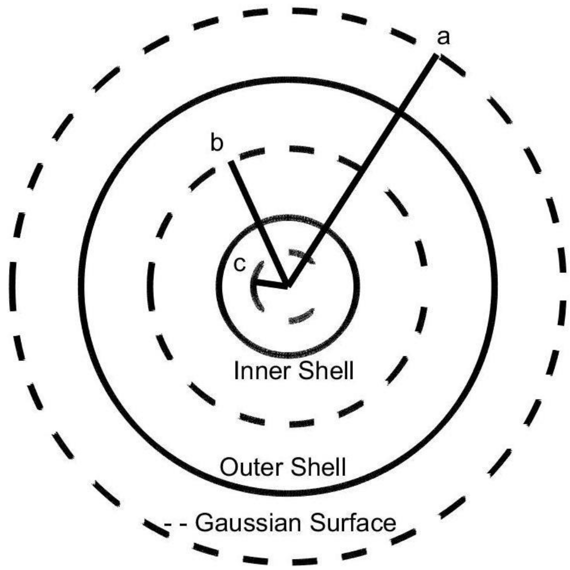
**29.** Two spherical shells have a common center. A -1.6 x $10^{-6}$ C charge is spread uniformly over the inner shell, which has a radius of 0.050 m. A +5.1 x $10^{-6}$ C charge is spread uniformly over the outer shell, which has a radius of 0.15 m. Find the magnitude and direction of the electric field at a distance (measured from the common center) of **(a)** 0.20 m, **(b)** 0.10 m, and **(c)** 0.025 m.




**With the charges dispersed about the spherical surfaces, the Gaussian surfaces are also spheres. So using Gauss's law**

$$\Phi_E = \vec{E} \cdot \vec{A} = EA\cos(\theta_{EA}) = \frac{q_{enclosed}}{\varepsilon_0}$$

**Using $A = 4\pi r^2$, and that the angle $\theta_{EA} = 0$, we can find E from**

$$E = \frac{q_{enclosed}}{4\pi r^2 \varepsilon_0}$$

**So for (a) r = 0.20 m,**

$$q_{enclosed} = q_{inner\ shell} + q_{outer\ shell} = (-1.6\ x\ 10^{-6}\ C) + (+5.1\ x\ 10^{-6} C\ )$$

$$q_{enclosed} = (-1.6\ x\ 10^{-6}\ C) + (+5.1\ x\ 10^{-6} C\ ) = +3.5\ x\ 10^{-6} C$$

**So with a net positive charge enclosed, the direction of the electric field will be radially outward from the outer shell. The magnitude is found by plugging in below:**

$$E_a = \frac{q_{enclosed}}{4\pi r^2 \varepsilon_0} = \frac{(3.5\ x\ 10^{-6} C)}{4\pi (0.20\ m)^2 \left(8.85\ x\ 10^{-12}\ {C^2}/{(Nm^2)}\right)} = 7.868\ x\ 10^5\ {N}/{C}$$

**for (b) r = 0.10 m,**

$$q_{enclosed} = q_{inner\ shell} = -1.6\ x\ 10^{-6}\ C$$

**So with a net negative charge enclosed, the direction of the electric field will be radially inward to the inner shell. The magnitude is found by plugging in below:**

$$E_b = \frac{q_{enclosed}}{4\pi r^2 \varepsilon_0} = \frac{(1.6\ x\ 10^{-6} C)}{4\pi(0.10\ m)^2 \left(8.85\ x\ 10^{-12}\ C^2/(Nm^2)\right)} = 1.439\ x\ 10^6\ N/C$$

**for (c) r = 0.025 m,**

$$q_{enclosed} = 0$$

**So with a net zero charge enclosed, there is no electric field, so there is no direction of the electric field. The magnitude is found by plugging in below:**

$$E_c = \frac{q_{enclosed}}{4\pi r^2 \varepsilon_0} = \frac{(0.00 C)}{4\pi(0.025\ m)^2 \left(8.85\ x\ 10^{-12}\ C^2/(Nm^2)\right)} = 0.00\ N/C$$

$$\vec{E_a} = 7.9\ x\ 10^5\ N/C\ \widehat{+r}$$
$$\vec{E_b} = 1.4\ x\ 10^6\ N/C\ \widehat{-r}$$
$$\vec{E_c} = 0.0\ N/C$$