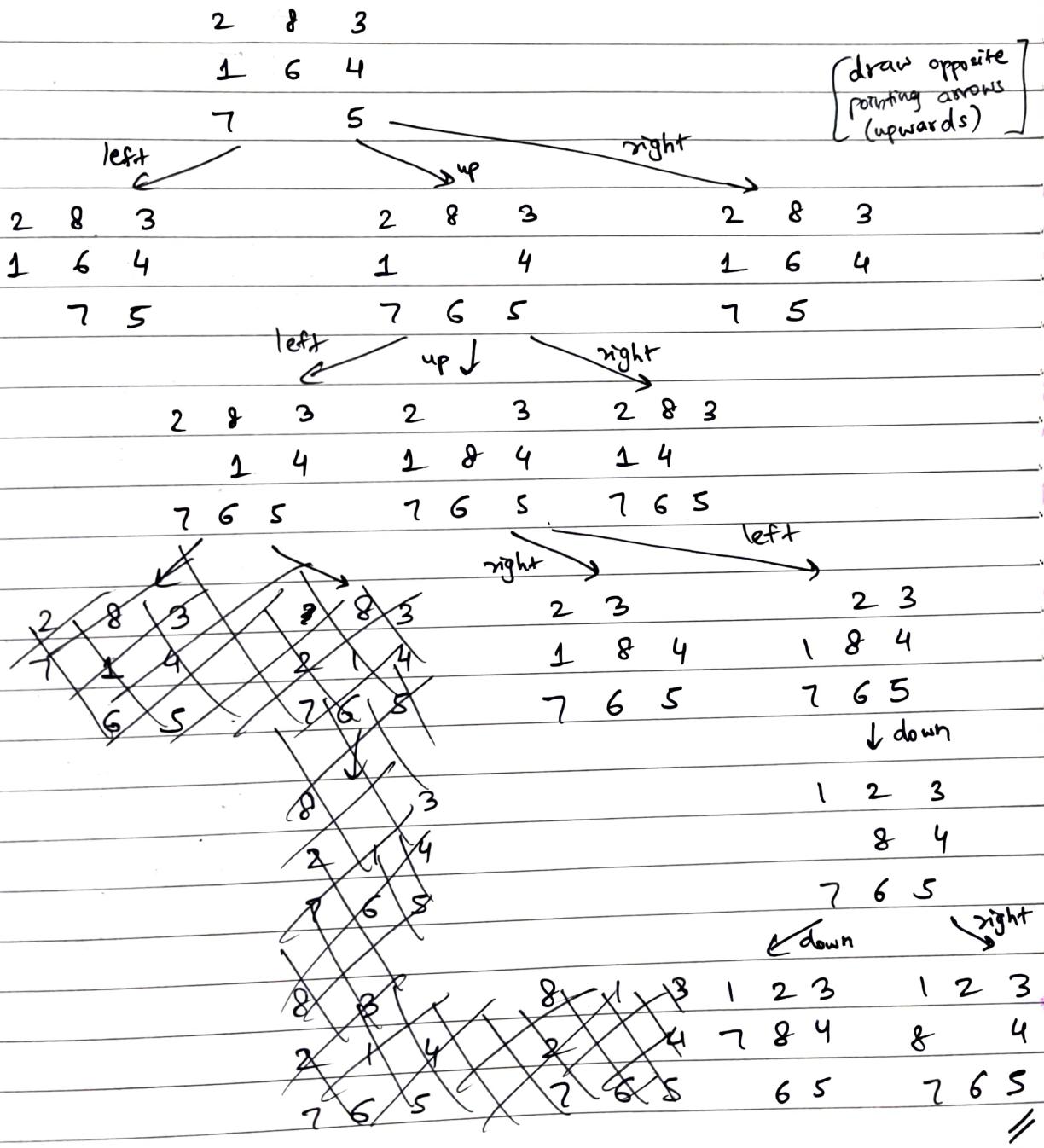


AI

→ 8-Puzzle :

$$\begin{array}{ccccc}
 \text{Q.} & \begin{matrix} 1 & 2 & 3 \\ 8 & 4 & \leftarrow \\ 7 & 6 & 5 \end{matrix} & & \begin{matrix} 2 & 8 & 3 \\ 1 & 6 & 4 \\ 7 & 5 \end{matrix} & \\
 & \text{Goal} & & \text{Initial} &
 \end{array}$$

Ans.



