NACS 643 Homework #6
Spring 2009

Build and study a simple model of oscillations arising from the interaction of excitatory and inhibitory populations of neurons. The firing rate of the excitatory neurons is v_E, and that of the inhibitory neurons is v_I and these are characterized by equations 7.50 and 7.51 from Dayan & Abbott. Set $M_{EE} = 1.25$, $M_{IE} = 1$, $M_{II} = 0$, $M_{EI} = -1$, $\gamma_E = -10$ Hz, $\gamma_I = 10$ Hz, $\tau_E = 10$ ms, and vary the value of τ_I. The negative value of γ_E means that this parameter serves as a source of background activity (activity in the absence of excitatory input) rather than as a threshold.

1) Solving the differential equations as a function of time, show what happens for a few reasonable initial conditions for $\tau_I = 30$ ms: Plot v_E and v_I as a function of time for one initial condition, and plot v_I vs. v_E on the phase plane for all cases. Make sure you pick initial conditions appropriate for examining trajectories that cover a large area of phase space.
2) Repeat (a) for $\tau_I = 50$ ms.
3) For (a) and/or (b), when the solution is a stable oscillation, estimate the period of the oscillation. How does that compare to the frequency obtained by dividing the imaginary part of the eigenvalues by 2π using equation 7.53?
4) Find the value of τ_I, to within 1 ms, for which there is a transition between fixed-point and oscillatory behavior, thereby verifying the results obtained analytically in chapter 7 on the basis of equation 7.53. Demonstrate this by plotting trajectories on the phase plane.