Programming with Recursion

The Recursion Pattern (§ 2.5)

- **Recursion**: when a method calls itself
- Classic example - the factorial function:
  - $n! = 1 \cdot 2 \cdot 3 \cdot \cdots \cdot (n-1) \cdot n$
- Recursive definition:

$$f(n) = \begin{cases} 1 & \text{if } n = 0 \\ n \cdot f(n-1) & else \end{cases}$$

- As a Java method:

```
// recursive factorial function
public static int recursiveFactorial(int n) {
  if (n == 0) return 1;      // basis case
  else return n * recursiveFactorial(n- 1); // recursive case
}
```

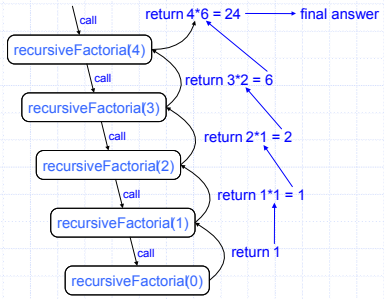

Content of a Recursive Method

- **Base case(s).**
  - Values of the input variables for which we perform no recursive calls are called **base cases** (there should be at least one base case).
  - Every possible chain of recursive calls **must** eventually reach a base case.
- ***Recursive calls.***
  - Calls to the current method.
  - Each recursive call should be defined so that it makes progress towards a base case.

Visualizing Recursion

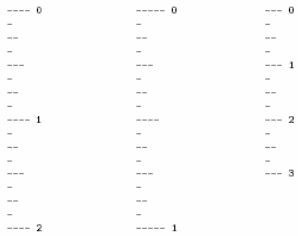
- Recursion trace
- A box for each recursive call
- An arrow from each caller to callee
- An arrow from each callee to caller showing return value

Example recursion trace:



Example – English Rulers

- Define a recursive way to print the ticks and numbers like an English ruler:



A Recursive Method for Drawing Ticks on an English Ruler

```
    // draw a tick with no label
public static void drawOneTick(int tickLength) { drawOneTick(tickLength, - 1); }
    // draw one tick
public static void drawOneTick(int tickLength, int tickLabel) {
  for (int i = 0; i < tickLength; i++)
    System.out.print("-");
  if (tickLabel >= 0) System.out.print(" " + tickLabel);
  System.out.print("\n");
}
public static void drawTicks(int tickLength) { // draw ticks of given length
  if (tickLength > 0) {                  // stop when length drops to 0
    drawTicks(tickLength- 1);            // recursively draw left ticks
    drawOneTick(tickLength);             // draw center tick
    drawTicks(tickLength- 1);            // recursively draw right ticks
  }
}
public static void drawRuler(int nInches, int majorLength) { // draw ruler
  drawOneTick(majorLength, 0);           // draw tick 0 and its label
  for (int i = 1; i <= nInches; i++)     {
    drawTicks(majorLength- 1);           // draw ticks for this inch
    drawOneTick(majorLength, i);         // draw tick i and its label
  }
}
```


Visualizing the DrawTicks Method

- An interval with a central tick length $L \geq 1$ is composed of the following:
  - an interval with a central tick length L-1,
  - a single tick of length L,
  - an interval with a central tick length L-1.