

Write **clearly** and **in the box**:

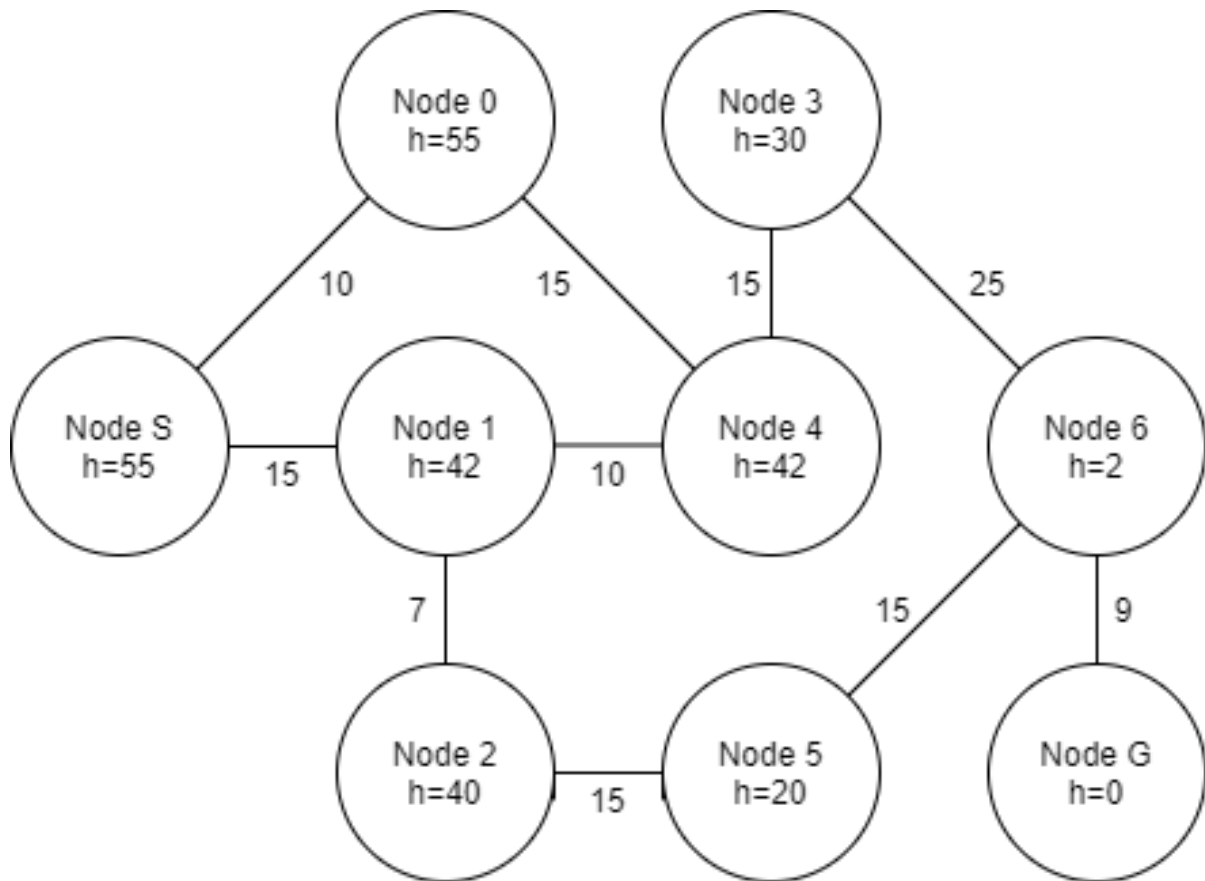
CSCI 3202  
Midterm Exam  
Remote edition  
Fall 2020

<b>Name:</b>
<b>Student ID:</b>
<b>Section number:</b>

- **RIGHT NOW!** Include your name, student ID and section number on the top of your exam. If you're handwriting your exam, write this information at the top of the first page!
- You may use the textbook, your notes, lecture materials, and Piazza as recourses. Piazza posts should not be about exact exam questions, but you may ask for technical clarifications and ask for help on review/past exam questions that might help you. You may not use external sources from the internet or collaborate with your peers.
- You may use a calculator.
- If you print a copy of the exam, clearly mark answers to multiple choice questions in the provided answer box. If you type or hand-write your exam answers, write each problem on their own line, clearly indicating both the problem number and answer letter. Start each new problem on a new page.
- Mark only one answer for multiple choice questions. If you think two answers are correct, mark the answer that **best** answers the question. No justification is required for multiple choice questions. For handwriting multiple choice answers, clearly mark both the number of the problem and your answer for each and every problem.
- For free response questions you must clearly justify all conclusions to receive full credit. A correct answer with no supporting work will receive no credit.
- The Exam is due to Gradescope by midnight on Monday, October 12.
- When submitting your exam to Gradescope, use their submission tool to mark on which pages you answered specific questions.

Problem	Student Points	Max Points
Discrete Search		35
Games		30
Short Response		20
Information		15
Total		100

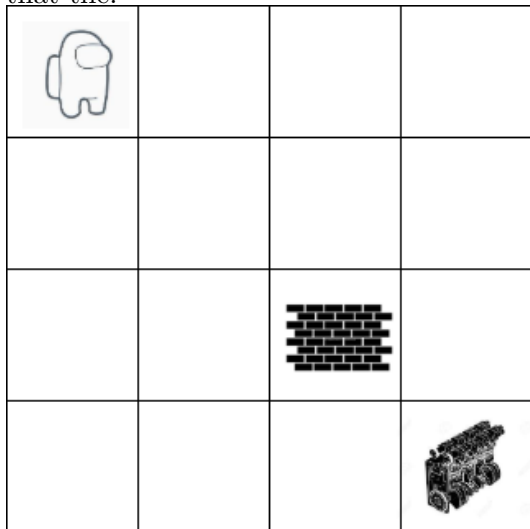
- <sup>2</sup> (1) [35 points] For problem 1, refer to the following graph, with heuristic values  $h(n)$  depicted inside each node in parenthesis. Consider the task of finding the shortest path from **S** to **G**, where step costs to travel between two nodes are given as edge weights.



- 1A) [5 points] In what order would BFS **expand** the nodes of the graph? List all nodes that are expanded and the order in which they are expanded. Assume that numeric nodes are expanded lowest-first when an option exists.
- 1B) [5 points] In what order would DFS **expand** the nodes of the graph? List all nodes that are expanded in the order in which they are expanded. Assume that numeric nodes are expanded lowest-first when an option exists.
- 1C) [5 points] In what order would UCS **expand** the nodes of the graph? List all nodes that are expanded in the order in which they are expanded.
- 1D) [5 points] In what order would A\* **expand** the nodes of the graph? List all nodes that are expanded in the order in which they are expanded.

- 1E) [5 points] Is the heuristic  $h$  on the graph admissible? If so, explain why. If not, explain for which single state  $n$  you could change the values of  $h(n)$  to make everything admissible and consistent. What range of values for  $h$  are possible to make this correction?
- 1F) [4 points] Suppose after making any adjustments that you've arrived at a consistent and admissible heuristic  $h_1(n)$ . You then decide to use the new heuristic  $h_2(n) = 2h_1(n)$ . Is the  $A^*$  solution found using  $h_2$  *guaranteed* to be optimal? Justify your answer.
- 1G) [3 points] Provide a reason as to why using an inadmissible or inconsistent heuristic may be a bad idea.
- 1H) [3 points] Provide a reason as to why using an inadmissible or inconsistent heuristic may be a good idea.

- 4 (2) **[30 points]** Parts A-D refer to this game. We're playing our favorite new game, "walls among us." In this game, we play as a noble space explorer, maintaining our 2-dimensional ship represented by the 4x4 grid below. On our turn, we may move in one of the 4 cardinal directions, and must move into an unoccupied square. Our opponent is attempting to sabotage us, and has sabotaged the ship's warp drive! We have to fix it, but our opponent is in the game, and plays as a brick wall trying to block our way. On the wall's turn, they also must move in one of the 4 cardinal directions, and must also move to an unoccupied square. The game ends - with us as the victor - when we move to the goal in the bottom-right corner of the map. The wall may never move to that tile.

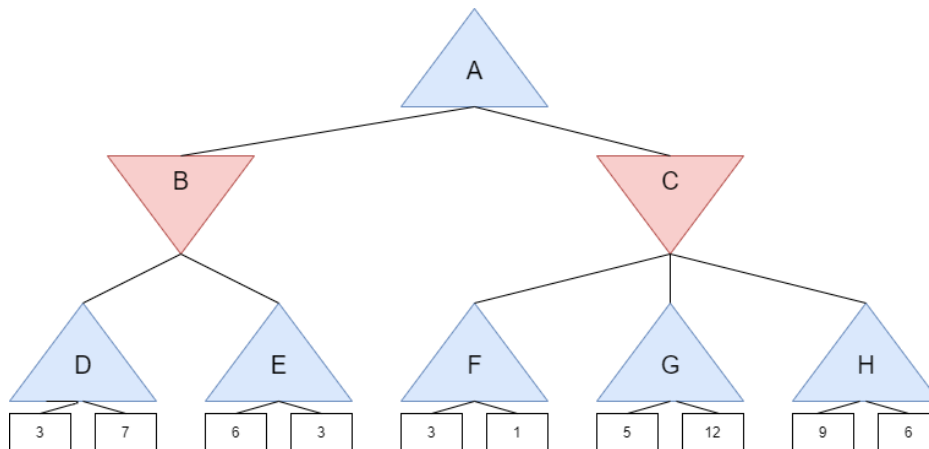


- 2A) **[4 points]** Assuming the engine might be located in different playthroughs to any tile on the board, what is the size of the overall state space? The exact result should use the fact that the wall can *never* overlap with either you or the engine.
- 2B) **[10 points]** Draw a game tree with one move for each player from the starting position shown. Nodes in the tree represent game states (location of all agents and walls). Edges in the tree connect successor states to their parent states. Draw only the legal moves.

2C) [4 points] On the shallow game tree of depth 2 from part 2B, what would we infer is the value of the game? Use the score of "number of warp drives reached by the player" as your evaluation function.

2D) [4 points] If we were to consider a game tree of depth 16 - holding eight moves for each player instead of only one - what would minimax compute as the value of the starting position of the game? Explain your reasoning.

2E) [8 points] Consider the minimax tree below. Upward pointing triangles are MAX nodes, downward pointing triangles are MIN nodes.



What are the minimax values associated with each node? Do not consider any pruning at this point.

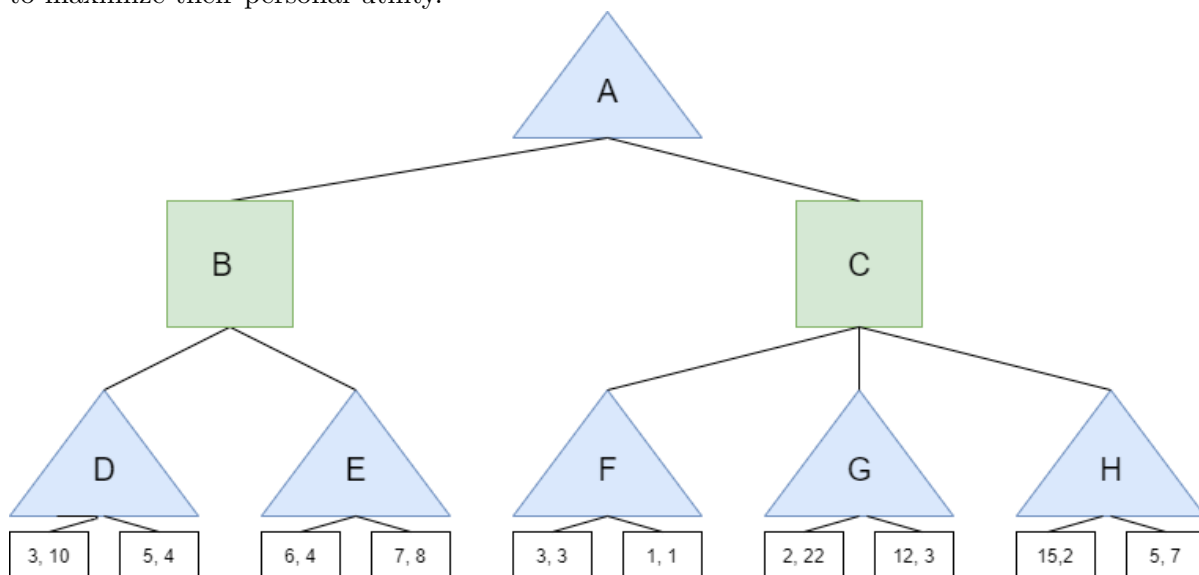
A: \_\_\_\_\_ B: \_\_\_\_\_ C: \_\_\_\_\_ D: \_\_\_\_\_

E: \_\_\_\_\_ F: \_\_\_\_\_ G: \_\_\_\_\_ H: \_\_\_\_\_

On the diagram of the tree, indicate clearly which branches/leaves are pruned when alpha-beta pruning is applied to this game tree. Assume that nodes are expanded from left-to-right at each layer. Briefly justify how you know those branches/leaves can be pruned. Vague responses along the lines of simply saying "alpha-beta pruning algorithm" will receive 0 points.

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2F) [5 points (EXTRA CREDIT)]. Consider a non zero-sum representation of a game. In this setup, player A's utility is denoted as the first of two leaf numbers and player B's utility by the second. Fill in this non-zero game tree assuming that each player is acting optimally to maximize their personal utility.



- (3) [20 points] Other Searches. For each question, answer the prompt and provide at least one full sentence of reasoning and justification. More than one sentence may be necessary.

3A) [4 points] In what situation(s) is Breadth First Search identical to Uniform Cost Search?

3B) [4 points] Is hill climbing guaranteed to find the optimal solution? Why or why not?

3C) [12 points] Suppose we were interested in using the genetic algorithm to find a solution or solutions to the system given by:  $a + 5b + 6c - 12d + e = 1204$  for positive integers  $a, b, c, d, e$ . Suppose your initial population consists of 100 lists of the form  $[a, b, c, d, e]$ , where each term is initialized as a random integer from 1 to 500.

Propose a working genetic algorithm for this problem. This includes: a fitness function to minimize - so one that will return zero when at a valid solution - and a selection/breeding/mutation scheme that will find valid solutions to the problem.

**Proposed Fitness Function:**

**Proposed  $P(\text{breeding})$  Function:**

**Proposed Breeding/Mutation Scheme:**

- <sup>8</sup> 4A) [15 points] Suppose we're going to catch the Buff Bus, and want to decide when to go wait for it. We decide to use the linear loss function

$$L_l(d, x) = \begin{cases} 2(x - d) & x \geq d \\ 4(d - x) & x < d \end{cases}$$

- 4A) [7 points] We model the Buff Bus arrival times as an exponential random variable  $X$  that arrives on average once per hour, so they have probability density function of  $f(x) = e^{-x}$  for  $x > 0$  (note: this has mean of  $E_X[x] = 1$ ). Set up but don't evaluate an integral or integrals for the *expected* loss  $E_X[L(d, x)]$ .

- 4B) [4 points] In class we discussed some conditions where the expected value of including uncertainty (EVIU) might be zero; do those apply here? Why or why not? What's larger in this problem, the expected value of perfect information (EVPI) or the EVIU? You do not need to calculate the exact values but you may if you wish.

- 4C) [4 points] In the loss function above, are we considering it more costly to overestimate or to underestimate? How do you know? Do you think this is a reasonable model for waiting-for-the-bus?