# Artificial Intelligence (CS308)

## Assignment - 1

## U19CS012

### Water Jug Problem

You are given two Jugs, a **4-gallon** one and a **3-gallon** one, a Pump which has **unlimited water** which you can use to fill the jug, and the **ground** on which water may be poured. Neither jug has any measuring markings on it.

How can you get **exactly 2 gallons** of water in the 4-gallon jug?

### State Space Representation

We will represent a state of the problem as a **Tuple (x, y),**

where **x** represents the amount of water in the 4-gallon jug and

**y** represents the amount of water in the 3-gallon jug.

[ Note: **$(0 \leq x \leq 4)$ & $(0 \leq y \leq 3)$** ]

### Initial State

**(0, 0)** OR User Input State [Valid]

### Final State

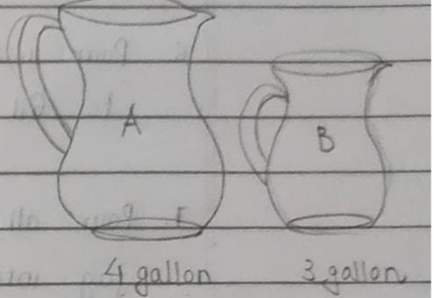
(2, **y**), where **$0 <= y <= 3$**

# WATER JUG PROBLEM

U19CS012

Problem: You are given two Jugs, a 4 gallon one and a 3 gallon one

A pump which has unlimited water which you can use to fill the jug, and the ground on which water may be poured.



How can you get exactly 2 gallons of water in 4-gallon jug?

State Represention : We will represent a state of the problem as a tuple $(x, y)$

$x$ : amount of water in 4-gallon Jug

$y$ : amount of water in 3-gallon Jug

[ $0 \leq x \leq 4$ and $0 \leq y \leq 2$ ]

Intial State : $(0, 0)$ [ or User Input ]

Goal State : $(2, y)$ where $0 \leq y \leq 3$

Operators - we must define a set of operators that will take us from one state to another.

1. Fill 4-gal Jug $\quad (x, y) \longrightarrow (4, y)$
   $x < 4$

2. Fill 3-gal Jug $\quad (x, y) \longrightarrow (x, 3)$
   $y < 3$

3. Empty 4-gal jug on ground $\quad (x, y) \longrightarrow (0, y)$
   $x > 0$

4. Empty 3-gal jug on ground $\quad (x, y) \longrightarrow (x, 0)$
   $y > 0$

5. Pour water from 3-gal Jug to fill 4 gal Jug — $(x,y) \longrightarrow (4, y-(4-x))$

   $0 < x+y \geq 4$ and $y > 0$

6. Pour water from 4-gal Jug to fill 3-gal Jug — $(x,y) \longrightarrow (x-(3-y), 3)$

   $0 < x+y \geq 3$ and $x > 0$

7. Pour all of water from 3-gal jug into 4-gal Jug — $(x,y) \longrightarrow (x+y, 0)$

   $0 < x+y \leq 4$ and $y \geq 0$

8. Pour all of water from 4-gal jug into 3-gal Jug — $(x,y) \longrightarrow (0, x+y)$

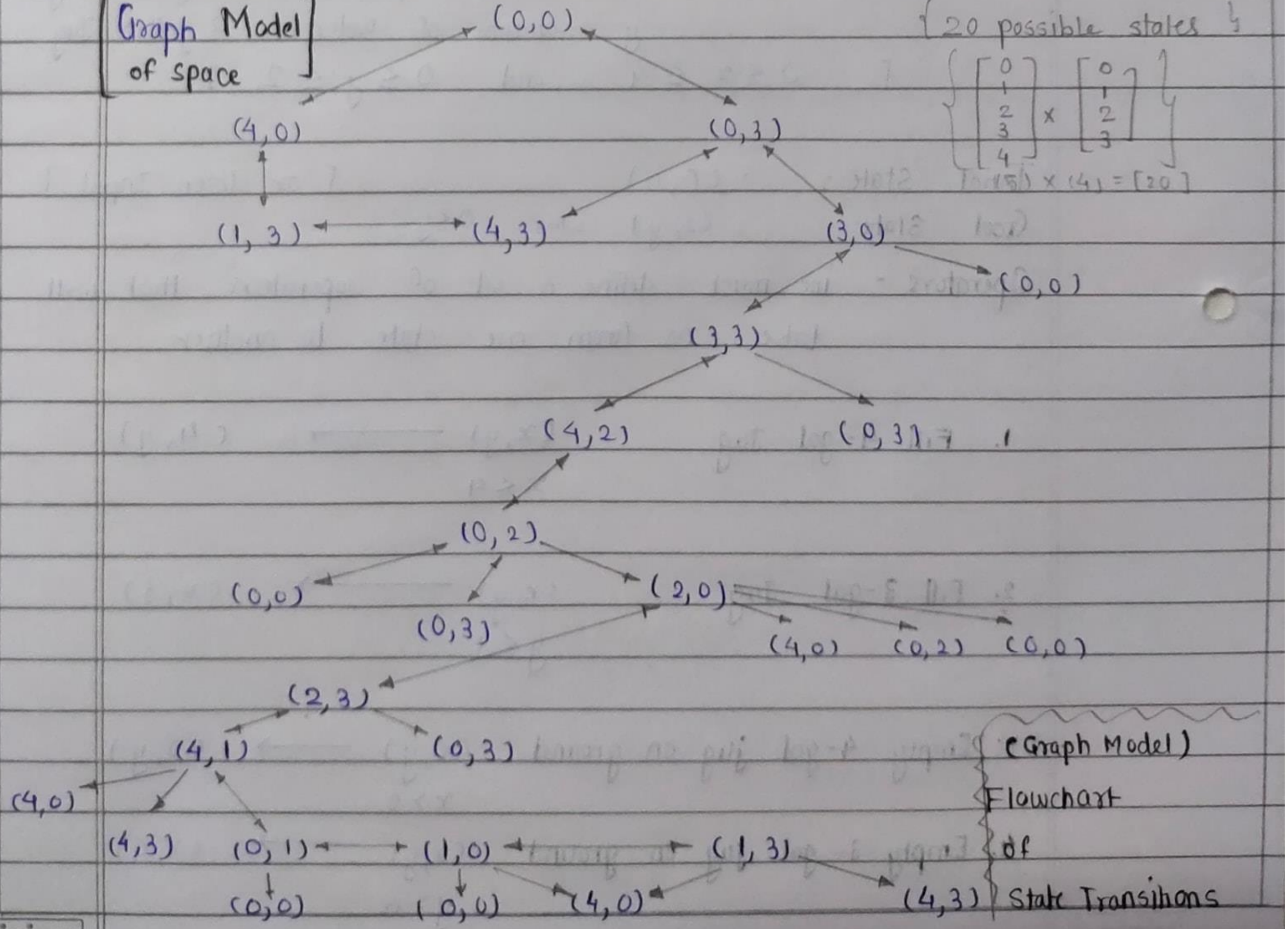
   $0 < x+y \leq 3$ and $x \geq 0$

[Graph Model of space]

{20 possible states}

$$\left\{ \begin{bmatrix} 0 \\ 1 \\ 2 \\ 3 \\ 4 \end{bmatrix} \times \begin{bmatrix} 0 \\ 1 \\ 2 \\ 3 \end{bmatrix} \right\}$$

$(5) \times (4) = [20]$

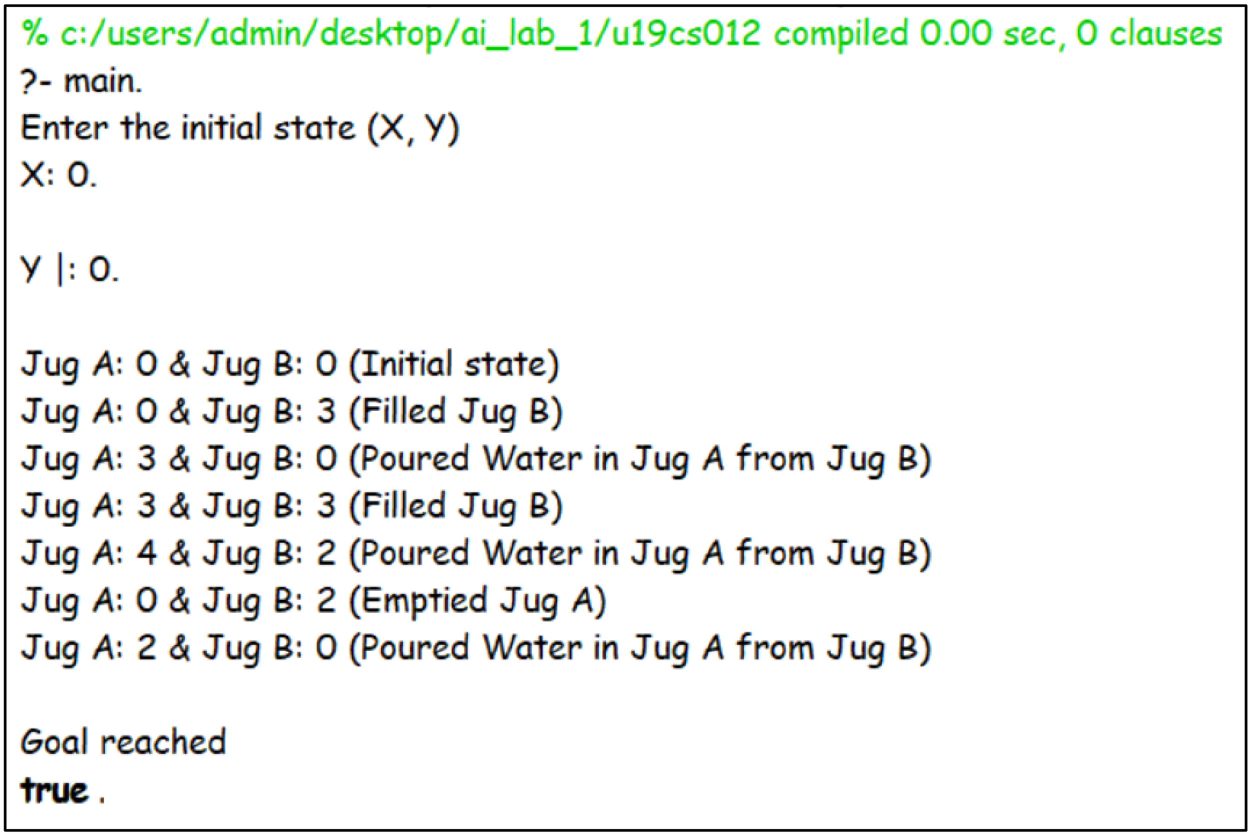


(Graph Model) Flowchart of State Transitions

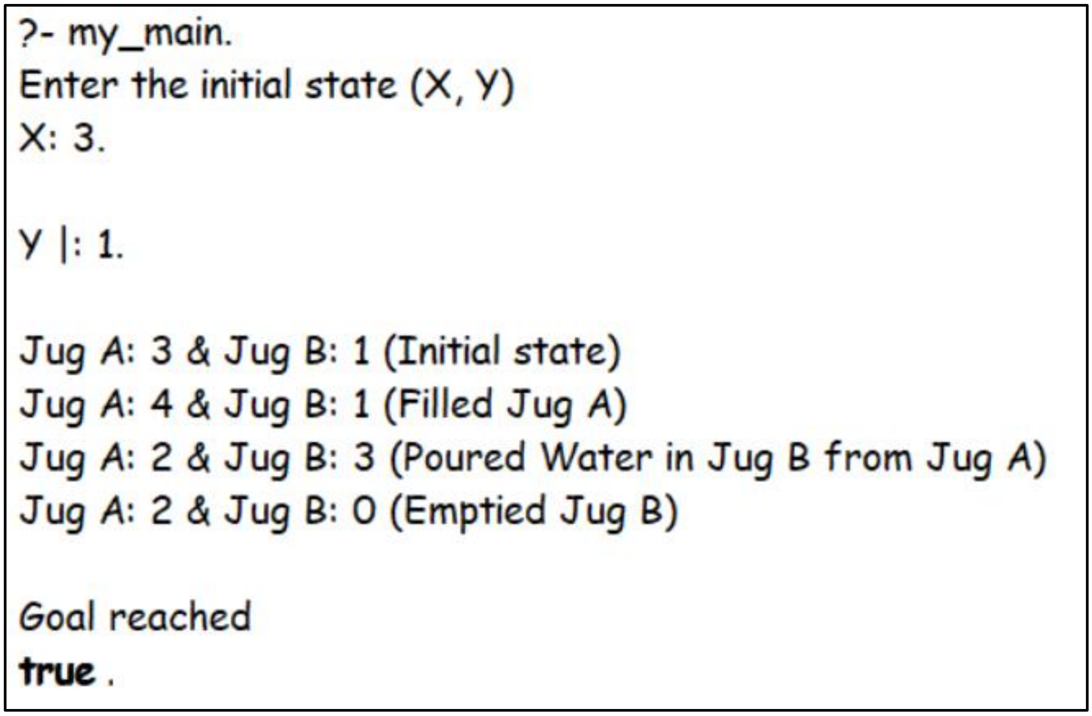
# Code

```
% Water Jug Problem [U19CS012] BHAGYA VINOD RANA

% Dead States in the Process [In-case if occurs]
water_jug(X, Y):-X>4, Y<3, write('jug 1 overflow\n').
water_jug(X, Y):-X<4, Y>3, write('jug 2 overflow\n').
water_jug(X, Y):-X>4, Y>3, write('jug 1 and 2 overflow\n').

% Final Goal State to be Achieved
water_jug(X, Y):- X=:=2, Y=:=0, write('\nGoal reached\n').

% Static Path to final state {2,0}
water_jug(X, Y):-

X=:=0, Y=:=0, write('Jug A: 0 & Jug B: 3 (Filled Jug B)\n'), water_jug(0, 3);
X=:=0, Y=:=3, write('Jug A: 3 & Jug B: 0 (Poured Water in Jug A from Jug B)\n'), water_jug(3,
0);
X=:=3, Y=:=0, write('Jug A: 3 & Jug B: 3 (Filled Jug B)\n'), water_jug(3, 3);
X=:=3, Y=:=3, write('Jug A: 4 & Jug B: 2 (Poured Water in Jug A from Jug B)\n'), water_jug(4,
2);
X=:=4, Y=:=2, write('Jug A: 0 & Jug B: 2 (Emptied Jug A)\n'), water_jug(0, 2);
X=:=0, Y=:=2, write('Jug A: 2 & Jug B: 0 (Poured Water in Jug A from Jug B)\n'), water_jug(2,
0);
X=:=4, Y=:=0, write('Jug A: 1 & Jug B: 3 (Poured Water in Jug B from Jug A)\n'), water_jug(1,
3);
X=:=1, Y=:=3, write('Jug A: 1 & Jug B: 0 (Emptied Jug B)\n'), water_jug(1, 0);
X=:=1, Y=:=0, write('Jug A: 0 & Jug B: 1 (Poured Water in Jug B from Jug A)\n'), water_jug(0,
1);
X=:=0, Y=:=1, write('Jug A: 4 & Jug B: 1 (Filled Jug A)\n'), water_jug(4, 1);
X=:=4, Y=:=1, write('Jug A: 2 & Jug B: 3 (Poured Water in Jug B from Jug A)\n'), water_jug(2,
3);
X=:=2, Y=:=3, write('Jug A: 2 & Jug B: 0 (Emptied Jug B)\n'), water_jug(2, 0).

% Other States Transitions.

water_jug(X, Y):-
X=:=2, Y>0, write('Jug A: 2 & Jug B: 0 (Emptied Jug B)\n'), water_jug(2, 0);
X=:=1, Y=:=1, write('Jug A: 2 & Jug B: 0 (Poured Water in Jug A from Jug B)\n'), water_jug(2,
0);
X=:=2, Y>0, write('Jug A: 2 & Jug B: 0 (Emptied Jug B)\n'), water_jug(2, 0);
X>0, Y=:=2, write('Jug A: 0 & Jug B: 2 (Emptied Jug A)\n'), water_jug(0, 2);
X>0, Y=:=3, write('Jug A: 0 & Jug B: 3 (Emptied Jug A)\n'), water_jug(0, 3);
X>0, Y=:=1, write('Jug A: 4 & Jug B: 1 (Filled Jug A)\n'), water_jug(4, 1).

main:- write("Enter the initial state (X, Y) \nX: "), read(A), write("\nY "), read(B),
write("\nJug A: "), write(A), write(" & Jug B: "), write(B),
write(" (Initial state)\n"), water_jug(A, B).
```

## Output



```
% c:/users/admin/desktop/ai_lab_1/u19cs012 compiled 0.00 sec, 0 clauses
?- main.
Enter the initial state (X, Y)
X: 0.

Y |: 0.

Jug A: 0 & Jug B: 0 (Initial state)
Jug A: 0 & Jug B: 3 (Filled Jug B)
Jug A: 3 & Jug B: 0 (Poured Water in Jug A from Jug B)
Jug A: 3 & Jug B: 3 (Filled Jug B)
Jug A: 4 & Jug B: 2 (Poured Water in Jug A from Jug B)
Jug A: 0 & Jug B: 2 (Emptied Jug A)
Jug A: 2 & Jug B: 0 (Poured Water in Jug A from Jug B)

Goal reached
true .
```



```
?- my_main.
Enter the initial state (X, Y)
X: 3.

Y |: 1.

Jug A: 3 & Jug B: 1 (Initial state)
Jug A: 4 & Jug B: 1 (Filled Jug A)
Jug A: 2 & Jug B: 3 (Poured Water in Jug B from Jug A)
Jug A: 2 & Jug B: 0 (Emptied Jug B)

Goal reached
true .
```

**SUBMITTED BY**: U19CS012

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