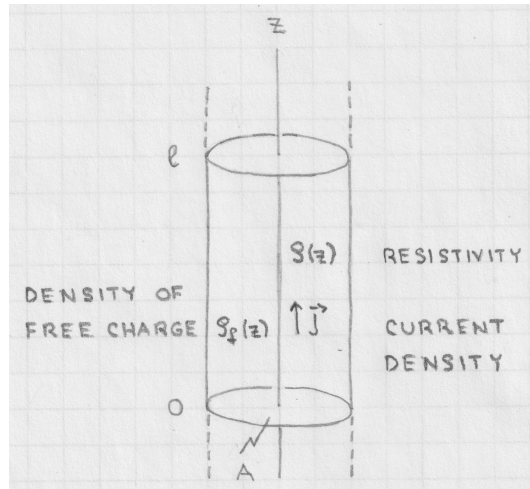


[lex33] Charge accumulated in conductor with steady current

A wire of length l and cross-sectional area A is positioned along the z -axis with one end at $z = 0$ and the other at $z = l$. It carries a steady current I in the positive z direction. The resistivity of its material is inhomogeneous, specified by a continuous and differentiable function $\rho(z)$. The permittivity of the material is assumed to be constant: $\epsilon = \text{const.}$ The wire is connected at both ends to leads with much lower resistivity.

Use the local relations between electric field, current density, resistivity, and charge density established in [ln11] to determine the volume density of free charge, $\rho_f(z)$, across the wire and the surface densities of free charge, $\sigma_f(0)$ and $\sigma_f(l)$, at the two ends of the wire. Show that the total charge accumulated is zero.



Solution: