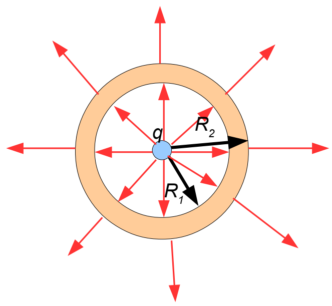
Chapter 6 Problem 90 †



Given

$q = 5.0 \times 10^{-8}\ C$
$R_1 = 6.0\ cm = 0.060\ m$
$R_2 = 9.0\ cm = 0.090\ m$

Solution

Find the electric field at different radii.

Since the point charge and conducting shell match spherical symmetry, Gauss's Law will reduce to Coulomb's law with the recognition that q is the charge enclosed by the Gaussian surface.

$$\vec{E} = k\frac{q_{enc}}{r^2} = \frac{1}{4\pi\epsilon_0}\frac{q_{enc}}{r^2}$$

a) Find the electric field at $r = 4.0\ cm$.

The enclosed charge is the charge at the middle of the sphere; therefore,

$$\vec{E} = \frac{1}{4\pi\epsilon_0}\frac{5.0 \times 10^{-8}\ C}{(0.040\ m)^2} = 2.81 \times 10^5\ N/C$$

b) Find the electric field at $r = 8.0\ cm$.

Since this Gaussian surface is embedded in the conductor, there can be no electric field here. Therefore, there is no net charge inside the Gaussian surface. You can conclude that there is $-5.0 \times 10^{-8}\ C$ on the inside surface of the conductor. When this charge migrates to the interior of the shell, the is an equal amount of positive charge that migrates to the outside of the shell. As a result, the conducting shell is still uncharged, having no net charge on it.

c) Find the electric field at $r = 12.0\ cm$.

Since the conducting shell is uncharged, at this distance the Gaussian surface encompasses a total charge of $5.0 \times 10^{-8}\ C$. This gives an electric field of

$$\vec{E} = \frac{1}{4\pi\epsilon_0}\frac{5.0 \times 10^{-8}\ C}{(0.120\ m)^2} = 3.12 \times 10^4\ N/C$$

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†Problem from Univesity Physics by Ling, Sanny and Moebs (OpenStax)