The Superior University, Lahore

LAB-TASK (3) (Spring-2026)

Course Title:	Programming for AI (Lab)				Course Code:		-	Credit Hours	1
Instructor:	Sir Rasikh				Program:		BSDS		
Semester:	4th	Batch:	Morning	Section:	4A		Date:		-
Time Allowed:	-				Maximum Marks:			N/A	
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Work Assigned:

Question # 01:

Implement the Water Jug Problem using Depth-First Search (DFS) and print the rules applied at each step

DEPARTMENT OF
SOFTWARE
ENGINEERING

Introduction

The Water Jug Problem is a classic puzzle in computer science and artificial intelligence that teaches how to solve complex problems using logical thinking and systematic exploration. The challenge is simple: using two jugs with capacities of 4 liters and 3 liters, figure out a sequence of steps to measure exactly 2 liters of water. Although it sounds straightforward, the problem requires careful planning and exploration of different possibilities to find a solution. This project demonstrates how computers can automatically find solutions to such problems by exploring all possible states systematically.

Why I Made

This was created to learn and practice several important concepts in computer science. The main goals were:

- Understand how to break down complex problems into smaller, manageable steps
- Learn about state-space representation, where a problem is viewed as exploring different possible states
- Practice implementing search algorithms, specifically Depth-First Search, which explores possibilities systematically
- Understand the concept of backtracking when one path doesn't work, the algorithm reverses and tries another path
- Develop problem-solving skills by implementing code that finds logical solutions automatically
- Create clean, well-documented code that is easy to understand and explain

Through this project, I learned that many real-world problems can be solved using the same principles as the Water Jug Problem by representing the problem as states and transitions, and using search algorithms to find the path to the solution.

How It Works

Problem Definition

The Water Jug Problem has the following constraints:

- Jug 1 has a capacity of 4 liters
- Jug 2 has a capacity of 3 liters
- We start with both jugs empty
- We need to measure exactly 2 liters in one of the jugs

Allowed Operations

At each step, we can perform any of these six operations:

1. Fill Jug 1 completely
2. Fill Jug 2 completely
3. Empty Jug 1 completely
4. Empty Jug 2 completely
5. Pour water from Jug 1 to Jug 2 (until Jug 2 is full or Jug 1 is empty)
6. Pour water from Jug 2 to Jug 1 (until Jug 1 is full or Jug 2 is empty)

Representing the Problem

Each state of the problem is represented as a pair of numbers (x, y), where:

- x = amount of water currently in Jug 1 (can be 0, 1, 2, 3, or 4)
- y = amount of water currently in Jug 2 (can be 0, 1, 2, or 3)

For example, (4, 0) means Jug 1 is full with 4 liters and Jug 2 is empty. The goal state is either (2, y) or (x, 2) meaning we have exactly 2 liters in one of the jugs.

The Search Algorithm

The program solves this problem using a search algorithm that explores all possible states:

7. Step 1: Start with the initial state (0, 0)
8. Step 2: Check if the current state is the goal
9. Step 3: If not, generate all possible next states using the allowed operations
10. Step 4: Visit each new state and repeat the process
11. Step 5: If a state doesn't lead to the solution, go back and try a different path
12. Step 6: Once the goal is found, display the complete path

The Solution

The program finds the following steps to measure 2 liters:

Step	State (Jug 1, Jug 2)	Operation
Start	(0, 0)	Both jugs are empty
Step 1	(4, 0)	Fill Jug 1
Step 2	(4, 3)	Fill Jug 2
Step 3	(0, 3)	Empty Jug 1
Step 4	(3, 0)	Pour Jug 2 into Jug 1
Step 5	(3, 3)	Fill Jug 2
Step 6	(4, 2)	Pour Jug 2 into Jug 1 until Jug 1 is full

Goal achieved at Step 6: Jug 2 contains exactly 2 liters!

Summary

• The Water Jug Problem is a logical puzzle that can be solved by exploring different states systematically. It teaches important concepts about problem-solving and how computers can find solutions automatically.

• The solution requires exactly 6 operations to measure 2 liters in Jug 2. The program finds this solution by exploring different possibilities and keeping track of which states have already been visited to avoid going in circles.

• This project demonstrates that many complex problems can be solved using basic principles: represent the problem clearly, explore possibilities systematically, and remember what you've already tried. These skills are useful not just in computer science, but in solving any kind of problem.

Program Output

```
Found solution!
Jug 1: 4L, Jug 2: 3L, Target: 2L

Path:
0: (0, 0)
1: (4, 0)
2: (4, 3)
3: (0, 3)
4: (3, 0)
5: (3, 3)
6: (4, 2)

Operations:
1: Fill jug 1: (0, 0) => (4, 0)
2: Fill jug 2: (4, 0) => (4, 3)
3: Empty jug 1: (4, 3) => (0, 3)
4: Pour jug 2 to 1: (0, 3) => (3, 0)
5: Fill jug 2: (3, 0) => (3, 3)
6: Pour jug 2 to 1: (3, 3) => (4, 2)

Total moves: 6
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Conclusion

This Water Jug Problem project successfully demonstrates how algorithms can solve logical puzzles by exploring state spaces and finding optimal paths. The solution is found in just 6 steps, proving that what seems like a difficult puzzle is solvable through systematic exploration. This project has helped me understand fundamental concepts in problem-solving and artificial intelligence that form the foundation of computer science.