THE UNIVERSITY OF PENNSYLVANIA

SAMPLE EXAM – Given in
Fall, 2015
Points Possible: 100
POINT COUNTS
ACCURATE

CIS 521

INTRODUCTION TO ARTIFICIAL INTELLIGENCE

Midterm I

(Time allowed: 80 minutes)

Section		Points	Max
1	True/False Multiple Choice		20
2	Search		20
3	Heuristics		20
4	Adversarial search		10
5	Constraint Satisfaction		15
6	Naïve Bayes	NOT APPLICABLE	15
	TOTAL		100

Question 1. [20] True-False & Multiple Choice

[All questions worth 2 points.]

a) In Python, what does the last command in this sequence print?

```
> x = [[(x, y) for x in 1,2,3] for y in 1,2,3]
> len(x)
```

(a) 1

(b) 3

(c) 6

(d) 9

b) TRUE or FALSE: Depth-first search is complete.

c) TRUE or FALSE: Depth-first search has, in general, much lower space complexity than iterative deepening.

d) TRUE or FALSE: In estimating the travel distance between two locations, Euclidean distance is a consistent and admissible heuristic.

e) TRUE or FALSE: A* search uses heuristics to prune the search space so that the use of space is effectively O(bd).

f) TRUE or FALSE: Iterative deepening is complete in that it is guaranteed to halt if there is a solution path to the goal.

g) TRUE or FALSE: Uniform-cost search is a special case of A* search.

h) Which of the following is true?

a. All admissible heuristics are consistent
b. All consistent heuristics are admissible
c. Both of the above
d. Neither of the above

i) Given the joint probabilities in Table 1 below, what is the probability of having a cavity if there's no toothache?

	toothache	¬ toothache
cavity	0.12	0.4
¬ cavity	0.1	0.38

Table 1: Joint probabilities

(a) 0.12
(b) 0.4
(c) 0.4/(0.12 + 0.4)
(d) none of the above

j) What assumption is made in deriving the Naive Bayes model? (c_i is the class random variable and x_i is the feature random variable; note that there are N classes and also N features)

(a) $P(x_1 \ldots x_N \mid c_i) = P(x_1 \mid c_i)\, P(x_2 \mid c_i) \ldots\ P(x_N \mid c_i)$

(b) $P(x_1 \ldots x_{N,}\ c_1 \ldots c_N) = P(x_1, c_1) \ldots P(x_N\ , c_N)$

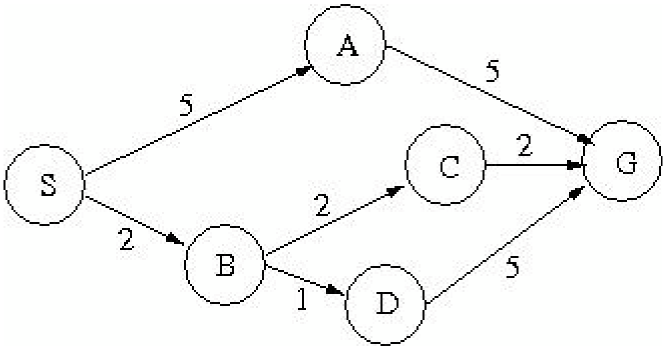
(c) $P(c_1 \ldots c_N \mid x_i) = P(c_1|x_i)\, P(c_2|x_i) \ldots\ P(c_N|x_i)$

(d) $P(x_1 \ldots x_{N,}\, c_1 \ldots c_N) = P(c_1)\ P(x_1|c_1)P\,(c_2\,|x_1, c_1) \ldots P(x_N\,|x_1 \ldots x_{N-1}, c_1 \ldots c_N)$

(e) None of the above.

Question 2. [20] Search

Consider the following search space where we want to find a path from the start state S to the goal state G. The table shows three different heuristic functions *h1, h2*, and *h3*.



Node	*h1*	*h2*	*h3*
S	0	5	6
A	0	3	5
B	0	4	2
C	0	2	5
D	0	5	3
G	0	0	0

a) [5] What solution path is found by Greedy Best-first search using *h2*? Break ties alphabetically.

b) [15] Give the three solution paths found by algorithm A* using each of the three heuristic functions, respectively. Break ties alphabetically.

h1:

h2:

h3:

Question 3. [20] Heuristics

Consider the 8-puzzle consisting of a 3 x 3 board with eight tiles numbered 1 through 8. The goal is to move the tiles from a start configuration to a goal configuration, where a move consists of a horizontal or vertical move of a tile into an adjacent position where there is no tile. Each move has cost 1.

