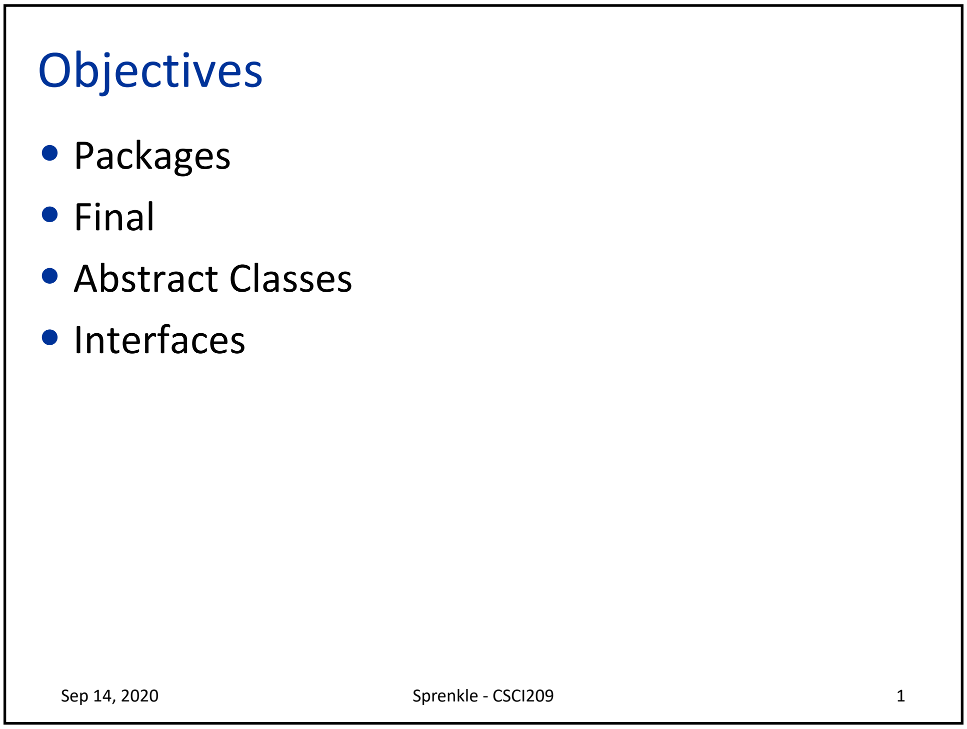
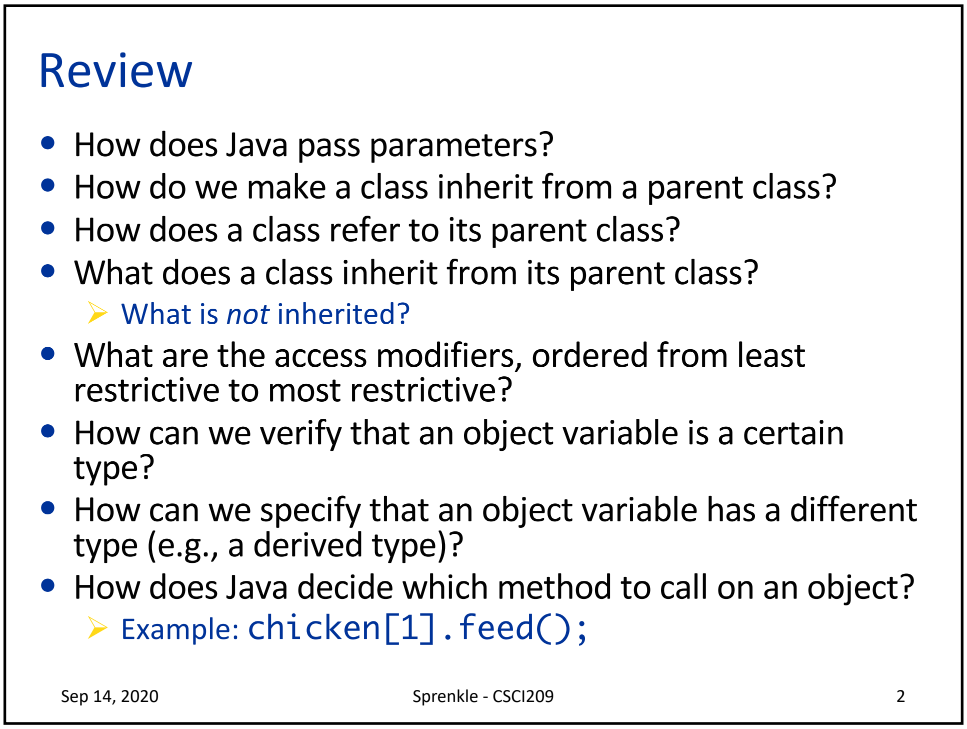


