BIO 365L: Fall 2009

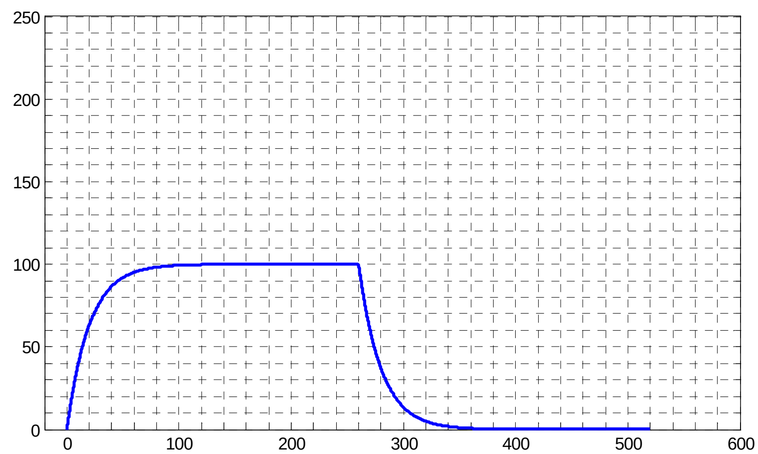
Dr. Markham

Homework 1 (10 points total): Ohm's Law, RC circuits, and membrane time constants.

First, some helpful background information. You can think of the time constant of an RC circuit (or cell membrane) as the amount of time required to charge or discharge the capacitor 63.2% of the way toward its final voltage. After one time constant, the capacitor will be charged to 63.2% of its final voltage. After the next time constant, it will be charged to 86.5% its final value because it has charged by 63.2% closer toward its final voltage, starting from the voltage reached after the first time constant (36.8% * .632 + 63.2% = 86.5%). The process repeats itself, until the change in voltage across time approaches zero. You can use this information to estimate the time course of voltage change in an RC circuit with a simple hand calculator.

Shown in the figure below is the voltage response of a cell (in milliVolts) to a 260ms-long step current of 1000pA. The X-axis is in milliseconds. The time constant (tau) for this cell is 20 ms.

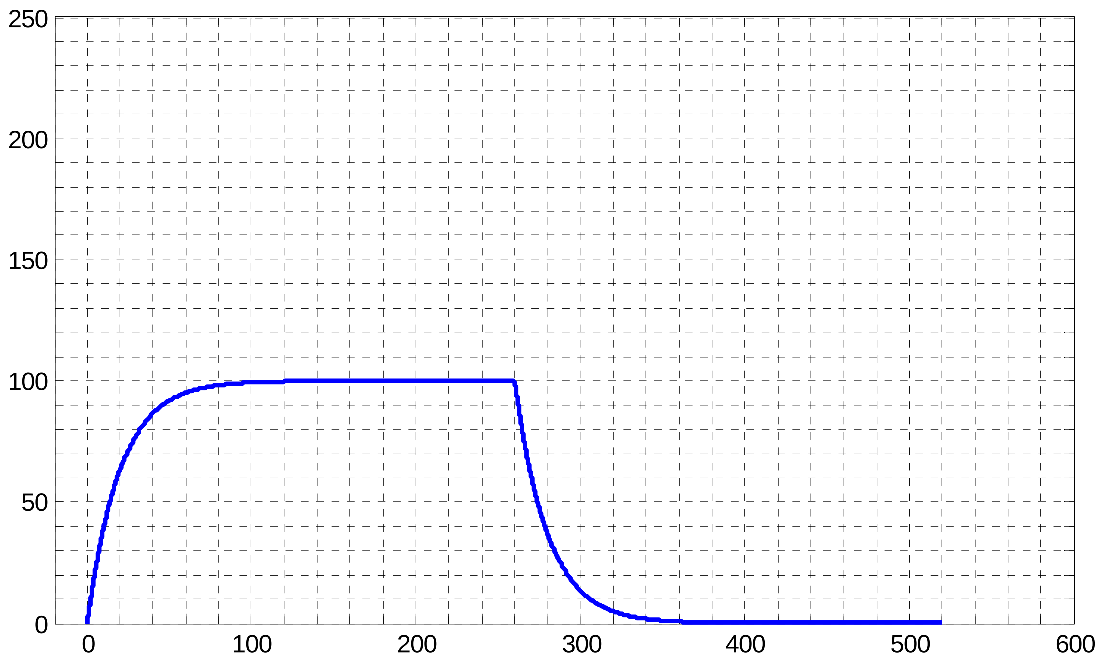
1. (0.5 point) What is the membrane resistance of this cell in MegOhms (MΩ)? Show your work.



2. (0.5 points) What is the capacitance of the cell membrane (in picoFarads)? Show your work.

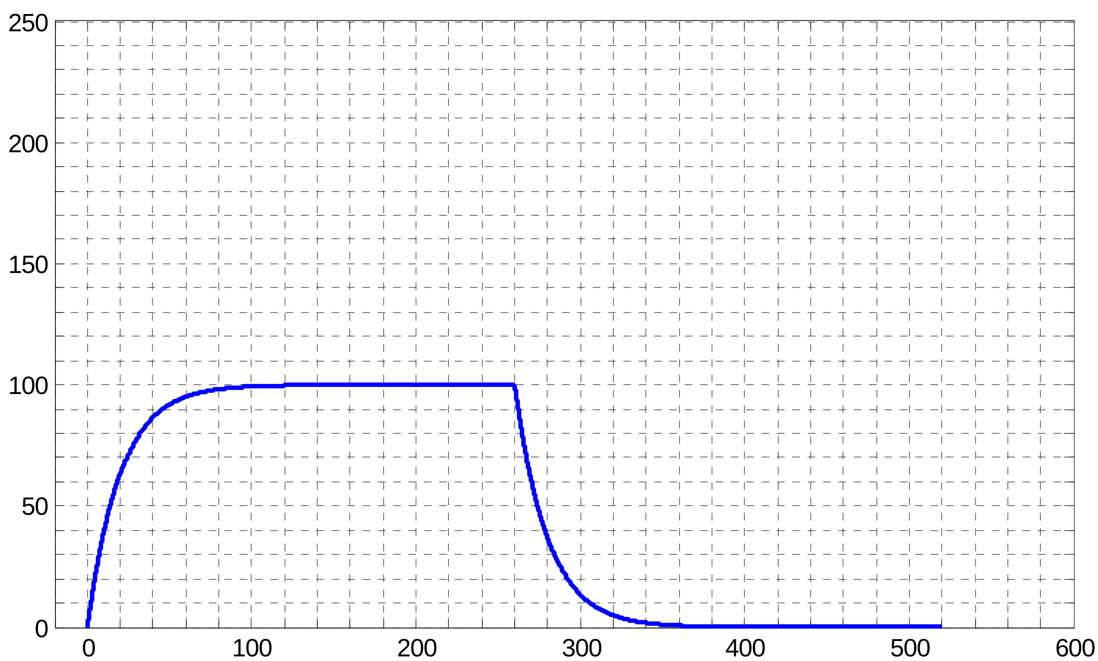
3. (2 points) Draw on the following graph what the voltage response would look like **if the membrane time constant remained the same**, but the membrane resistance was decreased to 50 MΩ. Draw the voltage response if the membrane resistance was increased to 200 MΩ and the **time constant remained the same**. Fill in the following tables to help guide your calculations and to plot points on the graph to help you sketch your predicted voltage response.

Time (ms)	Membrane Voltage (mV)	Time (ms)	Membrane Voltage (mV)
0	0	0	0
20		20	
40		40	
60		60	
280		280	
300		300	
320		320	

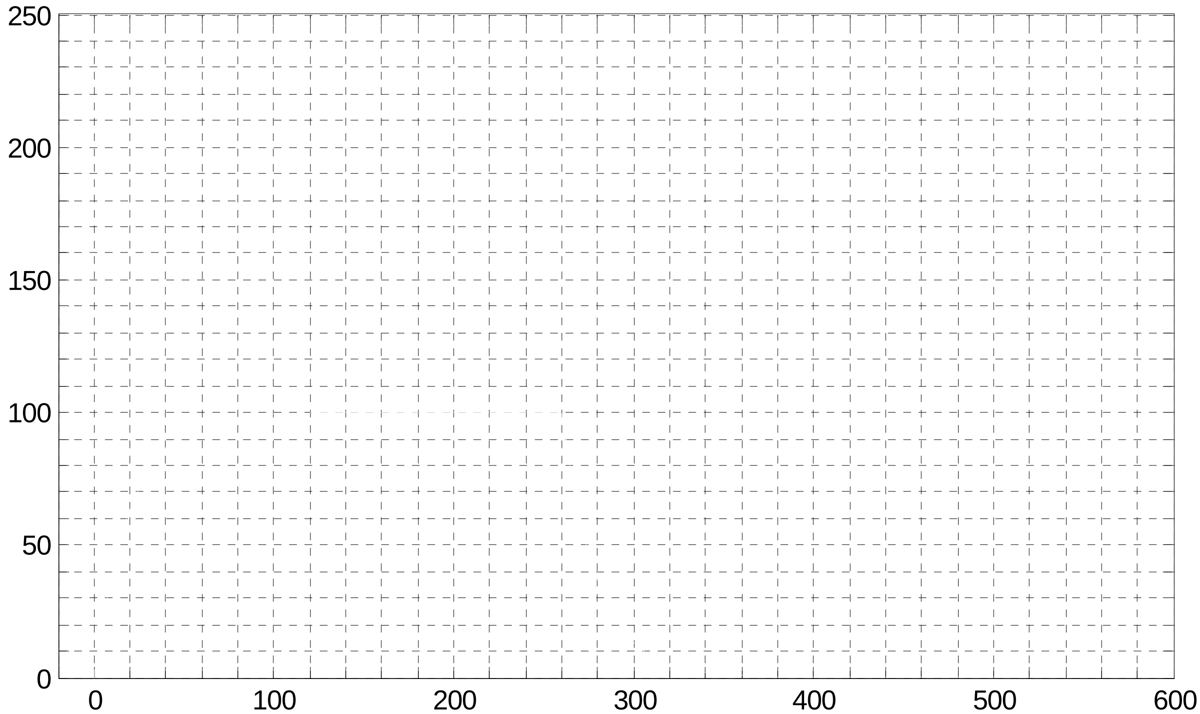


4. (2 points) In the following graph, draw what the voltage response would look like **if the membrane capacitance remained the same** (from your answer to #2 above), but the membrane resistance decreased to 50 MΩ.   What would the new time constant be for this membrane?

Draw what the voltage response would look like **if the membrane capacitance remained the same** (your answer to #2 above), but the membrane resistance increased to 200 MΩ.   What would the new time constant be for this membrane?



5. (2points) In the following graph, plot the voltage response of a passive cell membrane in response to a 260 ms duration current step of 2000 pA. The membrane resistance is 75 MΩ and the membrane capacitance is 400 pF.6/



6. (3 points) In a paragraph or so, describe what effects the cell's resistance and capacitance have on the **speed** and **size** membrane's response to input currents.