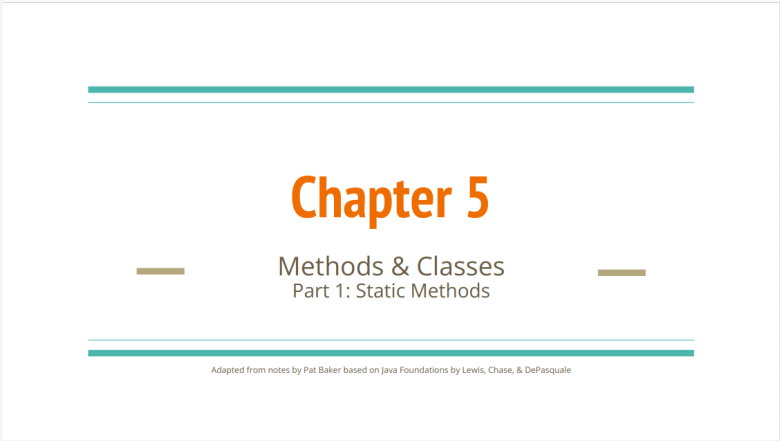
Module 8 - User-defined Method Basics

General Notes

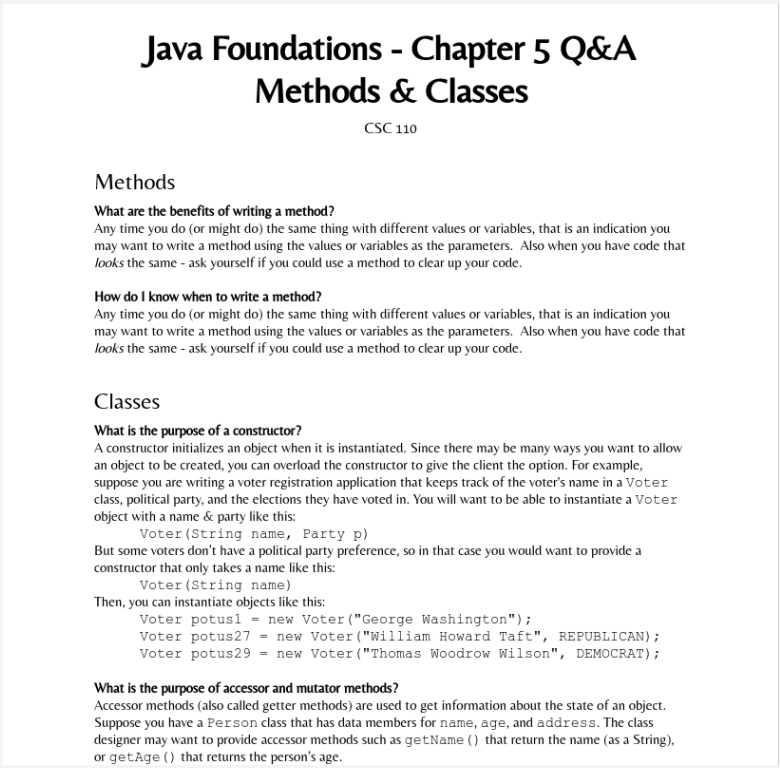
Module Content

Instructor Slides

> **Instructor Slides:** PDF



- **Q&A From Chapter 5:** DOCX



Java Foundations - Chapter 5 Q&A
Methods & Classes

CSC 110

Methods

What are the benefits of writing a method?
Any time you do (or might do) the same thing with different values or variables, that is an indication you may want to write a method using the values or variables as the parameters. Also when you have code that *looks* the same - ask yourself if you could use a method to clear up your code.

How do I know when to write a method?
Any time you do (or might do) the same thing with different values or variables, that is an indication you may want to write a method using the values or variables as the parameters. Also when you have code that *looks* the same - ask yourself if you could use a method to clear up your code.

Classes

What is the purpose of a constructor?
A constructor initializes an object when it is instantiated. Since there may be many ways you want to allow an object to be created, you can overload the constructor to give the client the option. For example, suppose you are writing a voter registration application that keeps track of the voter's name in a `Voter` class, political party, and the elections they have voted in. You will want to be able to instantiate a `Voter` object with a name & party like this:

```
Voter(String name, Party p)
```

But some voters don't have a political party preference, so in that case you would want to provide a constructor that only takes a name like this:

```
Voter(String name)
```

Then, you can instantiate objects like this:

```
Voter potus1 = new Voter("George Washington");
Voter potus27 = new Voter("William Howard Taft", REPUBLICAN);
Voter potus29 = new Voter("Thomas Woodrow Wilson", DEMOCRAT);
```

What is the purpose of accessor and mutator methods?
Accessor methods (also called getter methods) are used to get information about the state of an object. Suppose you have a `Person` class that has data members for `name`, `age`, and `address`. The class designer may want to provide accessor methods such as `getName()` that return the name (as a String), or `getAge()` that returns the person's age.

Sample Code & Videos

- GitHub Code

Web Resources

- **Video:** Introduction to static methods -basic
- **Video:** Overloaded Methods
- **Video:** Methods and arrays 1
- **Video:** Methods and arrays 2
- **Video:** Methods and arrays 3

Zybooks

User-defined Method Basics

Methods (General)

Program redundancy can be reduced by creating a grouping of predefined statements for repeatedly used operations, known as a **method**.

A **method** is a named list of statements.

- A **method definition** consists of the new method's name and a block of statements.

```
public static double calcPizzaArea() {
    /* block of statements */
}
```

- A **Method call** is an invocation of a method's name, causing the method's statements to execute.
- A **block** is a list of statements surrounded by braces.

```
public class PizzaArea {
   public static double calcPizzaArea() {
      double pizzaDiameter;
      double pizzaRadius;
      double pizzaArea;
      double piVal = 3.14159265;

      pizzaDiameter = 12.0;
      pizzaRadius = pizzaDiameter / 2.0;
      pizzaArea = piVal * pizzaRadius * pizzaRadius;
      return pizzaArea;
   }

   public static void main(String[] args) {
      System.out.println("12 inch pizza is " +
       calcPizzaArea() + " inches squared");
   }
}
```

- Both the methods `calcPizzaArea()` and `main()` use the **access modifiers** `public static` .
  - `public` indicates the method may be called from any class in the program.
  - `static` indicates the method only uses values that passed to the method.
- A program must define a `main()` method, which is automatically called first when a program executes.

Returning a Value From a Method

A value is returned using a **return statement**.

```
public class SquareComputation {

   public static int computeSquare(int numToSquare) {
      return numToSquare * numToSquare;
   }

   public static void main (String [] args) {
      int numSquared;

      numSquared = computeSquare(7);
      System.out.println("7 squared is " + numSquared);
  }
}
```

- A method can only return one value.

Parameters

- **Parameter:** A method input specified in a method definition.
- **Argument:** A value provided to a method's parameter during a method call.

A parameter is like a variable declaration. Upon a call, the parameter's memory location is allocated, and the parameter is assigned with the argument's value. Upon returning to the original call location, the parameter is deleted from memory.

Multiple or No Parameters

```
// Multiple parameters
public static double calcPizzaVolume(double pizzaDiameter, double
pizzaHeight) {
    /* Code Statements */
}

// No parameters
public static void doSomething() {
    /* Code Statements */
}
```

Calling Methods From Methods

```
public class MethodsCallingMethods {

   public static double calcCircleArea(double circleDiameter) {
      double circleRadius;
      double circleArea;
      double piVal = 3.14159265;

      circleRadius = circleDiameter / 2.0;
      circleArea = piVal * circleRadius * circleRadius;

      return circleArea;
   }

   public static double pizzaCalories(double pizzaDiameter) {
      double totalCalories;
      double caloriesPerSquareInch = 16.7;    // Regular crust pepperoni
pizza

      totalCalories = calcCircleArea(pizzaDiameter) *
caloriesPerSquareInch;

      return totalCalories;
   }

   public static void main (String [] args) {
      System.out.printf("12 inch pizza has %.2f calories.\n",
pizzaCalories(12.0));
      System.out.printf("14 inch pizza has %.2f calories.\n",
pizzaCalories(14.0));
   }
}

/* Output:
 * 12 inch pizza has 1888.73 calories.
 * 14 inch pizza has 2570.77 calories.
 */
```

Print Methods

Printing From a Method

The **void** keyword indicates a method does not return a value. A method with a void return type is often called a **void method**.

- Once a void method finishes execution, control returns back to the caller and no value is returned.
- A print method prints out arguments passed to the parameter, but does not have to return anything.

```java
import java.util.Scanner;

public class MenuSystem {
   public static void printMenu() {
      System.out.println("Today's Menu:");
      System.out.println("   1) Gumbo");
      System.out.println("   2) Jambalaya");
      System.out.println("   3) Quit\n");
   }

   public static void main(String[] args) {
      Scanner scnr = new Scanner(System.in);
      boolean quit = false;
      int choice;

      while (!quit) {
         printMenu();
         System.out.print("Enter choice: ");
         choice = scnr.nextInt();
         if (choice == 3) {
            System.out.println("Goodbye");
            quit = true;
         }
         else {
            System.out.print("Order: ");
            if (choice == 1) {
               System.out.println("Gumbo");
            }
            else if (choice == 2) {
               System.out.println("Jambalaya");
            }
            System.out.println();
         }
      }
   }
}
```

Reasons for Defining Methods

- Improve program readability
- Modular and incremental program development

    - **Modular Development:** The process of dividing a program into separate modules that can be developed and tested separately and then integrated into
      a single program.
    - **Incremental Development:** The process in which a programmer writes, compiles, and tests a small amount of code, then writes, compiles, and tests a small amount more (an incremental amount), and so on.
    - **Method Stub:** A method definition whose statements have not yet been written.
- Avoid writing redundant code
    - The skill of decomposing a program's behavior into a good set of methods is
      a fundamental part of programming that helps characterize a good programmer.
    - Each method should have easily-recognizable behavior, and the behavior of `main()` (and any method that calls other methods) should be easily understandable via the sequence of method calls.
- Methods may cause slightly slower execution, but have other far more important advantages, like improved readability.

Method Stub

```
import java.util.Scanner;

public class MileageCalc {
   public static double convKilometersToMiles(double numKm) {
      System.out.println("FIXME: Convert km to m");
      return 0.0;
   }

   public static double convLitersToGallons(double numLiters) {
      System.out.println("FIXME: Convert l to gal");
      return 0.0;
   }

   public static double calcMpg(double distMiles, double gasGallons) {
      System.out.println("FIXME: Calculate MPG");
      return 0.0;
   }

   public static void main(String[] args) {
      Scanner scnr = new Scanner(System.in);
      double distKm;
      double distMiles;
      double gasLiters;
      double gasGal;
      double userMpg;

      System.out.print("Enter kilometers driven: ");
      distKm = scnr.nextDouble();
      System.out.print("Enter liters of gas consumed: ");
      gasLiters = scnr.nextDouble();

      distMiles = convKilometersToMiles(distKm);
      gasGal = convLitersToGallons(gasLiters);
      userMpg = calcMpg(distMiles, gasGal);

      System.out.println("Miles driven: " + distMiles);
      System.out.println("Gallons of gas: " + gasGal);
      System.out.println("Mileage: " + userMpg + " mpg");
   }
}
```

Writing Mathematical Methods

Mathematical Methods

A method is commonly defined to compute a mathematical calculation involving several numerical parameters and returning a numerical result.

Convert height in feet and inches to total centimeters:

```java
import java.util.Scanner;

public class HeightConverter {

   /* Converts a height in feet/inches to centimeters */
   public static double heightFtInToCm(int heightFt, int heightIn) {
      final double CM_PER_IN = 2.54;
      final int IN_PER_FT = 12;
      int totIn;
      double cmVal;

      totIn = (heightFt * IN_PER_FT) + heightIn; // Total inches
      cmVal = totIn * CM_PER_IN;                 // Conv inch to cm
      return cmVal;
   }

   public static void main(String[] args) {
      Scanner scnr = new Scanner(System.in);
      int userFt;  // User defined feet
      int userIn;  // User defined inches

      // Prompt user for feet/inches
      System.out.print("Enter feet: ");
      userFt = scnr.nextInt();

      System.out.print("Enter inches: ");
      userIn = scnr.nextInt();

      // Output the conversion result
      System.out.print("Centimeters: ");
      System.out.println(heightFtInToCm(userFt, userIn));
   }
}
```

Modular Methods for Mathematical Expressions

Complex mathematical methods often call other mathematical methods.

Program to calculate cylinder volume and surface area by calling a modular method for the cylinder's base:

```
import java.util.Scanner;

public class Demo {
   public static double calcCircularBaseArea(double radius) {
      return Math.PI * radius * radius;
   }

   public static double calcCylinderVolume(double baseRadius, double
height) {
      return calcCircularBaseArea(baseRadius) * height;
   }

   public static double calcCylinderSurfaceArea(double baseRadius, double
height) {
      return (2 * Math.PI * baseRadius * height) + (2 *
calcCircularBaseArea(baseRadius));
   }

   public static void main(String[] args) {
      double radius;  // User defined feet
      double height;  // User defined height
      Scanner scnr = new Scanner(System.in);

      // Prompt user for radius
      System.out.println("Enter base radius: ");
      radius = scnr.nextDouble();

      // Prompt user for height
      System.out.println("Enter height: ");
      height = scnr.nextDouble();

      // Output the cylinder volume result
      System.out.print("Cylinder volume: ");
      System.out.printf("%.1f\n", calcCylinderVolume(radius, height));

      // Output the cylinder surface area result
      System.out.print("Cylinder surface area: ");
      System.out.printf("%.3f\n", calcCylinderSurfaceArea(radius,
height));
   }
}
```

Methods With Loops

Average List of Numbers

```
import java.util.Scanner;

public class ListAverage {
   // Method prompts to enter a list of values
   public static double computeAverage(Scanner scnr, int numCount) {
      double valuesSum = 0;
      int currValue = 0;

      for (int i = 0; i < numCount; ++i) {
         System.out.print("Enter number: ");
         currValue = scnr.nextInt();
         valuesSum += currValue;
      }

      return valuesSum / numCount;
   }

   public static void main(String [] args) {
      Scanner scnr = new Scanner(System.in);
      int numValues;
      double averageVal;

      System.out.println("Enter number of values: ");
      numValues = scnr.nextInt();
      averageVal = computeAverage(scnr, numValues);

      System.out.print("Average: ");
      System.out.printf("%.3f", averageVal);
      System.out.println("");
   }
}
```

Least-Common Multiple Calculator

```
import java.util.Scanner;

public class LeastCommonMultiple {

   // Method prompts user to enter positive non-zero number
   public static int promptForPositiveNumber(Scanner scnr) {
      int userNum;

      userNum = 0;

      while (userNum <= 0) {
         System.out.println("Enter a positive number (>0): ");
         userNum = scnr.nextInt();

         if (userNum <= 0) {
            System.out.println("Invalid number.");
         }
      }

      return userNum;
   }

   // Method returns greatest common divisor of two inputs
   public static int findGCD(int aVal, int bVal) {
      int numA;
      int numB;

      numA = aVal;
      numB = bVal;

      while (numA != numB) { // Euclid's algorithm
         if (numB > numA) {
            numB = numB - numA;
         } else {
            numA = numA - numB;
         }
      }

      return numA;
   }
```

```
   // Method returns least common multiple of two inputs
   public static int findLCM(int aVal, int bVal) {
      int lcmVal;

      lcmVal = Math.abs(aVal * bVal) / findGCD(aVal, bVal);

      return lcmVal;
   }

   public static void main(String[] args) {
      Scanner scnr = new Scanner(System.in);
      int usrNumA;
      int usrNumB;
      int lcmResult;

      System.out.println("Enter value for first input");
      usrNumA = promptForPositiveNumber(scnr);

      System.out.println("\nEnter value for second input");
      usrNumB = promptForPositiveNumber(scnr);

      lcmResult = findLCM(usrNumA, usrNumB);

      System.out.println("\nLeast common multiple of " + usrNumA
              + " and " + usrNumB + " is " + lcmResult);
   }
}
```

Parameter Error Checking

Verifying Parameter Values

A good practice is to check that a parameter's value is within an expected range. If not, the method might take one or more various actions, such as:

- An error message
- Assigning a valid value
- Returning a value indicating failure
- Exiting the program
- Etc.

Example

```
public class DatePrinterWithCheck {
   public static void printDate(int currDay, int currMonth, int currYear)
{

      // Parameter error checking
      if ((currDay < 1) || (currDay > 31)) {
         System.out.println("Invalid day (" + currDay + "). Using 1.");
         currDay = 1;
      }

      if ((currMonth < 1) || (currMonth > 12)) {
         System.out.println("Invalid month (" + currMonth + "). Using
1.");
         currMonth = 1;
      }

      // Begin method's normal behavior
      System.out.print(currMonth + "/" + currDay + "/" + currYear);
   }


   public static void main(String[] args) {
      printDate(30, 7, 2012);
      System.out.print("\n\n");

      printDate(40, 7, 2012);
      System.out.print("\n\n");

      printDate(30, 13, 2012);
      System.out.print("\n\n");
   }
}
```

Scope of Variable / Method Definitions

- The name of a defined variable or method item is only visible to part of a program, known as the item's **scope**.
- Because a compiler scans a program line-by-line from top-to-bottom, the scope of a variable starts *after* the declaration until the method's end.

- A variable declared within a class but outside any method is called a ***class member variable*** or **field**.
    - A field's scope extends from the class's opening brace to the class's closing brace, and reaches into methods regardless of where the field is declared within the class.
- If a method's local variable (including a parameter) has the same name as a field, then in that method the name refers to the local item and the field is inaccessible.
    - Attempting to declare a method's local variable as the same name as a method
      parameter will generate a compiler error.
- If a method updates a field, the method has effects that go beyond its parameters and return value, sometimes known as **side effects**.
- **A method also has scope**, which extends from the class's opening brace to the class's closing brace.
    - A method can access any other method defined in the same class, regardless of the order in which the methods are defined.
    - Method Definition and Overloading

Common Errors

- Copy-pasting code among methods, but then not completing all necessary modifications to the pasted code.
- Returning the wrong variable or no variable when one is required to be returned.

Unit Testing (Methods)

- **Unit Testing:** The process of individually testing a small part or unit of a program, typically a method.
- A unit test is usually conducted by creating a **testbench** *(a.k.a. test harness)*, which is a separate program whose sole purpose is to check that a method returns correct output values for a variety of input values.
    - Each unique set of input values is known as a **test vector**.

Example For hrMinToMin()

```
public class HrMinToMinTestHarness {
   public static int hrMinToMin(int origHours, int origMinutes) {
      int totMinutes;     // Resulting minutes

      totMinutes = (origHours * 60) + origMinutes;

      return origMinutes;
   }

   public static void main(String[] args) {
      System.out.println("Testing started");

      System.out.println("0:0, expecting 0, got " + hrMinToMin(0, 0));
      System.out.println("0:1, expecting 1, got " + hrMinToMin(0, 1));
      System.out.println("0:99, expecting 99, got " + hrMinToMin(0, 99));
      System.out.println("1:0, expecting 60, got " + hrMinToMin(1, 0));
      System.out.println("5:0, expecting 300, got " + hrMinToMin(5, 0));
      System.out.println("2:30, expecting 150, got " + hrMinToMin(2,
30));
      // Many more test vectors would be typical...

      System.out.println("Testing completed");
   }
}
/* Output:
* Testing started
* 0:0, expecting 0, got 0
* 0:1, expecting 1, got 1
* 0:99, expecting 99, got 99
* 1:0, expecting 60, got 0
* 5:0, expecting 300, got 0
* 2:30, expecting 150, got 30
* Testing completed
*/
```

`assert` Operator

Java provides a compact way to print an error message when an expression evaluates to `false`: `assert`.

- `assert` is an operator that prints an error message and exits the program if the provided test expression evaluates to false.
- Programming With Assertions

Syntax

```
assert testExpression: detailedMessage;
```

Example

```
public class HrMinToMinTestHarness {
   public static double hrMinToMin(int origHours, int origMinutes) {
      int totMinutes;      // Resulting minutes

      totMinutes = (origHours * 60) + origMinutes;

      return origMinutes;
   }

   public static void main(String[] args) {
      System.out.println("Testing started");

      assert (hrMinToMin(0, 0) == 0) : "Assertion (hrMinToMin(0, 0) == 0)
failed";
      assert (hrMinToMin(0, 1) == 1) : "Assertion (hrMinToMin(0, 1) == 1)
failed";
      assert (hrMinToMin(0, 99) == 99) : "Assertion (hrMinToMin(0, 99) ==
99) failed";
      assert (hrMinToMin(1, 0) == 60) : "Assertion (hrMinToMin(1, 0) ==
60) failed";
      assert (hrMinToMin(5, 0) == 300) : "Assertion (hrMinToMin(5, 0) ==
300) failed";
      assert (hrMinToMin(2, 30) == 150) : "Assertion (hrMinToMin(2, 30)
== 150) failed";
      // Many more test vectors would be typical...

      System.out.println("Testing completed");
   }
}

/* Output:
* Testing started
* Exception in thread "main" java.lang.AssertionError: Assertion
(hrMinToMin(1, 0) == 60) failed
*         at HrMinToMinTestHarness.main(HrMinToMinTestHarness.java:16)
*/
```

- Assertions are not enabled by default and Java programs must be run with additional command-line options in order to enable them:

```
java -ea HrMinToMinTestHarness
```

- The `-ea` command-line option is what enables assertions.

Good test vectors include:

- Rich variety of typical input values.
- Mixture of small and large numbers.
- Some 0 values.
- **Border Cases** that represent fringe scenarios.
    - I.e. two huge numbers, a negative number, two negative numbers, etc.
    - Extreme or abnormal inputs that might cause the method to fail.

How Methods Work

Each method call creates a new set of local variables, forming part of what is known as a **stack frame**. A return causes those local variables to be discarded.

Method Name Overloading

- Method Definition and Overloading

Method overloading, or **method name overloading**, is when two methods have the same name but differ in the number or types of parameters.

```
public class DatePrinter {
   public static void printDate(int currDay, int currMonth, int currYear)
{
      System.out.print(currMonth + "/" + currDay + "/" + currYear);
   }

   public static void printDate(int currDay, String currMonth, int
currYear) {
      System.out.print(currMonth + " " + currDay + ", " + currYear);
   }

   public static void main(String[] args) {

      printDate(30, 7, 2012);
      System.out.println();

      printDate(30, "July", 2012);
      System.out.println();
   }
}
```

- The compiler determines which method to call based on the argument types of the method call.
- More than two same-named methods is allowed as long as each has distinct parameter types.
- A method's return type does not influence overloading.

Using Scanner in Methods

- A program should use only one `Scanner` per input stream.
- A `Scanner` object may read more input than needed to make subsequent reads faster. Thus, using multiple of them for the same input stream may lead to unexpected results.
- If a method needs to read user input, a good practice is to create a single `Scanner` object in `main()` and pass that `Scanner` object to the method.

```
import java.util.Scanner;

public class CalculatePizzaCalories {

   public static double calcCircleArea(double circleDiameter) {
      double circleRadius;
      double circleArea;
      double piVal = 3.14159265;

      circleRadius = circleDiameter / 2.0;
      circleArea = piVal * circleRadius * circleRadius;

      return circleArea;
   }

   public static double getPizzaCalories(Scanner scnr) {
      double pizzaDiameter;
      double totalCalories;
      double caloriesPerSquareInch = 16.7;    // Regular crust pepperoni
pizza

      System.out.print("Enter pizza's diameter (inches): ");
      pizzaDiameter = scnr.nextDouble();

      totalCalories = calcCircleArea(pizzaDiameter) *
caloriesPerSquareInch;

      return totalCalories;
   }

   public static void main (String [] args) {
      Scanner scnr = new Scanner(System.in);

      System.out.println("Pizza has " + getPizzaCalories(scnr) + "
calories.");
      System.out.println("Pizza has " + getPizzaCalories(scnr) + "
calories.");
   }
}
```

Array Parameters

- Argument values are copied into a local variable for the parameter, meaning that assignments to parameters do not affect the arguments.
- An array is passed to a method by passing a reference to the array, meaning that only the array reference is copied to the method's parameters. The method can modify the elements of an array argument.
    - Assigning an array parameter only updates the local reference, leaving the argument unchanged.

Perfect Size Arrays

A **perfect size array** is an array where the number of elements if exactly equal to the memory allocated.

When To Use Perfect Size Arrays

Perfect sized arrays are used when the size of the array is fixed by the context of the program.

- For example, having the names of the days of the week in a perfect sized array makes sense because the number of days in a week will not change.
    - The array should be constant as well since the names of the days of the week
      will not change:

```
final String[] daysOfWeek = { /* Days of week */ };
```

It is also possible to return perfect size arrays from a method:

```
double[] createInitializedArray(int numberElements, double
initializeValue) { /* Code */ }
```

- The method declaration implicitly tells a programmer that perfect size arrays are used because the method returns an array. A method cannot return two items, so returning the array reference means the size cannot be returned.

Example

```
public static void fill(int[] arrayRef, int initializedValue) {
   int index;

   for (index = 0; index < arrayRef.length; ++index) {
      arrayRef[index] = initializedValue;
   }
}
```

Oversize Arrays

Oversize Arrays Introduction

Oversize Array: An array where the number of elements used is less than or equal to the memory allocated.

- A separate integer variable is often used to keep track of how many array elements are currently used in an oversize array, because the number of elements is usually less than the array's length.

```
int[] salesTransactions = new int[1000];
int salesTransactionsSize = 0;
```

- Oversize arrays are useful when the number of elements stored in the array is not known in advance, or when the number of elements stored in an array varies over time.
    - I.e. A shopping list

Size of an Oversize Array

- Select a size that will not be too small *(or the program will fail when the number of required elements exceeds the number of allocated elements)* and not too large *(or it can degrade performance)*.
- The size should be relevant to the task.

Variables for Oversize Arrays

Oversize arrays typically use three variables:

- The array reference
- The current size
- A constant for the array capacity

```
final int QUIZ_ANSWER_CAPACITY = 200;                          // Array
Capacity
boolean[] quizAnswers = new boolean[QUIZ_ANSWER_CAPACITY];     // Array
Reference
int quizAnswerSize = 0;                                        // Current
Size
```

Methods With Oversize Arrays

Methods With Oversize Arrays

- Two parameters are needed when an oversize array is passed to a method:
  - The array reference
  - The current size

```
public static void printOversizeArray(String[] arrayRef, int
arraySize) {
   int index;

   System.out.print("[");
   for (index = 0; index < arraySize; ++index) {
      System.out.print(arrayRef[index]);
      if (index != arraySize - 1) {  // Don't print trailing , for
last element
         System.out.print(", ");
      }
   }
   System.out.println("]");
}
```

Methods Updating Oversize Arrays: Adding Elements

- If the array size is changed by a method, then the new array size needs to be returned by the method.

```
final int LIST_SIZE = 4;
String[] toDoList = new String[LIST_SIZE];
int toDoListSize = 0;

toDoListSize = addElement(toDoList, toDoListSize, "Study");

...

public static int addElement(String[] arrayRef,
                             int currentSize,
                             String addMe) {
   // Check that array has space
   if (currentSize == arrayRef.length) {
      return currentSize;
   }

   // If array has space, add the element to the array
   arrayRef[currentSize] = addMe;
   ++currentSize;
   return currentSize;
}
```

Methods Updating Oversize Arrays: Removing Elements

```
public static int removeFirst(int[] arrayRef, int arraySize, int
targetVal) {
   boolean targetFound;
   int index;

   targetFound = false;

   // Step through the array one element at a time
   for (index = 0; index < arraySize; ++index) {
      // If matching element found, move each element to the previous
index
      if (targetFound) {
         arrayRef[index-1] = arrayRef[index];
      }

      // Check if matching element found
      if (arrayRef[index] == targetVal) {
         targetFound = true;
      }
   }

   // If matching element found, array size is one element smaller
   // otherwise array size hasn't changed
   if (targetFound) {
      return arraySize - 1;
   }
   else {
      return arraySize;
   }
}
```

Common Errors: Methods With Oversize Arrays

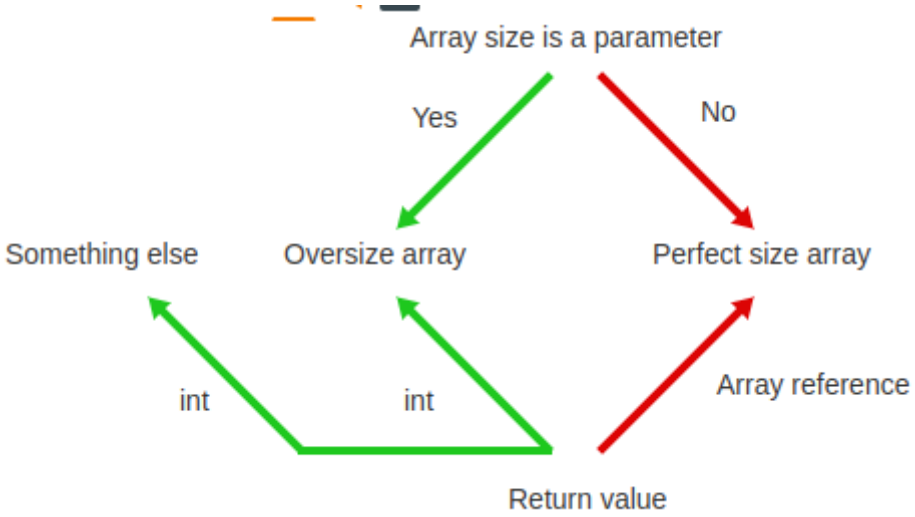
A common error is to not return the new size of an oversize array that was modified in a method.

- This mistake occurs because programmers forget that primitive data values, like the size of an array, cannot be modified within methods.

Comparing Perfect Size and Oversize Arrays

- When using a perfect array, assume that all elements will be addressed or used.
- When using an oversize array, there are most likely elements at the end of the array that have not been populated.
    - Because of this, you need to know how many elements to consider, or what is
      the index of the last element used.

Comparing Method Signatures for Perfect Size and Oversize Arrays



- A method signature can tell a programmer whether a perfect size or oversize array is expected as an argument.
    - A method that expects a perfect size array as an argument will have one parameter for the array reference, but no parameter for the array size

```
int findIndexMax(String[] arrayReference)
```

    - A method that expects an oversize array as an argument will have two parameters to pass the array: one for the array reference and one for the array size.

```
int binarySearch(String[] arrayReference, int arraySize, String
searchKey)
```

- The return type can also be used to help determine whether a method uses a perfect size or an oversize array.
    - If a method returns an array reference, the method constructs a perfect size
      array.
        - An oversize array cannot be constructed inside a method because the method
          would need to return both an array reference and array size, which is not
          permitted in Java.
    - If a method returns an int, the method may use an oversize array, where the
      return value indicates the new array size.

```
int removeAll(String[] arrayReference, int arraySize, String
target)
```

Passing a Perfect Size Array to Method Expecting Oversize Array

```
search(String[] arrayReference, int fromIndex, int toIndex, String
target)

// Passing a perfect array to the above method
foundIndex = search(carsNames, 0, carNames.length, "VW");
```

- `0` is passed to `fromIndex` and the array's length field is passed to `toIndex`.

Perfect Size and Oversize Arrays In The Java API

- Arrays Class Documentation
- The `fill()` method is heavily overloaded to allow both perfect size and overload size arrays.

Choosing Method Signatures for Perfect and Oversize Arrays

Oversize Array Example

```
// Oversize array method 1
String toString(int[] a, int size)

// Oversize array method 2
String toString(int[] a, int fromIndex, int toIndex)
```

- The second method is better because it can be used to print any range in the array.

An oversize array cannot be returned by a method.

Selecting Method Parameters and Return Values

Situation	Perfect size array		Oversize array	
	Parameter(s)	*Return*	*Parameter(s)*	*Return*
Array not modified	Array reference		Array reference and array size	
Array contents modified, but array size not modified	Array reference		Array reference and array size	
Array size modified	Consider if an oversize array should be used	Array reference	Array reference and array size	New array size
Array reference returned		Must be perfect size		Impossible

Oversize Array `fill()` Example

```
public static int fill(int[] arrayRef, int arraySize, int value) {
   // Stop at the end of the array, even if arraySize is too big
   int size = Math.min(arrayRef.length, arraySize);

   for (int index = 0; index < size; ++index) {
      arrayRef[index] = value;
   }

   return size;
}
```

Advantages of Perfect Size Arrays

- Methods that use perfect size arrays have fewer parameters than methods that use oversize arrays.
- A perfect size array contains no excess elements.
- A **disadvantage** of perfect size arrays is that if the number of array elements needs to change, a new array will have to be constructed.
    - Creating a new array and copying elements can be time-consuming, especially
      for very large arrays.

Adding Elements to Perfect Size and Oversize Arrays

```
// Method uses a perfect size array.
public static String[] addElement(String[] arrayRef, String addMe) {
   String[] returnArray = new String[arrayRef.length + 1];
   int index;

   // Copy the array elements to the newly constructed array
   for (index = 0; index < arrayRef.length; ++index) {
      returnArray[index] = arrayRef[index];
   }

   // Add in the new element to the end of the array
   returnArray[arrayRef.length] = addMe;

   return returnArray;
}

// Method uses an oversize array.
public static int addElement(String[] arrayRef, int currentSize, String
addMe) {
    // Check that array has space
   if (currentSize == arrayRef.length) return currentSize;

   arrayRef[currentSize] = addMe;
   ++currentSize;

   return currentSize;
}
```

Using References In Methods

- Primitive data types are passed in by value
  - The original primitive variable cannot be changed inside the method. A copy of it can change in the method, but the original value stays the same. This is called **pass by value**.
- The reference to an array is passed into a method. This is called **pass by reference**.

- An array can be changed inside the method.

Storage of Primitive Data Types and Arrays

- Primitive data types are stored directly in the **stack frame**.
- An array is stored indirectly in **the heap**, and only the reference to the array is stored in the stack frame.

```
int[] topScores = {100, 99, 99};
int[] bottomScores = {80, 82, 81};
int totalScores;
```

- `totalScores` is stored on the **Stack**
- `topScores` is stored on the **Stack**
- `topScores[0]` is stored on the **Heap**
- `bottomScores` is stored on the **Stack**

Passing Array References

```
String[] plannedCities = {"Ann Arbor", "Dexter", "Chelsea"};
String[] myVisits = {"Ann Arbor", "Chelsea", "Dexter"};

if (equals(plannedCities, myVisits)) {
   System.out.println("My visit was exactly the same as the plan.");
}

...

public static boolean equals(String[] firstArray, String[] secondArray) {
   int index;

   // If the arrays are not the same length, the arrays cannot have the
same contents
   if (firstArray.length != secondArray.length)
        return false;

   // Both arrays are now known to be the same length
   for (index = 0; index < firstArray.length; ++index) {
      if (!firstArray[index].equals(secondArray[index])) {
         return false;
      }
   }
   // Both arrays are known to be the same length and have
   // exactly the same items in the same order
   return true;
}
```

Common Error

- Modifying an array reference in a method.

Returning Arrays From Methods

- Constructing an array in a method and then returning the array is a common strategy.

Constructing an Array in a Method

An array can be constructed in a method, and the reference to the array can be returned.

```
int[] uniformSizes = {5, 16, 9};

String[] orderSizes = convertSizes(uniformSizes);

...

public static String[] convertSizes(int[] sourceArr) {
 String[] resultArr = new String[sourceArr.length];
 int index;

 for (index = 0; index < sourceArr.length; ++index) {
    resultArr[index] = "Misses " + sourceArr[index];
 }

 return resultArr;
}
```

Modifying An Array's Size in a Method

- An array's length cannot be modified, so instead a new array with the modified size must be constructed.
    - The adjacent memory locations may hold other data, or may be used by other programs.

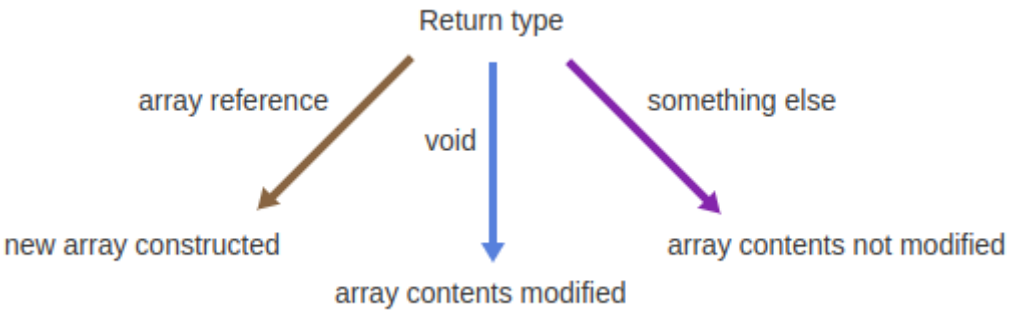
```
String[] originalArray = {"Raven", "Daisy", "Jasmine"};
originalArray = resize(originalArray, 5);

...

public static String[] resize(String[] arrayReference, int newSize) {
   String[] resultArray = new String[newSize];
   int index;
   int numToCopy;

   // Determine the number of array elements to copy
   numToCopy = Math.min(newSize, arrayReference.length);

   // Copy elements from arrayReference to resultArray
   for (index = 0; index < numToCopy; ++index) {
      resultArray[index] = arrayReference[index];
   }

   return resultArray;
}
```

- The method must construct a new array with the new size, copy the existing array's elements to the new array, and return a reference to the newly constructed array.
- The original array reference must be assigned with the reference to the new array returned by the method.

Common Errors: Methods and Arrays

- Method Signature Errors
  - A method should be designed with a single purpose. If the purpose is to change an array's contents, then the method should not perform a secondary calculation that returns a value.

A method that uses arrays typically has one of three purposes, each of which can often be identified by the method signature:



1. Calculates a value based on the array, leaving the array unchanged.
    - If a method does not change the array contents, then the method must be calculating some other value that must be returned.
    - Ex: The `Arrays` class' method

      ```
      int binarySearch(int[] arrayReference, int target)
      ```

      determines whether target exists in the array data. The returned value is the index of target in the array, or a negative number if target is not in the array.
2. Changes an array's contents, but not the array's size.
    - If a method changes the array's contents, the method usually has a void return.
    - Ex: The `Arrays` class' method

      ```
      void sort(int[] arrayReference)
      ```

      changes the array contents to be in ascending order.
3. Creates a new array or changes the array's size (and possibly contents).
    - Since array references cannot be changed inside a method, a method that returns a newly constructed array must return an array reference.
    - Ex: The `Arrays` class' method

      ```
      double[] copyOf(double[] arrayReference, int newLength)
      ```

      creates a copy of the arrayReference with the length `newLength`.

Common Errors

- Errors with array references

- A method signature mistake error often occurs in tandem with errors in handling array parameters.
- An error that unintentionally modifies data is known as a **side effect**.
    - A common side effect is a method that calculates values based on an array, but unintentionally modifies the array.

Java Documentation For Methods

Documentation: A written description of a program and its various parts, intended to be read by programmers who must maintain or interface with the program.

- Documentation written directly into the program is easier to keep consistent with the program.

Javadoc is a tool that parses specially formatted multi-line comments to generate program documentation in HTML format.

- The program documentation is also known as an **API (application programming interface)**.
- Those special **doc comments** begin with `/**` and end with `*/`
    - The beginning two asterisks distinguish doc comments from regular comments.
- Doc comments can only describe specific program items, like methods or classes.
- The doc comment must immediately precede the item *(whitespace is OK)*. **Javadoc silently ignores incorrectly placed doc comments**.
- Doc comments consist of an overall description, and a tags section.

Example Documentation: Java String Documentation

Doc comments produce standalone HTML documentation of a program and its methods.

- The format is the same as Oracle uses to describe Java class library, like the above example.
- The destination directory for documentation can be changed using

```
javadoc -d destination myProg.java
```

Doc Comment Syntax

```
/**
 * The overall description is written here.
 * The text below is the tag section.
 * @blockTag text associated with tag
 * @blockTag text associated with tag
 */
```

- The overall description describes the items purpose and extends to the first `@`, which denotes the beginning of the tags section.
- A Javadoc comment tags section consists of **block tags**, each of the form `@keyword` plus text, each block tag on its own line.
- A method's doc comment typically has an overall description summarizing the method, and tags for parameters, return types, and other items.
    - Good practice is to include a doc comment for every method, having at least an overall description, a `@param` block tag for each parameter, and a `@return` block tag if not void.
- Each class typically also has doc comments

Common Block Tags in Doc Comments

Block tag	Description
`@author`	Lists the item's author.
`@version`	Indicates the item's version number *(typically for a program)*.
`@param`	Describes a method parameter's type, purpose, etc.
`@return`	Describes a method's return type, purpose, etc. *Optional if return type is void.*
`@see`	Refers to relevant information like a website, another method, etc.

Example of Using Javadoc Comments

```
import java.util.Scanner;

/**
 * Program reports the fees charged by ebay.com given an item's
 * selling price.
 *
 * @author Zyante Developers
 * @version 1.0
 */
public class EbayFeeCalc {
   /**
    * Returns fees charged by ebay.com given selling price of
    * fixed-price books/movies/music/video-games. $0.50 to list
    * plus 13% of selling price up to $50.00, %5 of amount from
    * $50.01 to $1000.00, and 2% for amount $1000.01 or more.
    *
    * @param sellPrice the item's selling price
    * @return a double representing the imposed fees
    * @see "http://pages.ebay.com/help/sell/fees.html"
    */
   public static double ebayFee(double sellPrice) {
      final double BASE_LIST_FEE = 0.50;     // Listing Fee
      final double PERC_50_OR_LESS = 0.13;   // % $50 or less
      final double PERC_50_TO_1000 = 0.05;   // % $50.01..$1000.00
      final double PERC_1000_OR_MORE = 0.02; // % $1000.01 or more
      double feeTot;                         // Resulting eBay fee

      feeTot = BASE_LIST_FEE;

      // Determine additional fee based on selling price
      if (sellPrice <= 50.00) { // $50.00 or lower
         feeTot = feeTot + (sellPrice * PERC_50_OR_LESS);
      }
      else if (sellPrice <= 1000.00) { // $50.01..$1000.00
         feeTot = feeTot + (50 * PERC_50_OR_LESS)
                 + ((sellPrice - 50) * PERC_50_TO_1000);
      }
      else { // $1000.01 and higher
         feeTot = feeTot + (50 * PERC_50_OR_LESS)
                 + ((1000 - 50) * PERC_50_TO_1000)
                 + ((sellPrice - 1000) * PERC_1000_OR_MORE);
```

```
        }

        return feeTot;
    }

    /**
     * Asks for an item's selling price and calls ebayFee() to
     * calculate the imposed fees.
     *
     * @param args command-line arguments
     */
    public static void main(String[] args) {
        Scanner scnr = new Scanner(System.in);
        double sellingPrice;        // User defined selling price

        // Prompt user for selling price, call eBay fee method
        System.out.print("Enter item selling price (e.g., 65.00): ");
        sellingPrice = scnr.nextDouble();
        System.out.println("eBay fee: $" + ebayFee(sellingPrice));
    }
}
```

Exploring Further

- The Javadoc Specification

  from Oracle's Java documentation
- How to Write Javadoc Comments

  from Oracle's Java documentation
- How to Run The Javadoc Tool

  from Oracle's Java documentation