AI

Missionaries and Cannibals problem:

(LEFT) (RIGHT)

Initial Positions: OM, OC and 3M, 3C (B)

~~Send 2 cannibals to left: (B) OM, 2C and 3M, 1C~~

~~1 cannibal moves to right: OM, 1C and 3M, 2C (B)~~

~~1 man, 2 cannibals move to left: (B) 2M, OM, 3C and 3M, 0C~~

~~1 cannibal moves to right: OM, 2C and 3M, 1C (B)~~

~~1 cannibal, 1 man move to left: (B) 1M (LEFT) (RIGHT)~~

Send 2 cannibals to left: (B) OM, 2C and 3M, 1C

1 cannibal returns: OM, 1C and 3M, 2C (B)

2 cannibals move to left: (B) OM, 3C and 3M, 0C

1 cannibal returns: OM, 2C and 3M, 1C (B)

2 ~~missionaries~~ move to left: (B) 2M, 2C and 1M, 1C

1 missionary 1 cannibal return: 1M, 1C and 2M, 2C (B)

2 missionaries move to left: (B) 3M, 1C and OM, 2C (B)

1 cannibal returns: 3M, 0C and OM, 3C (B)

2 cannibals move to left: (B) 3M, 2C and OM, 1C

1 cannibal returns: 3M, 1C and OM, 2C (B)

2 cannibals move to left: (B) 3M, 3C and OM, 0C

Q. 8-Puzzle

$$\begin{array}{ccc} 8 & 3 & 5 \\ 4 & 1 & 6 \end{array} \rightarrow \begin{array}{ccc} 1 & 2 & 3 \\ 8 & & 4 \end{array}$$

$$\begin{array}{cc} 2 & 7 \\ & \end{array} \quad \begin{array}{ccc} 7 & 6 & 5 \end{array}$$

(Initial)

(Goal)

Ans.

$$\begin{array}{ccc} 8 & 3 & 5 \\ 4 & 1 & 6 \end{array}$$

$$\begin{array}{cc} 2 & 7 \\ \nearrow \text{left} & \uparrow \text{up} \end{array}$$

$$\begin{array}{ccc} 8 & 3 & 5 \\ 4 & 1 & 6 \\ 2 & 7 & \uparrow \text{up} \end{array}$$

$$\begin{array}{ccc} 8 & 3 & 5 \\ 4 & 1 & 6 \\ 2 & 7 & \uparrow \text{up} \end{array}$$

$$\begin{array}{ccc} 8 & 3 & 5 \\ 4 & 1 & 6 \\ 2 & 7 & 6 \end{array}$$

$$\begin{array}{cccc} 8 & 3 & 5 & 8 & 3 & 5 \\ 4 & 1 & 6 & 4 & 1 & 6 \\ 2 & 7 & 6 & 2 & 7 & 6 \\ \uparrow \text{left} & & \uparrow \text{up} & & & \end{array}$$

$$\begin{array}{cc} 8 & 3 \\ 4 & 1 \\ 2 & 7 \end{array}$$

$$\begin{array}{cc} 8 & 3 \\ 4 & 1 \\ 2 & 7 \end{array}$$

$$\begin{array}{cc} 8 & 3 \\ 4 & 5 \\ 2 & 7 \end{array}$$

$$\begin{array}{cc} 8 & 3 \\ 2 & 4 \\ 7 & 6 \end{array}$$

$$\begin{array}{cc} 8 & 3 \\ 2 & 4 \\ 7 & 6 \end{array}$$

$$\begin{array}{cc} 8 & 3 \\ 2 & 4 \\ 7 & 6 \end{array}$$

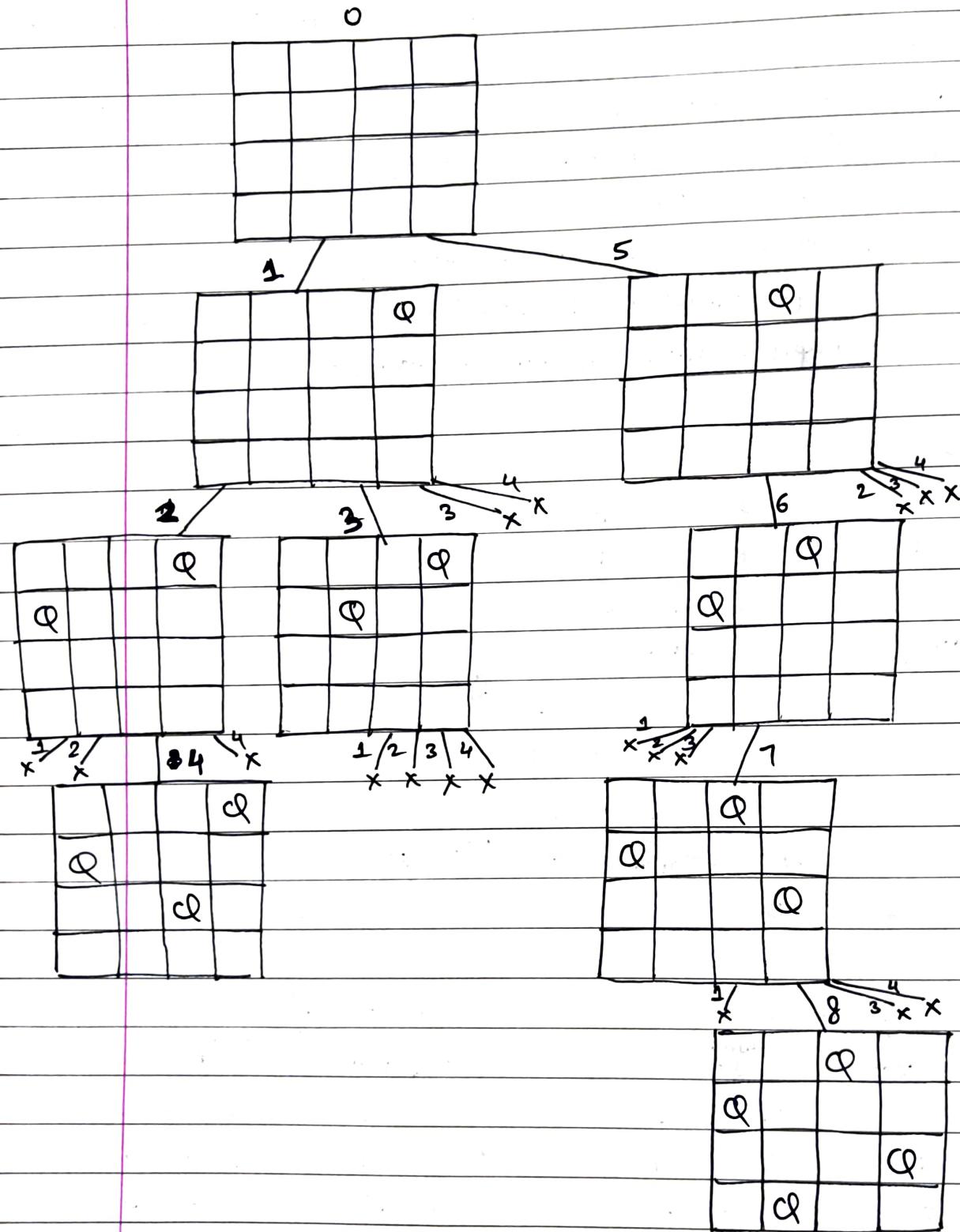
$$\begin{array}{cc} 8 & 3 \\ 2 & 4 \\ 7 & 6 \end{array}$$

$$\begin{array}{cc} 8 & 3 \\ 2 & 4 \\ 7 & 6 \end{array}$$

$$\begin{array}{cc} 8 & 3 \\ 2 & 4 \\ 7 & 6 \end{array}$$

$$\begin{array}{cc} 8 & 3 \\ 2 & 4 \\ 7 & 6 \end{array}$$

→ 4-Queens Problem :



2 → 9 → 2 → 7 → 5 → 11

Water - Jug problem:

You have a 4-gallon and a 3-gallon jug. Write steps to get exactly 2 gallons in the 4-gallon jug.

