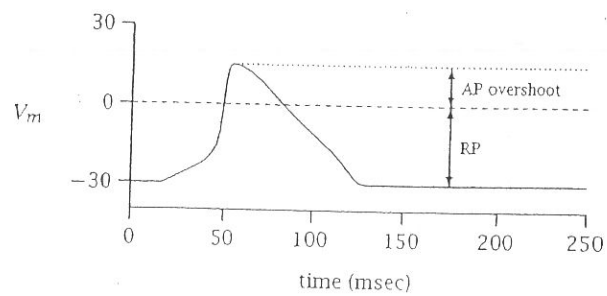
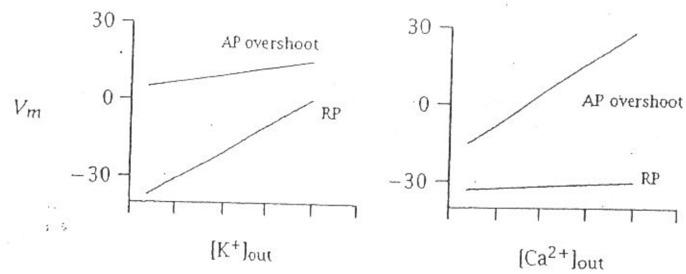
MCB 166 Problem Set #3

This problem set consists of three nice problems taken from Johnson & Wu, chps 2,3.

1. The unicellular organism *Paramecium caudatum* shows a resting potential (RP) and an action potential (AP) that are similar in many respects to corresponding neural potentials. With the cell in "typical pond water," the following measurements were made with an intracellular electrode:



If one varies $[K^+]_{out}$ only, or $[Ca^{2+}]_{out}$ only, one observes the following:



In the following questions, assume that the membrane of *P. caudatum* is normally permeable only to K^+, Ca^{2+}, and water.

(a) In the resting state, which of these is true? Explain concisely.

i. $P_K > P_{Ca}$

ii. $P_K = P_{Ca}$

iii. $P_K < P_{Ca}$

(b) Which is true during the peak of the AP? Explain concisely.

(c) Compared to the ionic concentrations of "typical pond water," is $[K^+]_{in}$ greater than, equal to, or less than $[K^+]_{out}$? Explain.

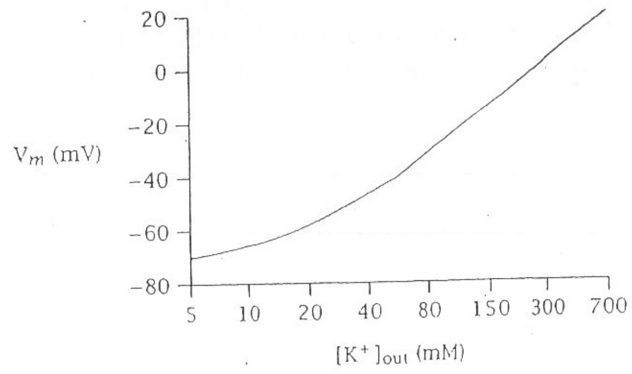
(d) Compare also $[Ca^{2+}]_{in}$ with $[Ca^{2+}]_{out}$.

(e) When the posterior end of the organism is mechanically tapped, the membrane transiently hyperpolarizes. What permeability change(s) might be responsible? Explain.

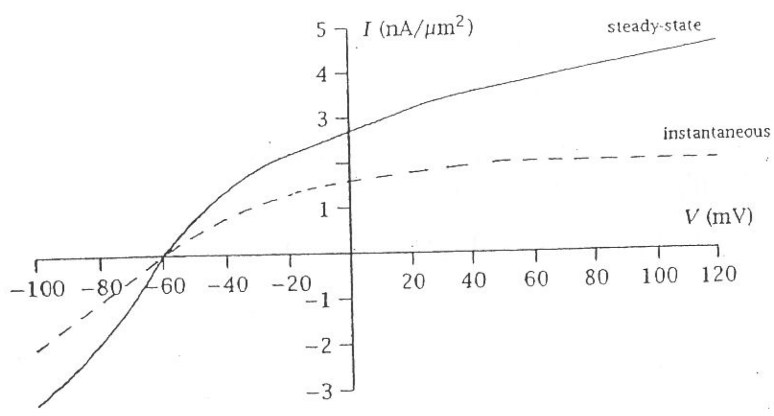
2. (a) *Briefly* state the assumptions for the constant field model.

(b) Sketch approximately the *I-V* relations predicted by the constant field model for various ratios of intracellular and extracellular ion concentrations, i.e., when $\frac{[C]_{in}}{[C]_{out}} = 0, 0.1, 1, 30$, or ∞.

(c) Using the data provided in the figure below, calculate the ratio of P_{Na}/P_K that predicts the resting potential as a function of $[K^+]_{out}$ for the *Myxicola* neuron. Note: $[Na^+]_{out} = 430$ mM, $[Na^+]_{in} = 12$ mM, $[K^+]_{in} = 270$ mM, and $P_{Cl} = 0$.



3. The instantaneous and steady-state *I-V* relations of a neuron obtained from voltage-clamp experiments are shown below:



The time-dependent current follows first-order kinetics with the time constant $\tau = 0.1$ sec.

(a) Draw the membrane current with respect to time after the membrane voltage is stepped from $V_H = -60$ mV to $V_c = 0$ mV and to $V_c = -80$ mV. Label the current and time axes with the appropriate units.

(b) Repeat (a) after the membrane voltage is stepped from $V_H = +50$ mV to $V_c = +100$ mV.