**Lab no: 1**

**Title: WAP to create a tic tac toe game in python.**

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## Tic-Tac-Toe

Tic -tac-toe is a simple 2-player game played on a 3×3 grid. Players take turns marking a cell with either X or O. The first player to align **three of their symbols** (horizontally, vertically, or diagonally) wins. If the grid is full and no one has won, it's a draw.

It's a great beginner project to practice:

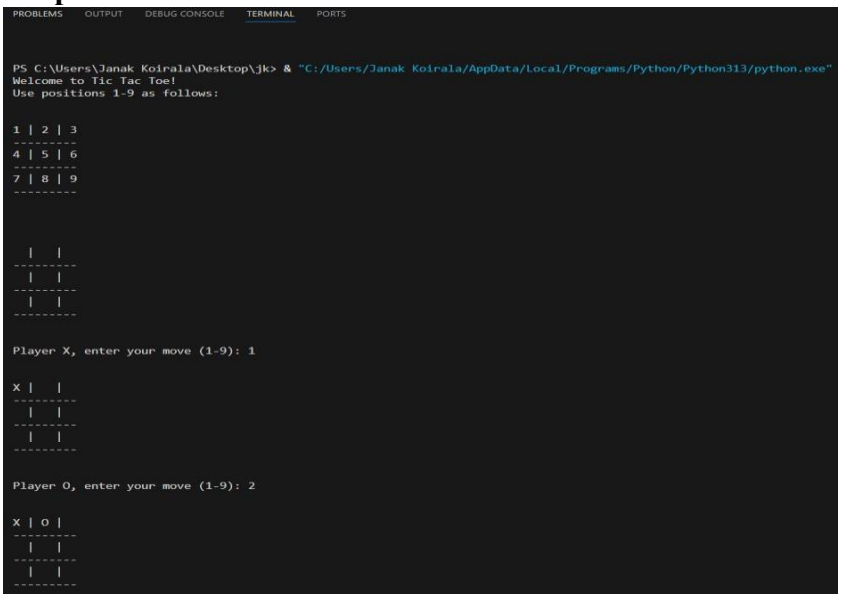
- Loops
- Conditionals
- Lists
- Functions

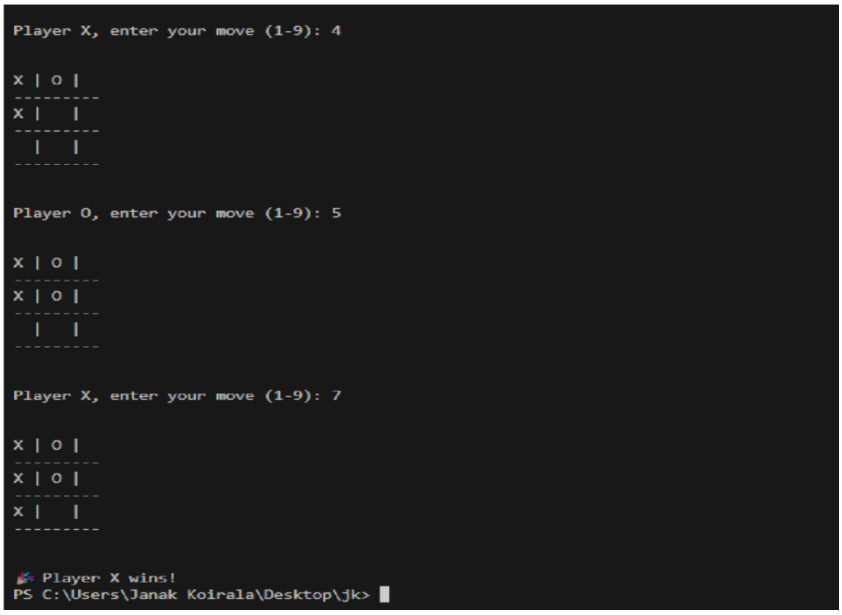
**Source code:**

```
def print_board(board):    print("\n")    for row in board:        print(" | ".join(row))
print("-" * 9)
   print("\n")

def check_winner(board, player):    # Rows, columns,
diagonals    for row in board:        if all(cell == player for
cell in row):            return True    for col in range(3):
if all(board[row][col] == player for row in range(3)):
         return True    if all(board[i][i] ==
player for i in range(3)):
      return True    if all(board[i][2 - i] == player
for i in range(3)):        return True
   return False

def is_draw(board):
   return all(cell in ['X', 'O'] for row in board for cell in row)

def  get_move(player,  board):
while True:        try:
         move = int(input(f"Player {player}, enter your move (1-9): "))
if move < 1 or move > 9:
            print("Invalid move. Choose a number between 1 and 9.")
continue           row = (move - 1) // 3           col = (move - 1) % 3
if board[row][col] == ' ':
            return row, col
else:
            print("Cell already taken. Choose another.")
except ValueError:
         print("Invalid input. Please enter a number between 1 and 9.")

def tic_tac_toe():    board = [[' ' for _ in range(3)]
for _ in range(3)]    current_player = 'X'

   print("Welcome to Tic Tac Toe!")    print("Use
positions 1-9 as follows:")
print_board([['1','2','3'], ['4','5','6'], ['7','8','9']])

   while True:
print_board(board)        row, col
= get_move(current_player,
board)        board[row][col] =
current_player
```

```
    if check_winner(board, current_player):
print_board(board)
        print(f" Player {current_player} wins!")
break       if is_draw(board):
        print_board(board)
print("It's a draw!")
        break

    current_player = 'O' if current_player == 'X' else 'X'

# Run the game
tic_tac_toe()
```

**Output:**



**Lab no: 2**

**Title: WAP to create water jug puzzle in python.**

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## Water Jug Problem :

The Water Jug Problem is a classic puzzle where you're given two jugs of different capacities and an unlimited supply of water. The goal is to measure an exact amount of water using only these two jugs.

You can:

- Fill a jug completely
- Empty a jug
- Pour water from one jug to the other until one is full or the other is empty

This problem is often used to teach logical reasoning, problem-solving, and state-space search in computer science and artificial intelligence.

