Classes and Objects Miscellany: I/O, Statics, Wrappers & Packages

CMSC 202H (Honors Section)

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Basic Input/Output

Printing to the Screen

In addition to `System.out.print()` (and `println()`):

- Formatted output
  - `System.out.printf("Printing integer %d%n",5);`
  - `System.out.printf("%d %c %d", 1, 'a', 2);`
- Place holders can be added to represent variables to be output in the format string.
  - %d, %c, %f, %s – What does each stand for?
  - Every place holder that appears inside the output string must have a matching value separated by a comma.
- Add proceeding white space characters and precision to variables printed.
  - `System.out.printf("2 points of precision %10.2d", 89.999);`
  - "Two points of precision ____90.00" ← no newline character
- Other special formatting
  - %n – platform independent newline character
  - \t – horizontal tab

Reading From the Console

- Java’s ***Scanner object*** reads in input that the user enters on the command line.

```
Scanner input = new Scanner(System.in);
```

- System.in is a reference to the ***standard input buffer.***
- We can read values from the Scanner object using the dot notation to invoke a number of functions.
  - nextInt() — returns the next integer from the buffer
  - nextFloat() — returns the next float from the buffer
  - nextLine() — returns the entire line as a String

Scanner Notes

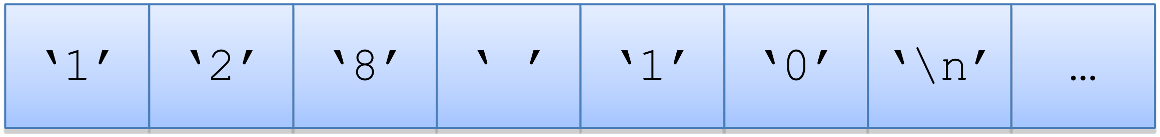
- In order to use the Scanner class, you’ll need to add the following line to the top of your code…

```
import java.util.Scanner;
```

- You should ***never*** declare more than one Scanner object on a given input stream.
- The Scanner object will wait for a user to type, and read all text entered up until the user presses the “enter” key (including the newline character).

Reading from the Console

```
System.out.print("Enter 2 numbers to sum: ");
Scanner input = new Scanner(System.in);
int n1 = input.nextInt();
int n2 = input.nextInt();
System.out.printf("%d + %d = %d", n1, n2, n1 + n2);
```



‘1’	‘2’	‘8’	‘ ’	‘1’	‘0’	‘\n’	…

- Let’s assume the user has entered “128 10” .
- The first call to nextInt() reads the characters “128” leaving “ 10\n” in the input buffer.
- The second call to nextInt() reads the “10” and leaves the “\n” in the buffer.

Reading via UNIX Redirection

```java
int sum = 0;
Scanner input = new Scanner(System.in);
while(input.hasNextInt()) {
        sum += input.nextInt();
}
System.out.println("Sum: " + sum);
```

```
% cat numbers
1 2 3
4
5 6 7
8
% java Sum < numbers
Sum: 36
%
```

- The Scanner class also has a bunch of hasNextX() methods to detect if there’s another data item of the given type in the stream.
- For example, this is useful if we were reading an unknown quantity of integers from a file that is redirected into our program (as above).

Packages, Compilation and Execution

Packages

- Java allows you to partition your classes into sets and subsets, called *packages.*
- You place your class into a package with the directive:

```
package myPackage;
```

- If the “package” directive is missing, the class is placed into the *unnamed package*
- A Java package is similar to a “namespace”: it implicitly prepends a prefix of your choice to all classes you define.

Packages

- You can refer to all objects via its fully-qualified name, e.g.:

```
myPackage.MyClass foo = new myPackage.MyClass();
```

- Within a class definition, class references without explicit package name prefixes refer to other classes in your package
  - This is modified by importing other packages
- In addition to its use for namespaces, packages affect the function of some *visibility modifiers* (later)

Importing Packages

- Import single *class* by using:

```
import java.util.Random;
```

- Or, import many classes, with wildcard:

```
import java.util.*;
```

  - Cannot “`import java.*.*;`”
  - Importing is not recursive (e.g. java.* != java.util.*)
  - Importing singly is preferred (why?)
- java.lang.* is already implicitly imported
- However, all other java.*… must be explicitly imported

Package Naming Conventions

- Initially, beginners use the *unnamed package*
- For simple, standalone applications, use simple one-token package names, e.g.: “proj1” (note lowercase)
- For packages to be deployed outside the organization, use inverse-domain-address-like notation, e.g.:

  edu.umbc.csee.cmsc202.utilityPackage

Packages: Example

```
package proj3;
import java.util.Random;
public class MyClass {
     // Stuff inside this class definition
     public static int someMethod() {
            Random rand = new Random();
            …
     }
}
---------------------------------------------------------

// No “package” directive, so in unnamed package
// No “import” directive, so all class names must be full
public class MyOtherClass {
     // Stuff inside this class definition
     public static int someMethod() {
            proj3.MyClass myClassInst = new proj3.MyClass();
            java.util.Random rand = new java.util.Random();
            …
     }
}
```

Java Program Review

```java
package demos;

public class SimpleProgram {
  public static void main (String[] args){
    System.out.println("Hello World");
  }
}
```

```java
package demos;

public class OtherProgram {
  public static void main (String[] args){
    System.out.println("Hello World 2");
  }
}
```

- Java source code can be compiled under any operating system.
  - javac -d . SimpleProgram.java
  - javac -d . OtherProgram.java
- Java will create a directory named *demos* containing
  - SimpleProgram.class
  - OtherProgram.class
- We can execute SimpleProgram with the following.
  - java demos.SimpleProgram
- We can execute OtherProgram with the following.
  - Java demos.OtherProgram
- We can execute any class’ main in a similar manner.
  - java <package name>.<Class name>

Command Line Arguments

```java
package demos;

public class ArgsDemo {
        public static void main (String[] args){
                for(int i = 0; i < args.length; i++){
                        System.out.println(args[i]);
                }
        }
}
```

- Anything that follows the name of the main class to be executed will be read as a ***command line argument***.
- All text entered will be stored in the String array specified in main (typically ***args*** by convention).
  - java demos.ArgsDemo Hi
  - Results in “Hi” stored at args[0]
- Individual arguments can be separated by spaces like so
  - java demos.ArgsDemo foo 123 bar
  - Results in “foo” stored at args[0], “123” at args[1] and “bar” at args[2]

What Does “Static” Mean?

