

CISC 3250 example exam questions

This gives a sense of the type of questions that can be included. Further math topics covered in the homeworks (but not in this practice set) may appear on the exam as well.

We use the voltage model: $\tau \frac{dv}{dt} = -(v(t) - E_L) + RI(t)$

With voltage resetting to E_L once it reaches the threshold v_{thresh} , as specified by $v(t^f + \delta) = E_L$

Let us say $E_L = -60\text{mV}$, $\tau = 1$, and $v_{\text{thresh}} = -35\text{mV}$.

Furthermore, we define the axon voltage at time $t = 0\text{ms}$ to be: $v(0) = -40\text{mV}$

Presuming a constant input $RI(t) = 10\text{mV}$, how does the axon voltage change from time $t = 0\text{ms}$ to $t = 1,000\text{ms}$? For example, does the voltage spike, stay the same, plateau at another voltage value? Explain why, using the above equation(s) for the voltage model.

Presuming the input rises to $RI(t) = 300\text{mV}$ starting at $1,001\text{ms}$, what is the axon voltage from time $t = 1,001\text{ms}$ to $t = 2,000\text{ms}$? Does the voltage spike, stay the same, plateau at another voltage value? Explain why, using the above equation(s) for the voltage model.

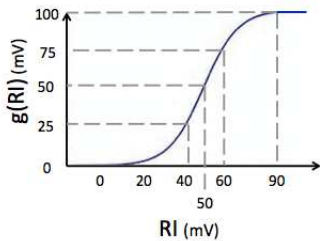
Presuming a constant positive input $RI(t)$ over a long period of time, what is the minimum input value to produce spiking?

Let us assume $\tau = 1000$ (and all other parameters are the same as initially described). Presuming a constant positive input $RI(t)$ over a long period of time, what is the minimum input value to produce spiking?

Explain a biological mechanism by which spiking information is communicated from the axon of neuron A to the dendrite of neuron B.

We can replace the $RI(t)$ term from the equation above with $g(RI(t))$, where $g()$ is the sigmoid function we learned in class, now scaled to have a maximum output of 100mV, rather than just 1:

$$\frac{dv}{dt} = -(v(t) - E_L) + g(RI(t))$$



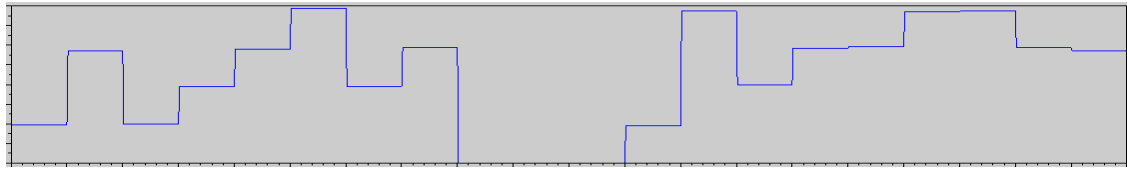
Let us consider three scenarios:

- 1: RI is a constant 60 mV
- 2: RI is a constant 120 mV
- 3: RI is a constant 240 mV

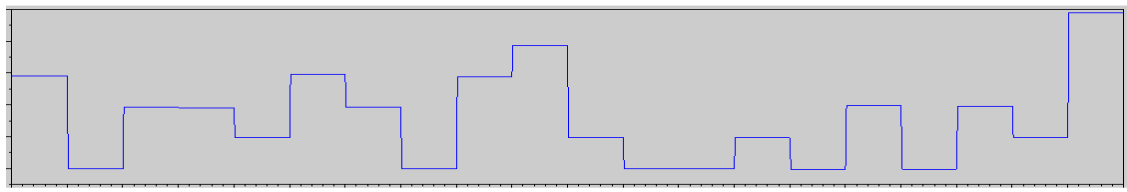
What is the change in spiking frequency from scenario 1 to scenario 2 (increase, decrease, stay roughly the same)? What is the change in spiking frequency from scenario 2 to scenario 3?

Which rate plot describes the spiking pattern shown here?

