Name ____________________

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Signature ____________________

University of California, Berkeley, Department of Physics

Physics 7B

Midterm 2, Spring 2013

You are allowed 1 sheet (single side) of notes. Calculators or other electronic devices are not permitted. Put a box around your final answer and cross out any work you wish the grader to disregard. Try to be neat and organized.

Remember to look over your work. Good Luck!

Problem 1	____/20
Problem 2	____/20
Problem 3	____/20
Problem 4	____/20
Problem 5	____/20
Total	____/100

Problem 1. [20 points] A very long solid nonconducting cylinder of radius a has a charge density $\rho(r) = \rho_0(1-(\frac{r}{a})^2)$. Express your answers to the questions below in terms of ρ_0, ϵ_0, a, and numerical constants and assume the cylinder is infinitely long.

(a) Find the charge per unit length λ on the cylinder.

(b) Find the electric field for $r<a$ and $r>a$.

(c) Find the potential for $r<a$ and $r>a$. Assume $V(r=0)=0$.

(d) Find the total energy per unit length stored in the field in the region $r<R$, where $R>a$. Your answer will depend on R as well as ρ_0, ϵ_0, a, and numerical constants.

Problem 2. [20 points] A parallel plate capacitor has square plates with sides of length L and the plates are separated by a small distance $d<<L$. A dielectric slab of thickness d and area LxL is partially inserted a distance **s<L** into the capacitor. The capacitor plates have charge Q and –Q. They are not connected to a voltage source. Express all your answers in terms of d, s, L, K, Q and ϵ_0.

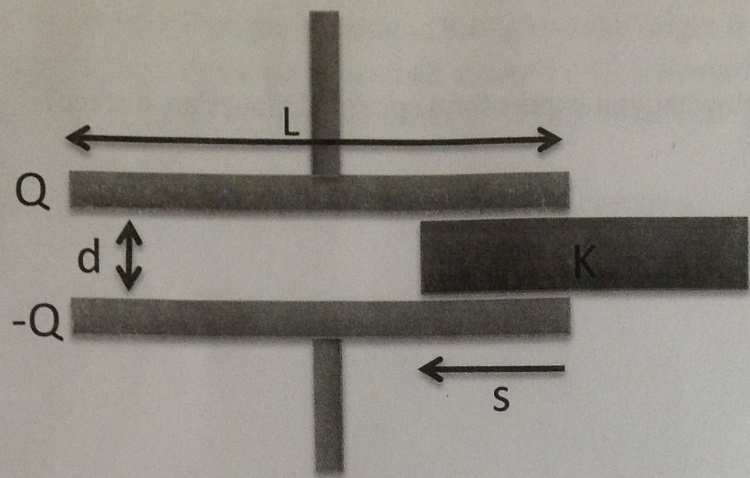
(a) Find the total capacitance of the capacitor before the dielectric is inserted. Do not copy your formula from a sheet. Show how it is derived.

(b) Find the total capacitance after the dielectric is partially inserted into the capacitor.

(c) Find the voltage drop across the plates after the dielectric is inserted.

(d) Find the energy stored in the capacitor with the dielectric partially inserted.

(d) Find the force (magnitude and direction) that the capacitor exerts on the dielectric.



Problem 3. [20 points] Assume an electric field is E(V/m) pointing downwards towards the surface of the Earth. There are cosmic rays and natural radioactivity which produce n_+ singly charged positive ions per cubic meter and n_- singly charged negative ions per cubic meter in the atmosphere. The positively charged ions have mass M_+ and collision time τ_+ and the negatively charged ions have mass M_- and collision time τ_-. Express your answers to the questions below in terms of n_+, n_-, τ_+, τ_-, M_+, M_-, E and e (the magnitude of the electron charge).

(a) Find v_{D+} and v_{D-}, the drift velocities of the positively and negatively charged ions.

(b) Find the current density (magnitude and direction).

(c) Find the resistivity of the atmosphere ρ $[\Omega\text{-m}]$.

(d) What is the power per unit volume dissipated through collisions.

Problem 4. [20 points] Consider a point charge q located at the origin (x=0,y=0,z=0). Imagine a very long *cylindrical* Gaussian surface of radius R centered on the x-axis.

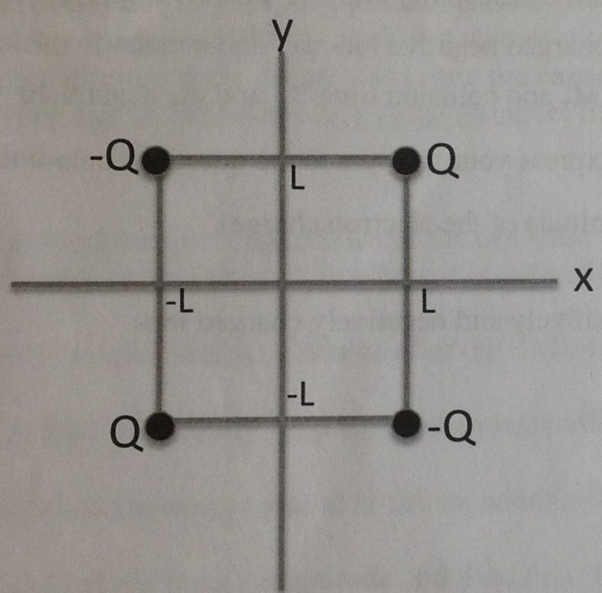
(a) Draw a sketch of the problem showing the charge q and the Gaussian cylinder.

(b) Calculate the flux of the electric field through this cylinder assuming the cylinder is infinitely long. You may need

$$\int_{-\infty}^{\infty} \frac{dx}{(R^2 + x^2)^{(3/2)}} = \frac{2}{R^2}.$$

(b) [4 points] Does your answer agree with what you expect for a spherical Gaussian surface?

Problem 5. [20 points]



Four charges (+Q,-Q,+Q,-Q), where Q>0, are located at the corners of a square with sides of length L. The corners of the square have z=0 and (x,y) coordinates (L,L),(-L,L),(-L,-L) and (L,-L).

Express your answers to questions (a) and (b) below in terms of Q, L, ϵ_0 and numerical constants.

(a) What is the potential V and electric field E (magnitude and direction) at the origin? Assume V=0 at infinity.

(b) What is the energy required to assemble this collection of charges?

(c) A charge $q>0$ with mass m is brought to the origin from a long distance away. The charge is then slightly displaced by a small amount $s \ll L$ towards the charge at (L, L). Find the electric field as function of the displacement s (magnitude and direction).

(d) Find the frequency of oscillation of the charge q.