Java Review

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Java

- Java Basics
- Java Program Statements
  - Conditional statements
  - Repetition statements (loops)
- Writing Classes in Java
  - Class definitions
  - Encapsulation and Java modifiers
  - Method declaration, invocation, and parameter passing
  - Method overloading

Programming Rules of Thumb

- *Learn program patterns* of general utility (branching, loops, etc.) and *use relevant patterns* for the problem at hand
- *Seek inspiration* by systematically working test data by hand and ask yourself: “what am I doing?”
- *Declare variables* for each piece of information you maintain when working problem by hand
- *Decompose* problem into manageable tasks
- *Remember* the problem’s boundary conditions
- *Validate* your program by tracing it on test data with known output

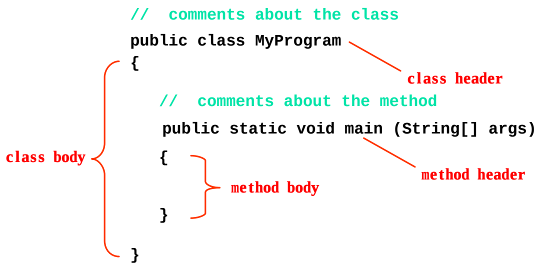
Introduction to Objects

- An *object* represents something with which we can interact in a program
- An object provides a collection of services that we can tell it to perform for us
- The services are defined by methods in a *class* that defines the object
- A class represents a concept, and an object represents the embodiment of a class
- A class can be used to create multiple objects

Java Program Structure

- In the Java programming language:
  - A program is made up of one or more *classes*
  - A class contains one or more *methods*
  - A method contains program *statements*
- Attributes/properties correspond to fields (or variables)
- Behaviors/operations correspond to methods
- A Java application always contains a method called `main`

Java Program Structure



```
//  comments about the class
public class MyProgram
{
   //  comments about the method
   public static void main (String[] args)
   {

   }
}
```

Variables

- A *variable* is a name for a location in memory
- A variable must be *declared* by specifying the variable's name and the type of information that it will hold

data type variable name

```
int total;

int count, temp, result;
```

Multiple variables can be created in one declaration

Primitive Data

- There are exactly eight primitive data types in Java
- Four of them represent integers:
  - `byte`, `short`, `int`, `long`
- Two of them represent floating point numbers:
  - `float`, `double`
- One of them represents characters:
  - `char`
- And one of them represents boolean values:
  - `boolean`

Numeric Primitive Data

- The difference between the various numeric primitive types is their size, and therefore the values they can store:

Type	Storage	Min Value	Max Value
byte	8 bits	-128	127
short	16 bits	-32,768	32,767
int	32 bits	-2,147,483,648	2,147,483,647
long	64 bits	< -9 x 10^{18}	> 9 x 10^{18}
float	32 bits	+/- 3.4 x 10^{38} with 7 significant digits	
double	64 bits	+/- 1.7 x 10^{308} with 15 significant digits	

Arithmetic Expressions

- An *expression* is a combination of one or more operands and their operators
- *Arithmetic expressions* use the operators:

Addition	+	
Subtraction	-	
Multiplication	*	
Division	/	
Remainder	%	(no ^ operator)

- If either or both operands associated with an arithmetic operator are floating point, the result is a floating point

Division and Remainder

- If both operands to the division operator (`/`) are integers, the result is an integer (the fractional part is discarded)

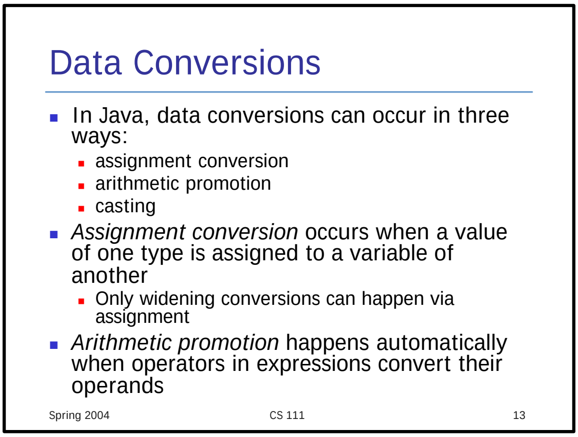
`14 / 3`	equals?	4
`8 / 12`	equals?	0

- The remainder operator (%) returns the remainder after dividing the second operand into the first

`14 % 3`	equals?	2
`8 % 12`	equals?	8

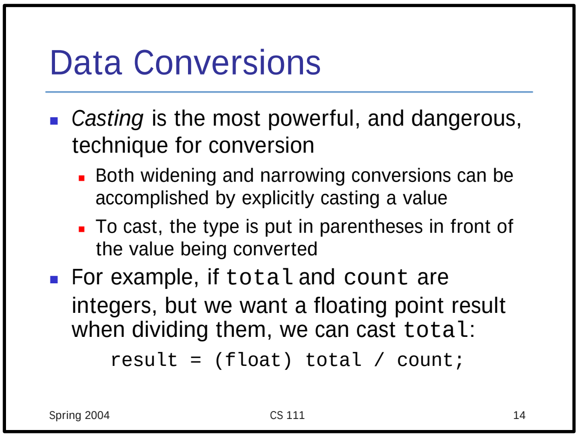
String Concatenation

- The *string concatenation operator* (+) is used to append one string to the end of another
- The plus operator (+) is also used for arithmetic addition
- The function that the + operator performs depends on the type of the information on which it operates
  - If at least one operand is a string, it performs string concatenation
  - If both operands are numeric, it adds them
- The + operator is evaluated left to right
- Parentheses can be used to force the operation order



Data Conversions

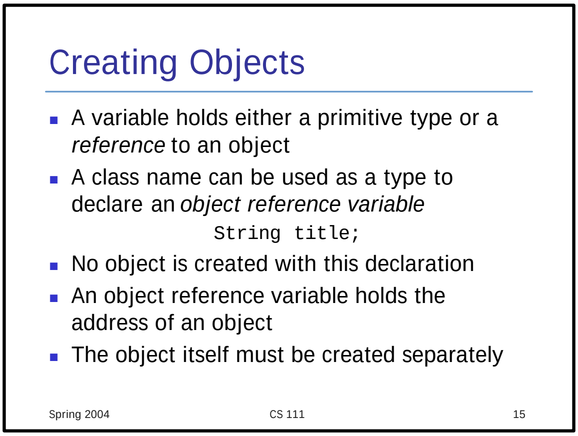
- In Java, data conversions can occur in three ways:
  - assignment conversion
  - arithmetic promotion
  - casting
- *Assignment conversion* occurs when a value of one type is assigned to a variable of another
  - Only widening conversions can happen via assignment
- *Arithmetic promotion* happens automatically when operators in expressions convert their operands



Data Conversions

- *Casting* is the most powerful, and dangerous, technique for conversion
  - Both widening and narrowing conversions can be accomplished by explicitly casting a value
  - To cast, the type is put in parentheses in front of the value being converted
- For example, if `total` and `count` are integers, but we want a floating point result when dividing them, we can cast `total`:

```
result = (float) total / count;
```

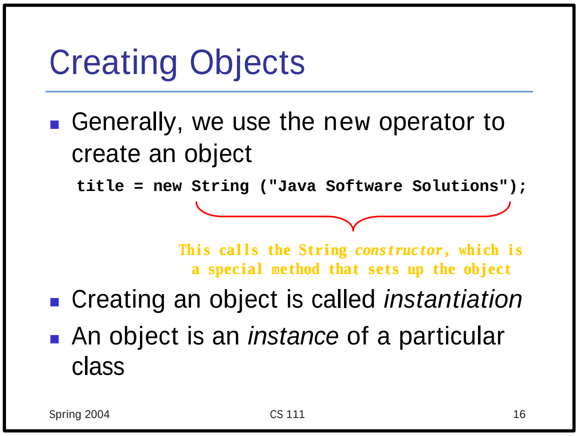


Creating Objects

- A variable holds either a primitive type or a *reference* to an object
- A class name can be used as a type to declare an *object reference variable*

```
String title;
```

- No object is created with this declaration
- An object reference variable holds the address of an object
- The object itself must be created separately



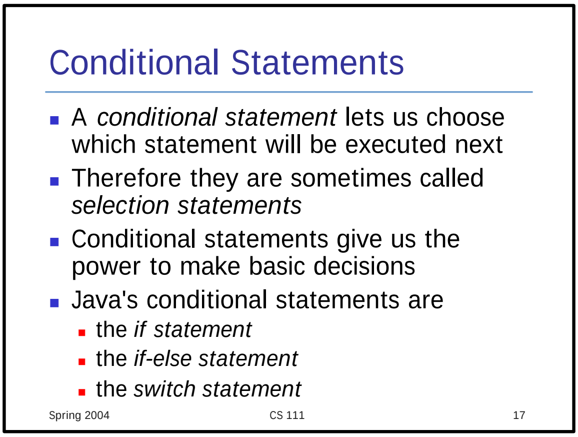
Creating Objects

- Generally, we use the `new` operator to create an object

```
title = new String ("Java Software Solutions");
```

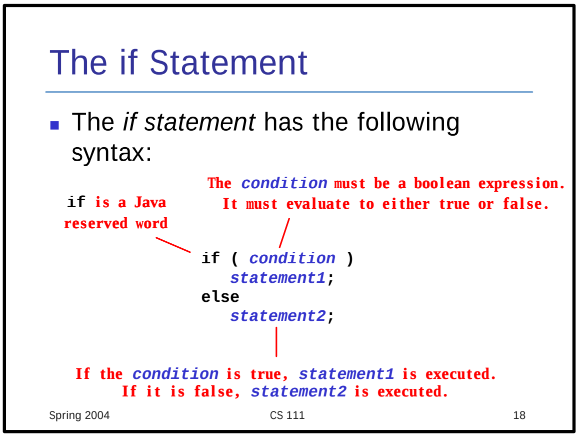
This calls the String *constructor*, which is a special method that sets up the object

- Creating an object is called *instantiation*
- An object is an *instance* of a particular class



Conditional Statements

- A *conditional statement* lets us choose which statement will be executed next
- Therefore they are sometimes called *selection statements*
- Conditional statements give us the power to make basic decisions
- Java's conditional statements are
  - the *if statement*
  - the *if-else statement*
  - the *switch statement*



The if Statement

- The *if statement* has the following syntax:

The *condition* must be a boolean expression. It must evaluate to either true or false.

if is a Java reserved word

```
if ( condition )
   statement1;
else
   statement2;
```

If the *condition* is true, *statement1* is executed. If it is false, *statement2* is executed.

Boolean Expressions

- A condition often uses one of Java's *equality operators* or *relational operators*, which all return boolean results:

==	equal to
!=	not equal to
<	less than
>	greater than
<=	less than or equal to
>=	greater than or equal to

- Note the difference between the equality operator (==) and the assignment operator (=)

Logical Operators

- Boolean expressions can use the following *logical operators*:

!	Logical NOT
&&	Logical AND
||	Logical OR

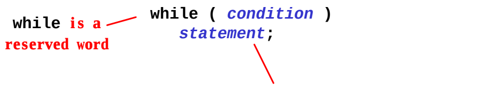
- They all take boolean operands and produce boolean results
- Logical NOT is a unary operator (it operates on one operand)
- Logical AND and logical OR are binary operators (each operates on two operands)

Repetition Statements

- *Repetition statements* allow us to execute a statement multiple times
- Often they are referred to as *loops*
- Like conditional statements, they are controlled by boolean expressions
- Java has three kinds of repetition statements:
  - the *while loop*
  - the *do loop*
  - the *for loop*
- The programmer should choose the right kind of loop for the situation

The while Statement

- The *while statement* has the following syntax:



```
while ( condition )
   statement;
```

while is a reserved word

If the *condition* is true, the *statement* is executed. Then the *condition* is evaluated again.

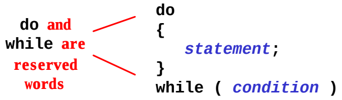
The *statement* is executed repeatedly until the *condition* becomes false.

Example

```
//********************************************************************
//  Counter.java       Author: Lewis/Loftus
//
//  Demonstrates the use of a while loop.
//********************************************************************

public class Counter
{
   //-----------------------------------------------------------------
   //  Prints integer values from 1 to a specific limit.
   //-----------------------------------------------------------------
   public static void main (String[] args)
   {
      final int LIMIT = 5;
      int count = 1;

      while (count <= LIMIT)
      {
         System.out.println (count);
         count = count + 1;
      }

      System.out.println ("Done");
   }
}
```

The do Statement

- The *do statement* has the following syntax:



```
do
{
   statement;
}
while ( condition )
```

do and while are reserved words

The *statement* is executed once initially, and then the *condition* is evaluated

The *statement* is executed repeatedly until the *condition* becomes false

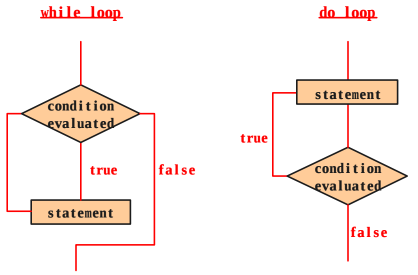
The do Statement

- A do loop is similar to a while loop, except that the condition is evaluated after the body of the loop is executed
- Therefore the body of a do loop will execute at least once

Example

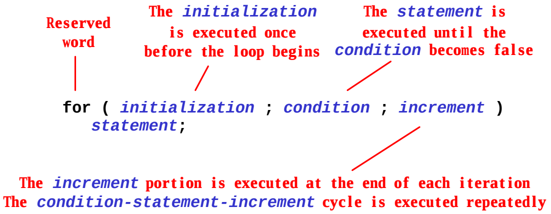
```
//********************************************************************
//  Counter2.java       Author: Lewis/Loftus
//
//  Demonstrates the use of a do loop.
//********************************************************************

public class Counter2
{
   //-----------------------------------------------------------------
   //  Prints integer values from 1 to a specific limit.
   //-----------------------------------------------------------------
   public static void main (String[] args)
   {
      final int LIMIT = 5;
      int count = 0;

      do
      {
         count = count + 1;
         System.out.println (count);
      }
      while (count < LIMIT);

      System.out.println ("Done");
   }
}
```

Comparing while and do



The for Statement

- The *for statement* has the following syntax:



Reserved word

The *initialization* is executed once before the loop begins

The *statement* is executed until the *condition* becomes false

```
for ( initialization ; condition ; increment )
   statement;
```

