SHOW ALL WORK!!!!!
REPORT ALL NUMBERS TO THREE SIGNIFICANT FIGURES!
Use the conversion constants and data given on the front page.

A very long cylinder of non-conducting material has a radius $R_c$ and a volume charge density given by $\rho = BR^3$ for $R < R_c$ and $\rho = 0$ for $R > R_c$. $B$ is a constant.

(a) Using Gauss' Law, calculate the electric field a distance $R$ from the axis of the cylinder where $R > R_c$.

(b) Using Gauss' Law, calculate the magnitude of the electric field at an arbitrary point $P$ while the cylinder a distance $R$ from the cylinder axis, $R < R_c$.

(c) Calculate the magnitude of the potential difference between the wall of the cylinder and its axis $[V(R_c) - V(0)]$.

(d) If the sign of the charge on the cylinder is negative, state clearly the sign of $V(R_c) - V(0)$, and give a physical reason for it.

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Length of Cylinder $L = 2\pi R_c L$

\[ \Phi = \frac{1}{2} \int \vec{E} \cdot d\vec{l} = \frac{1}{2} \int_0^L E d\ell = \frac{1}{2} \int_0^L \frac{q}{\varepsilon_0} \cdot d\ell = \frac{qL}{2\varepsilon_0} \]

(a) \[ E(\ell) = \frac{1}{\ell} \int_0^\ell E d\ell = \frac{q}{2\varepsilon_0} \]

(b) \[ E(\ell) = \frac{2\pi R_c^3}{2\varepsilon_0} \]

(c) \[ \Delta V = V(R_c) - V(0) = -\int_0^{R_c} \frac{dV}{d\ell} = \frac{(1/2) R_c^2}{2\varepsilon_0} = \frac{R_c^2}{2\varepsilon_0} \]

D) $V(R_c) - V(0) > 0$. The Electric field is directed inward, therefore the Potential $\phi$ increases the further away from the center you go. The Potential is positive.