MID SEMESTER EXAMINATION, AUTUMN 2025-26

Subject: Artificial Intelligence for Data Science   **Code:** CS4103
**Total Marks:** 30   **Duration:** 1.5 Hours

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MODEL SOLUTION
## [for those questions where majority of the students got stuck or did mistake]

Q1. (a) Ans.

	Breadth-First Search (BFS)	**Uniform Cost Search (UCS)**
Completeness	BFS is complete if the branching factor is finite;	UCS is complete if the branching factor is finite and also if step costs $\geq \epsilon$ for positive ϵ;
Optimality	BFS is optimal if the step costs are identical	UCS is optimal

(b) Ans. <u>Any of the following</u> will be considered as the correct search tree generated by BFS graph-search version:
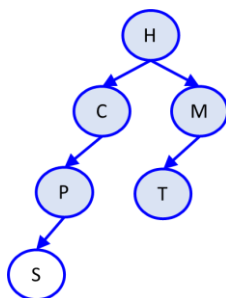
OR
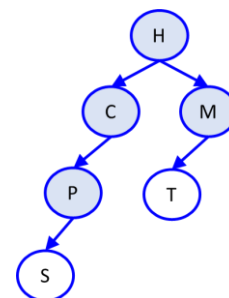
Blue-border-Shaded nodes indicate explored nodes. Blue-border-White nodes indicate generated nodes waiting in the fringe/frontier.
The path returned by the algorithm BFS (Graph search version): H→C→P→S

(c) [Last part]
Ans.
<u>All possible *non-negative integer values*</u> of $h(P)$ for which A* algorithm with *graph-search* version *does not* give you the optimal path are: 0, 1, 2,

If $h(P)$=0, $h(M) = 5 > 2 + 0 = cost(M,P) + h(P)$
If $h(P)$=1, $h(M) = 5 > 2 + 1 = cost(M,P) + h(P)$
If $h(P)$=2, $h(M) = 5 > 2 + 2 = cost(M,P) + h(P)$

In all the above three cases h does not remain a consistent heuristic, and in such cases A* with GRAPH-SEARCH will not give optimal solution.

Note that, in case of $h(P)$=3, the algorithm may or may not give you the optimal solution. This will depend on the order of successor generation. If we follow the assumption in Q1(b), then $h(P)$=3 will also lead to sub-optimal solution.

Q3. (a) Ans. Any four of the following can be considered:
Fully-observable, Multi-agent, Deterministic, Sequential, Discrete

(b) Ans. It is a good heuristic to choose the most constrained variable because it is the variable that is *most likely to cause a failure*, and it is more efficient to fail as early as possible (thereby pruning large parts of the search space).

This heuristic is also known as minimum remaining value (MRV) heuristic.

(c) Ans. Formally, the constraints can be expressed as follows:

$$E + L = S + 10. X1 \qquad \text{(i)}$$
$$S + L + X1 = E + 10. X2 \qquad \text{(ii)}$$
$$A + A + X2 = M + 10. X3 \qquad \text{(iii)}$$
$$B + B + X3 = A + 10. X4 \qquad \text{(iv)}$$
$$X4 = G \qquad G \neq 0, \quad B \neq 0$$
$$Alldiff(A, B, S, L, E, G, M)$$

X1	X2	X3	X4	G	A	B	E	L	M	S
{0, 1}	{0, 1}	{0, 1}	{1}	{1}	{0,1, 2,3 4, 5, 6, 7,8, 9}	{2,3, 4, 5, 6, 7,8, 9}	{2,3, 4, 5, 6, 7,8, 9}	{1, 2,3, 4, 5, 6, 7,8, 9}	{1, 2,3, 4, 5, 6, 7,8, 9}	{1, 2, 3, 4, 5, 6, 7,8, 9}
{0, 1}	{0, 1}	{0, 1}	1	1	{0,2,3 4, 5, 6, 7,8, 9}	{5, 6, 7,8, 9}	{0, 2,3, 4, 5, 6, 7,8, 9}	{0,2,3, 4, 5, 6, 7,8, 9}	{0,2, 3, 4, 5, 6, 7,8, 9}	{0,2, 3, 4, 5, 6, 7,8, 9}
{0, 1}	{0, 1}	0	1	1	{2,4}	{6, 7}	{0,2,3, 4, 5, 6, 7,8, 9}	{0,2,3, 4, 5, 6, 7,8, 9}	{4,5,8,9}	{0,2, 3, 4, 5, 6, 7,8, 9}
{0}	1	0	1	1	{2,4}	{6,7}	{0,2,3,4}	{5}	{5,9}	{5,7,8,9}
0	1	0	1	1	{2,4}	{6,7}	{2,3,4}	5	{9}	{7,8,9}
0	1	0	1	1	{4}	{6,7}	{2,3}	5	9	{7,8}
0	1	0	1	1	4	{7}	{2,3}	5	9	{7,8}
0	1	0	1	1	4	7	{3}	5	9	{8}
0	1	0	1	1	4	7	3	5	9	8

Hence, A = 4, B = 7, E = 3, G = 1, L = 5, M = 9, S = 8
7483+7455=14938

Note that, if X2 is 0, then X1 can be neither 0 nor 1

If X2 is 0 and X1 is 0, then from (i) and (ii) we get:
$$E + L = S$$
$$S + L = E$$
This means S = E......violating the constraint

If X2 is 0 and X1 is 1, then from (i) and (ii) we get:
$$E + L = S + 10$$
$$S + L + 1 = E$$
This means L = 9/2 i.e. not a single digit......not a valid domain value.
Hence, X2 must be 1, if there is any solution.