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

A long non-conducting rod of radius $R_o$, is electrically charged. The charge density within the rod is uniform and can be represented as $\lambda \text{ (C/m)}$ along the rod. (A length $l$ of the rod has a total charge $\lambda l$.)

(a) Find an expression for the electric field for any value of $R > R_o$.
(b) Find an expression for the electric field for any value of $R < R_o$.
(c) What is the magnitude of the potential difference between $R_o/2$ and $R_o$.
(d) Determine the energy stored in the electric field, per meter length, between $R_o$ and $2R_o$.

$$a) \ R > R_o \quad \phi E \cdot d\vec{A} = \frac{q_{enc}}{\varepsilon_0}$$
$$\phi E \cdot d\vec{A} = E \cdot d\vec{A} = 2\pi RPE$$
$$q_{enc} = \lambda l \Rightarrow E = \frac{\lambda}{2\pi \varepsilon_0 R} \quad (E = \frac{2\kappa \lambda}{R})$$

$$b) \ R < R_o$$
$$q_{enc} = \lambda l \frac{R^2}{R_o^2} \Rightarrow E = \frac{dR}{2\pi \varepsilon_0 R_o^2}$$

$$c) \ \Delta V = -\int_{R_{o/2}}^{R_o} E \cdot d\vec{A} \quad E \text{ for } R < R_o$$
$$\Delta V = -\frac{\lambda}{2\pi \varepsilon_0 R_o^2} \int_{R_{o/2}}^{R_o} R dR = -\frac{3\lambda}{16\pi \varepsilon_0}$$

$$d) \ U_e = \frac{1}{2} \varepsilon_0 \int E^2 dV \quad E \text{ for } R > R_o$$
$$U_e = \int_{R_o}^{2R_o} \left(\frac{1}{2} \varepsilon_0 E^2\right) 2\pi R dR = \frac{1}{2} \varepsilon_0 \int_{R_o}^{2R_o} \left(\frac{\lambda}{2\pi \varepsilon_0 R^2}\right) R dR =$$
$$= \frac{\lambda^2}{4\pi \varepsilon_0} \int_{R_o}^{2R_o} \frac{1}{R} dR = \frac{\lambda^2}{4\pi \varepsilon_0} \ln 2$$