steps: (1) Fill 3-gallon jug

(2) Empty jug's contents into 4-gallon jug

(3) Refill 3-gallon jug

(4) Fill 4-gallon jug using 3-gallon jug

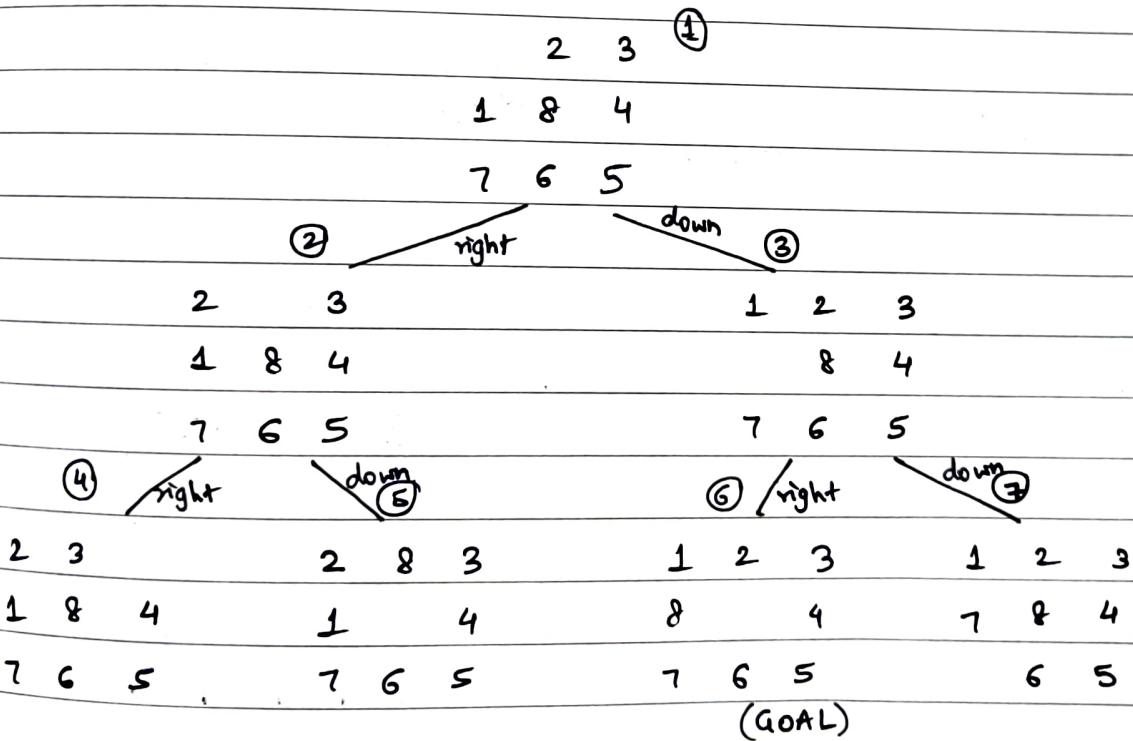
(5) Empty contents of 4-gallon jug

(6) Empty 3-gallon jug into 4-gallon jug

8-puzzle

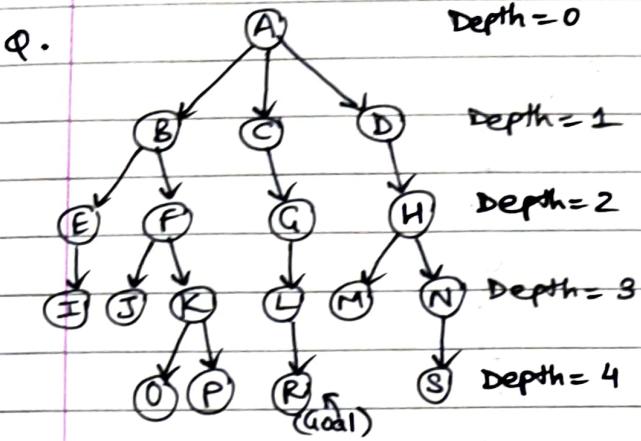
2 3	1 2 3
1 8 4	→ 8 4
7 6 5	7 6 5
(Initial)	(Goal)

Ans.



BFS : 1 → 2 → 3 → 4 → 5 → 6

DFS : 1 → 2 → 4 → 5 → 3 → 6



Sequence using IDDS (all steps)
[Iterative Deepening Depth-first search]

Ans. Iteration 1 (Depth=0) \Rightarrow A

Iteration 2 (Depth = 1) \Rightarrow A \rightarrow B \rightarrow C \rightarrow D

Iteration 3 (Depth=2) \Rightarrow A \rightarrow B \rightarrow E \rightarrow F \rightarrow C \rightarrow G \rightarrow D \rightarrow H

Iteration 4 (Depth=3) $\Rightarrow A \rightarrow B \rightarrow E \rightarrow I \rightarrow F \rightarrow J \rightarrow K \rightarrow C \rightarrow G \rightarrow L \rightarrow D \rightarrow H \rightarrow M \rightarrow N$

Iteration 5 (Depth=4) $\Rightarrow A \rightarrow B \rightarrow E \rightarrow I \rightarrow F \rightarrow J \rightarrow K \rightarrow O \rightarrow P \rightarrow C \rightarrow G \rightarrow L \rightarrow R$ [Reached Goal]

