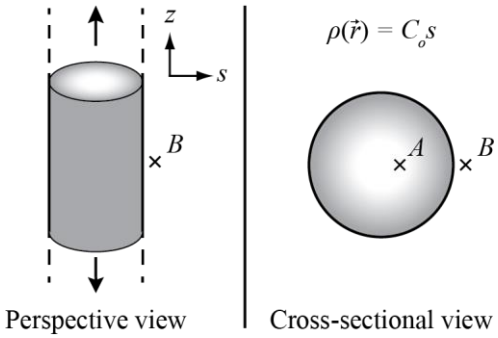
Name _____ **Student ID** _____ **Score**_____
last *first*

IV. [20 points total] Tutorial question.

A charged rod with non-uniform charge density $\rho(\vec{r}) = C_o s$ (while inside the rod) is shown at right, where C_o is a positive constant. There is no charge outside of the rod. The rod is infinitely long.



Point *A* is located near the center of the rod, whereas point *B* is located just outside the surface.

A. Suppose you were to evaluate the magnitude of the electric field at point *B* using Gauss' Law in integral form.

i. [3 pts] Describe and/or sketch a Gaussian surface for which the electric flux integral will be easy to simplify. If there is no Gaussian surface possible, state so explicitly.

A <u>closed cylinder</u> <u>concentric with the rod</u> such that <u>point B lies on the curved surface</u>.

ii. [5 pts] Explain *in words* why the flux integral will be (or cannot be) easily simplified. Any math must be paired with a verbal interpretation of each step.

The flux simplification process requires going from $\int \vec{E} \cdot d\vec{A} \rightarrow \int |\vec{E}| dA \rightarrow |\vec{E}| \int dA$ to evaluate the magnitude of the electric field at point B. For the first step, we need to have the direction of the <u>electric field be perpendicular or parallel to the area vectors</u> on each surface. For the second step, we need to have the magnitude of the <u>electric field be constant along each surface</u> where the flux is non-zero.

B. [4 pts] How does electric field within the rod depend on *z* (*e.g.*, constant with *z*, proportional to 1/*z*, z^2, etc.)? Explain your reasoning.

The electric field is <u>independent</u> of (does not depend on, is constant with) z.

This describes field nature, so we use the continuous translational symmetry along the z-axis to show that regardless of the z-position of the point of interest, the behavior should be the same.

C. [8 pts] Is the divergence of the electric field at point *A greater than, less than,* or *equal to* the divergence of the electric field at point *B?* If the divergence at either point is zero, state so explicitly. Explain your reasoning.

<u>Greater than, with the divergence at point B being zero.</u>

The divergence of the electric field describes the charge density. Point A is a location with positive charge density, while point B is outside of the rod and has no charge.