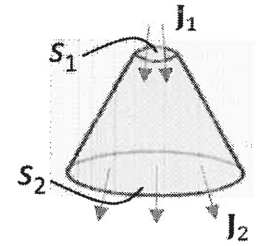
Student Name:

SIS ID (starts with letter "e"):

1. Current density, as a vector field, must satisfy the continuity equation.

$$\nabla \cdot \mathbf{J} = -\frac{\partial \rho}{\partial t}$$

In the magneto-static limit, argue that the current fluxes through the S_1 and S_2 surfaces must add up to zero for the object below.



In the magneto-static limit $\nabla \cdot \vec{J} = 0$

because $\frac{\partial \rho}{\partial t} = 0$

Choose the object as Gaussian surface

$\nabla \cdot \vec{J} = 0 \Rightarrow \oint \vec{J} \cdot d\vec{a} = 0$

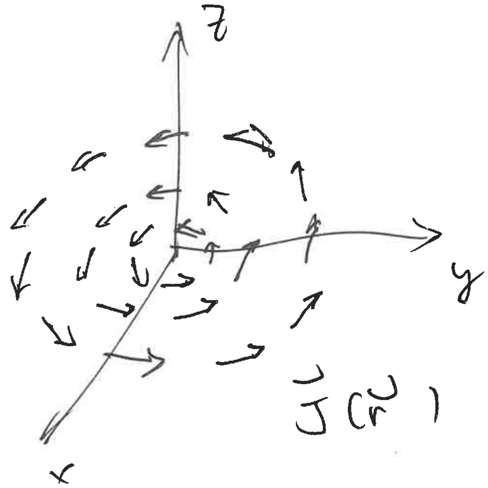
$\Rightarrow \int_{S_1} \vec{J} \cdot d\vec{a} + \int_{S_2} \vec{J} \cdot d\vec{a} + \int_{S_3} \vec{J} \cdot d\vec{a} = 0$

0, because no current passes through there

side surface of cone

$\Rightarrow \int_{S_1} \vec{J} \cdot d\vec{a} + \int_{S_2} \vec{J} \cdot d\vec{a} = 0$

2. Sketch a current density $\mathbf{J}(\mathbf{r})$ that has nonzero curl (hint: simpler to visualize on a 2D plane). Can you guess in what case this would happen?



$\nabla \times \vec{J} \neq 0$, from Ohm's law

$\nabla \times (\sigma \vec{E}) \neq 0$, if σ constant

$\Rightarrow \nabla \times \vec{E} \neq 0$

This cannot happen in the static limit.

Some time-varying effect must occur.

We'll learn later that, from motional emf

$\nabla \times \vec{E} = -\frac{\partial \vec{B}}{\partial t} \longrightarrow$ "eddy current"