Recursive Programming

How Recursive Programs Work

A recursive method is a method that calls itself

```
public static void example1(int a, int b) {
    if (a>b) {
       System.out.println("a: "+a+", b: "+b);
       example1(a-1,b);
    }
 }
```

What will be the output of this method, given the call

```
example1(6,2);
```

```
1 public class NonRecursive {

2     public static void main(String[] args) {
3       m1(3);
4     }
5     public static void m1(int a) {
6        System.out.println("a: "+a);
7        m2(a-1);
8    }
9     public static void m2 (int a) {
10       System.out.println("a: "+a);
11       m3(a-1);
12    }
13    public static void m3 (int a) {
14       System.out.println("a: "+a);
      }
   }
```

method: *main*; return: JVM

```
1 public class NonRecursive {

2     public static void main(String[] args) {
3       m1(3);
4     }
5     public static void m1(int a) {
6        System.out.println("a: "+a);
7        m2(a-1);
8    }
9     public static void m2 (int a) {
10       System.out.println("a: "+a);
11       m3(a-1);
12    }
13    public static void m3 (int a) {
14       System.out.println("a: "+a);
      }
   }
```

method: *main*; return: 4
method: *main*; return: JVM

```
1 public class NonRecursive {

2     public static void main(String[] args) {
3       m1(3);
4     }
5     public static void m1(int a) {
6        System.out.println("a: "+a);
7        m2(a-1);
8    }
9     public static void m2 (int a) {
10       System.out.println("a: "+a);
11       m3(a-1);
12    }
13    public static void m3 (int a) {
14       System.out.println("a: "+a);
      }
   }
```

Output:
a: 3

method: m1; return: 7; a=3
method: *main*; return: 4
method: *main*; return: JVM

```
1 public class NonRecursive {

2     public static void main(String[] args) {
3       m1(3);
4     }
5     public static void m1(int a) {
6        System.out.println("a: "+a);
7        m2(a-1);
8    }
9     public static void m2 (int a) {
10       System.out.println("a: "+a);
11       m3(a-1);
12    }
13    public static void m3 (int a) {
14       System.out.println("a: "+a);
      }
   }
```

Output:
a: 3

method: m1; return: 8; a=3
method: *main*; return: 4
method: *main*; return: JVM

```
1 public class NonRecursive {

2     public static void main(String[] args) {
3       m1(3);
4     }
5     public static void m1(int a) {
6        System.out.println("a: "+a);
7        m2(a-1);
8    }
9     public static void m2 (int a) {
10       System.out.println("a: "+a);
11       m3(a-1);
12    }
13    public static void m3 (int a) {
14       System.out.println("a: "+a);
      }
   }
```

Output:
a: 3
a:2

method: m2; return=11; a=2
method: m1; return: 8; a=3
method: *main*; return: 4
method: *main*; return: JVM

```
1 public class NonRecursive {

2     public static void main(String[] args) {
3       m1(3);
4     }
5     public static void m1(int a) {
6        System.out.println("a: "+a);
7        m2(a-1);
8    }
9     public static void m2 (int a) {
10       System.out.println("a: "+a);
11       m3(a-1);
12    }
13    public static void m3 (int a) {
14       System.out.println("a: "+a);
      }
   }
```

Output:
a: 3
a:2

method: m2; return=12; a=2
method: m1; return: 8; a=3
method: *main*; return: 4
method: *main*; return: JVM

```
1 public class NonRecursive {

2     public static void main(String[] args) {
3       m1(3);
4     }
5     public static void m1(int a) {
6        System.out.println("a: "+a);
7        m2(a-1);
8    }
9     public static void m2 (int a) {
10       System.out.println("a: "+a);
11       m3(a-1);
12    }
13    public static void m3 (int a) {
14       System.out.println("a: "+a);
15      }
   }
```

Output:

a: 3

a:2

a: 1

method: m3; return=15;a=1
method: m2; return=12; a=2
method: m1; return: 8; a=3
method: *main*; return: 4
method: *main*; return: JVM

```
1 public class NonRecursive {

2     public static void main(String[] args) {
3       m1(3);
4     }
5     public static void m1(int a) {
6        System.out.println("a: "+a);
7        m2(a-1);
8    }
9     public static void m2 (int a) {
10       System.out.println("a: "+a);
11       m3(a-1);
12    }
13    public static void m3 (int a) {
14       System.out.println("a: "+a);
15     }
   }
```

