DS & AI ENGINEERING

Artificial Intelligence

Informed search

Lecture No.- 04

By- Aditya sir

Recap of Previous Lecture

- Topic
- Topic — A* Search
- Topic — Weighted A* Search
- Topic

Topics to be Covered

- Topic
- Topic
- Topic

Practice Questions

About Aditya Jain sir

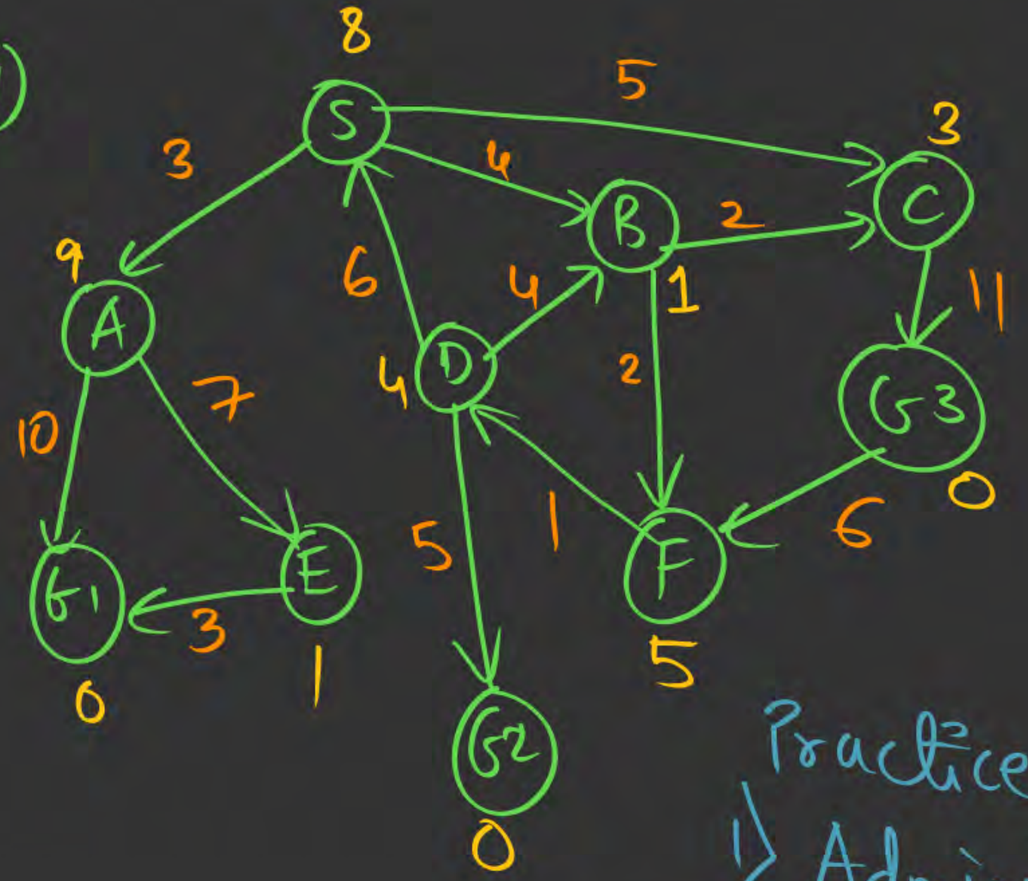
1. Appeared for GATE during BTech and secured AIR 60 in GATE in very first attempt - City topper
2. Represented college as the first Google DSC Ambassador.
3. The only student from the batch to secure an internship at Amazon. (9+ CGPA)
4. Had offer from IIT Bombay and IISc Bangalore to join the Masters program
5. Joined IIT Bombay for my 2 year Masters program, specialization in Data Science
6. Published multiple research papers in well known conferences along with the team
7. Received the prestigious excellence in Research award from IIT Bombay for my Masters thesis in ML
8. Completed my Masters with an overall GPA of 9.36/10
9. Joined Dream11 as a Data Scientist
10. Have mentored 15,000+ students & working professions in field of Data Science and Analytics
11. Have been mentoring & teaching GATE aspirants to secure a great rank in limited time
12. Have got around 27.5K followers on Linkedin where I share my insights and guide students and professionals.

Telegram

Telegram Link for Aditya Jain sir:

https://t.me/AdityaSir_PW

(Q.1)



1) Apply A* Graph Search to find which goal is reached first?

