PHY2061 Name:________________________ ___
9-29-05

Exam 1

Closed book exam. A calculator is allowed, as is one 8.5×11" sheet of paper with your own written notes. Please show all work leading to your answer to receive full credit. Numerical answers should be calculated to 2 significant digits. Exam is worth 100 points, 25% of your total grade.

UF Honor Code: "On my honor, I have neither given nor received unauthorized aid in doing this exam."

Sphere: $S = 4\pi r^2$ $V = \frac{4}{3}\pi r^2$ $\pi = 3.1415927$ $e = 1.6022\times 10^{-19}$ C

$\mathbf{a}\cdot\mathbf{b} = a_x b_x + a_y b_y + a_z b_z$ $\mathbf{a}\times\mathbf{b} = \left(a_y b_z - b_y a_z\right)\mathbf{x} - \left(a_x b_z - b_x a_z\right)\mathbf{y} + \left(a_x b_y - b_x a_y\right)\mathbf{z}$

$K = \frac{1}{4\pi\varepsilon_0} = 9\times 10^9\ \text{N m}^2/\text{C}^2$ $\varepsilon_0 = 8.8542\times 10^{-12}\ \text{C}^2/\text{N m}^2$ $c = 3.0\times 10^8$ m/s

$\mathbf{F} = K\frac{q_1 q_2}{r^2}\hat{\mathbf{r}}_{12}$ $\mathbf{E} = \frac{\mathbf{F}}{q_0}$ $\Phi_E = \oint_S \mathbf{E}\cdot d\mathbf{A} = \frac{q_{\text{enc}}}{\varepsilon_0}$ $\nabla\cdot\mathbf{E} = \frac{\rho}{\varepsilon_0}$

$\mathbf{E} = -\nabla V$ $V = \frac{U}{q_0}$ $W = -\Delta U = \int_C \mathbf{F}\cdot d\mathbf{s}$ $\Delta V = -\int_C \mathbf{E}\cdot d\mathbf{s}$

$\nabla = \hat{x}\frac{\partial}{\partial x} + \hat{y}\frac{\partial}{\partial y} + \hat{z}\frac{\partial}{\partial z}$ $\nabla\cdot\mathbf{F} = div\left(\mathbf{F}\right) = \frac{\partial F_x}{\partial x} + \frac{\partial F_y}{\partial y} + \frac{\partial F_z}{\partial z}$

$\int_V \nabla\cdot\mathbf{F}\, dV = \oint_S \mathbf{F}\cdot d\mathbf{A}$

$Q = C\Delta V$ $U = \frac{1}{2}C\left(\Delta V\right)^2 = \frac{Q^2}{2C}$ $C_{\text{eff}} = C_1 + C_2$ $\frac{1}{C_{\text{eff}}} = \frac{1}{C_1} + \frac{1}{C_2}$

1 μC $= 10^{-6}$ C 1 μF $= 10^{-6}$ F 1 pF $= 10^{-12}$ F 1 eV $= 1.6\times 10^{-19}$ J

$K = \frac{1}{2}mv^2$ $x = \frac{-b\pm\sqrt{b^2-4ac}}{2a}$ $g = 9.8\ \text{m/s}^2$

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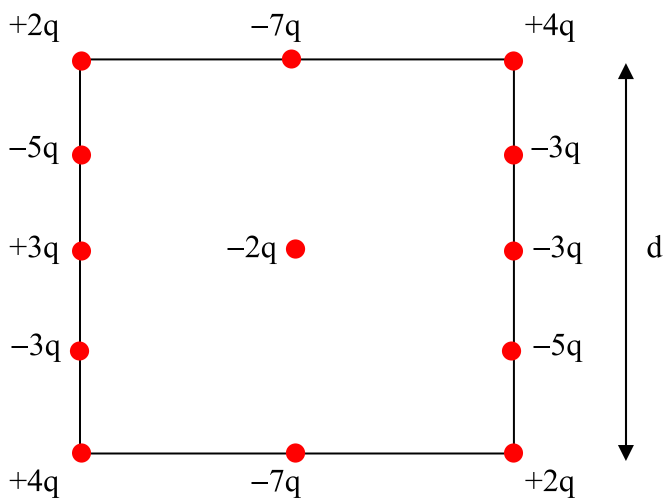

1. [6 points] A central particle of charge $-2q$ is surrounded by a square array of charged particles. The length of the square side is d, and charges are placed at the square corners, at the midpoint of the sides, and midway between the corner and the midpoint for two sides. What are the magnitude and direction of the net electrostatic force on the central particle due to the other particles?

2. [6 points] Particles 1, with a charge q_1 , and 2, with a charge q_2, are on the x-axis with particle 1 at $x = 2a$ and particle 2 at $x = -a$. For the net force on a third charged particle placed at the origin to be zero, what must be q_2 in terms of q_1 ?

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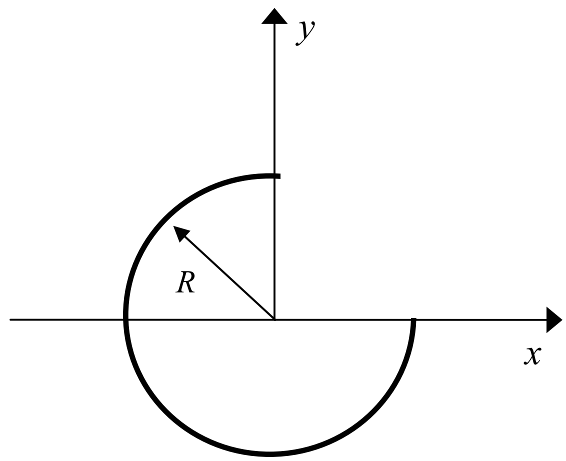

3. Consider electric charge distributed along a one-dimensional path in the form shown as ¾ of a circle. The circle is centered at the origin with a radius of *R*, and the linear charge density λ is positive.

   (a) [6 points] Find the component of the electric field along the *x*-axis (E_x) at the origin (0,0).

   (b) [6 points] Find the component of the electric field along the *y*-axis (E_y) at the origin (0,0).

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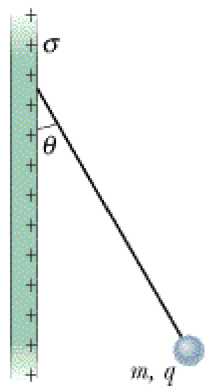

4. [8 points] In the figure shown, a small, non-conducting ball of mass $m = 3\times10^{-6}$ kg and charge $q = +4.8\ \mu\text{C}$ (distributed uniformly through its volume) hangs from an insulating thread that makes an angle θ with a vertical, uniformly charged non-conducting sheet (shown in cross section). The sheet has a surface charge density of $\sigma = 3\times10^{-11}\ \text{C/m}^2$. Considering the gravitational force of the ball and assuming that the sheet extends far vertically and into and out of the page, calculate the angle θ.

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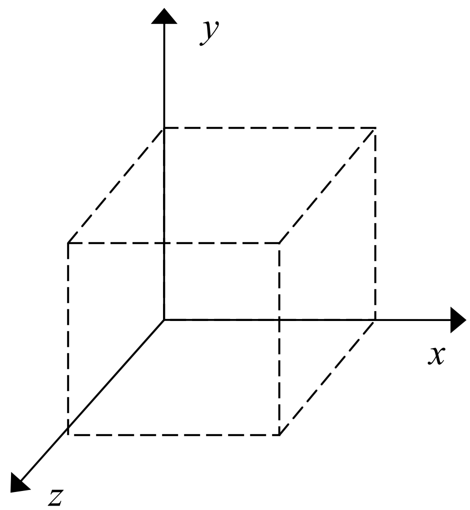

5. Consider a cube with side length s = 0.5 m and one corner at the origin (0,0,0) as shown.
   (c) [6 points] What is the total charge enclosed by the cube if the electric field is $\mathbf{E} = \left(2\hat{\mathbf{x}} + 4y^3\hat{\mathbf{y}} + 6z\,\hat{\mathbf{z}}\right)$ N/C ?

   (d) [6 points] What is the electric charge density (C/m^3) at the center of the top face at y = 0.5 m if the electric field is the same as in part (a)?

6.

(a) [6 points] A solid non-conducting sphere of radius $R = 0.05$ m has a uniform charge density $\rho = 0.01\ \text{C/m}^3$ constant throughout the volume of the sphere. What is the ratio of the magnitude of the electric field at $r = R/2$ to that at $r = R$?

(b) [6 points] Suppose the solid non-conducting sphere in part (a) has a non-uniform charge density $\rho(r) = \rho_0 r,$ where $\rho_0 = 0.267\ \text{C/m}^4$ (i.e. varies with radius). What is the ratio of the magnitude of the electric field at $r = R/2$ to that at $r = R$?

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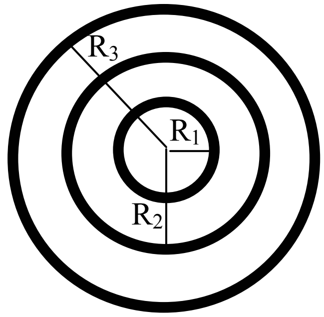

7. Three charged, concentric conducting shells have radii $R_1 = 10$ cm, $R_2 = 15$ cm, $R_3 = 20$ cm . The thickness of the conducting shells, while not zero, is considered negligible. The charge on the innermost shell is −15μC, the charge on the middle shell is −20μC, and the charge on the outermost shell is +25μC.

(a) [6 points] What is the charge on the inner surface of the outermost conducting shell?

(b) [6 points] What is the direction and magnitude of the electric field at radius $r = 17$ cm?

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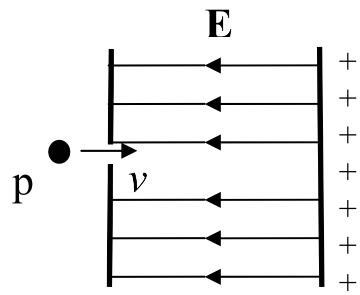

8. [8 points] A proton is injected with a velocity of $v = 2\times10^6$ m/s into a region of uniform electric field between two large plates separated by 1m and maintained with an electric potential difference of 30,000 V. The proton travels from lower electric potential to higher on a path perpendicular to the plates. Does the proton reach the far plate, and if not, what is the distance of closest approach to it? The charge of the proton is $+e = 1.6\times10^{-19}$ C, and the proton mass is $m_p = 1.67\times10^{-27}$ kg.

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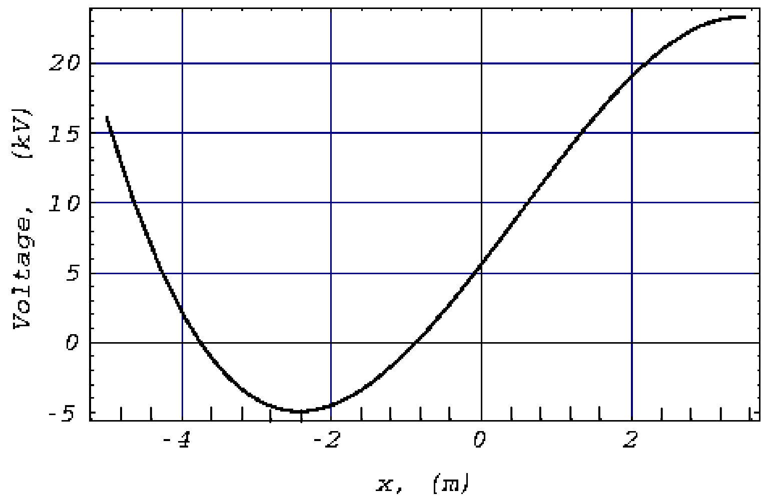

9. [6 points] The electric potential along the *x*-axis (in kV=10^3 V) is plotted versus the value of *x* (in meters). Evaluate the *x*-component of the electrical force (in Newtons) on a charge of 4.70 μC located on the x-axis at x= −1.2 m.

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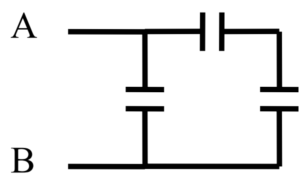
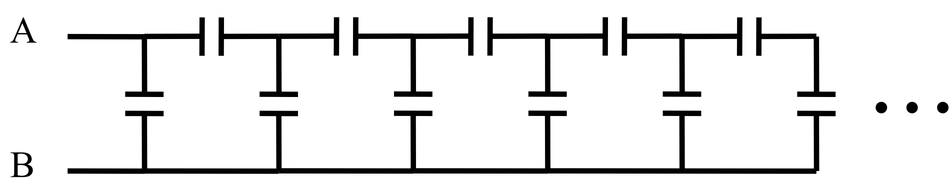


10.

(a) [6 points] Consider the shown arrangements of capacitors above. Calculate the effective capacitance, C_{eff}, of the network between the terminals A and B given that each of the shown capacitors has a capacitance $C = 4$ μF.



(b) [6 points] Consider the shown arrangements of capacitors above. Calculate the effective Consider the above infinite chain of capacitors. Calculate the effective capacitance, C_{eff}, of the network between the terminals A and B given that each of the shown capacitors has a capacitance $C = 4$ μF.

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11. [6 points] A parallel plate capacitor with a capacitance of 12 μF is connected to a battery that maintains an electric potential difference of 6V. If the plates are squeezed to
one-third of the original separation, how much work must be done by the battery to maintain the same potential difference across the plates?