Set 27: Recursion

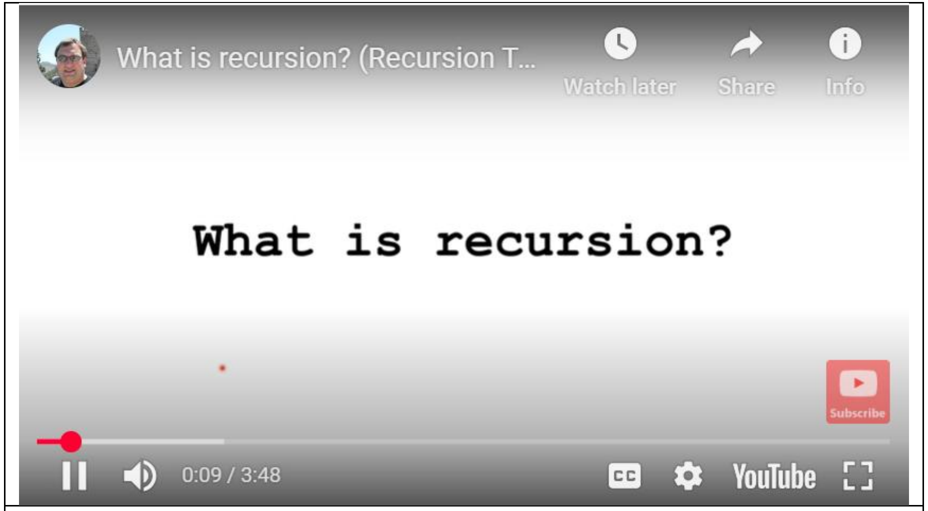
Skill 27.01: Explain what recursion is in JAVA
Skill 27.02: Implement a recursive method
Skill 27.03: Interpret the call stack
Skill 27.04: Trace recursive algorithms

Skill 27.01: Explain what recursion is in JAVA

Skill 27.01 Concepts

Recursion is a basic programming technique you can use in Java, in which a method calls itself to solve some problem. A method that uses this technique is recursive. Many programming problems can be solved only by recursion, and some problems that can be solved by other techniques are better solved by recursion.

The video below illustrates how recursion can be applied to solve a problem.



https://youtu.be/jc1gKVbu2aY

Skill 27.02: Implement a recursion method

Skill 27.02 Concepts

Before we write a recursive method, let's revisit how method calls are stored in memory.

Consider the example depicted below. In this example, the main method is the first method called, and it is the first method placed on the stack. Once inside the main method, we call aRecursiveMethod() and this method is placed on the stack. Inside aRecursiveMethod(), we call aRecursiveMethod() again, and it too is placed on the stack. Notice that, because aRecursiveMethod() calls aRecursiveMethod(), there is no end to the program. Eventually, you will incure
a stackOverflow error, because there is only so such much memory.

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Code	Call	Stack
`public class test{`	`main()`	`… stack overflow!`
`    public static void main(String[] args){`	`aRecursiveMethod()`	`aRecursiveMethod()`
`        Recursion.aRecursiveMethod();`	`aRecursiveMethod()`	`aRecursiveMethod()`
`    }`	`aRecursiveMethod()`	`aRecursiveMethod()`
`}`	`aRecursiveMethod()`	`aRecursiveMethod()`
	`aRecursiveMethod()`	`aRecursiveMethod()`
`class Recursion{`	`aRecursiveMethod()`	`aRecursiveMethod()`
`    public static void aRecursiveMethod(){`		`main()`
`        aRecursiveMethod();`		
`    }`		
`}`		

Avoiding a **stackOverflow** error requireds a **base case**. A **base case** is a condition that once met, stops the recursive call process.

In our example, we will create a new variable *count*. Each time *aRecursiveMethod*() is called, we will increment count. The calls to *aRecursiveMethod()* will end once the count reaches 4.

Code	Call	Stack	Count
`public class test{`	`main()`	`aRecursiveMethod()`	4
`    public static void main(String[] args){`	`aRecursiveMethod()`	`aRecursiveMethod()`	3
`        Recursion.aRecursiveMethod();`	`aRecursiveMethod()`	`aRecursiveMethod()`	2
`    }`	`aRecursiveMethod()`	`aRecursiveMethod()`	1
`}`	`aRecursiveMethod()`	`main()`	0
`class Recursion{`			
`    static int count = 0;`			
`    public static void aRecursiveMethod(){`			
`        count++;`			
`        while(count < 4)`			
`            aRecursiveMethod();`			
`    }`			
`}`			

Skill 27.03: Interpret the call stack

Skill 27.03 Concepts

In Java the **call stack** keeps track of the methods that you have called since the main method executes. A stack is a way of organizing data that adds and removes items only from the top of the stack. An example is a stack of cups. You can grap a cup from the top of the stack or add more cups at the top of the stack.

When you are executing one method (method a) and it calls another method (method b) the method call is placed on the call stack along with information about where it was called from, which tells the run-time where to return to when the current method finishes executing. Once method b finishes executing, the run-time pops method b off of the call stack and returns execution to the next line to be executed in method a.

Consider the example below.

The code below will cause a run-time error of division by zero when it runs. The main method calls the method test1 (at line 20) which calls the method test2 (at line 6) which has the divide by zero error (line 14). This can be seen in the call stack shown below which shows the call stack from the top (most recent method called) to the bottom (first method called).

Code

```java
public class Stack {

    public static void main(String[] args){
        System.out.println("In main");
        test1();
    }

    public static void test1(){
        System.out.println("In test1");
        test2();
        System.out.println("In test1 after test2");
    }

    public static void test2(){
        System.out.println("In test2");
        int y = 0;
        int x = 3/y;
    }
}
```

Output

```
In main
In test1
In test2
```

Call Stack

```
Exception in thread "main" java.lang.ArithmeticException: / by zero
        at Stack.test2(Stack.java:17)
        at Stack.test1(Stack.java:10)
        at Stack.main(Stack.java:5)
```

Skill 27.03: Exercise 1

Skill 27.04: Trace recursive algorithms

Skill 27.04 Concepts

When a program calls a function, that function goes on top of the call stack. This similar to a stack of books. You add things one at a time. Then, when you are ready to take something off, you always take off the top item.
Recursive functions add to the call stack until a **base case** is met. Once the base condition is met, the method calls "pop" off the stack.

This concept is further illustrated in the video below.

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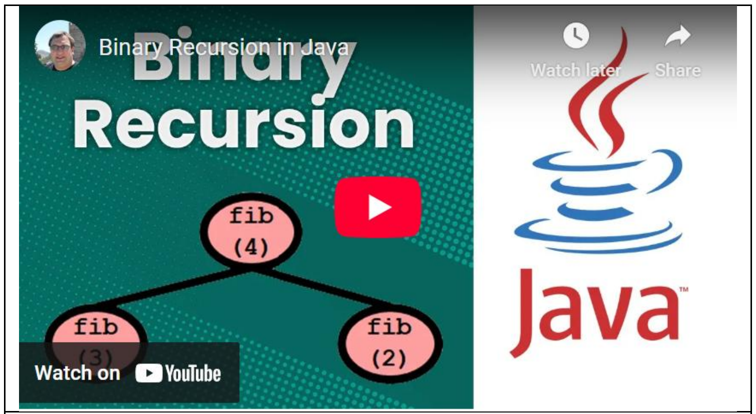
https://youtu.be/_rLBeHD3xps

The above illustrates a simple example of recursion. The next two examples, illustrate how to interpret **binary recursion** and **head and tail recursion**.

Binary recursion



https://youtu.be/wP19CnwXnIU

Head and tail recursion

https://youtu.be/o2nQDij5eqs

Skill 27.04: Exercises 1 thru 4

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