Name: _____

CptS 440/540 – Artificial Intelligence
Fall 2018

Sample Final Exam

No solution will be provided.

Duration: 120 minutes

Instructions: Clearly write your name at the top of this exam. Complete all problems on this exam. Write all your work on this exam. The exam is closed book, closed notes, and closed neighbor. No electronic devices are allowed, except your own calculator. Failure to turn in your exam at the end of 120 minutes will result in deduction of points. Anyone cheating on the exam will receive a zero.

Problem	Points Possible	Your Score
1	8	
2	8	
3	8	
4	8	
5	6	
6	12	
7	9	
8	9	
9	10	
10	10	
11	6	
12	6	
Total	100	

1. (8 points) Short answer questions.
   a. (3 points) List the four approaches to AI and indicate which one best describes Strong AI.

   b. (2 points) Suppose you are a computer participating in a Turing test, and the judge asks the question "What is your favorite color?" Give an example of an answer that will cause you to fail the Turing test.

   c. (3 points) For each of the following scenarios indicate whether it is fully or partially observable, deterministic or stochastic, and static or dynamic.

      - 8-puzzle

      - Driving a car around Pullman

2. (8 points) Suppose we want to solve the following 8-puzzle problem with A* search. Your search should consider the possible moves (moving the blank tile) in the order: left, right, up, down; only if the blank tile can move in that direction. Show the search tree generated by A* to solve this problem using the city-block distance for the heuristic *h*. Next to each node show the values of *f*, *g* and *h*.

1	2	3
4	5	6
	7	8

Initial State

1	2	3
4	5	6
7	8	

Goal State

3. (8 points) Convert the following English sentences to first-order logic using the predicates: Color(*s*,*c*), Shining(*s*), where *s* is a variable representing an object, and *c* is a variable representing a color.

    a. (2 points) If the Sky is Blue, then the Sun is Shining.

    b. (2 points) If any object is Blue, then that object is Shining.

    c. (2 points) Something is Shining.

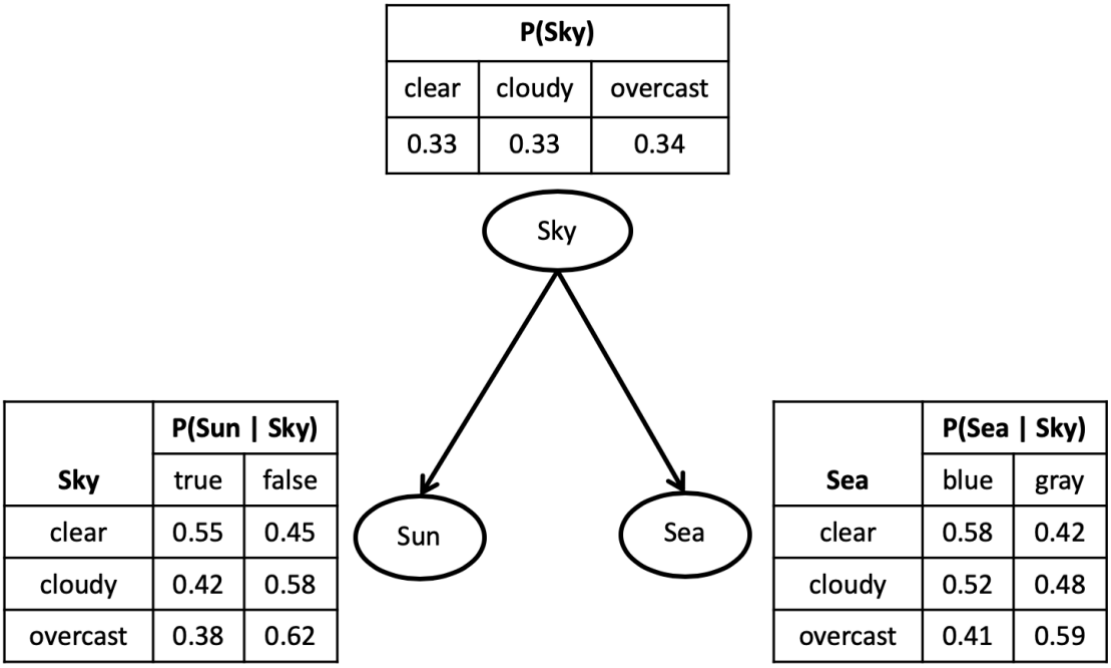
    d. (2 points) Nothing is Shining.

