Midterm Exam 1

CSCI 561 Spring 2016: Artificial Intelligence

Student ID: | | | | | | | | | | |

Last Name: ____

First Name: ____

USC email: | | | | | | | | | @usc.edu

Instructions:

1. Date: **2/16/2015 from 5:00pm – 6:20 pm**
2. Maximum credits/points/percentage for this midterm: 100
3. The percentages for each question are indicated in square brackets [ ] near the question.
4. **No books** (or any other material) are allowed.
5. **Write down your name, student ID and USC email address.**
6. **Your exam will be scanned and uploaded online.**
7. **Answers must be written in the provided boxed only.** Please make sure NOT to write the answer to one question in the box for another one.
8. **Do NOT write on the 2D barcode.**
9. **The back of the pages will NOT be graded.** You should use the back of the pages only for SCRATCH PAPER, not the actual answers.
10. No questions during the exam. **If something is unclear to you, write that in your exam.**
11. **Be brief: a few words are often enough if they are precise and use the correct vocabulary studied in class.**
12. When finished, raise completed exam sheets until approached by proctor.
13. **Adhere to the Academic Integrity code.**

Problems	**100 Percent total**
1- General AI Knowledge	10
2- Search	30
3- Game Playing	10
4- Constraint satisfaction	20
5- Heuristic design	20
6- AI applications	10

1. [10%] General AI Knowledge

For each of the statements below, fill in the bubble T if the statement is always and unconditionally true, or fill in the bubble F if it is always false, sometimes false, or just does not make sense.

a)	T	F
b)	T	F
c)	T	F
d)	T	F
e)	T	F
f)	T	F
g)	T	F
h)	T	F
i)	T	F
j)	T	F

a) A* Search is a special case of Uniform-cost search.

b) A model-based reflex agent can handle a partially observable environment.

c) Breadth-First Search is usually more space-efficient than Depth-First Search.

d) The solution path found by Uniform-cost search may change if we add the same positive constant, c, to every arc cost.

e) There does not exist a task environment in which every agent is rational.

f) $\alpha - \beta$ pruning can alter the computed minimax value of the root of a game search tree.

g) Hill climbing can be viewed as DFS in the space of partial assignments.

h) Sound logical reasoning is necessary for passing the Turing Test.

i) It is possible to get stuck in a local maximum in simulated annealing.

j) If one search heuristic $h_1(s)$ is admissible and another one $h_2(s)$ is inadmissible, then $h_3(s) = \min(h_1(s), h_2(s))$ will be admissible.