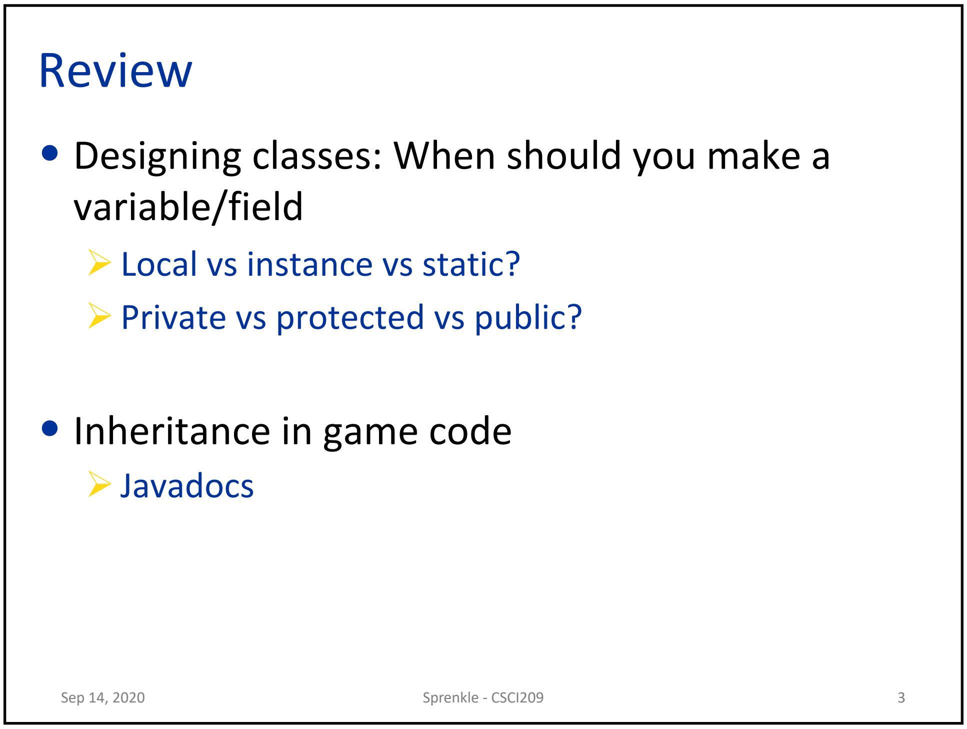
Objectives

- Packages
- Final
- Abstract Classes
- Interfaces



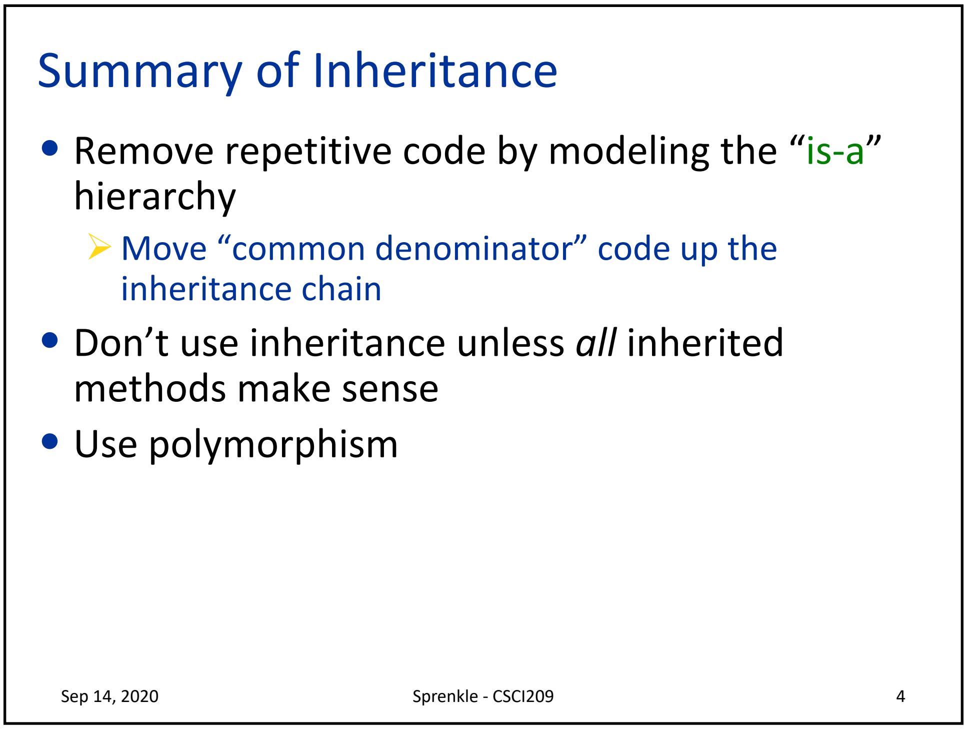
Review

- How does Java pass parameters?
- How do we make a class inherit from a parent class?
- How does a class refer to its parent class?
- What does a class inherit from its parent class?
  - What is *not* inherited?
- What are the access modifiers, ordered from least restrictive to most restrictive?
