optimality : quality of an algorithm

solution exists

Section A: Attempt all

1. What is an admissible heuristic ? If I have two connected nodes $A - B$ with an actual distance between them of 19. Which of the following are admissible heuristics of the distance $A - B$: $H1 = 21$, $H2 = 18$, $H3 = 19$, $H4 = 11$. [4 Marks]

2. Consider a CSP with variables X and Y. If both initially have the domain $\{1, 2, 3, 4, 5, 6, 7, 8, 9\}$ and constraints $X \leq Y - 4$. Using forward checking what would be the resultant domains of: (i) X and (ii) Y ? [4 marks]

,8,9}

3. Differentiate informed search from uninformed search algorithms giving an example of each. [4 marks]

4. Differentiate optimal search from any-path search giving an example of each. [4 marks] - optimal searches are looking for the best possible path while any path searches will just settle for finding some solution.

5. What is meant by the following in relation to search algorithms. [2 marks]

   (a) Completeness - if it terminates with a solution when one exists

   (b) Optimality - quality of an algorithm of returning only solutions that are atleast as good as any other solution (doesnt overestimate)

6. Consider a hypothetical case where emails are sent by John and Jane. John has sent the following emails with the following letters. Calculate P(John), P(Jane), P(2 | John), P(3 | Jane) [6 marks]

   John: $[(b, 2, 3, 2, b, b, x, c,), (d, e, 2, f, d, a, t), (a, f), (e, d, x), (a, 2), (a, 3)]$

   Jane: $[(3, 2, a), (c, t, t, t, d), (e, f, a, b, e, e, f, g, s), (a, 3, 10)]$

7. Differentiate min-max search from expectimax search. [2 marks]

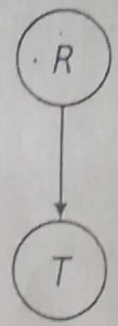
8. Consider the following CSP with 3 variables X, Y and Z with the following domains $X = \{1, 2, \ldots, 10\}$, $Y = \{5, 6, \ldots, 15\}$ and $Z = \{5, 6, \ldots, 20\}$. The constraints on 3 the variables are: $2X = Y$, $Y + Z = 18$ and $X + Z = 12$. Are the constraints arc consistent? If no, apply arc consistency method repeatedly so they become arc consistent. What is the updated domain of each variable? [5 marks]

9. Figure 1 shows a Bayes Net depicting the relationship between Rain and Temperature.

   (a) What conditional independence assumptions are encoded in a Bayes Net? [2 marks]

   (b) Calculate the probabilities P(T=-t, R=+r), P(T=+t, R=-r), P(T=-t, R=-r), and P(T=+t, R=+r) [4 marks]

   (c) Should the sum of all these probabilities above be 1 or should they not ? Explain. What do yours add up to ? [1 marks]



$P(R)$

+r	1/4
-r	3/4

$P(T|R)$

+r	+t	3/4
	-t	1/4
-r	+t	1/2
	-t	1/2

Figure 1: Bayes Net of Rainfall and Temperature

10. Given $P(A) = 0.4$, and $P(B|A) = 0.5$. Calculate
   - $P(A, B)$ assuming A and B are not independent [1 mark]
   - $P(A, B)$ assuming A and B are independent [1 mark]

Section B: Attempt any 3 questions

Question 1

1. Jane is a person who enjoys playing golf. Data on the weather conditions was recorded for different days and whether Jane played or did not play on those days. The data is shown in Table 1.

   (a) Using observations in Table 1. Calculate : [10 marks]

   i. P($P = yes$)
   ii. P($O = sunny|P = yes$)
   iii. P($O = overcast|P = yes$)
   iv. P($O = rainy|P = yes$)
   v. P($T = hot|P = yes$)
   vi. P($T = mild|P = yes$)
   vii. P($T = cool|P = yes$)
   viii. P($H = normal|P = yes$)
   ix. P($H = high|P = yes$)
   x. P($W = false|P = yes$)

   (b) If todays weather outlook is sunny, temperature is cool, humidity is high and it is windy. Assuming all these weather conditions are independent of each other, use the Naïve Bayes algorithm, to determine if Jane will play today or not? Justify you answer. [4 marks]

2. A doctor is called to see a sick child. The doctor has prior information that 90% of sick children in that neighborhood have the flu (F), while the other 10% are sick with measles (M). Assuming that there no other sickness in that neighborhood. A well-known symptom of measles is a rash (R). The probability of having a rash if a child has measles is 0.95. However, occasionally children with flu also develop rash, and the probability of having a rash if a child has flu is 0.08.

6

Outlook(O)	Temperature(T)	Humidity(H)	Windy(W)?	Play(P)?
sunny	hot	high	false	no
sunny	hot	high	true	no
overcast	hot	high	false	yes
rainy	mild	high	false	yes
rainy	cool	normal	false	yes
rainy	cool	normal	true	no
overcast	cool	normal	true	yes
sunny	mild	high	false	no
sunny	cool	normal	false	yes
rainy	mild	normal	false	yes
sunny	mild	normal	true	yes
overcast	mild	high	true	yes
overcast	hot	normal	false	yes
rainy	mild	high	true	no

Table 1: Weather conditions vs Janes decision to play golf

(a) Calculate [2 marks]
   i. $P(\neg R|M)$
   ii. $P(\neg R|F)$

(b) Upon examining the child, the doctor finds a rash. Show your working.
   i. What is the probability that the child has Flue? [2 marks]
   ii. What is the probability that the child has measles? [2 marks]

Question 2

1. Consider the search problem in Figure 2. In this problem the start state is S, and the goal state is G. The transition costs are next to the edges, and the heuristic estimate, h, of the distance from the state to the goal is in the state's node. Assume ties are always broken by choosing the state which comes first alphabetically.

   (a) What is the order of states expanded using Depth First Search? [2 marks]

   (b) What is the order of states expanded using Breadth First Search? [2 marks]

   (c) What is the order of states expanded using A* search and the cost of the solution? [3 marks]

   (d) What is the path returned by the greedy search and the cost of the solution ? [3 marks]

   (e) What path is returned by Uniform Cost Search and the cost of the solution ? [3 marks]

2. Kapere primary school is in the process of recruiting new teachers in the school. The head-teacher of the school has determined that the school will need to recruit 2 Mathematics teachers, 2 English teachers, 1 Music teacher, 1 Fine Art teacher, 1 swimming teacher and 2 Science teachers.

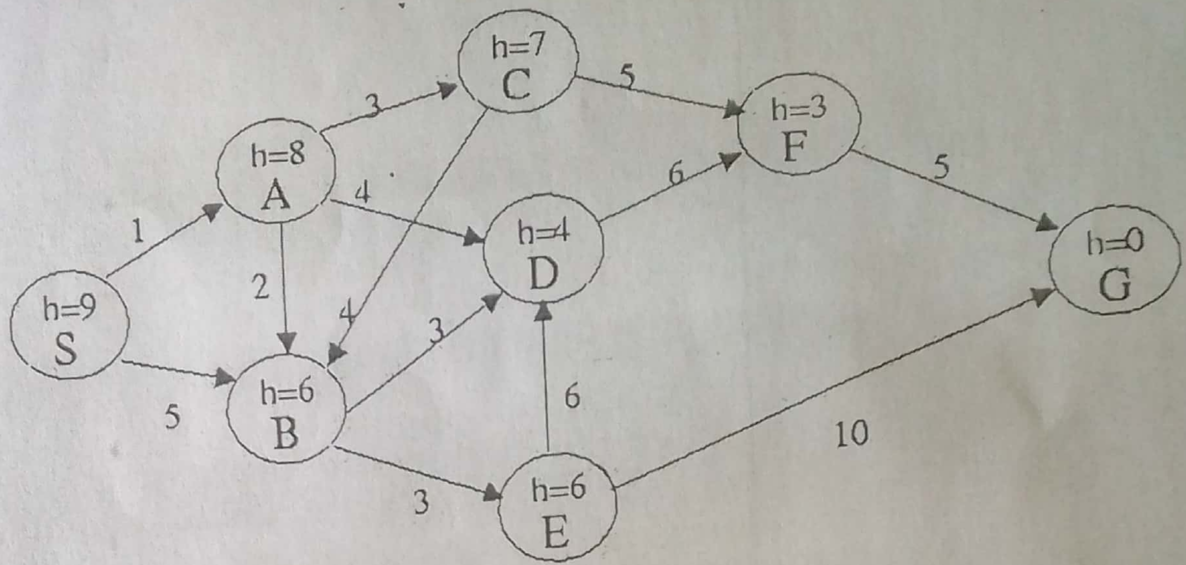


Figure 2:

If a teacher knows two subjects he/she can take on the two subjects in the school. As the process of recruitment proceeds the head-teacher narrows his selection on the following teachers as shown in Table 2

Tearchers's Name	Subject abilities
Peter	Mathematics and English
John	Science and English
Jim	English and Swimming
Jane	Mathematics and Fine art
Mary	Music and English
Bruce	Swimming and Mathematics
Chuck	Music and English

Table 2: List of Teachers

(a) Suppose the head-teacher can teach Mathematics and Science, and the school only has funds to hire four more teachers. Model this scenario as a CSP using *each subject ability* as a variable. Note a teacher cannot take two teaching roles which require same subject ability e.g Peter cannot fill the two positions for mathematics. **[5 marks]**

(b) List one solution to the problem or stat none. **[2 marks]**

Question 3

1. You are asked to determine the layout of a new, small recreation center. The recreation center will have the following structures: administration block(A), a bus stop(B), playground(P), a refreshment block(R) and a hotel(H). Each structure must be placed somewhere on the grid shown in Figure 3. The following constraints must be satisfied:

   (-) The bus stop(B) must be adjacent to the road.

   (-) The administration block(A) and refreshment block(R) must both be adjacent to the bus stop(B).

   (-) The hotel(H) must be on a hill or adjacent to the road.

   (-) The refreshment block(R) must be adjacent to the hotel(H).

   (-) The playground (P) must be adjacent to the hotel(H).

   (-) The administration block(A) must not be adjacent to the playground(P).

   (-) The administration block(A) must not be on a hill.

   (-) The play ground(P) must not be on a hill or adjacent to the road.

   (-) All structures must be in different grid squares.

   Here, *adjacent* means that the structures must share a grid edge, not just a corner.

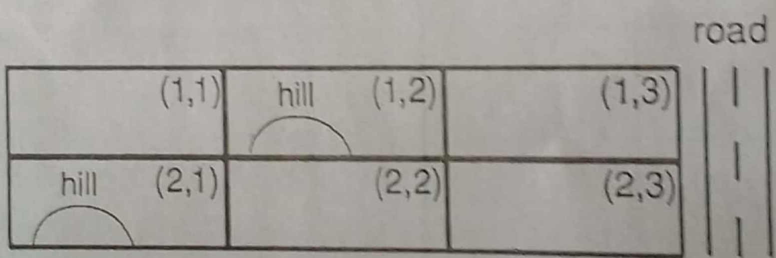


Figure 3: Grid

   (a) Let the variables A, B, H, P and R each range over the set of locations on the grid. Express the description above as unary and binary constraints over these variables. **[4 marks]**

   (b) Cross out eliminated values to show the domains of the variables after B = (1, 3) has been assigned and arc consistency has been run. **[4 marks]**

   (c) List one solution to this CSP or state that none exist. **[2 marks]**

2. Consider the game tree in Figure 4

   (a) If we assume this is a minmax search tree. What are the utilities at the states S,T,U,V,W,X,Y,Z ? **[4 marks]**

   (b) What is player's A next move? **[2 marks]**

   (c) Which nodes *would not* be visited if Alpha-Beta search is used? **[4 marks]**

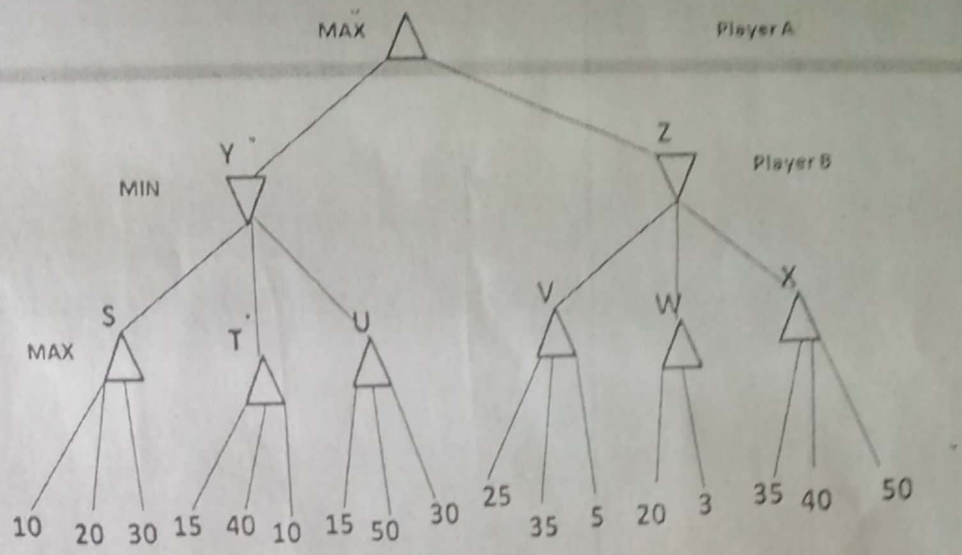


Figure 4: Game tree

Question 4

1. Figure 5 shows the game tree of a two-player game; the first player is the maximizer and the second player is the minimizer. Use the tree to answer the following questions.

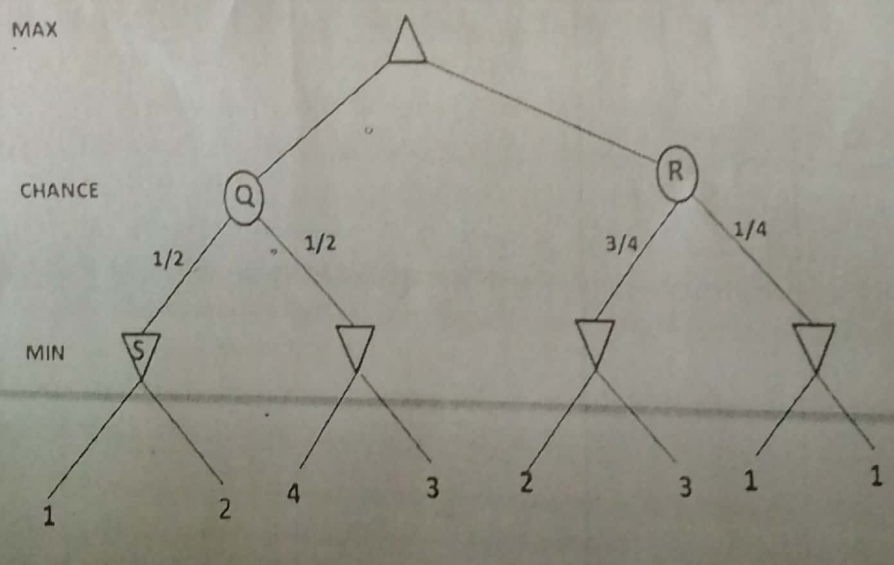


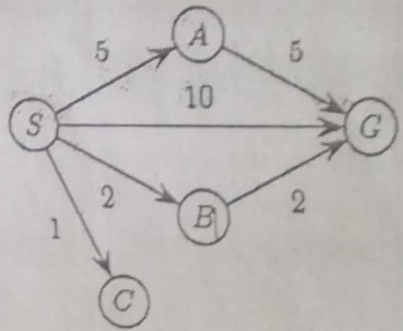
Figure 5: Game tree

(a) What is the value of the node labeled S? [2 marks]

(b) What is the expected values for the nodes labeled Q and R [4 marks]

(c) What is the expected value of the game? [2 marks]

2. Consider the following search problem with start state S and goal state G and a corresponding table of heuristics.



Node	h(n)
S	4
A	3
B	2
C	5
G	0

Which path will each search algorithm return, assuming all successor functions work out in such a way that nodes are explored in alphabetical order whenever possible?

(a) i. Breadth-first search [1 marks]
   ii. Depth-first search [1 marks]
   iii. Uniform-cost search and the cost [2 marks]
   iv. A^* search and the cost [3 marks]
   v. Greedy search and the cost [2 marks]

(b) Describe a reasonably general case in which each of the following will occur, or state that the scenario is impossible. [1 marks @]
   i. Depth-first search never terminates, despite a finite goal.
   ii. Breadth-first search never terminates, despite a finite goal.
   iii. Uniform cost search and breadth-first search expand the same nodes and return the same goal.

Question 5

1. Consider a miniature version of the 8-puzzle, called the 3-puzzle, with start and goal states. Assume that the operations (when allowed) are to move the blank tile *right*,

Table 3: start state

3	-
5	4

Table 4: Goal state

3	4
-	5

left, *up* and *down*. Assume further that we do not generate any duplicate states. You may also assume that all operations have unit cost.

(a) Draw the state space for this problem with a depth limit of 4 (to be precise, consider the initial state at depth 0, and stop expanding nodes at depth 4, thus showing all states that are within 4 moves of the start state) [2 marks]

(b) Consider the heuristic h_1 = Manhattan distance (the sum of horizontal and vertical distance) of the blank tile from its desired position. Label each state in the state space in (1a) with h_1 = number showing the heuristic cost of the state. E.g. for the start state $h_1 = 2$ [4 marks]

(c) Consider the heuristic h_2 = number of misplaced tiles. Label each state in the state space in (1a) with h_2 = number showing the heuristic cost of the state. Assume that the blank is not counted as a tile. E.g. for the start state $h_2 = 2$ [4 marks]

2. Tom and Mary are two people that communicate alot via email. An example of some key words of interest from their previous emails are : Tom: = [soccer, soccer, soccer, soccer, messi, messi, nrm, nrm, nrm, nrm, nrm, soccer, kardashians, soccer, nrm] Mary: = [kardashians, messi, messi, nrm, nrm, soccer, kardashians, kardashians, kardashinans, nrm, nrm, nrm] Using probability theory,

   (i) Calculate the following probabilities: P(soccer|Tom), P(kardashians|Tom), P(nrm|Tom), P(messi|Tom). [4 marks]

   (ii) Calculate the following probabilities: P(soccer|Mary), P(kardashians|Mary), P(nrm|Mary), P(messi|Mary) [4 marks]

3. Based on the information about Mary and Tom communicating (in the previous question). If you receive an email with the following works: [nrm, messi, soccer]. Using Bayes rule, calculate the probability that the email came from Mary. [2 marks]

End

School of Computing & IT

CSC 2114 Artificial Intelligence - CAT1 (BSc CS & BSc SE)
Instructions: Attempt all

Question 1

1. A search problem is formally defined by specifying 4 or so main things. Imagine as a lecturer I want to seat students in the class so they are evenly mixed male and female. Write this problem as a search problem. [4 marks]

2. Consider the search graph Figure 1 (a). Assuming that children of a node are visited in alphabetical order provide the solutions for the following search strategies. Clearly showing the contents of whatever data structure you are using as the search progresses. [6 marks]

   (a) Breadth first search

   (b) Depth first search

   (c) Uniform cost search

3. What is an admissible heuristic ? [2 marks]

4. Consider these heuristics here related to the Figure 1 (a). Provide a solution, showing your working of using the following search strategies to get a solution to this the search graph Figure 1 (a). [6 marks]

   H1:heuristic 1 = $h(A) = 3, h(B) = 6, h(C) = 4, h(D) = 3$

   H2:heuristic 2 = $h(A) = 3, h(B) = 3, h(C) = 0, h(D) = 2$

   (a) Best-first search

   (b) A* search

5. Which of the two heuristics H1 and H2 were admissible ? and for which search strategy ? [2 marks]

Question 2

1. Consider the 8 puzzle game. The goal is to arrange the pieces of the puzzle so they are in the the right order. Figure 2 shows the goal state in state G. For each of these heuristics below, provide the value of the heuristic for each of the states A, B, C and order them in terms of a search algorithm like Best First i.e. what order would the the search follow among the three states. [8 marks]

   (a) Heuristic 1: Number of misplaced pieces/tiles

   (b) Heuristic 2: Manhattan distance i.e. each piece has the ability to slide in any direction at any time ignoring the other tiles.

2. Define any two ways of improving backtracking search for solving CSPs. [4 marks]