Output:

a: 3

a:2

a: 1

method: m3; return=15;a=1

method: m2; return=12; a=2

method: m1; return: 8; a=3

method: *main*; return: 4

method: *main*; return: JVM

```
1 public class NonRecursive {

2     public static void main(String[] args) {
3       m1(3);
4     }
5     public static void m1(int a) {
6        System.out.println("a: "+a);
7        m2(a-1);
8    }
9     public static void m2 (int a) {
10       System.out.println("a: "+a);
11       m3(a-1);
12    }
13    public static void m3 (int a) {
14       System.out.println("a: "+a);
15      }
   }
```

Output:

a: 3

a:2

a: 1

method: m3; return=15;a=1

method: m2; return=12; a=2

method: m1; return: 8; a=3

method: *main*; return: 4

method: *main*; return: JVM

```
1 public class NonRecursive {

2     public static void main(String[] args) {
3       m1(3);
4     }
5     public static void m1(int a) {
6        System.out.println("a: "+a);
7        m2(a-1);
8    }
9     public static void m2 (int a) {
10       System.out.println("a: "+a);
11       m3(a-1);
12    }
13    public static void m3 (int a) {
14       System.out.println("a: "+a);
15      }
   }
```

Output:

a: 3

a:2

a: 1

method: m3; return=15;a=1

method: m2; return=12; a=2

method: m1; return: 8; a=3

method: *main*; return: 4

method: *main*; return: JVM

```
1 public class NonRecursive {

2     public static void main(String[] args) {
3       m1(3);
4     }
5     public static void m1(int a) {
6        System.out.println("a: "+a);
7        m2(a-1);
8    }
9     public static void m2 (int a) {
10       System.out.println("a: "+a);
11       m3(a-1);
12    }
13    public static void m3 (int a) {
14       System.out.println("a: "+a);
15      }
   }
```

Output:

a: 3

a:2

a: 1

method: m3; return=15;a=1
method: m2; return=12; a=2
method: m1; return: 8; a=3
method: *main*; return: 4
method: *main*; return: JVM

```
1 public class NonRecursive {

2     public static void main(String[] args) {
3       m1(3);
4     }
5     public static void m1(int a) {
6        System.out.println("a: "+a);
7        m2(a-1);
8    }
9     public static void m2 (int a) {
10       System.out.println("a: "+a);
11       m3(a-1);
12    }
13    public static void m3 (int a) {
14       System.out.println("a: "+a);
15      }
   }
```

Output:

a: 3

a:2

a: 1

method: m3; return=15;a=1
method: m2; return=12; a=2
method: m1; return: 8; a=3
method: *main*; return: 4
method: *main*; return: JVM

```
1  public class Example1 {
2    public static void main(String[] args) {
3       example1(6,2);
4    }
5    public static void example1(int a, int b) {
6       if (a>b) {
7          System.out.println("a: "+a+", b: "+b);
8          example1(a-1,b);
9       }
10   }
11 }
```

method: *main*; return: 4;

```
1  public class Example1 {
2    public static void main(String[] args) {
3       example1(6,2);
4    }
5    public static void example1(int a, int b) {
6       if (a>b) {
7          System.out.println("a: "+a+", b: "+b);
8          example1(a-1,b);
9       }
10   }
11 }
```

method: *example1;* return: 4; a=6; b=2
method: *main*; return: 4;

```
1  public class Example1 {
2    public static void main(String[] args) {
3       example1(6,2);
4    }
5    public static void example1(int a, int b) {
6       if (a>b) {
7          System.out.println("a: "+a+", b: "+b);
8          example1(a-1,b);
9       }
10   }
11 }
```

