Given a very long, thin wire of radius \( r \) and a charge density of \( +\lambda \) c/m.

(a) Calculate the electric potential difference between the surface of the wire, and a point at a distance \( R \) away from the center of the wire where \( R > r \).

(b) State clearly the sign of the potential difference, \( V(R) - V(r) \), and give a physical reason for it.

\[
V(R) - V(r) = \frac{2\pi \lambda}{2\pi \varepsilon_0} R - \frac{2\pi \lambda}{2\pi \varepsilon_0} r = \frac{2\pi \lambda}{2\pi \varepsilon_0} (R - r)
\]

\[
\therefore V(r) < V(R) \Rightarrow V(R) - V(r) > 0
\]

**Note:** Several people (all unsuccessfully) attempted part (a) by a direct calculation of the potential. This is the way to do it: Let the wire be of length \( 2L \) with \( L > R > r \).

\[
V(R) = 2k \left[ \ln \left( \frac{2L}{2L-r} \right) - \ln \left( \frac{2L}{2L-R} \right) \right] = 2k \ln \left( \frac{2L}{2L-r} \right) - 2k \ln \left( \frac{2L}{2L-R} \right)
\]

\[
\therefore V(R) - V(r) = 2k \left[ \ln \left( \frac{2L}{2L-r} \right) - \ln \left( \frac{L}{L-r} \right) \right] = -2k \ln \left( \frac{L}{L-r} \right)
\]