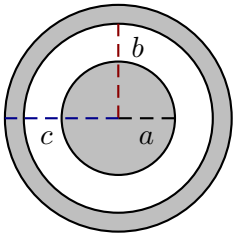
Electromagnetic Theory: Homework 13

Due: 10 October 2019

1 Capacitance of a coaxial cable

An infinitely long coaxial cable consists of two concentric conducting cylinders, whose cross-section is as illustrated. The radii from inside to outside are $a < b < c$.



a) Determine the capacitance for a length L of the coaxial cable.

b) Does the capacitance depend on the outer radius of the outer cylinder?

c) Suppose that the inner cylinder were reaplced by a hollow cylinder with the same radius. Would this change the capacitance of the coaxial cable? Explain your answer.

2 Capacitance of a single spherical conducting shell

The capacitance of a single spherical shell can be determined by first considering two concentric conducting shells, with the inner shell having radius a and the outer shell radius b. The capacitance of this can be determined as a function of a and b. The capacitance of a single shell is determined by taking the limit $b \to \infty$.

a) Determine the capacitance of a single spherical shell of radius a.

b) Determine the energy stored, using the capacitance, in a single charged shell of radius a if the shell carries a total charge q.

3 Parallel plate capacitors

Two conducting parallel plates are initially arranged as illustrated. The area of each plate, A, is large compared to d and the plates can effectively be treated as infinite sheets. Charge $+Q$ is placed on the upper plate and $-Q$ on the lower plate.

Another conducting plate of thickness t is placed between the two plates as illustrated.

a) Use Gauss' Law to determine the charge density on the upper side of the middle plate. Repeat this for the lower side of the middle plate.

b) Determine ΔV from the upper plate to the middle plate. Determine ΔV from the middle plate to the lower plate.

c) Determine the capacitance of the upper/lower plate combination when the middle plate is present and show that it is different to that when the middle plate is absent. Verify that there is no difference when $t = 0$.

4 Energy in concentric spherical capacitors

Consider a capacitor that consists of a solid conducting sphere with radius a and a concentric conducting spherical shell with radius $b > a$.

a) Suppose that the charge on each sphere is multiplied by a factor of α. By what factor does the energy stored in the capacitor change?

b) Suppose that the charge on each sphere is held constant but that the radius of the outer sphere is increased. Does the energy stored increase, decrease or stay the same? Explain your answer.