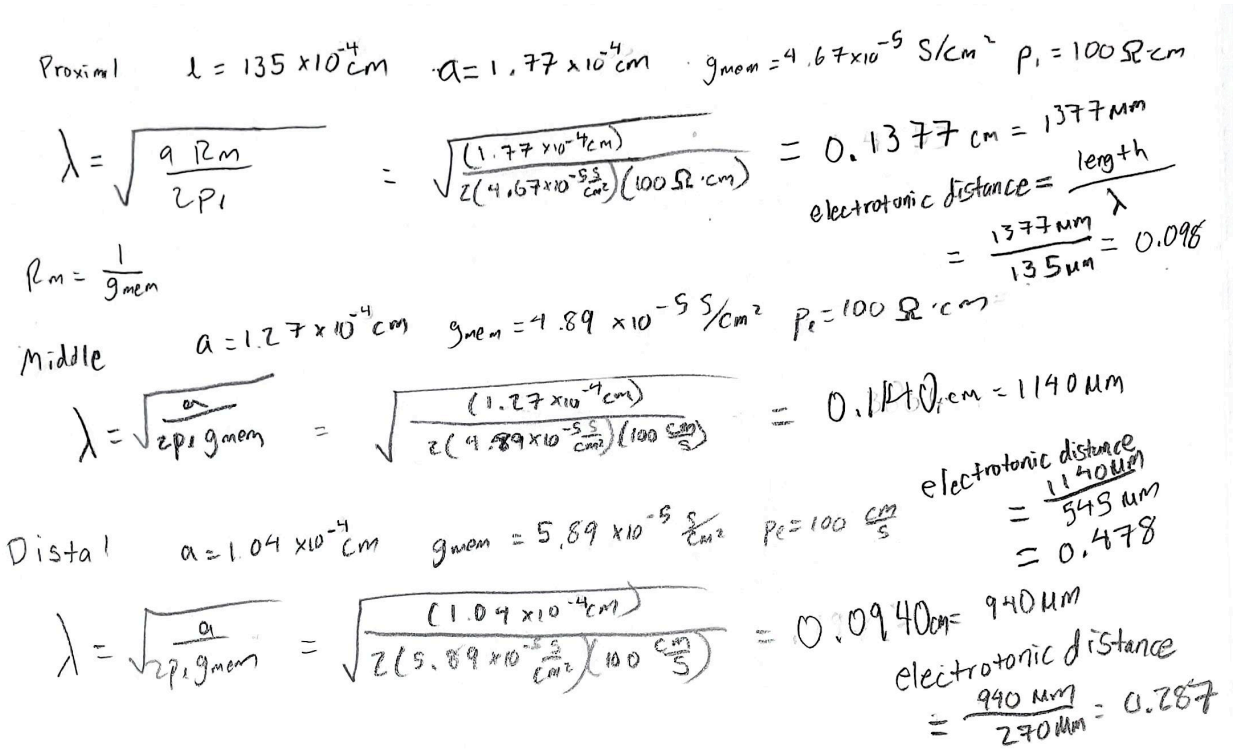
1. When the synaptic input is to the soma, the soma has a extracellular potential heatmap that the signal does not propagate much beyond the sink which is at distance 0. The extracellular potential time course plot shows both that the voltage reading is low, in the microvolt range, and also we can see that there is a brief increase in the voltage before the measurement is over the sink and the measurement dips. Looking at the membrane potential over time, there is an increase at t = 2.5 ms, but the change is not sufficient to reach the threshold and begins to return to resting potential. On the other hand, the tuft has a much more delayed increase in the membrane potential because of the passive spread of charge and also does not reach the aptitude that the soma does. This is the result of the charge dissipating as it propagates down the neuron. When the synapse input is to the tuft, the plots are almost the opposite of the soma plots. First, the heat map shows that the sink is over the area farther away from distance 0, which would be the tufts. This can be seen again with the extracellular potential time course plot as the change all occurs at distances far from the soma. The shape of the plot looks very similar to the plot for the soma where there is an initial slight increase in voltage before it goes down when over the sink. Lastly, the membrane potential plot is basically the same plot as before, but the membrane potential for the tufts reaches a higher amplitude and the soma is delayed and much weaker of a change in voltage over time.
2. When the conductance is set to 0.02, the neuron fires an action potential. This can be seen with the heat map as there is a large negative charge at y = 0, indicative of an action potential. We also see that in the soma, there is the spike we would expect to see in the membrane potential, but there is no spike in the membrane potential of the tuft. Likely, the diffusion of the charge down the neuron did not stay large enough because of leakage or axial resistance and it did not reach the threshold there. During the depolarization stage of the action potential, the sink is found over the soma, where all the positive current rushes into the cell. At this point, the source is the surrounding areas to the soma where there is some passive current leaking. On the other hand, the repolarizing phase of the action potential has opposite sources and sinks. Here the source is the soma where the potassium current is rushing out of the cell, creating a positive extracellular potential. The sink then becomes the parts of the neuron adjacent to the soma as the current rushing out flows back into the cell.
3. When the beta value is changed to 180 degrees, there is essentially a flip over the x axis of the extracellular potential plots. The amplitudes are the same, but the direction is the opposite. The current propagated in the negative direction when beta was 0, so now with beta being 180, the propagation is in the positive direction. When the beta value is changed to 90 degrees, there is now an even spread of charge over distance because the electrode is not parallel to the neuron. As a result, all parts of the electrode measure the same change, but as the electrodes get further away from the neuron, the signal gets much weaker. The part of the cell that intersects with the electrode still enables us to visualize the sink and source change that occurs from depolarization to repolarization.




4.

Based on these calculations, we see that the electrotonic distances are similar but a little different from the notebook. I would expect the distal electrotonic distance to be close to 2, but when summing up all the distances to get to the distal part of the neuron, it is closer to 1. Otherwise, the results seem to be reasonable and line up with what is displayed in the notebook.