## Problem Statement (Most Common Version)

You are given:

- A **5-liter** jug
- A **3-liter** jug
- An unlimited water supply
- Both jugs are initially empty

**Source code:** def

```
print_jars(jars):
   print("\nCurrent Jars:")     for i, count in
enumerate(jars, start=1):        print(f"Jar
{i}: {'●' * count} ({count})")     print()

def get_move(player, jars):
while True:        try:
          jar = int(input(f"Player {player}, choose a jar (1-3): "))
if jar not in [1, 2, 3]:
              print("Invalid jar number. Choose 1, 2, or 3.")
continue            if jars[jar - 1] == 0:
              print("That jar is empty. Choose another.")               continue
count = int(input(f"Player {player}, how many to remove from Jar {jar}? "))
if not (1 <= count <= jars[jar - 1]):               print(f"Choose between 1 and {jars[jar
- 1]}.")              continue           return jar - 1, count        except ValueError:
print("Please enter valid integers.")

def is_game_over(jars):
return sum(jars) == 1

def three_jar_game():
   jars = [3, 5, 7]
   current_player = 1

   print(" Welcome to the 3 Jar Game!")
   print("Rules:\n1. Take turns removing 1 or more items from one jar.")
print("2. The player forced to take the LAST item loses.\n")

   while True:
      print_jars(jars)

      if is_game_over(jars):
print("Only one item remains!")
          print_jars(jars)
          print(f" Player {current_player} is forced to take the last item.")
print(f" Player {3 - current_player} wins!")           break

      jar_index, remove_count = get_move(current_player, jars)
jars[jar_index] -= remove_count
      current_player = 3 - current_player  # Switch players

three_jar_game()
```

**Output:**

```
PS C:\Users\Janak Koirala\Desktop\jk> & "C:/Users/Janak Koirala/AppData/Local/Programs/Python/Python313/python.exe"
🎮 Welcome to the 3 Jar Game!
Rules:
1. Take turns removing 1 or more items from one jar.
2. The player forced to take the LAST item loses.


Current Jars:
Jar 1: ●●● (3)
Jar 2: ●●●●● (5)
Jar 3: ●●●●●●● (7)

Player 1, choose a jar (1-3): 3
Player 1, how many to remove from Jar 3? 3

Current Jars:
Jar 1: ●●● (3)
Jar 2: ●●●●● (5)
Jar 3: ●●●● (4)

Player 2, choose a jar (1-3): 2
Player 2, how many to remove from Jar 2? 5

Current Jars:
Jar 1: ●●● (3)
Jar 2:  (0)
Jar 3: ●●●● (4)

Player 1, choose a jar (1-3): 1
Player 1, how many to remove from Jar 1? 2

Current Jars:
Jar 1: ● (1)
Jar 2:  (0)
Jar 3: ●●●● (4)

Player 2, choose a jar (1-3): 3
Player 2, how many to remove from Jar 3? 3

Current Jars:
Jar 1: ● (1)
Jar 2:  (0)
Jar 3: ● (1)

Player 1, choose a jar (1-3): 1
Player 1, how many to remove from Jar 1? 1

Current Jars:
Jar 1:  (0)
Jar 2:  (0)
Jar 3: ● (1)

Only one item remains!

Current Jars:
Jar 1:  (0)
Jar 2:  (0)
Jar 3: ● (1)

💥 Player 2 is forced to take the last item.
🎉 Player 1 wins!
PS C:\Users\Janak Koirala\Desktop\jk>
```

**Lab no: 3**

**Title: WAP to create Chatbot in python.**

---

## Chatbot:

Chatbot is a computer program that uses rules or artificial intelligence to communicate with people automatically, usually through text or voice, to answer questions or help with tasks.

- It **doesn't learn or adapt** like AI chatbots.
- Only works **within the limits** of the programmed rules.

### Purpose of the Program

This chatbot, named **Jarvis**, is a basic conversational agent implemented in Python. It interacts with users by recognizing predefined keywords or phrases and responding with appropriate answers. The chatbot can greet users, respond to simple questions, tell jokes, and remember the user's name during the conversation

### Key Features

- **Pattern Matching**: The chatbot matches user input against keys in a dictionary to generate responses.
- **State Maintenance**: Remembers the user's name once provided.
- **Simple Natural Language Handling**: Handles common phrases and can recognize commands like "my name is" or "what is my name."

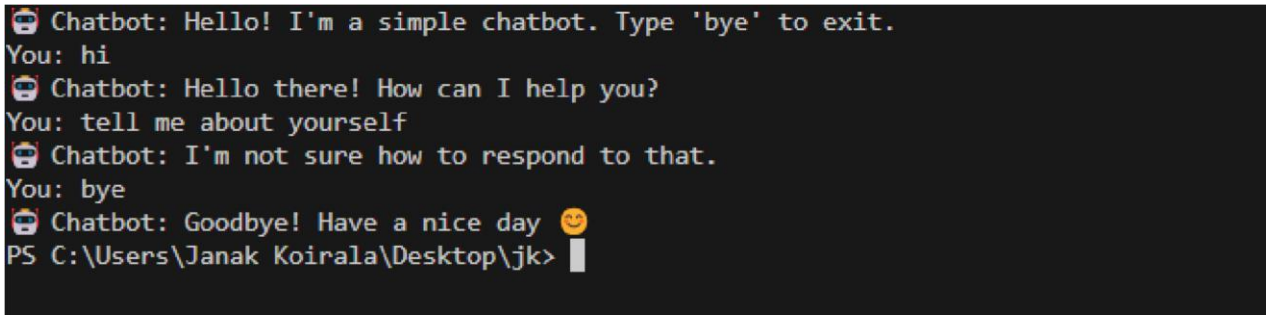
### Exit Condition

Allows graceful exit on user command

**Source code:**

```
def chatbot():
   print("🤖 Chatbot: Hello! I'm a simple chatbot. Type 'bye' to exit.")

   while True:        user_input =
input("You: ").lower()

       if user_input in ['bye', 'exit', 'quit']:
          print("🤖 Chatbot: Goodbye! Have a nice day 😊")
break        elif "hello" in user_input or "hi" in user_input:
          print("🤖 Chatbot: Hello there! How can I help you?")
elif "how are you" in user_input:
          print("🤖 Chatbot: I'm just code, but thanks for asking! How are you?")
elif "name" in user_input:
          print("🤖 Chatbot: I'm a simple Python chatbot.")
elif "help" in user_input:
          print("🤖 Chatbot: I can respond to greetings, tell you my name, and say goodbye.")
else:
          print("🤖 Chatbot: I'm not sure how to respond to that.")

# Run the chatbot chatbot()
```

