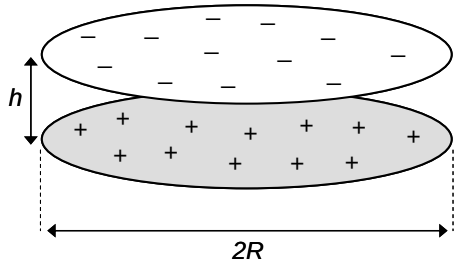
PHYS 402: Electricity & Magnetism II
Due date: Thursday, September 24, 2015

Problem Set #3

Griffiths 4th Ed. [3rd Ed.] problems
8.2 [8.2], 8.7 [8.5], 8.13 [8.9], 8.16 [8.10], 8.19 [8.12]

Problem: AC capacitance of a parallel disk capacitor
Consider the parallel disk capacitor below with disc radius *R* and disc separation *h*.



a) If the capacitor has charge -Q and +Q on the top and bottom disks, respectively, then derive an expression for the electric field *E* between the two plates. You may ignore the fringe electric field.

b) Derive an expression for the capacitance *C* of this capacitor.

We now consider an AC voltage applied to the parallel disk capacitor, and assume that the electric field *E* that you calculated in part 3 is modulated as $E\, e^{i\omega t}$

c) Starting from your expression for the electric field in the capacitor from part a), derive an approximate expression for the magnetic field generated inside the capacitor.

d) The AC magnetic field from part 4a generates an electric field of its own. Derive an approximate expression for the total electric field inside the capacitor.

You could now recalculate the magnetic field based on the electric field from d) and so on, but we will stop at this first order approximation.

e) Hard: Derive an (approximate) expression for the AC capacitance of the capacitor. Does the capacitance go up, down, or stay the same at high frequencies?
hint: do not assume a uniform charge density on the capacitor and use C=Q/V.