4. (8 points) Consider the following first-order logic knowledge base.
    i. Shining(Sun)
    ii. Color(Moon,Gray)
    iii. $\forall x$ Color(x,Gray) $\wedge$ Shining(Sun) $\Rightarrow$ Shining(x)

    a. (4 points) Convert the knowledge base to CNF. Give each clause a number.

    b. (4 points) Show a resolution proof by refutation that "Shining(Moon)" is true. Show each resolution step by indicating the two clause numbers being resolved, the resulting clause (give it a new number), and any necessary substitutions. Be sure to standardize variables.

5. (6 points) Given the following Bayesian network, compute P(Sun=true | Sea=blue). Show your work.



6. (12 points) Suppose we want to learn a decision tree from the following examples in order to predict whether or not to Sail given the Sky and Sea conditions.

Example #	Sky	Sea	Sail
1	clear	blue	yes
2	cloudy	blue	yes
3	overcast	blue	no
4	clear	gray	yes
5	overcast	gray	no

   a. (2 points) Compute the entropy of the training set, consisting of the above five examples. Show your work.

   b. (3 points) Compute the information gain for using the Sky attribute at the root of the decision tree. Show your work.

   c. (3 points) Compute the information gain for using the Sea attribute at the root of the decision tree. Show your work

d. (3 points) Show the final decision tree that correctly predicts all five examples.

e. (1 point) How would the decision tree classify the instance <Sky=cloudy, Sea=gray>?

7. (9 points) Suppose we want to apply naïve Bayes learning to the scenario in Problem 6.

   a. (2 points) Compute the prior probabilities P(Sail=yes) and P(Sail=no). Show your work.

   b. (3 points) Compute P(Sail=yes | Sky=cloudy, Sea=gray). You may leave the normalization constant α in your answer. Show your work.

   c. (3 points) Compute P(Sail=no | Sky=cloudy, Sea=gray). You may leave the normalization constant α in your answer. Show your work.

   d. (1 point) How would naïve Bayes classify the instance <Sky=cloudy, Sea=gray>?

8. (9 points) Suppose we want to apply nearest neighbor learning to the scenario in Problem 6. First, we map the attribute values to integers as follows.

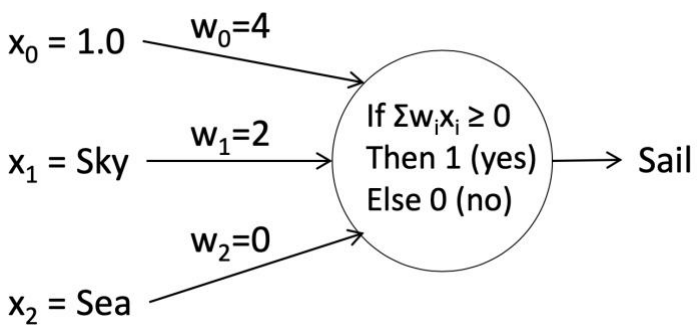
Example #	Sky	Sea	Sail	Distance?
1	1	1	1	
2	2	1	1	
3	3	1	0	
4	1	2	1	
5	3	2	0	

   a. (5 points) Show the Euclidean distance between the test instance <Sky=2, Sea=2> and each of the five training examples in the Distance column in the table above.

   b. (3 points) Indicate which examples would be used by 3-nearest-neighbor to classify the test instance.

   c. (1 point) Which class would 3-nearest-neighbor choose for the test instance?