- How can we verify that an object variable is a certain type?
- How can we specify that an object variable has a different type (e.g., a derived type)?
- How does Java decide which method to call on an object?
  - Example: `chicken[1].feed();`



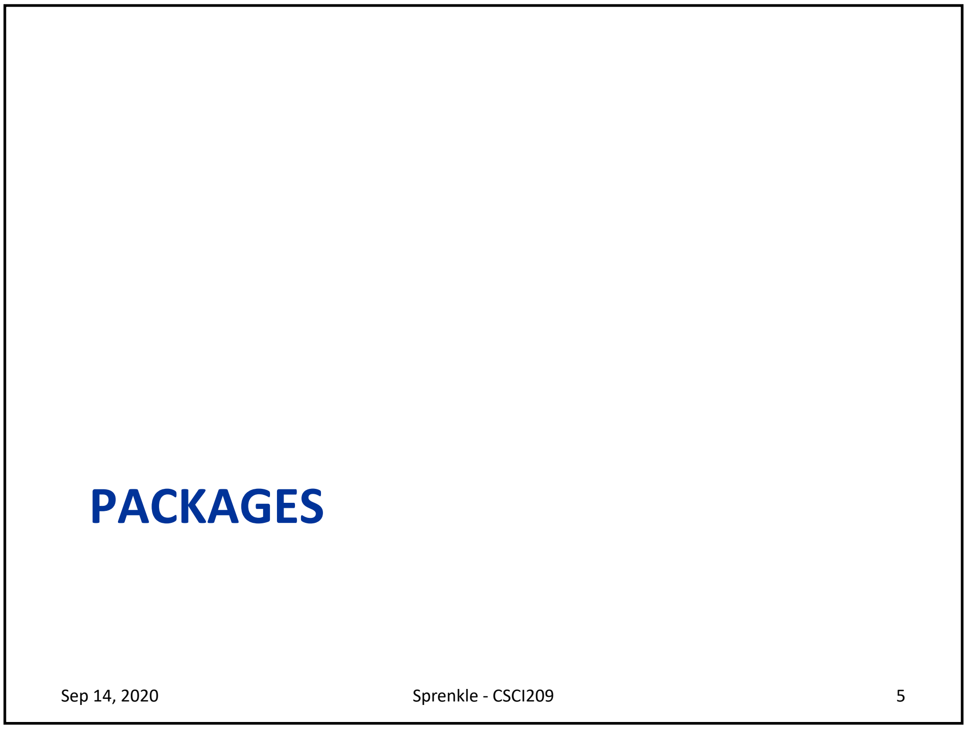
Review

- Designing classes: When should you make a variable/field
  - Local vs instance vs static?
  - Private vs protected vs public?
- Inheritance in game code
  - Javadocs