**Output:**



**Lab no: 4**

**Title: Create Breadth First Search Algorithm in python.**

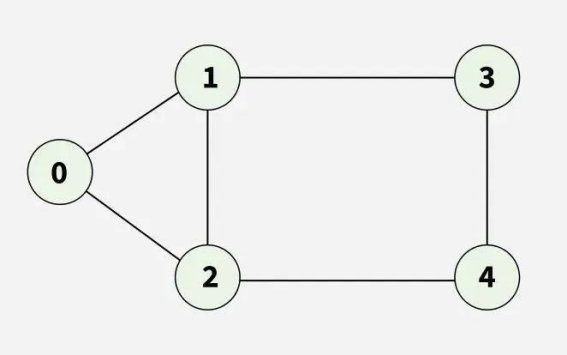
---

**Breadth First Search**

Breadth First Search (BFS) is a fundamental graph traversal algorithm. It begins with a node, then first traverses all its adjacent nodes. Once all adjacent are visited, then their adjacent are traversed.

**For example:**

Input: adj[][] = [[1,2], [0,2,3], [0,1,4], [1,4], [2,3]]




Output: [0, 1, 2, 3, 4]

Explanation: Starting from 0, the BFS traversal will follow these steps: Visit 0 → Output: [0]

Visit 1 (first neighbor of 0) → Output: [0, 1]

Visit 2 (next neighbor of 0) → Output: [0, 1, 2]

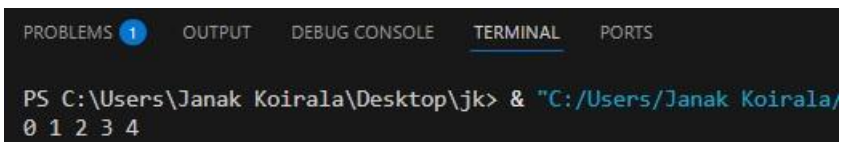
Visit 3 (next neighbor of 1) → Output: [0, 1, 2, 3]

Visit 4 (neighbor of 2) → Final Output: [0, 1, 2, 3, 4]

**Source code:**

```
def bfs(adj):
V = len(adj)
   res = []
   s = 0  # starting node

   # Create a queue for BFS
q = deque()

   # Initially mark all the vertices as not visited
visited = [False] * V

   # Mark source node as visited and enqueue it
visited[s] = True     q.append(s)

   # Iterate over the queue
while q:
      # Dequeue a vertex from queue and store it
      curr = q.popleft()
      res.append(curr)

      for x in adj[curr]:
if not visited[x]:
visited[x] = True
q.append(x)

   return res


if __name__ == "__main__":
   # Create the adjacency list
   # Example: [[1, 2], [0, 2, 3], [0, 4], [1, 4], [2, 3]]
   adj = [[1, 2], [0, 2, 3], [0, 4], [1, 4], [2, 3]]

   ans = bfs(adj)
for i in ans:
      print(i, end=" ")
```

**Output:**



**Lab no: 5**

**Title: Create Depth First Search Algorithm in python.**

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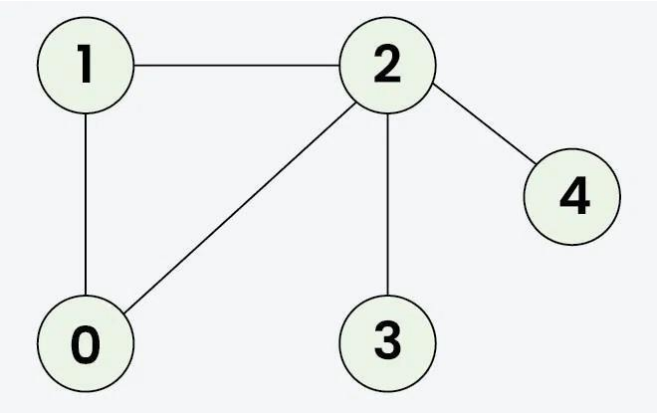
**Depth First Search:**

In Depth First Search (or DFS) for a graph, we traverse all adjacent vertices one by one. When we traverse an adjacent vertex, we completely finish the traversal of all vertices reachable through that adjacent vertex. This is similar to a tree, where we first completely traverse the left subtree and then move to the right subtree. The key difference is that, unlike trees, graphs may contain cycles (a node may be visited more than once). To avoid processing a node multiple times, we use a boolean visited array.

**For example:**

Input: adj = [[1, 2], [0, 2], [0, 1, 3, 4], [2], [2]]




**Output:** [0 1 2 3 4]

Explanation: The source vertex s is 0. We visit it first, then we visit an adjacent.

Start at 0: Mark as visited. Output: 0

Move to 1: Mark as visited. Output: 1

Move to 2: Mark as visited. Output: 2

Move to 3: Mark as visited. Output: 3 (backtrack to 2)

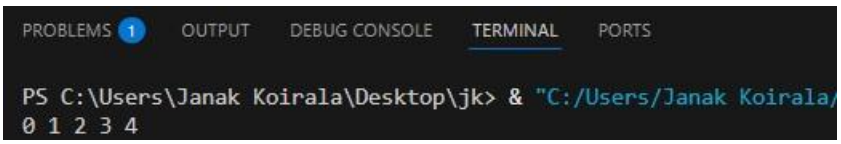
Move to 4: Mark as visited. Output: 4 (backtrack to 2, then backtrack to 1, then to 0)

*(**Note**: There can be multiple DFS traversals of a graph according to the order in which we pick adjacent vertices).*

**Source code:**

```
def dfsRec(adj, visited, s, res):
    visited[s] = True
    res.append(s)

    # Recursively visit all adjacent vertices that are not visited yet
    for i in range(len(adj)):
        if adj[s][i] == 1 and not visited[i]:
            dfsRec(adj, visited, i, res)

def DFS(adj):
    visited = [False] * len(adj)
    res = []
    dfsRec(adj, visited, 0, res)  # Start DFS from vertex 0
    return res

def add_edge(adj, s, t):
    adj[s][t] = 1
    adj[t][s] = 1

V = 5
adj = [[0] * V for _ in range(V)]  # Adjacency matrix

# Define the edges of the graph
edges = [(1, 2), (1, 0), (2, 0), (2, 3), (2, 4)]

for s, t in edges:
    add_edge(adj, s, t)

# Perform DFS res = DFS(adj)
print(" ".join(map(str, res)))
```

**Output:**



**Lab no: 6**

**Title: Create Depth Limit Search Algorithm in python.**

---

**Depth Limit Search:**

Depth Limited Search is a key algorithm used in solving problem space concerned with artificial intelligence. But before starting it lets first understand Depth First Search which is an algorithm that explores a tree or graph by starting at the root node and exploring as far as possible along each branch before backtracking. It follows a path from the root to a leaf node then backtracks to explore other path.

