

$n = 296$

4

THIRD MIDTERM

Name (Print) Bob Brown Name (Signed) X=15.02 0=8.64


Discussion Instructor (Circle One): Brown Chung Pollard Rothman

Discussion Section #: 1 & 2 Schweizer Soderberg Vaseghi Viohl

REPORT ALL NUMBERS TO THREE SIGNIFICANT FIGURES!

Use the conversion constants and data given on the front page.

Given a long cylindrical nonconductor of radius  $R_0$ . calculate the total energy stored in the electric field inside the cylinder per length  $L$ . The cylinder has a uniform charge density of  $\rho$  C/m<sup>3</sup>.

$R_0$    $\rho = \rho_0$  uniform charge density

$$\int \vec{E} \cdot d\vec{A} = \frac{Q}{\epsilon_0} \quad Q = \int \rho dV = \int \rho_0 2\pi r L dr$$
$$Q = \rho_0 \pi r^2 L$$

$$E(2\pi r L) = \frac{\rho_0}{\epsilon_0} \pi r^2 L$$

+10

$$E = \frac{\rho_0}{2\epsilon_0} r \quad \underline{\underline{\text{Electric Field}}}$$

$$U_E = \frac{1}{2} \epsilon_0 E^2 = \frac{1}{2} \epsilon_0 \left( \frac{\rho_0^2}{4\epsilon_0^2} r^2 \right)$$

+5

$$U_E = \frac{\rho_0^2}{8\epsilon_0} r^2 \quad \underline{\underline{\text{Energy Density}}}$$

$$U = \int U_E dV \quad dV = 2\pi r L dr$$

$$U = \int_0^{R_0} \frac{\rho_0^2}{8\epsilon_0} r^2 2\pi r L dr$$

$$U = \frac{\rho_0^2 \pi L}{4\epsilon_0} \int_0^{R_0} r^3 dr = \frac{\rho_0^2 \pi L}{16\epsilon_0} r^4 \Big|_0^{R_0}$$

$$U = \frac{\rho_0^2 \pi L R_0^4}{16\epsilon_0}$$

(+10)

$$\frac{U}{L} = \frac{\rho_0^2 \pi R_0^4}{16\epsilon_0}$$

Energy per length