Start: S

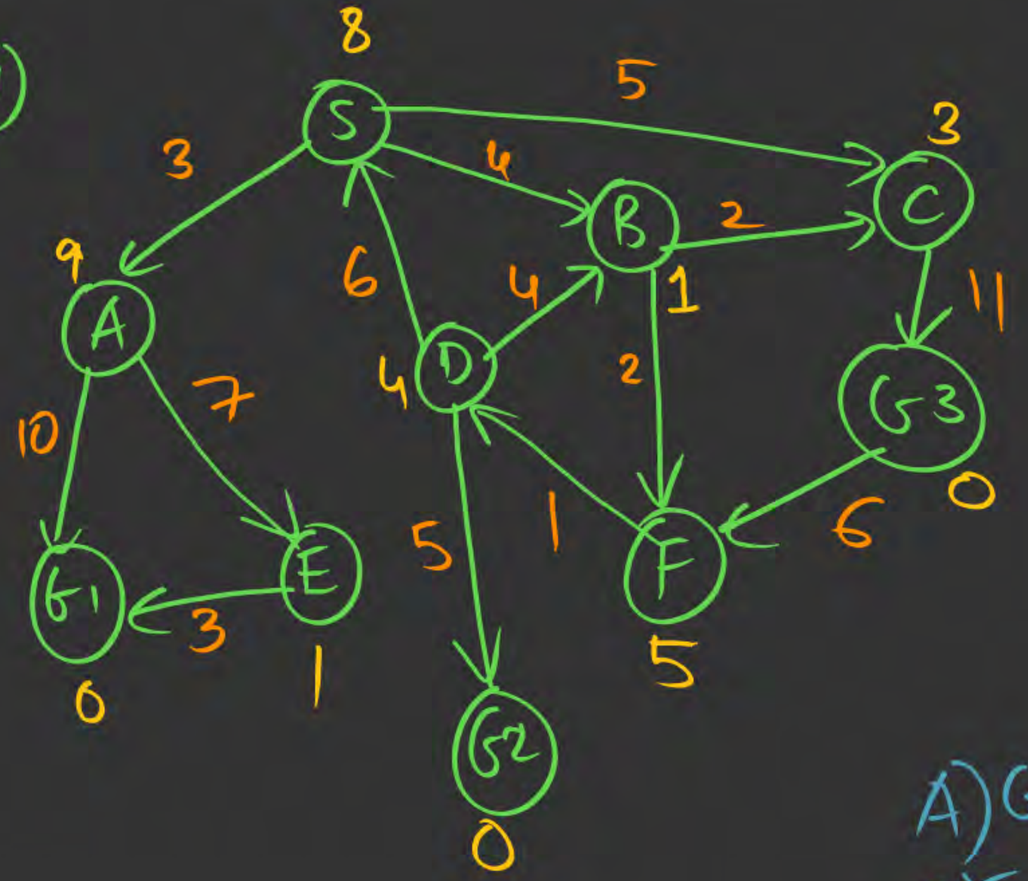
if same Cost: G1 > G2 > G3

Practice

1) Admissible ?

2) Consistent ?

(Q.1)



✓ 1) Apply A* Graph Search to find which goal is reached first?

Start: S

if same Cost among goals, [G1 > G2 > G3]

path: S B F D G2

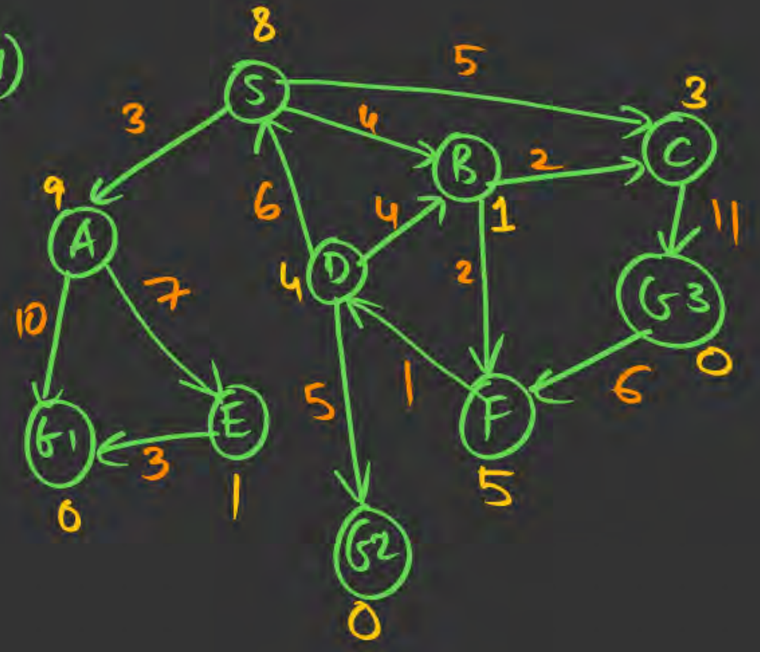
cost: 12

A) G1

~~B) G2~~

C) G3

(Q.1)



open	closed							
	S	B	C	F	D	A	E	G2
S ✗								
A ✗	12	12	12	12	(12)	12	12	
B ✗	(5)	5	5	5	5	5	5	
C ✗	8	(8)	8	8	8	8	8	
F ✗	✗	11	(11)	11	11	11	11	
G3 ✗	✗	✗	16	16	16	16	16	
D ✗	✗	✗	✗	(11)	11	11	11	
G2 ✗	✗	✗	✗	✗	12	12	(12)	
E ✗	✗	✗	✗	✗	✗	(11)	11	
G1	✗	✗	✗	✗	✗	13	13	

Stop

Cost = 12

path = SBFDG$_2$

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#Q. Consider the search graph below, where S is the start node and G1, G2, and G3 are goal states. Arcs are labeled with the cost of traversing them and the heuristic cost to a goal is shown inside the nodes. For each of the three search strategies below, indicate which of the goal states is reached:

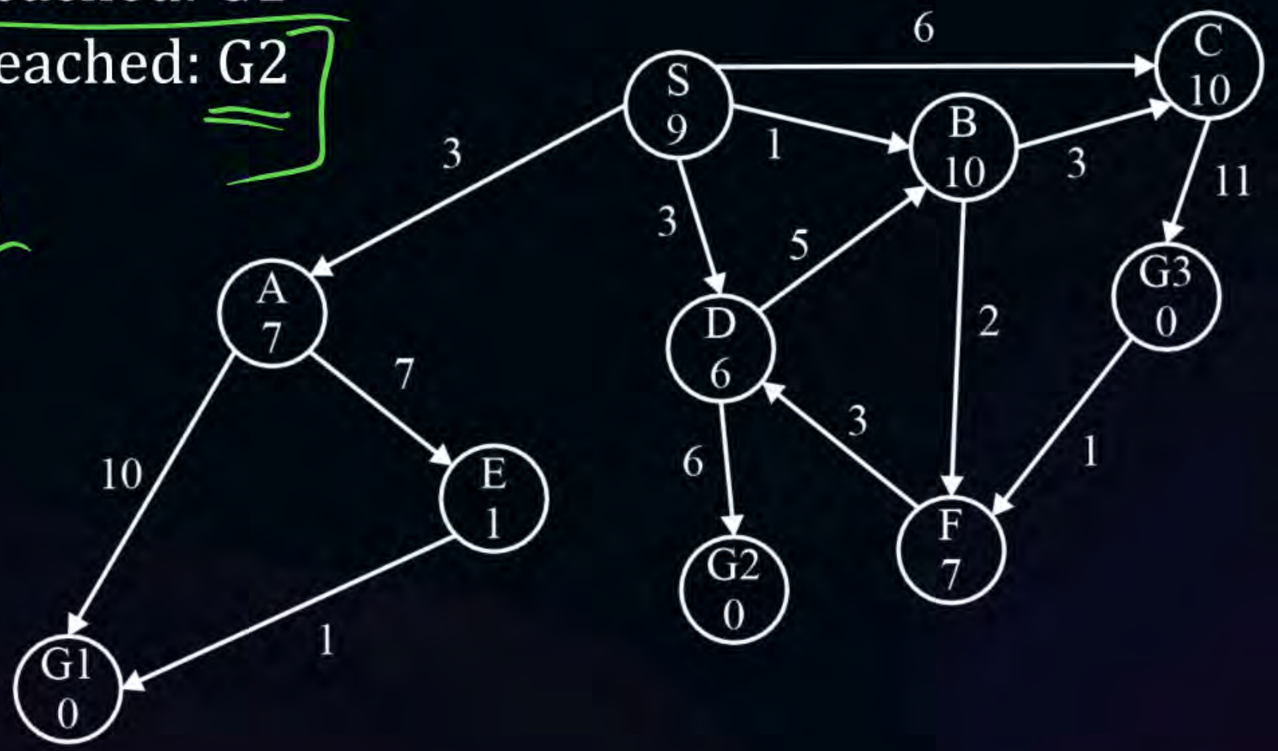
(a) Breadth-first search. Goal reached: G1

(b) Uniform cost search. Goal reached: G2

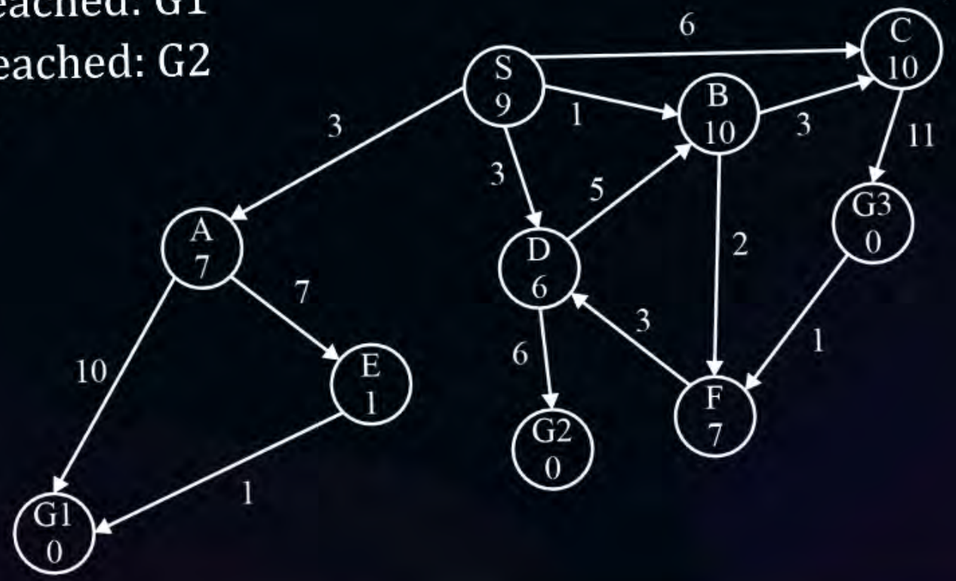
(c) A* search. Goal reached: G2

cost =

path =



reached: G1
reached: G2
2



SDG₂ (9)

1) UCS

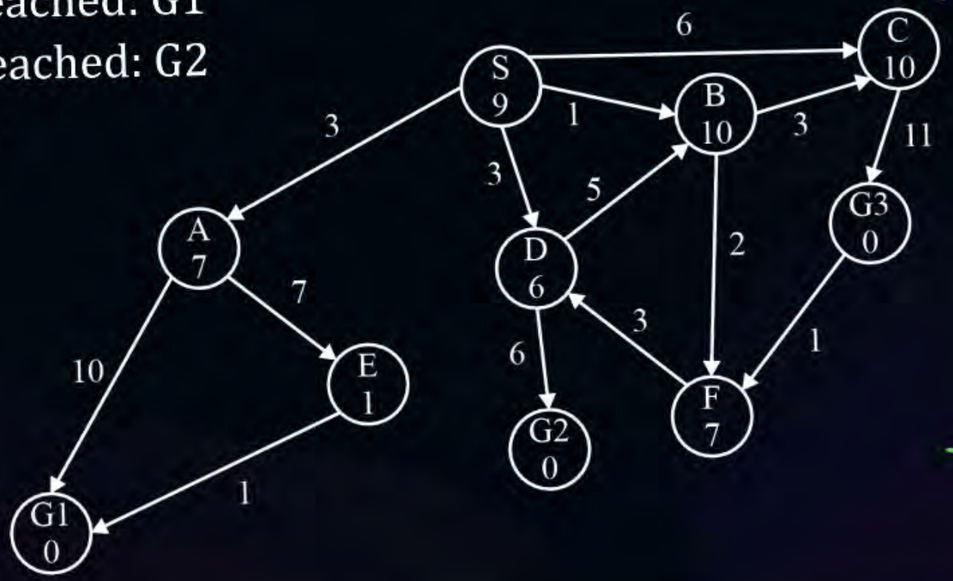
	Open	Closed						
	S	B	A	D	F	C	G2	
S	X	S	B	A	D	F	C	G2
A	X	3	(3)	3	3	3	3	
B	X	(1)		1	1	1	1	
C	X	6	4	4	4	(4)	4	
D	X	3	3	3	3	3	3	
F	X	x	3	3	(3)	3	3	
E		x	x	10	10	10	10	
G1		x	x	13	13	13	13	
G2		x	x	x	9	9	(9)	
G3		x	x	x	x	x	17	

→ Stop

Cost = 9

Path = SDG₂

reached: G1
reached: G2
2



2> A* graph Search

$f = h + g$

Open	Closed		
S ✗	S	D	G2
A	10	10	
B	11	11	
C	16	16	
D	(9)	9	
G2	✗	(9)	

G2 → goal

Cost = 9

path = SDG2 ✓

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Time Complexity

THE TIME COMPLEXITY OF A* LARGELY DEPENDS ON THE HEURISTIC FUNCTION AND THE STRUCTURE OF THE SEARCH SPACE. IN THE WORST CASE, The time complexity is O(b^d), where:

- b is the branching factor (the average number of successors per state).
- d is the depth of the shallowest solution.

However, if the heuristic function is good (i.e., it is admissible and consistent), the time complexity can be significantly reduced, though it remains exponential in the worst case.

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Space Complexity

The space complexity of A* is generally O(b^d) as well. A* keeps all generated nodes in memory, which can lead to high space usage, particularly in large or complex search spaces. This is because it stores the open list (the set of nodes that have been generated but not yet expanded) and the closed list (the set of nodes that have been fully explored).

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Advantages

- Optimality: A* is guaranteed to find the least-cost path to the goal if the heuristic used is admissible (never overestimates the true cost) and consistent (satisfies the triangle inequality).
- Efficiency: A* is generally more efficient than uninformed search algorithms like Dijkstra's algorithm because it uses heuristics to guide the search. This often results in exploring fewer nodes, reducing the overall computation.
- Flexibility: A* can be adapted to various problems by changing the heuristic function. This flexibility makes it applicable to a wide range of scenarios, from simple grid navigation to complex graph-based pathfinding.
- Combines Advantages of Greedy and Uniform-Cost Search: A* combines the strengths of greedy best-first search (which is fast but not always optimal) and uniform-cost search (which is optimal but can be slow) by balancing exploration and exploitation.

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Disadvantages

- High Memory Usage: A* requires storing all generated nodes in memory, which can lead to high memory consumption, especially in large search spaces. This makes it less suitable for problems with very large state spaces.
- Computationally Intensive: In the worst case, A* can be computationally expensive, especially if the branching factor is high or the heuristic is not well-optimized. The algorithm's time complexity is exponential in the worst case.
- Heuristic Dependency: The performance of A* heavily depends on the quality of the heuristic. If the heuristic is poorly chosen, the algorithm can degrade to a less efficient search, potentially exploring many unnecessary nodes.
- Not Always Practical for Real-Time Applications: Due to its potential high time and space complexity, A* may not be suitable for real-time applications where quick decisions are necessary.