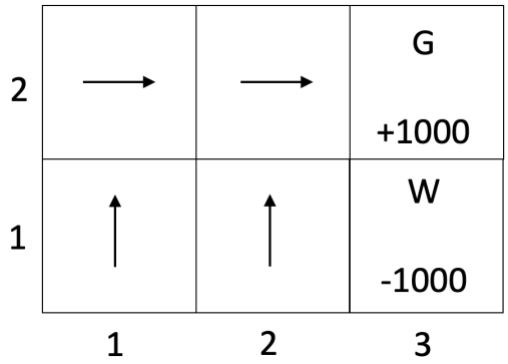
9. (10 points) Suppose we want to train the perceptron below on the scenario in Problem 8. Assume that the weights have already been partially trained to $w_0 = 4$, $w_1 = 2$, $w_2 = 0$.



a. (8 points) Complete the training of the perceptron above by updating the weights according to the perceptron learning rule with the learning rate $\alpha = 1$. Consider each example in the order presented in the table in Problem 8 and *show the calculation* of weight updates for each incorrectly-classified example. Continue until the perceptron correctly classifies all the training examples, and show the final perceptron weights. *Hint*: The perceptron should correctly classify all five examples on the 2nd pass through the examples.

b. (2 points) How would the final learned perceptron classify the test instance <Sky=2, Sea=2>? Show your work.

10. (10 points) Consider the 3x2 wumpus world shown below. The goal of this simplified game is to be collocated with the gold (where we get a +1000 reward) and not collocated with the wumpus (or we get a -1000 reward). All other states have a reward of -1. As before, the agent starts in [1,1], but has only four possible actions: Up, Down, Left, Right (there is no orientation or turning). Each of these actions always works, although attempting to move into a wall results in the agent not moving. We will use reinforcement learning to solve this problem.



a. (5 points) Compute the utility *U(s)* of each non-terminal state *s* given the policy shown above. Note that [3,1] and [3,2] are terminal states, where U([3,1]) = -1000, and U([3,2]) = +1000. You may assume the discount factor $\gamma = 0.9$.

b. (5 points) Using temporal difference Q-learning, compute the Q values for Q([1,1],Up), Q([1,2],Right), Q([2,2],Right), after each of three executions of the action sequence: Up, Right, Right (starting from [1,1] for each sequence). You may assume learning rate $\alpha = 1$, discount factor $\gamma = 0.9$, and all Q values for non-terminal states are initially zero.

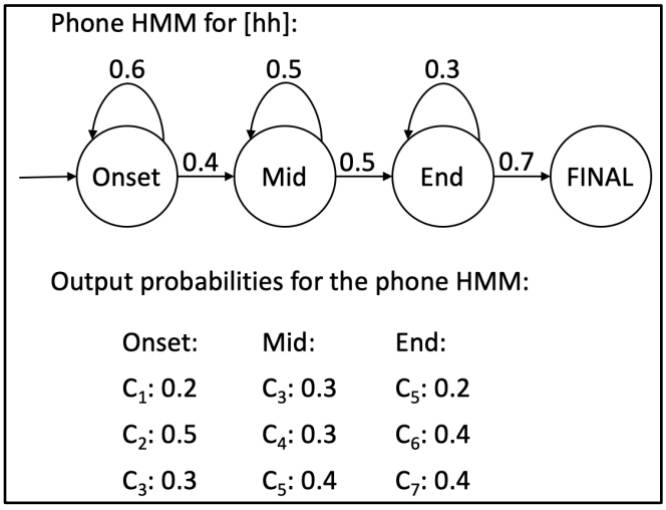
11. (6 points) Given the following grammar and lexicon, show a parse tree (or indicate no parse) for the sentences below.

S → NP VP
NP → Noun | Article Noun
VP → Verb | VP NP
Article → "a" | "an" | "the"
Noun → "wumpus" | "agent" | "gold"
Verb → "ate" | "shot" | "grabbed"

a. (3 points) "the agent shot the wumpus"

b. (3 points) "gold ate an wumpus"

12. (6 points) Below is the Hidden Markov Model for the [hh] phoneme. Compute the maximum probability that the [hh] phoneme was spoken given the sequence of feature values $C_2C_3C_4C_5C_6$. Show your work.



Hint: $V_{4,Onset} = 0$, $V_{4,Mid} = 0.00216$, $V_{4,End} = 0.00108$, $V_{4,Final} = 0$.