Output:

```
a: 6, b: 2
```

method: *example1;* return: 4; a=6; b=2
method: *main*; return: 4;

```
1  public class Example1 {
2    public static void main(String[] args) {
3       example1(6,2);
4    }
5    public static void example1(int a, int b) {
6       if (a>b) {
7          System.out.println("a: "+a+", b: "+b);
8          example1(a-1,b);
9       }
10   }
11 }
```

method: *example1;* return: 4; a=6; b=2

Output:

```
a: 6, b: 2
```

method: *example1;* return: 9; a=5; b=2
method: *example1;* return: 4; a=6; b=2
method: *main*; return: 4;

```
1  public class Example1 {
2    public static void main(String[] args) {
3       example1(6,2);
4    }
5    public static void example1(int a, int b) {
6       if (a>b) {
7          System.out.println("a: "+a+", b: "+b);
8          example1(a-1,b);
9       }
10   }
11 }
```

Output:

```
a: 6, b: 2
```

method: *example1;* return: 9; a=5; b=2
method: *example1;* return: 4; a=6; b=2
method: *main*; return: 4;

```
1  public class Example1 {
2    public static void main(String[] args) {
3       example1(6,2);
4    }
5    public static void example1(int a, int b) {
6       if (a>b) {
7          System.out.println("a: "+a+", b: "+b);
8          example1(a-1,b);
9       }
10   }
11 }
```

Output:

```
a: 6, b: 2
a: 5, b: 2
```

method: *example1;* return: 9; a=5; b=2
method: *example1;* return: 4; a=6; b=2
method: *main*; return: 4;

```
1  public class Example1 {
2    public static void main(String[] args) {
3       example1(6,2);
4    }
5    public static void example1(int a, int b) {
6       if (a>b) {
7          System.out.println("a: "+a+", b: "+b);
8          example1(a-1,b);
9       }
10   }
11 }
```

Output:

```
a: 6, b: 2
a: 5, b: 2
```

method: *example1;* return: 9; a=4; b=2
method: *example1;* return: 9; a=5; b=2
method: *example1;* return: 4; a=6; b=2
method: *main*; return: 4;

```
1  public class Example1 {
2    public static void main(String[] args) {
3       example1(6,2);
4    }
5    public static void example1(int a, int b) {
6       if (a>b) {
7          System.out.println("a: "+a+", b: "+b);
8          example1(a-1,b);
9       }
10   }
11 }
```

Output:

```
a: 6, b: 2
a: 5, b: 2
```

method: *example1;* return: 9; a=4; b=2
method: *example1;* return: 9; a=5; b=2
method: *example1;* return: 4; a=6; b=2
method: *main*; return: 4;

```
1  public class Example1 {
2    public static void main(String[] args) {
3       example1(6,2);
4    }
5    public static void example1(int a, int b) {
6       if (a>b) {
7          System.out.println("a: "+a+", b: "+b);
8          example1(a-1,b);
9       }
10   }
11 }
```

Output:

```
a: 6, b: 2
a: 5, b: 2
a: 4, b: 2
```

method: *example1;* return: 9; a=4; b=2
method: *example1;* return: 9; a=5; b=2
method: *example1;* return: 4; a=6; b=2
method: *main*; return: 4;

```
1  public class Example1 {
2    public static void main(String[] args) {
3       example1(6,2);
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5    public static void example1(int a, int b) {
6       if (a>b) {
7          System.out.println("a: "+a+", b: "+b);
8          example1(a-1,b);
9       }
10   }
11 }
```

Output:

```
a: 6, b: 2
a: 5, b: 2
a: 4, b: 2
```

method: *example1;* return: 9; a=3; b=2
method: *example1;* return: 9; a=4; b=2
method: *example1;* return: 9; a=5; b=2
method: *example1;* return: 4; a=6; b=2
method: *main*; return: 4;

```
1  public class Example1 {
2    public static void main(String[] args) {
3       example1(6,2);
4    }
5    public static void example1(int a, int b) {
6       if (a>b) {
7          System.out.println("a: "+a+", b: "+b);
8          example1(a-1,b);
9       }
10   }
11 }
```

Output:

```
a: 6, b: 2
a: 5, b: 2
a: 4, b: 2
```

method: *example1;* return: 9; a=3; b=2
method: *example1;* return: 9; a=4; b=2
method: *example1;* return: 9; a=5; b=2
method: *example1;* return: 4; a=6; b=2
method: *main*; return: 4;

```
1  public class Example1 {
2    public static void main(String[] args) {
3       example1(6,2);
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5    public static void example1(int a, int b) {
6       if (a>b) {
7          System.out.println("a: "+a+", b: "+b);
8          example1(a-1,b);
9       }
10   }
11 }
```

