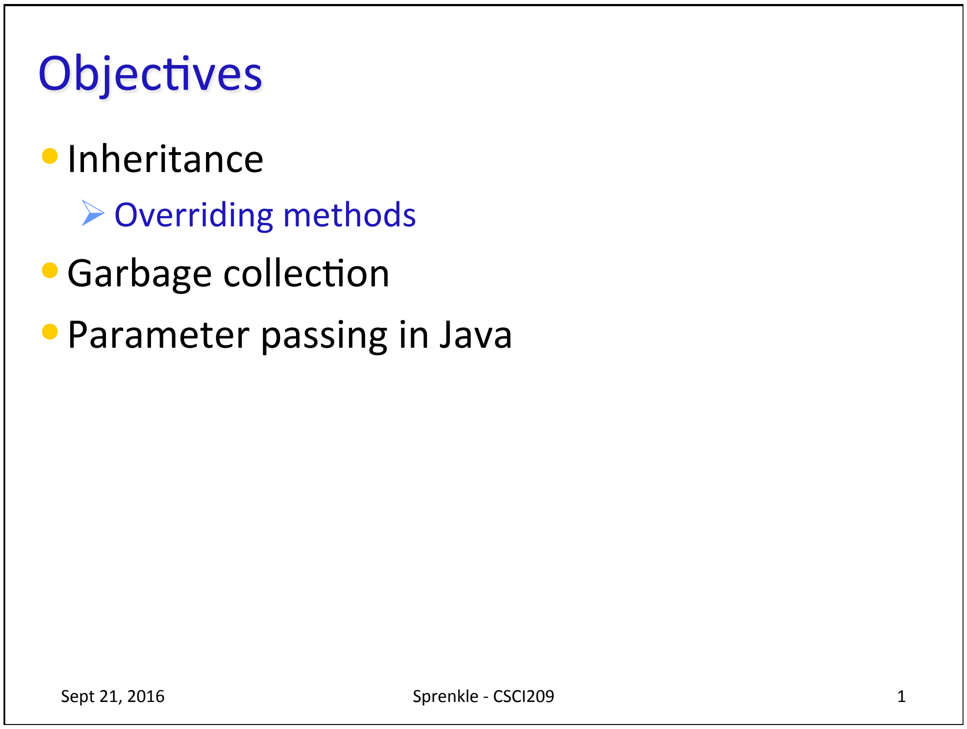
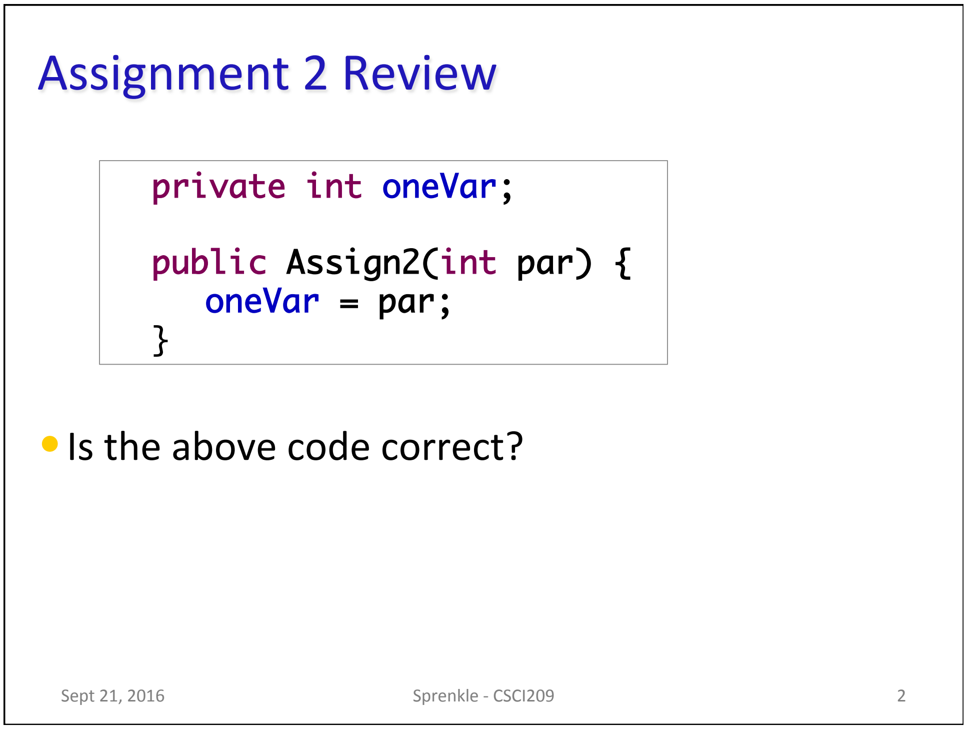


Objectives

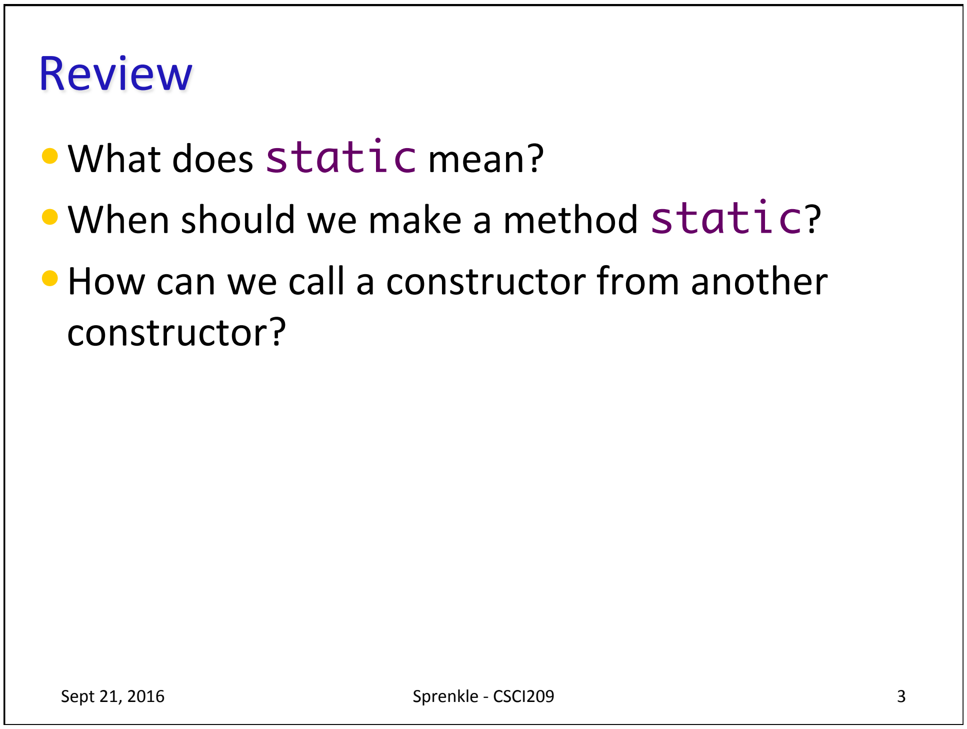
- Inheritance
  - Overriding methods
- Garbage collection
- Parameter passing in Java



Assignment 2 Review

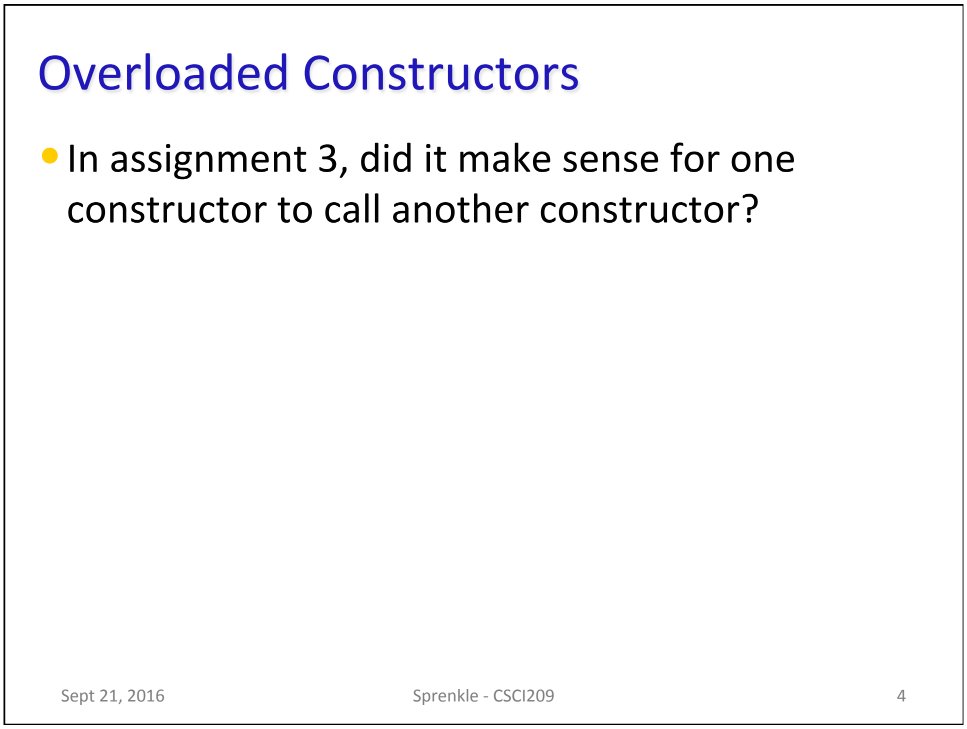
```
private int oneVar;

public Assign2(int par) {
   oneVar = par;
}
```

- Is the above code correct?