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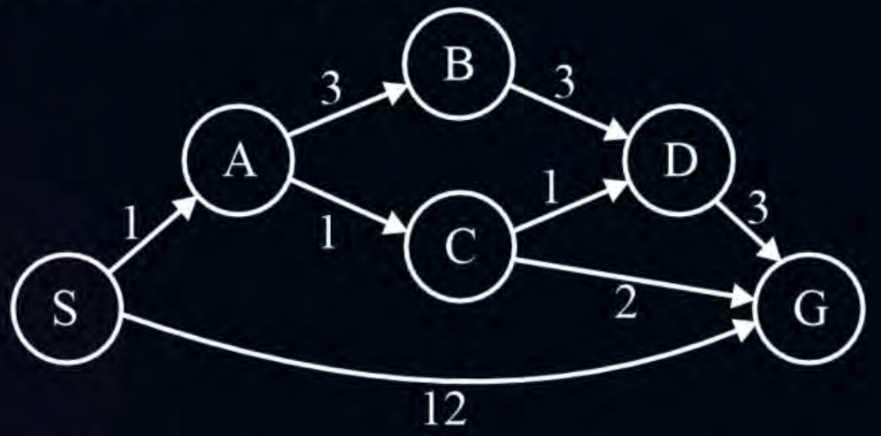
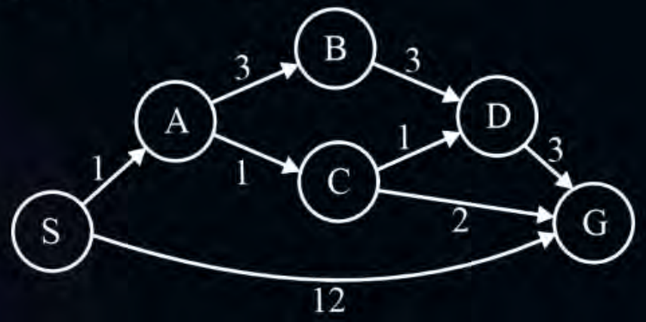
#Q. Answer the following questions about the search problem shown above. Break any ties alphabetically. For the questions that ask for a path, please give your answers in the form 'S – A – D – G'.



Start : S
goal : G

(a) What path would breadth-first graph search return for this search problem?
(b) What path would uniform cost graph search return for this search problem?
(c) What path would depth-first graph search return for this search problem?
(d) What path would A* graph search, using a consistent heuristic, return for this search problem?

answers in the form S-A-B-C-D-G.



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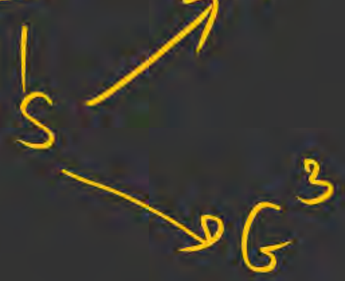
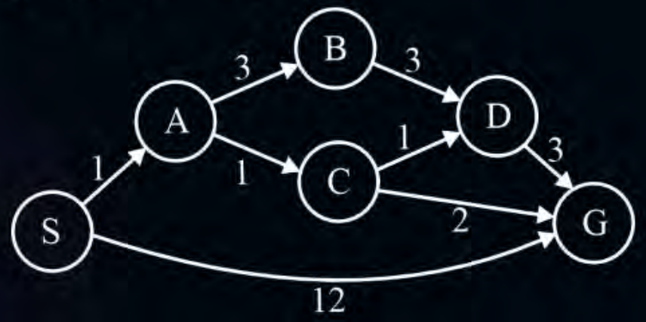
a) BFS



path: S-G

answers in the form S → A → D → G.



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(b) What path would uniform cost graph search return for this search problem?
(c) What path would depth-first graph search return for this search problem?
(d) What path would A* graph search, using a consistent heuristic, return for this search problem?

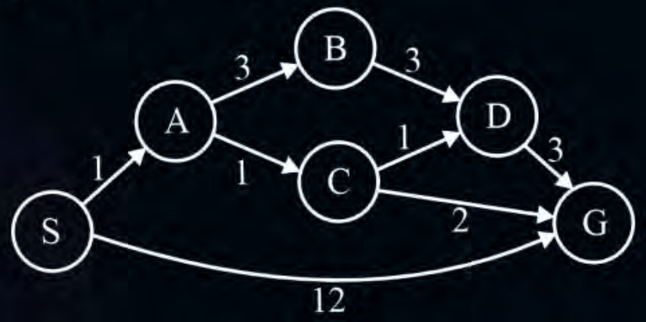
b) UCS

open	closed					
	S	A	C	D	B	G
S x	(1)	1	1	1	1	
A x	12	12	4	4	(4)	
G ^	x	4	4	(4)	4	
B x	x	(2)	2	2	2	
C x	x	x	(3)	3	3	
D x						

→ stop

Cost = 4
path: SACG

answers in the form S-A-B-C.



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(b) What path would uniform cost graph search return for this search problem?
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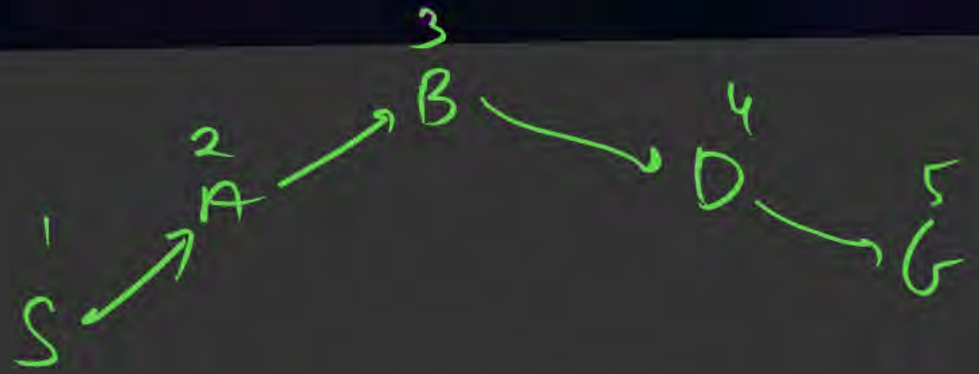
c) DFS



