Northeastern University

# Lecture 21: Recursion - 1

Prof. Chen-Hsiang (Jones) Yu, Ph.D.

College of Engineering

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# What Is Recursion?

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- Consider hiring a contractor to build
  - He hires a subcontractor for a portion of the job
  - That subcontractor hires a sub-subcontractor to do a smaller portion of job
- The last sub-sub- … subcontractor finishes
  - Each one finishes and reports “done” up the line

# Example: The Countdown

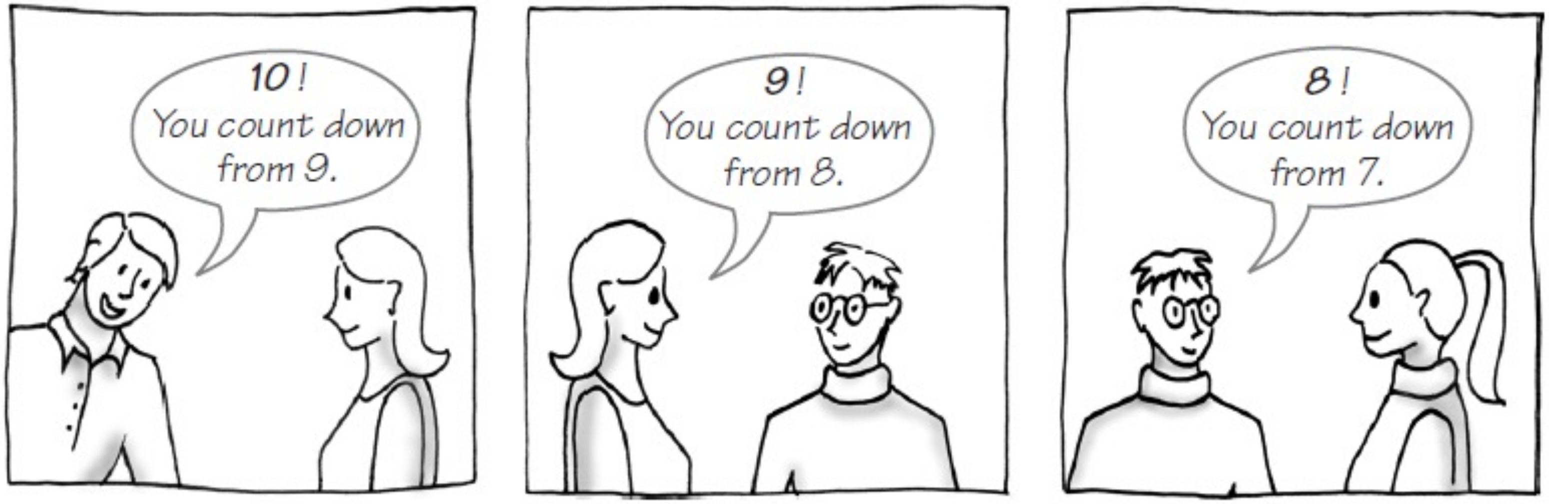
10! You count down from 9.
9! You count down from 8.
8! You count down from 7.

Figure 9-1: Counting down from 10

# Example: The Countdown

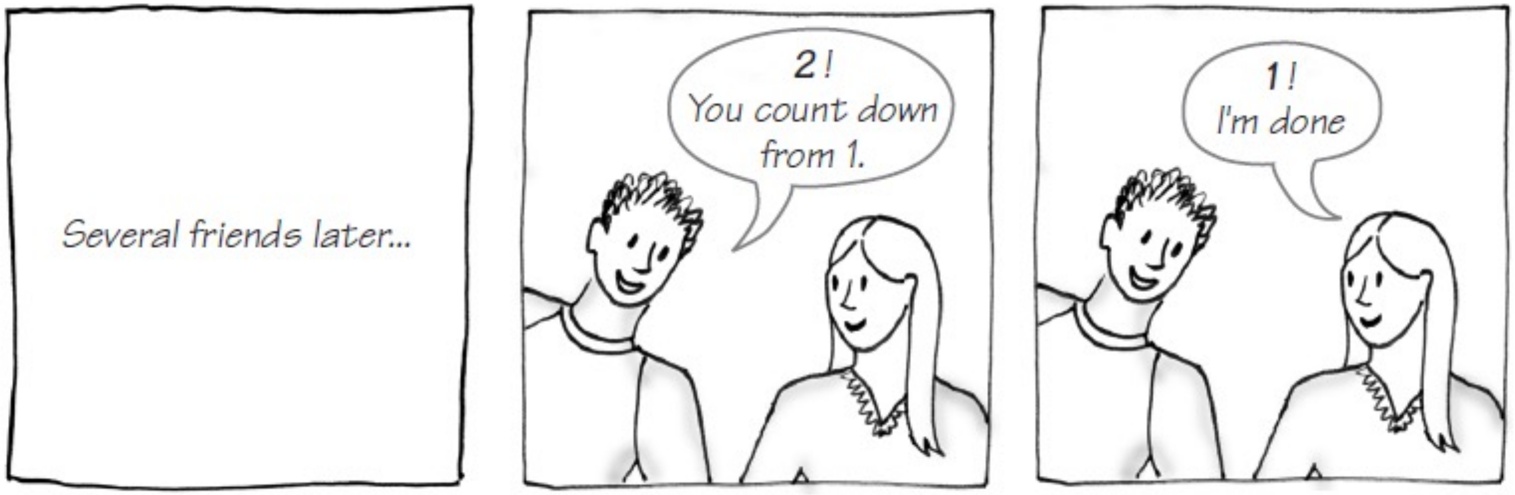

Figure 9-1: Counting down from 10

# Example: The Countdown

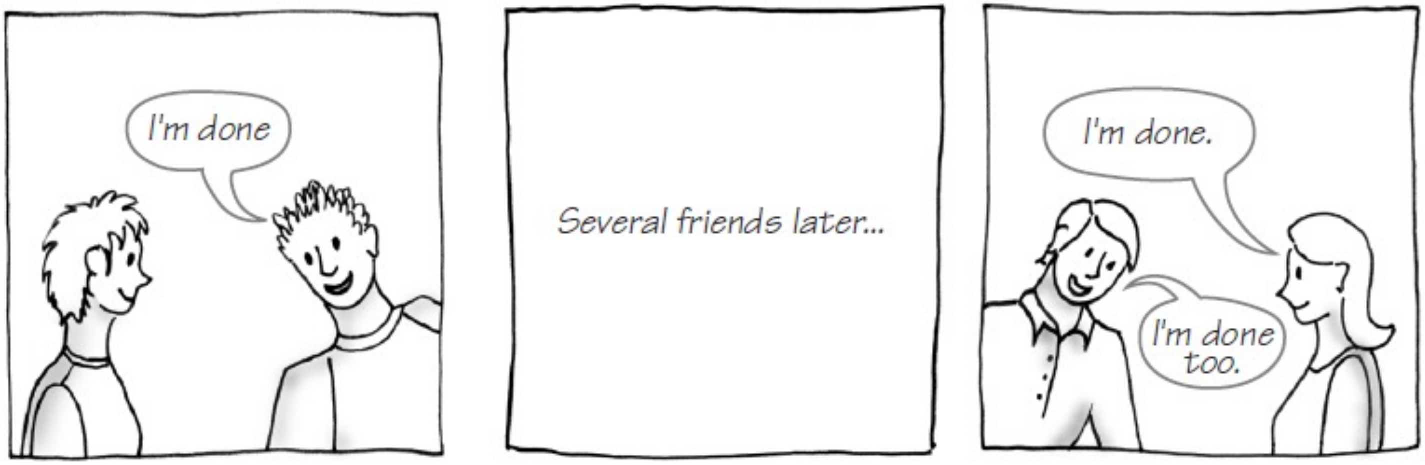

Figure 9-1: Counting down from 10

# Example: The Countdown

```java
/** Counts down from a given positive integer.
    @param integer  An integer > 0.
*/
public static void countDown(int integer)
{
   System.out.println(integer);
   if (integer > 1)
      countDown(integer - 1);
} // end countDown
```

Recursive Java method to do countdown.

# Definition

- Recursion is a problem-solving process
  - » Breaks a problem into identical but smaller problems.
- A method that calls itself is a recursive method.
  - » The invocation is a recursive call or recursive invocation.

# Design Guidelines

- Method must be given an input value.
- Method definition must contain logic that involves this input, leads to different cases.
- One or more cases should provide solution that does not require recursion.
  - » Otherwise, it is an infinite recursion
- One or more cases must include a recursive invocation.

# Programming Tip

- While iterative method contains a loop, recursive method calls itself.
- Some recursive methods contain a loop and call themselves.
  - » If the recursive method with loop uses `while`, make sure you did not mean to use an `if` statement.

# Tracing a Recursive Method

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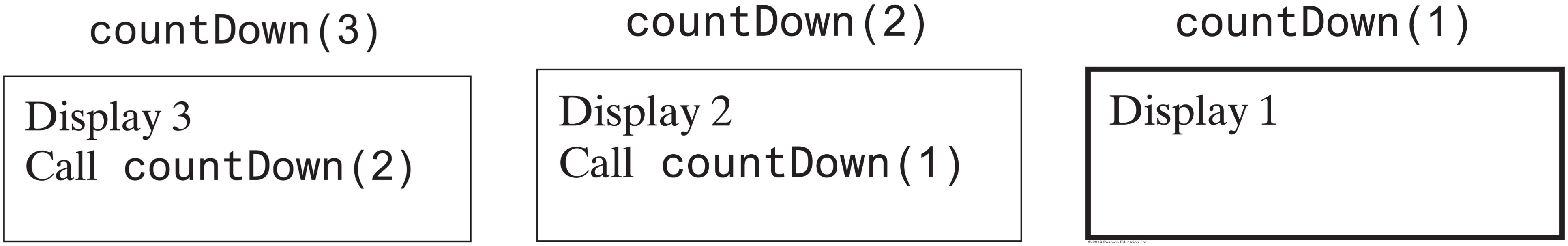

countDown(3)

Display 3
Call countDown(2)

countDown(2)

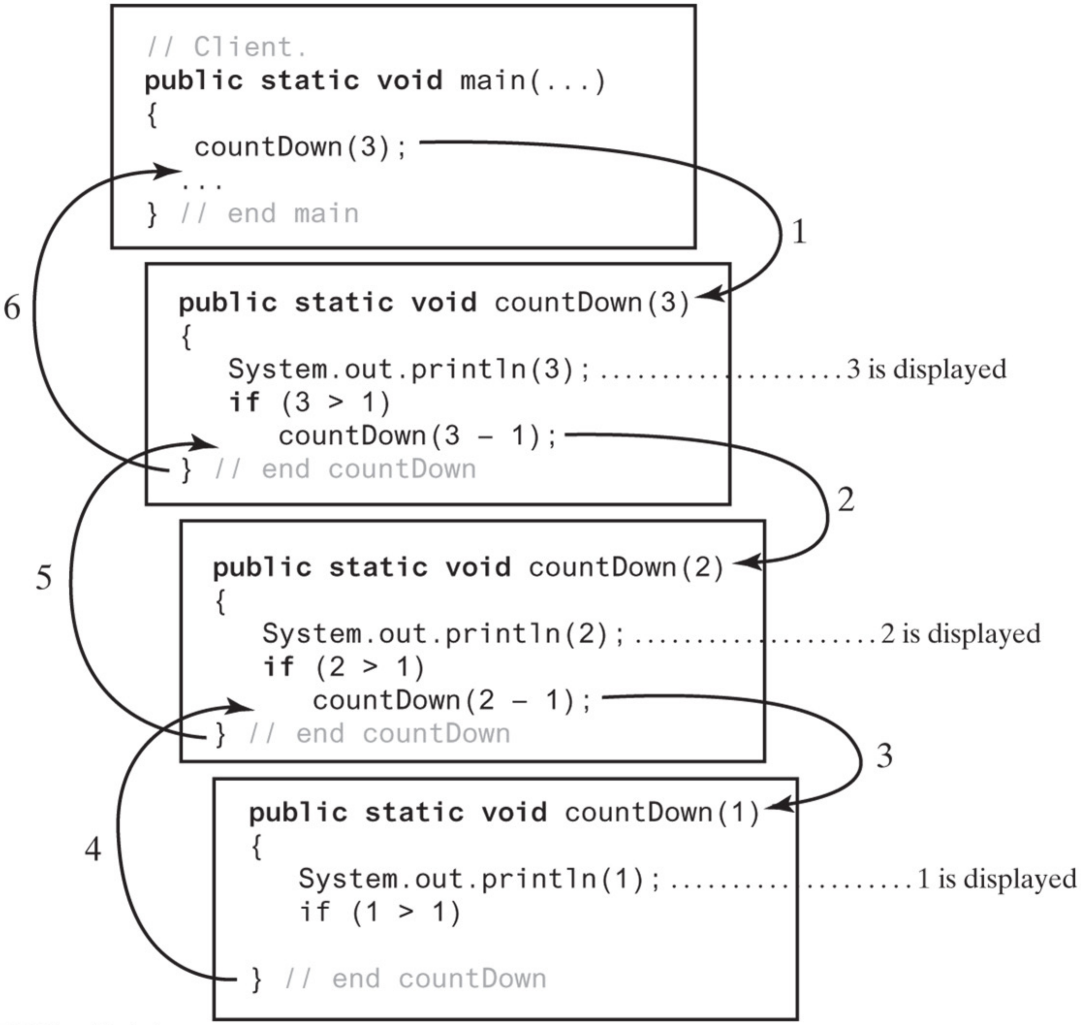
Display 2
Call countDown(1)

countDown(1)

Display 1

Figure 9-2: The effect of the method call `countDown(3)`

# Tracing a Recursive Method



```
// Client.
public static void main(...)
{
   countDown(3);
   ...
} // end main
```

```
public static void countDown(3)
{
   System.out.println(3);
   if (3 > 1)
      countDown(3 – 1);
} // end countDown
```

```
public static void countDown(2)
{
   System.out.println(2);
   if (2 > 1)
      countDown(2 – 1);
} // end countDown
```

```
public static void countDown(1)
{
   System.out.println(1);
   if (1 > 1)

} // end countDown
```

Figure 9-3: Tracing the execution of `countdown(3)`

# Tracing a Recursive Method

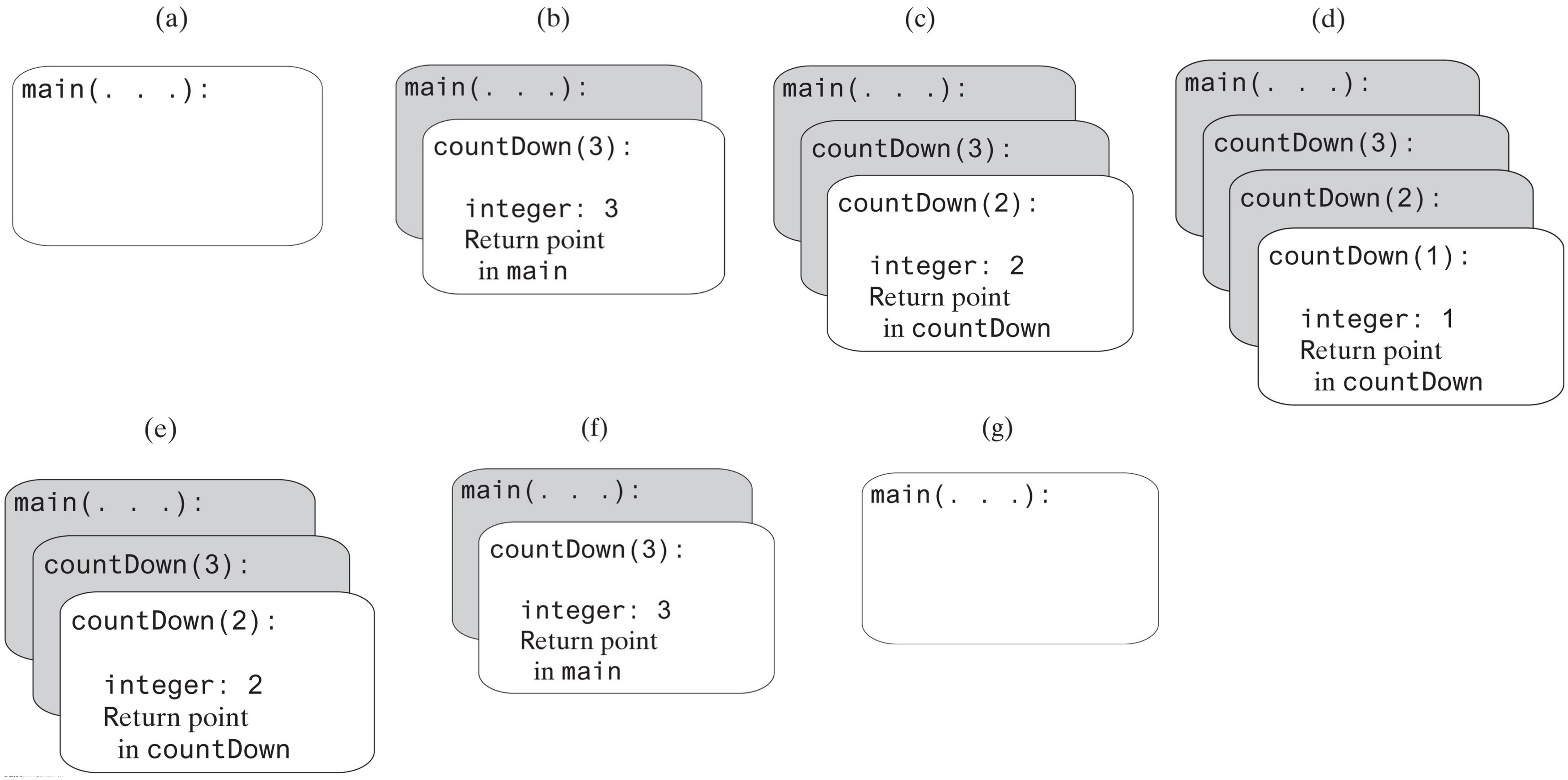


Figure 9-4: The stack of activation records during the execution of the call `countDown(3)`

# Stack of Activation Records

- Each call to a method generates an activation record.
- Recursive method uses more memory than an iterative method.
  - Each recursive call generates an activation record.
- If recursive call generates too many activation records, it could cause stack overflow.

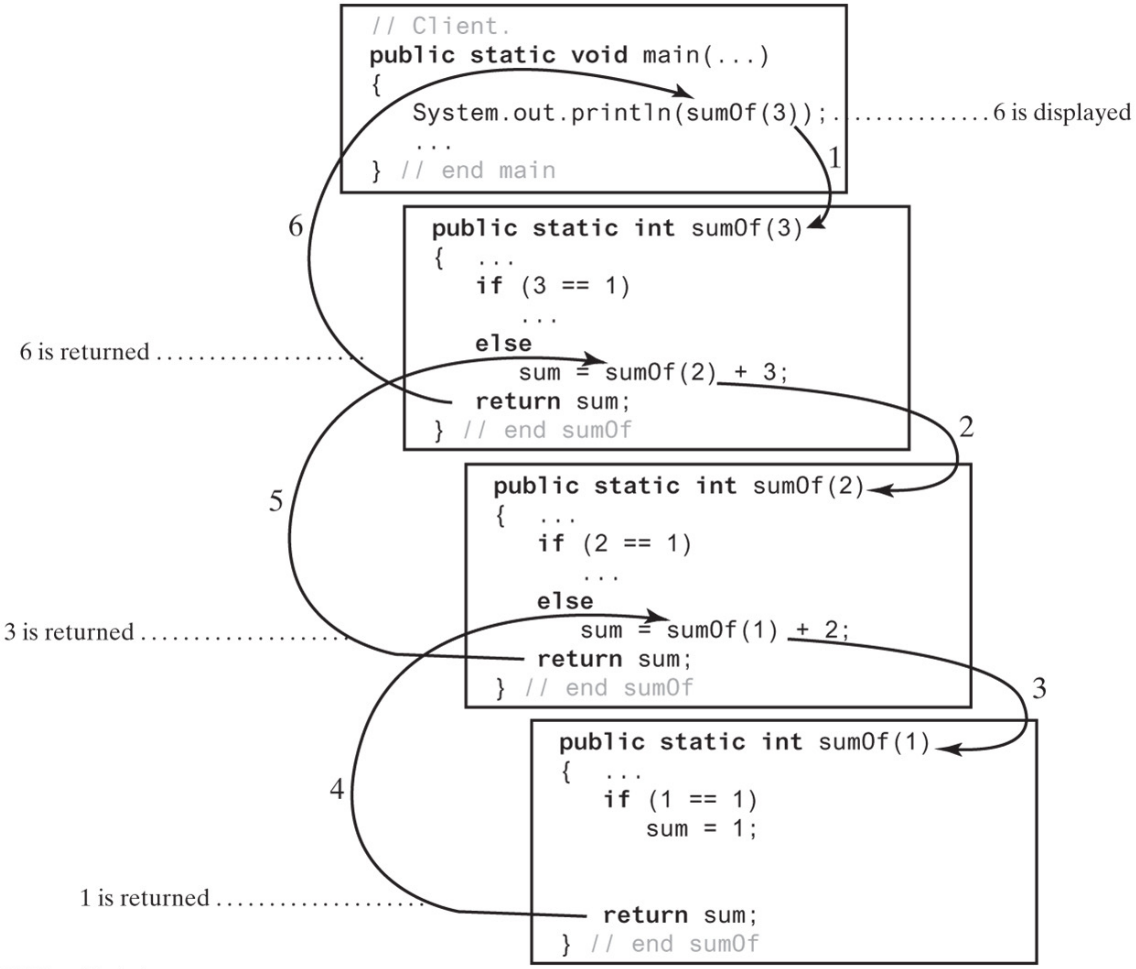
# Recursive Methods That Return a Value

```
/** @param n  An integer > 0.
    @return  The sum 1 + 2 + ... + n. */
public static int sumOf(int n)
{
   int sum;
   if (n == 1)
      sum = 1;                        // Base case
   else
      sum = sumOf(n - 1) + n; // Recursive call

   return sum;
} // end sumOf
```

Recursive method to calculate $\sum_{i=1}^{n} i$

# Tracing a Recursive Method



```
// Client.
public static void main(...)
{
   System.out.println(sumOf(3));
   ...
} // end main
```

```
public static int sumOf(3)
{  ...
   if (3 == 1)
      ...
   else
      sum = sumOf(2) + 3;
   return sum;
} // end sumOf
```

```
public static int sumOf(2)
{  ...
   if (2 == 1)
      ...
   else
      sum = sumOf(1) + 2;
   return sum;
} // end sumOf
```

```
public static int sumOf(1)
{  ...
   if (1 == 1)
      sum = 1;


   return sum;
} // end sumOf
```

Figure 9-5: Tracing the execution of `sumOf(3)`

# Exercise (L21_E1)

- A child is running up a staircase with *n* steps, and can hop either 1 step, 2 steps, or 3 steps at a time.
- Implement a method to count how many possible ways the child can run up the stairs.

# Answer

```java
public class L21_E1 {

  public static void main(String[] args){
    //Assume the staircase has 20 steps
    int result = countWays(20);
    System.out.println("There are " + result + " ways");
  }

  private static int countWays(int n){
    if(n<0){
      return 0;
    }else if(n == 0){
      return 1;
    }else{
      return countWays(n-1)+countWays(n-2)+countWays(n-3);
    }
  }

}
```