7B. Object-Oriented Design II

- Objectives - when we have completed this set of notes, you should be familiar with:
  - writing interfaces
  - using interfaces in the Java API including Comparable and Iterator
  - method and constructor overloading
  - method design
  - types of testing

Interfaces

- A Java *interface*, in its most common form, consists of abstract methods and/or constants
  - An *abstract method* is a method header without a method body:

```
public abstract double getPerimeter();
```

  - The abstract reserved word can be left off because all methods in an interface are assumed to be abstract:

```
public double getPerimeter();
```

- An interface is used to establish a set of methods that a class will implement

Interfaces

interface is a reserved word

```
public interface TwoDShape {

      public double getNumberSides();

      public double getPerimeter();

}
```

None of the methods in an interface are given a definition (body); an interface may also contain constants

A semicolon immediately follows each method header

Interfaces

- An interface cannot be instantiated
- Methods in an interface have public visibility by default so the *public* modifier is optional
- A class formally implements an interface:
  - By stating so in the class header

    ```
    public class Triangle implements TwoDShape
    ```

    - The Triangle class must now have a getNumberSides and a getPerimeter method
  - And then by providing a body (or implementation) for each abstract method in the interface

Interfaces

- A class that implements an interface can implement other methods as well
  - See Triangle.java and Rectangle.java, which both implement the TwoDShape interface
- In addition to (or instead of) abstract methods, an interface can contain constants
- When a class implements an interface, it gains access to all its constants

Multiple Interfaces

- A class can implement multiple interfaces
- The interfaces are listed in the `implements` clause
- The class must implement all methods in all interfaces listed in the header (see Rectangle.java)

```
class ManyThings implements Interface1, Interface2
{
   // all methods of both interfaces
}
```

Comparable Interface

- The Java standard class library contains many helpful interfaces
- The `Comparable` interface contains one abstract method called `compareTo`, which is used to compare two objects
- Recall the compareTo method of String:
  - The compareTo method is defined in the String class to compare objects based on lexographic order

```
str1.compareTo(str2);
```

The Comparable Interface

- Any class can implement the `Comparable` interface to define how objects are compared, making the following code possible:

```
obj1.compareTo(obj2);
```

- The value returned from `compareTo` should be…
  - negative if `obj1` is less that `obj2` `(returning` any negative number is ok)
  - 0 if they are equal
  - positive if `obj1` is greater than `obj2` `(returning` any positive number is ok)

The Comparable Interface

- The customer/designer/programmer decides what makes one object less than another
- For example, you may define the `compareTo` method of an `Employee` class to order employees by name (alphabetically) or by employee number
- The compareTo method for Rectangle.java is based on area

Interfaces

- You could implement `compareTo` without implementing the interface `Comparable`, but you would limit the functionality
  - For example, Arrays.sort relies on compareTo.
  - If you try to use Arrays.sort on an array of Rectangles, it will generate a run-time error **unless Comparable is implemented** (even if you have defined compareTo and it compiled okay)
  - Try commenting out implements Comparable<Rectangle> in Rectangle.java and running RectangleSorter.java

The Iterator Interface

- An iterator is an object that provides a means of processing a collection of objects one at a time
- An iterator is created formally by implementing the `Iterator` interface, which contains three methods
  - The `hasNext` method returns a boolean result – true if there are items left to process
  - The `next` method returns the next object in the iteration
  - The `remove` method (optional) removes the object most recently returned by the `next` method

The Iterator Interface

- An example of a class that implements Iterator:
  - Scanner: iterates through “tokens” based on a delimiter (default delimiter is one or more spaces)
- In COMP 1210, we use classes that implement the Iterator interface, but we will not implement the interface in our own methods
- In COMP 2210, you will implement the Iterator interface when you start building data structures like lists

Method Overloading

- *Method overloading* is the process of giving a single method name multiple definitions
- If a method is overloaded, the method name is not sufficient to determine which method is being called
- The *signature* of each overloaded method must be unique
- The signature includes the method's name and its parameters (number, type, and order), but it does not include the return type

Method Overloading

- The compiler determines which method is being invoked by analyzing the parameters

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

Invocation

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

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

Method Overloading

- The `println` method is overloaded:

```
println (String s)
println (int i)
println (double d)
```

and so on...

- The following lines invoke different versions of the `println` method:

```
System.out.println ("The total is:");
System.out.println (total);
```

Overloading Notes

- Remember, the return type of the method is <u>not</u> part of the signature; i.e., overloaded methods cannot differ only by their return type
- When you compile your program, the compiler must find the class and matching method signature for each method call in your program; otherwise, your program will not compile.
- The class and matching method signature may be found in your program, the Java API, or other classes imported by your program

Constructor Overloading

- **Constructors** can be overloaded as well; for example, if we had a class Book, we might have the following constructors:
  - Book()
  - Book(String titleIn)
  - Book(String titleIn, String authorIn)
- Many classes in the JDK API have multiple constructors. For the String class:
  - String(String original)
  - String(char[] value)
  - . . . plus 6 other constructors

Method Design

- An *algorithm* is a step-by-step process for solving a problem
- Examples: a recipe, travel directions
- Every method implements an algorithm that determines how the method accomplishes its goals
- An algorithm may be expressed in *pseudocode*, a mixture of code statements and English that communicate the steps to take

Method Decomposition

- A method should be relatively small, so that it can be understood as a single entity
- A potentially large method should be decomposed into several smaller methods as needed for clarity
- A public service method of an object may call one or more private support methods to help it accomplish its goal
- Support methods might call other support methods if appropriate

Method Decomposition

- Let's look at an example that requires method decomposition – translating English into Pig Latin
- Pig Latin is a language in which each word is modified by moving the initial sound of the word to the end and adding "ay"
- Words that begin with vowels have the "yay" sound added on the end
- Examples

book →	ookbay	table →	abletay
item →	itemyay	chair →	airchay

Method Decomposition

- The primary objective (translating a sentence) is too complicated for one method to accomplish
- Therefore we look for natural ways to decompose the solution into pieces
- Translating a sentence can be decomposed into the process of translating each word
- The process of translating a word can be separated into translating words that:
  - begin with vowels
  - begin with consonant blends (sh, cr, th, etc.)
  - begin with single consonants

Method Decomposition

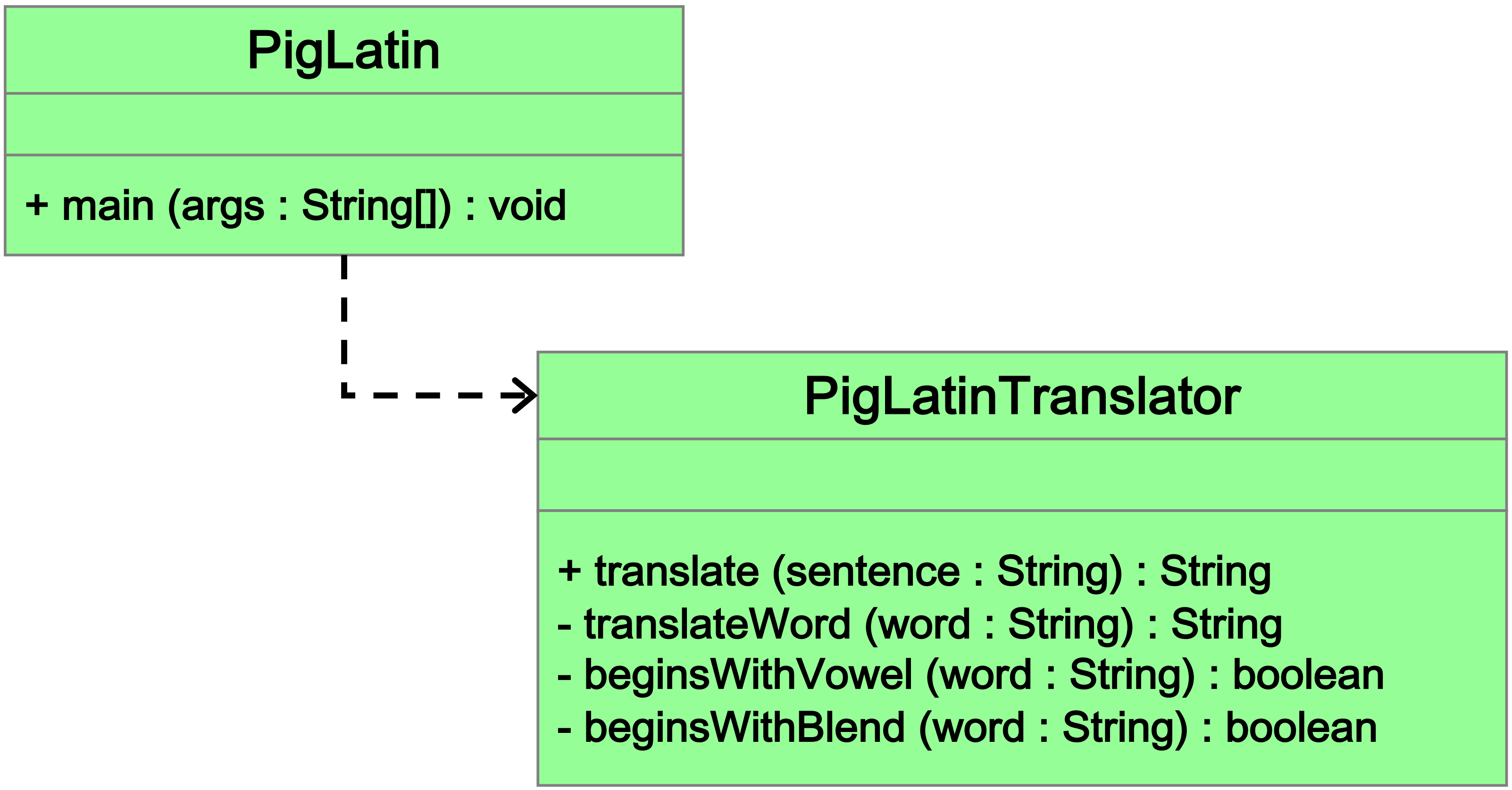
- See PigLatin.java
- See PigLatinTranslator.java

- In a UML class diagram, the visibility of a variable or method can be shown using special characters

- Public class members are preceded by a plus sign

- Private class members are preceded by a minus sign

Class Diagram for Pig Latin



Objects as Parameters

- Another important issue related to method design involves parameter passing
- Parameters in a Java method are *passed by value*
- A copy of the actual parameter (the value passed in) is stored into the formal parameter (in the method header)
- Therefore passing parameters is similar to an assignment statement
- When an object is passed to a method, the actual parameter and the formal parameter become aliases of each other

Passing Objects to Methods

- What a method does with a parameter may or may not have a permanent effect (outside the method)

- See ParameterTester.java
- See ParameterModifier.java
- See Num.java

- Note the difference between changing the internal state of an object versus changing which object a reference points to

Testing

- Testing can mean many different things
- It includes running a “completed” program with various inputs and checking the output
- It also includes any evaluation performed by human or computer to assess quality
- Some evaluations should occur before coding even begins
- The earlier we find an problem, the easier and cheaper it is to fix

Testing

- The goal of testing is to find defects (via failures)
- As we find and fix defects, we raise our confidence that a program will perform as intended
- For most large programs, we can never really be sure that all defects have been eliminated
- So when do we stop testing?
  - Theoretical answer: Never
  - Unfortunate Practical answer: When we run out of time
  - Engineering answer: When we are willing to risk that undiscovered defects still exists

Test Cases

- A *test case* is a set of input and/or user actions, coupled with the expected results
- Often test cases are organized formally into *test suites* which are stored and reused as needed
- For medium and large systems, testing must be a carefully managed process
- Many organizations have a separate Quality Assurance (QA) department to lead testing efforts

Defect and Regression Testing

- *Defect testing* is the execution of test cases to uncover defects/errors
- The act of fixing a defect/error may introduce new defects
- After fixing a set of defects/errors we should perform *regression testing* – running previous test suites to ensure new errors haven't been introduced
- It is not possible to create test cases for all possible input and user actions
- Therefore we should design tests to maximize their ability to find problems

Black-Box Testing

- In *black-box testing*, test cases are developed without considering the internal logic
- They are based on the input and expected output
- Input can be organized into *equivalence categories*
- Two input values in the same equivalence category would produce similar results
- Therefore a good test suite will cover all equivalence categories and focus on the boundaries between categories

White-Box Testing

- *White-box testing* focuses on the internal structure of the code
- The goal is to ensure that every <u>independent</u> path through the code is tested
- Paths through the code are determined by conditional or looping statements in a program
- A good testing effort will include both black-box and white-box tests