ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)

ORGANISATION OF ISLAMIC COOPERATION (OIC)

Department of Computer Science and Engineering (CSE)

QUIZ 2 **WINTER SEMESTER, 2021-2022**

DURATION: 20 Minutes **FULL MARKS: 15**

CSE 4711: Artificial Intelligence

Answer all **3 (three)** questions. Marks of each question and corresponding CO and PO are written in the right margin with brackets.

Student ID: _____

Figure 1 shows the state space graph for an informed search problem. Here, A is the start state and G is the goal state. The cost for executing each action (in both directions) is shown near each arc.

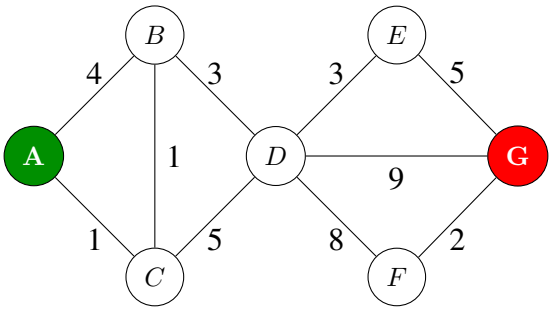


Figure 1: State Space Graph

An incomplete heuristic function, h is shown in Table 1.

Table 1: Incomplete Heuristic Function

Node	A	B	C	D	E	F	G
h	10	9	?	7	4.5	1.5	0

1. For each of the following scenarios, determine the tightest upper bound and lower bound for $h(C)$ with brief explanation. **(CO1, PO1)**

   a) h is admissible. **4**

   Solution: To make h admissible, $h(C)$ has to be less than or equal to the actual optimal cost from C to goal G, which is the cost of the path $C \rightarrow B \rightarrow D \rightarrow E \rightarrow G$, i.e. 12. And the minimum possible value for heuristic is no heuristic, which makes all the values 0.
   The answer is $0 \leq h(C) \leq 12$.

   Rubric:

   - For the correct range: 2 points
   - For a correct explanation of the lower bound: 1 point
   - For a correct explanation of the upper bound: 1 point

   b) h is consistent. **5**

Solution: All the other nodes except node C satisfy the consistency conditions. The consistency conditions that involve the state C are:

- $h(A) \leq c(A, C) + h(C)$
  $\rightarrow 10 \leq 1 + h(C)$
  $\rightarrow 9 \leq h(C)$
- $h(B) \leq c(B, C) + h(C)$
  $\rightarrow 9 \leq 1 + h(C)$
  $\rightarrow 8 \leq h(Q)$
- $h(D) \leq c(D, C) + h(C)$
  $\rightarrow 7 \leq 5 + h(C)$
  $\rightarrow 2 \leq h(C)$
- $h(C) \leq c(C, A) + h(A)$
  $\rightarrow h(C) \leq 1 + 10$
  $\rightarrow h(C) \leq 11$
- $h(C) \leq c(C, B) + h(B)$
  $\rightarrow h(C) \leq 1 + 9$
  $\rightarrow h(C) \leq 10$
- $h(C) \leq c(C, D) + h(D)$
  $\rightarrow h(C) \leq 5 + 7$
  $\rightarrow h(C) \leq 12$

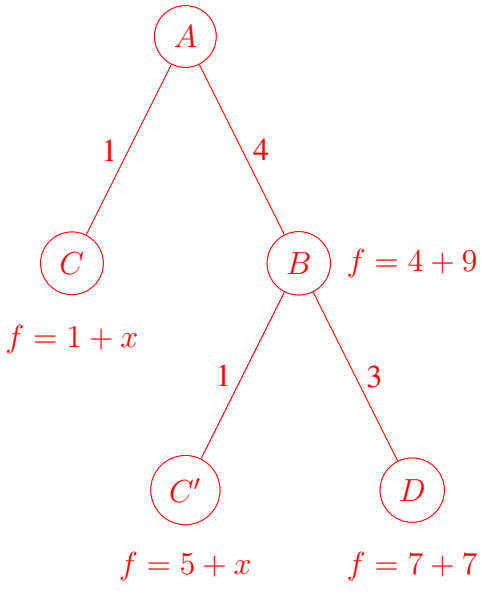
Using the tightest bounds from the equations above: $9 \leq h(C) \leq 10$

Rubric:

- For the correct range: 2 points
- For a correct explanation of the lower bound: 1.5 point
- For a correct explanation of the upper bound: 1.5 point

c) A* Graph Search expands nodes in the following order: $A \rightarrow B \rightarrow C \rightarrow D$. **6**

Solution: Let, $h(C) = x$.



The search tree for A* Graph Search using the heuristic h is shown above. Node A is expanded first since it's the start state. After expanding A, B and C will go into the fringe. To make A* graph search expand node B before node C, we need

$$f(C) > f(B)$$
$$1 + x > 13$$
$$x > 12$$

After expanding B, C and D will go into the fringe. We denote this C as C'. Now, we need to either expand C' or C before D. To expand C',

$$\begin{aligned} F(C') &< F(D) \\ 5 + x &< 14 \\ x &< 9 \end{aligned}$$

which violates the earlier constraint. So we cannot expand C'. To expand C,

$$\begin{aligned} F(C) &< F(D) \\ 1 + x &< 14 \\ x &< 13 \end{aligned}$$

After expanding C, C' and D will be in the fringe. Here, $F(D) = 14$ and $F(C') > 5 + 12 = 17$ (Considering the lower bound). So, D will be expanded afterwards.
So we can get $12 < h(C) < 13$.

Rubric:

- For the correct range: 2 points
- For a correct explanation of the lower bound: 2 points
- For a correct explanation of the upper bound: 2 points