path: SABDG

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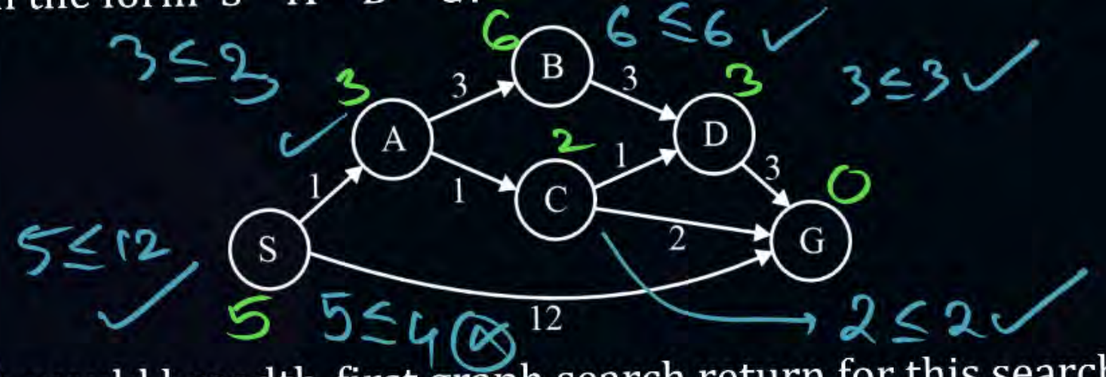
#Q. Consider the heuristics for this problem shown in the table below.

(i) Is h_1 admissible? Yes No
(ii) Is h_1 consistent? Yes No
(iii) Is h_2 admissible? Yes No
(iv) Is h_2 consistent? Yes No

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

answers in the form S-A-B-...



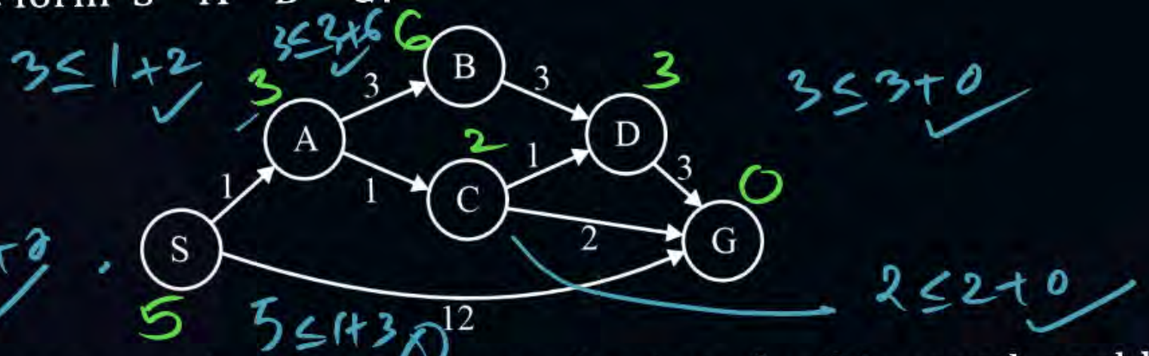
(a) What path would breadth-first graph search return for this search problem?

(b) What path would uniform cost graph search return for this search problem?

(c) What path would depth-first graph search return for this search problem?

(d) What path would A* graph search, using a consistent heuristic, return for this search problem?

d) h1 → Not admissible



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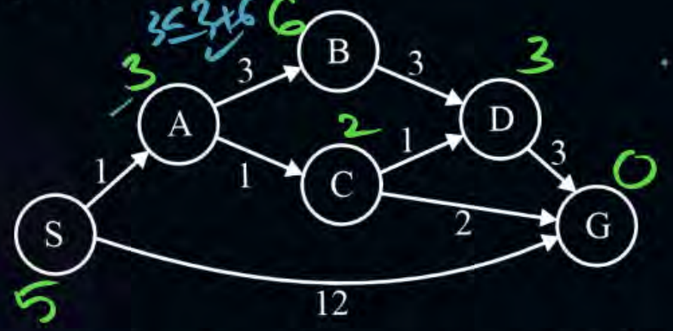
(c) What path would depth-first graph search return for this search problem?

