Answer on Question#53294 - Physics - Field Theory

A very long nonconducting cylinder of radius ρ and length L ($\rho < L$) passes a uniform charge of density α. Determine the electric field outside of cylinder.

Solution:

According to the Gauss's law (considering that the cylinder is very long) the electric flux through the very long coaxial cylindrical surface is equal to the inner charge divided by ε_0. Let's consider a piece of such cylinder with radius R and length l. Since the surface area of this piece is $A = 2\pi Rl$, the electric flux through this surface is

$$\Phi = A \cdot E(R) = 2\pi Rl \cdot E(R),$$

where $E(R)$ – is the electric field created by the charged cylinder. Electrical charge surrounded by this surface (if $R > \rho$) is $Q = 2\pi\rho l \cdot \alpha$. Therefore we obtain

$$\Phi = \frac{Q}{\varepsilon_0}$$

$$2\pi Rl \cdot E(R) = \frac{2\pi\rho l \cdot \alpha}{\varepsilon_0}$$

$$E(R) = \frac{\rho}{R}\frac{\alpha}{\varepsilon_0}$$

For $R < \rho$ there are no inner electrical charge, thus

$$E(R) = 0, \qquad R < \rho$$

Answer:

$$E(R) = \begin{cases} 0, & R < \rho \\ \frac{\rho}{R}\frac{\alpha}{\varepsilon_0}, & R > \rho \end{cases}$$