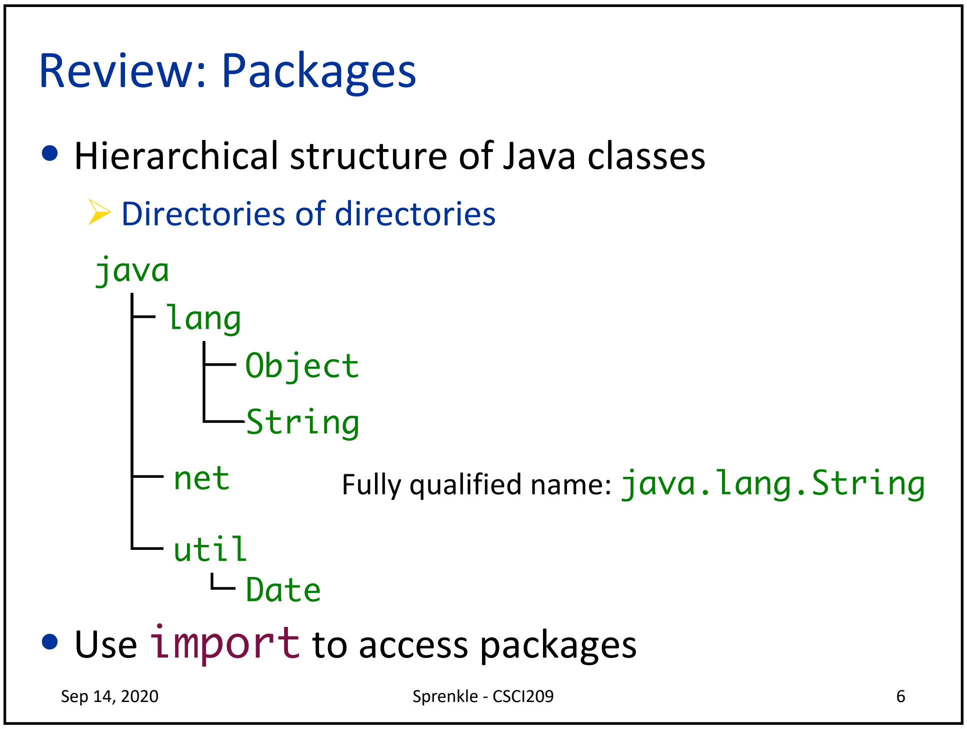


Summary of Inheritance

- Remove repetitive code by modeling the "is-a" hierarchy
  - Move "common denominator" code up the inheritance chain
- Don't use inheritance unless *all* inherited methods make sense
- Use polymorphism



PACKAGES



Review: Packages

- Hierarchical structure of Java classes
  - ➢ Directories of directories

```
java
 ├ lang
 │   ├ Object
 │   └ String
 ├ net
 └ util
     └ Date
```

Fully qualified name: `java.lang.String`

- Use `import` to access packages

Review: Importing Packages

- Can import one class at a time or all the classes within a package
- Examples:

```
import java.util.Date;
import java.io.*;
```

