Your name:

1	2	3	4	5	6	7	total
20	*40*	*35*	*30*	*5*	*15*	*5*	*150*

UMBC CMSC 671 Midterm Exam

22 October 2012

Write all of your answers on this exam, which is closed book and consists of six problems, summing to 200 points. You have the entire class period, seventy-five minutes, to work on this exam. Good luck.

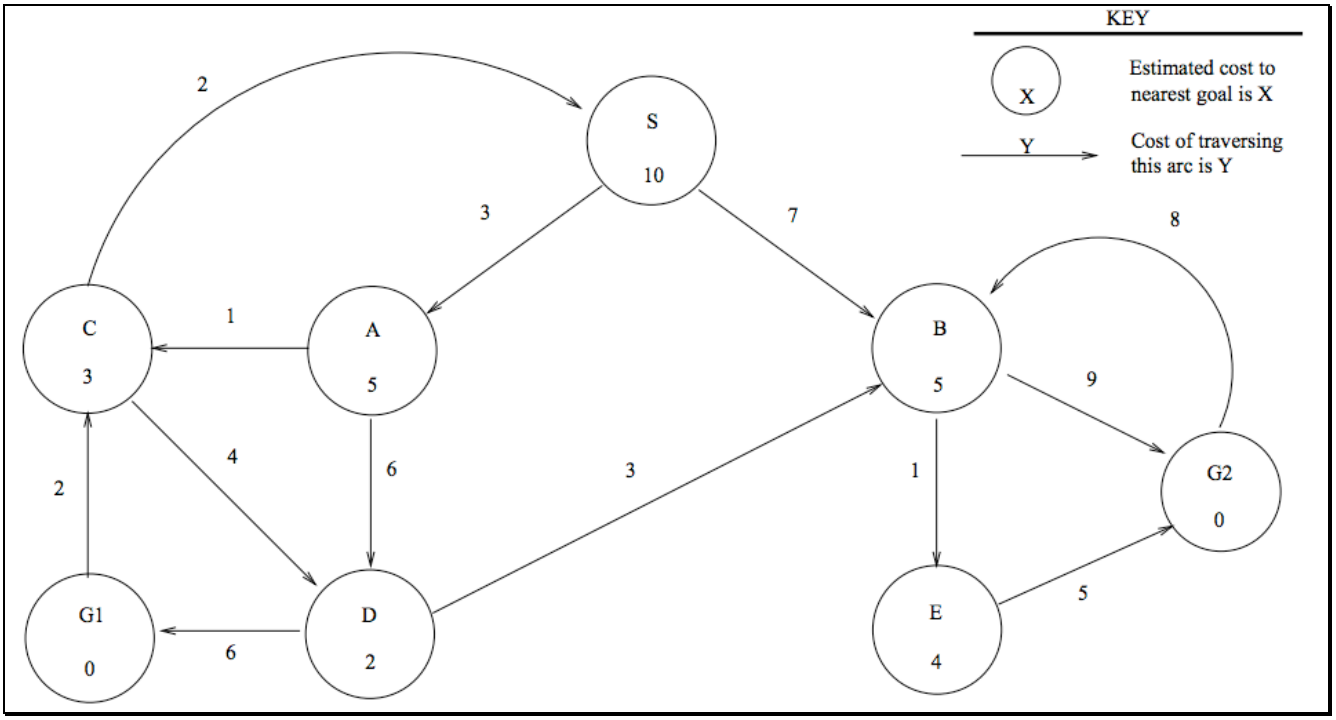
1. True/False [20 points]

Circle either T or an F in the space before each statement to indicate whether the statement is true or false. If you think the answer is simultaneously true and false, quit while you are ahead. There is no penalty for incorrect answers but then, there are no points for incorrect answers either

