The length of each side of the square is $a = 40$ cm.

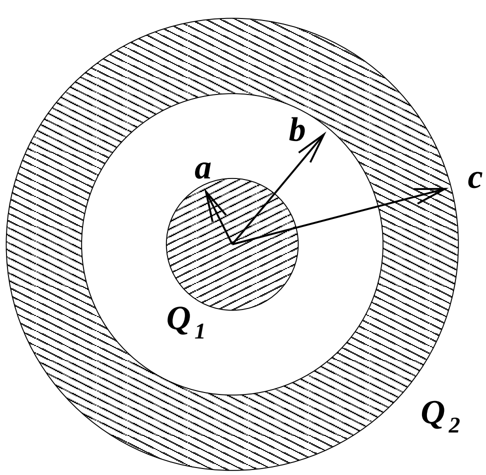
(a) What are the x and y components of the electric field at the center P of the square?

(b) Find the magnitude and direction of the force on an electron placed at P.

(c) How much work do you have to do to bring the electron from infinity to the point P?



Problem 3



A spherical conductor of radius $a = 0.6$ m and negative charge $Q_1 = -3\ \mu C$ is inside a conducting spherical shell of inner radius $b = 1.2$ m and outer radius $c = 1.8$ m, as shown. The shell carries positive charge $Q_2 = +7\ \mu C$.

(a) What are the surface charge densities at $r = a, b, c$?

(b) Find the electric field everywhere and plot it as a function or r.

(c) Find the potential everywhere and plot it as a function or r. Assume that the potential is zero at infinite r.