Problem 3: (30 pts.) A positive point charge of magnitude $Q = 3\,\mu\text{C}$ is at the center of an uncharged spherical *conducting* shell of inner radius $a = 0.05\,\text{m}$ and outer radius $b = 0.11\,\text{m}$ (see figure).

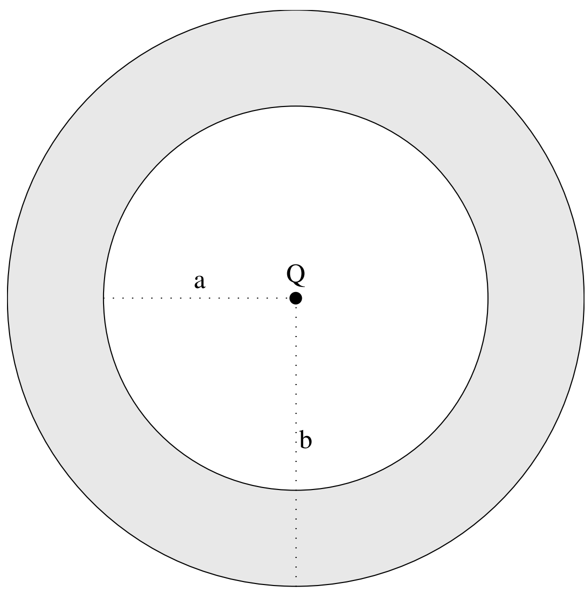
a. (3 pts.) Sketch the Gaussian surface you will use to calculate the electric field at a distance $r = 0.02\,\text{m}$ from the center. (You may sketch it right on the figure.)

b. (12 pts.) Use Gauss's law to calculate the electric field at $r = 0.02\,\text{m}$ from the center. Explain your reasoning.

c. (5 pts.) What is the electric field at $r = 0.08\,\text{m}$? Explain your reasoning.

d. (5 pts.) What is the surface charge density on the inner surface of the shell? Explain your reasoning.

e. (5 pts.) Suppose a charge $Q_2 = 4\,\mu\text{C}$ is placed on the conductor. Would your answer to part (d) change? If so, explain why. If not, explain why not.



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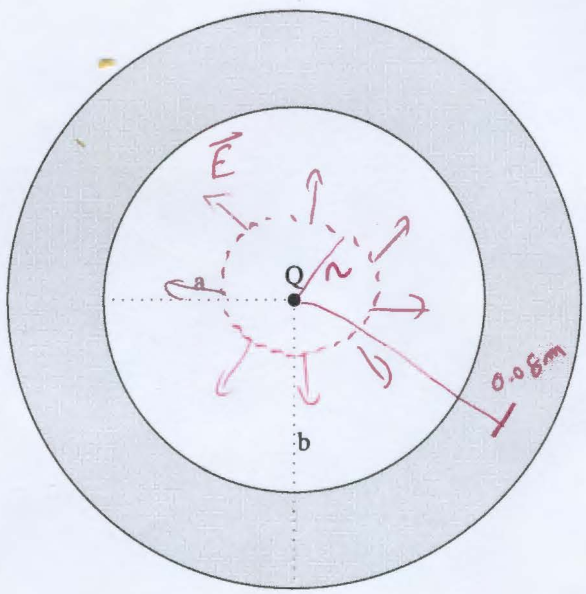

a. Gaussian surface at $r = 0.02\,\text{m}$ is a sphere of radius r.

b. $\Phi = \frac{Q_{enclosed}}{\epsilon_0}$. $\Phi = E \cdot 4\pi r^2$, since $\vec{E}$ points radially outward. $Q_{enclosed}$ is just $Q = 3\times10^{-6}\,\text{C}$.

$\therefore 4\pi r^2 E = Q/\epsilon_0$, $E = \frac{1}{4\pi\epsilon_0}\frac{Q}{r^2} = 6.75\times10^{7}\,\text{N/C}$.

c. at $r = 0.08$, $E = 0$ (inside the conductor.)

d. $\therefore Q_{inside} = 0$, and $-3\,\mu\text{C}$ is spread over inside surface.

$\sigma_a = \frac{-3\,\mu\text{C}}{4\pi a^2} = -9.55\times10^{-5}\,\text{C/m}^2$

e. No. E is still 0 inside the conductor, so Q_{inside} is still 0.