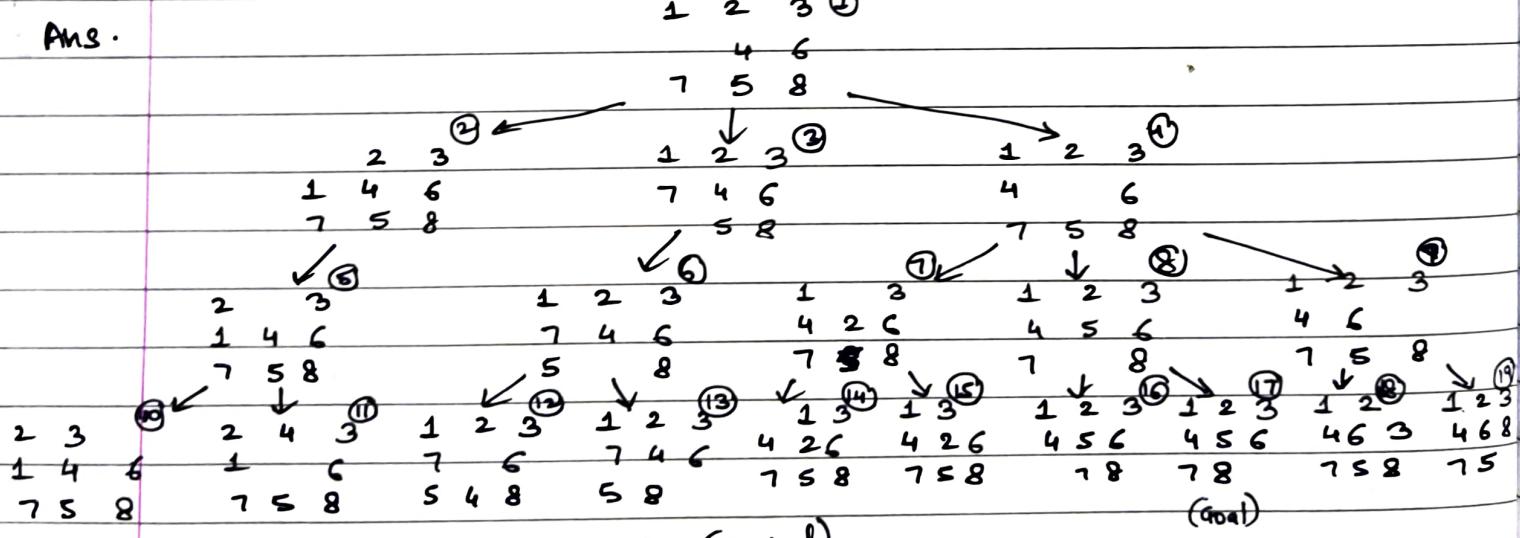
Q. Solve using BFS, DFS, DLS, IDS

1 2 3 1 2 3

$$4 \ 6 \Rightarrow 4 \leq 6$$

7 5 8 7 8
(Initial) (Goal)

Ans.



(Depth = 2) DLS → 1 - 2 - 5 - 3 - 6 - 4 - 7 - 8 - 9 (Failed)

~~BGS → 1-2-3-4-5-6-7-8-9-10-11-12-13-14-15-16-17-18~~

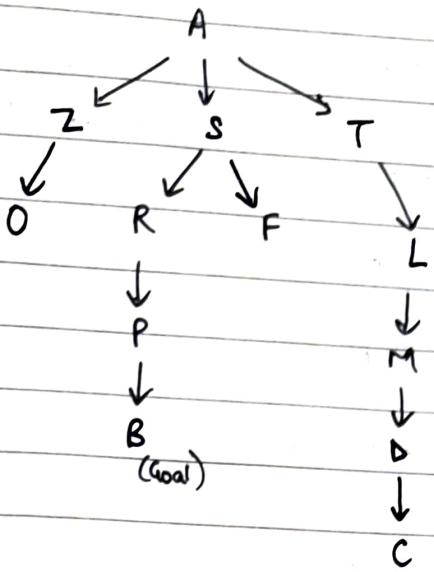
DF8 → 1 - 2 - 5 - 10 - 11 - 3 - 6 - 12 - 13 - 4 - 7 - 14 - 15 - 8 - 16 - 17

(Depth=3) DLS → 1 - 2 - 3 - 4 10 - 11 - 3 - 6 - 12 - 13 - 4 - 7 - 14 - 15 - 8 - 16 - 17

It 3 (Depth=2) 1 - 2 - 5 - 3-6-4 -7 -8 -9 (Failed)

I+4 (Depth=3) 1-2 -5-10-11 -3-6-12 -(3-4-7-14-15-8-16-17) (✓)

Q.