**How Depth Limited Search Works:**

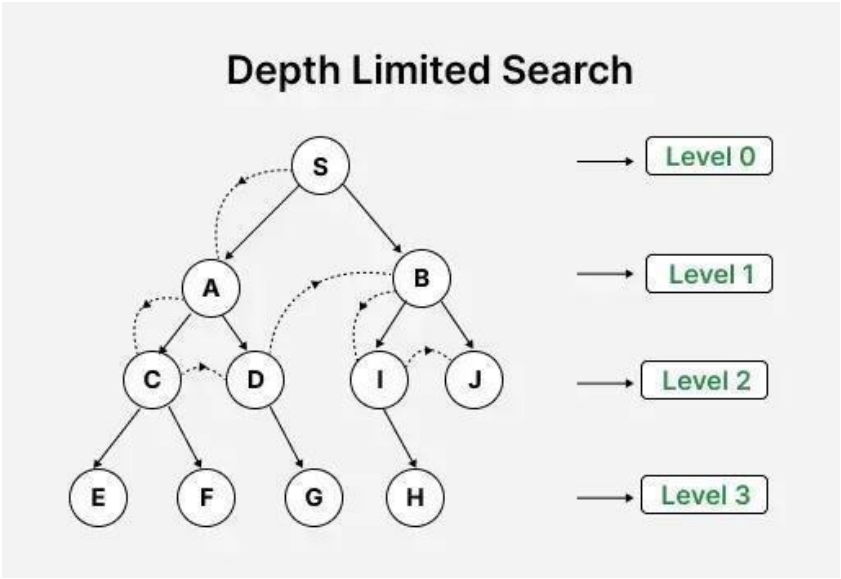
Initialization: Begin at the root node with a specified depth limit.

Exploration: Traverse the tree or graph, exploring each node's children.

Depth Check: If the current depth exceeds the set limit, stop exploring that path and backtrack.

Goal Check: If the goal node is found within the depth limit, the search is successful.

Backtracking: If the search reaches the depth limit or a leaf node without finding the goal, backtrack and explore other branches.



**Source code:**

```
def depth_limited_search(graph, start, goal, limit):
def recursive_dls(node, goal, depth):        if depth
== 0 and node == goal:
          return [node]        if depth > 0:            for
neighbor in graph.get(node, []):                path =
recursive_dls(neighbor, goal, depth - 1)                if
path:
                return [node] + path
      return None

   return recursive_dls(start, goal, limit)



graph = {
   'A': ['B', 'C'],
'B': ['D', 'E'],
   'C': ['F'],
   'D': ['G', 'H'],
   'E': [],
   'F': ['G']
}

start_node = 'A' goal_node = input("Enter
the goal node: ")
depth_limit = int(input("Enter depth limit: "))

result = depth_limited_search(graph, start_node, goal_node, depth_limit)

if result:
   print("Path found:", " -> ".join(result))
else:     print("No path found within depth
limit.")
```

**Output:**

```
PS C:\Users\Janak Koirala\Desktop\jk> & "C:/Users/Janak Koirala
Enter the goal node: G
Enter depth limit: 4
No path found within depth limit.
```

**Lab no: 7**

**Title: Create Iterative Deepening Depth First Search (IDDFs) Algorithm in python.**

---

**Iterative Deepening Depth First Search**:

Iterative Deepening Depth-First Search (IDDFS), also known as Iterative Deepening Search (IDS), is an uninformed search algorithm that combines the memory efficiency of DepthFirst Search (DFS) with the completeness and optimality (for unweighted graphs) of Breadth-First Search (BFS).

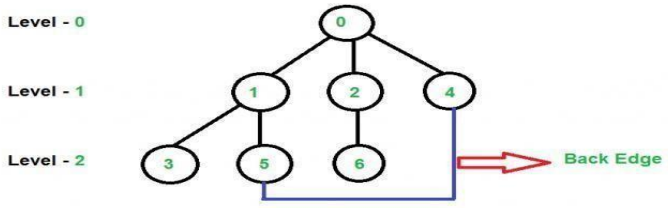
**How does IDDFS works:**

IDDFS calls DFS for different depths starting from an initial value. In every call, DFS is restricted from going beyond given depth. So basically we do DFS in a BFS fashion.

**Illustration:** There can be two cases:

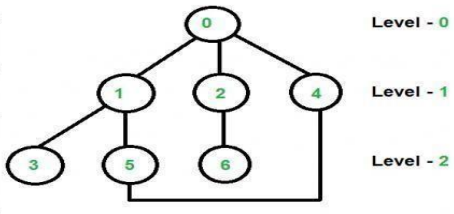
***When the graph has no cycle:*** This case is simple. We can DFS multiple times with different height limits.

