This lecture will look at a java program for solving the water-jugs problem.

We have two jugs X and Y.

X can hold 4 pints.

Y can hold 3.

Permissable moves are to fill X from Y, to fill Y from X, and to empty or fill either jug completely.

The aim is to find a sequence of actions, starting from empty jugs, which achieves a state in which Y contains exactly two pints.
Preliminaries

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Produce a sketch of the successor method

Represent jug contents by numbers.

State representation is a data structure containing two numbers.

Successor generation will involve looking at two numbers and finding out which actions are possible.

Is it possible to transfer from one jug to another?

Is it possible to empty a jug?

Is it possible to fill a jug?

How will these actions be applied within the chosen state representation?
import java.util.*;

class Node {
    int x = 0, y = 0; /* state variables */
    Node parent = null; /* parent link */

    Node (int x, int y, Node parent) {
        this.x = x;
        this.y = y;
        this.parent = parent;
    }

    public String toString() {
        return(x + " " + y);
    }

    public boolean equals(Object node) { /* argument has to be an Object */
        return(((Node)node).x == x && ((Node)node).y == y);
    }
}
NB. Use Vector instead of ArrayList because they allow ‘insert’ mutations.

```java
Vector<Node> getPath(Vector<Node> v) {
    v.insertElementAt(this, 0);
    if (parent != null) v = parent.getPath(v);
    return(v);
}

Vector<Node> getPath() { return(getPath(new Vector<Node>()));
}
public class WaterJugsSearch {
    
    boolean isGoal(Node node) {
        return(node.y == 2);
    }
}
Vector<Node> getSuccessors(Node parent) {
    int x = parent.x, y = parent.y;
    Vector<Node> successors = new Vector<Node>();
    if (x < 4 && y > 0) { /* transfer amount z from y to x */
        int z = Math.min(y, 4-x);
        successors.add(new Node(x+z, y-z, parent)); }
    if (y < 3 && x > 0) { /* transfer amount z from x to y */
        int z = Math.min(x, 3-y);
        successors.add(new Node(x-z, y+z, parent)); }
    if (x > 0) { /* empty x */
        successors.add(new Node(0, y, parent)); }
    if (y > 0) { /* empty y */
        successors.add(new Node(x, 0, parent)); }
    if (x < 4) { /* fill x from tap */
        successors.add(new Node(4, y, parent)); }
    if (y < 3) { /* fill y from tap */
        successors.add(new Node(x, 3, parent)); }
    return(successors);
}
void run() {
    Vector<Node> open = new Vector<Node>();
    open.add(new Node(0, 0, null));

    while (open.size() > 0) {
        Node node = open.remove(0);
        if (isGoal(node)) {
            System.out.println("Solution: " + node.getPath());
        } else {
            Vector<Node> successors = getSuccessors(node);
            for (int i = 0; i < successors.size(); i++) {
                Node child = successors.get(i);
                if (!node.getPath().contains((Object)child)) {
                    open.add(child);
                }
            }
        }
    }
}
public static void main(String args[]) { // do the search
    new WaterJugsSearch().run();
}
There are 12 distinct solutions:

Solution: [0 0, 0 3, 3 0, 3 3, 4 2]
Solution: [0 0, 4 0, 1 3, 0 3, 3 0, 3 3, 4 2]
Solution: [0 0, 4 0, 4 3, 0 3, 3 0, 3 3, 4 2]
Solution: [0 0, 4 0, 1 3, 4 3, 0 3, 3 0, 3 3, 4 2]
Solution: [0 0, 4 0, 1 3, 1 0, 0 1, 4 1, 2 3, 2 0, 0 2]
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- Node class
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Node class
WaterJugsSearch class with successor function
Summary

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- WaterJugsSearch class with successor function
- Main loop
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WaterJugsSearch class with successor function
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Output generated
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- Modify the program so that it implements an iterative-deepening search strategy.
Implement a version of the WaterJugsSearch program which searches for a debt-minimising sequence of card transfers (as detailed in the previous lecture).