The Problem of Words

"When I use a word," Humpty Dumpty said in rather a scornful tone, "it means just what I choose it to mean -- neither more nor less."
"The question is," said Alice, "whether you can make words mean so many different things."
"The question is," said Humpty Dumpty, "which is to be master - - that's all."
Lewis Carroll, *Through the Looking Glass*

- So, what do `static` (and `final`) mean in Java?
  - `public static final float PI = 3.14159;`
  - `public static int timesCreated;`
  - `public static void main(String[] args) {…}`
- …and *why* do they mean ***that***?!

History of `static`

- In C, originally needed a way to let a variable keep its value unchanged across calls, i.e., keep it “static”
- Extended scope to repurpose `static` keyword for file-scope global variables
- Java repurposed the word multiple times again, in an OOP context
- Humpty Dumpty would have loved `static`

What Does “static” Mean in Java?

- Instance variables, constants, and methods may all be labeled as `static`.
- In this context, static means that there is one copy of the variable, constant, or method that belongs to the class as a whole, and not to a particular instance.
- It is not necessary to instantiate an object to access a static variable, constant or method.

Static Variables

- A ***static variable*** belongs to the class as a whole, not just to one object.
- There is only one copy of a static variable per class.
- All objects of the class can read and change this static variable.
- A static variable is declared with the addition of the modifier **`static`**.

```
    static int myStaticVariable;
```

- Static variables can be declared and initialized at the same time.

```
    static int myStaticVariable = 0;
```

Static Constants

- A ***static constant*** is used to symbolically represent a constant value.
- In some languages (e.g., C) constants are simply implemented as macros, used to replace text.
- In Java, constants derive from regular variables, by "finalizing" them
  - The declaration for a static defined constant must include the modifier `final`, which indicates that its value cannot be changed.

```
public static final int BIRTH_YEAR = 1954;
```

(The modifier `final` is also overloaded, and means other things in other contexts, as we shall see later.)

- Static constants belong to the class as a whole, not to each object, so there is only one copy of a static constant

- When referring to such a defined constant outside its class, use the name of its class in place of a calling object.

```
int year = MyClass.BIRTH_YEAR;
```

Static Methods

So far,

- class methods required a calling object in order to be invoked.

```
Date birthday = new Date(1, 23, 1982);
String s = birthday.toString( );
```

- These are sometimes known as ***non-static methods***.

Static methods:

- still belong to a class, but need no calling object, and
- often provide some sort of utility function.

monthString Method

Recall the Date class private helper method monthString.

- Translates an integer month to a string
- Note that the monthString method
  - Does not call any other methods of the Date class, and
  - Does not use any instance variables (month, day, year) from the Date class.

- This method can be made available to users of the Date class without requiring them to create a Date object.

```
public static String monthString( int monthNumber ) {
     switch ( monthNumber )   {
              case 1:   return "January";
              case 2:   return "February";
              case 3:   return "March";
              case 4:   return "April";
              case 5:   return "May";
              case 6:   return "June";
              case 7:   return "July";
              case 8:   return "August";
               case 9:   return "September";
              case 10: return "October";
              case 11: return "November";
              case 12: return "December";
              default: return “????”;
     }
}
```

It is now a public static method.

monthString Demo

- Code outside of the Date class can now use the monthString method without creating a Date object.
- Prefix the method name with the name of the class instead of an object.

Date is a class name, not an object name.

monthString is the name of a static method

```
class MonthStringDemo
{
   public static void main( String [ ] args )
   {
         String month = Date.monthString( 6 );
         System.out.println( month );
   }
}
```

Rules for Static Methods

- Static methods have no calling/host object (they have no `this`).
- Therefore, static methods cannot:
  - Refer to any instance variables of the class
  - Invoke any method that has an implicit or explicit `this` for a calling object
- Static methods may invoke other static methods or refer to static variables and constants.
- A class definition may contain both static methods and non-static methods.

Static F^{o} to C^{o} Convert Example

```
public class FtoC
{
   public static double convert( double degreesF )
        { return 5.0 / 9.0 * (degreesF – 32 ); }
}
```

```
public class F2CDemo
{
   public static void main( String[ ] args )
   {
        double degreesF = 100;

        // Since convert is static, no object is needed
        // The class name is used when convert is called

        double degreesC = FtoC.convert( degreesF );
        System.out.println( degreesC );
   }
}
```

main is a Static Method

Note that the method header for main( ) is

```
public static void main(String [] args)
```

Being static has two effects:

- main can be executed without an object.
- “Helper” methods called by main must also be static.

Any Class Can Have a main( )

- Every class can have a public static method name main( ).
- Java will execute main in whichever class is specified on the command line.

```
java <className>
```

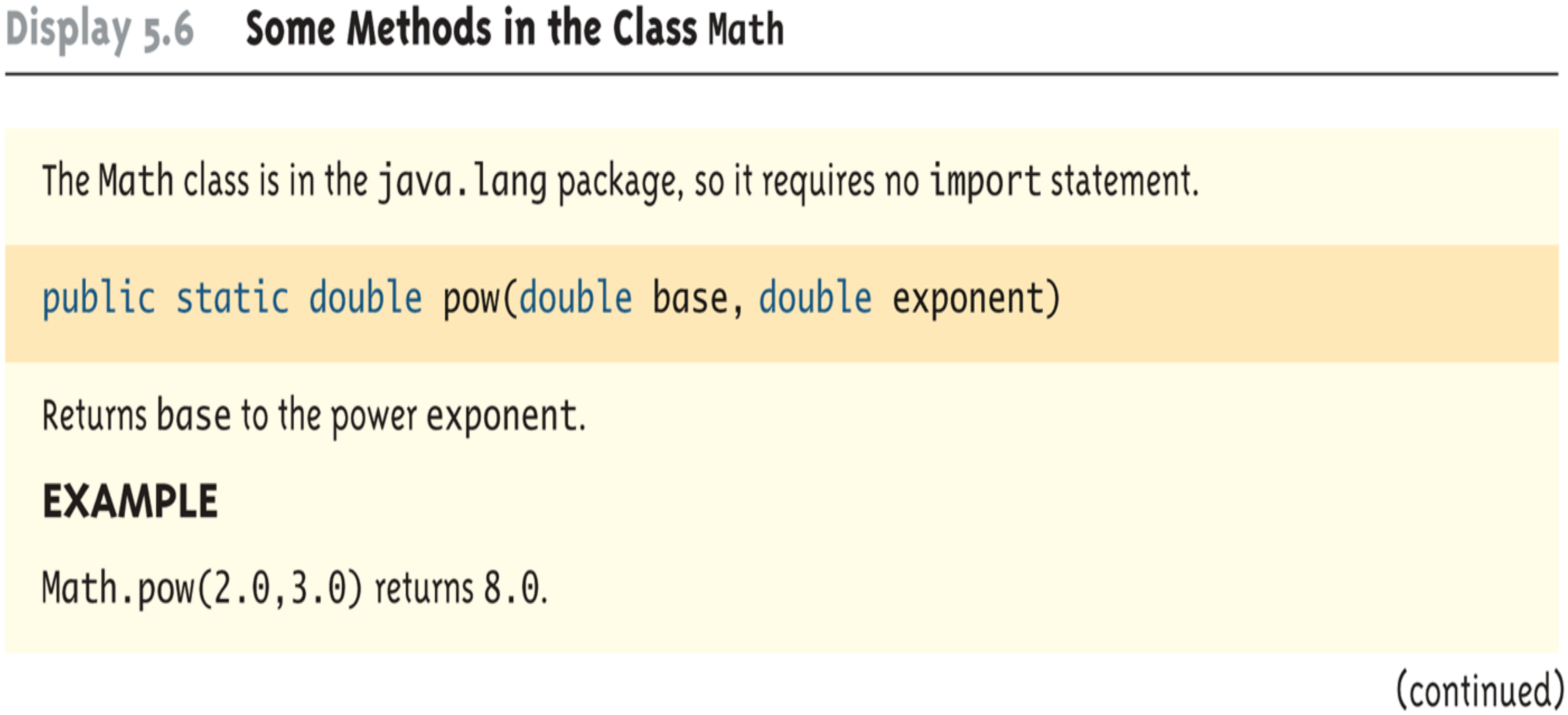
- A convenient way to write test code for your class.

The `Math` Class

- The `Math` class provides a number of standard mathematical methods.
  - Found in the `java.lang` package, so it does not require an `import` statement
  - All of its methods and data are static.
    - They are invoked with the class name `Math` instead of a calling object.
  - The `Math` class has two predefined constants, `E` (*e*, the base of the natural logarithm system) and `PI` (π, 3.1415 . . .).

```
area = Math.PI * radius * radius;
```

Some Methods in the Class **`Math`**
(Part 1 of 5)



Display 5.6 **Some Methods in the Class** Math

The Math class is in the `java.lang` package, so it requires no `import` statement.

```
public static double pow(double base, double exponent)
```

Returns base to the power exponent.

EXAMPLE

`Math.pow(2.0,3.0)` returns `8.0`.

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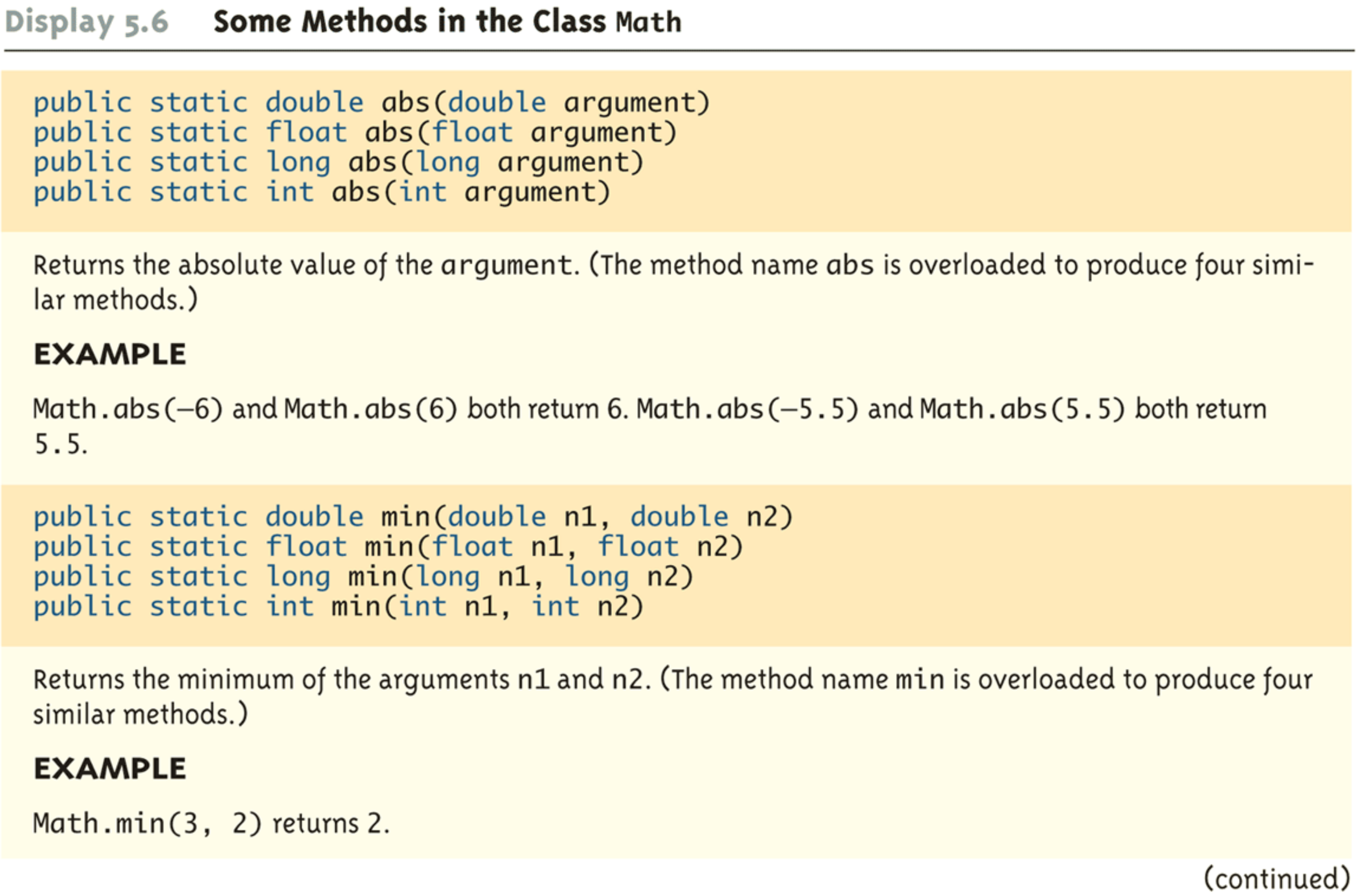
Some Methods in the Class **Math** (Part 2 of 5)



Display 5.6 Some Methods in the Class Math

```
public static double abs(double argument)
public static float abs(float argument)
public static long abs(long argument)
public static int abs(int argument)
```

Returns the absolute value of the argument. (The method name abs is overloaded to produce four similar methods.)

EXAMPLE

Math.abs(−6) and Math.abs(6) both return 6. Math.abs(−5.5) and Math.abs(5.5) both return 5.5.

```
public static double min(double n1, double n2)
public static float min(float n1, float n2)
public static long min(long n1, long n2)
public static int min(int n1, int n2)
```

Returns the minimum of the arguments n1 and n2. (The method name min is overloaded to produce four similar methods.)

EXAMPLE

Math.min(3, 2) returns 2.

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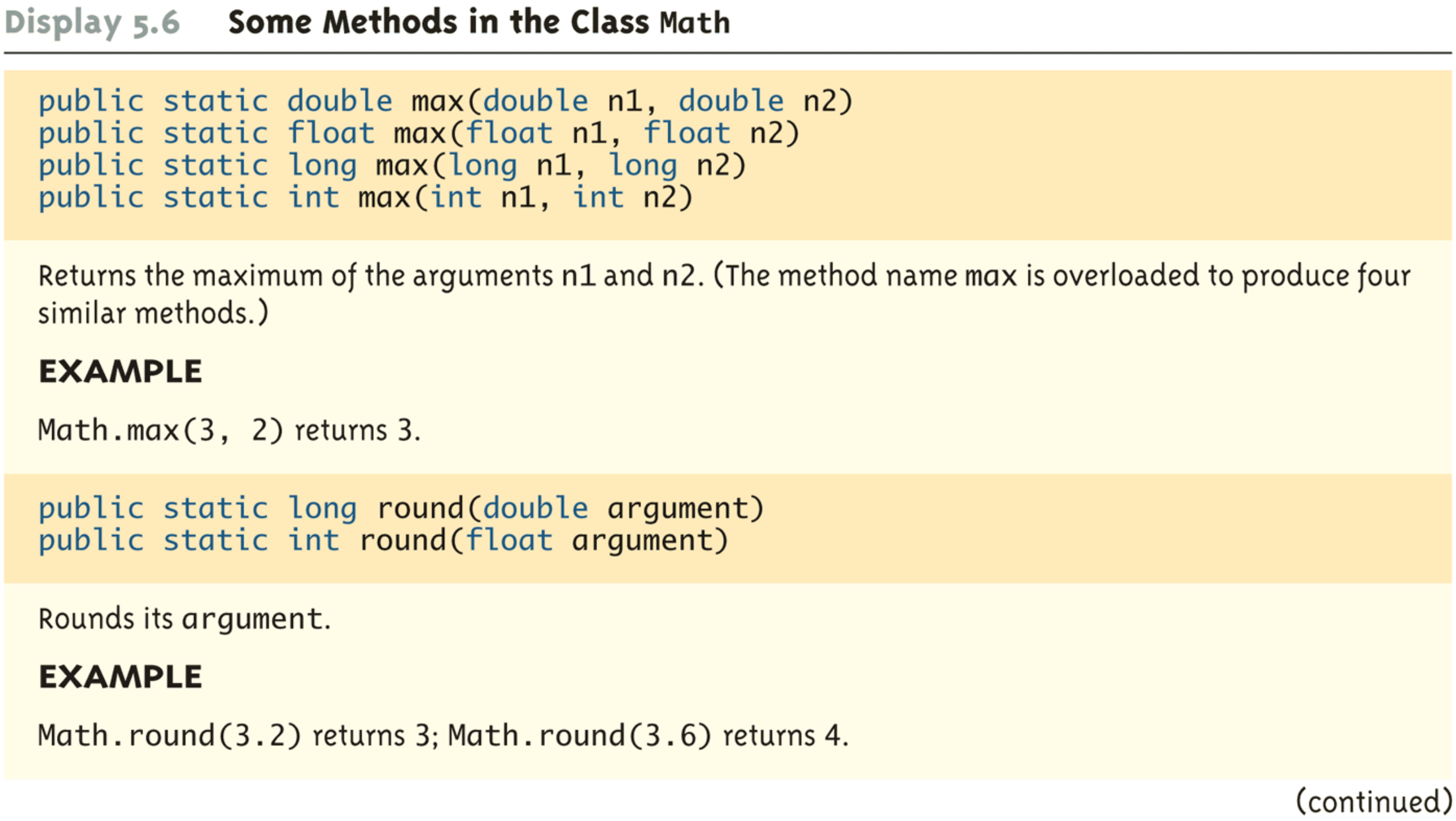
Some Methods in the Class **Math** (Part 3 of 5)



Display 5.6 **Some Methods in the Class Math**

```
public static double max(double n1, double n2)
public static float max(float n1, float n2)
public static long max(long n1, long n2)
public static int max(int n1, int n2)
```

Returns the maximum of the arguments n1 and n2. (The method name max is overloaded to produce four similar methods.)

EXAMPLE

Math.max(3, 2) returns 3.

```
public static long round(double argument)
public static int round(float argument)
```

Rounds its argument.

EXAMPLE

Math.round(3.2) returns 3; Math.round(3.6) returns 4.

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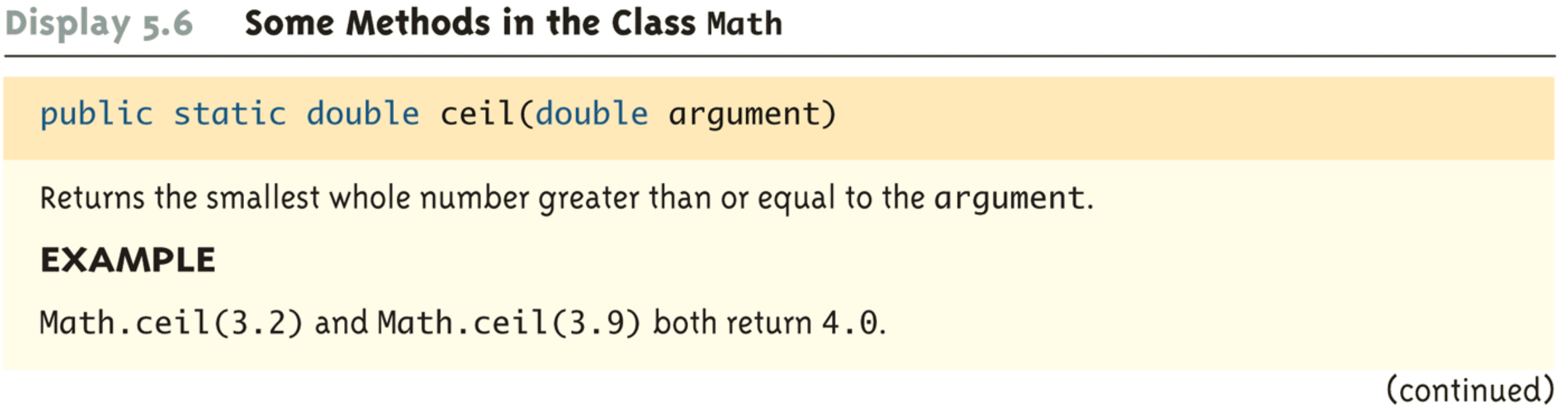
Some Methods in the Class **`Math`**
(Part 4 of 5)



Display 5.6 **Some Methods in the Class `Math`**

```
public static double ceil(double argument)
```

Returns the smallest whole number greater than or equal to the `argument`.

EXAMPLE

`Math.ceil(3.2)` and `Math.ceil(3.9)` both return `4.0`.

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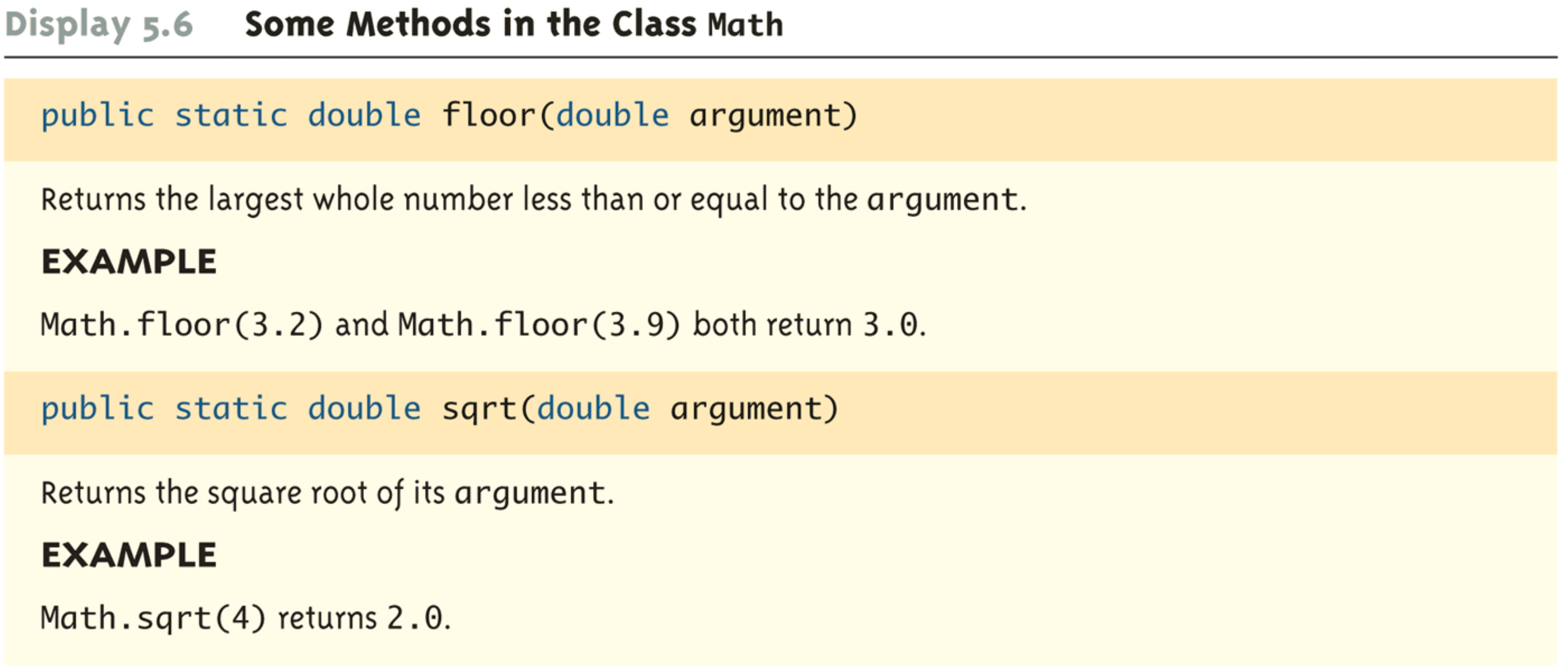
Some Methods in the Class **`Math`** (Part 5 of 5)



Display 5.6 **Some Methods in the Class `Math`**

```
public static double floor(double argument)
```

Returns the largest whole number less than or equal to the `argument`.

EXAMPLE

`Math.floor(3.2)` and `Math.floor(3.9)` both return `3.0`.

```
public static double sqrt(double argument)
```

Returns the square root of its `argument`.

EXAMPLE

`Math.sqrt(4)` returns `2.0`.

Static Review

- Given the skeleton class definition below

```
public class C
{
  public int a = 0;
  public static int b = 1;

  public void f( ) { …}
  public static void g( ) {…}
}
```

- Can body of f( ) refer to a?
- Can body of f( ) refer to b?
- Can body of g( ) refer to a?
- Can body of g( ) refer to b?
- Can f( ) call g( )?
- Can g( ) call f( )?
  - For each, explain why or why not.

Wrapper Classes

Wrapper Classes

- ***Wrapper classes***
  - Provide a class type corresponding to each of the primitive types
  - Makes it possible to have class types that behave somewhat like primitive types
  - The wrapper classes for the primitive types:

`byte`, **`short`**, **`int`**, **`long`**, **`float`**, **`double`**, and **`char`**

are (in order)

`Byte`, **`Short`**, **`Integer`**, **`Long`**, **`Float`**, **`Double`**, and **`Character`**

  - Wrapper classes also contain useful
    - predefined constants
    - static methods

Constants and Static Methods in Wrapper Classes

- Wrapper classes include constants that provide the largest and smallest values for any of the primitive number types.
  - `Integer.MAX_VALUE`, `Integer.MIN_VALUE`, `Double.MAX_VALUE`, `Double.MIN_VALUE`, etc.
- The `Boolean` class has names for two constants of type `Boolean`.
  - `Boolean.TRUE` corresponds to `true`
  - `Boolean.FALSE` corresponds to `false`

  of the primitive type `boolean`.

Constants and Static Methods in Wrapper Classes

- Some static methods convert a correctly formed string representation of a number to the number of a given type.
  - The methods `Integer.parseInt()`, `Long.parseLong()`, `Float.parseFloat()`, and `Double.parseDouble()`

    do this for the primitive types (in order) `int`, `long`, `float`, and `double`.
- Static methods convert from a numeric value to a string representation of the value.
  - For example, the expression

    ```
    Double.toString(123.99);
    ```

    returns the string value `"123.99"`
- The `Character` class contains a number of static methods that are useful for string processing.

Wrappers and Command Line Arguments

- Command line arguments are passed to main via its parameter conventionally named args.

```
public static void main (String[ ] args)
```

- For example, if we execute our program as

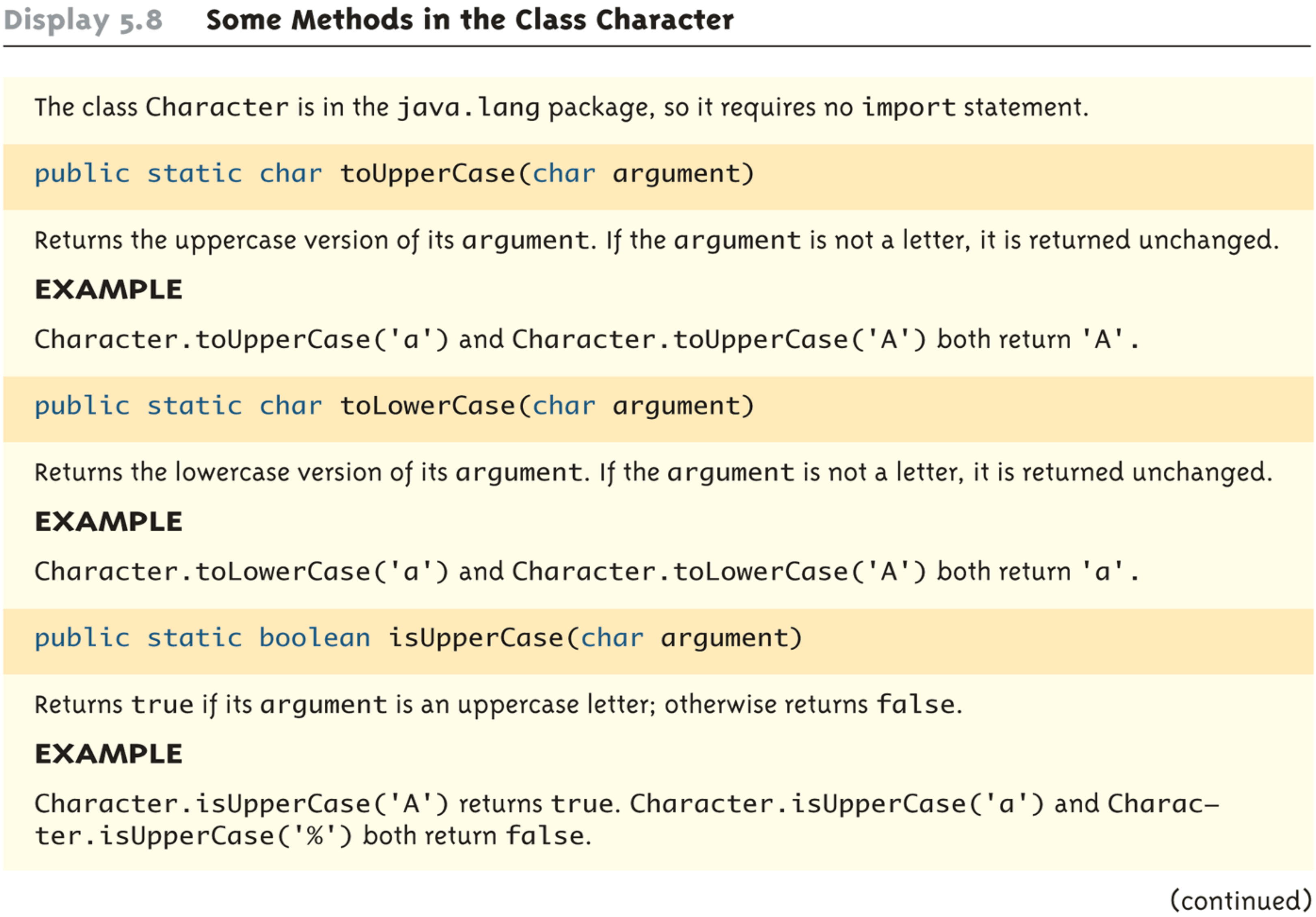
```
java proj1.Project1 Bob 42
```

then args[0] = "Bob" and args[1] = "42".

- We can use the static method **Integer.parseInt( )** to change the argument "42" to an integer variable via

```
int age = Integer.parseInt( args[ 1 ] );
```

Methods in the Class `Character` (1 of 3)



Display 5.8 Some Methods in the Class Character

The class `Character` is in the `java.lang` package, so it requires no `import` statement.

`public static char toUpperCase(char argument)`

Returns the uppercase version of its `argument`. If the `argument` is not a letter, it is returned unchanged.

EXAMPLE

`Character.toUpperCase('a')` and `Character.toUpperCase('A')` both return `'A'`.

`public static char toLowerCase(char argument)`

Returns the lowercase version of its `argument`. If the `argument` is not a letter, it is returned unchanged.

EXAMPLE

`Character.toLowerCase('a')` and `Character.toLowerCase('A')` both return `'a'`.

`public static boolean isUpperCase(char argument)`

Returns `true` if its `argument` is an uppercase letter; otherwise returns `false`.

EXAMPLE

`Character.isUpperCase('A')` returns `true`. `Character.isUpperCase('a')` and `Character.isUpperCase('%')` both return `false`.

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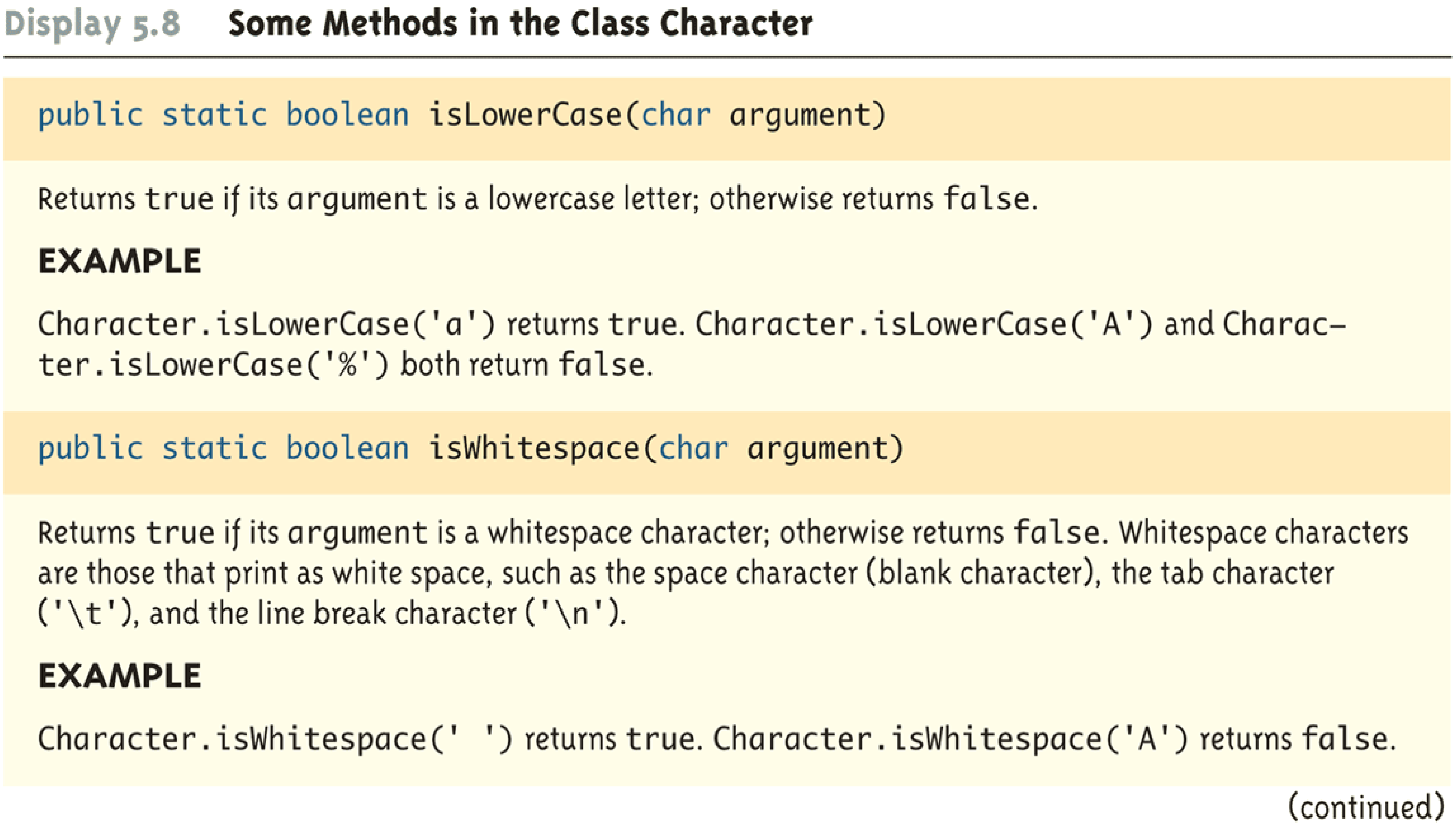
Methods in the Class **Character** (2 of 3)



Display 5.8 **Some Methods in the Class Character**

`public static boolean isLowerCase(char argument)`

Returns `true` if its argument is a lowercase letter; otherwise returns `false`.

EXAMPLE

`Character.isLowerCase('a')` returns `true`. `Character.isLowerCase('A')` and `Character.isLowerCase('%')` both return `false`.

`public static boolean isWhitespace(char argument)`

Returns `true` if its argument is a whitespace character; otherwise returns `false`. Whitespace characters are those that print as white space, such as the space character (blank character), the tab character (`'\t'`), and the line break character (`'\n'`).

EXAMPLE

`Character.isWhitespace(' ')` returns `true`. `Character.isWhitespace('A')` returns `false`.

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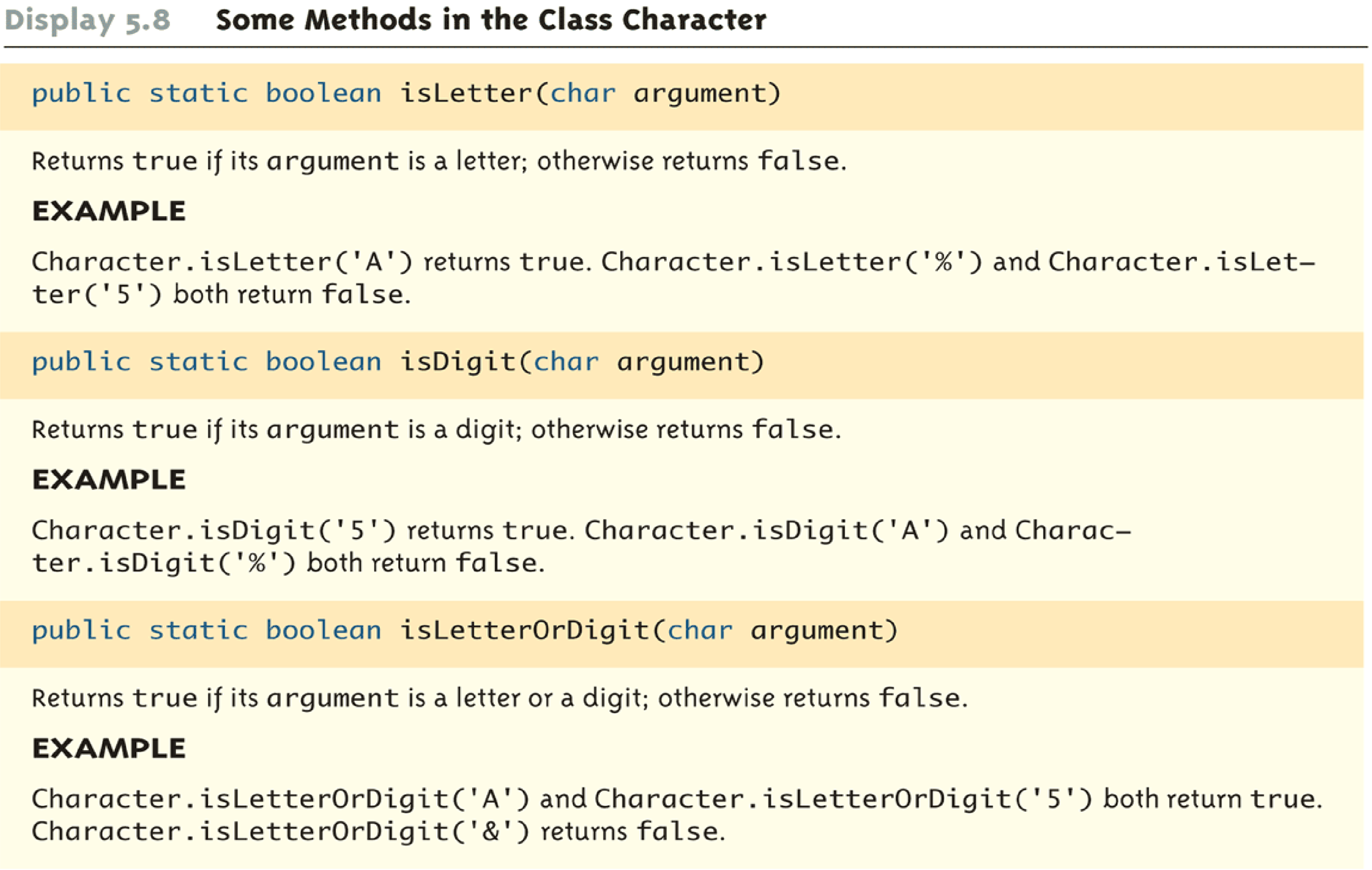
Methods in the Class **`Character`** (3 of 3)



Display 5.8 Some Methods in the Class Character

```
public static boolean isLetter(char argument)
```

Returns `true` if its argument is a letter; otherwise returns `false`.

EXAMPLE

`Character.isLetter('A')` returns `true`. `Character.isLetter('%')` and `Character.isLetter('5')` both return `false`.

```
public static boolean isDigit(char argument)
```

Returns `true` if its argument is a digit; otherwise returns `false`.

EXAMPLE

`Character.isDigit('5')` returns `true`. `Character.isDigit('A')` and `Character.isDigit('%')` both return `false`.

```
public static boolean isLetterOrDigit(char argument)
```

Returns `true` if its argument is a letter or a digit; otherwise returns `false`.

EXAMPLE

`Character.isLetterOrDigit('A')` and `Character.isLetterOrDigit('5')` both return `true`. `Character.isLetterOrDigit('&')` returns `false`.

Boxing

- ***Boxing***: The process of converting from a value of a primitive type to an object of its wrapper class.
  - Create an object of the corresponding wrapper class using the primitive value as an argument
  - The new object will contain an instance variable that stores a copy of the primitive value.

```
Integer integerObject = new Integer(42);
```

  - Unlike most other classes, a wrapper class does not have a no-argument constructor.
  - The value inside a Wrapper class is ***immutable***.

Unboxing

- ***Unboxing***: The process of converting from an object of a wrapper class to the corresponding value of a primitive type.
  - The methods for converting an object from the wrapper classes

    `Byte`, `Short`, `Integer`, `Long`, `Float`,
    `Double`, and `Character`

    to their corresponding primitive type are (in order)

    `byteValue`, `shortValue`, `intValue`,
    `longValue`, `floatValue`, `doubleValue`,
    and `charValue`.

  - None of these methods take an argument.

```
int i = integerObject.intValue();
```

Automatic Boxing and Unboxing

Starting with version 5.0, Java can automatically do boxing and unboxing for you.

- Boxing:

```
Integer integerObject = 42;
```

rather than:

```
Integer integerObject = new Integer(42);
```

- Unboxing:

```
int i = integerObject;
```

rather than:

```
int i = integerObject.intValue();
```