Output:

```
a: 6, b: 2
a: 5, b: 2
a: 4, b: 2
a: 3, b: 2
```

method: *example1;* return: 9; a=3; b=2
method: *example1;* return: 9; a=4; b=2
method: *example1;* return: 9; a=5; b=2
method: *example1;* return: 4; a=6; b=2
method: *main*; return: 4;

```
1  public class Example1 {
2    public static void main(String[] args) {
3       example1(6,2);
4    }
5    public static void example1(int a, int b) {
6       if (a>b) {
7          System.out.println("a: "+a+", b: "+b);
8          example1(a-1,b);
9       }
10   }
11 }
```

Output:

```
a: 6, b: 2
a: 5, b: 2
a: 4, b: 2
a: 3, b: 2
```

method: *example1;* return: 9; a=2; b= 2
method: *example1;* return: 9; a=3; b=2
method: *example1;* return: 9; a=4; b=2
method: *example1;* return: 9; a=5; b=2
method: *example1;* return: 4; a=6; b=2
method: *main*; return: 4;

```
1  public class Example1 {
2    public static void main(String[] args) {
3       example1(6,2);
4    }
5    public static void example1(int a, int b) {
6       if (a>b) {
7          System.out.println("a: "+a+", b: "+b);
8          example1(a-1,b);
9       }
10   }
11 }
```

Output:

```
a: 6, b: 2
a: 5, b: 2
a: 4, b: 2
a: 3, b: 2
```

method: *example1;* return: 9; a=2; b= 2
method: *example1;* return: 9; a=3; b=2
method: *example1;* return: 9; a=4; b=2
method: *example1;* return: 9; a=5; b=2
method: *example1;* return: 4; a=6; b=2
method: *main*; return: 4;

```
1  public class Example1 {
2    public static void main(String[] args) {
3       example1(6,2);
4    }
5    public static void example1(int a, int b) {
6       if (a>b) {
7          System.out.println("a: "+a+", b: "+b);
8          example1(a-1,b);
9       }
10   }
11 }
```

Output:

```
a: 6, b: 2
a: 5, b: 2
a: 4, b: 2
a: 3, b: 2
```

method: *example1;* return: 9; a=2; b= 2
method: *example1;* return: 9; a=3; b=2
method: *example1;* return: 9; a=4; b=2
method: *example1;* return: 9; a=5; b=2
method: *example1;* return: 4; a=6; b=2
method: *main*; return: 4;

```
1  public class Example1 {
2    public static void main(String[] args) {
3       example1(6,2);
4    }
5    public static void example1(int a, int b) {
6       if (a>b) {
7          System.out.println("a: "+a+", b: "+b);
8          example1(a-1,b);
9       }
10   }
11 }
```

Output:

```
a: 6, b: 2
a: 5, b: 2
a: 4, b: 2
a: 3, b: 2
```

method: *example1;* return: 9; a=2; b= 2
method: *example1;* return: 9; a=3; b=2
method: *example1;* return: 9; a=4; b=2
method: *example1;* return: 9; a=5; b=2
method: *example1;* return: 4; a=6; b=2
method: *main*; return: 4;

```
1  public class Example1 {
2    public static void main(String[] args) {
3       example1(6,2);
4    }
5    public static void example1(int a, int b) {
6       if (a>b) {
7          System.out.println("a: "+a+", b: "+b);
8          example1(a-1,b);
9       }
10   }
11 }
```

Output:

```
a: 6, b: 2
a: 5, b: 2
a: 4, b: 2
a: 3, b: 2
```

method: *example1;* return: 9; a=2; b= 2
method: *example1;* return: 9; a=3; b=2
method: *example1;* return: 9; a=4; b=2
method: *example1;* return: 9; a=5; b=2
method: *example1;* return: 4; a=6; b=2
method: *main*; return: 4;

```
1  public class Example1 {
2    public static void main(String[] args) {
3       example1(6,2);
4    }
5    public static void example1(int a, int b) {
6       if (a>b) {
7          System.out.println("a: "+a+", b: "+b);
8          example1(a-1,b);
9       }
10   }
11 }
```

Output:

```
a: 6, b: 2
a: 5, b: 2
a: 4, b: 2
a: 3, b: 2
```

method: *example1;* return: 9; a=2; b= 2
method: *example1;* return: 9; a=3; b=2
method: *example1;* return: 9; a=4; b=2
method: *example1;* return: 9; a=5; b=2
method: *example1;* return: 4; a=6; b=2
method: *main*; return: 4;

```
1  public class Example1 {
2    public static void main(String[] args) {
3       example1(6,2);
4    }
5    public static void example1(int a, int b) {
6       if (a>b) {
7          System.out.println("a: "+a+", b: "+b);
8          example1(a-1,b);
9       }
10   }
11 }
```

Output:

```
a: 6, b: 2
a: 5, b: 2
a: 4, b: 2
a: 3, b: 2
```

method: *example1;* return: 9; a=2; b= 2
method: *example1;* return: 9; a=3; b=2
method: *example1;* return: 9; a=4; b=2
method: *example1;* return: 9; a=5; b=2
method: *example1;* return: 4; a=6; b=2
method: *main*; return: 4;

```
1  public class Example1 {
2    public static void main(String[] args) {
3       example1(6,2);
4    }
5    public static void example1(int a, int b) {
6       if (a>b) {
7          System.out.println("a: "+a+", b: "+b);
8          example1(a-1,b);
9       }
10   }
11 }
```

Output:

```
a: 6, b: 2
a: 5, b: 2
a: 4, b: 2
a: 3, b: 2
```

method: *example1;* return: 9; a=2; b= 2
method: *example1;* return: 9; a=3; b=2
method: *example1;* return: 9; a=4; b=2
method: *example1;* return: 9; a=5; b=2
method: *example1;* return: 4; a=6; b=2
method: *main*; return: 4;

```
1  public class Example1 {
2    public static void main(String[] args) {
3       example1(6,2);
4    }
5    public static void example1(int a, int b) {
6       if (a>b) {
7          System.out.println("a: "+a+", b: "+b);
8          example1(a-1,b);
9       }
10   }
11 }
```

Output:

```
a: 6, b: 2
a: 5, b: 2
a: 4, b: 2
a: 3, b: 2
```

method: *example1;* return: 9; a=2; b= 2
method: *example1;* return: 9; a=3; b=2
method: *example1;* return: 9; a=4; b=2
method: *example1;* return: 9; a=5; b=2
method: *example1;* return: 4; a=6; b=2
method: *main*; return: 4;

```
1  public class Example2 {
2     public static void main(String[] args) {
3        example1(6,2);
4     }
5     public static void example1(int a, int b) {
6        if (a>b) {
7           example1(a-1,b);
8           System.out.println("a: "+a+", b: "+b);
9
10       }
11    }
12 }
```

What is the output?

```
1  public class Example2 {
2     public static void main(String[] args) {
3        example1(6,2);
4     }
5     public static void example1(int a, int b) {
6        if (a>b) {
7           example1(a-1,b);
8           System.out.println("a: "+a+", b: "+b);
9
10       }
11    }
12 }
```

What is the output?

```
a: 3, b: 2

a: 4, b: 2

a: 5, b: 2

a: 6, b: 2
```

```
public class Example3 {
   public static void main(String[] args) {
      example3("elephant",0,8);
   }
   public static void example3(String s, int left, int n) {
      if (left<n) {
         System.out.println(s.substring(left,n));
         example3(s,left+1, n-1);
      }
   }
}
```

Output:

```
elephant
```

s: "elephant"; left=0; n=8

```
public class Example3 {
   public static void main(String[] args) {
      example3("elephant",0,8);
   }
   public static void example3(String s, int left, int n) {
      if (left<n) {
         System.out.println(s.substring(left,n));
         example3(s,left+1, n-1);
      }
   }
}
```

Output:

```
elephant
lephan
```

s: "elephant"; left=1; n=7
s: "elephant"; left=0; n=8

```
public class Example3 {
   public static void main(String[] args) {
      example3("elephant",0,8);
   }
   public static void example3(String s, int left, int n) {
      if (left<n) {
         System.out.println(s.substring(left,n));
         example3(s,left+1, n-1);
      }
   }
}
```

