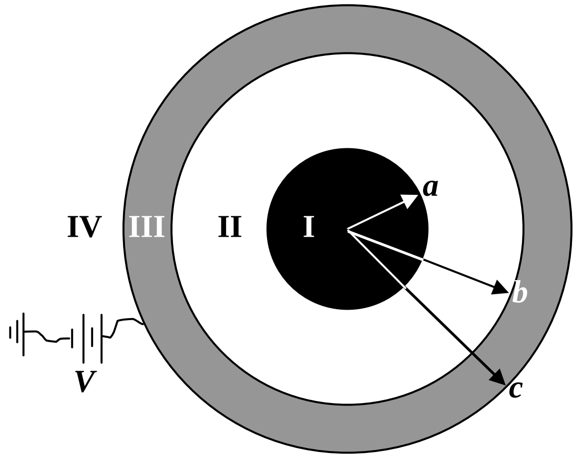
A uniform charge density sphere of radius *a* has total charge *Q*. It is surrounded by a spherical shell that is centered on the same origin. Let *r* denote the radial distance from this origin. The shell is made of copper, having inner and outer radii *b* and *c*, respectively, and the shell is kept at potential *V*.



(a) Find the potential Φ and the field $\vec{E}$ in the four marked regions: I (charged sphere); II (vacuum); III (copper shell); and IV (vacuum). Assume $\Phi(\infty) = 0$. Carefully sketch the radial $\Phi(r)$, label the axes, and indicate the values of the potential at $r = a$, *b*, and *c*.

(b) Find the total electrostatic energy inside radius *b*.

(c) Next, consider the slightly modified geometry shown below. The copper shell that surrounds the sphere is now grounded and the inner sphere of radius *a* is different. It has a surface charge distribution arranged so that $\Phi(a,\theta,\phi) = V\cos^2\theta$. Find $\Phi(r,\theta,\phi)$ for the region between the sphere and the shell; i.e., $a < r < b$