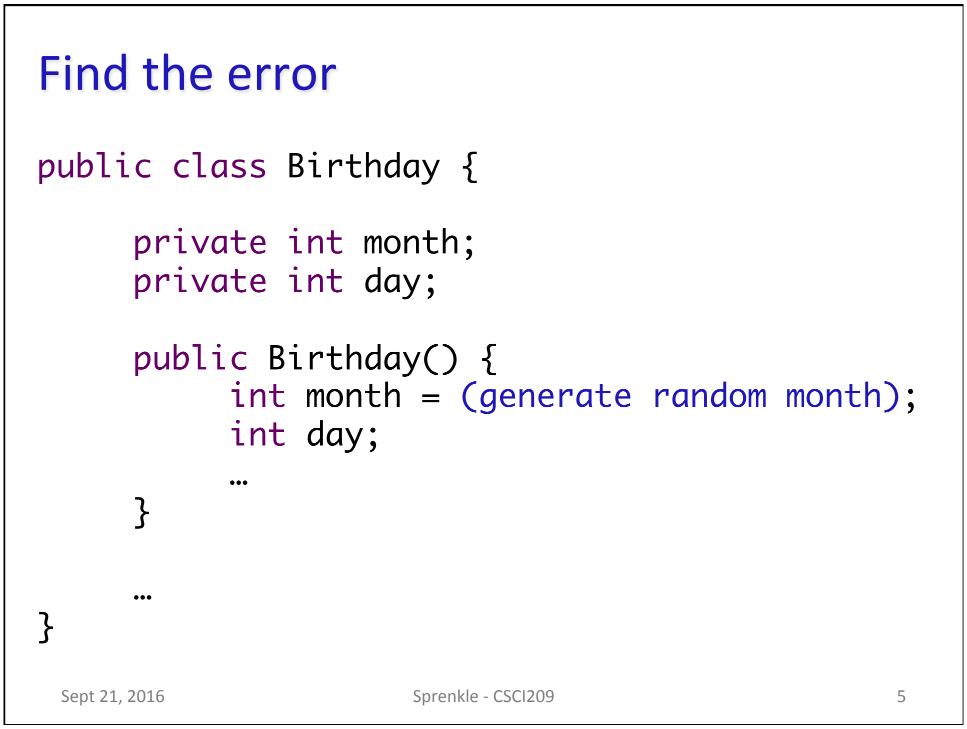
Review

- What does `static` mean?
- When should we make a method `static`?
- How can we call a constructor from another constructor?



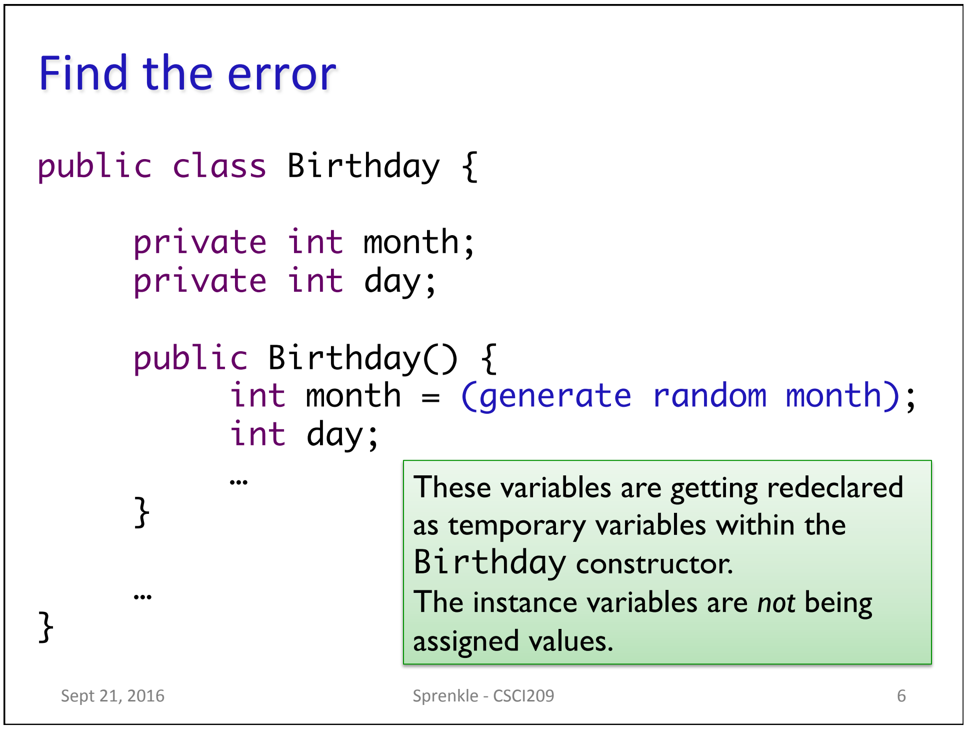
Overloaded Constructors

- In assignment 3, did it make sense for one constructor to call another constructor?



Find the error

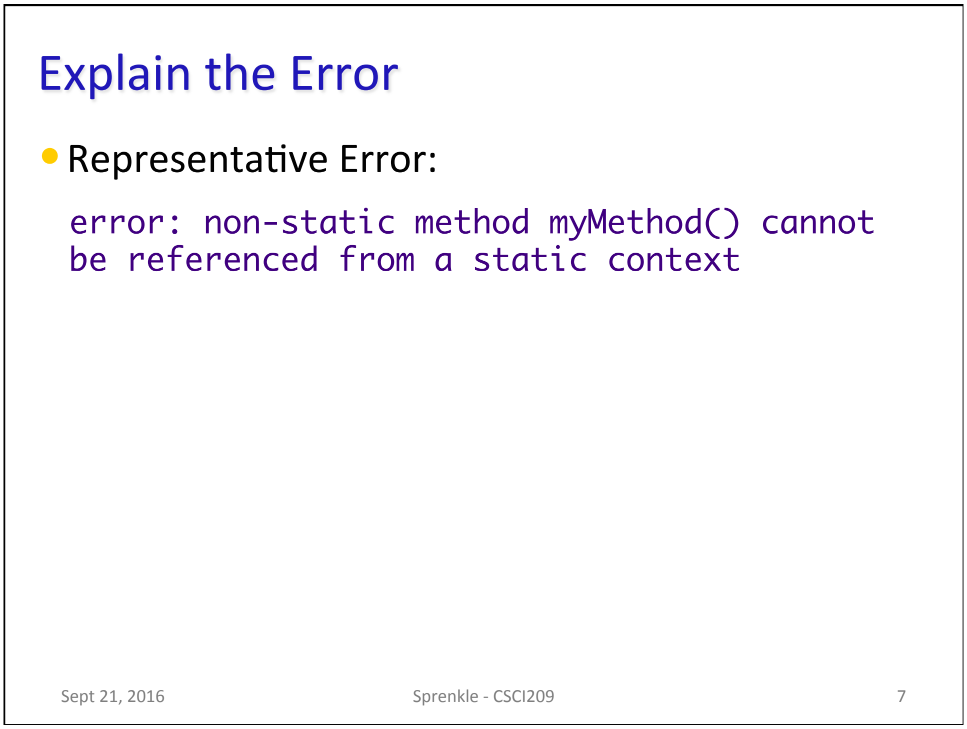
```
public class Birthday {

     private int month;
     private int day;

     public Birthday() {
          int month = (generate random month);
          int day;
          …
     }

     …
}
```



