Problem Set 3

1. **Finite Passive Cable**
   Consider a finite, passive cable of length $L$, $0 \leq x \leq L$, into which a steady current is injected at a position $x_0$,
   $$i_e = I_e \delta(x - x_0)/2\pi a.$$ Determine the steady-state voltage $v(x)$ if no current can flow through the ends of the cable.

2. **Coupled Integrator Neurons**
   Consider two neurons described by Izhikevich’s simple model in an integrator mode: $a = 1$, $b = 0$, $c = -55$, $d = 6$. In effect, this is simply the quadratic integrate-and-fire neuron. Apply a steady current injection of $I_e = 17$ into both neurons.
   Couple these two neurons with two identical slow synapses described by the difference of two exponentials as described in the class notes. As maximal conductance use $\bar{g} = 0.3$ and for the decay times use $\tau_1 = 0.2$ and $\tau_2 = 0.1$. Choose $\Delta P_s = 0.1$.
   Investigate the dynamics of these two neurons up to a time $t_{max} = 500$ as a function of the reversal potential $E_{syn}$ of the two synapses, using slightly different initial conditions for the two neurons. Keep track of all the spike times $t_j^{(1,2)}$ of the neurons and plot the difference $t_j^{(1)} - t_j^{(2)}$ between the times of the $j^{th}$ spike of neuron 1 and of neuron 2 as a function of time for different values of $E_{syn}$. Do you observe a qualitative change in behavior when you scan across the range $-65 \leq E_{syn} \leq 50$?