(a) [10] Is the heuristic function defined by $h = \sum_{i=1} \alpha_i d_i$ **admissible**, where d_i is the number of vertical plus the number of horizontal moves of tile *i* from its current position to its goal position assuming there are no other tiles on the board, and $0 \leq a_i \leq 1$ is a constant weight associated with tile *i*? Explain briefly why or why not.

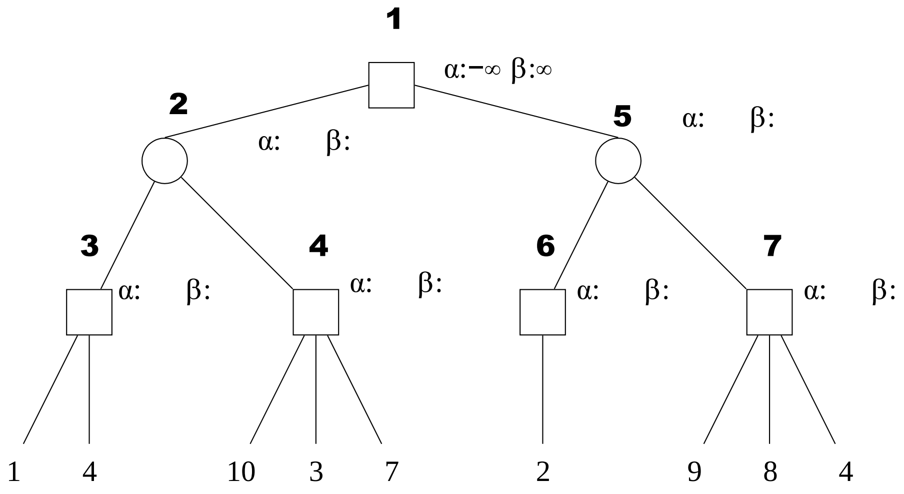
(b) [10] Given two arbitrary admissible heuristics, *h1* and *h2*, which composite heuristic of the following three is best to use?

a) max(*h1*, *h2*)
b) (*h1* + *h2*)/2
c) min(*h1*, *h2*)

Briefly explain why.

Question 4. [10] Adversarial Search

The following tree represents all possible outcomes of a hypothetical zero-sum game:



This tree is from the perspective of the MAX player; MAX nodes are represented by squares and MIN nodes by circles. The leaves of the tree represent the value of the game for the MAX player. The index of each node indicates the order in which they are considered by the Minimax and α-β pruning algorithms.

α) [5 point] What are the "back-up" values of each node in tree using the Mini-max strategy? (The lists are ordered by the node numbers, 1 to 7.)

(a) 3, 3, 1, 3, 4, 2, 4

(b) 4, 4, 4, 10, 2, 2, 9

(c) 10, 10, 4, 10, 9, 2, 9

(d) 1, 1, 1, 3, 2, 2, 4

(e) None of the above

β) [5 point] Run the α-β pruning algorithm and list each leaf (by its value) and node (by its index) that would NOT be considered by the α-β pruning algorithm. (Assume that leaves are considered in left-to-right order.)

(a) Nodes: 7; Leaves: 3, 7, 9, 8 ,4

(b) Nodes: 5,6,7; Leaves: 2, 9, 8, 4

(c) Nodes: 4, 7; Leaves: 10, 3, 7, 9, 8, 4

(d) Nodes: None; Leaves: None

(e) None of the above

Question 5. [15] Constraint Satisfaction

Consider the problem of assigning colors to the five squares on the board below such that horizontally adjacent and vertically adjacent squares do not have the same color. Assume there are two possible colors, red (***R***) and black (***B***)***.*** Formulated as a constraint satisfaction problem, there are five variables (the squares) with two possible values (***R, B***) as the domain of each variable.

1	2	3
4	5	

a) [5] If initially every variable has both possible values and we then assign variable **1** to have value ***R***, what values remain for each cell after running the *Forward Checking algorithm*?

1:
2:
3:
4:
5:

b) [5] If initially every variable has both possible values, what values remain for each cell after running *AC-3*?

1:
2:
3:
4:
5:

c) [5] If initially every variable has both possible values and we then assign variable **5** to have value ***B***, what values remain for each cell after running *AC-3*?

1:
2:
3:
4:
5: