

Name (print) ROMAN BASKO Name (signed) _____

Discussion Instructor (circle): Basko Chakhbazian DiCarlo Gundlach Romer Wei

Discussion Section # _____

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-conductor of radius R_0 has a charge density given by $\rho = AR^2$ for $R < R_0$, and $\rho = 0$ for $R > R_0$. A is a constant.

- (a) Using Gauss' Law, calculate the magnitude of the electric field at an arbitrary point *within* the cylinder a distance R from the cylinder axis.
 (b) Calculate the magnitude of the potential difference between the wall of the cylinder and its axis $[V(R_0) - V(0)]$.
 (c) If the sign of the charge on the cylinder is negative, state clearly the sign of $V(R_0) - V(0)$, and give a physical reason for it.

$$(a) \text{ Gauss' Law: } \oint \mathbf{E} \cdot d\mathbf{A} = \frac{q}{\epsilon_0}$$

$$\oint \mathbf{E} \cdot d\mathbf{A} = E \cdot 2\pi R \cdot \ell$$

$$q = \int_0^R \rho \cdot 2\pi r \ell \, dr = 2\pi A \ell \int_0^R r^3 \, dr = 2\pi A \ell \frac{R^4}{4}$$

$$E \cdot 2\pi R \ell = 2\pi A \ell \frac{R^4}{4} \cdot \frac{1}{\epsilon_0}$$

$$E = \frac{AR^3}{4\epsilon_0}$$

$$(b) V(R_0) - V(0) = - \int_0^{R_0} \mathbf{E} \cdot d\mathbf{r} = - \int_0^{R_0} \frac{Ar^3}{4\epsilon_0} \, dr = - \frac{AR_0^4}{16\epsilon_0}$$

(c) $\rho < 0$, the direction of \mathbf{E} is to the center of the cylinder. Positive work has to be done to move positive charge from $R=0$ to $R=R_0$, therefore $V(R_0) > V(0)$, $V(R_0) - V(0) > 0$