Output:

```
elephant
lephan
epha
```

s: "elephant"; left=2; n=6
s: "elephant"; left=1; n=7
s: "elephant"; left=0; n=8

```
public class Example3 {
   public static void main(String[] args) {
      example3("elephant",0,8);
   }
   public static void example3(String s, int left, int n) {
      if (left<n) {
         System.out.println(s.substring(left,n));
         example3(s,left+1, n-1);
      }
   }
}
```

Output:

```
elephant
lephan
epha
ph
```

s: "elephant"; left=3; n=5
s: "elephant"; left=2; n=6
s: "elephant"; left=1; n=7
s: "elephant"; left=0; n=8

```
public class Example3 {
   public static void main(String[] args) {
      example3("elephant",0,8);
   }
   public static void example3(String s, int left, int n) {
      if (left<n) {
         System.out.println(s.substring(left,n));
         example3(s,left+1, n-1);
      }
   }
}
```

Output:

```
elephant
lephan
epha
ph
```

s: "elephant"; left=4; n=4
s: "elephant"; left=3; n=5
s: "elephant"; left=2; n=6
s: "elephant"; left=1; n=7
s: "elephant"; left=0; n=8

```
public class Example3 {
   public static void main(String[] args) {
      example3("elephant",0,8);
   }
   public static void example3(String s, int left, int n) {
      if (left<n) {
         System.out.println(s.substring(left,n));
         example3(s,left+1, n-1);
      }
   }
}
```

Output:

```
elephant
lephan
epha
ph
```

s: "elephant"; left=4; n=4
s: "elephant"; left=3; n=5
s: "elephant"; left=2; n=6
s: "elephant"; left=1; n=7
s: "elephant"; left=0; n=8

```
public class Example3 {
   public static void main(String[] args) {
      example3("elephant",0,8);
   }
   public static void example3(String s, int left, int n) {
      if (left<n) {
         System.out.println(s.substring(left,n));
         example3(s,left+1, n-1);
      }
   }
}
```

Output:

```
elephant
lephan
epha
ph
```

s: "elephant"; left=4; n=4
s: "elephant"; left=3; n=5
s: "elephant"; left=2; n=6
s: "elephant"; left=1; n=7
s: "elephant"; left=0; n=8

```
public class Example3 {
   public static void main(String[] args) {
      example3("elephant",0,8);
   }
   public static void example3(String s, int left, int n) {
      if (left<n) {
         System.out.println(s.substring(left,n));
         example3(s,left+1, n-1);
      }
   }
}
```

Output:

```
elephant
lephan
epha
ph
```

s: "elephant"; left=4; n=4
s: "elephant"; left=3; n=5
s: "elephant"; left=2; n=6
s: "elephant"; left=1; n=7
s: "elephant"; left=0; n=8

```
public class Example3 {
   public static void main(String[] args) {
      example3("elephant",0,8);
   }
   public static void example3(String s, int left, int n) {
      if (left<n) {
         System.out.println(s.substring(left,n));
         example3(s,left+1, n-1);
      }
   }
}
```

Output:

```
elephant
lephan
epha
ph
```

s: "elephant"; left=4; n=4
s: "elephant"; left=3; n=5
s: "elephant"; left=2; n=6
s: "elephant"; left=1; n=7
s: "elephant"; left=0; n=8

```
public class Example3 {
   public static void main(String[] args) {
      example3("elephant",0,8);
   }
   public static void example3(String s, int left, int n) {
      if (left<n) {
         System.out.println(s.substring(left,n));
         example3(s,left+1, n-1);
      }
   }
}
```

Output:

```
elephant
lephan
epha
ph
```

s: "elephant"; left=4; n=4
s: "elephant"; left=3; n=5
s: "elephant"; left=2; n=6
s: "elephant"; left=1; n=7
s: "elephant"; left=0; n=8

```
public class Example5 {
   public static void main(String[] args) {
      example4(8,1);
   }
   public static void example4(int n, int m) {
      if (n>0) {
         printDots(n-1);
         printStars(m);
         printDots(n-1);
         System.out.println();
         example4(n-1,m+2);
         }
   }
   public static void printDots (int num) {
      for (int i=0; i<num; i++)
         System.out.print(".");
   }
   public static void printStars (int num) {
      for (int i=0; i<num; i++)
         System.out.print("*");

   }
}
```