PHYS-207(5) (Kaldon-19884) **Name** ____________________

WMU-Fall 2001 **Book Title** ____________________

Exam 0 - 000,000 points + 00,000 ☆ points **Section:** **5a** A to D **5b** E to I **5c** J to M **5d** N to S **5e** T to Z

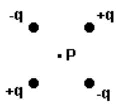
Sample – Not a Real Exam

Rev. 9/09/2001 Su · REVISED 1/27/2003 · Revised 09/11/2005

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 ☐☆2b ☐☆2c ☐☆3c ☐☆4c

Four Charges and An E-Field (25,000 points)

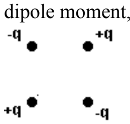
1.) Four charges, $|q| = 6.00 \times 10^{-6}$ C, are rigidly arranged in a square (L = 10.0 cm = 0.100 m) as shown.
(a) Find the electric field vector, $\vec{E}_{total}$, at the center of the square of charges at point P.



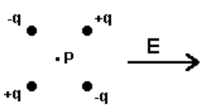
(b) Find the electric field vector, $\vec{E}_{total}$, at a point +10.0 cm **k** (0.100 m) out of the plane of the paper, above the point P.

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

(d) One of the +q charges and one of the -q charges can be thought of as forming a dipole. Find the dipole moment, p, of any of these dipoles, and sketch all the possible dipole vectors, $\vec{p}$.



(e) A constant electric field, $\vec{E} = 150.\, N/C\,\hat{i}$, applies everywhere. Show whether these four charges, rigidly held together, will translate or rotate in the applied E-field.



Earth 2 - The Problem (25,000 points)

2.) In class Dr. Phil commented that it is very important the charge of the electron (-e) and the proton (+e) are exactly the same magnitude. Suppose this is not true. Suppose that the charge on the electron was $-1.602\,000\,000\,100 \times 10^{-19}$ C and the charge on the proton was $+1.602\,000\,000\,200 \times 10^{-19}$ C. Then there would be this charge difference for every proton-electron pair in every atom in the entire Earth. There is one mole (6.02×10^{23}) of these charge differences, Δq, for every <u>gram</u> of matter. (a) If the mass of the Earth is 5.98×10^{24} kg, find the total number of these charge differences, n, the total charge on the Earth, Q, and the charge density, ρ. ($R_{earth} = 6.37 \times 10^6$ m; $V_{sphere} = 4/3\, \pi\, r^3$)

☆(b) Use Gauss' Law and integrate over a spherical Gaussian surface to find the E-field on the surface of the Earth.

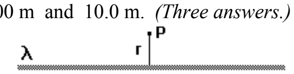
☆(c) Use Gauss' Law and integrate to find the E-field on a spherical Gaussian surface inside the Earth, R $= 1.00 \times 10^6$ m.

(d) The Moon (mass = 7.36×10^{22} kg) translates to a charge difference in this problem of $Q' = 4.43 \times 10^{20}$ C. The distance between the Moon and the Earth is 3.82×10^8 m. Find the Coulomb Force between Moon and Earth in this problem.

(e) We are also fortunate that the Coulomb Force is exactly $1/r^2$. If the Coulomb Force was something else, such as $1/r^{2.1}$, express the difference in the Coulomb Force between the Earth and the Moon in some manner. If you cannot evaluate an expression on your calculator, at least do the set-up.

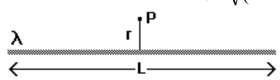
Gauss' Law & Order (25,000 points)

3.) Consider an infinite line of charge, $\lambda = 1.00 \times 10^{-4}$ C/m, and (a) use Gauss' Law to find the E-field at a point P a distance *r* from the line, where r is 0.100 m, 1.00 m and 10.0 m. *(Three answers.)*

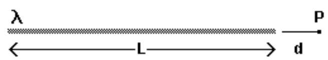


(b) Using the result from Chapter 24 -Problem 33P †, for the magnitude of E at a point P above the middle of a finite line of charge, L = 1.00 m and $\lambda = 1.00 \times 10^{-4}$ C/m, at a distance *r* from the line, where r is 0.100 m, 1.00 m and 10.0 m.

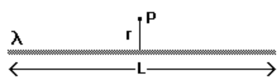
$$E = \frac{q}{2\pi\varepsilon_0 r}\frac{1}{\sqrt{(L^2 + 4r^2)}}$$



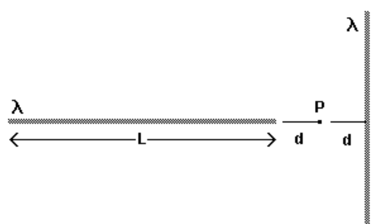
☆(3c) Find the magnitude of E by direct integration at a point P from a finite line of charge, L = 1.00 m and $\lambda = 1.00 \times 10^{-4}$ C/m, where d is 0.100 m, 1.00 m and 10.0 m.



(d) Find the magnitude of E at a point P above a finite line of charge, L = 1.00 m and $\lambda = 1.00 \times 10^{-4}$ C/m, at a distance r from the line by assuming that the entire charge q is a point charge at the center of the line of charge, where r is 0.100 m, 1.00 m and 10.0 m.



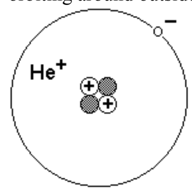
(e) Finally, find the vector $\vec{E}$ at point P, at a distance d from the end of a line charge λ of length L plus a distance d from an infinite line charge λ.



† The textbook used in Summer 1995 was Fundamentals of Physics (4th edition) / Halliday, Resnick and Walker.

The Atoms Family (25,000 points)

4.) A helium ion, He^+, consists of two protons and two neutrons in the nucleus, and a single electron orbiting around outside. (a) Find the electric field, E, at a point 1.00 m from this ion.



(b) The two protons are about 1 fermi apart. This is 1 femtometer or 1.00×10^{-15} m. Find the electric force between the two protons, and find the initial acceleration of one of the protons assuming that there was no strong nuclear force from the neutrons holding the nucleus together.

☆(c) If the proton starts out at rest, find the work done on the proton as it is repelled. Integrate $\int_a^\infty F_E\,dx$, where $a = 1.00 \times 10^{-15}$ m. Assume that the second proton remains at rest.

(d) Use the work done on the proton in (c) to find the final speed of the proton. $m_p = 1.67 \times 10^{-27}$ *kg.*

(e) If we take a classical view of the atom, then the electron in orbit (r = 1 Å = 1.00×10^{-10} m) is in Uniform Circular Motion: $a_c = v^2/r$. Find the speed of the electron.