A wire has a radius is 0.25 mm and a length of 20 cm. The wire is in the center of a metal tube whose inner radius is 1.55 cm. A potential of 4000 V is applied between the wire and the tube. Calculate the energy stored in the electric field between the wire and tube.

Gauss's Law Gives
\[ \int \vec{E} \cdot d\vec{A} = \frac{Q}{\epsilon_0} = \frac{2}{\pi r} \]
\[ E = \frac{2}{2 \pi \epsilon_0} \]

Integrating this from one conductor to the next:
\[ V = \int_{a}^{b} E \cdot dl = \frac{2}{2 \pi \epsilon_0} \ln \left( \frac{b}{a} \right) \]
\[ \lambda = \frac{2 \pi \epsilon_0 V}{\ln \left( \frac{b}{a} \right)} \]

Now we can calculate the capacitance and then the energy stored:
\[ C = \frac{\lambda L}{V} = \frac{\lambda L}{2 \pi \epsilon_0 \ln \left( \frac{b}{a} \right)} = \frac{2 \pi \epsilon_0 L}{\ln \left( \frac{b}{a} \right)} \]

\[ U = \frac{1}{2} CV^2 = \frac{\pi \epsilon_0 \lambda L V^2}{\ln \left( \frac{b}{a} \right)} = \frac{2.16 \times 10^{-5} J}{\ln \left( \frac{b}{a} \right)} \]

Alternatively, we can integrate the energy density over the volume between the two conductors. (U = energy density, \( \frac{dU}{dV} \) = total energy)
\[ U = \frac{1}{2} \epsilon_0 E^2 \]
\[ U = \int_{a}^{b} \int_{z}^{x} \int_{y}^{w} \left( \frac{2 \pi \epsilon_0}{z \pi r} \right) \frac{dV}{V} = \frac{2 \pi \epsilon_0}{2 \pi \epsilon_0} \int_{a}^{b} \frac{dV}{V} = \frac{\lambda L}{\epsilon_0} \left( \frac{2 \pi \epsilon_0 V}{\ln \left( \frac{b}{a} \right)} \right)^2 \ln \left( \frac{b}{a} \right) \]
\[ = \frac{\pi \epsilon_0 L V^2}{\ln \left( \frac{b}{a} \right)} \]