

29. Consider an infinitesimal segment of the rod, located between x and $x+dx$. It has length dx and contains charge $dq = \lambda dx = cx dx$. Its distance from P_1 is $d+x$ and the potential it creates at P_1 is

$$dV = \frac{1}{4\pi\epsilon_0} \frac{dq}{d+x} = \frac{1}{4\pi\epsilon_0} \frac{cx dx}{d+x} .$$

To find the total potential at P_1 , integrate over the rod:

$$V = \frac{c}{4\pi\epsilon_0} \int_0^L \frac{x dx}{d+x} = \frac{c}{4\pi\epsilon_0} [x - d \ln(x+d)] \Big|_0^L = \frac{c}{4\pi\epsilon_0} \left[L - d \ln\left(1 + \frac{L}{d}\right) \right] .$$