(d) What path would A* graph search, using a consistent heuristic, return for this search problem?

d) h1 ⟶ not consistent



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(b) What path would uniform cost graph search return for this search problem?
(c) What path would depth-first graph search return for this search problem?
(d) What path would A* graph search, using a consistent heuristic, return for this search problem?

d) h1 → A* graph search

open	closed
S*	S A C G
AX	(4) 4 4
G	12 12 (4)
B	X 10 10
C	X (4) 4
D	X X 6

stop

SACG

cost = 4

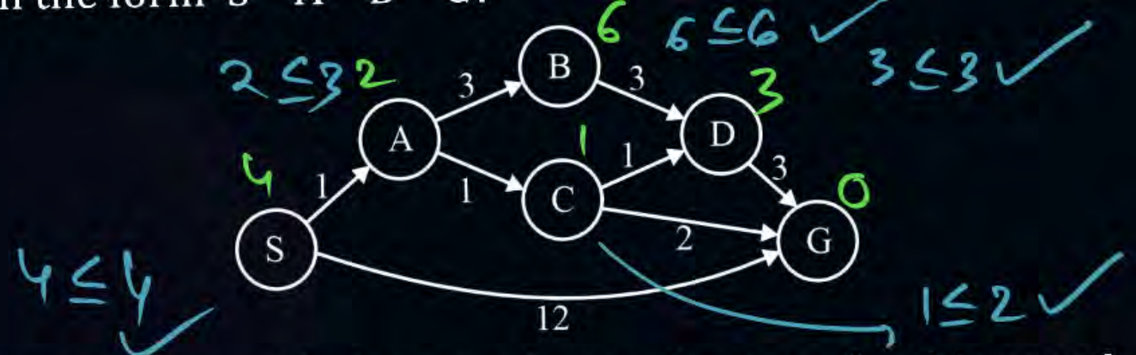
Topic : Artificial Intelligence

#Q. Consider the heuristics for this problem shown in the table below.

(i) Is h_1 admissible? Yes No
(ii) Is h_1 consistent? Yes No
(iii) Is h_2 admissible? Yes No
(iv) Is h_2 consistent? Yes No

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

answers in the form S-A-B-C-D-G.



(a) What path would breadth-first graph search return for this search problem?

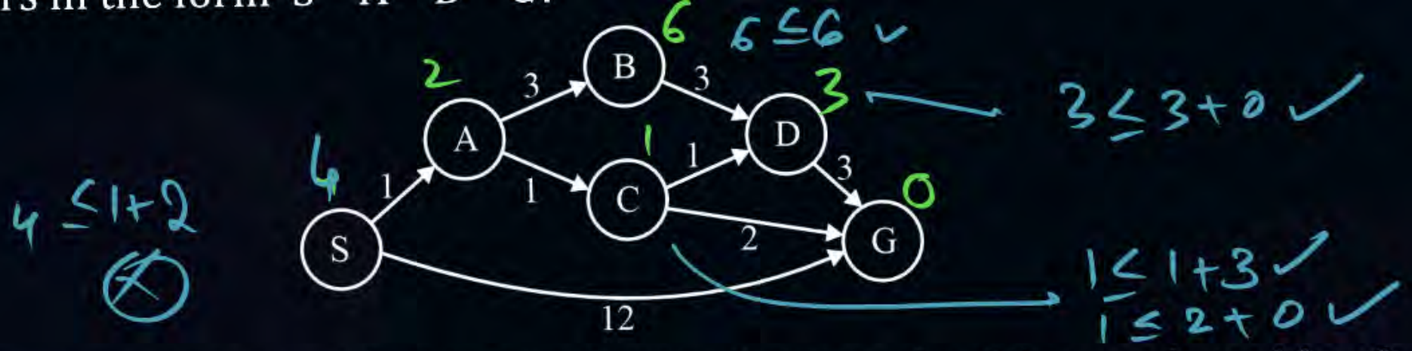
(b) What path would uniform cost graph search return for this search problem?

(c) What path would depth-first graph search return for this search problem?

(d) What path would A* graph search, using a consistent heuristic, return for this search problem?

d) h_2 → Admissible

answers in the form S → A → D → G.



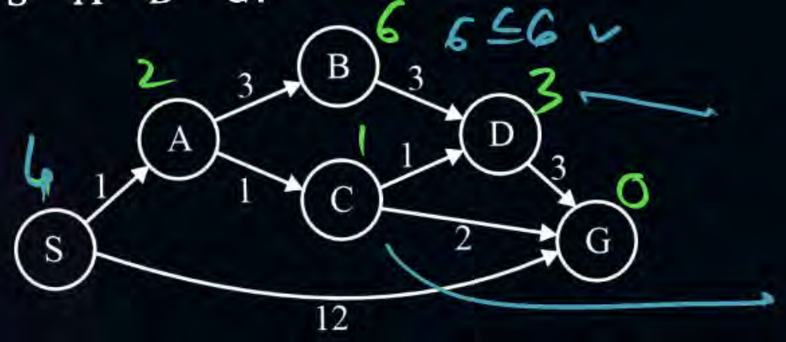
(a) What path would breadth-first graph search return for this search problem?

(b) What path would uniform cost graph search return for this search problem?

(c) What path would depth-first graph search return for this search problem?

(d) What path would A* graph search, using a consistent heuristic, return for this search problem?

d) h2 → Not Consistent



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(b) What path would uniform cost graph search return for this search problem?
(c) What path would depth-first graph search return for this search problem?
(d) What path would A* graph search, using a consistent heuristic, return for this search problem?

d) h2 → A* Graph Search

Open	Closed			
S*	S	A	C	G
A*	(3)	3	3	
G	12	12	(4)	
B	12 X	10	10	
C*	X	(3)	3	
D	X	X	6	

Stop

SACG

Cost = 4

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#Q. Which of the following algorithms is/are guaranteed to give an optimal solution?

