1. (15 points) Label each of the following as “afferent” or “efferent”.

(a) Information from M1 to move of your bend your thumb upwards
(b) Information from semicircular canals about direction of current head motion
(c) Information from elbow about degree of muscle stretch achieved

2. (42 points) You have been sitting at rest for at least ten time-steps at position 20. Starting at time \( t=1 \), you start moving to get to position 50.

(a) Assuming your motion strategy is:
   \[
   \text{Motion}_t = 3/4 \times (\text{Target} - \text{Actual}_t)
   \]
   What is your location at time \( t=4 \)?

(b) Assuming your motion strategy is:
   \[
   \text{Motion}_t = 3/4 \times (\text{Target} - \text{Sensed}_t)
   \]
   and your Sensed location is your actual location 3 steps in the past
   \[
   \text{Sensed}_t = \text{Actual}_{t-3}
   \]
   What is your location at time \( t=4 \)?

(c) In class we commented there is a relation between the fraction you multiply – e.g., \( 3/4 \) or \( 1/2 \) -- and the sensation delay. For a given delay, a properly sized fraction will cause you to converge towards your target rather than have ever growing oscillations away from your target.

   **Given a sensation delay of 3 time points, find a fraction to multiply by to prevent ever growing oscillation (the oscillation should converge)!.** Try numbers such as 0.8 (4/5), 0.2 (1/5), and 0.5 (1/2) to get an intuition. (It may help to run a simulation in Matlab like we implemented in class; you also can just try to reason about it and you may explain your reasoning for partial credit.)
(d) In the Forward model, presume there is a sensation delay of 3 time steps. At time \( t=5 \), you unexpectedly get pushed off track by the wind. At with time point \( (t=??) \) will \( D-S \) no longer be equal to 0?

3. (28 points) Reflecting the binding hypothesis/binding problem, list the set of objects (e.g., “big red ball,” “pink flamingo”) present in the scene producing the following spiking patterns. Each row reflects the spiking of a neuron encoding the feature named at the beginning of the row. In this assignment, spikes are considered to be synchronous if they occur within 1 ms of one another.

a:

```
Flower  Tree  Bush  Green  Red  Yellow
Big  Dangerous
```

b:

```
Open-door  Old  Blue  White  Tent  Building
House
```

[Diagram of spiking patterns]
c Let us say I redefine synchrony as spikes occurring within 10 ms of one another. Will this definition of synchrony change the interpretation of the spiking patterns for part b above?

d Estimate the widest spike synchrony window you can define without changing the interpretation of the spiking patterns above. Provide a separate answer for parts a and b each.

4. (15 points) Thinking back to the beginning of the semester, we learned that the voltage of a neuron could be modelled by the “leaky integrate and fire” equations:

\[ \tau \frac{dv(t)}{dt} = -(v(t) - E_L) + RI(t) \]
\[ v(t + \delta) = v_{reset} \quad \text{if} \quad v(t) > v_{thresh} \]

Let us assume \( \tau = 100 \), \( RI(t) = 60 \) mV, \( E_L = v_{reset} = -65 \) mV, \( v_{thresh} = -25 \) mV, \( v(0\text{ms}) = -60 \) mV

We wish to simulate voltage at every 1ms, for time t=0 – 1000 ms.

Provide code to compute the voltage values at time t=1ms, 2ms, 3ms, ... 1000ms. Store the results in the vector: \texttt{voltage}

(Optional: It will be worthwhile for you to \texttt{plot(voltage)}).