171/271 HW4 - fall 2007

1. Textbook, Chapter 10: problems 6,7,9,15

2. Consider an integrate and fire neuron with reset voltage of -80mv, threshold of -54mv, time constant of 20msec. An external current of size $R_m I_{ext}$ of magnitude 30mv is turned on for a fixed period of time T. Find the range of T over which exactly one spike is generated.

3. (271 only) Consider a generalization of the simple integrate-and-fire neuron in which the membrane voltage obeys the nonlinear equation

$$\tau_m \frac{dV}{dt} = a_0(V - V_r)(V - V_c) + RI_{ext}$$

where $V_c > V_r$ and everytime the voltage reaches a threshold V_{th}, a spike is triggered and V is reset to V_{reset}. Find an implicit equation relating the spiking period to the value of the input current (assumed constant in time)

4. Consider the Morris-Lecar two component neuron model which can be written in the form

$$\begin{aligned} \frac{du}{dt} &= -g_c m_0(u)(u-1) - g_k w(u - u_k) - g_L(u - u_L) \\ \frac{dw}{dt} &= \frac{\phi}{\tau_w(u)}(w_0(u) - w) \end{aligned}$$

with parameters $g_K = 2$, $g_L = .5$, $u_1 = -.01$, $u_2 = .15$. The functions are given by

$$\begin{aligned} m_0(u) &= \frac{1}{2}(1 + \tanh \frac{u - u_1}{u_2}) \\ w_0(u) &= \frac{1}{2}(1 + \tanh \frac{u - u_3}{u_4}) \\ \tau_w(u) &= \frac{1}{\cosh \frac{u-u_3}{2u_4}} \end{aligned}$$

a. Draw the nullclines of this system for the case of $\phi = .2$, $g_c = 1.1$, $u_3 = 0$ and $u_4 = .3$

b. Do the same for the alternate case of $\phi = .33$, $g_c = 1$, $u_3 = .1$ and $u_4 = .145$

c. Which of these cases can be expected to be type I (saddle-node rather than Hopf bifurcation)?