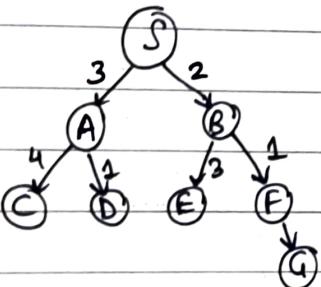


Ans. BFS : A - Z - S - T - O - R - F - L - P - M - B

DFS : A - Z - O - S - R - P - B //

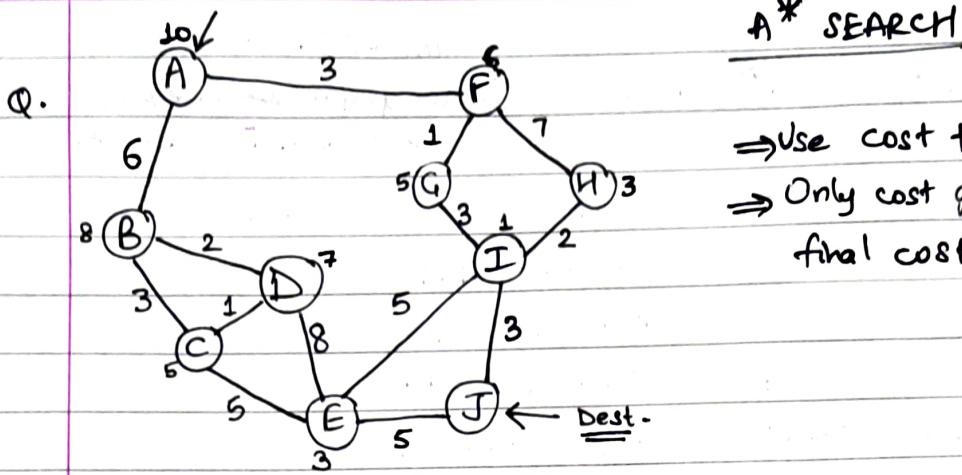
→ Greedy Best-First-Search : (using heuristic values)

Q.



Q. (from PPT)

BFS Best-First-Search : $75 + 71 + 151 + 80 + 97 + 101 = 575$,Greedy Best-First-Search : ~~$253 + 178 + 0 = 431$~~ , $140 + 99 + 211 = 450$,
(Do using multiple trees)



⇒ Use cost + heuristic

⇒ Only cost gets added to total final cost

Ans. Step 1:

Starting with node A, 2 choices : B and F

$$\text{By A* algorithm, } f(B) = 6 + 8 = 14$$

$$f(F) = 3 + 6 = 9$$

$\therefore f(F) < f(B)$, Path: A → F, Cost = 3

Step 2:

At node F, 2 choices : G and H

$$\text{By A* algorithm, } f(G) = 3 + (1+5) = 9$$

$$f(H) = 3 + (7+3) = 13$$

$\therefore f(G) < f(H)$, Path: A → F → G, Cost = 4

Step 3:

At node G, 1 choice : I

$$f(I) = 4 + (3+1) = 8$$

Path: A → F → G → I, Cost = 7

Step 4:

At node I, 3 choices : H, E and J

$$\text{By A* algorithm, } f(E) = 7 + (5+3) = 15, \quad f(H) = 7 + (2+3) = 12$$

$$f(J) = 7 + (3+0) = 10$$

$\therefore f(J) < f(E)$, Path: A → F → G → I → J, Cost = 10

Destination reached //

Q. (Graph from PPT) A* Search

[Atleast last one]

(Draw graph for in exam
(preferably for each step)

Ans. Step 1:

Starting from node A, 3 choices : Z, S and T

By A* algorithm, $f(Z) = 75 + 374 = 449$

$$f(S) = 140 + 253 = 393$$

$$f(T) = 118 + 329 = 447$$

$\therefore f(S)$ is least, Path: A \rightarrow S, cost: 140

Step 2:

At node S, 3 choices: O, F and R

By A* algorithm, $f(O) = 140 + (151 + 380) = 671$

$$f(F) = 140 + (99 + 178) = 417$$

$$f(R) = 140 + (80 + 193) = 413$$

$\therefore f(R)$ is least, Path: A \rightarrow S \rightarrow R, cost: 220

Step 3:

At node R, 2 choices: P and C

By A* algorithm, $f(P) = 220 + (97 + 98) = 415$

$$f(C) = 220 + (146 + 160) = 526$$

$\therefore f(P) < f(C)$, Path A \rightarrow S \rightarrow R \rightarrow P, cost = 317

Step 4:

At node P, 2 choices: C and B

By A* algorithm, $f(C) = 317 + (138 + 160) = 615$

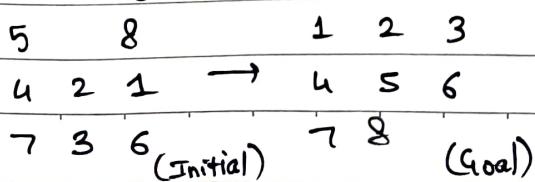
$$f(B) = 317 + (101 + 0) = 418$$

$\therefore f(B) < f(C)$, Path A \rightarrow S \rightarrow R \rightarrow P \rightarrow B, cost = 418

→ Heuristics for 8-puzzle problem:

$h_1(N)$ = number of misplaced numbered tiles

$h_2(N)$ = sum of Manhattan distance of every numbered tile to its goal position

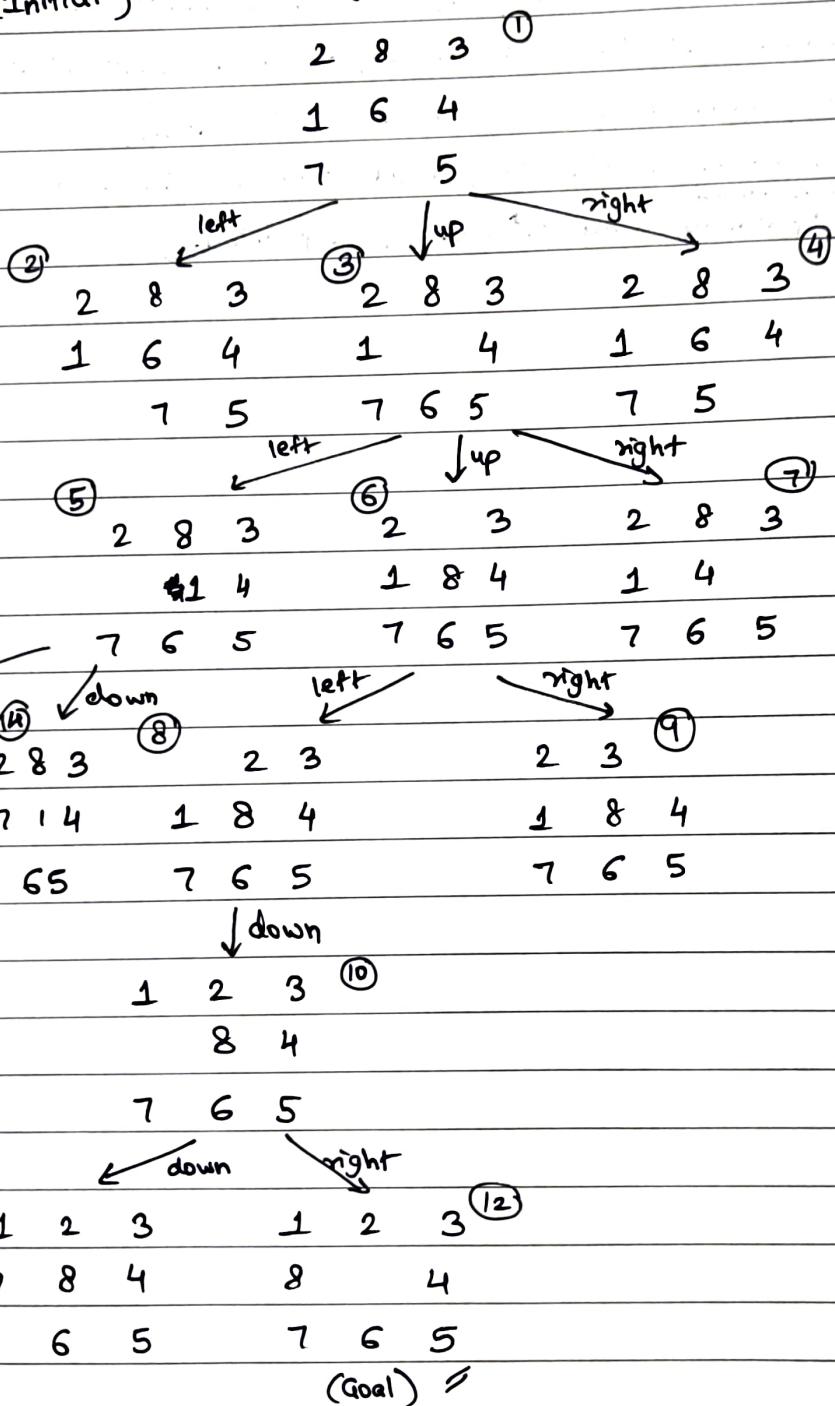


$$\therefore h_1(N) = 6,,$$

$$h_2(N) = 2+3+0+1+3+0+3+1 \\ = 13,,$$

Q. $\begin{matrix} 2 & 8 & 3 \\ 1 & 6 & 4 \\ 7 & 5 \end{matrix}$ \rightarrow $\begin{matrix} 1 & 2 & 3 \\ 8 & 4 \\ 7 & 6 & 5 \end{matrix}$ Solve using heuristics.
 (Initial) (Goal)

Ans.



