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AI Assignment - 2

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1. a. Optimality with an Admissible Heuristic:
   - If an admissible heuristic in A*, eliminating the storage of the explored set, won't change the algorithm's ability to find optimal solution.
   - A* select nodes to explore based on combination of both g-cost and h-cost, so it always favour lower cost nodes.
   - Admissible heuristic never overestimates true cost to reach goal. Therefore, even if we don't keep track of explored set, A* will continue to use heuristic and search towards the optimal solution.

b. Completeness:
   - Completeness means algorithm will find a solution if one exists in the search space. In our case, A* will still remain complete.
   - A* might take some time but it will still explore all the reachable nodes until it finds a solution or exhausts entire search space even if we removed the explored set.

c. Efficiency:
   - Removing the explored set will significantly increase the search time in majority cases because without explored set the algorithm may revisit nodes it has already visited, leading to redundant work.
   - The explored set ensures that once a node has been expanded, it is not explored again reducing overall search time.

2. a) A^* search : $f(n) = g(n) + h(n)$

explored = { }
frontier = { }

- explored = {S}
  $f(A) = g(A) + h(A) = 4 + 8 = 12$
  $f(B) = g(B) + h(B) = 18 + 6 = 24$
  $f(C) = g(C) + h(C) = 11 + 2 = 13$
  frontier = {(A, 12), (C, 13), (B, 24)}

- explored = {S, A}
  $f(B) = g(B) + h(B) = 12 + 6 = 18$
  $f(D) = g(D) + h(D) = 9 + 7 = 16$

  frontier = {(C, 13), (D, 16), (B, 18)}

- explored = {S, A, C}
  $f(D) = g(D) + h(D) = (11 + 13) + 7 = 31$
  $f(E) = g(E) + h(E) = (11 + 20) + 3 = 34$
  $f(F) = g(F) + h(F) = (11 + 2) + 2 = 15$

  frontier = {(F, 15), (D, 16), (B, 18), (E, 34)}

- explored = {(S, A, C, F)}
  $f(G) = g(G) + h(G) = (11 + 2 + 13) + 0 = 26$

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We have reached our goal state but there are some node values in the frontier which are less than the current $f(G)$.
So, we will explore those nodes whose value is less than current value of $f(G)$, popping out the rest.

- explored = {S, A, C}
  frontier = {(D, 16), (B, 18)}
  $f(H) = g(H) + h(H) = (4+5+1)+9 = 19$
  $f(I) = g(I) + h(I) = (4+5+20)+11 = \underbrace{40 > 26,}_{\text{discarded}}$
  $f(F) = g(F) + h(F) = (4+5+1)+2 = 12$

- explored = {S, A, C, D}
  $f(G) = g(G) + h(G) = (4+5+1+13)+0 = 23$

→ Removing all values greater than 23.
  frontier = {(B,18), (H,19)}

- B doesnot have any outgoing edge
  explored = {S, A, C, D, B, F}

  $f(I) = g(I) + h(I) = (4+5+1+1)+(11) = 22$
  $f(J) = g(J) + h(J) = (4+5+1+2)+13 = \underbrace{25 > 23,}_{\text{discarded}}$

  frontier = {(I,22)}

- explored = {S, A, C, D, B, F, I}
  $f(J) = g(J) + h(J) = (4+5+1+1+5)+13 = 29$
  $f(K) = g(K) + h(K) = (4+5+1+1+13)+4 = 28$
  $f(G) = g(G) + h(G) = (4+5+1+1+3)+0 = 14$

  frontier = { }   removing nodes with val > 14

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$\therefore$ $f(G) = 14$ [Cost]

Path : $S \rightarrow A \rightarrow D \rightarrow H \rightarrow I \rightarrow G$

b) Best - First Search :

We have heuristic values for each node in the graph.

- Frontier = $\{(S,1)\}$

  $h(A) = 8$

  $h(B) = 6$

  $h(C) = 2$

- Frontier = $\{(C,2) ; (B,6) ; (C,8)\}$

  $h(D) = 7$

  $h(E) = 3$

  $h(F) = 2$

- Frontier : $\{(E,3) ; (D,7) ; (B,6) ; (F,2) ; (C,8)\}$

  $h(G) = 0$

$\therefore$ Best cost optimal solution :

$S \longrightarrow C \longrightarrow F \longrightarrow G$

[We expanded each node with minimal cost at each step.]

A	B	C	D	E	F	G	H	I	J	K
4	18	11	∞	∞	∞	∞	∞	∞	∞	∞
4	12	11	9	∞	∞	∞	∞	∞	∞	∞
4	12	11	**9**	∞	10	∞	10	29	∞	∞
4	12	11	**9**	∞	**10**	23	10	29	∞	∞
4	12	11	**9**	∞	**10**	23	**10**	11	12	∞
4	12	**11**	**9**	31	**10**	23	**10**	11	12	∞
4	12	**11**	**9**	31	**10**	14	**10**	**11**	12	24
4	**12**	**11**	**9**	31	**10**	14	**10**	**11**	12	24
4	**12**	**11**	**9**	31	**10**	14	**10**	**11**	**12**	19
4	**12**	**11**	**9**	31	**10**	**14**	**10**	**11**	**12**	19
4	**12**	**11**	**9**	**31**	**10**	**14**	**10**	**11**	**12**	19
4	**12**	**11**	**9**	**31**	**10**	**14**	**10**	**11**	**12**	**19**

Cost of Optimal Path till Goal Node G : 14

Path : S-->A-->D-->H-->I-->G