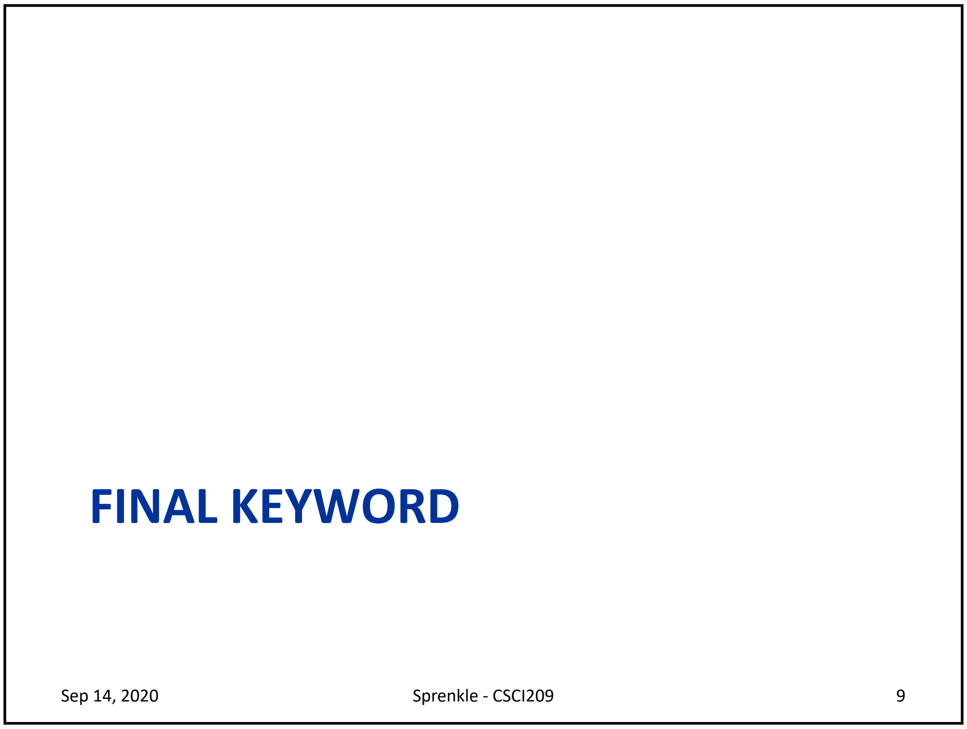
Import entire package

  - * form may increase compile time
    - BUT, no effect on run-time performance

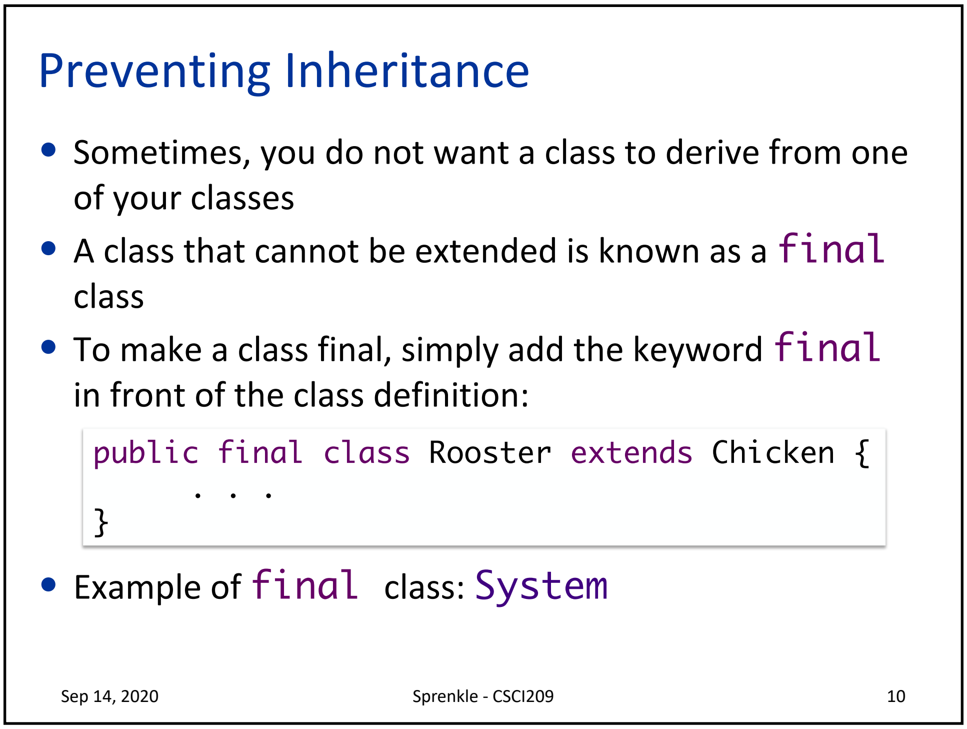
Standard Practice

- To reduce chance of a conflict between names of classes, put classes in ***packages***
- Use `package` keyword to say that a class belongs to a package:
  - `package java.util;`
  - *First* line in class file
- Typically, use a unique prefix, similar to domain names
  - `com.ibm`
  - `edu.wlu.cs.logic`
- Organize code by the packages
  - For example, code in edu.wlu.cs.logic package would be in a `logic` directory inside a `cs` directory inside a `wlu` directory inside a `logic` directory

We will start organizing our code in packages soon



FINAL KEYWORD



Preventing Inheritance

- Sometimes, you do not want a class to derive from one of your classes
- A class that cannot be extended is known as a `final` class
- To make a class final, simply add the keyword `final` in front of the class definition:

```
public final class Rooster extends Chicken {
      . . .
}
```

- Example of `final` class: `System`

Final methods

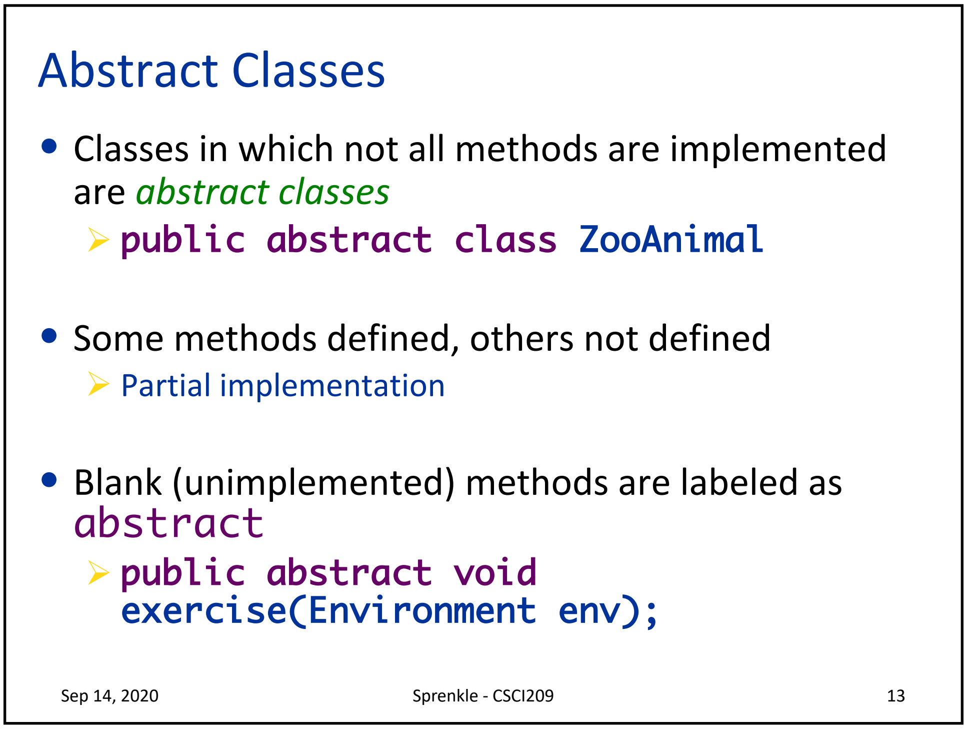
- Can make a method `final`
  - Any class derived from this class **cannot override** the `final` methods

```
class Chicken {
        . . .
        public final String getName() { . . . }
        . . .
}
```

- By default, **all** methods in a `final` class are `final` methods.

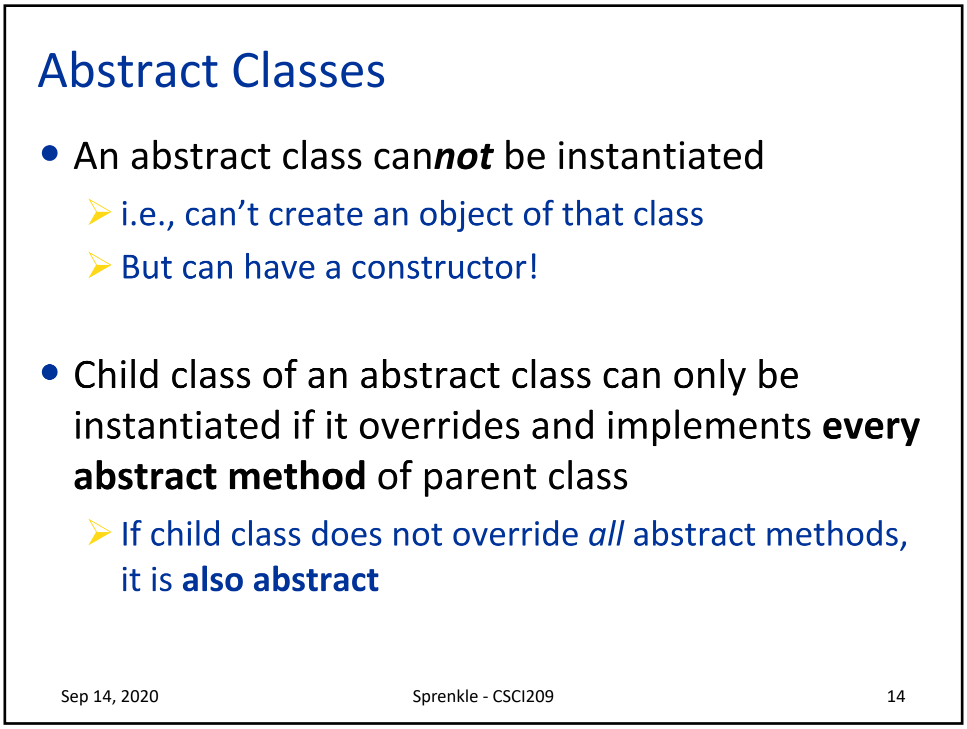
Why would we want to make methods `final`?
What are possible benefits to us, the compiler, …?

