Week 14 - Monday

COMP 2000

Last time

- What did we talk about last time?
- JUnit test examples

Questions?

Project 4

Final exam

- Final exam will be held virtually:
  - Monday, April 27, 2020
  - 10:15 a.m. to 12:15 p.m.
- There will be multiple choice, short answer, and programming questions
- I recommend that you use an editor like Notepad++ to write your answers, since Blackboard doesn't play nice with tabs
- I **don't** recommend that you use Eclipse, since the syntax highlighting features will make you doubt yourself and try to get things perfect when getting them done is more important

Review

Java basics

- Primitive types: **`byte`**, **`char`**, **`short`**, **`int`**, **`long`**, **`float`**, **`double`**, **`boolean`**
- Operations: **`+`**, **`-`**, **`*`**, **`/`**, **`%`**, and shortcut versions
- Case sensitivity
- White space doesn't (usually) matter
- Three kinds of comments
- Arrays

Control structures

- Selection
  - **`if`**
  - **`switch`**
- Loops
  - **`while`**
  - **`do-while`**
  - **`for`**
  - Enhanced **`for`**
- **`break`** and **`continue`**: don't use them

Enhanced `for` loops

- Used to iterate over the contents of an array (or other collection of data)
- Similar to **`for`** loops in Python
- The **`type`** must match the elements of the array (or other collection)
- Syntax:

```
for(type value : array) {
  // Statements
  // Braces not needed for single statement
}
```

Objects and methods

- Static methods do work but are not connected to objects
- Reference types are arrows to objects
  - More than one arrow can point at a single object
- Objects contain
  - Members
  - Methods
- Objects should be compared with the **`equals()`** method instead of **==**
- **Notable exception:** comparing objects with **==** can make sense when working with a linked list, since we might care whether or not two references point at the same thing

Classes

- In addition to holding static methods, classes are template for objects
- Members (data) are usually private
- Methods (actions) are usually public
- Special kinds of methods:
  - Constructors specify how an object should be initialized
  - Accessors (getters) specify how an object can give back information
  - Mutators (setters) specify how an object changes data inside itself
- Static variables live in the class, not in an object (and shouldn't be used)
  - Unless they are constant (**`final`**)

Enums

- An enum is a special kind of class that has pre-defined constant objects
- These objects are intended to represent a fixed collection of named things:

```
public enum Day {
  SUNDAY, MONDAY, TUESDAY, WEDNESDAY, THURSDAY, FRIDAY,
  SATURDAY
}
```

- Individual days can be referenced like static variables: **`Day.MONDAY`** or **`Day.FRIDAY`**
- Since enum values are constants, it's convention to name them in ALL CAPS
- In addition to **`int`**, **`char`**, and **`String`** values, enums can be used for cases in **`switch`** statements

Packages

- To organize classes, they are often inside of packages
- This approach allows to tell the difference between two different classes with the same name that are in different libraries
- Packages correspond to folders with the same names
- Most packages are inside of other packages
- The default package (no package) should not be used for professional programming
- To use classes from other packages, import them:
  - `import java.util.Scanner;` or
  - `import java.util.*;`

Interfaces

Interface basics

- An **interface** is a set of methods which a class must have
- **Implementing** an interface means making a promise to define each of the listed methods
- It can do what it wants inside the body of each method, but it **must** have them to compile
- A class can implement as many interfaces as it wants

Interface definition

- An interface looks a lot like a class, but all its methods are generally empty
- Interfaces have no members except for (**`static final`**) constants

```
public interface Guitarist {
    void strumChord(Chord chord);
    void playMelody(Melody notes);
}
```

Interfaces

- Many interfaces only have a single method
- Consider the following example:

```
public interface NoiseMaker {
    String makeNoise();
}
```

- To implement this interface, a class must:
  - State that it implements the interface
  - Have a public, non-static method called **`makeNoise()`** that takes no parameters and returns a **`String`**

Example classes

- Here are classes that implement **`NoiseMaker`**:

```
public class Pig implements NoiseMaker {
	public String makeNoise() {
		return "Grunt!";
	}
}
public class Explosion implements NoiseMaker {
	public String makeNoise() {
		return "BOOM!";
	}
}
public class Wind implements NoiseMaker {
	public String makeNoise() {
		return "Woosh!";
	}
}
```

Default methods

- As of Java 8, interfaces can also have default methods
- The interface expects you to implement these methods, but if you don't, a default implementation is provided

```
public interface Punchable {
    default boolean wantsPunch() { // Default
        return false;
    }
    void getPunched(Punch punch); // Abstract
}
```

Interfaces can extend other interfaces

- Like classes, you can use inheritance to extend an interface
- When you do so, the child interface gets all of the required methods from the parent interface
- It can also reference the constants and static methods within the parent interface
- Consider the following interface:

```
public interface Defender {
    boolean blockWithShield(Attack attack);
}
```

Child interface

- We can make a child interface from **`Defender`** using the **`extends`** keyword

```
public interface NinjaDefender extends Defender {
    boolean parryWithKatana(Attack attack);
}
```

- This interface contains the **`blockWithShield()`** abstract method as well as the **`parryWithKatana()`** abstract method
- A class that implements this interface must have both

Inheritance

Inheritance

- The idea of inheritance is to take one class and generate a child class
- This child class has everything that the parent class has (members and methods)
- But you can also add more functionality to the child
- The child can be considered to be a **specialized** version of the parent

Subclass relationship

- Java respects the subclass relationship
- If you have a **`Vehicle`** reference, you can store a **`Car`** object in that reference
- A subclass (in this case a **`Car`**) is a more specific version of the superclass (**`Vehicle`**)
- For this reason, you can use a **`Car`** anywhere you can use a **`Vehicle`**
- You **`cannot`** use a **`Vehicle`** anywhere you would use a **`Car`**

Extending a superclass

- We use the **`extends`** keyword to create a subclass from a superclass

```
public class Car extends Vehicle {
  private String model;
  public Car(String s) { model = s; }

  public String getModel() { return model; }

  public void startEngine() {
     System.out.println("Vrooooom!");
  }
}
```

- A **`Car`** can do everything that a **`Vehicle`** can, plus more

Subclass example

- As long as **Car** is a subclass of **Vehicle**, we can store a **Car** in a **Vehicle** reference

```
Vehicle v = new Car("Lancer Evolution"); // okay
```

- Even in an array is fine

```
Vehicle[] vehicles = new Vehicle[100];
for( int i = 0; i < vehicles.length; i++ )
  vehicles[i] = new RocketShip();  // cool
```

- Storing a **Vehicle** into a **Car** doesn't work

```
Car c = new Vehicle(); // gives error
```

Constructors

- A child class has to create a version of the parent class "inside" itself
- Consequently, the first line of a child class constructor is reserved for a call to the parent constructor
- If the parent has a default constructor (with no arguments), no call is necessary
- Otherwise, a call to the parent constructor **must** be made by using the keyword **`super`**, followed by parentheses and the arguments passed to the parent constructor

FoieGras class

- The **FoieGras** class extends **Food** and consequently must call the **Food** constructor as the first thing in its constructor
- The **FoieGras** constructor can be completely different from the **Food** constructor as long as it calls the **Food** constructor correctly

```
public class FoieGras extends Food {
  private int grams;

  public FoieGras(int grams) {
     super("Foie Gras", 462*grams/100);
     this.grams = grams;
  }
}
```

`protected` keyword

- In addition to public and private modifiers, the **`protected`** keyword is meaningful in the context of inheritance
  - Methods and members that are **`public`** can be accessed by any code
  - Methods and members that are **`private`** can only be accessed by methods from the same class
  - Methods and members that are **`protected`** can be accessed by code in the same package and by methods of any classes that inherit from the class
- Hard-core OOP people dislike the **`protected`** keyword since it allows child classes to fiddle with stuff that they probably shouldn't

Adding to existing classes is nice…

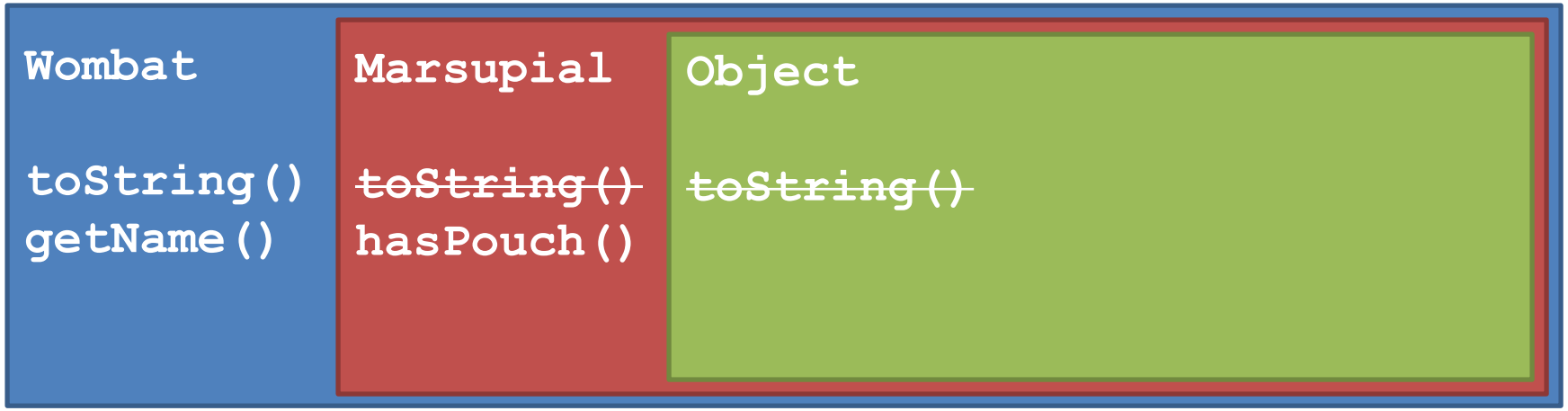
- Sometimes you want to do more than add
- You want to change a method to do something different
- You can write a method in a child class that has the same name as a method in a parent class
- The child version of the method will always get called
- This is called **overriding** a method

Dynamic binding

- All normal Java methods use dynamic binding
- This means that the most up-to-date version of a method is always called
  - It also means that the method called by a reference is often not known until run-time
- Consider a class **`Wombat`** which extends **`Marsupial`** which extends **`Object`**
- Let's say that **`Wombat`**, **`Marsupial`**, and **`Object`** all implement the **`toString()`** method

How to think about inheritance

- Every object has a copy of its parent object inside (which has its parent inside, and so on)
- All methods from the class and parents are available, but the outermost methods are always chosen
  - If a class overrides its parent's method, you always get the overridden method



The `final` keyword

- As you know, the **`final`** keyword is used to mark both member variables and local variables as constant
- **`final`** can be applied to methods and classes as well
- A **`final`** method cannot be overridden by a child class
- A **`final`** class cannot be extended at all
- **`String`** is an example of a **`final`** class
  - You can't extend **`String`** to make your own special kind of **`String`**!
  - We want **`String`** behavior to be totally consistent

Abstract methods

- All methods in interfaces are, by default, abstract
- An abstract method is only the signature of a method, not its definition
- Abstract methods end with a semicolon instead of a body defining what they do
- Any class that wants to implement the interface must complete all its abstract methods
- You can put abstract methods in classes, but
  - The method must be marked with the **`abstract`** keyword
  - The class must be abstract too

Abstract classes

- An **abstract class** is one that can't be instantiated
- It's intended to be the basis for inherited classes
- It's kind of like an interface in that it can contain abstract methods
  - But you can put regular methods in an abstract class
  - And member variables!
- An abstract class gives you a framework but not all of the implementation

Abstract class example

- The **`Polygon`** abstract class makes a foundation for polygons:

```
public abstract class Polygon {
  private final int sides;
  public Polygon(int sides) {
     this.sides = sides;
  }
  public final int getSides() {
     return sides;
  }
  public abstract double getArea();
  public abstract double getPerimeter();
}
```

instanceof keyword

- Sometimes it's useful to know the true type of an object
- You can use the **instanceof** keyword to see if the type of an object inherits from a particular class
- Syntax (produces a **boolean**):
  - **object instanceof Class**
- An **instanceof** is almost always in an if statement:

```
Object object = getRandomObject();
if(object instanceof Hurricane)
  System.out.println("You can call me slurricane.");
```

More on `instanceof`

- **`instanceof`** doesn't tell you if an object is a particular class
- Instead, it tells you if it is that class or inherits from it
- Consider an object of type **`Whiskey`**, which inherits from **`Alcohol`**, which inherits from **`Beverage`** (which inherits from **`Object`**)

```
Object object = new Whiskey();
if(object instanceof Whiskey)          // true
  System.out.println("Whiskey!");
if(object instanceof Alcohol)          // true
  System.out.println("Alcohol!");
if(object instanceof Beverage)         // true
  System.out.println("Beverage!");
if(object instanceof Object)           // true
  System.out.println("Object!");
if(object instanceof String)           // false
  System.out.println("String?");
```

getClass() method

- For situations where you need to know if the type of an object matches exactly, you can use its **`getClass()`** method
- This returns a **`Class`** object, which you can compare using **`==`** to the name of a type followed by **`.class`**

```
Object object = new Whiskey();
if(object.getClass() == Whiskey.class)      // true
  System.out.println("Whiskey!");
if(object.getClass() == Alcohol.class)      // false
  System.out.println("Alcohol!");
if(object.getClass() == Beverage.class)     // false
  System.out.println("Beverage!");
if(object.getClass() == Object.class)       // false
  System.out.println("Object!");
```

Exceptions

Exceptions

- Instead of checking every method, Java has a general way of handling errors (and other exceptional situations)
- The name for this system is **exception handling**
- When an error happens, code will **throw** an exception
  - Throwing an exception usually means something went wrong
- A special block of code **catches** the exception
- When you catch an exception, you can
  - Deal with the problem and move on
  - Throw the same (or a new) exception and make someone else deal with it

Catching an exception

- The **`risky()`** method has a chance of destroying the world
- If the world is destroyed, execution will jump into the **`catch`** block

```
try {
  System.out.println("About to do something risky!");
  risky();
  System.out.println("That was worth it!");
}
catch(WorldDestroyedException e) {
  System.out.println("Whoops. We destroyed the world.");
}
```

Multiple catch statements

- If a some code can cause many different exceptions, you can use multiple catches to handle them
- When a problem happens, execution will jump to the first catch that matches

```
try {
   useNumber(100 / divisor);
   getHoney();
   stayUpAllNight();
}
catch(ArithmeticException e) {
   System.out.println("We divided by zero!");
}
catch(BeeStingException e) {
   if(allergic)
       System.out.println("We're dying!");
   else
       System.out.println("Youch!");
}
catch(ExhaustedException e) {
   System.out.println("*YAWN*");
}
```

A `finally` block

- If an exception is thrown, the remaining code inside a **`try`** won't be executed
- If an exception isn't thrown, none of the **`catch`** blocks will be executed
- If you want code that is executed no matter what, it can be put in a **`finally`** block after all the **`catch`** blocks
- **`finally`** blocks are often used to do clean-up so we're sure it gets done
  - Things like closing files or network connections

The throws keyword

- If a method doesn't want to catch a (checked) exception, it must be marked as throwing that exception with the **throws** keyword

```
void pet(Goat goat) throws GoatBiteException {
  goat.touch(); // can throw GoatBiteException
}
```

- This **pet()** method doesn't handle a **GoatBiteException** and thus must use the **throws** keyword to warn other code that it could throw a **GoatBiteException**

Creating an exception class

- Exceptions are classes like any other in Java
- They can have members, methods, and constructors
- All you need to do is make a class that extends **`Exception`**, the base class for all exceptions

```
public class SimpleException extends Exception {
}
```

- That's it.
- Although it makes them long, it's good style to put the word **`Exception`** at the end of any exception class name

`throw` keyword

- The **`throw`** keyword is used to start the exception handling process
- You simply type **`throw`** and then the exception object that you want to throw
- Most of the time, you'll create a new exception object on the spot
  - Why would you have one lying around?

```
throw new CardiacArrestException();
```

- Don't confuse it with the **`throws`** keyword!

Exception throwing example

- Here's a method that finds the integer square root of an integer

```
public static int squareRoot(int value) {
  if(value < 0)
     throw new IllegalArgumentException("Negative value!");
  int root = 0;
  while(root*root <= value) {
     ++root;
  }
  return root - 1;
}
```

- If **`value`** is negative, an **`IllegalArgumentException`** will be thrown

Multiple catches with inheritance

- Because a parent **`catch`** will catch a child, you have to organize multiple **`catch`** blocks from most specific to most general:

```
try {
   dangerousMethod();
}
catch(FusionNuclearExplosionException e) {
   System.out.println("Fusion!");
}
catch(NuclearExplosionException e) {
   System.out.println("Nuclear!");
}
catch(ExplosionException e) {
   System.out.println("Explosion!");
}
catch(Exception e) { // Don't do this!
   System.out.println("Some arbitrary exception!");
}
```

Practice

Sample Question 1

- Write a **`LonelyGoatherd`** class that implements the following interface with a **`yodel()`** method that returns the lyrics concatenated with itself repetitions times
- For example, values of **`"Yodelay!"`** and 3 would return:
  - **`"Yodelay!Yodelay!Yodelay!"`**

```
public interface Yodelable {
  String yodel(String lyrics, int repetitions);
}
```

Sample Question 2

- Write a (non-abstract) **`Salmon`** class that extends the **`Fish`** class
- Its species name should be **`"salmon"`**
- Implement the **`swim()`** method however you want

```
public abstract class Fish {
  private String species;
  public Fish(String species) {
     this.species = species;
  }
  public String getSpecies() {
     return species;
  }
  public abstract String swim();
}
```

Sample Question 3

- What would the following code print out?

```
try {
   System.out.println("Let's eat some week-old scallops!");
   if(Math.random() < .5)
       throw new FoodPoisoningException();
   System.out.println("That went great!");
}
catch(NullPointerException e) {
   System.out.println("Null!");
}
catch(FoodPoisoningException e) {
   System.out.println("Barf!");
}
catch(ArrayIndexOutOfBoundsException e) {
   System.out.println("Index!");
}
finally {
   System.out.println("Tomorrow is another day.");
}
```

Extended programming practice

- We can imagine a hierarchy of inheritance starting with a **`Person`** with the following members:
  - Name (final)
  - Age
- **`Student`** extends **`Person`** and adds:
  - Major
  - GPA
- **`Politician`** extends **`Person`** and adds:
  - Political party
- **`OtterbeinStudent`** extends **`Student`** and adds:
  - ID number (final)
- Members should have getters and setters as appropriate
- All classes should override the **`toString()`** and **`equals()`** methods

Upcoming

Next time…

- Review up to Exam 2
  - GUIs
  - Recursion
  - Files
  - Networking

Reminders

- **Finish Project 4**
  - **Due Friday**
- Review chapters 7, 15, 19-21
- Look over labs, quizzes, and projects to prepare
- Final Exam:
  - Monday, April 27, 2020
  - 10:15 a.m. to 12:15 p.m.