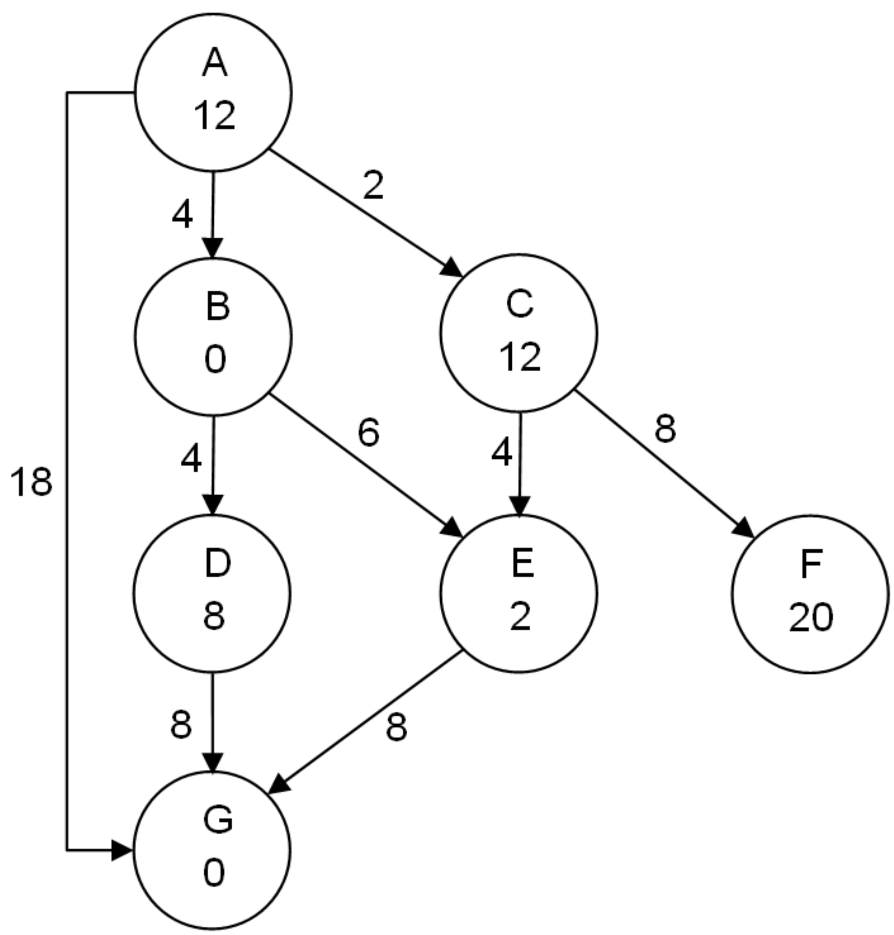
2. [30%] Search

Consider the search space on the following page, where the directed arcs represent the legal successors of a node. The number on the arc gives the actual cost of moving to a successor node. The estimated cost to a goal is reported inside nodes. A is the start state and G is the goal state.

For each of the search strategies (next page), give

(i) the sequence of nodes popped off from the OPEN queue (for expansion or before halting at the goal), and

(ii) the solution path found. When all else is equal, nodes should be removed from the OPEN queue in alphabetical order.



Note how the arcs in the figure are oriented, which means that you can only go from one state to another if the arc points from the first to the second. For example, you can go from A to B but not from B to A.

2A. [10%] Uniform cost graph search (i.e., use an Explored set)

(i) Sequence of nodes popped:

(ii) Solution path:

2B. [10%] Greedy Best-First tree search (i.e., do not use Explored set)

(i) Sequence of nodes popped:

(ii) Solution path:

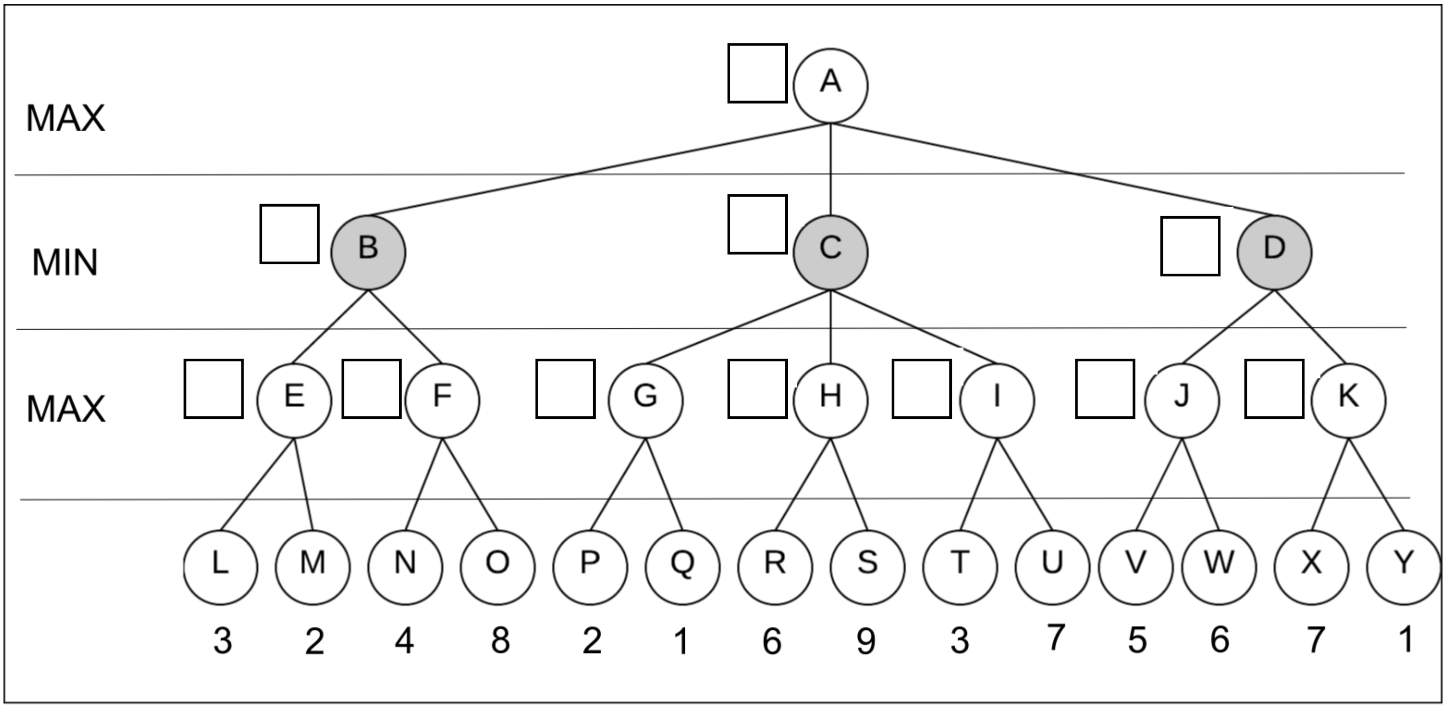
2C. [10%] A* tree search (i.e., do not use Explored set)

(i) Sequence of nodes popped:

(ii) Solution path:

3. [10%] Game Playing

Consider the following game tree in which the evaluation function values are shown below each leaf node.
The maximizing player goes first.
Assume that the search always visits children left-to-right.



3A. [4%] Compute the backed-up values according to the minimax algorithm. Show your answer by writing values in the boxes next to the appropriate nodes in the above tree.

3B. [2%] What series of nodes will be selected by the players if they are both rational and both know the outcome? Write down the letters corresponding to the series of nodes from the root to the leaf node.

3C. [4%] List the nodes that will not be examined by the alpha-beta pruning algorithm. Write down the letters corresponding to the pruned nodes.

4.[20%] Constraint Satisfaction

Consider the following equation in which each letter represents a digit:

$$\begin{array}{ccccc} & X & Y & Z & \\ & & B & A & D \\ + & & B & A & D \\ \hline & C & R & A & B \end{array}$$

The goal is to find a value for each digit so that the sum is arithmetically correct. All the digits A-B-C-D-R must be **distinct** and the first digit of a line cannot be 0.

Additionally, we add the constraint that **A must be 0**.

We will note **X**,**Y**,**Z** the carry digits for the 3 columns from left to right. This means, for instance, that **D**+**D**=**ZB**.

4A. [8%] Using the letters as variables, formulate this problem as a CSP with variables, domains and constraints. Constraints should be specified formally and precisely.

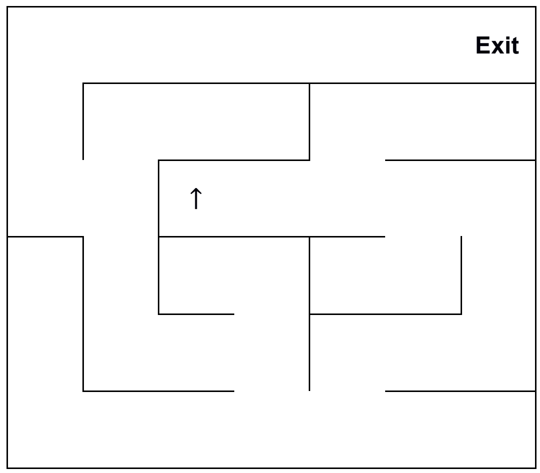
4B. [1%] Derive the value of X,Y,Z using arc-consistency and the constraint A=0. Briefly justify your answers.

4C. [7%] Now that the values for X-Y-Z are known, the constraints that relate the other variables can be reduced to binary (or unary). Show the domains of the variables after running arc-consistency and enforcing any unary constraints.

4D. [4%] Give all the solutions to this CSP.

5.[20%] Heuristic design

Imagine that a vehicle-like agent wishes to exit a maze (not necessarily this one; the size could be larger):



The agent is directional and at all times faces some direction d ∈ (N, S, E, W). With a single action, the agent can either move forward at an adjustable velocity v or turn. The turning actions are left and right, which change the agent's direction by 90 degrees. Turning is only permitted when the velocity is zero (and leaves it at zero). The moving actions are fast and slow. Fast increments the velocity by 1 and slow decrements the velocity by 1; in both cases the agent then moves a number of squares equal to its NEW adjusted velocity. Any action that would collide with a wall crashes the agent and is illegal. Any action that would reduce v below 0 or above a maximum speed V_{max} (V_{max} is a positive integer larger than 1) is also illegal. The agent's goal is to park itself (stationary) on the exit square using as few actions (time steps) as possible. As an example: if the agent shown were initially stationary, it might first turn to the east using (right), then move one square east using fast, then two more squares east using fast again. The agent will of course have to slow to turn.

5A. [4%] Assume that the agent could reach all squares at any possible speed (0~V_{max}) facing any direction. If the grid is M by N, what is the size of the state space, as a simple numerical formula?

5B. [4%] **What is the maximum branching factor of this problem? You may assume that illegal actions are simply not returned by the successor function. Briefly justify your answer.**

5C. [8%] **Are following heuristic functions admissible on arbitrary M × N mazes? (Answer by filling in the bubble Yes/No below)**

Yes No $h = 0$

Yes No h = Manhattan distance from the agent's location to the exit's location

Yes No h = Manhattan distance divided by V_{max}

Yes No h = Current velocity

5D. [2%] **If we used an inadmissible heuristic in A* tree search, could it change the completeness of the search? (Answer by filling in the bubble Yes/No below)**

Yes No

5E. [2%] **If we used an inadmissible heuristic in A* tree search, could it change the optimality of the search? (Answer by filling in the bubble Yes/No below)**

Yes No

6. [10%] AI Applications.

Write down the **best** answer for each question in the boxes:

1. [2%] What AI agent is most likely to have a natural language processing model?

a. Robocup Soccer robots
b. IBM Watson
c. An agent in the DARPA Urban Challenge
d. All of the above
e. None of the above

2. [2%] Assume that a rook can move on a chessboard any number of squares in a straight line, vertically or horizontally, but cannot jump over other pieces. Which is an admissible heuristic for the problem of moving the rook from square A to square B in the smallest number of moves?

a. Straight-line distance
b. Manhattan distance
c. h(n)=0
d. All of the above
e. None of the above

3. [2%] Which AI application has a static environment?

a. Ada & Grace
b. Google Self-driving car
c. IBM's Deep Blue
d. All of the above
e. None of the above

4. [2%] In a genetic algorithm, successor states are generated by combining *two* parent states rather than by modifying a single state. What is the advantage of this compared to hill-climbing?

a. To not get stuck on local maxima
b. It allows genetic algorithm to be complete
c. To reduce space complexity
d. All of the above
e. None of the above

5. [2%] Which chat bot passed the Turing test in 2014?

a. Mitsuku
b. Marvin Minsky
c. Eugene Goostman
d. All of the above
e. None of the above