Lecture 5

Object-Oriented Programming in Java

Aleksandar Stefanovski

CSCI 053
Department of Computer Science
The George Washington University
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Learning Goals

Introduce Eclipse

Create objects in Java

Introduce variables as object references

Invoke methods on objects in Java

Create a method in Java

Pass a parameter to a method in Java

Introduce subclasses

Using Turtles in Java

We will work with Turtles in a World in Java

We have to define what we mean by a Turtle to the computer

We do this by writing a Turtle class definition

`Turtle.java`

We compile it to convert it into something the computer can understand

- Bytes codes for a virtual machine

`Turtle.class`

History of Turtles

Seymour Papert at MIT in the 60s

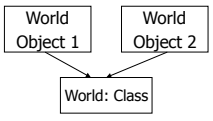
By teaching the computer to do something the kids are thinking about thinking

- Develop problem solving skills
- Learn by constructing and debugging something
  - Learn by making mistakes and fixing them

Creating Objects

To create objects we ask the object that defines the class to create it

- Each object is created in memory with space for the fields it needs
- Each object keeps a reference to the class that created it



The class is like a cookie cutter

- It knows how much space each object needs (shape)
- Many objects can be created from the class

Class as Object Factory

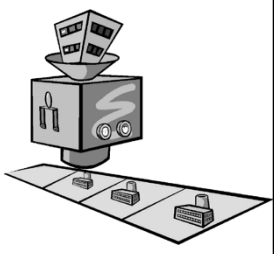
A class is like a factory that creates objects of that class

We ask a class to create an object by using the keyword:

`new` *`ClassName`*

We can also ask the class to initialize the object

- And pass data to help initialize it



Creating Objects in Java

In Java the syntax for creating an object is:

```
new Class(value, value, …);
```

Our Turtle objects live in a World object

- We must create a World object first
- Try typing the following in the interactions pane:

```
new World();
```

Creating Objects

If you just do

```
new World();
```

You will create a new World object and it will display

- But you will not have any way to refer to it again
- Once you close the window the object can be garbage collected
  - The memory that the object was using can be reused

We need a way to refer to the new object

- to be able to work with it again

Alice named your objects for you

- bunny, bunny2

Naming is Important

If you create a new contact in your cell phone you enter a phone number and a name

- Later you use the name to find the phone number

In programming we name things we want to refer to again

- Gives us a way to work with them
- Like the World object

In programming this is called declaring a variable

Declaring a Variable

To be able to refer to an object again we need to specify what type of thing it is and give it a name

- This is also called declaring a variable
- *Type name*; OR

```
Type name = new Class(value, value, …);
```

The equal sign doesn't mean equal

- But assign the value of the variable on the left to the result of the stuff on the right
- The following creates a variable named earth which refers to a World object created on the right
  - `World earth = new World();`

Declaring Variables

When you declare a variable the computer assigns memory to it

- The amount of memory depends on the type

For each variable the computer stores a map of the name to the memory location and the type

When you use the name the computer looks up the memory location

- And uses the value at that location

address	memory	
1	00000000	Object of type World
2	00001111	
3	00000000	
4	00111000	
5	00000000	
6	00111100	
7	01111000	
8	00000000	earth variable holds a reference to the World Object above
9	00000000	
10	00000000	
11	00000000	
12	00000001	

Limits on Declaring Variables

You can't declare two variables with the same name!

```
> World earth = new World();
> World earth = new World();
```

Error: Redefinition of 'earth'

You can change what an object variable refers to

```
> World earth = new World();
> earth = new World();
```

Cell Phones use Variables

In your cell phone you have names that map to phone numbers
- When you pick Home it looks up the number and uses it to make the call

You can't have two names that are exactly the same
- The phone wouldn't know which number you are referring to

You can modify the phone number for a name

- Barb 555-1235
- Home 555-2938
- Michael 555-3214
- Shannon 555-2921

Variables Sizes

What value(s) does the memory on the right represent?
- It could be 4 char values
  - 2 bytes each (16 bits)
  - Unicode
- Or 2 int values
  - 4 bytes each (32 bits)
  - 2's compliment
- Or 1 double value
  - 8 bytes each (64 bits)
  - In IEEE format
- Or an object reference
  - The size is up to the virtual machine

1 00001000
2 00100000
3 00000100
4 01000000
5 00000001
6 10000000
7 00111000
8 11110000

Declaring Variables and Creating Objects

You can declare a variable and assign it to refer to a new object in one statement

```
World earth1 = new World();
Turtle tommy = new Turtle(earth1);
```

Declaration of variables

Creating the objects

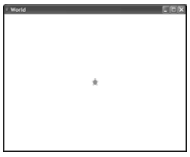
Turtle Basics

The world starts off with a size of 640 by 480
- With no turtles

```
World earth1 = new World();
```

The turtle starts off facing north and in the center of the world by default
- You must pass a World object when you create the Turtle object
  - Or you will get an error: java.lang.NoSuchMethodException: Turtle constructor

```
Turtle tommy = new Turtle(earth1);
```



Java Naming Conventions

Notice that we capitalize the names of the classes, but not the variable names
- This `World earth1 = new World();`
- is different than English
  - Capitalize proper nouns (the names of things)
  - Not the type of thing
    - Earth is a world.
    - Tommy is a turtle.

In Java it is the class names that are the most important
- Not the variable or method names

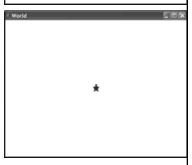
Creating Several Objects

You can create several World objects

```
World mars = new World();
```

You can create several Turtle objects

```
Turtle shar = new Turtle(mars);
Turtle jen = new Turtle(mars);
```



- One turtle is on top of the other

Moving a Turtle

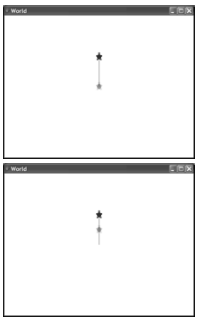
Turtles can move forward

```
jen.forward();
```

– The default is to move by
  - 100 steps (pixels)

You can also tell the turtle how far to move

```
shar.forward(50);
```



Turning a Turtle

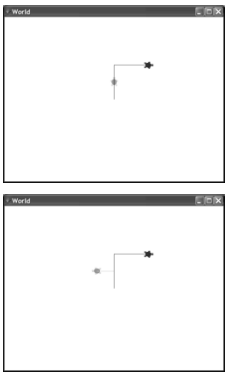
Turtles can turn

Right

```
jen.turnRight();
jen.forward();
```

Left

```
shar.turnLeft();
shar.forward(50);
```



Turning a Turtle

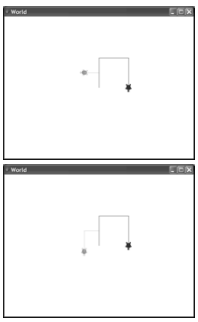
Turtles can turn by a specified amount

A positive number turns the turtle to the right

```
jen.turn(90);
jen.forward(100);
```

A negative number turns the turtle to the left

```
shar.turn(-90);
shar.forward(70);
```



The Pen

Each turtle has a pen

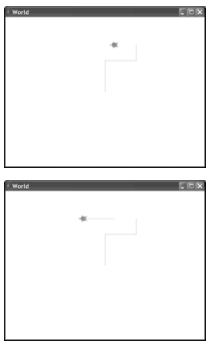
The default is to have the pen down to leave a trail

You can pick it up:

```
turtle1.penUp();
turtle1.turn(-90);
turtle1.forward(70);
```

You can put it down again:

```
turtle1.penDown();
turtle1.forward(100);
```



Drawing a Letter

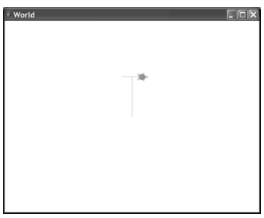
How would you use a turtle to draw a large letter T?

Process

- Create a World variable and a World object and a Turtle variable and object.
- Ask the Turtle object to go forward 100
- Ask the Turtle object to pick up the pen
- Ask the Turtle object to turn left
- Ask the Turtle object to go forward 25
- Ask the Turtle object to turn 180 degrees
- Ask the Turtle object to put down the pen
- Ask the Turtle object to go forward 50

Drawing a T

```
World world1 = new World();
Turtle turtle1 = new Turtle(world1);
turtle1.forward(100);
turtle1.penUp();
turtle1.turnLeft();
turtle1.forward(25);
turtle1.turn(180);
turtle1.penDown();
turtle1.forward(50);
```



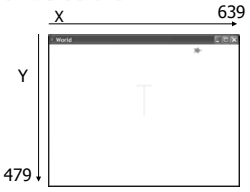
Moving to a Location

A turtle can move to a particular location

```
turtle1.penUp();
turtle1.moveTo(500,20);
```

Coordinates are given as x and y values

- X starts at 0 on the left and increases horizontally to the right
- Y starts at 0 at the top of the window and increases to the bottom
- A new turtle starts out at 320,240 by default



Challenge

Create a World object

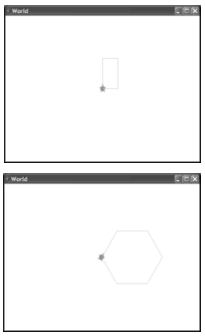
- Don't forget to declare a variable to hold a reference to it

Create a turtle object

- Don't forget to declare a variable to hold a reference to it

Use the turtle to draw a

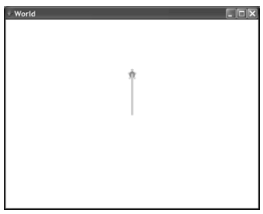
- Rectangle (but, not a square)
- Equilateral triangle
- Hexagon



Setting the Pen Width

You can change the width of the trail the pen leaves

```
World world1 = new World();
Turtle turtle1 = new Turtle(world1);
turtle1.setPenWidth(5);
turtle1.forward(100);
```



Setting the Pen Color

Use `setPenColor` to set the color of the pen

```
turtle1.setPenColor(java.awt.Color.RED);
```

There are several predefined colors

- In the package `java.awt`
  - A package is a group of related classes
- In the class Color

To use them you can use the full name

- `java.awt.Color.RED`

Setting Colors

You can change the pen color

```
turtle.setPenColor(java.awt.Color.RED);
```

You can change the turtle color

```
turtle1.setColor(java.awt.Color.BLUE);
```

You can change the turtle's body color

```
turtle1.setBodyColor(java.awt.Color.CYAN);
```

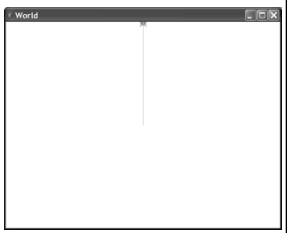
You can change the turtle's shell color

```
turtle1.setShellColor(java.awt.Color.RED);
```

Objects can Refuse

Turtles won't move completely out of the boundaries of the world

```
World world2 = new World();
Turtle turtle2 = new Turtle(world2);
turtle2.forward(600);
```



Objects send Messages

Objects don't "tell" each other what to do
- They "ask" each other to do things

Objects can refuse to do what they are asked
- The object must protect it's data
  - Not let it get into an incorrect state
  - A bank account object shouldn't let you withdraw more money that you have in the account

Creating Methods

In Alice you could create a method
- like teaching a bunny to hop

Creating a Method

We can name a block of Java statements and then execute them again
- By declaring a method in a class

The syntax for declaring a method is
- *visibility returnType name*(*parameterList*)
- Visibility determines access
  - Usually public or private
  - The return type is the type of thing returned
  - If nothing is returned use the keyword **void**
- Name the method starting with a lowercase word and uppercasing the first letter of each additional word

Example Method

```
public void drawSquare
  ()
  {
    this.turnRight();
    this.forward(30);
    this.turnRight();
    this.forward(30);
    this.turnRight();
    this.forward(30);
    this.turnRight();
    this.forward(30);
  }
```

- The visibility is **public**
- The keyword **void** means this method doesn't return a value
- The method name is **drawSquare**
- There are no parameters
  - Notice that the parentheses are still required
- The keyword **this** means the object this method was invoked on

Adding a Method to a Class

1. Open file Turtle.java
2. Type the method before the last }
3. Compile open files

Try the New Method

Compiling resets the interactions pane

Clearing all variables
- But you can still use the up arrow to pull up previous statements

You will need to create a world and turtle again

```
World world1 = new World();
Turtle turtle1 = new Turtle(world1);
turtle1.forward(50);
turtle1.drawSquare();
turtle1.turn(30);
turtle1.drawSquare();
```

Adding a Main Method

In Alice there is a way to specify what method to execute when the world starts

In Java when you execute a class you can have a main method
- This is where execution will start

Main Method Syntax

The main method is a class (static) method that can take an array of strings
- It is a class (static) method since no objects of the class exist yet

```
public static void main(String[] args)
{
  // statements to execute
}
```

Better Method to Draw a Square

A method to draw a square

```
public void drawSquare()
  {
    int width = 30;
    this.turnRight();
    this.forward(width);
    this.turnRight();
    this.forward(width);
    this.turnRight();
    this.forward(width);
    this.turnRight();
    this.forward(width);
  }
```

- We added a local variable for the width
  - Only known inside the method
- This makes it easier to change the width of the square
- But, we still have to recompile to draw a different size square

Testing the Better Method

Test with:

```
public static void main(String[] args)
  {
   World world1 = new World();
   Turtle turtle1 = new Turtle(world1);
   turtle1.forward(50);
   turtle1.drawSquare();
   turtle1.turn(30);
   turtle1.drawSquare();
 }
```

Passing a Parameter

```
public void drawSquare(int width)
  {
    this.turnRight();
    this.forward(width);
    this.turnRight();
    this.forward(width);
    this.turnRight();
    this.forward(width);
    this.turnRight();
    this.forward(width);
  }
```

- Parameter lists specify the type of thing passed and a name to use to refer to the value in the method
- The type of this parameter is **int**
  - For integer
- The name is **width**
- Values are passed by making a copy of the passed value

Testing with a Parameter

Test a method with a parameter

```
public static void main(String[] args) {
   World world1 = new World();
   Turtle turtle1 = new Turtle(world1);
   Turtle turtle2 = new Turtle(world1);
   turtle1.forward(50);
   turtle1.drawSquare(30);
   turtle2.turn(30);
   turtle2.drawSquare(50);
}
```

How Does That Work?

When you ask `turtle1` to `drawSquare(30)`

```
turtle1.drawSquare(30);
```

- It will ask the Turtle Class if it has a method `drawSquare` that takes an int value
  - And start executing that method
  - The parameter width will have the value of 30 during the executing of the method
  - The `this` keyword refers to turtle1

When you ask `turtle2` to `drawSquare(50)`

```
turtle2.drawSquare(50);
```

- The width will have a value of 50
- The `this` refers to turtle2 (the object the method was invoked on)

Challenges

Create a method for drawing a rectangle
- Pass the width and height

Create a method for drawing an equilateral triangle
- all sides have the same length
- Pass in the length

Create a method for drawing a house
- Using the other methods

Create a method for drawing a school
- Using the other methods

Subclasses in Java

The Turtle class is a subclass of `SimpleTurtle`
- public class Turtle *extends* SimpleTurtle

This means it inherits methods and fields from `SimpleTurtle`
- See if you can find the forward and `turnRight` methods in `SimpleTurtle`

Classes can subclass another class in Java and Alice

Summary

You can create objects from classes in Alice and Java

Each object needs a unique way to refer to it
- In Java we call this declaring a variable

You can create new methods
- *visibility returnType name*(*Type name*, *Type name*, …)
- Let's you reuse a block of statements

You can pass parameters to methods
- To make them more flexible and reusable

You can create subclasses of other classes
- They will inherit fields and methods from the parent class