Name:

USC ID:

Notes:

- Write your name and ID number in the spaces above.
- No books, cell phones or other notes are permitted. Only one letter size cheat sheet (back and front) and a calculator are allowed.
- Problems are not sorted in terms of difficulty. Please avoid guess work and long and irrelevant answers.
- Show all your work and your final answer. Simplify your answer as much as you can.
- Open your exam only when you are instructed to do so.

Problem	Score	Earned
1	20	
2	25	
3	20	
4	20	
5	25	
Total	110	

1. Consider a MLP with one input, two layers, one neuron in each layer, and one output. The activation function of the first layer is $f^{(1)}(n) = 2n$ and the activation function of the second layer is $f^{(2)}(n) = 3n$. The initial weights of the first and the second layers are respectively $w^{(1)} = 1$ and $w^{(2)} = -1$. There are no bias terms, so $b^{(1)} = b^{(2)} = 0$ and they are kept zero during training. Assume that we present the data point with $x = 1$ and $y = 2$ to the network. Perform one step of the Stochastic Gradient Descent algorithm by using the backpropagation algorithm, assuming the learning rate $\alpha = 0.5$. Use the objective function $J = (y - a^{(2)})^2$. This means that you should calculate the updated weights.

2. We are trying to estimate the temperature of consecutive years based on *observations* on tree ring sizes. Possible ring sizes are Very Small = VS, Small = S, Medium = M, Large = L, and Very Large = VL. Years can be Cold = C or Hot = H. Assume that we observed VS, VL tree ring sizes in two consecutive years. Also, Assume that $\pi = [0.8\ 0.2]$ shows the initial distribution of C and H, respectively. Which of the following HMMs is more likely to have given rise to the observation O= {VS,VL} and why? First rows of A_1, B_1, A_2, B_2 represent C and second rows represent H.

(a)

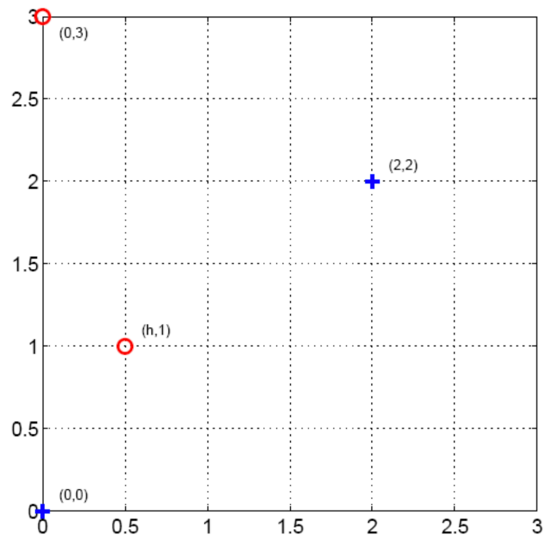
$$A_1 = \begin{array}{c} \begin{array}{cc} C & H \end{array} \\ \begin{bmatrix} 0.8 & 0.2 \\ 0.3 & 0.7 \end{bmatrix} \end{array} \quad B_1 = \begin{array}{c} \begin{array}{ccccc} VS & S & M & L & VL \end{array} \\ \begin{bmatrix} 0.2 & 0.3 & 0.3 & 0.1 & 0.1 \\ 0.3 & 0.2 & 0.1 & 0.1 & 0.3 \end{bmatrix} \end{array}$$

(b)

$$A_2 = \begin{array}{c} \begin{array}{cc} C & H \end{array} \\ \begin{bmatrix} 0.5 & 0.5 \\ 0.6 & 0.4 \end{bmatrix} \end{array} \quad B_2 = \begin{array}{c} \begin{array}{ccccc} VS & S & M & L & VL \end{array} \\ \begin{bmatrix} 0.1 & 0.1 & 0.1 & 0.1 & 0.6 \\ 0.5 & 0.1 & 0.1 & 0.1 & 0.2 \end{bmatrix} \end{array}$$

Solution:

3. Suppose we only have four training observations in two dimensions:



positive examples are $\mathbf{x}_1 = [0\ 0]^T, \mathbf{x}_2 = [2\ 2]^T$ and negative examples are $\mathbf{x}_3 = [h\ 1]^T, \mathbf{x}_4 = [0\ 3]^T$. h is a parameter.

(a) What is the largest value of h for which the training data are still linearly separable?

(b) Determine the support vectors when $h = 0.5$.

(c) When the training points are separable, does the slope of the maximum margin classifier change? Why?

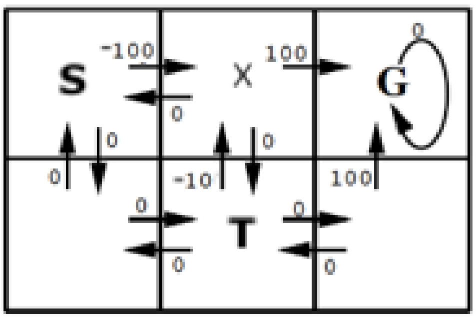
(d) Assume that $h = .5$ and we have unlabeled data $\mathbf{x}_5 = [3\ 3]^T, \mathbf{x}_6 = [2\ 0.5]^T, \mathbf{x}_7 = [1\ 1.5]^T, \mathbf{x}_8 = [2.5\ 1.5]^T$. Which one will be labeled first, if we are performing self-training? Which one will be labeled first, if we are performing active learning?

4. Consider the unlabeled dataset with one feature: $\{1, 5, 6, 21, 27\}$.

   (a) What will single linkage (minimum distance between members of clusters), complete linkage (maximum distance between members of clusters), and average linkage (average distance between members of clusters) output as the two clusters?

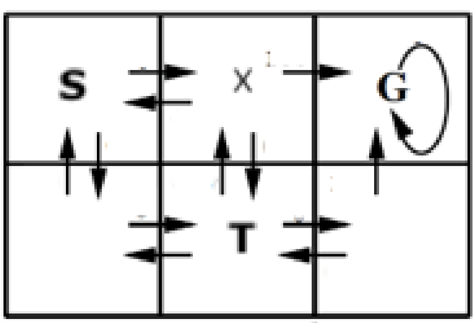
   (b) Assume that we want to perform k-medoids clustering and initialized the algorithm with two clusters randomly and we got $\{1, 5, 6, 27\}$ and $\{21\}$ as the initial clusters. What are the final two clusters?

5. Consider the following grid world, in which an agent can explore the environment until it finds the Goal (G). In this problem, you will update the estimates of the Q function based on experiences of the agent. In this environment, all actions in all squares result in a zero reward, *except the actions that result in entering the goal square and the actions that result entering the danger square X that result in a punishment, i.e. negative reward.* The rewards $r(s,a)$ of each action a in state s was shown in the below figure. Assume that the initial estimate $\hat{Q}(s,a)$ is zero for all state and action pairs.



$r(s,a)$ (immediate reward) values

The agent starts at S and performs the following actions: $\rightarrow, \downarrow, \uparrow, \rightarrow$. Then it starts from T and performs $\uparrow, \rightarrow$. Show the updated estimates $\hat{Q}(s,a)$ for all states after the agent completes both paths. Use discount factor $\gamma = 0.9$ if needed. You can use the following table in each update to show $\hat{Q}(s,a)$ for each state and action pair.



$\hat{Q}(s,a)$ values

Solution:

Scratch paper

Name:

USC ID:

Scratch paper

Name:

USC ID: