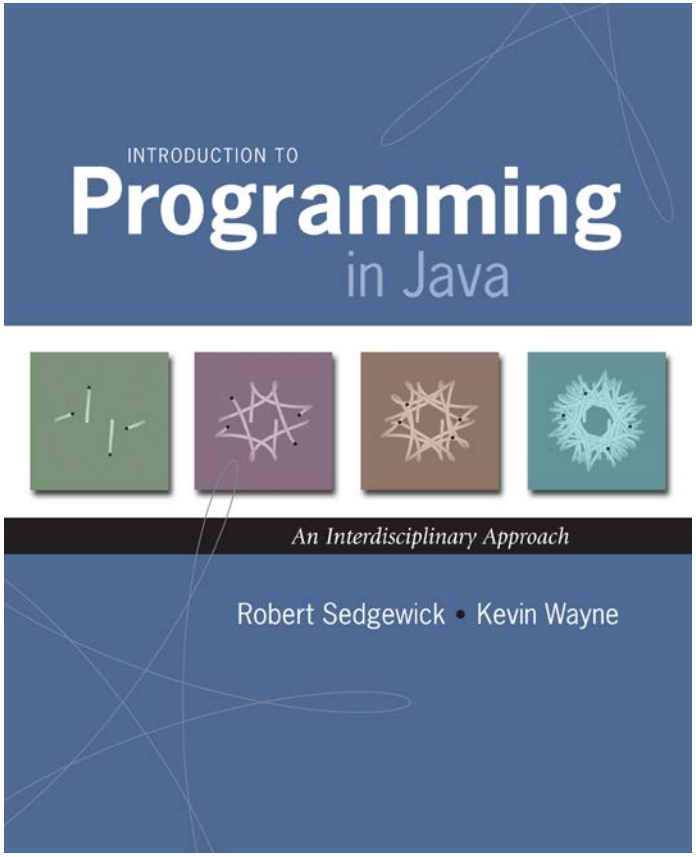
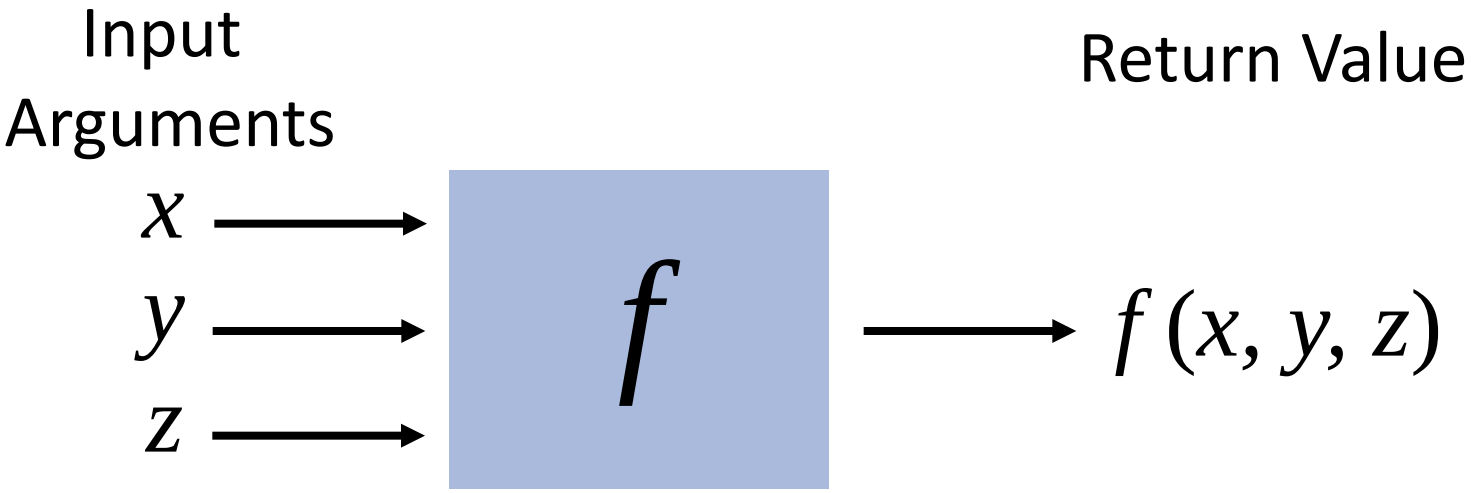
2.1 Functions



Functions

- Take in input arguments (zero or more)
- Perform some computation
  - May have side-effects (such as drawing)
- Return one output value



Functions (Static Methods)

- Applications:
  - Use mathematical functions to calculate formulas
  - Use functions to build modular programs

- Examples:
  - Built-in functions:

    `Math.random()`, `Math.abs()`, `Integer.parseInt()`

    These methods return, respectively, a double, double, and int value.

  - I/O libraries:

    `PennDraw.circle(x,y,halfRadius)`,
    `PennDraw.line(x0,y0,x1,y1)`

  - User-defined functions:

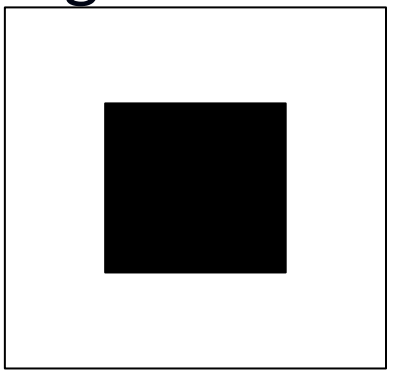
    `main()`

Why do we need functions?

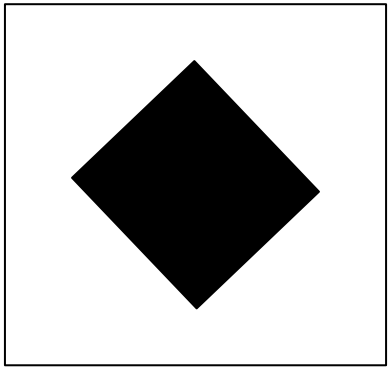
- Break code down into logical sub-steps
- Readability of the code improves
- Testability - focus on getting each individual function correct

Method Signatures

- We need some way to uniquely identify a method
- The name of the method alone isn't enough
  - PennDraw.square(0.5, 0.5, 0.25)



  - PennDraw.square(0.5, 0.5, 0.25, 45)



The methods have the same name, but do different things!

In Class Poll

- Which of these sets of elements are part of the method signature?

1) Method name, return type, name of parameters

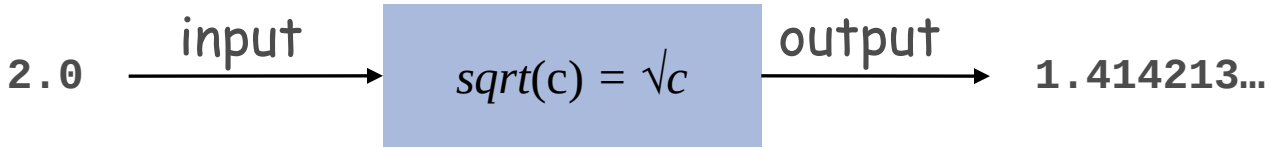
2) Method name, return type, type of parameters

3) Method name, number of parameters

4) Method name, type of parameters

Anatomy of a Java Function

- Java functions – It is easy to write your own
  - Example: `double sqrt(double c)`



return type *method name* *arguments*

```
public static double sqrt(double c) {
    ...
}
```

method signature
(excludes return type)

Please note that the method signature is defined incorrectly in the figure on pg 188 of your textbook

Anatomy of a Java Function

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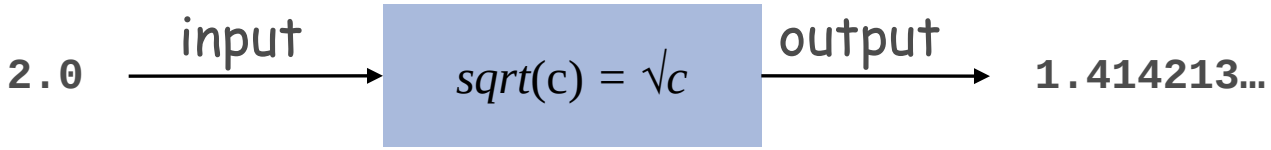
  - Example: `double sqrt(double c)`




```
public static double sqrt(double c)
{
   if (c < 0) return Double.NaN;
   double err = 1e-15;
   double t = c;
   while (Math.abs(t - c/t) > err * t)
      t = (c/t + t) / 2.0;
   return t;
}
```

local variables

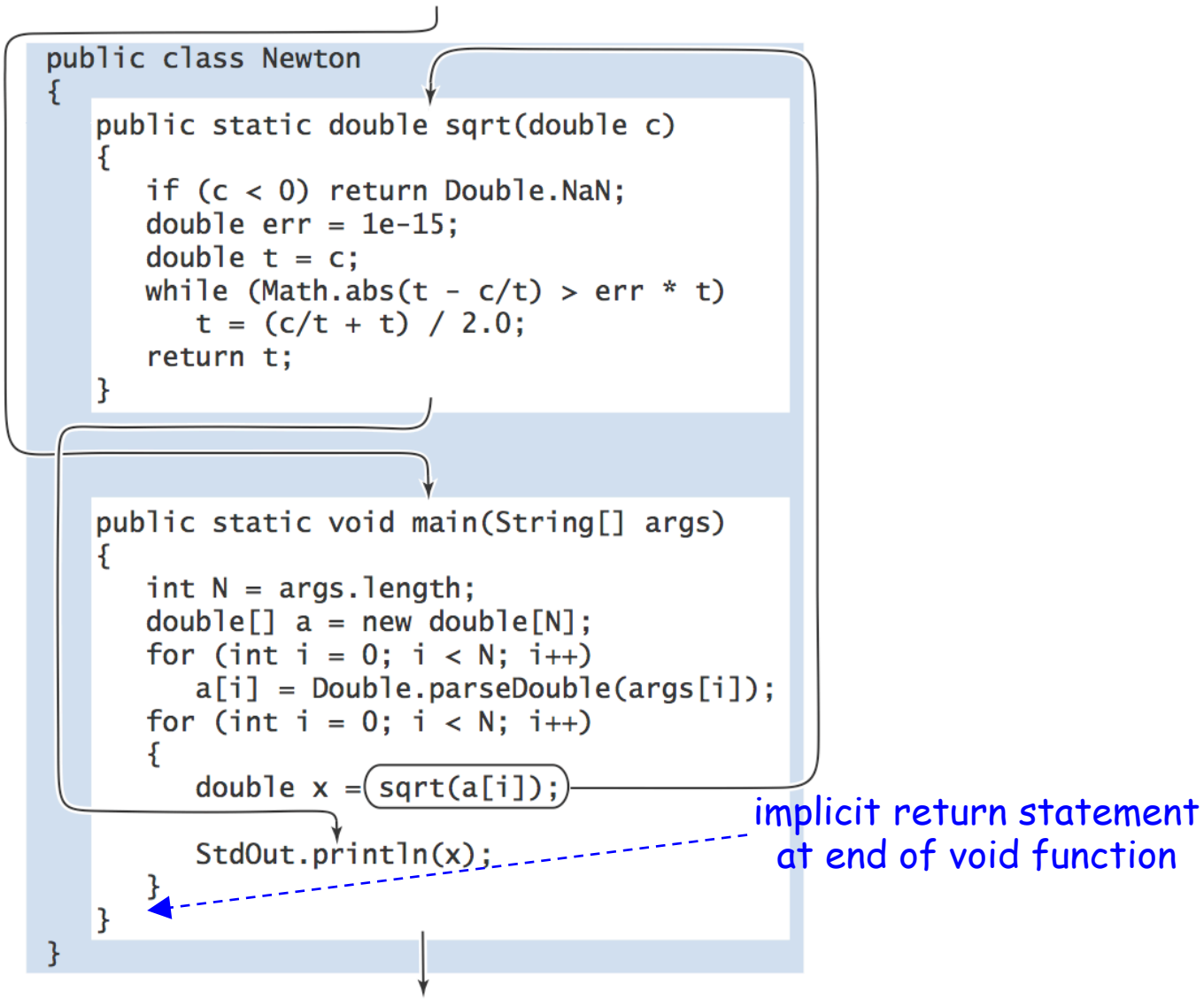
method body

return statement

call on another method

Flow of Control

Functions provide a new way to control the flow of execution

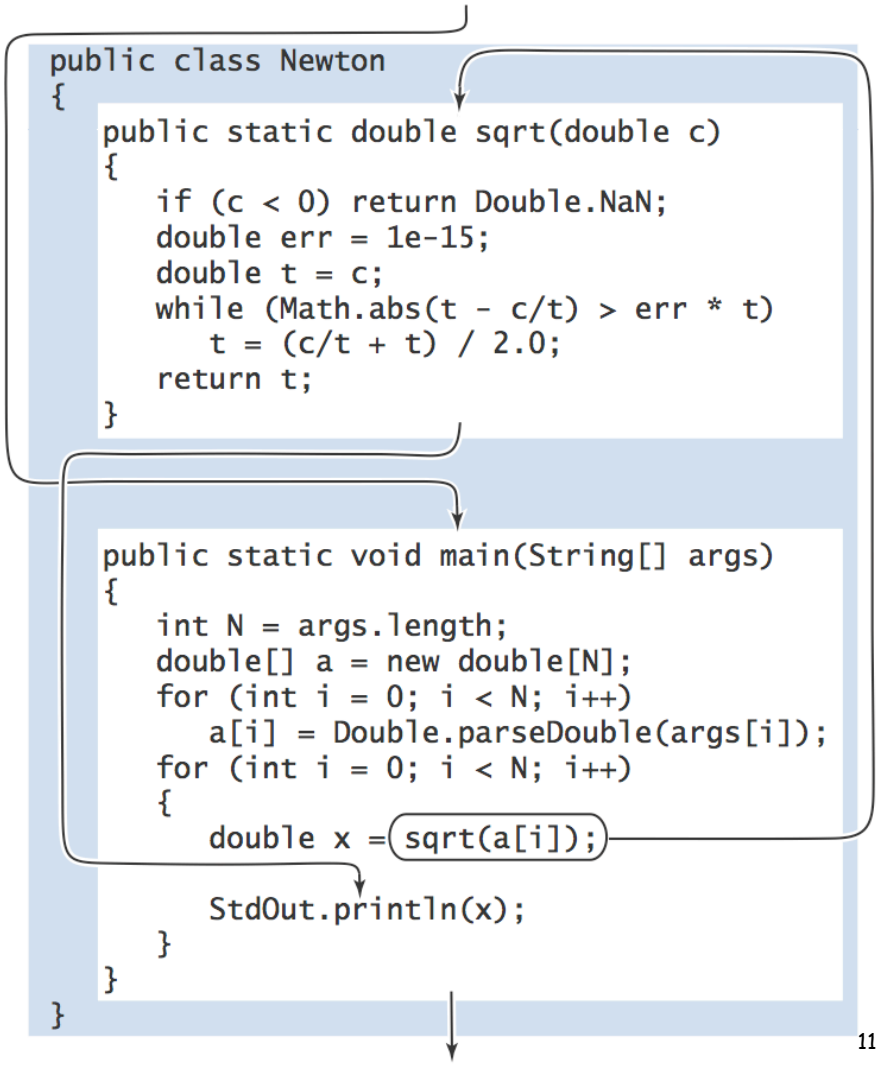


Flow of Control

What happens when a function is called:

- Control transfers to the function
- Argument variables are assigned the values given in the call
- Function code is executed
- Return value is substituted in place of the function call in the calling code
- Control transfers back to the calling code

Note: This is known as "pass by value"



Example

- Function to reverse a word
- Apply this word reversal function to reverse a sentence that is entered via command line arguments.

Live coding time …..

Organizing Your Program

- Functions help you organize your program by breaking it down into a series of steps
  - Each function represents some abstract step or calculation
  - Arguments let you make the function have different behaviors

- **Key Idea**: write something ONCE as a function then reuse it many times

Scope

Scope: the code that can refer to a particular variable

- A variable's scope is the entire code block (any any nested blocks) after its declaration

Simple example:

```
int count = 1;
for (int i = 0; i < 10; i++) {
      count *= 2;
}
// using 'i' here generates
// a compiler error
```

Best practice: declare variables to limit their scope

Function Challenge 1

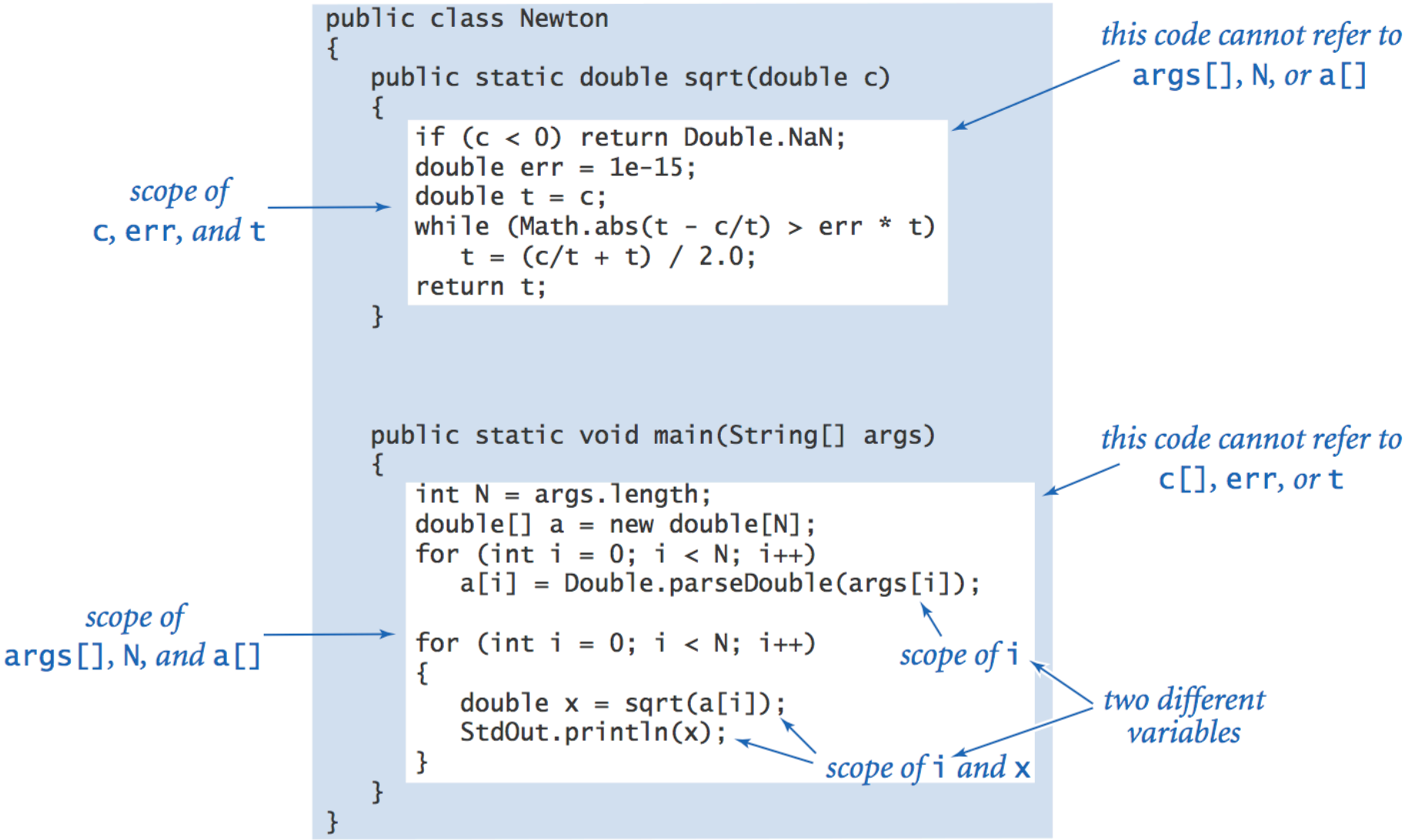
Q. What happens when you compile and run the following code?

```
public class Cubes1 {

   public static int cube(int i) {
      int j = i * i * i;
      return j;
   }

   public static void main(String[] args) {
      int N = Integer.parseInt(args[0]);
      for (int i = 1; i <= N; i++)
         System.out.println(i + " " + cube(i));
   }
}
```

Scope with Functions



Tracing Functions

```
public class Cubes1 {

   public static int cube(int i) {
      int j = i * i * i;
      return j;
   }

   public static void main(String[] args) {
      int N = Integer.parseInt(args[0]);
      for (int i = 1; i <= N; i++)
         System.out.println(i + " " + cube(i));
   }
}
```

```
% javac Cubes1.java
% java Cubes1 6
1 1
2 8
3 27
4 64
5 125
6 216
```

Last In First Out (LIFO) Stack of Plates

Method Overloading

- Two or more methods *in the same class* may also have the same name
- This is called ***method overloading***

absolute value of an `int` *value*

```
public static int abs(int x)
{
   if (x < 0) return -x;
   else       return  x;
}
```

absolute value of a `double` *value*

```
public static double abs(double x)
{
   if (x < 0.0) return -x;
   else         return  x;
}
```

Method Signature

- A method is uniquely identified by
  - its **name** and
  - **its parameter list** (parameter types and their order)
- This is known as its ***signature***

Examples:

```
static    int min(int a, int b)
static double min(double a, double b)
static  float min(float a, float b)
```

Return Type is Not Enough

- Suppose we attempt to create an overloaded `circle(double x, double y, double r)` method by using different return types:

```
static void    circle(double x, double y, double r) {...}

//returns true if circle is entirely onscreen, false otherwise
static boolean circle(double x, double y, double r) {...}
```

- This is NOT valid method overloading because the code that calls the function can ignore the return value

```
circle(50, 50, 10);
```

  - The compiler can't tell which `circle()` method to invoke
  - Just because a method returns a value doesn't mean the calling code has to use it

Too Much of a Good Thing

Automatic type promotion and overloading can sometimes interact in ways that confuse the compiler

For example:

```
// version 1
static void printAverage(int a, double b) {
    ...
}

// version 2
static void printAverage(double a, int b) {
    ...
}
```

Why might this be problematic?

Too Much of a Good Thing

```
static void average(int a, double b) { /*code*/ }
static void average(double a, int b) { /*code*/ }
```

- Consider if we do this

```
public static void main (String[] args) {
    ...
    average(4, 8);
    ...
}
```

- The Java compiler can't decide whether to:
  - promote 7 to 7.0 and invoke the first version of `average()`, or
  - promote 5 to 5.0 and invoke the second version
- Take-home lesson: don't be too clever with method overloading

Function Examples

absolute value of an `int` *value*

```
public static int abs(int x)
{
   if (x < 0) return -x;
   else       return  x;
}
```

absolute value of a `double` *value*

```
public static double abs(double x)
{
   if (x < 0.0) return -x;
   else         return  x;
}
```

overloading

primality test

```
public static boolean isPrime(int N)
{
   if (N < 2) return false;
   for (int i = 2; i <= N/i; i++)
      if (N % i == 0) return false;
   return true;
}
```

hypotenuse of a right triangle

```
public static double hypotenuse(double a, double b)
{  return Math.sqrt(a*a + b*b);  }
```

multiple arguments

Function Challenge 2

Q. What happens when you compile and run the following code?

```
public class Cubes2 {

   public static int cube(int i) {
      int i = i * i * i;
      return i;
   }

   public static void main(String[] args) {
      int N = Integer.parseInt(args[0]);
      for (int i = 1; i <= N; i++)
         System.out.println(i + " " + cube(i));
   }
}
```

Function Challenge 3

Q. What happens when you compile and run the following code?

```
public class Cubes3 {

   public static int cube(int i) {
      i = i * i * i;
   }


   public static void main(String[] args) {
      int N = Integer.parseInt(args[0]);
      for (int i = 1; i <= N; i++)
         System.out.println(i + " " + cube(i));
   }
}
```

Function Challenge 4

Q. What happens when you compile and run the following code?

```
public class Cubes4 {

   public static int cube(int i) {
      i = i * i * i;
      return i;
   }

   public static void main(String[] args) {
      int N = Integer.parseInt(args[0]);
      for (int i = 1; i <= N; i++)
         System.out.println(i + " " + cube(i));
   }
}
```

Function Challenge 5

Q. What happens when you compile and run the following code?

```
public class Cubes5 {

   public static int cube(int i) {
      return i * i * i;
   }


   public static void main(String[] args) {
      int N = Integer.parseInt(args[0]);
      for (int i = 1; i <= N; i++)
         System.out.println(i + " " + cube(i));
   }
}
```