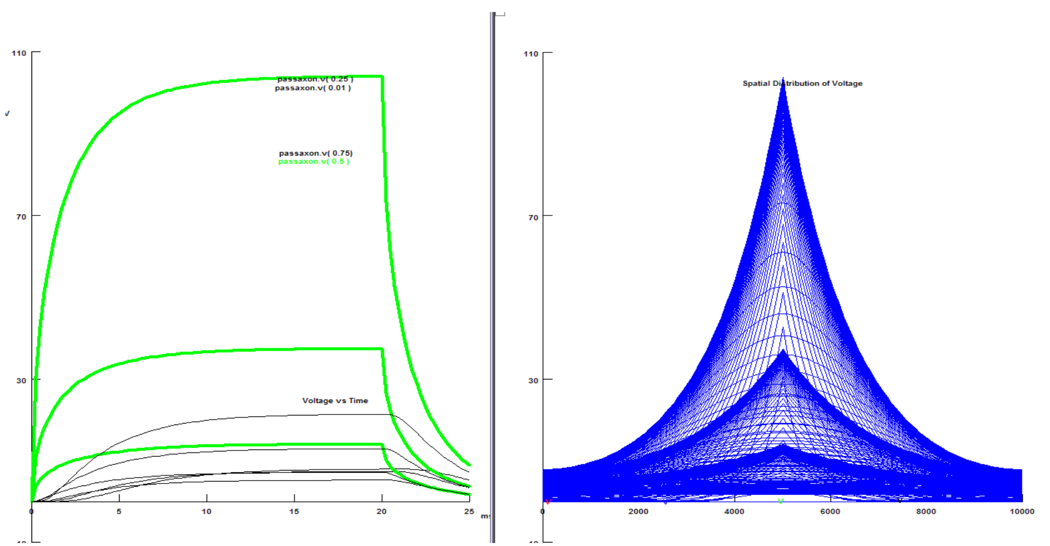
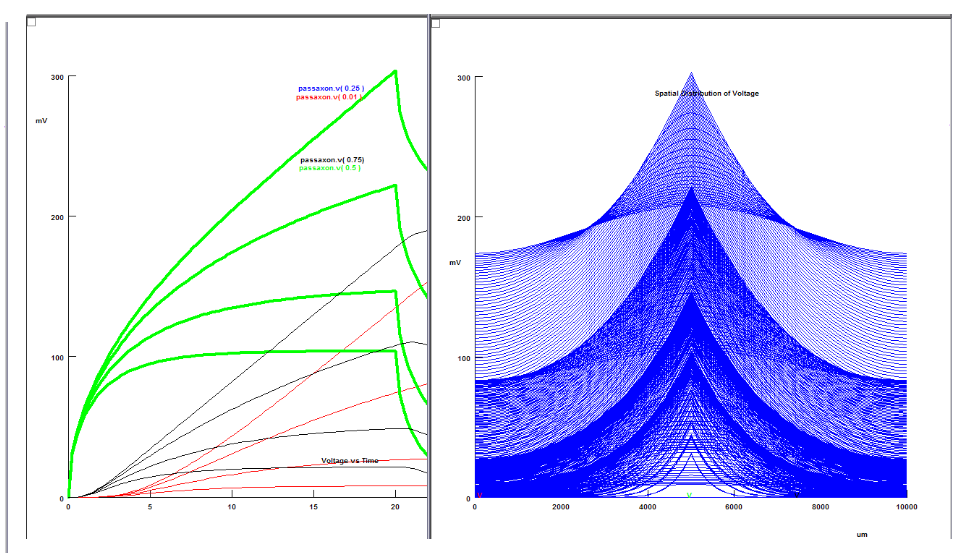
Lab K

With Bonus?

Observation: Effects of Axon Diameter and Resistance on Total Voltage change and length constant

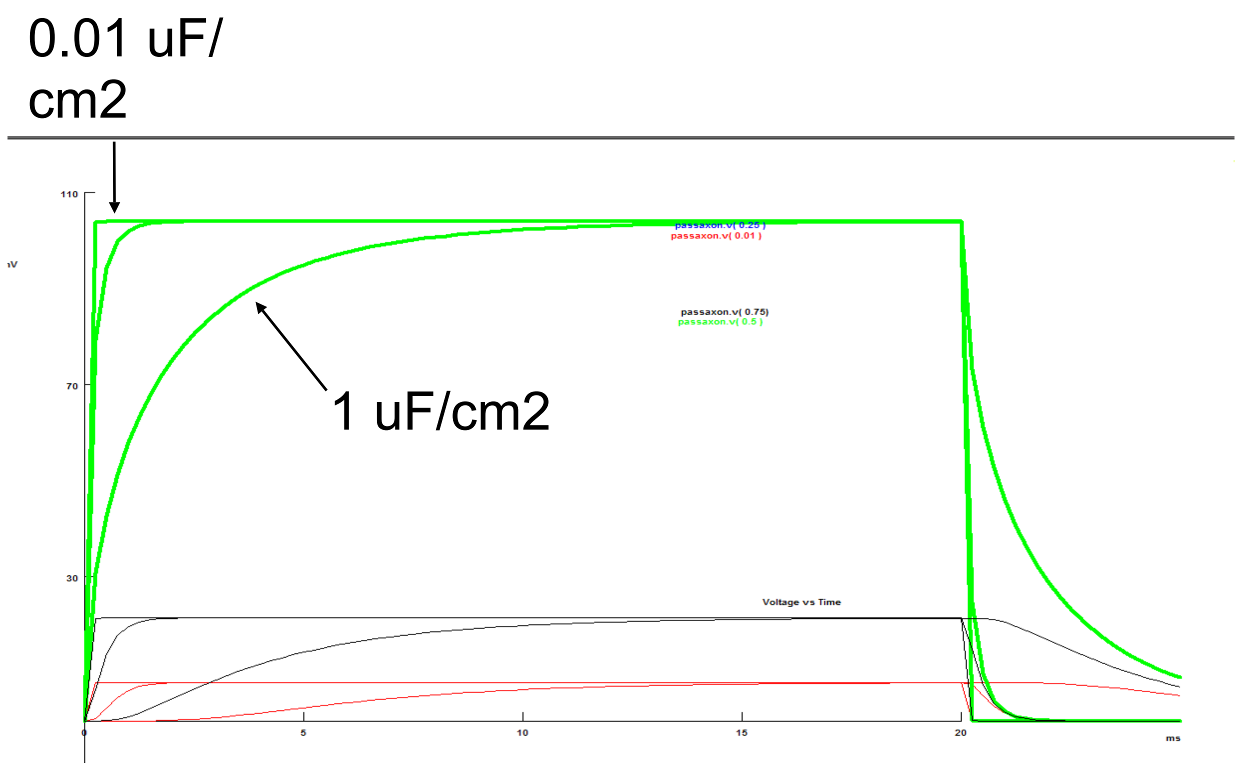
To the left below is the membrane voltage over time for axons of diameter 10, 20 and 40 um (top to bottom). To the right are the voltage profiles for axons of resistances (leak currents) of .003, .0015, .005, and 0 (bottom to top). These two graphs demonstrate the length constant equation ***L*** = square root **(r*m* / *ra*)**. As can be seen, if the diameter of an axon is increased while the charge is held current, the axonal resistance becomes greatly reduced. This results in an increase in the length constant as ions can more easily flow down the axon. (The reduced peak voltage mostly reflects the increased volume – since the stimulus length and amplitude are constant only a fixed number of ions enter the axon.) A similar effect is witnessed with a decrease in leak current. As the membrane becomes impermeable to ions, rm increases, as does the length constant. Moreover, since current is not being lost, the charge buildup in the fixed size axon grows progressively larger as leak channels are removed.





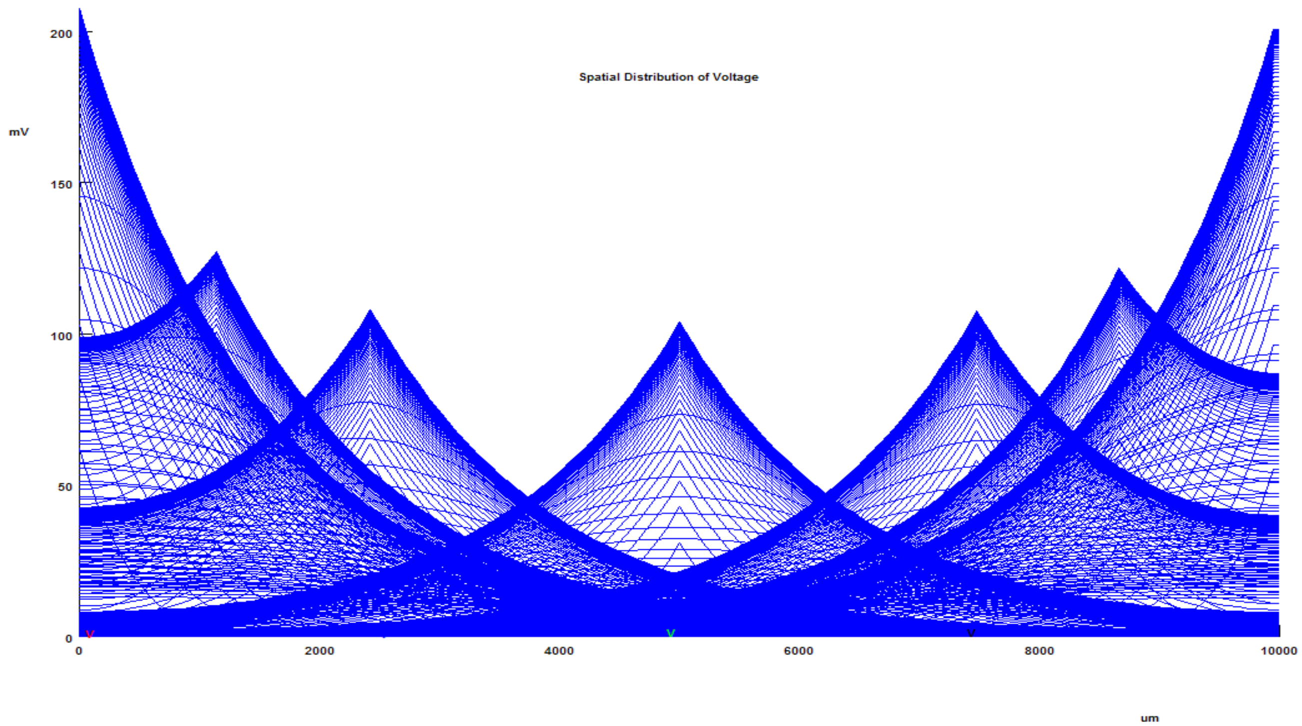
Observation: Effects of Changing Membrane Capacitance

Shown below are the effects of altering the membrane capacitance. Although the overall voltage change and length constant are unaffected, the rate of change for each location is significantly increased as capacitance decreases. The reason for this is simple. Capacitance can be though of as opposing charges aligning themselves with each other across the membrane to neutralize the imbalance as best as possible. As capacitance is reduced – eg if surface area is reduced or the membrane is thickened, the electrical attraction between these charges decreases. Consequently the ease with which charge can build up inside the cell is increased.



Observation: Effect of Varying Electrode Placement on the Axon

The effect of placing the electrode at varying points along the axon can be seen here, with the peak at the point along the axon where the electrode was placed. As can be seen, since the axons in Neuron are assumed to have capped ends, when a charge is applied near an end, the greatest voltage change for a point on the axon under those conditions is observed. Since the voltage change essentially reflects the diffusion of charge in either direction – with charge reaching the capped end free to reverse its course – as the electrode moves away from either end there is a steep drop off in the peak current. This decline slows exponentially and asymptotically to ½ of the charge observed at either end. (Since towards the middle charge is free to diffuse in either direction along the linear path, in this nearly one-dimensional situation)



Bonus: Time Constant

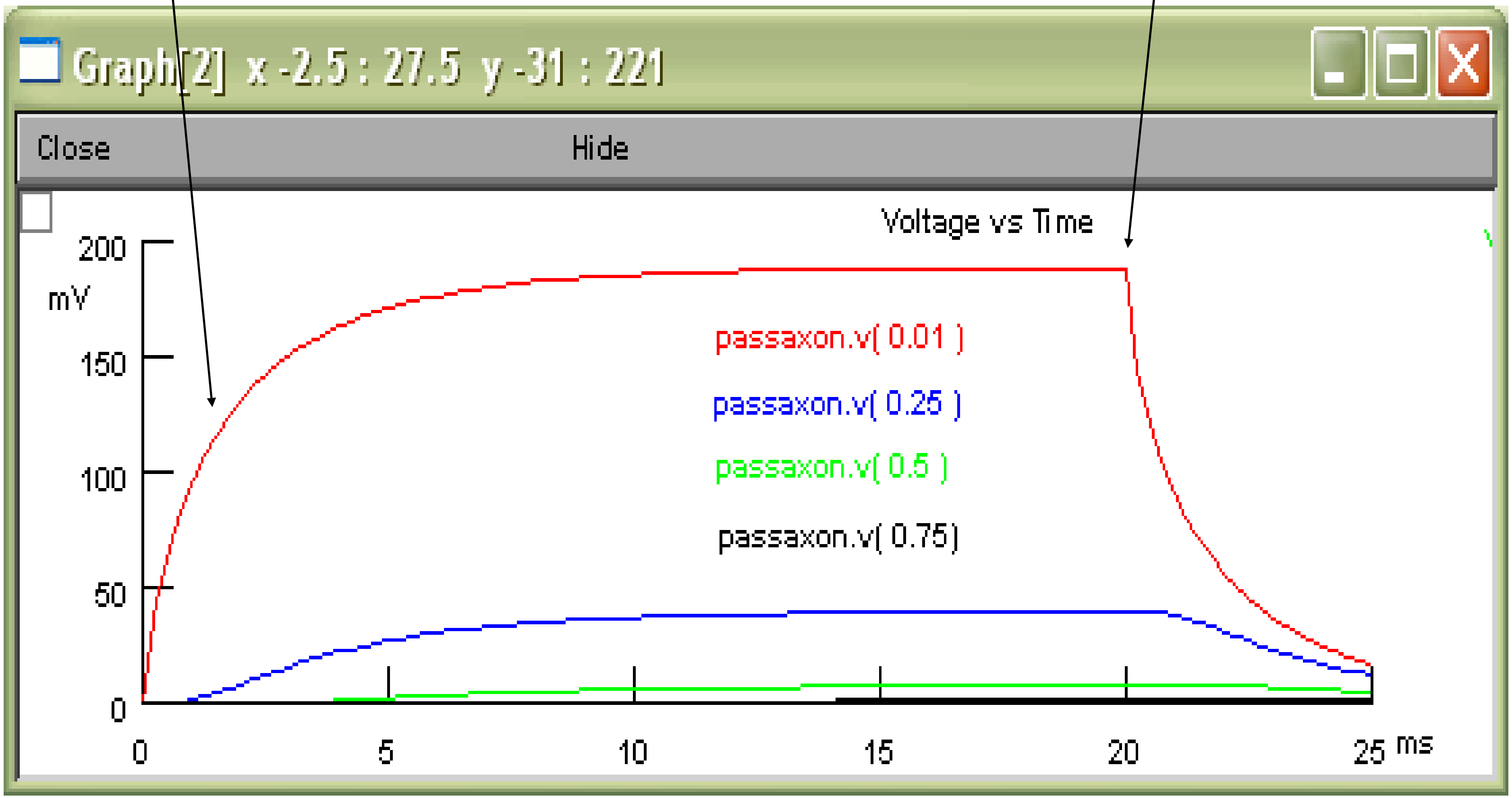
$$\tau = r_m c_m$$

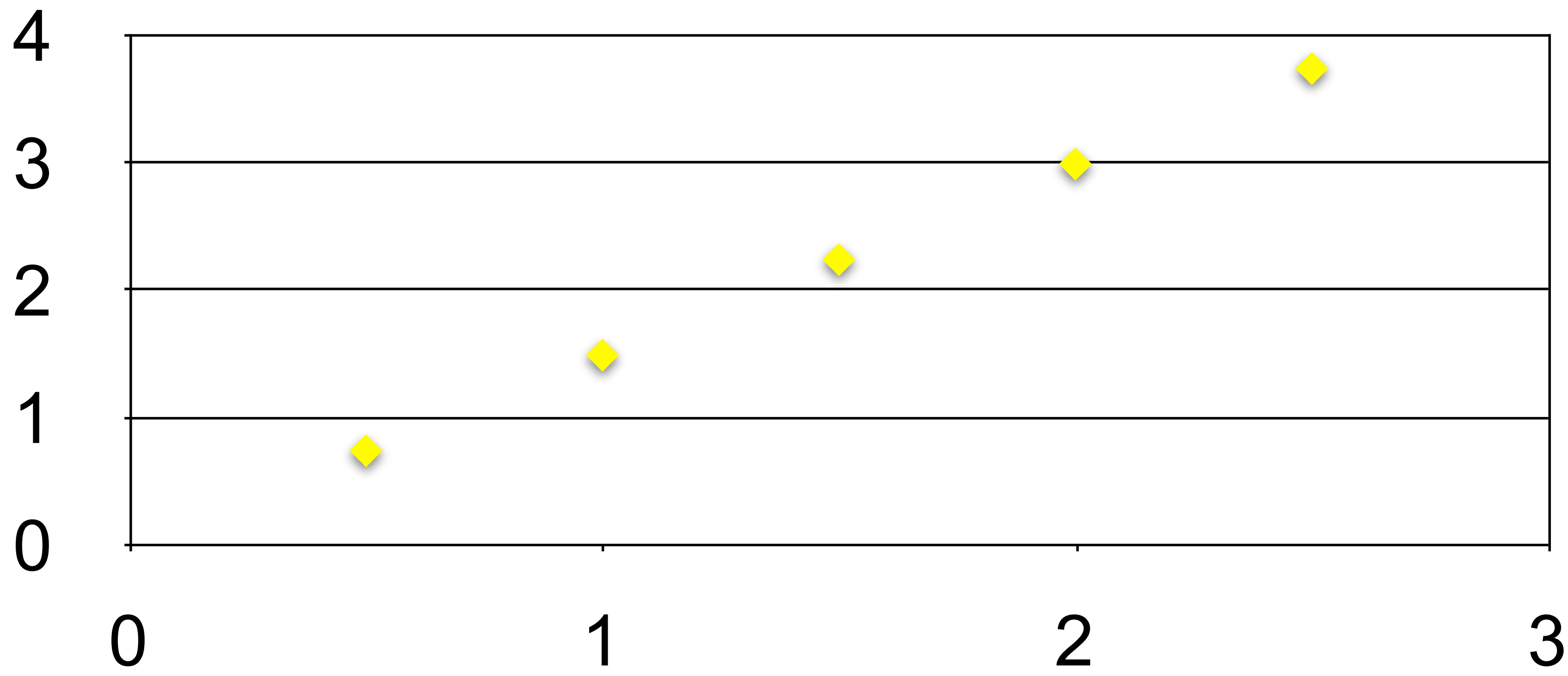
- Time constant = membrane resistance * membrane capacitance

118 mv

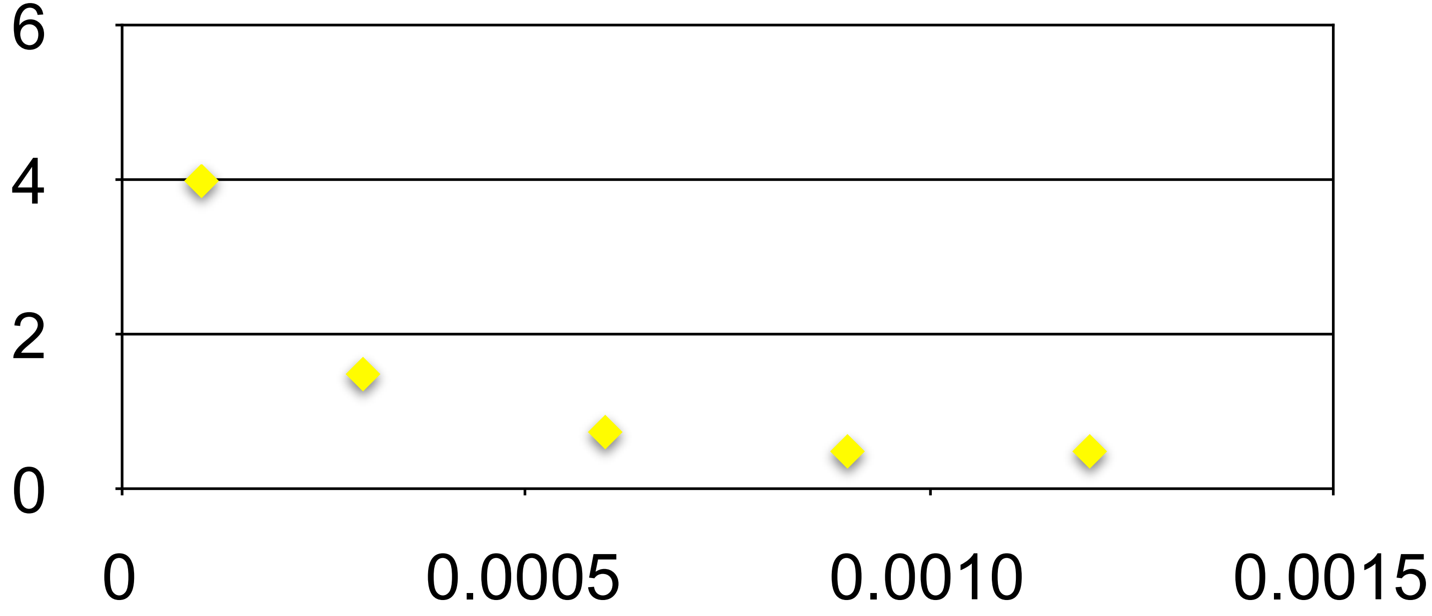
(188 * 1 – 1/e) = T

188 mV





- As membrane capacitance is increased, the time constant increases
- T and C_m are directly proportional



- As Leakage conductance is increased (membrane resistance decreased), time constant decreases
- r_m and T are directly proportional