***When the graph has cycles.*** This is interesting as there is no visited flag in IDDFS.




**Although, at first sight, it may seem that since there are only 3 levels, so we might think that Iterative Deepening Depth First Search of level 3, 4, 5,...and so on will remain same. But, this is not the case. You can see that there is a cycle in the above graph, hence IDDFS will change for level-3,4,5..and so on.**

| Depth | Iterative Deepening Depth First Search |
|---|---|
| 0 | 0 |
| 1 | 0 1 2 4 |
| 2 | 0 1 3 5 2 6 4 5 |
| 3 | 0 1 3 5 4 2 6 4 5 1 |




**The explanation of the above pattern is left to the readers.**

**Source code:**

```
graph = {
   "a": ["b", "c", "d"],
   "b": ["e", "f"],
   "c": ["g", "h"],
   "d": ["i"],
   "e": [],
   "f": [],
   "g": [],
   "h": [],
   "i": [],
}

def dfs(node, goal, d_limit, visited, path):
if node == goal:
      return "FOUND", path + [node]
elif d_limit == 0:
      return "NOT_FOUND", path
else:
      visited.add(node)
for child in graph[node]:
if child not in visited:
            result, tv_path = dfs(child, goal, d_limit - 1, visited, path + [node])
if result == "FOUND":                  return "FOUND", tv_path
      return "NOT_FOUND", path

def iddfs(root, goal):
   d_limit = 0
while True:
      visited = set()
      result, tv_path = dfs(root, goal, d_limit, visited, [])
print("Depth Limit:", d_limit, "Traversed path:", ' -> '.join(tv_path))
if result == "FOUND":           return "Goal node found! Traversed path:
" + ' -> '.join(tv_path)        else:
         d_limit += 1

# Input and run root = input('Enter the start node:
').strip().lower() goal = input('Enter the goal node:
').strip().lower()

# Ensure node keys match case root = root
if root in graph else root.lower() goal = goal
if goal in graph else goal.lower() result =
iddfs(root, goal) print(result)
```

**Output:**

```
PS C:\Users\Janak Koirala\Desktop\jk> & "C:/Users/Janak Koirala/
Enter the start node: a
Enter the goal node: g
Depth Limit: 0 Traversed path:
Depth Limit: 1 Traversed path:
Depth Limit: 2 Traversed path: a -> c -> g
Goal node found! Traversed path: a -> c -> g
```

**Lab no: 8**

**Title: Create Bidirectional Search Algorithm in python.**

---

**Bidirectional Search:**

Bidirectional search is a graph search algorithm which find smallest path from source to goal vertex. It runs two simultaneous search.

Forward search from source/initial vertex toward goal vertex.

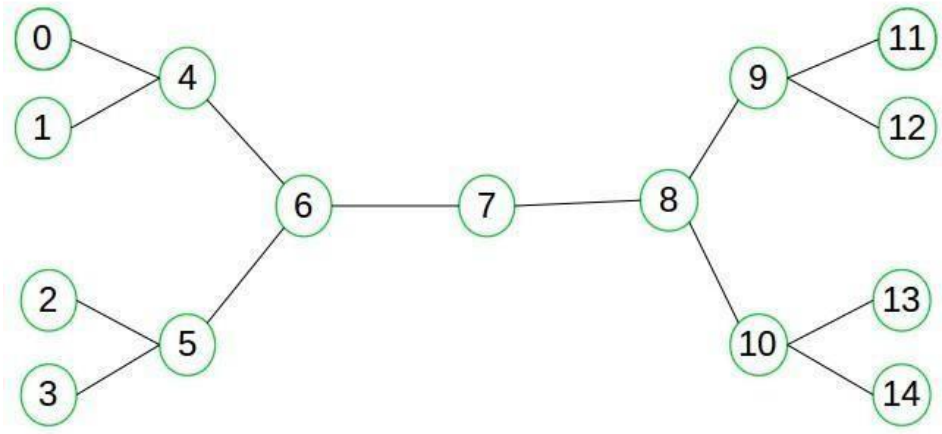
Backward search from goal/target vertex toward source vertex.

**When to use bidirectional approach?**

We can consider bidirectional approach when,

1. Both initial and goal states are unique and completely defined.
2. The branching factor is exactly the same in both directions.

**For Example:**




Suppose we want to find if there exists a path from vertex 0 to vertex 14. Here we can execute two searches, one from vertex 0 and other from vertex 14. When both forward and backward search meet at vertex 7, we know that we have found a path from node 0 to 14 and search can be terminated now. We can clearly see that we have successfully avoided unnecessary exploration.

**Source code:** from collections import deque class BidirectionalSearch: def __init__(self, vertices): self.vertices = vertices

```
        self.graph = [[] for _ in range(vertices)]

    def add_edge(self, src, dest):
self.graph[src].append(dest)
self.graph[dest].append(src)

    def bfs(self, queue, visited, parent):
        current = queue.popleft()  for neighbor in self.graph[current]:
if not visited[neighbor]:
visited[neighbor] = True
parent[neighbor] = current
                queue.append(neighbor)

    def is_intersecting(self, visited_src, visited_dest):
for i in range(self.vertices):  if visited_src[i] and visited_dest[i]:
                return i
        return -1

    def print_path(self, intersecting_node, src, dest, parent_src, parent_dest):
        # Path from src to intersection
        path = []  i = intersecting_node
while i != -1:
            path.append(i)
i = parent_src[i]
        path.reverse()

        # Path from intersection to dest
i = parent_dest[intersecting_node]
while i != -1:
            path.append(i)
            i = parent_dest[i]

        print("***** Path *****")
        print(" -> ".join(map(str, path)))

    def bidirectional_search(self, src, dest):
visited_src = [False] * self.vertices  visited_dest
```

```
= [False] * self.vertices        parent_src = [-1] *
self.vertices        parent_dest = [-1] * self.vertices

      queue_src = deque([src])
queue_dest = deque([dest])
visited_src[src] = True
      visited_dest[dest] = True

      while queue_src and queue_dest:
         self.bfs(queue_src, visited_src, parent_src)
self.bfs(queue_dest, visited_dest, parent_dest)

         intersecting_node = self.is_intersecting(visited_src, visited_dest)
if intersecting_node != -1:
            print(f"Path exists between {src} and {dest}")
print(f"Intersection at: {intersecting_node}")
            self.print_path(intersecting_node, src, dest, parent_src, parent_dest)
return True
      return False

# Example usage if
__name__ == "__main__":
   n = 15
src = 0
dest = 14
   graph = BidirectionalSearch(n)

   edges = [
      (0, 4), (1, 4), (2, 5), (3, 5),
      (4, 6), (5, 6), (6, 7), (7, 8),
      (8, 9), (8, 10), (9, 11), (9, 12),
      (10, 13), (10, 14)
   ]
   for u, v in edges:
      graph.add_edge(u, v)

   if not graph.bidirectional_search(src, dest):
      print(f"Path does not exist between {src} and {dest}")
```

**Output:**

```
PS C:\Users\Janak Koirala\Desktop\jk> & "C:/Users/Janak Koirala/
Path exists between 0 and 14
Intersection at: 7
***** Path *****
0 -> 4 -> 6 -> 7 -> 8 -> 10 -> 14
```

**Lab no: 9**

**Title: Create Uniform Cost Search Algorithm in python.**

---

**Uniform Cost Search:**

Uniform Cost Search (UCS) is a search algorithm used in artificial intelligence (AI) for finding the least cost path in a graph. It is a variant of Dijkstra's algorithm and is particularly useful when all edges of the graph have different weights, and the goal is to find the path with the minimum total cost from a start node to a goal node.