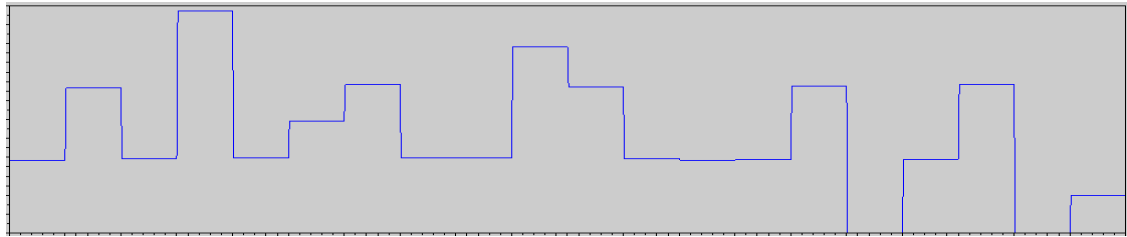
Rate plots have time on the x axis and rate over fixed time window on the y axis.



A



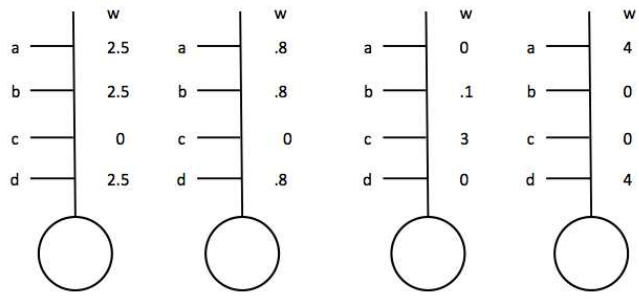
B



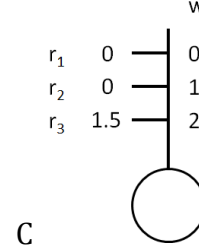
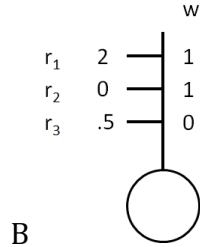
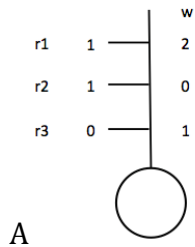
C

The following neuron computes the weighted sum of its inputs as $h = \sum_j w_j r_j$. It then outputs a 1 if $h > 2$ and otherwise outputs a 0. Each input provides a rate r_j of either 0 or 1 (no values in between).

For each set of weights, say if the neuron performs generalization/pattern completion, and if so, name the inputs that are tied together in the pattern.



Presume each of the following neuron's output is computed by taking the weighted sum of inputs $h = \sum_j w_{ij}r_j$, and outputting 2 if $h > 1.5$ and outputting 0 otherwise.

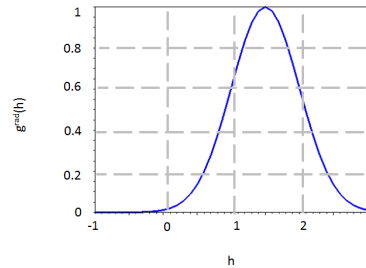
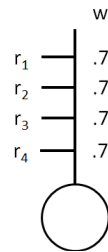


Provide new weights using learning rule $\Delta w_{ij} = \epsilon r_i r_j$ and $\epsilon(w) = \begin{cases} 1 & \text{if } w \geq 0 \\ -1 & \text{if } w < 0 \end{cases}$ for all weight values

Provide new weights using learning rule above, followed by normalization of weights

Provide new weights using the Willshaw learning rule.

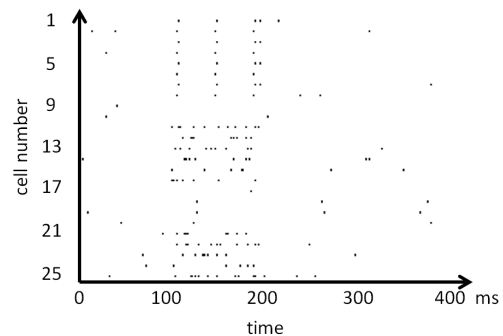
The neuron 5 takes four inputs r_1 , r_2 , r_3 , and r_4 . Presume each of the four inputs is either 0 or 1. Further presume neuron 5 takes the weighted sum of its inputs and then has an output determined by $g^{\text{rad}}(h)$ below.



Propose two combinations of inputs that will produce an output great than 0.8 .

Propose two combinations of inputs that will produce an output less than 0.1 .

To the right is a spikegram recording of a group of neurons in an animal's olfactory bulb. (This is actually fake data for the sake of testing concepts from class.) At some point, in time an odor is presented to the animal and at some later point the odor is removed.



Some of the recorded neurons respond through change in spiking rate. Which are these neurons?

For these neurons, estimate the spike rate (per second) while the smell is presented.

Some of the recorded neurons respond through change in temporal coding. Which are these neurons?

At what time is the smell presented? At what time is it taken away?