Electromagnetism

January 21, 2017

Work 2 (and only 2) of the 3 problems. Please put each problem solution on a separate sheet of paper and your name on each sheet.

Problem 1

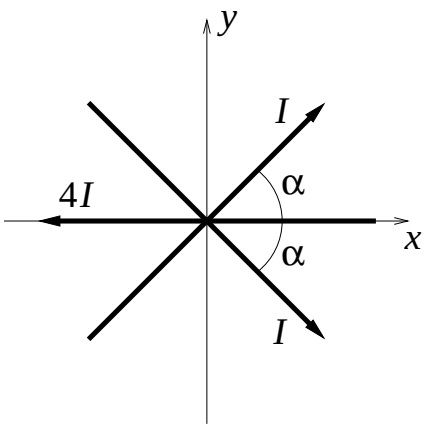
The potential of a grounded conducting sphere of radius R in a uniform electric field is given as

$$V(r,\theta) = -V_0 \left[1 - (R/r)^3\right] \cos\theta \ .$$

Find the surface charge distribution on the sphere in spherical coordinates.

Problem 2

Three infinitely long straight wires lie in the $x - y$ plane and cross at the origin, as shown in the figure. The wires carry currents I, I, and $4I$, respectively.



a.) Find the direction and magnitude of the magnetic field **B** on the y-axis.

b.) At what angle α would the magnetic field on the y-axis be equal to zero?

Problem 3

Consider a perfect conducting sphere at the origin with radius a. Along the z axis, a charge $+q$ is placed a distance $+d$ from the center of the sphere. Similarly, a charge $-q$ is placed at distance $-d$. Here, $d > a$ and the charges are *outside* the conducting sphere, see the figure below.

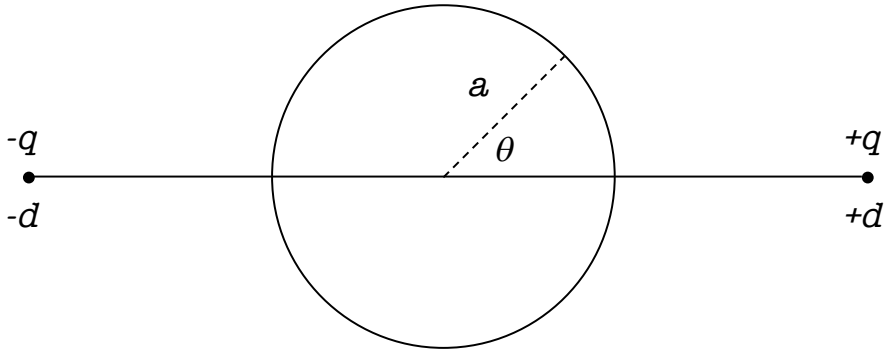


Figure 1: A perfect conducting sphere with charges outside.

a.) If the conducting sphere is *grounded*, then what is the potential everywhere outside the sphere?

b.) What can you say about the direction of the electric fields on the surface of the sphere? Why?

c.) Suppose now that the sphere is no longer grounded, and it contains a net charge Q. What is the potential everywhere outside of the sphere?

d.) What is the potential at the surface of the sphere?

e.) Finally, suppose that there is no longer a $-q$ charge, and the sphere is no longer grounded but it is neutral. Write the potential.