**How Uniform Cost Search Works:**

**Initialization**: UCS starts with the root node. It is added to the priority queue with a cumulative cost of zero since no steps have been taken yet.

**Node Expansion:** The node with the lowest path cost is removed from the priority queue. This node is then expanded, and its neighbors are explored.

**Exploring Neighbors**: For each neighbor of the expanded node, the algorithm calculates the total cost from the start node to the neighbor through the current node. If a neighbor node is not in the priority queue, it is added to the queue with the calculated cost. If the neighbor is already in the queue but a lower cost path to this neighbor is found, the cost is updated in the queue.

**Goal Check:** After expanding a node, the algorithm checks if it has reached the goal node. If the goal is reached, the algorithm returns the total cost to reach this node and the path taken.

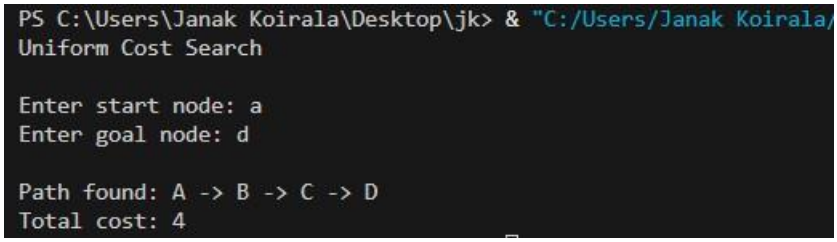
**Repetition:** This process repeats until the priority queue is empty or the goal is reached.

**Source code:** import heapq

```
class Node:    def __init__(self, position, cost=0,
parent=None):
      self.position = position
self.cost = cost
      self.parent = parent

   def __lt__(self, other):
      return self.cost < other.cost


def uniform_cost_search(start, goal, graph):
   open_list = []
   closed_list = set()

   start_node = Node(start, 0)
   heapq.heappush(open_list, start_node)

   while open_list:
      current_node = heapq.heappop(open_list)
current_position = current_node.position

      if current_position in closed_list:
         continue

      closed_list.add(current_position)

      if current_position == goal:          path =
[]          total_cost = current_node.cost
while current_node:
path.append(current_node.position)
current_node = current_node.parent
         return path[::-1], total_cost

      for neighbor, cost in graph.get(current_position, {}).items():
if neighbor in closed_list:
            continue
         neighbor_node = Node(neighbor, current_node.cost + cost, current_node)
heapq.heappush(open_list, neighbor_node)

   return None, float('inf')
```

```
# Example graph
graph = {
   'A': {'B': 1, 'C': 4},
   'B': {'A': 1, 'C': 2, 'D': 5},
   'C': {'A': 4, 'B': 2, 'D': 1},
   'D': {'B': 5, 'C': 1}
}

# Driver code print("Uniform Cost Search\n")
start = input("Enter start node: ").strip().upper()
goal = input("Enter goal node: ").strip().upper()

if start not in graph or goal not in graph:
   print("\nInvalid start or goal node. Please check the node names.") else:
   path, cost = uniform_cost_search(start, goal, graph)
if path:
      print("\nPath found:", " -> ".join(path))
      print("Total cost:", cost)
else:
      print("\nNo path found between the given nodes.")
```

**Output:**



Madan Bhandari Memorial College

**Lab no: 10**
**Title: Create a Greedy Best-First Search in python.**

---

## Greedy Best-First Search:

Greedy Best-First Search is an informed search algorithm that uses a heuristic function to guide its search towards the goal. Unlike other search algorithms, it always chooses the path that appears best at the moment according to the heuristic function. It uses a priority queue to always expand the node that appears to be closest to the goal.

## Key Features:

- **Heuristic-based**: Uses a heuristic function to estimate the cost from current node to goal
- **Greedy approach**: Always selects the node that appears best according to the heuristic
- **Informed search**: Unlike uninformed searches, it has knowledge about the goal location
- **Time complexity**: O(b^m) where b is branching factor and m is maximum depth
- **Space complexity**: O(b^m) in worst case **How Greedy Best-First Search Works:**

1. **Initialization**: Start with the initial node in a priority queue
2. **Heuristic Evaluation**: Calculate heuristic value for each node (distance to goal)
3. **Node Selection**: Always select the node with lowest heuristic value
4. **Expansion**: Expand the selected node and add neighbors to queue
5. **Goal Check**: Continue until goal is reached or queue is empty

