2020

HAVERFORD COLLEGE

Department of Physics

Physics 309b

Assignment #2

Reading: Griffiths; Chapter 2, section 5 and Chapter 3, sections 1 and 2

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1. What is the capacitance of the earth? (Most of the surface of the earth is covered by sea water, a fairly good conductor.)

2. A spherical balloon is made of lightweight, aluminized Mylar. It is suggested that it could be kept spherical simply by connecting it to a high-voltage source. The balloon has a diameter of 0.1 meter, and the maximum breakdown electric field in air is $3 \times 10^6$ volts/meter.

   (a) What is the maximum voltage that can be applied to the balloon?

   (b) What gas pressure inside the balloon would produce the same effect? What fraction of atmospheric pressure is this? Will it work?

3. Griffiths, Chapter 2, Problem 2.43.

4. Suppose the two cylinders in the previous problem are of length, L, and have nearly the same radii, i.e. $(b - a)/b << 1$. Further suppose that the inner cylinder is displaced along the axis so that its end is a distance, x, from the end of the outer cylinder. Assume that a charge Q is placed on the outer cylinder and that a charge $-Q$ is placed on the inner cylinder. How do you think the charge is distributed on the two conductors? Compute the force on the inner cylinder. Is it sucked in or pushed out of the outer cylinder? From your solution you will see that the analysis breaks down when $x = L$ and $x = 0$. Speculate as to why this occurs.

5. A point charge, Q, is placed equidistant between two parallel, grounded, conducting plates separated by a distance, D. Assume the sizes of the plates are much larger than their separation.

   (a) What are the strengths and positions of the image charges which will give the potential everywhere between the plates? (There are many, many of them!)

   (b) Find an expression for the surface charge density on either plate at the point adjacent to the charge. (Have you ever run into Catalan's Constant before?)

6. Example 3.2 on page 128 of Griffiths locates the appropriate image charge for the case of a point charge outside a grounded conducting sphere. What are the magnitudes and positions of the image charges (there are two of them) for the case of a point charge outside an isolated, neutral, conducting sphere? What is the potential of the sphere?

7. Two "infinite", parallel, conducting plates separated by a distance, s, are at potentials 0 and $V_0$.

   There is a volume charge density, $\rho = \rho_0(x/s)$, between the two plates where x is the distance from the plate at zero potential.

   (a) Use Poisson's equation to find the potential V in the region between the plates.

   (b) What are the surface charge densities on the plates?

   (c) Show that the total charge per unit area (on both plates plus the charge between them) vanishes as it must to ensure that E = 0 inside the conductors.