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.

What is the approximate ratio of the number of neurons in the primary auditory cortex to the number of neurons or in the cochlea?
    (a) 1:1
    (b) 300:1
    (c) 1:200
    (d) -5:4,020,000

This observed ratio supports which information representation principle in the brain?

Beyond studying vision, we can also use fMRI recordings of neural activity to study human emotions. It has been observed when one brain region (let's say the amygdala) shows high activity and another region (let's say the dorsomedial prefrontal cortex) shows low activity, we can predict the subject in the fMRI scanner is a calm person. If, on the other hand, the amygdala and the dorsomedial prefrontal cortex both show high activity, we can predict the subject in the scanner is an aggressive person.

|	Amydgala	dmPFC
Calm	High	Low
Aggressive	High	High

1: Presuming there are only two types of activity that can be measured (high or low) for each region, what is the maximum number of personality states (e.g., calm, aggressive, cheery) we can identify with just two brain regions?
        $2^2=$**4**

2: Let's say we perform another study where we identify 16 personality states using combinations of high and low brain region activity. What is the minimum possible number of brain regions he needs to use to identify these states?

Note: You do not need to have heard anything in the special Invited Lecture to be able to do this problem. Also, I am drastically simplifying Prof. Whalen's research. Assume my description is correct for the sake of doing the problem, but read his papers if you plan to study the neuroscience of emotion in the future!

As we discussed in class, neurons exhibit increasing invariance to location of an object (and other transformations of appearance) as we progress up the hierarchy of the visual object recognition pathway. Let us say the graph to the right shows the normalized firing rates for three neurons in V4 (from left to right, neurons **A**, **B**, and **C**) when a smiley face is shown shifted at differing horizontal distances from the center of vision.
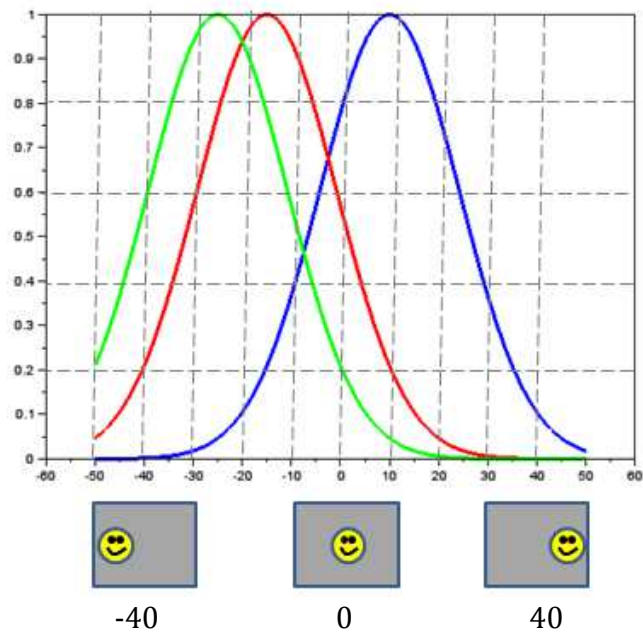
What is the horizontal location of the smiley face (rounded to the nearest 10, e.g., for a displacement of +27 you can answer +30) if the neuron firing rates are each of the following:

| | -40 | 0 | 40 |

Location 1: $\hat{r}_A$=0.5 $\hat{r}_B$=0.9 $\hat{r}_C$=0.4
Location 2: $\hat{r}_A$=0.5 $\hat{r}_B$=0.15 $\hat{r}_C$=0   **-40**

Now, let us consider three new neurons and compute smiley locations using normalized population coding. The favored direction of each neuron is as follows:
Neuron F: 0 degrees from center
Neuron G: -20 degrees from center
Neuron H: 30 degrees from center

The observed normalized firing rating rates are:
Location 1: r_F=.8 r_G=.2 r_H=.6 $0 \times \frac{.8}{1.6} + (-20) \times \frac{.2}{1.6} + 30 \times \frac{.6}{1.6} = -\frac{20}{8} + \frac{90}{8} = \frac{70}{8} =$
$8.75 \approx \mathbf{8.8}$
Location 2: r_F=.1 r_G=.6 r_H=.1

Neurons in the cochlear nucleus tend to be relatively "quiet" (spiking rather little), while neurons in the vestibular nucleus tend to be relatively "hyperactive" (spiking a lot). Let us say the minimum and maximum firing rates for a neuron in each nucleus are:

$r_{min}^{cochlear}$=5 Hz	$r_{max}^{cochlear}$=25 Hz
$r_{min}^{vestibular}$=20 Hz	$r_{max}^{vestibular}$=80 Hz

Convert the following firing rates into normalized firing rates:
$r^{cochlear}$=20 Hz

$r^{cochlear}$=10 Hz $\frac{10-5}{25} = \frac{5}{25} = \mathbf{0.2}$

$r^{vestibular}$=20 Hz

Below, we establish a miniature HMAX model, with two layer 1 neurons and one layer 2 neuron (performing the typical layer 1 and layer 2 computations for HMAX). Presume the weights into layer 1 are as specified below and the activation function is as shown to the right. Compute the output from layer 2 given the input values provided.


layer 1   layer 2

w_{DA}=2 w_{EA}=0
w_{DB}=-2 w_{EB}=1.5
w_{DC}=1 w_{EC}=-2
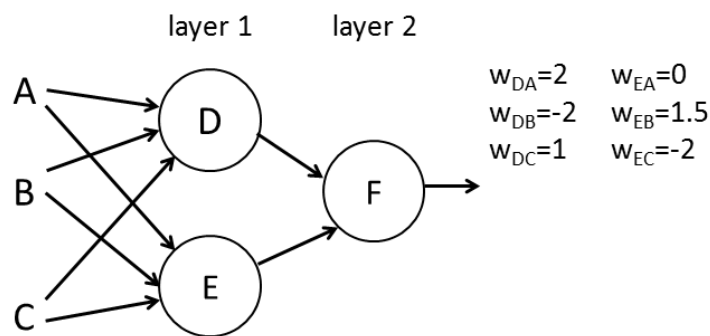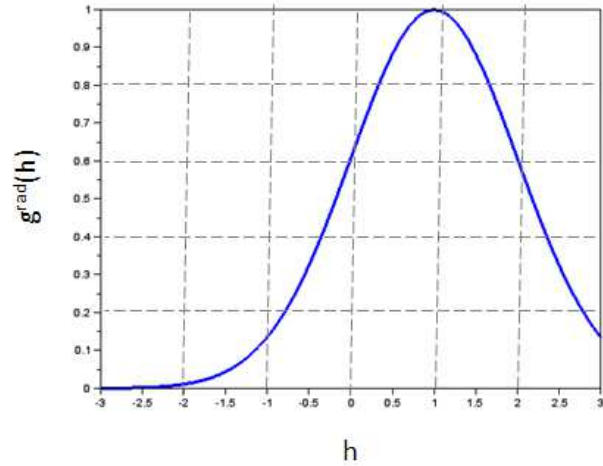
Input 1: r_A=0.5 r_B=1 r_C=0
Input 2: r_A=1 r_B=0.2 r_C=1

r_D=g(2 × 1 − 2 × 0.2 + 1 × 1)=g(2.6)=0.3
r_E=g(0 × 1 + 1.5 × 0.2 − 2 × 1)=g(-1.7)=0
r_F=max([0.3 0]) = **0.3**

Consider a model neuron whose output is determined solely by the weighted sum of its inputs (no complicated activation function this time). However, each input is modulated by a further attention weight, indicated by the dashed blue lines in the diagram at right. Given the rates for the four inputs A, B, C, and D, compute the output.
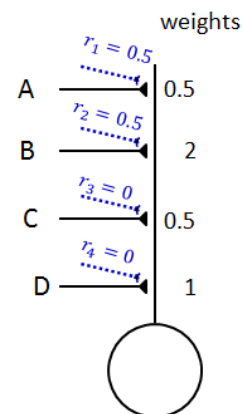
Input 1: r_A=1 r_B=0 r_C=0.5 r_D=0.5
Input 2: r_A=0 r_B=0.1 r_C=1 r_D=1

$r^{out} = 0.5 × 0.5 × 0 + 2 × 0.5 × 0.1 + 0.5 × 0 × 1 + 1 × 0 × 1$
$= 0 + 0.1 + 0 + 0 = $ **0.1**

You are trying to listen to a band in a crowded bar. While listening, you record the responses of 5 neurons. The 5 neurons have distributed firing rates to respond to the instrumental music, the singers, and people talking in the background. The maximum response for each individual sound source (i.e., at loudest volume) is as follows.

