CS 440 Midterm Exam

Question 1 (25 Points):

Connect 4 is a 2 player game where each player has a set of colored tokens (red or yellow). Players take turns during which they place a single token into one of the columns of an n by m grid (where n is the number of rows and m is the number of columns. They place their token into a slot at the top of the column and it falls into the lowest unoccupied slot in that column. A player wins when they form a horizontal, vertical or diagonal chain of 4 of their color tokens. Note that a player must place a token during their turn and they cannot place a token into a row if all of its cells are occupied.

Figure 1: A game of connect 4.

1. Define a State space, Action space, transition function and reward function for this problem.

2. What would be a good heuristic to use for this game and why (note that this heuristic does not have to be admissible).

3. Given the board state shown in Figure 2(red to move), use the minimax algorithm to determine the sequence of moves that 2 optimal players will make. You should show all work, the tree produced by the minimax algorithm and and indication of which child will be selected by the player at each internal node.

		R	R	R	
Y		Y	Y	R	
Y	Y	R	Y	Y	R

Figure 2: Board state for game of connect 4. Red to move.

Question 2 (20 Points):

Consider the problem of path planning on a hexagonal tiling where some of the cells are traversable (white) and some of the cells are untraversable (gray), as shown in Figure 3. An agent must find the shortest path from a start cell to a goal cell, with the length of a path being defined as the number of cells the path goes through.

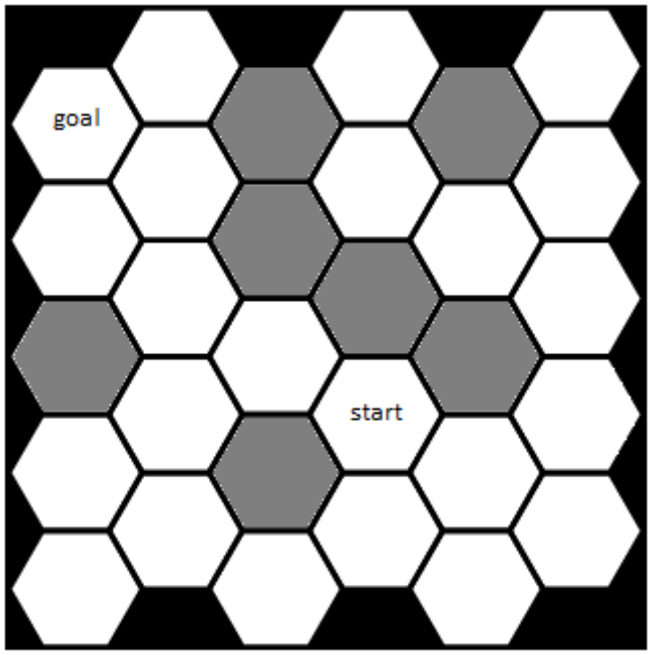

Figure 3: A hexagonal tiling with free cells colored white and impassable cells colored gray.

1. What is the minimum number of cells that the shortest path first algorithm needs to expand in the grid shown in Figure 3 before finding a path to the goal (and why).

2. Define an admissible heuristic for this problem. Show that this heuristic is admissible.

3. What is the minimum number of cells A* with your heuristic needs to expand in the grid shown in Figure 3 before finding a path to the goal.

Question 3 (25 Points):

Table 1 contains a list of Lord of the Rings characters along with their character class and a set of other attributes.

		Attributes			
	Class	Weapon	Height	Wears Armor	Age
Gandalf	Wizard	Staff	Tall	No	>1000
Bilbo	Hobbit	Dagger	Short	No	100-1000

Legolas	Elf	Bow	Tall	No	>1000
Saruman	Wizard	Staff	Tall	No	>1000
Elrond	Elf	Sword	Tall	Yes	>1000
Frodo	Hobbit	Dagger	Short	Yes	<100
Aragon	Human	Sword	Tall	No	<100
Gimli	Dwarf	Ax	Short	Yes	100-1000
Thorin Oakenshield	Dwarf	Sword	Short	Yes	100-1000
Boromir	Human	Sword	Tall	Yes	<100
Faramir	Human	Bow	Tall	No	<100

Table 1: Lord of the Rings Characters

a. If you divided these characters based on the weapons what would be the information gain.

b. Construct a classification tree that uses the attributes provided (Weapon, Height, Armor and Age) to classify the characters.

Question 4 (10 Points):

Consider the Boolean statement

$((A \vee B) \wedge (\neg A \vee C) \wedge (B \vee D) \wedge (\neg C \vee F) \wedge (\neg D \vee F)) \Rightarrow F$

Show that this statement is or is not an axiom.

Question 5 (20 Points):

Consider the Bayesian network shown in Figure 4, where variables A through E are all Boolean valued:

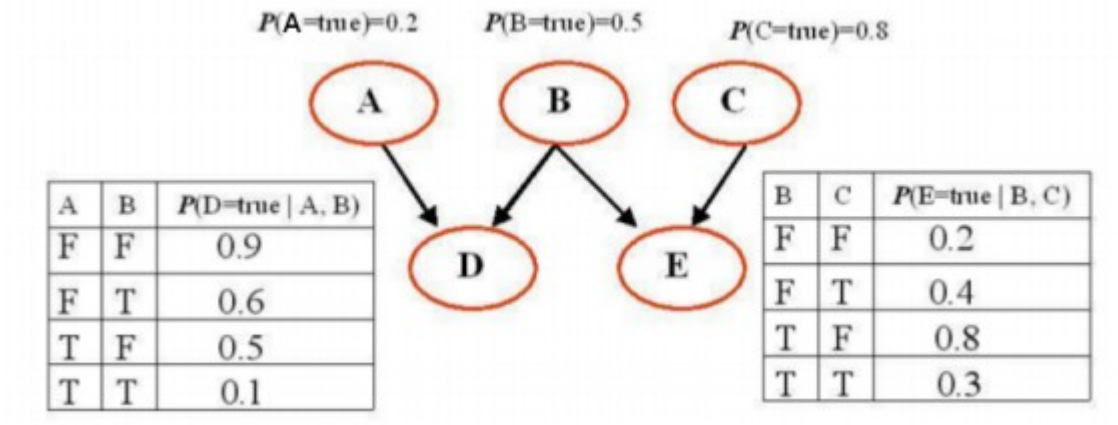

Figure 5: A Bayesian network.

a) What is the probability that all five of these Boolean variables are simultaneously true?

b) What is the probability that all five of these Boolean variables are simultaneously false?

c) What is the probability that A is false given that the four other variables are all known to be true?