Physics 7b
Fall 2004
Midterm 2
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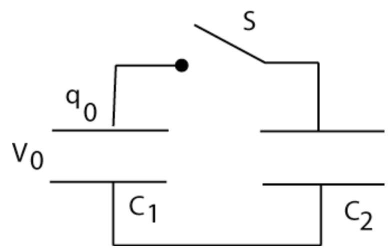
All algebraic answers should be expressed in terms of the given quantities. Box your final answer and show all your work. All problems are worth the same number of points.

1. A particle of mass m, charge $q>0$ and initial kinetic energy K is projected (from "infinity") towards a heavy nucleus of charge Q, assumed to have a fixed position in our reference frame.

(a) If the "aim is perfect," how close to the center of the nucleus is the particle when it comes to rest?

(b) With a particular imperfect aim the particle's closest approach to the nucleus is twice the distance determined in part *a*. Determine the speed of the particle at this closest distance of approach.



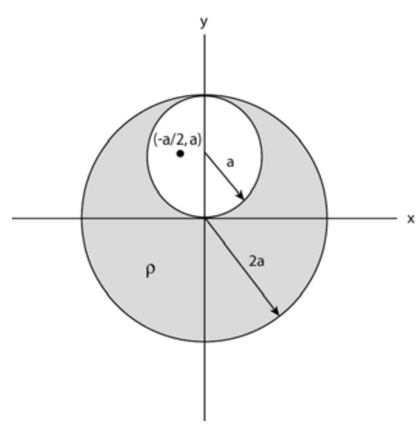
2. A capacitor C_1 is charged to a potential difference V_0. The charging battery is then removed and the capacitor is connected as in the figure to an uncharged capacitor C_2.

(a) What is the final potential difference V across the combination?

(b) What is the stored energy before and after the switch S is thrown?

(c) (*independent of parts a and b*) A parallel plate capacitor has plates with area A and separation d. A battery charges the plates to a potential difference V_0. The battery is then disconnected and a dielectric slab of area A, thickness d and dielectric constant κ is introduced. Calculate the stored energy both before and after the slab is introduced. Explain how total energy is conserved in this case.

3. A sphere of radius $2a$ is made of a non-conducting material that has uniform volume charge density ρ. A spherical cavity of radius a is now removed from the sphere as shown in the figure. Find the electric field (magnitude and direction) at the point x=-a/2, y=a.



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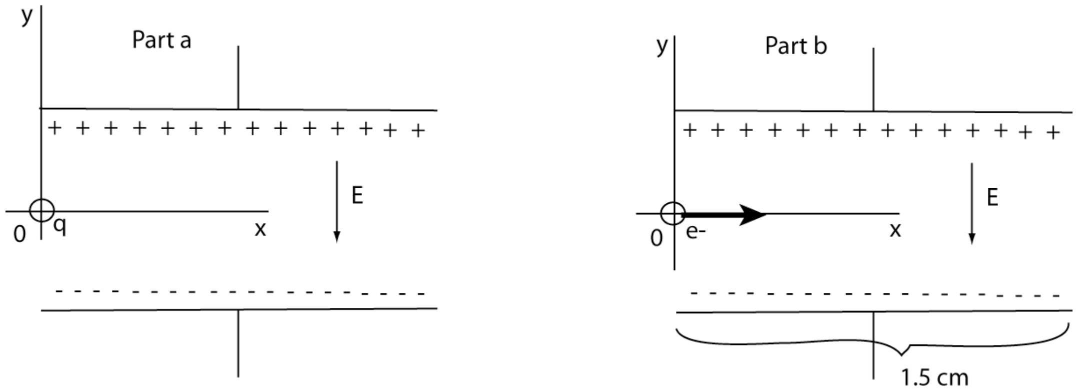
4. (a) A particle of mass *m* and charge *q* is placed at rest in the uniform electric field of a cathode-ray oscilloscope (see figure) and released. Write an equation for its position (x, y) as a function of time.

(b) Suppose the electric field between the plates is $1.2x10^4$ N/C. What deflection (Δy) will an electron experience if it enters at right angles to the field with a kinetic energy of 2000 eV (=$3.2x10^{-16}$ J), a typical value? The deflecting assembly is 1.5 cm long.



5. The figure below shows six concentric conducting spheres, A, B, C, D, E, and F, having radii R, 2R, 3R, 4R, 5R, and 6R, respectively. Spheres B and C are connected by a conducting wire as are spheres D and E. Determine the equivalent capacitance of this system.