Hand In 1

FYSC20

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Problem: Find the electrostatic field a distance s from the axis of an infinitely long straight cylinder with radius a that carries a uniform charge density ρ_0. Consider both $s < a$ (inside the cylinder) and $s > a$ (outside the cylinder).

Solution: We can start by drawing a sketch of the problem and define the coordinates. Since the cylinder is infinitely long there are no edge effects and we have cylindrical symmetry. Thus it is sensible to use cylindrical coordinates. We can see the sketch in Fig. 1. Then we can use Gauss's law to calculate the electrostatic field. We draw a Gaussian surface with length L, radius s and center at $z = 0$. The Gaussian surface can be seen in Fig. 2.

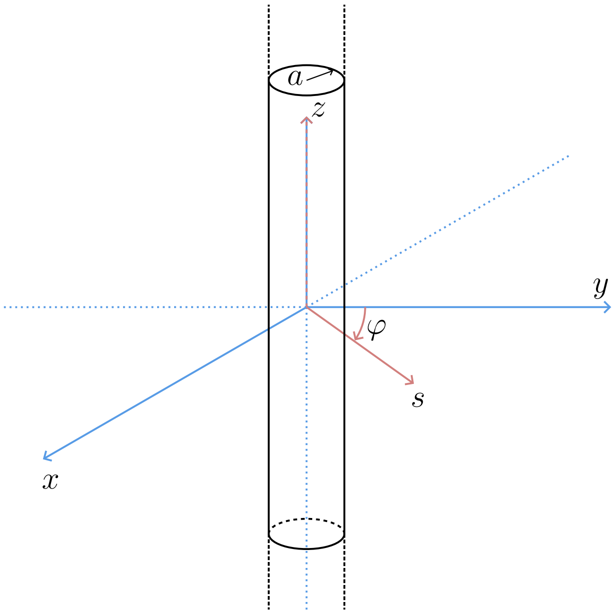

Figure 1: A drawing of the problem with both Cartesian and Cylindrical coordinate axis. The blue axis are Cartesian coordinate while the red axis are the Cylindrical coordinates. The z-axis is common.

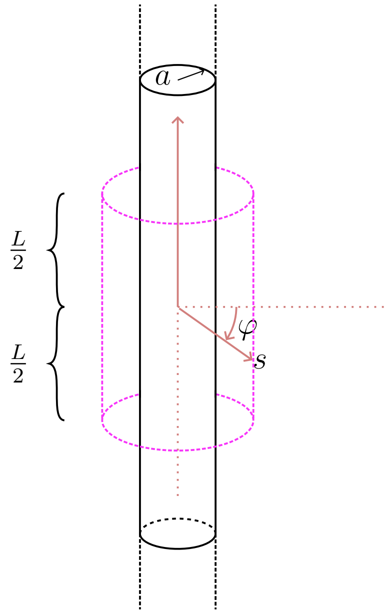

Figure 2: Cylindrical Gaussian surface drawn at radius s with length L.

Gauss's law tells us that

$$\nabla \cdot \mathbf{E} = \frac{\rho(\mathbf{r})}{\varepsilon_0}, \tag{1}$$

where $\mathbf{E}$ is the electrostatic field, ε_0 is the vacuum permittivity, and $\rho(\mathbf{r})$ is the charge density defined as

$$\rho(\mathbf{r}) = \begin{cases} \rho_0 & s \leq a \\ 0 & s > a \end{cases} \tag{2}$$