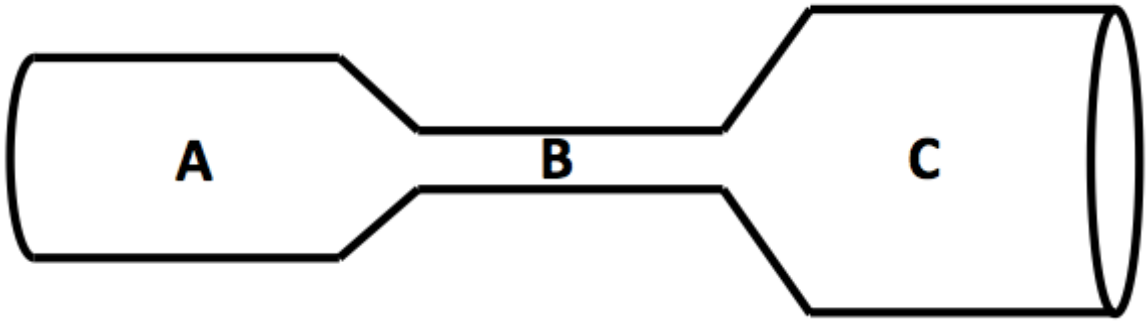
A. A copper cylinder is machined to have the following shape. The ends are connected to a battery so that a current flows through the copper.



For each of the following quantities, rank order their magnitudes in each of the three regions (e.g., A = C > B, etc…).

Total current:

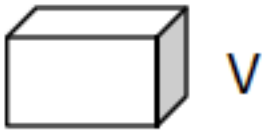
Current density:

Conductivity:

Electric field:

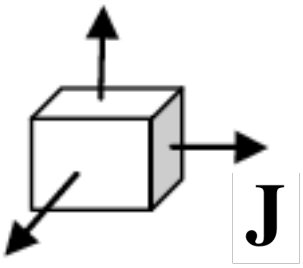
Resistance:

B. A volume V contains a net charge Q_{encl}. What is the relationship between Q_{encl} and the charge density ρ?



What is the relationship between the rate of change of Q_{encl} and the net current flowing *from the interior to the exterior* of the volume (the total charge *leaving* the volume per unit time)? (Watch your signs!)

Consider the *current density* $\mathbf{J}$, which is a function of position. What is the total charge leaving the volume per unit time, in terms of a flux integral of $\mathbf{J}$?



Explain how these results can be combined to get an integral equation that guarantees *charge is conserved*.

Challenge Question: Use the divergence theorem to convert the integral form of this equation to its differential form. Be sure to check your answer with an instructor!