Find the error

```
public class Birthday {

     private int month;
     private int day;

     public Birthday() {
          int month = (generate random month);
          int day;
          …
     }

     …
}
```

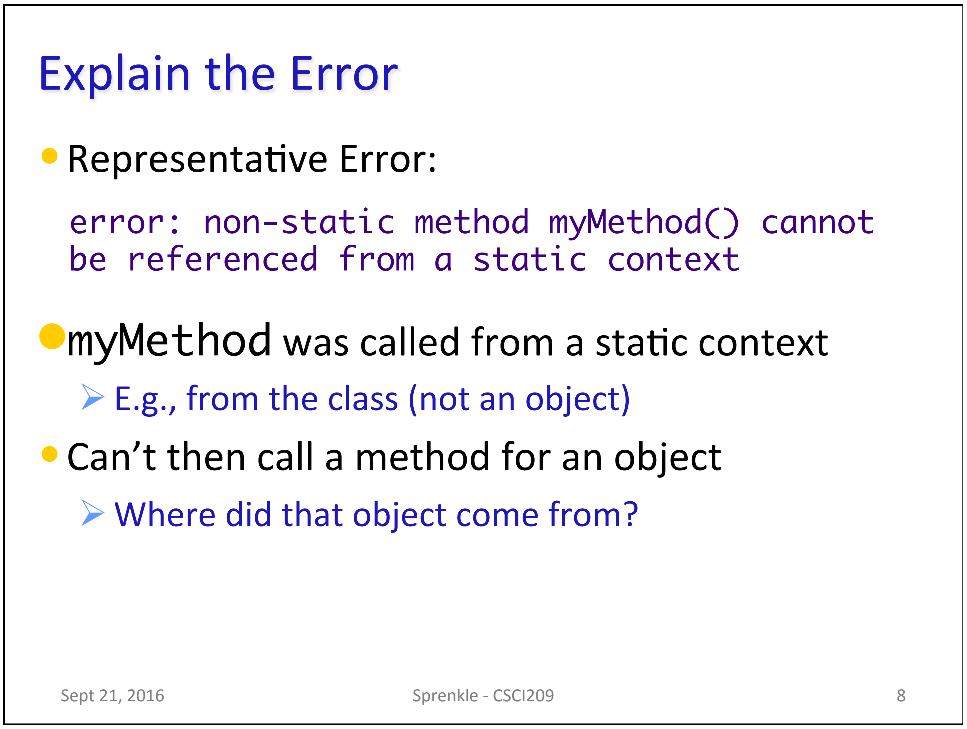
These variables are getting redeclared as temporary variables within the `Birthday` constructor.
The instance variables are *not* being assigned values.



Explain the Error

- Representative Error:

```
error: non-static method myMethod() cannot
be referenced from a static context
```



Explain the Error

- Representative Error:

```
error: non-static method myMethod() cannot
be referenced from a static context
```

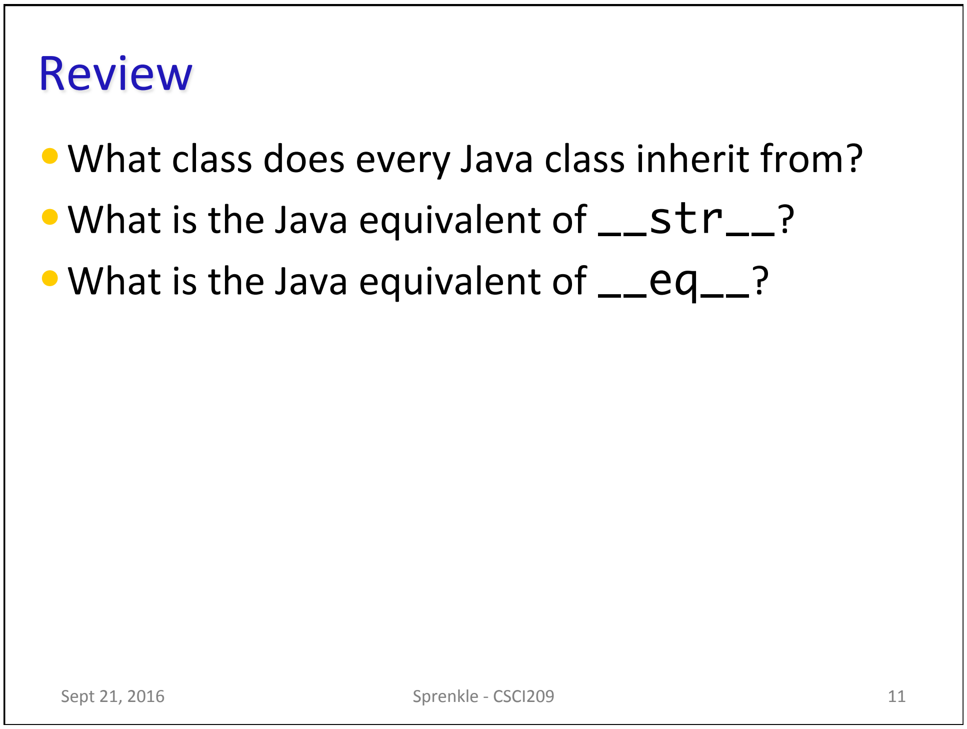
- `myMethod` was called from a static context
  - E.g., from the class (not an object)
- Can’t then call a method for an object
  - Where did that object come from?

final keyword

- An instance field can be final
- final instance fields **must** be set in the constructor or in the field declaration
  - Cannot be changed *after object is constructed*

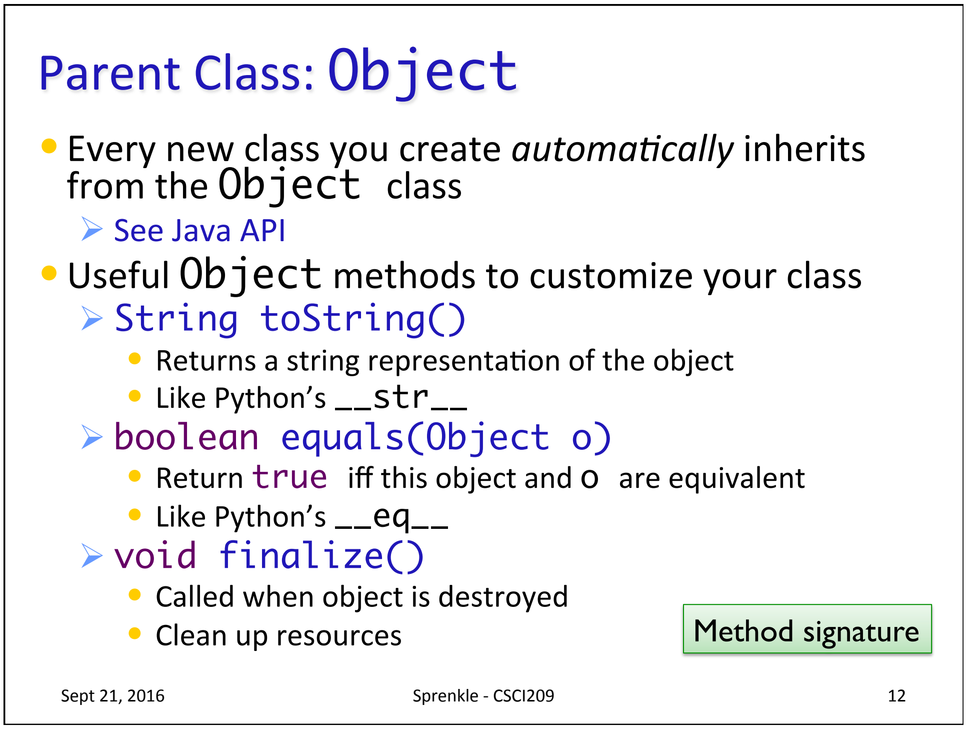
```
private final String dbname = "invoices";
private final String id;
…
public MyObject( String id ) {
	this.id = id;
}
```

BASICS OF JAVA INHERITANCE



Review

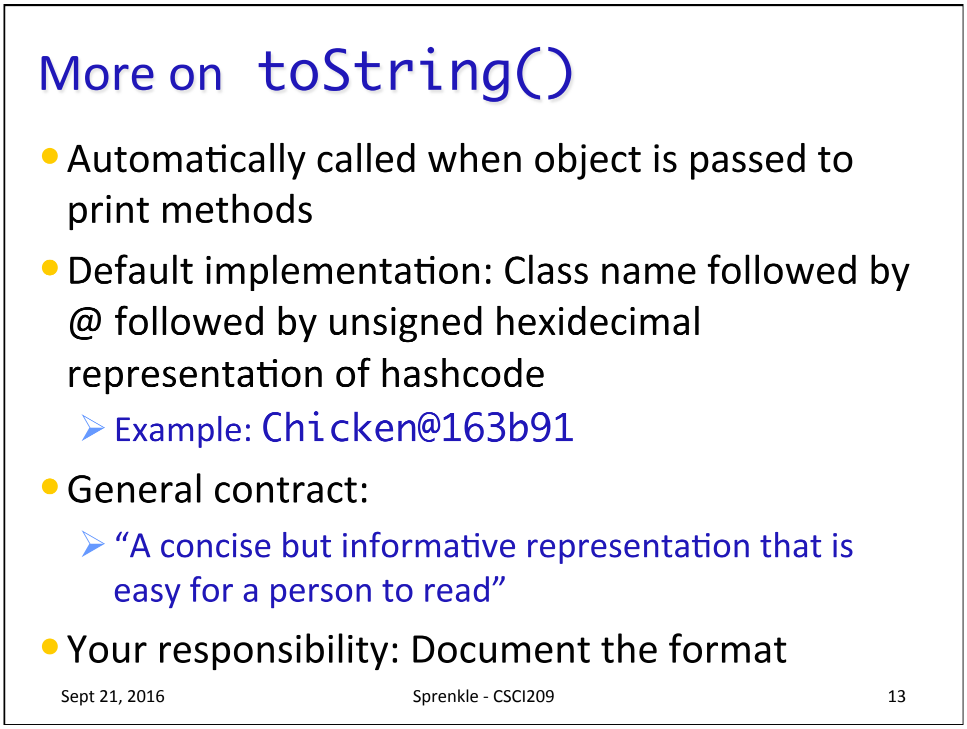
- What class does every Java class inherit from?
- What is the Java equivalent of `__str__`?
- What is the Java equivalent of `__eq__`?



Parent Class: `Object`

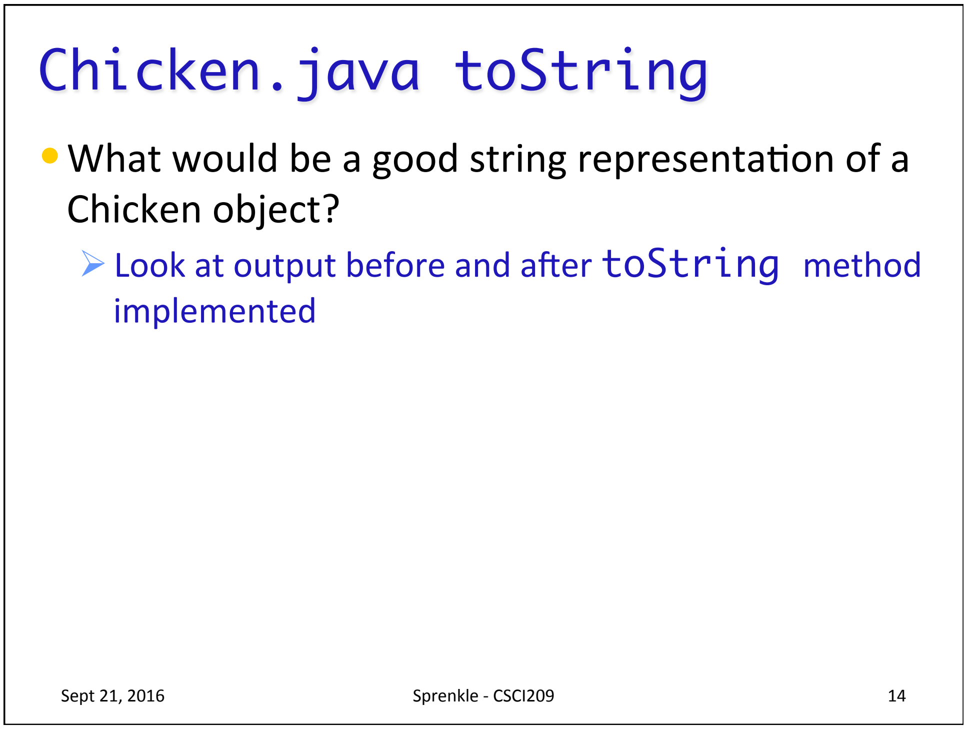
- Every new class you create *automatically* inherits from the `Object` class
  - See Java API
- Useful `Object` methods to customize your class
  - `String toString()`
    - Returns a string representation of the object
    - Like Python's `__str__`
  - `boolean equals(Object o)`
    - Return `true` iff this object and `o` are equivalent
    - Like Python's `__eq__`
  - `void finalize()`
    - Called when object is destroyed
    - Clean up resources

Method signature



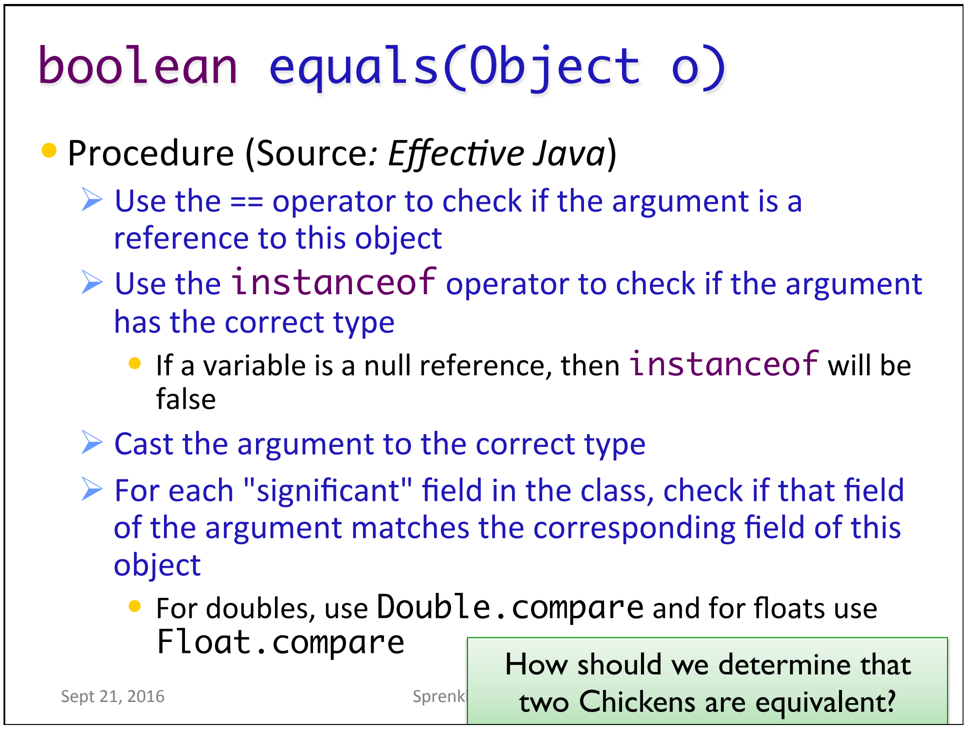
More on `toString()`

- Automatically called when object is passed to print methods
- Default implementation: Class name followed by @ followed by unsigned hexidecimal representation of hashcode
  - Example: `Chicken@163b91`
- General contract:
  - “A concise but informative representation that is easy for a person to read”
- Your responsibility: Document the format



`Chicken.java toString`

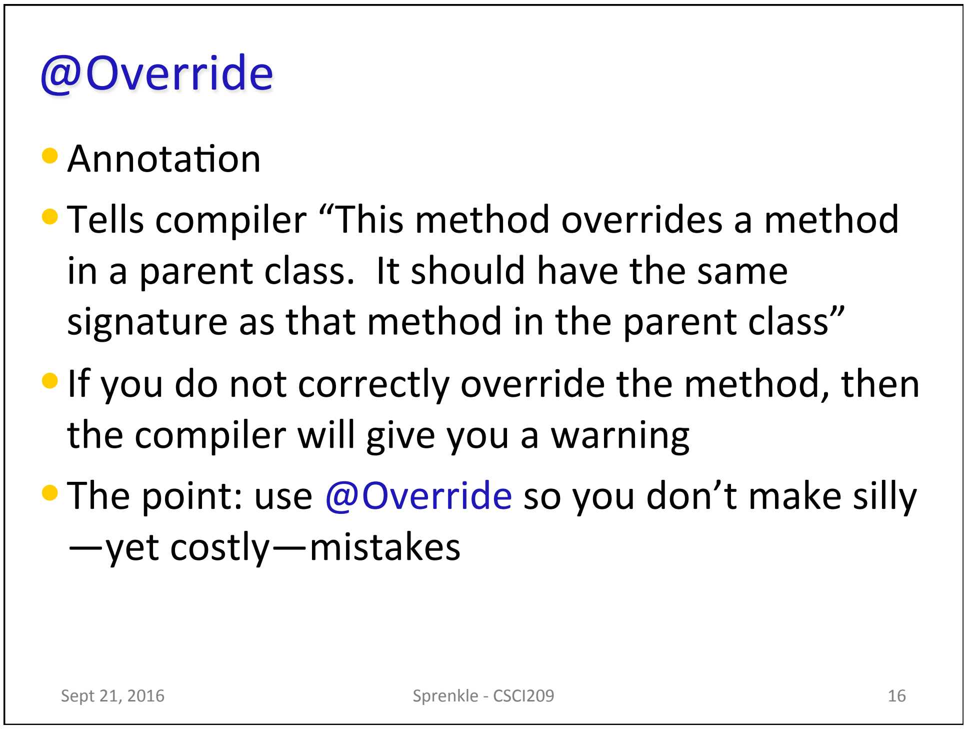
- What would be a good string representation of a Chicken object?
  - Look at output before and after `toString` method implemented



boolean equals(Object o)

- Procedure (Source: *Effective Java*)
  - Use the == operator to check if the argument is a reference to this object
  - Use the `instanceof` operator to check if the argument has the correct type
    - If a variable is a null reference, then `instanceof` will be false
  - Cast the argument to the correct type
  - For each "significant" field in the class, check if that field of the argument matches the corresponding field of this object
    - For doubles, use `Double.compare` and for floats use `Float.compare`

How should we determine that two Chickens are equivalent?



@Override

- Annotation
- Tells compiler "This method overrides a method in a parent class. It should have the same signature as that method in the parent class"
- If you do not correctly override the method, then the compiler will give you a warning
- The point: use @Override so you don't make silly—yet costly—mistakes

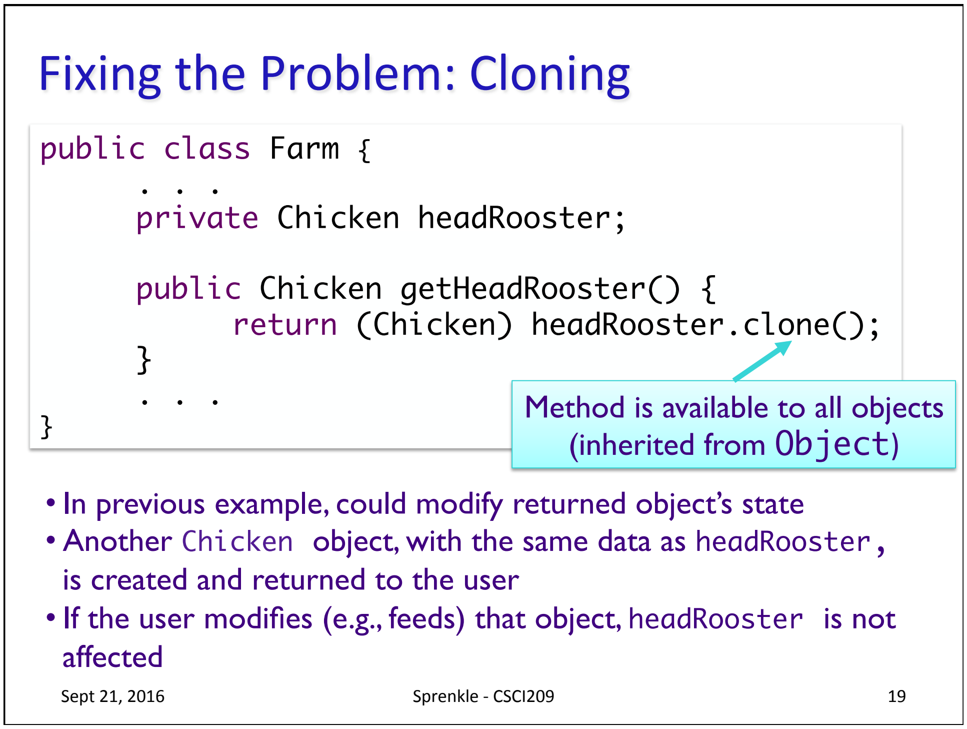
What is “bad” about this class?

```
public class Farm {
     . . .
     private Chicken headRooster;

     public Chicken getHeadRooster() {
          return headRooster;
     }
     . . .
}
```

Encapsulation Revisited

- Objects should hide their data and only allow other objects to access this data through **accessor** and **mutator** methods

- Common programmer mistake:
  - Creating an accessor method that returns a reference to a mutable (changeable) object

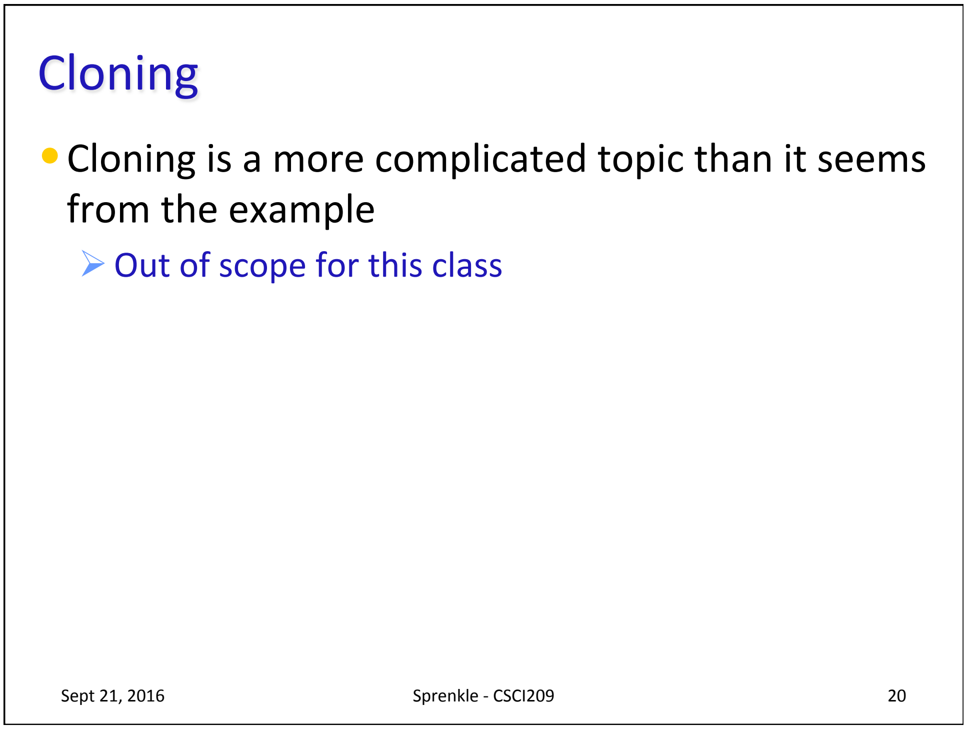


Fixing the Problem: Cloning

```
public class Farm {
     . . .
     private Chicken headRooster;

     public Chicken getHeadRooster() {
          return (Chicken) headRooster.clone();
     }
     . . .
}
```

Method is available to all objects (inherited from `Object`)

- In previous example, could modify returned object's state
- Another `Chicken` object, with the same data as `headRooster`, is created and returned to the user
- If the user modifies (e.g., feeds) that object, `headRooster` is not affected



Cloning

- Cloning is a more complicated topic than it seems from the example
  - Out of scope for this class

Review: Class Design/Organization

- Fields
  - Chosen first
  - Placed at the beginning or end of class definition
  - Have an access modifier, data type, variable name, and some optional other modifiers
  - Use `this` keyword to access the object
- Constructors
- Methods
  - Need to declare the return type
  - Have an access modifier

GARBAGE COLLECTION

Memory Management

- In C++ and some other OOP languages, classes have explicit *destructor* methods that run when an object is no longer used
- Java does not support destructors because it provides ***automatic garbage collection***
  - Waits until there are no references to an object
  - Reclaims memory allocated for the object that is no longer referenced

Do you know what Python does?

Garbage Collector

- Garbage collector is low-priority thread
  - Or runs when available memory gets tight
- Before GC can clean up an object, the object may have opened resources
  - Ex: generated temp files or open network connections that should be deleted/closed first
- GC calls object's `finalize`() method
  - Object's chance to clean up resources

Discussion: Benefits and limitations of garbage collection?

Garbage Collection

Benefits

- Fewer memory leaks
  - Less buggy code
  - But, memory leaks are still possible
- Code is easier to write

Limitations

- Garbage collection may not be as efficient as explicit freeing memory

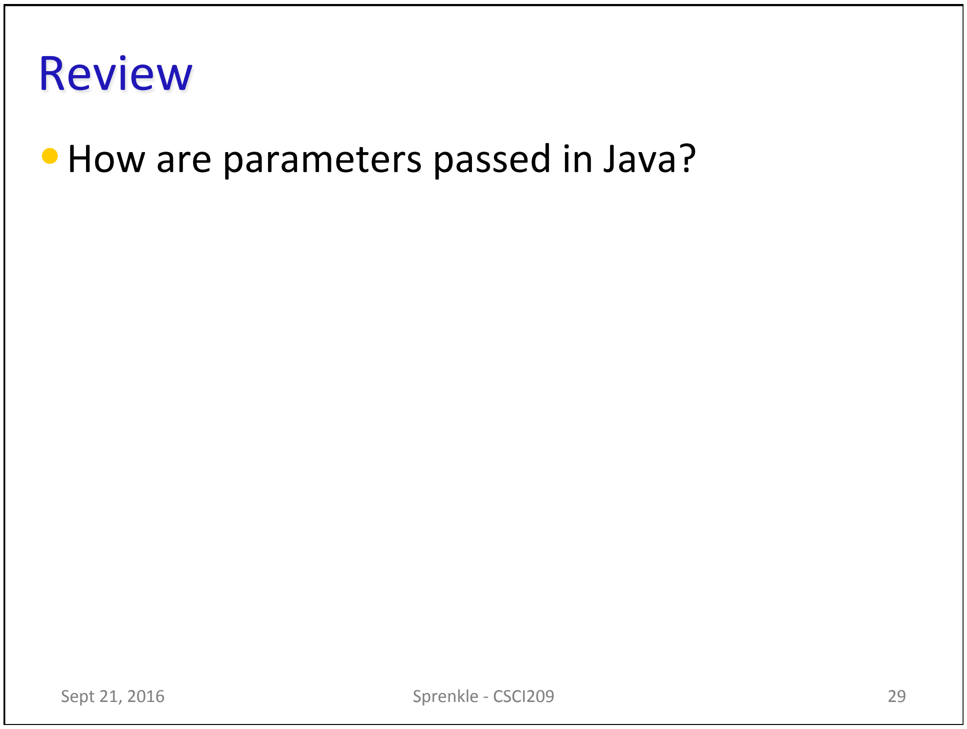
`finalize()`

- Inherited from `java.lang.Object`
- Called before garbage collector sweeps away an object and reclaims its memory
- Should not be used for reclaiming resources
  - i.e., *close resources as soon as possible*
  - Why?
    - *When* method is called is not deterministic or consistent
    - Only know it will run sometime before garbage collection
- Clean up anything that cannot be atomically cleaned up by the garbage collector
  - Close file handles, network connections, database connections, etc.
- Note: no finalizer chaining
  - Must explicitly call parent object's `finalize` method

Alternatives to `finalize`

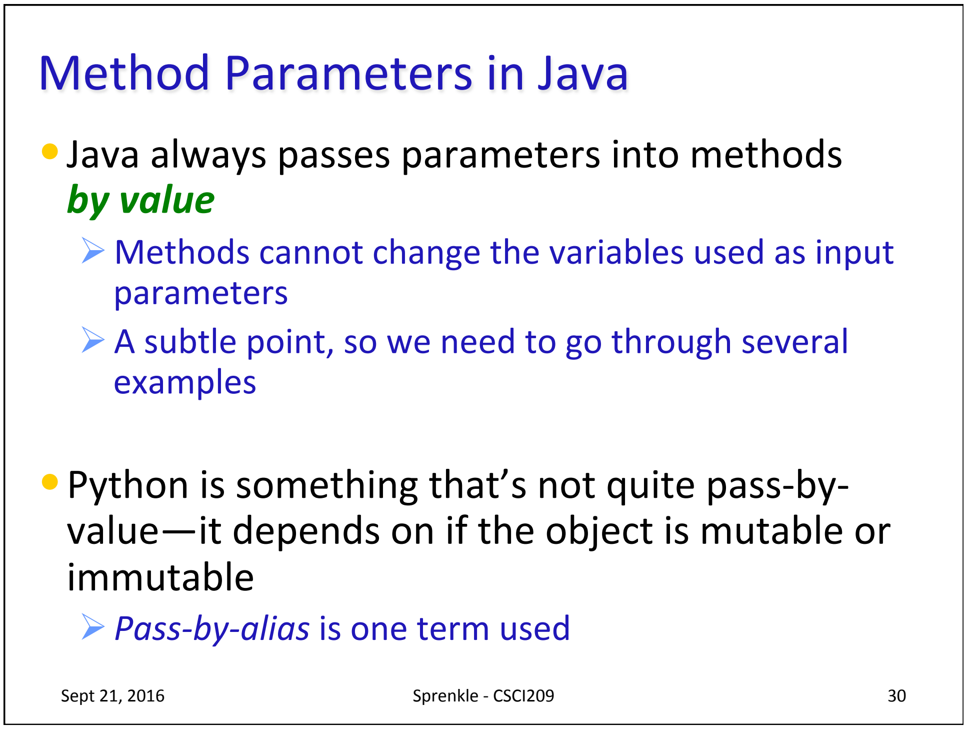
- Recall: unknown when `finalize` will execute —or *if* it will execute
  - Also *heavy performance cost*
- Solution: create your own terminating method
  - User of class terminates when done using object
- Examples: `File`'s or `Window`'s `close` method
- May still want `finalize()` as a safety net if user didn't call the terminate method
  - Log a warning message so user knows error in code

PARAMETER PASSING



Review

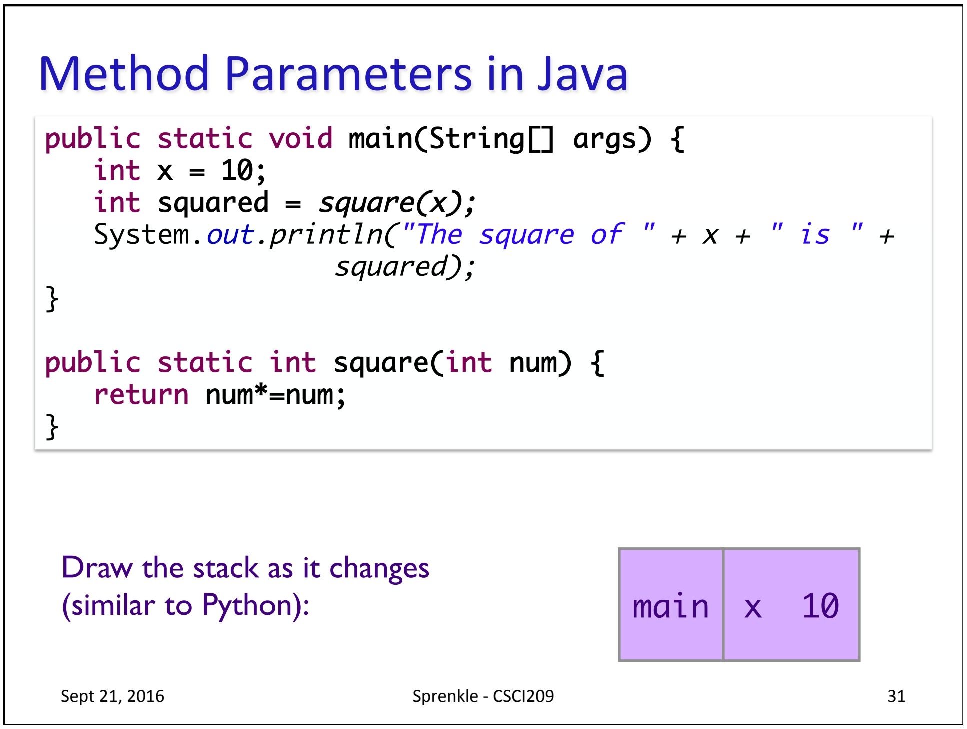
- How are parameters passed in Java?



Method Parameters in Java

- Java always passes parameters into methods ***by value***
  - Methods cannot change the variables used as input parameters
  - A subtle point, so we need to go through several examples

- Python is something that's not quite pass-by-value—it depends on if the object is mutable or immutable
  - *Pass-by-alias* is one term used

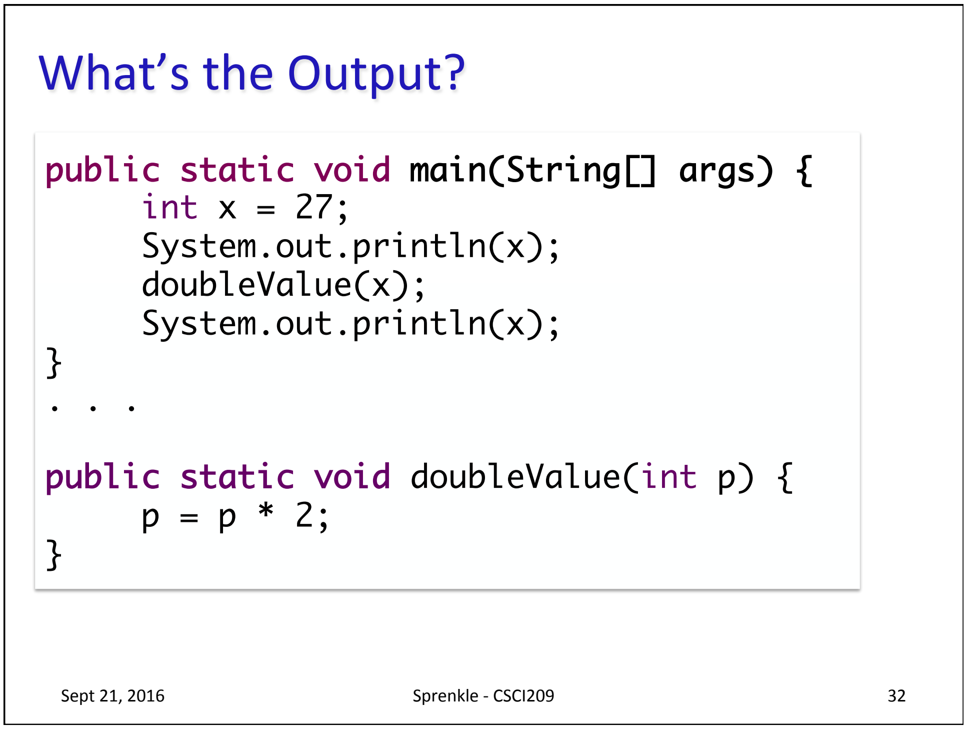


Method Parameters in Java

```
public static void main(String[] args) {
   int x = 10;
   int squared = square(x);
   System.out.println("The square of " + x + " is " +
                    squared);
}

public static int square(int num) {
   return num*=num;
}
```

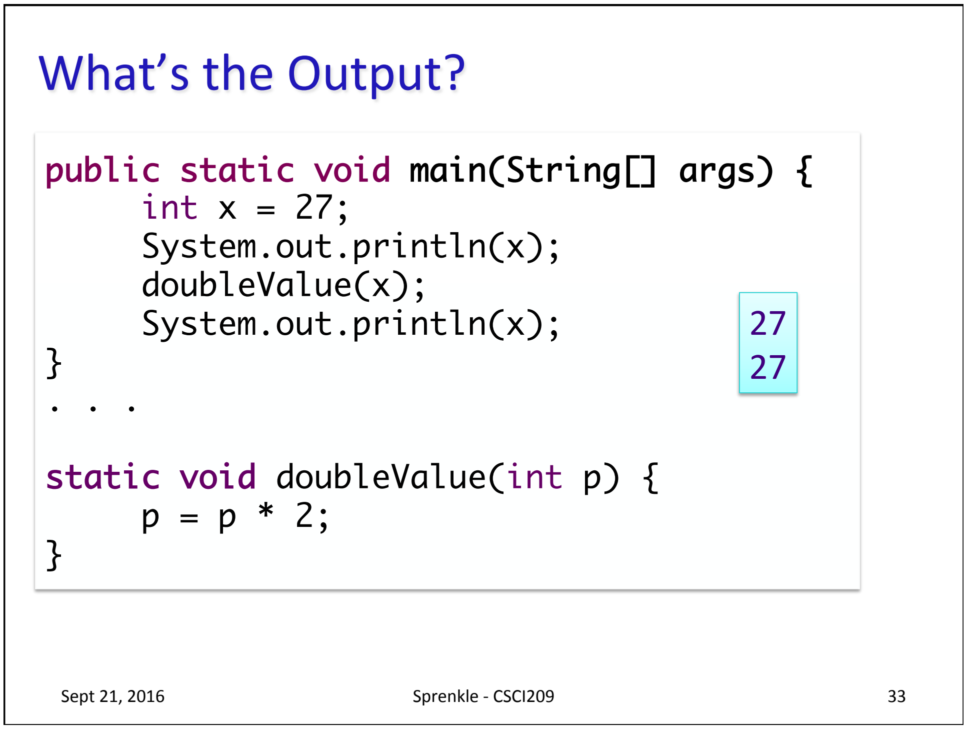
Draw the stack as it changes (similar to Python):

main	x 10



What’s the Output?

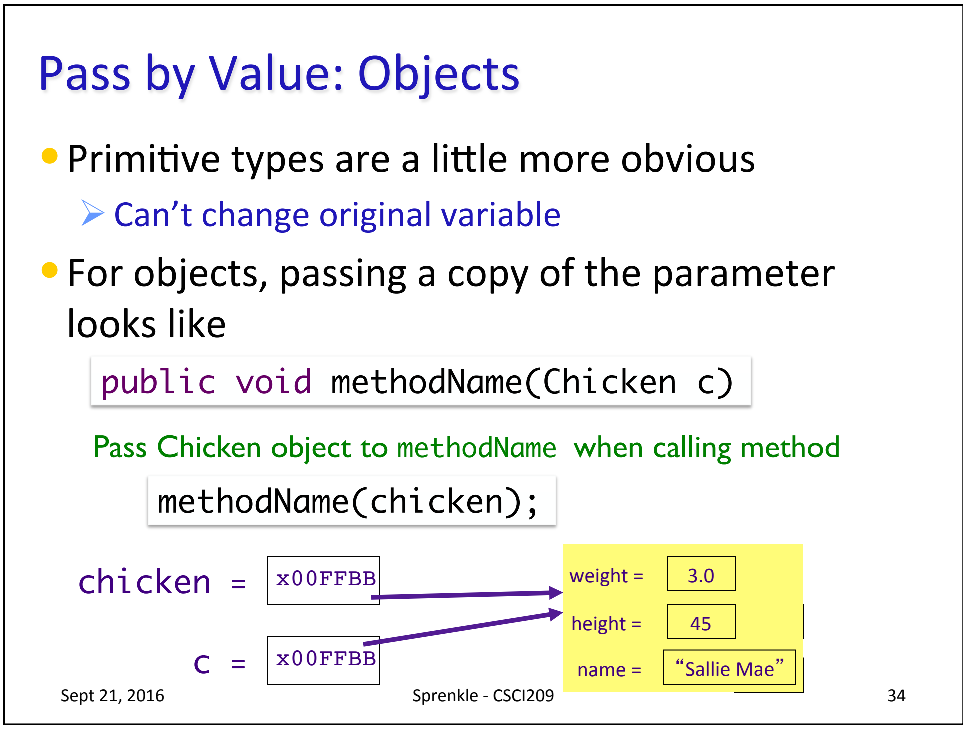
```
public static void main(String[] args) {
      int x = 27;
      System.out.println(x);
      doubleValue(x);
      System.out.println(x);
}
. . .

public static void doubleValue(int p) {
      p = p * 2;
}
```



What’s the Output?

```
public static void main(String[] args) {
     int x = 27;
     System.out.println(x);
     doubleValue(x);
     System.out.println(x);
}
. . .

static void doubleValue(int p) {
     p = p * 2;
}
```

```
27
27
```