## Source Code:

```
import heapq

# Graph representation with letter nodes
graph = {
   'A': {'B': 1, 'C': 4},
   'B': {'A': 1, 'C': 2, 'D': 5, 'E': 3},
   'C': {'A': 4, 'B': 2, 'F': 6},
   'D': {'B': 5, 'E': 1, 'G': 2},
   'E': {'B': 3, 'D': 1, 'F': 4, 'G': 1},
   'F': {'C': 6, 'E': 4, 'H': 3},
   'G': {'D': 2, 'E': 1, 'H': 2},
   'H': {'F': 3, 'G': 2}
}

# Heuristic values (estimated distance to goal) # These
represent straight-line distances to each node def
get_heuristic_values(goal):
   heuristics = {
      'A': {'A': 0, 'B': 7, 'C': 6, 'D': 8, 'E': 5, 'F': 9, 'G': 4, 'H': 3},
      'B': {'A': 7, 'B': 0, 'C': 3, 'D': 5, 'E': 2, 'F': 8, 'G': 3, 'H': 6},       'C':
{'A': 6, 'B': 3, 'C': 0, 'D': 8, 'E': 5, 'F': 4, 'G': 6, 'H': 7},
      'D': {'A': 8, 'B': 5, 'C': 8, 'D': 0, 'E': 2, 'F': 7, 'G': 1, 'H': 3},
      'E': {'A': 5, 'B': 2, 'C': 5, 'D': 2, 'E': 0, 'F': 4, 'G': 1, 'H': 3},       'F':
{'A': 9, 'B': 8, 'C': 4, 'D': 7, 'E': 4, 'F': 0, 'G': 5, 'H': 2},
      'G': {'A': 4, 'B': 3, 'C': 6, 'D': 1, 'E': 1, 'F': 5, 'G': 0, 'H': 2},
      'H': {'A': 3, 'B': 6, 'C': 7, 'D': 3, 'E': 3, 'F': 2, 'G': 2, 'H': 0}
   }
   return heuristics.get(goal, {})

# Greedy Best-First Search with letter nodes def
greedy_best_first_search(graph, start, goal):    if start
not in graph or goal not in graph:       return None,
"Invalid start or goal node"

   visited = set()    priority_queue = []
   heuristic_values = get_heuristic_values(goal)

   # Heap queue with (heuristic, node)
   heapq.heappush(priority_queue, (heuristic_values.get(start, float('inf')), start))
came_from = {start: None}
```

```
   print(f"\nSearching from {start} to {goal}...")     print("Search
Progress:")

   while priority_queue:
      current_heuristic, current = heapq.heappop(priority_queue)

      if current in visited:            continue

      visited.add(current)
      print(f"Visiting node {current} (heuristic: {current_heuristic})")

      if current == goal:            print(f"Goal
{goal} reached!")
         break

      # Explore neighbors        for neighbor in
graph.get(current, {}):
         if neighbor not in visited:
            neighbor_heuristic = heuristic_values.get(neighbor, float('inf'))
heapq.heappush(priority_queue, (neighbor_heuristic, neighbor))               if
neighbor not in came_from:                  came_from[neighbor] = current

   # Reconstruct path     if goal not
in came_from:
      return None, f"No path found from {start} to {goal}"

   path = []     node = goal     while node:
path.append(node)        node =
came_from.get(node)
   path.reverse()

   return path, "Path found successfully"

# Display available nodes def
display_graph():
   print("Available nodes in the graph:")
print("Nodes:", sorted(graph.keys()))
print("\nGraph connections:")     for node,
neighbors in graph.items():        print(f"{node}:
{list(neighbors.keys())}")

# Main execution def main():
   print("=" * 50)
```

```
   print("GREEDY BEST-FIRST SEARCH ALGORITHM BY JIGYASA KOIRALA")     print("=" *
50)

   display_graph()

   print("\n" + "-" * 30)

   # Get user input     while True:         start = input("\nEnter the source
node (A-H): ").strip().upper()         if start in graph:             break
       print("Invalid node! Please choose from A, B, C, D, E, F, G, H")

   while True:         goal = input("Enter the destination node (A-H):
").strip().upper()         if goal in graph:
           break
       print("Invalid node! Please choose from A, B, C, D, E, F, G, H")

   # Perform search
   path, message = greedy_best_first_search(graph, start, goal)

   # Display results     print("\n" + "="
* 50)     print("SEARCH RESULTS")
   print("=" * 50)

   if path:
       print(f"Status: {message}")         print(f"Path
found: {' -> '.join(path)}")
       print(f"Number of nodes in path: {len(path)}")

       # Calculate total cost
total_cost = 0         for i in
range(len(path) - 1):
current_node = path[i]
next_node = path[i + 1]
           cost = graph[current_node].get(next_node, 0)
           total_cost += cost
           print(f"  {current_node} -> {next_node}: cost = {cost}")

       print(f"Total path cost: {total_cost}")     else:
       print(f"Status: {message}")

# Run the program if __name__ ==
"__main__":     main()
```

# Output:

```
PROBLEMS 2   OUTPUT   DEBUG CONSOLE   TERMINAL   PORTS

PS C:\Users\user> & C:/Users/user/AppData/Local/Programs/Python/Python314/python.exe "c:/Users/user/Desktop/FCFS 10.py"
==================================================
GREEDY BEST-FIRST SEARCH ALGORITHM BY JIGYASA KOIRALA
==================================================
Available nodes in the graph:
Nodes: ['A', 'B', 'C', 'D', 'E', 'F', 'G', 'H']

Graph connections:
A: ['B', 'C']
B: ['A', 'C', 'D', 'E']
C: ['A', 'B', 'F']
D: ['B', 'E', 'G']
E: ['B', 'D', 'F', 'G']
F: ['C', 'E', 'H']
G: ['D', 'E', 'H']
H: ['F', 'G']

------------------------------

Enter the source node (A-H): A
Enter the destination node (A-H): G

Searching from A to G...
Search Progress:
Visiting node A (heuristic: 4)
Visiting node B (heuristic: 3)
Visiting node D (heuristic: 1)
Visiting node G (heuristic: 0)
Goal G reached!
```

```
==================================================
SEARCH RESULTS
==================================================
Status: Path found successfully
Path found: A -> B -> D -> G
Number of nodes in path: 4
  A -> B: cost = 1
  B -> D: cost = 5
  D -> G: cost = 2
Total path cost: 8
```

**Lab no: 11**
**Title: Create A* Search Algorithm in python.**

---

## A* Search Algorithm:

A* (A-star) is one of the most popular and widely used informed search algorithms in artificial intelligence and pathfinding. It combines the advantages of Dijkstra's algorithm (guarantees shortest path) and Greedy Best-First Search (uses heuristics for efficiency). A* uses both the actual cost from start to current node (g) and the estimated cost from current node to goal (h) to make optimal decisions.