A. Greedy Best First Search

B. A* with zero heuristic

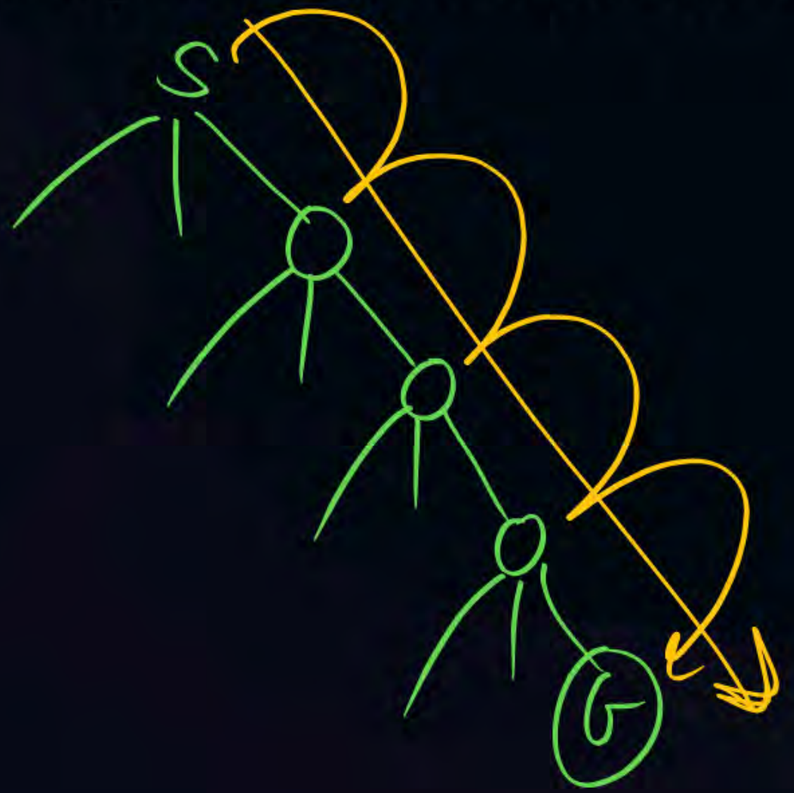
C. A* with consistent heuristic

D. Depth First Search

Topic : Artificial Intelligence

#Q. Given a search tree where A* search is applied, the branching factor is 3, the depth of the optimal solution is 4, and the heuristic is perfect (i.e., it always predicts the exact remaining cost).

How many nodes are expanded by A* in this tree?



Ans: 5

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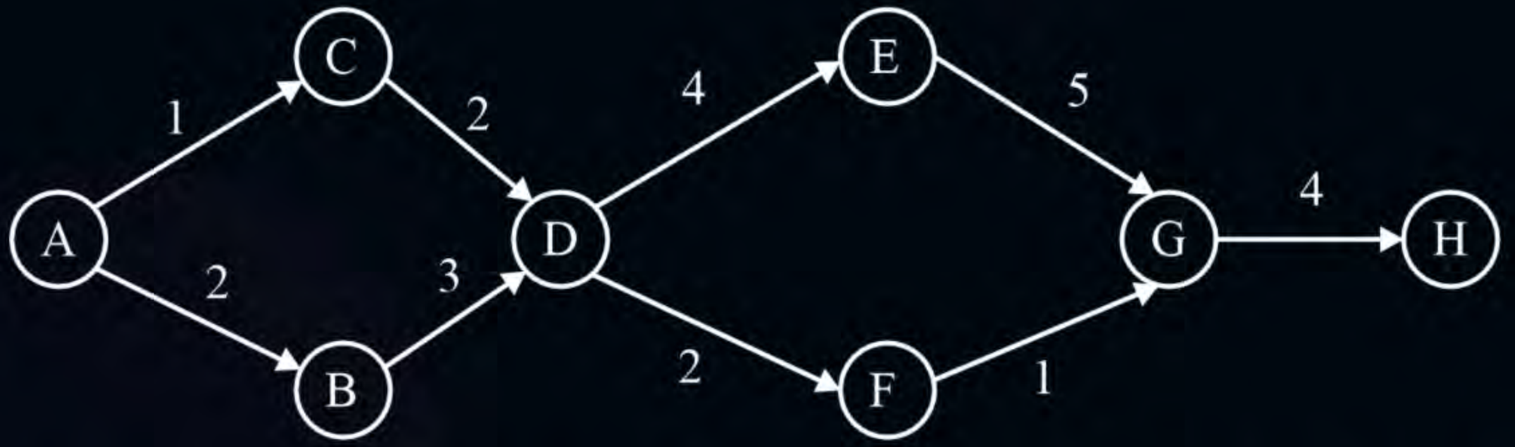
#Q. Consider the following directed graph.



The heuristic function for the nodes is defined as h(A) = 15, h(B) = 10, h(C) = 12, h(D) = 7, h(E) = 10, h(F) = 6, h(G) = 4, h(H) = 0. The start node is A and the goal node is H. Assume that ties in selecting node for expansion from the fringe are resolved by choosing the alphabetically smaller node.

Which of the following statements are correct?

THANK - YOU