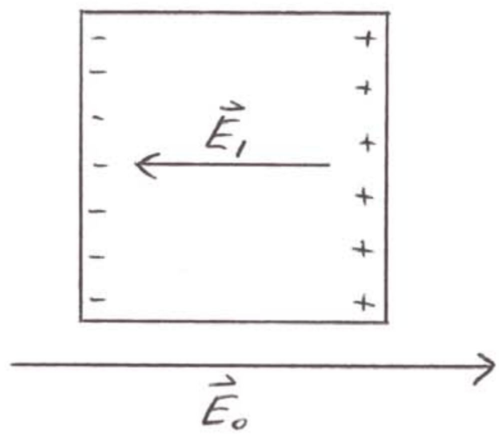
Assignment 3

1. Electrical Conductors An ideal conductor is a material having an unlimited supply of free charges. Consider a conductor placed in an external electric field $\vec{E}_o$.



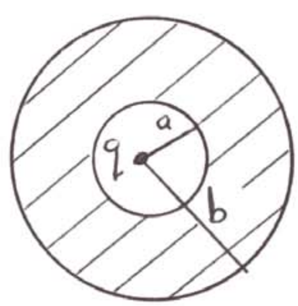
Inside the conductor, $\vec{E}_o$ drives positive charge to the right surface and negative charge to the left surface. These so called induced charges produce a field $\vec{E}_1$ opposing $\vec{E}_o$. Charges continue to move until $\vec{E}_1$ exactly cancels $\vec{E}_o$. The time for this movement of charge to occur is extremely short. Hence, we conclude that inside a conductor the electric field is zero.

a) Show the charge density $\rho = 0$ inside a conductor.

b) Show the potential Φ is constant inside a conductor.

c) Show that just outside a conductor $\vec{E}$ is perpendicular to the surface and equals $4\pi\sigma$ where σ is the surface charge density.

2. A charge q sits in a spherical hollow inside a spherical conductor.



a) Find $\vec{E}$ everywhere.

b) What are the charge densities on the conducting surfaces?

c) Find the potential everywhere taking $\Phi = 0$ at infinity.

3. Consider a sphere of radius a of uniform charge density ρ_o.

a) Find $\vec{E}$ everywhere.

b) Find the potential everywhere taking $\Phi = 0$ at the origin.

c) $a = 2$ cm, $\rho_o = \frac{3}{2\pi}$ esu/cm^3.

i) What is the total charge on the sphere?

ii) What is the electric field 10 cm from the sphere's center?

iii) What is the potential 10 cm from the sphere's center in statvolts?

d) A charge of 5 esu is moved from infinity to within 10 cm from the center of the sphere described in part c.

i) What is the work done in ergs in moving the charge?

ii) What is the force in dynes between the charge and the sphere when the charge is at its final position?

4. For a time independent or static situation, we showed the following.

$$-\int_a^b \vec{E} \cdot d\vec{l} = \Phi(b) - \Phi(a)$$

a) Show that for any closed path $\oint \vec{E} \cdot d\vec{l} = 0$.

b) Using Stoke's Theorem show $\oint \vec{E} \cdot d\vec{l} = 0$ implies $\nabla \times \vec{E} = 0$.

c) $-\int_a^b \vec{E} \cdot d\vec{l} = \Phi(b) - \Phi(a)$ was derived by integrating $\vec{E} = -\nabla\Phi$. Using Cartesian coordinates show this implies $\nabla \times \vec{E} = 0$.

d) Sketch a vector field $\vec{A}$ for which $\oint \vec{A} \cdot d\vec{l} \neq 0$.