1st heuristic technique: (misplaced tiles)

$$h_1(1) = 4, h_1(2) = 5, h_1(3) = 3, h_1(4) = 5$$

$$h_1(5) = 3, h_1(6) = 3, h_1(7) = 4, h_1(8) = 2, h_1(9) = 4$$

$$h_1(10) = 1, h_1(11) = 2, h_1(12) = 0, h_1(13) = 3, h_1(14) = 4$$

M	T	W	T	F	S	S
Page No.	10					
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2nd heuristic technique: (Manhattan distance)

$$h_2(1) = 1+2+0+1+1+0+0+0 = 5, h_2(2) = 1+2+0+1+1+0+1+0 = 6,$$

$$h_2(3) = 1+2+0+1+0+0+0+0 = 4, h_2(4) = 1+2+0+1+1+0+0+1 = 6,$$

$$h_2(5) = 1+2+0+2+0+0+0+0 = 5, h_2(6) = 1+0+1+1+0+0+0+0 = 3$$

$$h_2(7) = 1+2+0+1+1+0+0+0 = 5, h_2(8) = 0+0+1+1+0+0+0+0 = 2,$$

$$h_2(9) = 1+1+1+1+0+0+0+0 = 4, h_2(10) = 0+0+0+1+0+0+0+0 = 1,$$

$$h_2(11) = 0+0+0+1+1+0+0+0 = 2, h_2(12) = 0 \text{ (Goal)},$$

$$h_2(13) = 2+0+2+2+0+0+0+0 = 6, h_2(14) = 1+2+0+1+2+0+0+0 = 6$$

Now, solve ^{both techniques}, separately using A* search algorithm \rightarrow

⇒ Heuristics for 8-Queen

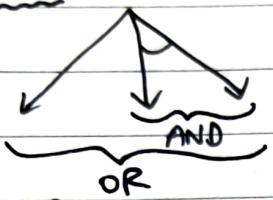
.
.
.
.
.	.	.	Q4
Q1	.	.	.	Q5	.	.	.
.	Q2	.	.	.	Q6	.	Q8
.	.	Q3	.	.	.	Q7	.

→ h = no. of pairs of queens attacking each other directly or indirectly.

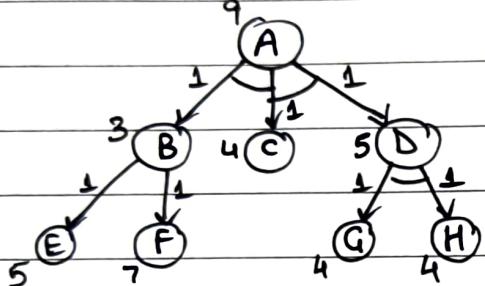
∴ All pairs from above attacking each other:

Q(1-2), (1-3), (2-3), (4-5), (4-6), (4-7), (5-6), (5-7),
 (2-4), (6-7), (7-8), (1-5), (2-6), (2-8), (6-8), (3-7), (3-5)

→ AO* Algorithm :



Q.



Solve using AO* Algorithm.

Ans.

$$\cancel{(A-B-E)} + \cancel{(A-B-F)} + (B-C) + (B-D) + (C-G) + (D-H) = 15$$

$$\cancel{(A-B-C-E)} + \cancel{(A-B-C-F)} + (B-E) + (B-F) + (C-G) + (D-H) = 16$$

$$\therefore (A-B-C-D-E) = (6+1)$$

$$\therefore f(A-B-C) = (3+1) + (4+1) = 9$$

$$f(B-E) = 5+1 = 6, f(B-F) = 7+1 = 8 \quad \text{so } f(B-E) \text{ is min.}$$

$$\therefore f(A-B-C) = (6+1) + (4+1) = 12 \quad [\text{Path 1}]$$

$$f(A-C-D) = (4+1) + (5+1) = 11$$

$$f(D-G) = 4+1 = 5, f(D-H) = 4+1 = 5 \quad \cancel{f(B-F) = 5+1 = 6}$$

$$\therefore f(A-C-D) = (4+1) + (5+1) = 11+5=16 \quad [\text{Path 2}]$$

∴ Path 1 chosen (least cost) [12]