## Key Features:

- **Optimal**: Guarantees the shortest path if heuristic is admissible
- **Complete**: Will find a solution if one exists
- **Informed Search**: Uses both actual cost (g) and heuristic (h)
- **f(n) = g(n) + h(n)**: Total estimated cost through node n
- **Admissible Heuristic**: Never overestimates the actual cost to goal

## How A* Search Works:

1. **Initialization**: Start with initial node in open set with f(start) = h(start)
2. **Node Selection**: Select node with lowest f(n) value from open set
3. **Goal Check**: If current node is goal, reconstruct and return path
4. **Expansion**: For each neighbor, calculate g, h, and f values
5. **Update**: Add to open set if better path found or node is new
6. **Repeat**: Continue until goal found or open set is empty

## Mathematical Foundation:

- **g(n)**: Actual cost from start to node n
- **h(n)**: Heuristic estimate from node n to goal
- **f(n) = g(n) + h(n)**: Total estimated cost of path through n

## Source code:

```
import heapq
# Graph representation with letter nodes and costs
graph = {
   'A': {'B': 2, 'C': 3},
   'B': {'A': 2, 'C': 1, 'D': 4, 'E': 2},
   'C': {'A': 3, 'B': 1, 'F': 5},
   'D': {'B': 4, 'E': 1, 'G': 3},
   'E': {'B': 2, 'D': 1, 'F': 2, 'G': 2},
   'F': {'C': 5, 'E': 2, 'H': 1},
   'G': {'D': 3, 'E': 2, 'H': 2},
   'H': {'F': 1, 'G': 2}
}

# Heuristic function (admissible - never overestimates) def
get_heuristic_values(goal):
   # Straight-line distances to each possible goal
   heuristics = {
      'A': {'A': 0, 'B': 2, 'C': 3, 'D': 6, 'E': 4, 'F': 7, 'G': 6, 'H': 8},
      'B': {'A': 2, 'B': 0, 'C': 1, 'D': 4, 'E': 2, 'F': 5, 'G': 4, 'H': 6},       'C':
{'A': 3, 'B': 1, 'C': 0, 'D': 5, 'E': 3, 'F': 4, 'G': 5, 'H': 5},
      'D': {'A': 6, 'B': 4, 'C': 5, 'D': 0, 'E': 1, 'F': 3, 'G': 2, 'H': 3},
      'E': {'A': 4, 'B': 2, 'C': 3, 'D': 1, 'E': 0, 'F': 2, 'G': 2, 'H': 3},       'F':
{'A': 7, 'B': 5, 'C': 4, 'D': 3, 'E': 2, 'F': 0, 'G': 3, 'H': 1},
      'G': {'A': 6, 'B': 4, 'C': 5, 'D': 2, 'E': 2, 'F': 3, 'G': 0, 'H': 2},
      'H': {'A': 8, 'B': 6, 'C': 5, 'D': 3, 'E': 3, 'F': 1, 'G': 2, 'H': 0}
   }
   return heuristics.get(goal, {})

# A* Search Algorithm def a_star_search(graph,
start, goal):    if start not in graph or goal not in
graph:
      return None, float('inf'), "Invalid start or goal node"

   # Priority queue: (f_score, g_score, node)    open_set = []
   heapq.heappush(open_set, (0, 0, start))

   # Track the path
   came_from = {}

   # Cost from start to each node g_score = {node:
   float('inf') for node in graph} g_score[start] = 0
```

```
    # Estimated total cost from start to goal through each node heuristic_values =
    get_heuristic_values(goal) f_score = {node: float('inf') for node in graph}
    f_score[start] = heuristic_values.get(start, 0)

    # Keep track of nodes in open set
    open_set_nodes = {start}

    print(f"\nA* Search from {start} to {goal}")     print("Search
Progress:")
    print(f"{'Node':<4} {'g(n)':<6} {'h(n)':<6} {'f(n)':<6} {'Action'}")     print("-" *
35)

    while open_set:
        # Get node with lowest f_score
        current_f, current_g, current = heapq.heappop(open_set)
open_set_nodes.discard(current)

        h_value = heuristic_values.get(current, 0)
        print(f"{current:<4} {current_g:<6} {h_value:<6} {current_f:<6} Exploring")

        # Goal reached        if
current == goal:
            print(f"{current:<4} {current_g:<6} {h_value:<6} {current_f:<6} GOAL!")
break

        # Explore neighbors        for neighbor, cost in
graph.get(current, {}).items():            tentative_g =
g_score[current] + cost

            # Better path found            if tentative_g <
g_score[neighbor]:                came_from[neighbor] = current
g_score[neighbor] = tentative_g                h_neighbor =
heuristic_values.get(neighbor, 0)                f_score[neighbor]
= tentative_g + h_neighbor

                if neighbor not in open_set_nodes:                    heapq.heappush(open_set,
(f_score[neighbor], tentative_g, neighbor))
open_set_nodes.add(neighbor)

    # Reconstruct path if goal not in came_from and
    start != goal:
        return None, float('inf'), f"No path found from {start} to {goal}"
```

```
    path = [] node = goal while node
    in came_from:
    path.append(node)     node =
    came_from[node]
    path.append(start)
    path.reverse()

    total_cost = g_score[goal]
    return path, total_cost, "Optimal path found"

# Display graph information def display_graph():     print("Available nodes in the
graph:")     print("Nodes:", sorted(graph.keys()))     print("\nGraph connections with
costs:")     for node, neighbors in graph.items():         connections =
[f"{neighbor}({cost})" for neighbor, cost in neighbors.items()]         print(f"{node}: {',
'.join(connections)}")

# Main execution function def main():
    print("=" * 60)
    print("A* (A-STAR) SEARCH ALGORITHM BY JIGYASA KOIRALA")     print("=" *
60)

    display_graph()

    print("\n" + "-" * 40)

    # Get user input     while True:         start = input("\nEnter the source
node (A-H): ").strip().upper()         if start in graph:             break
        print("Invalid node! Please choose from A, B, C, D, E, F, G, H")

    while True:
        goal = input("Enter the destination node (A-H): ").strip().upper()         if
goal in graph:
            break
        print("Invalid node! Please choose from A, B, C, D, E, F, G, H")

    # Perform A* search path, total_cost, message =
    a_star_search(graph, start, goal)

    # Display results print("\n" + "=" *
    60) print("A* SEARCH RESULTS")
    print("=" * 60)

    if path:
```

```
    print(f"Status: {message}")    print(f"Optimal
  path: {' -> '.join(path)}")    print(f"Total optimal
  cost: {total_cost}")
    print(f"Number of nodes in path: {len(path)}")

    print("\nDetailed path costs:")
    running_cost = 0
    for i in range(len(path) - 1):
current_node = path[i]          next_node =
path[i + 1]
        edge_cost = graph[current_node][next_node]
        running_cost += edge_cost                print(f"  {current_node} -> {next_node}:
+{edge_cost} (total: {running_cost})")    else:
    print(f"Status: {message}")
    print(f"Cost: {total_cost}")

# Run the program if __name__ ==
"__main__":    main()
```

## Output: