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Seat Number _____

Student Number

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Family Name _____

First Name _____

Total

Question 1.**(20 marks)**

Answer the following questions about the search problem shown in Figure 1. For the questions that ask for a path, please give your answers in the form 'S – A – D – G'. Break any ties alphabetically.

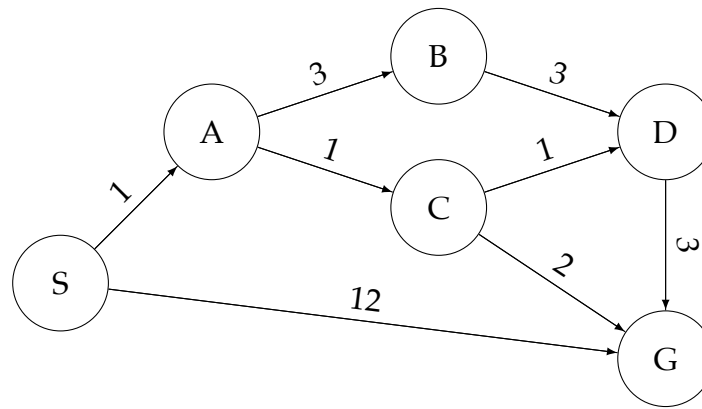


Figure 1: Search problem. The edge labels represent the cost of moving between nodes

- (a) What path would a breadth-first graph search return for this search problem?
(3 marks)
- (b) What path would a uniform cost graph search return for this search problem?
(3 marks)
- (c) What path would a depth-first graph search return for this search problem?
(3 marks)
- (d) What path would an A* graph search, using a consistent heuristic, return for this search problem?
(3 marks)
- (e) Consider the heuristics for this search problem shown in the table below.

State	h_1	h_2
S	5	4
A	3	2
B	6	6
C	2	1
D	3	3
G	0	0

- i) Is h_1 admissible? (2 marks)
- ii) Is h_1 consistent? (2 marks)
- iii) Is h_2 admissible? (2 marks)
- iv) Is h_2 consistent? (2 marks)

Question 2.**(20 marks)**

UQPark is a theme park with 5 rides: bumper cars, carousel, haunted class, roller coaster, and ferris wheel, where each ride can be turned on and off independently of the other rides. The set of rides that are open/closed must satisfy the following constraints:

1. Either bumper cars or carousel must be open.
 2. If bumper cars is closed, then roller coaster must be open.
 3. If carousel is open, then either bumper cars or haunted class must be open too.
 4. If haunted class is open, then ferris wheel must be open too.
 5. Bumper cars and ferris wheel cannot both be open on the same day.
 6. If roller coaster is open, then ferris wheel must be open too.
 7. If roller coaster is closed, then either haunted class or ferris wheel must be open.
- (a) Please frame this problem as a satisfiability problem with propositional logic representation and determine whether the constraints can be satisfied using DPLL.
(15 marks)
- (b) Can you determine whether the constraints can be satisfied with GSAT? Please explain why or why not.
(5 marks)

Question 3.**(20 marks)**

Suppose you are playing a turn-taking, zero-sum game, where the opponent is a rational agent and you would like to use two-step lookahead to decide your move. You know that the complete min-max tree of the two-step lookahead strategy for this game will be a complete binary tree as shown in Figure 2. Suppose you are given access to a heuristic function that will give you a good estimate on the value of the leaf nodes of the complete tree (these estimated values are given in the leaf nodes of Figure 2).

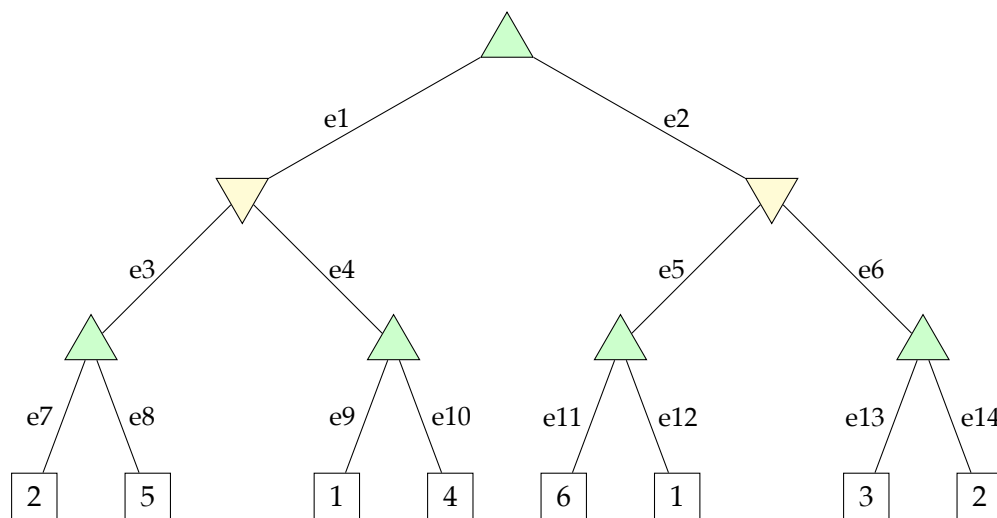


Figure 2: The complete min-max tree for the two-step lookahead strategy of the game. Max nodes are upward pointing triangles, starting from the top node, and min nodes are downward pointing triangles.

- (a) Relying on the given heuristic, how should the tree be expanded if we want to maximise the benefit of $\alpha\beta$ -pruning? Please write the answer as a sequence of edges to be visited.

(10 marks)

- (b) Please write pseudo-code of the strategy you use to answer the previous question (i.e., part (a))

(10 marks)

Question 4.**(20 marks)**

Suppose you are planning on investing your superannuation in either Property, Technology, or Bonds. Your return depends on the state of the economy (growing or declining), and the return of each investment option is as shown in Table 1. These values are based on the fixed amount in your superannuation, which is not needed in this question.

	Growing	Declining
Property	\$70	-\$13
Technology	\$53	-\$5
Bonds	\$20	\$20

Table 1: Return on different investment options in a growing or declining economy

You can hire an economic consultant to give you a report on the state of the economy. The report predicts the economy as positive or negative (which corresponds to predicting a growing or declining economy, respectively). This report comes at a cost of \$8, which is discounted to \$4 if the report is incorrect. The joint probability distribution of the report prediction and the state of the economy is shown in Table 2. The probability of a growing or declining economy can be inferred from this table.

	Growing	Declining
Positive report	0.35	0.2
Negative report	0.05	0.4

Table 2: Joint probability distribution of the economic consultant's report (positive or negative), and the state of the economy (growing or declining)

- (a) Assuming that you are risk neutral, and don't purchase the economic consultant's report, what should you invest your superannuation in: Property, Technology or Bonds? Please compute the Maximum Expected Utility (MEU) and Decision Tree to explain your selections.

(8 marks)

- (b) Again, assuming you are risk neutral, should you purchase the economic consultant's report? Please compute the Maximum Expected Utility (MEU) and Decision Tree to explain your selections.

(12 marks)

Question 5.**(20 marks)**

Prof. Yuri has invented a new update equation for solving Markov Decision Process (MDP) problems. The equation is called the Y update equation and is defined as follows:

$$Y_{i+1}(s) = \max_a \left(R(s, a) + \gamma \sum_{s'} T(s, a, s') \max_{a'} \left(R(s', a') + \gamma \sum_{s''} T(s', a', s'') Y_i(s'') \right) \right)$$

Prof. Yuri claimed that if we replace the Bellman update equation with the Y update equation, then the value iteration algorithm will converge to the optimal solution faster. To understand this new update equation better, please:

- (a) Find and explain the relationship between the Y update equation and the Bellman update equation, if there is any relation. If there is no relation, please explain how you came to that conclusion.

(10 marks)

- (b) Is Prof. Yuri's claim correct if "faster" is defined with respect to computation time? Please explain your answer.

(5 marks)

- (c) Is Prof. Yuri's claim correct if "faster" is defined with respect to the number of iterations the value iteration takes to solve the MDP problems? Please explain your answer.

(5 marks)

Question 6.**(20 marks)**

Darth Vader has kidnapped Luke Skywalker and placed him in one of the cells in his dungeon. R2D2 is sent to the dungeon to free Luke with as little cost as possible. The dungeon contains three cells, two of the cells contain Vader's monsters and one contains Luke. When R2D2 enters the dungeon, he assumes that Luke can be in any room with equal probability. Breaking into a cell with a monster inside, would cause R2D2 to be attacked by the monster and it must pay a cost of \$2,000 to repair itself. Breaking into a cell where Luke is, would free Luke and R2D2 will be rewarded \$1,000. With a cost of \$350, R2D2 can scan the dungeon to observe which cell Luke might be in. However, the result of this scanning is not perfect. A single scan of the dungeon identifies the cell where Luke is with 75% accuracy. All false scanning results are equally probable. The optimal strategy for R2D2 in this task can be framed as a Partially Observable Markov Decision Process (POMDP) problem. Please provide the POMDP model for this.

END OF EXAMINATION