Pass by Value: Objects

- Primitive types are a little more obvious
  - Can’t change original variable
- For objects, passing a copy of the parameter looks like

```
public void methodName(Chicken c)
```

Pass Chicken object to `methodName` when calling method

```
methodName(chicken);
```

chicken = x00FFBB

c = x00FFBB

weight = 3.0

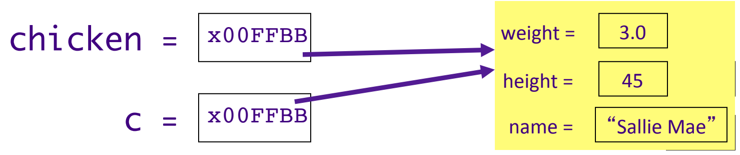
height = 45

name = “Sallie Mae”

Pass by Value: Objects

- What happens in this case?

```
methodName(chicken);
```



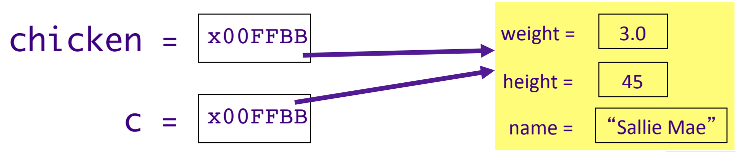
```
public void methodName(Chicken c) {
      if( c.getWeight() < MIN ) {
            c.feed();
      }
      …
}
```

Does chicken change in calling method?

Pass by Value: Objects

- What happens in this case?

```
methodName(chicken);
```



```
public void methodName(Chicken c) {
      if( c.getWeight() < MIN ) {
            c.feed();
      }
      …
}
```

Does chicken change in calling method?

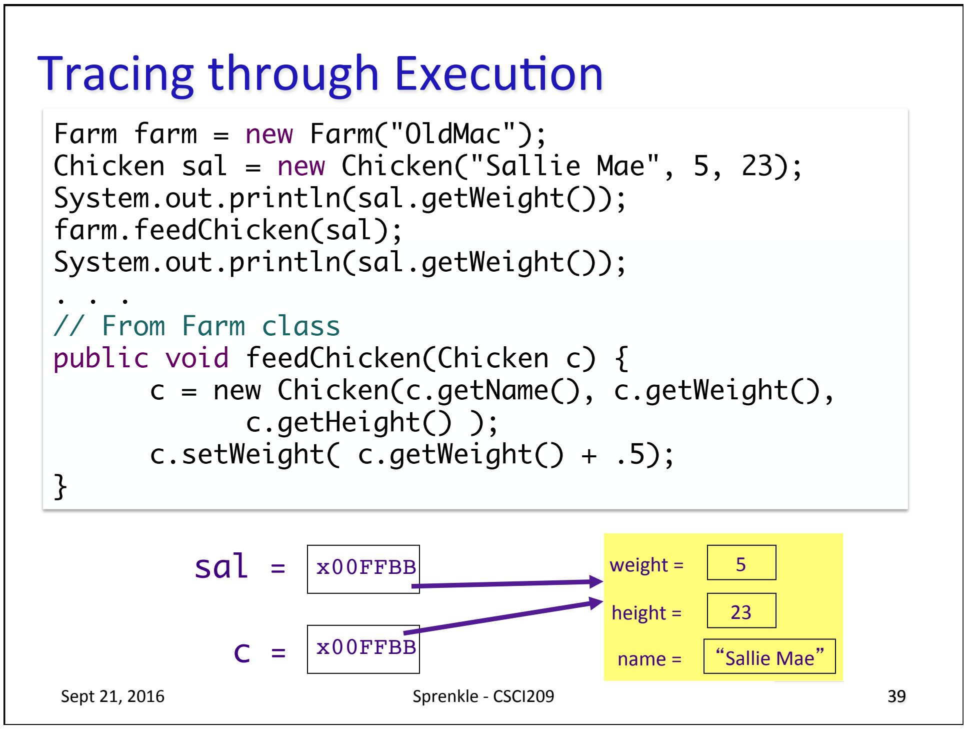
YES! Both chicken and c are pointing to the same object

What's the Output?

```
Farm farm = new Farm("OldMac");
Chicken sal = new Chicken("Sallie Mae", 5, 23);
System.out.println(sal.getWeight());
farm.feedChicken(sal);
System.out.println(sal.getWeight());
. . .

// From Farm class
public void feedChicken(Chicken c) {
      c.setWeight( c.getWeight() + .5);
}
```

What's the Output?

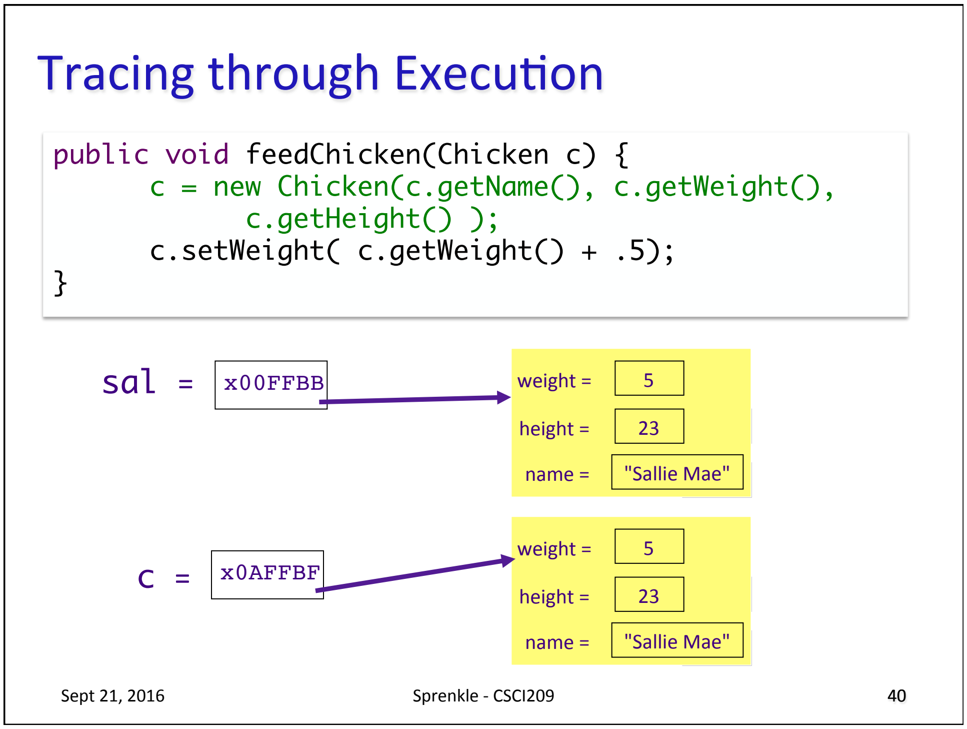
```
Farm farm = new Farm("OldMac");
Chicken sal = new Chicken("Sallie Mae", 5, 23);
System.out.println(sal.getWeight());
farm.feedChicken(sal);
System.out.println(sal.getWeight());
. . .

// From Farm class
public void feedChicken(Chicken c) {
      c = new Chicken(c.getName(), c.getWeight(),
            c.getHeight() );
      c.setWeight( c.getWeight() + .5);
}
```



Tracing through Execution

```
Farm farm = new Farm("OldMac");
Chicken sal = new Chicken("Sallie Mae", 5, 23);
System.out.println(sal.getWeight());
farm.feedChicken(sal);
System.out.println(sal.getWeight());
. . .
// From Farm class
public void feedChicken(Chicken c) {
      c = new Chicken(c.getName(), c.getWeight(),
            c.getHeight() );
      c.setWeight( c.getWeight() + .5);
}
```

sal =
x00FFBB
c =
x00FFBB
weight =
5
height =
23
name =
“Sallie Mae”



Tracing through Execution

```
public void feedChicken(Chicken c) {
      c = new Chicken(c.getName(), c.getWeight(),
            c.getHeight() );
      c.setWeight( c.getWeight() + .5);
}
```

sal =
x00FFBB
weight =
5
height =
23
name =
"Sallie Mae"
c =
x0AFFBF
weight =
5
height =
23
name =
"Sallie Mae"

Summary of Method Parameters

- Everything is passed ***by value*** in Java
- An ***object variable*** (not an object) is passed into a method
  - Changing the *state* of an object in a method changes the state of object outside the method
  - Method does not see a copy of the original object

To Do

- Assignment 4
  - Birthday class, application