T F The Turing test evaluates a system's ability to act rationally. FALSE
T F Iterative deepening will never expand more nodes than breadth-first search. TRUE
T F If a finite solution exists, depth-first search is guaranteed to find it. FALSE
T F A finite problem graph can give rise to an infinite search tree with depth-first search. TRUE
T F Depth-first iterative deepening always returns the same solution as breadth-first search if b is finite and the successor ordering is fixed. TRUE
T F In a finite search space containing no goal state, A* will always explore all states. TRUE
T F If f1(s) and f2(s) are two admissible A∗ heuristics, then their average f(s) = 0.5*(f1+f2) must also be admissible. TRUE
T F A problem of hill climbing search is the amount of memory it requires. FALSE
T F The arc-consistency algorithm is only useful if it is run after every variable assignment in CSP search. FALSE
T F A combination of backtracking search and arc-consistency will always find a solution to a CSP problem if one exists. TRUE
T F A combination of backtracking search and forward-checking may not find a solution to a CSP problem even if one exists. FALSE
T F The maximin principle in game theory is based on the idea that a good strategy is to plan on taking advantage of the tactical errors your opponent makes. FALSE
T F In a zero-sum two player game there is necessarily always a winner and a loser. FALSE
T F The amount of memory required to run minimax with alpha-beta pruning is O(b**d) for branching factor b and depth limit d. FALSE
T F The Prisoner's Dilemma is an example of a game in which both players have a dominant strategy. TRUE
T F In a Nash equilibrium, no player and unilaterally improve their utility by changing their strategy. TRUE
T F Every well-formed sentence in propositional logic can be rewritten in conjunctive normal form (CNF). TRUE
T F Every valid propositional sentence is satisfiable. TRUE
T F Every satisfiable propositional sentence is valid. FALSE
T F One can have a sound and complete reasoning system on a collection of well-formed propositional sentences using only the resolution inference rule. TRUE

2. Search I [40]

Assume the following search graph, where S is the start node and G1 and G2 are goal nodes. Arcs are labeled with the cost of traversing them and the estimated cost to a goal is reported inside nodes.



For each of the search strategies listed below, indicate which goal state is reached (if any) and list, in order, the states expanded. (Recall that a state is expanded when it is removed from the OPEN list.) When all else is equal, nodes should be expanded in alphabetical order.

Depth first [10]

goal found	**G2**
states expanded	**S A C D B E G2**

Breadth first [10]

goal found	**G2**
states expanded	**S A B C D E G2**

Hill Climbing [10] (using the h function only)

goal found	**G1**
states expanded	**S A D G1**

A* [10]

goal found	**G1**
states expanded	**S A C D B G1**

3. Constraint Satisfaction [35]

You are planning a menu for friends and you've narrowed down the choices for each of the four courses, appetizer (A), beverage (B), main course (C), and dessert (D) as follows.

A: veggies (v) or escargot (e)
B: water (w), soda (s), or milk (m)
C: fish (f), hamburger (h), or pasta (p)
D: tort (t), ice cream (i), or goat cheese (g)

Each person gets the same menu consisting of one item in each course. Dietary restrictions of the guests imply the following constraints:

i. The appetizer must be veggies or the main course must be pasta or fish.
ii. If you serve escargot, the beverage must be water.
iii. You must serve at least one of milk, ice cream or goat cheese.

(a) [5] Draw the constraint graph associated with this problem. (Just show a graph with four nodes (one for each variable) labeled A, B, C and D and arcs connecting appropriate pairs of nodes that are involved in a joint constraint.)

ANSWER: C – A – B – D

(b) [5] Show the initial domains of each of the four variables.

ANSWER: A={v, e}, B={w, s, m}, C={f, h, p}, and D={t, i, g}

(c) [10] Suppose we decide to have the appetizer be escargot, i.e., A=e. What are the domains of all the variables after applying the forwarding checking algorithm?

ANSWER: Eliminate values s, m and h, resulting in A={e}, B={w}, C={f, p}, D={t, i, g}

(d) [10] Instead of using forward checking, as in (c), say we initially set A=e and then apply the arc consistency algorithm (AC-3). What are the domains of all the variables after it finishes?

ANSWER: A={e}, B={w}, C={f, p}, D={i, g}. t is eliminated in addition to the values eliminated in (c) because there is no value for B that is compatible with t at D based on constraint iii.

(e) [5] Give one possible final solution to this CSP or say why none exists.

ANSWER: There are four possible consistent solutions: {A=e, B=w, C=f, D=i}, {A=e, B=w, C=f, D=g}, {A=e, B=w, C=p, D=i}, and {A=e, B=w, C=p, D=g}.

4. Games, minimax and optimal play [30]

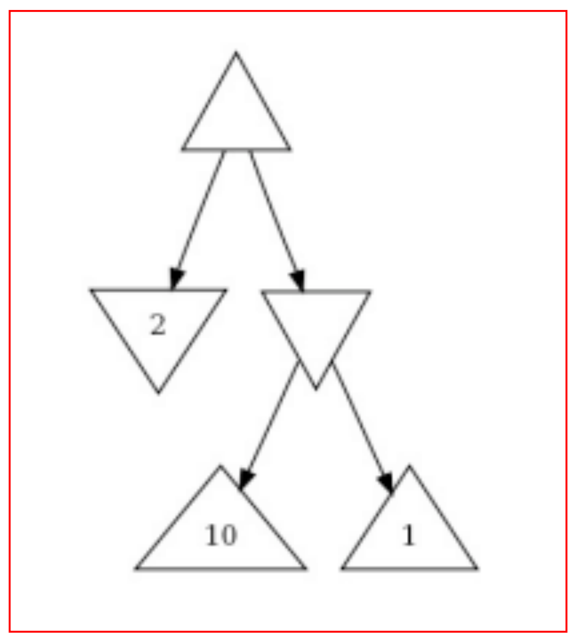
You (MAX) are playing a game against your friend (MIN). Your friend is very tired from studying for the CMSC671 exam and she is not playing well today and liable to make mistakes.

(a) You decide to use minimax decisions in playing against your friend. Can the fact that she is playing suboptimally hurt the performance of minimax? In other words, can the utility obtained by using minimax decisions against a suboptimal player be lower than that obtained against an optimal player? If so, provide a game tree that demonstrates this behavior. If not, provide a proof.

Proof: Using minimax can never hurt you. MIN playing suboptimally means that MIN selects a move with minimax utility greater than or equal to the move predicted by minimax. Since MAX maxes over these decisions, then the minimax utility against a suboptimal is greater than or equal to the minimax utility against an optimal min.

(b) Now suppose that you are aware when your friend will make a suboptimal move, and which move she will make (i.e., she will fall for the Scotch Gambit if you use it). Can you take advantage of this? In other words, can a suboptimal strategy on your part achieve higher utility than a minimax strategy if such assumptions are made? If so, provide a game tree that demonstrates this behavior. If not, provide a proof that this is not possible.

Answer: Yes, you can take advantage of it. The optimal move for MAX is to select the move that leads to the leaf with utility 2. But if MAX knows MIN will play suboptimally, MAX can select the other option, which would get her utility 1 against an optimal MIN, but will get her utility 10 against a suboptimal MIN.



5. Propositional logic I [5]

A propositional sentence is *well formed* if it follows the syntax of propositional logic, *satisfiable* if there is a way to assign true or false to each of its variables that makes the value of the overall sentence true, and *valid* if it is always true no matter what values its variables are assigned.

Circle all of the following that are true: The sentence $\mathbf{(P \rightarrow Q) \leftrightarrow (P \lor \neg Q)}$ is (a) *well formed*; (b) *valid*; (c) *satisfiable*; (d) *unsatisfiable?*

ANSWER: the sentence is (a) well formed; (c) satisfiable. A model for the sentence is (P=F,Q=F) so it is satisfiable. The model (P=T,Q=F) makes the sentence false, so it is not valid.

6. Propositional logic II [15]

Express each of the following English sentences as a single propositional logic expression when the symbols A, S, D and E have the following meaning:

A R2D2 was in an accident.
S R2D2 has a software malfunction.
D R2D2 is damaged.
E R2D2 needs to see an engineer.

a) R2D2 was in an accident, but he isn't damaged.

ANSWER: $A \land \neg D$

b) R2D2 needs to see an engineer if he has a software problem or is damaged.

ANSWER: $S \lor D \rightarrow E$

c) If R2D2 wasn't in an accident and doesn't have a software malfunction, then he doesn't need to see an engineer

ANSWER: $\neg A \land \neg S \rightarrow \neg E$

7. Propositional logic III [5]

Given a domain with a vocabulary of four propositional symbols, A, B, C, and D, how many models are there for the sentence: $(A \land B) \lor (B \land C)$

ANSWER: With four variables there are sixteen potential models (2**4). However, given that the sentence $(A \land B) \lor (B \land C)$ is true, there are only six consistent models. We can see that by noting that this sentence is the equivalent of $B \land (A \lor C)$, so the set of models are just those where B is True and either A or C is True: {(A=F,B=T,C=T,D=F), (A=T,B=T,C=F,D=F), (A=T,B=T,C=T,D=F), {(A=F,B=T,C=T,D=T), (A=T,B=T,C=F,D=T), (A=T,B=T,C=T,D=T)}. A brute force way to answer this is to write out the sixteen combinations (from TTTT to FFFF) and cross out those that are inconsistent with the sentence being True.