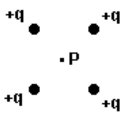
PHYS-207 (3) (Kaldon-10776) **Name** ______________________________
WMU - Summer 2000
Exam 1 - 100,000 points + 20,000 ☆ points **Book Title** ______________________________

07/06/2000•Rev.2 · Rev 9/11/2005

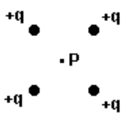
State Any Assumptions You Need To Make – Show All Work – Circle Any Final Answers
Use Your Time Wisely – Work on What You Can – Be Sure to Write Down Equations
Feel Free to Ask Any Questions ☐☆2a ☐☆2b ☐☆2c ☐☆2e

Read All Directions Carefully, Take Four Charges & See Dr. Phil on Monday (35,000 pts.)

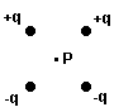
1.) Four charges, $|q| = 7.00 \times 10^{-6}$ C, are rigidly arranged in a square (L = 10.0 cm = 0.100 m) as shown.
(a) Find the electric field vector, $\vec{E}_{total}$, at the center of the square of charges at point P.



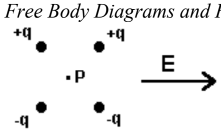
(b) Find the force vector, $\vec{F}_{total}$, on the upper left charge due to the other three charges.

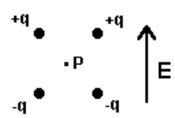


(c) Find the electric field vector, $\vec{E}_{total}$, at the center of the square of charges at point P.



In a constant electric field, applied everywhere, show whether these four charges, rigidly held together, will translate or rotate in the applied E-field, where (d) $\vec{E} = 150.\, {}^{N}\!/_{C}\ \hat{i}$ or (e) $\vec{E} = 150.\, {}^{N}\!/_{C}\ \hat{j}$. *Hint: Think Free Body Diagrams and Free Rotation Diagrams.*

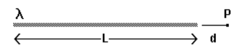




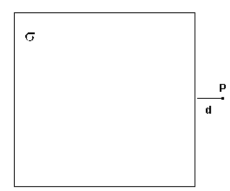
A Star Problem is Born (30,000 points)

2.) ☆(a) A spherical insulator of radius R has a total charge Q evenly distributed throughout the sphere. Use Gauss' Law to find the magnitude of the E-field at a radius r, where $r < R$. *NOTE: You may evaluate the integrals by using the known equations for things like the surface area and volume of a sphere.*

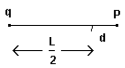
☆(b) Use direct integration to find the magnitude of the E-field for a line of charge of length L = 1.00 m and $\lambda = 1.00 \times 10^{-4}$ C/m, at a distance d from the end of the line of charge, where d is 0.100 m.



☆(c) Set up *but do not solve* the double integral for finding the magnitude of the E-field by direct integration for a square plate of charge of sides L = 1.00 m and $\sigma = 1.00 \times 10^{-4}$ C/m², at a distance d from the end of the line of charge, where d is 0.100 m



(d) Use Gauss' Law to find the vector electric field, $\vec{E}$, at a point *P* for a point charge of $q = 1.00 \times 10^{-4}$ C, where L = 1.00 m and d = 0.100 m.



☆(e) An electric potential is given as $V(x,y) = A\,(x^2 + y^2)$, where *A* is some arbitrary constant. Find the *x*-component of the E-field, E_x .

The Great Accelerator (35,000 points)

3.) The Stanford Linear Accelerator, SLAC, is a real machine that takes electrons and accelerates them for most of a mile up to 99.99% the speed of light. Consider an electron ($m_e = 9.11 \times 10^{-31}$ kg) in a constant electric field that starts from rest and ends up at 1.00×10^8 m/s† after traveling in the $+x$ direction a distance of 1150 meters in 23.0 μsec. Using our old friend from the kinematic equations, *The Equation Without Time*, we find that $a = \frac{v^2}{2d}$ or $a = 4.35 \times 10^{12}\ m/s^2$. (a) What is the magnitude and direction of the force on the electron?

(b) What is the magnitude and direction of the constant E-field required in part (a)?

† For those of you who care, this is below the threshold of where we have to worry about using Relativity.

(c) The electron volt is a unit of work (energy) defined as $1\ eV = 1.602 \times 10^{-19}$ J. Use the change in the kinetic energy of the electron from rest to 1.00×10^8 m/s, expressed in eV's, to find the magnitude of the potential difference ΔV from one end of the accelerator to the other. *Ignore the minus signs in this problem.*

(d) Although it doesn't take very long for an electron to travel down the accelerator, suppose someone was worried about it not falling at all during its trip down the tube. Find the magnitude and direction of a second E-Field that would cancel the weight of the electron.

(e) In the space below, make a sketch of some of the electric field lines and some equipotential surfaces due to two positive charges, q_1 and q_2, where $q_1 = 2\,q_2$.