Neuron 1	30 Hz	0 Hz	0 Hz
Neuron 2	10 Hz	30 Hz	0 Hz
Neuron 3	0 Hz	20 Hz	0 Hz
Neuron 4	0 Hz	10 Hz	30 Hz
Neuron 5	30 Hz	0 Hz	30 Hz
	Instruments	Singers	Talkers

What is the neural response for:

hearing instruments at maximum volume (1), not hearing the singers (0), and hearing the talkers at half volume (0.5)

$$1\begin{bmatrix}30\\10\\0\\0\\30\end{bmatrix} + 0 + 0.5\begin{bmatrix}0\\0\\0\\30\\30\end{bmatrix} = \begin{bmatrix}\mathbf{30}\\\mathbf{10}\\\mathbf{0}\\\mathbf{15}\\\mathbf{45}\end{bmatrix}$$

hearing instruments at low volume (0.2), hearing the singers fairly loudly (0.8), and not hearing the talkers (0)

If we wish to focus on the singers and ignore the instruments and talkers as much as possible, what multiplying attention weights should we give to each of the 5 neurons?

Let us consider the following matrices:

$$A = \begin{bmatrix} 2 & 0 & 1 \\ -2 & 3 & 0 \end{bmatrix} \qquad B = \begin{bmatrix} 0.5 & 1 \\ 2 & -3 \\ 0 & 0.5 \end{bmatrix} \qquad C = \begin{bmatrix} -3 \\ 2 \\ 0 \end{bmatrix}$$

$$D = \begin{bmatrix} 4 & -2 \\ 0 & 5 \end{bmatrix} \qquad E = \begin{bmatrix} 0.5 \\ 0.5 \end{bmatrix}$$

What is AxB

What is AxC $\begin{bmatrix} 2 & 0 & 1 \\ -2 & 3 & 0 \end{bmatrix} \times \begin{bmatrix} -3 \\ 2 \\ 0 \end{bmatrix} = \begin{bmatrix} 2 \times -3 + 0 + 0 \\ -2 \times -3 + 3 \times 2 + 0 \end{bmatrix} = \begin{bmatrix} -6 \\ 12 \end{bmatrix}$

What is DxE

For Scilab:
How can we define the matrix B as a variable?
B=[0.5 1; 2 -3; 0 0.5]

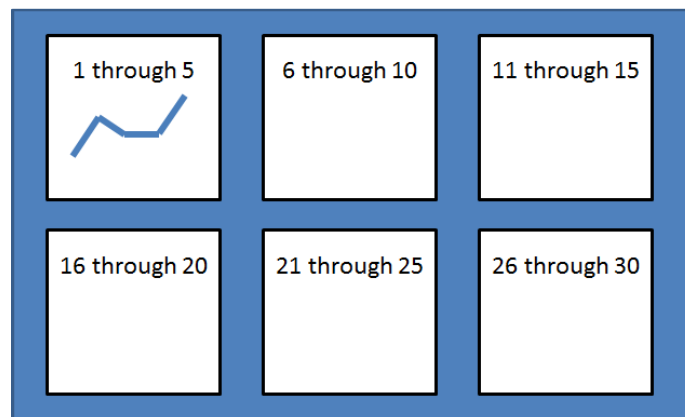What command will create Anew=[] based on the a variable A corresponding to matrix A?

We have a vector containing 80 numbers. Let us call the vector vec.
What command can we use to determine how many of the numbers are greater than 10?
length(find(vec>10));
What command can we use to determine the smallest positive number?

We wish to create a set of 6 plots, as follows:

The first plot has the first 5 numbers in the vector, the second plot the second 5 numbers (elements 6 through 10) in the vector, the third plot has the third 5 numbers (elements 11 through 10) in the vector and so on.

Provide a command to do this. Include the for command.