The *increment* portion is executed at the end of each iteration

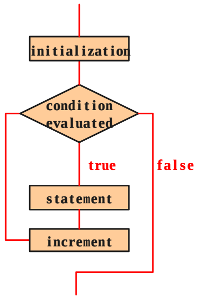
The *condition-statement-increment* cycle is executed repeatedly

The for Statement

- A for loop is functionally equivalent to the following while loop structure:

```
initialization;
while ( condition )
{
   statement;
   increment;
}
```

Logic of a for loop



The for Statement

- Like a `while` loop, the condition of a `for` statement is tested prior to executing the loop body
- Therefore, the body of a `for` loop will execute zero or more times
- It is well suited for executing a loop a specific number of times that can be determined in advance

Example

```
//********************************************************************
//  Counter3.java       Author: Lewis/Loftus
//
//  Demonstrates the use of a for loop.
//********************************************************************

public class Counter3
{
   //-----------------------------------------------------------------
   //  Prints integer values from 1 to a specific limit.
   //-----------------------------------------------------------------
   public static void main (String[] args)
   {
      final int LIMIT = 5;

      for (int count=1; count <= LIMIT; count++)
         System.out.println (count);

      System.out.println ("Done");
   }
}
```

Choosing a Loop Structure

- When you can't determine how many times you want to execute the loop body, use a `while` statement or a do statement
  - If it might be zero or more times, use a `while` statement
  - If it will be at least once, use a do statement
- If you can determine how many times you want to execute the loop body, use a `for` statement

The switch Statement

- The general syntax of a `switch` statement is:

```
switch ( expression )
{
   case value1 :
      statement-list1;
      break;
   case value2 :
      statement-list2;
      break;
   case value3 :
      statement-list3;
      break;
   case  ...
}
```

switch and case are reserved words

If *expression* matches *value2*, control jumps to here

The switch Statement

- The expression of a `switch` statement must result in an *integral type*, meaning an `int` or a `char`
- It cannot be a `boolean` value, a floating point value (`float` or `double`), a `byte`, a `short`, or a `long`
- The implicit boolean condition in a `switch` statement is equality - it tries to match the expression with a value
- You cannot perform relational checks with a `switch` statement

Comparing Strings

- Remember that a character string in Java is an object
- The `equals` method can be called with strings to determine if two strings contain exactly the same characters in the same order
- The `String` class also contains a method called `compareTo` to determine if one string comes before another in lexicographic order (based on the Unicode character set)
- This is not strictly alphabetical when uppercase and lowercase characters are mixed

Comparing Float Values

- We also have to be careful when comparing two floating point values (`float` or `double`) for equality
- You should rarely use the equality operator (`==`) when comparing two floats
- In many situations, you might consider two floating point numbers to be "close enough" even if they aren't exactly equal
- Therefore, to determine the equality of two floats, you may want to use the following technique:

```
if (Math.abs(f1 - f2) < 0.00001)
   System.out.println ("Essentially equal.");
```

Increment and Decrement

- The increment and decrement operators are arithmetic and operate on one operand
- The *increment operator* (`++`) adds one to its operand
- The *decrement operator* (`--`) subtracts one from its operand
- The statement

```
        count++;
```

is functionally equivalent to

```
        count = count + 1;
```

Assignment Operators

- There are many assignment operators, including the following:

Operator	Example	Equivalent To
`+=`	`x += y`	`x = x + y`
`-=`	`x -= y`	`x = x - y`
`*=`	`x *= y`	`x = x * y`
`/=`	`x /= y`	`x = x / y`
`%=`	`x %= y`	`x = x % y`

Objects and Classes

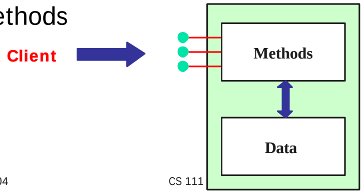
- An object has:
  - *state* - descriptive characteristics
  - *behaviors* - what it can do (or what can be done to it)
- A class is the model or pattern from which objects are created
- For example, consider a coin that can be flipped so that it's face shows either "heads" or "tails"
- The state of the coin is its current face (heads or tails)
- The behavior of the coin is that it can be flipped

Encapsulation

- We can take one of two views of an object:
  - internal - the variables the object holds and the methods that make the object useful
  - external - the services that an object provides and how the object interacts
- Any changes to the object's state (its variables) should be made only by that object's methods
- We should make it difficult, if not impossible, to access an object's variables other than via its methods
- The user, or *client*, of an object can request its services, but it should not have to be aware of how those services are accomplished

Encapsulation

- An encapsulated object can be thought of as a *black box*
- Its inner workings are hidden to the client, which invokes only the interface methods



Visibility Modifiers

- In Java, we accomplish encapsulation through the appropriate use of *visibility modifiers*
- A *modifier* is a Java reserved word that specifies particular characteristics of a method or data value
- Members of a class that are declared with *public visibility* can be accessed from anywhere (public variables violate encapsulation)
- Members of a class that are declared with *private visibility* can only be accessed from inside the class

Visibility Modifiers

	public	private
Variables	Violate encapsulation	Enforce encapsulation
Methods	Provide services to clients	Support other methods in the class

Data Scope

- The *scope* of data is the area in a program in which that data can be used (referenced)
- Data declared at the class level can be used by all methods in that class
- Data declared within a block (enclosed within { and }, if statements, loops) can be used only in that block

Example

```
import java.text.NumberFormat;

public class Account
{
   private NumberFormat fmt = NumberFormat.getCurrencyInstance();
   private final double RATE = 0.035;  // interest rate of 3.5%
   private long acctNumber;
   private double balance;
   private String name;

   //-----------------------------------------------------------------
   //  Sets up the account by defining its owner, account number,
   //  and initial balance.
   //-----------------------------------------------------------------
   public Account (String owner, long account, double initial)
   {
      name = owner;
      acctNumber = account;
      balance = initial;
   }

   //-----------------------------------------------------------------
   //  Validates the transaction, then deposits the specified amount
   //  into the account. Returns the new balance.
   //-----------------------------------------------------------------
   public double deposit (double amount)
   {
      if (amount < 0)  // deposit value is negative
      {
         System.out.println ();
         System.out.println ("Error: Deposit amount is invalid.");
         System.out.println (acctNumber + "  " + fmt.format(amount));
      }
      else
         balance = balance + amount;

      return balance;
   }
…
```

Example

```
…
   //-----------------------------------------------------------------
   //  Validates the transaction, then withdraws the specified amount
   //  from the account. Returns the new balance.
   //-----------------------------------------------------------------
   public double withdraw (double amount, double fee)
   {
      amount += fee;

      if (amount < 0)  // withdraw value is negative
      {
         System.out.println ();
         System.out.println ("Error: Withdraw amount is invalid.");
         System.out.println ("Account: " + acctNumber);
         System.out.println ("Requested: " + fmt.format(amount));
      }
      else
         if (amount > balance)  // withdraw value exceeds balance
         {
            System.out.println ();
            System.out.println ("Error: Insufficient funds.");
            System.out.println ("Account: " + acctNumber);
            System.out.println ("Requested: " + fmt.format(amount));
            System.out.println ("Available: " + fmt.format(balance));
         }
         else
            balance = balance - amount;

      return balance;
   }
…
```

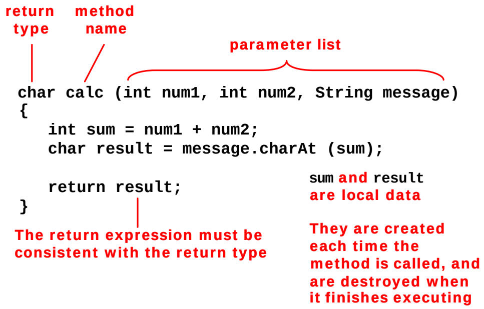
Example

```
…
   //-----------------------------------------------------------------
   //  Adds interest to the account and returns the new balance.
   //-----------------------------------------------------------------
   public double addInterest ()
   {
      balance += (balance * RATE);
      return balance;
   }

   //-----------------------------------------------------------------
   //  Returns the current balance of the account.
   //-----------------------------------------------------------------
   public double getBalance ()
   {
      return balance;
   }

   //-----------------------------------------------------------------
   //  Returns the account number.
   //-----------------------------------------------------------------
   public long getAccountNumber ()
   {
      return acctNumber;
   }

   //-----------------------------------------------------------------
   //  Returns a one-line description of the account as a string.
   //-----------------------------------------------------------------
   public String toString ()
   {
      return (acctNumber + "\t" + name + "\t" + fmt.format(balance));
   }
}
```

Example

```
public class Banking
{
   //-----------------------------------------------------------------
   //  Creates some bank accounts and requests various services.
   //-----------------------------------------------------------------
   public static void main (String[] args)
   {
      Account acct1 = new Account ("Ted Murphy", 72354, 102.56);
      Account acct2 = new Account ("Jane Smith", 69713, 40.00);
      Account acct3 = new Account ("Edward Demsey", 93757, 759.32);

      acct1.deposit (25.85);
      double smithBalance = acct2.deposit (500.00);
      System.out.println ("Smith balance after deposit: " +
                          smithBalance);
      System.out.println ("Smith balance after withdrawal: " +
                          acct2.withdraw (430.75, 1.50));
      acct3.withdraw (800.00, 0.0);  // exceeds balance
      acct1.addInterest();
      acct2.addInterest();
      acct3.addInterest();

      System.out.println ();
      System.out.println (acct1);
      System.out.println (acct2);
      System.out.println (acct3);
   }
}
```

Method Header and Body



```
char calc (int num1, int num2, String message)
{
   int sum = num1 + num2;
   char result = message.charAt (sum);

   return result;
}
```

sum and result are local data

The return expression must be consistent with the return type

They are created each time the method is called, and are destroyed when it finishes executing

The return Statement

- The *return type* of a method indicates the type of value that the method sends back to the calling location
- A method that does not return a value has a `void` return type
- A *return statement* specifies the value that will be returned

  `return` ***`expression`*** `;`

- Its expression must conform to the return type

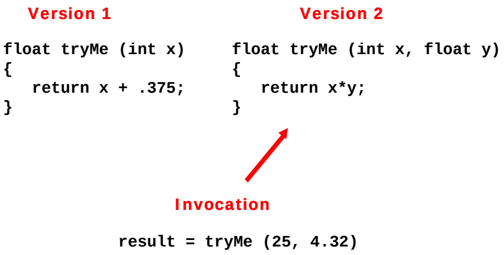
Constructors Revisited

- Recall that a constructor is a special method that is used to initialize a newly created object
- When writing a constructor, remember that:
  - it has the same name as the class
  - it does not return a value
  - it has no return type, not even `void`
  - it typically sets the initial values of instance variables
- The programmer does not have to define a constructor for a class

Overloading Methods

- *Method overloading* is the process of using the same method name for multiple methods
- The *signature* of each overloaded method must be unique
- The signature includes the number, type, and order of the parameters
- The compiler determines which version of the method is being invoked by analyzing the parameters
- The return type of the method is <u>not</u> part of the signature

Overloading Methods



Version 1

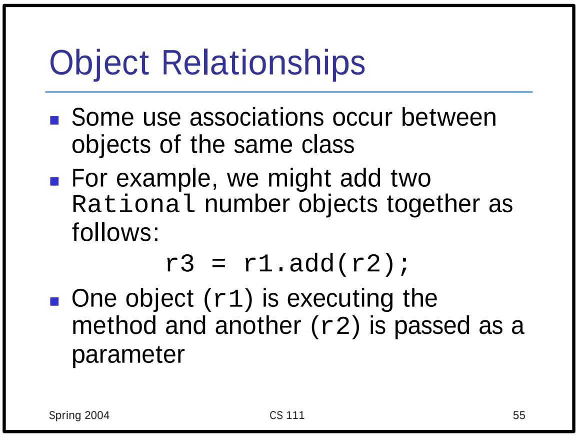
```
float tryMe (int x)
{
   return x + .375;
}
```

Version 2

```
float tryMe (int x, float y)
{
   return x*y;
}
```

Invocation

```
result = tryMe (25, 4.32)
```

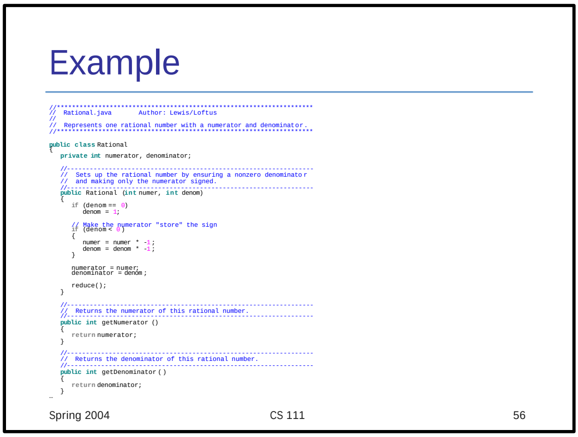


Object Relationships

- Some use associations occur between objects of the same class
- For example, we might add two `Rational` number objects together as follows:

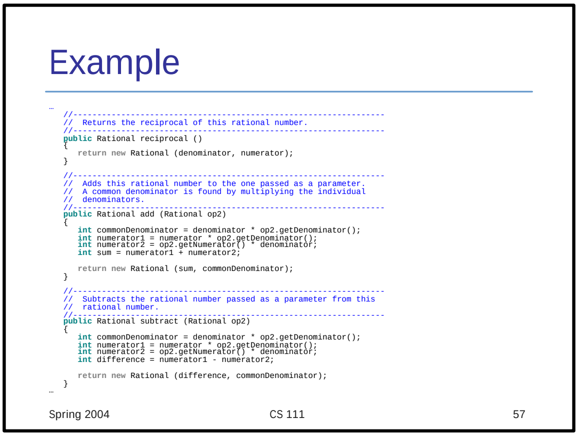
  `r3 = r1.add(r2);`

- One object (`r1`) is executing the method and another (`r2`) is passed as a parameter



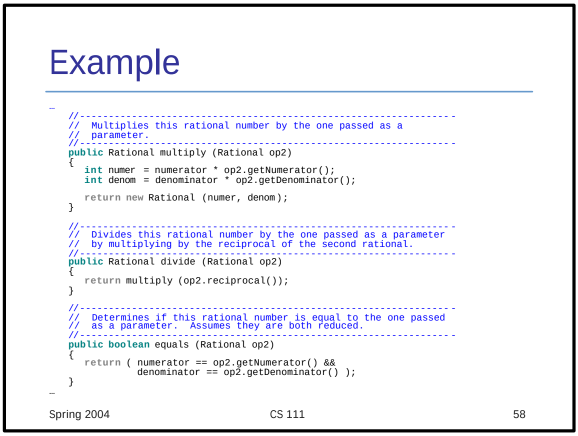
Example

```
//********************************************************************
//  Rational.java       Author: Lewis/Loftus
//
//  Represents one rational number with a numerator and denominator.
//********************************************************************

public class Rational
{
   private int numerator, denominator;

   //-----------------------------------------------------------------
   //  Sets up the rational number by ensuring a nonzero denominato r
   //  and making only the numerator signed.
   //-----------------------------------------------------------------
   public Rational (int numer, int denom)
   {
      if (denom == 0)
         denom = 1;

      // Make the numerator "store" the sign
      if (denom < 0 )
      {
         numer = numer * -1 ;
         denom = denom * -1 ;
      }

      numerator = numer;
      denominator = denom ;

      reduce();
   }

   //-----------------------------------------------------------------
   //  Returns the numerator of this rational number.
   //-----------------------------------------------------------------
   public int getNumerator ()
   {
      return numerator;
   }

   //-----------------------------------------------------------------
   //  Returns the denominator of this rational number.
   //-----------------------------------------------------------------
   public int getDenominator ( )
   {
      return denominator;
   }
…
```



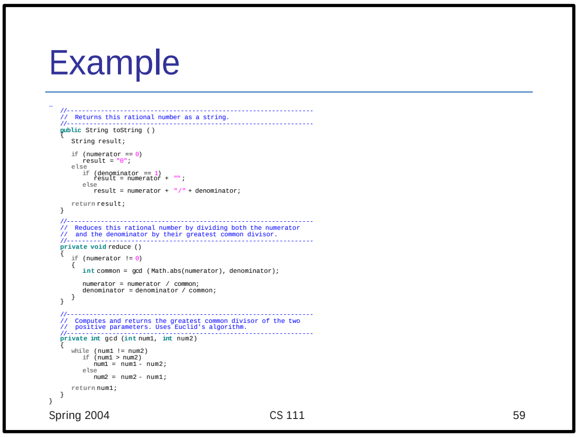
Example

```
…
   //-----------------------------------------------------------------
   //  Returns the reciprocal of this rational number.
   //-----------------------------------------------------------------
   public Rational reciprocal ()
   {
      return new Rational (denominator, numerator);
   }

   //-----------------------------------------------------------------
   //  Adds this rational number to the one passed as a parameter.
   //  A common denominator is found by multiplying the individual
   //  denominators.
   //-----------------------------------------------------------------
   public Rational add (Rational op2)
   {
      int commonDenominator = denominator * op2.getDenominator();
      int numerator1 = numerator * op2.getDenominator();
      int numerator2 = op2.getNumerator() * denominator;
      int sum = numerator1 + numerator2;

      return new Rational (sum, commonDenominator);
   }

   //-----------------------------------------------------------------
   //  Subtracts the rational number passed as a parameter from this
   //  rational number.
   //-----------------------------------------------------------------
   public Rational subtract (Rational op2)
   {
      int commonDenominator = denominator * op2.getDenominator();
      int numerator1 = numerator * op2.getDenominator();
      int numerator2 = op2.getNumerator() * denominator;
      int difference = numerator1 - numerator2;

      return new Rational (difference, commonDenominator);
   }
…
```



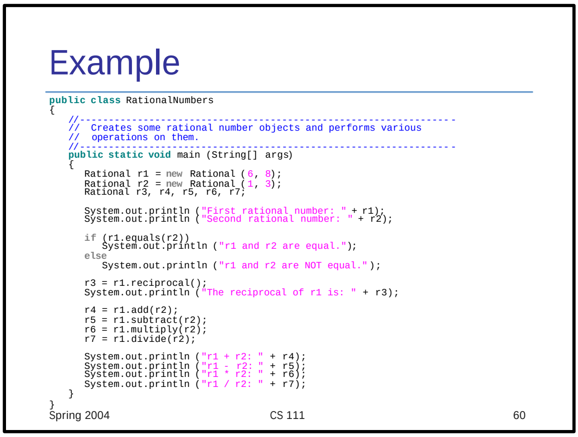
Example

```
…
   //-----------------------------------------------------------------
   //  Multiplies this rational number by the one passed as a
   //  parameter.
   //-----------------------------------------------------------------
   public Rational multiply (Rational op2)
   {
      int numer = numerator * op2.getNumerator();
      int denom = denominator * op2.getDenominator();

      return new Rational (numer, denom);
   }

   //-----------------------------------------------------------------
   //  Divides this rational number by the one passed as a parameter
   //  by multiplying by the reciprocal of the second rational.
   //-----------------------------------------------------------------
   public Rational divide (Rational op2)
   {
      return multiply (op2.reciprocal());
   }

   //-----------------------------------------------------------------
   //  Determines if this rational number is equal to the one passed
   //  as a parameter.  Assumes they are both reduced.
   //-----------------------------------------------------------------
   public boolean equals (Rational op2)
   {
      return ( numerator == op2.getNumerator() &&
               denominator == op2.getDenominator() );
   }
…
```



Example

```
…
   //-----------------------------------------------------------------
   //  Returns this rational number as a string.
   //-----------------------------------------------------------------
   public String toString ()
   {
      String result;

      if (numerator == 0)
         result = "0";
      else
         if (denominator == 1)
            result = numerator + "";
         else
            result = numerator + "/" + denominator;

      return result;
   }

   //-----------------------------------------------------------------
   //  Reduces this rational number by dividing both the numerator
   //  and the denominator by their greatest common divisor.
   //-----------------------------------------------------------------
   private void reduce ()
   {
      if (numerator != 0)
      {
         int common = gcd (Math.abs(numerator), denominator);

         numerator = numerator / common;
         denominator = denominator / common;
      }
   }

   //-----------------------------------------------------------------
   //  Computes and returns the greatest common divisor of the two
   //  positive parameters. Uses Euclid's algorithm.
   //-----------------------------------------------------------------
   private int gcd (int num1, int num2)
   {
      while (num1 != num2)
         if (num1 > num2)
            num1 = num1 - num2;
         else
            num2 = num2 - num1;

      return num1;
   }
}
```



Example

```
public class RationalNumbers
{
   //-----------------------------------------------------------------
   //  Creates some rational number objects and performs various
   //  operations on them.
   //-----------------------------------------------------------------
   public static void main (String[] args)
   {
      Rational r1 = new Rational (6, 8);
      Rational r2 = new Rational (1, 3);
      Rational r3, r4, r5, r6, r7;

      System.out.println ("First rational number: " + r1);
      System.out.println ("Second rational number: " + r2);

      if (r1.equals(r2))
         System.out.println ("r1 and r2 are equal.");
      else
         System.out.println ("r1 and r2 are NOT equal.");

      r3 = r1.reciprocal();
      System.out.println ("The reciprocal of r1 is: " + r3);

      r4 = r1.add(r2);
      r5 = r1.subtract(r2);
      r6 = r1.multiply(r2);
      r7 = r1.divide(r2);

      System.out.println ("r1 + r2: " + r4);
      System.out.println ("r1 - r2: " + r5);
      System.out.println ("r1 * r2: " + r6);
      System.out.println ("r1 / r2: " + r7);
   }
}
```

Example

```java
public class Address
{
   private String streetAddress, city, state;
   private long zipCode;

   //-----------------------------------------------------------------
   //  Sets up this Address object with the specified data.
   //-----------------------------------------------------------------
   public Address (String street, String town, String st, long zip)
   {
      streetAddress = street;
      city = town;
      state = st;
      zipCode = zip;
   }

   //-----------------------------------------------------------------
   //  Returns this Address object as a string.
   //-----------------------------------------------------------------
   public String toString()
   {
      String result;

      result = streetAddress + "\n";
      result += city + ", " + state + "  " + zipCode;

      return result;
   }
}
```

Example

```java
public class Student
{
   private String firstName, lastName;
   private Address homeAddress, schoolAddress;

   //-----------------------------------------------------------------
   //  Sets up this Student object with the specified initial values.
   //-----------------------------------------------------------------
   public Student (String first, String last, Address home,
                   Address school)
   {
      firstName = first;
      lastName = last;
      homeAddress = home;
      schoolAddress = school;
   }

   //-----------------------------------------------------------------
   //  Returns this Student object as a string.
   //-----------------------------------------------------------------
   public String toString()
   {
      String result;

      result = firstName + " " + lastName + "\n";
      result += "Home Address:\n" + homeAddress + "\n";
      result += "School Address:\n" + schoolAddress;

      return result;
   }
}
```

Example

```java
//********************************************************************
//  StudentBody.java       Author: Lewis/Loftus
//
//  Demonstrates the use of an aggregate class.
//********************************************************************

public class StudentBody
{
   //-----------------------------------------------------------------
   //  Creates some Address and Student objects and prints them.
   //-----------------------------------------------------------------
   public static void main (String[] args)
   {
      Address school = new Address ("800 Lancaster Ave.", "Villanova",
                                    "PA", 19085);

      Address jHome = new Address ("21 Jump Street", "Lynchburg",
                                   "VA", 24551);
      Student john = new Student ("John", "Smith", jHome, school);

      Address mHome = new Address ("123 Main Street", "Euclid", "OH",
                                   44132);
      Student marsha = new Student ("Marsha", "Jones", mHome, school);

      System.out.println (john);
      System.out.println ();
      System.out.println (marsha);
   }
}
```