ABSTRACT CLASSES



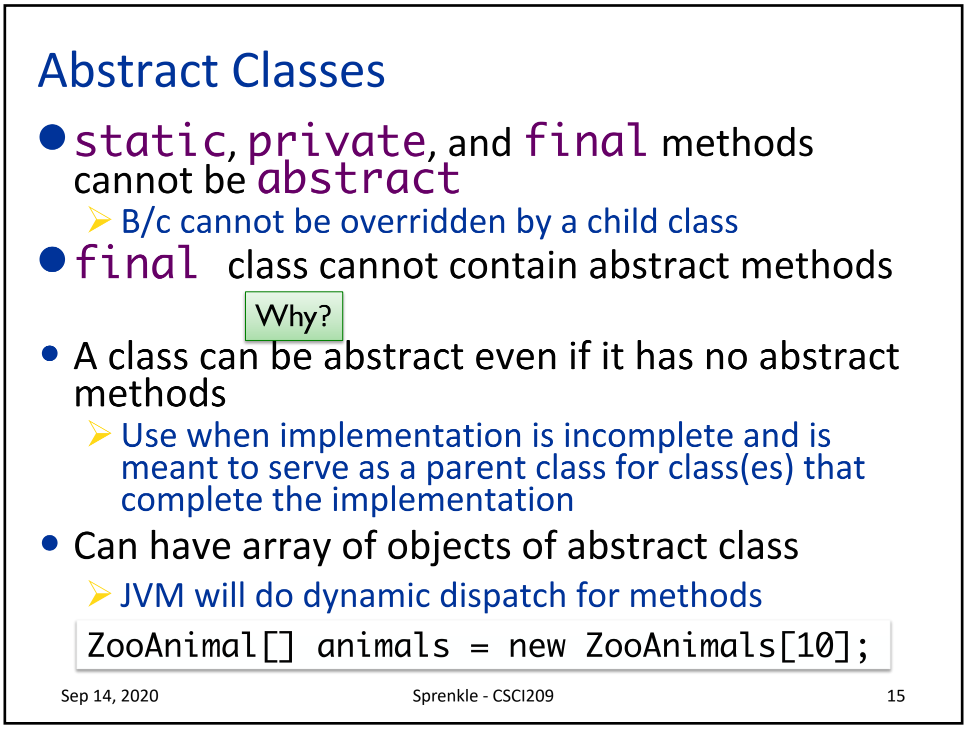
Abstract Classes

- Classes in which not all methods are implemented are *abstract classes*
  - `public abstract class ZooAnimal`
- Some methods defined, others not defined
  - Partial implementation
- Blank (unimplemented) methods are labeled as `abstract`
  - `public abstract void exercise(Environment env);`



Abstract Classes

- An abstract class can***not*** be instantiated
  - i.e., can't create an object of that class
  - But can have a constructor!
- Child class of an abstract class can only be instantiated if it overrides and implements **every abstract method** of parent class
  - If child class does not override *all* abstract methods, it is **also abstract**



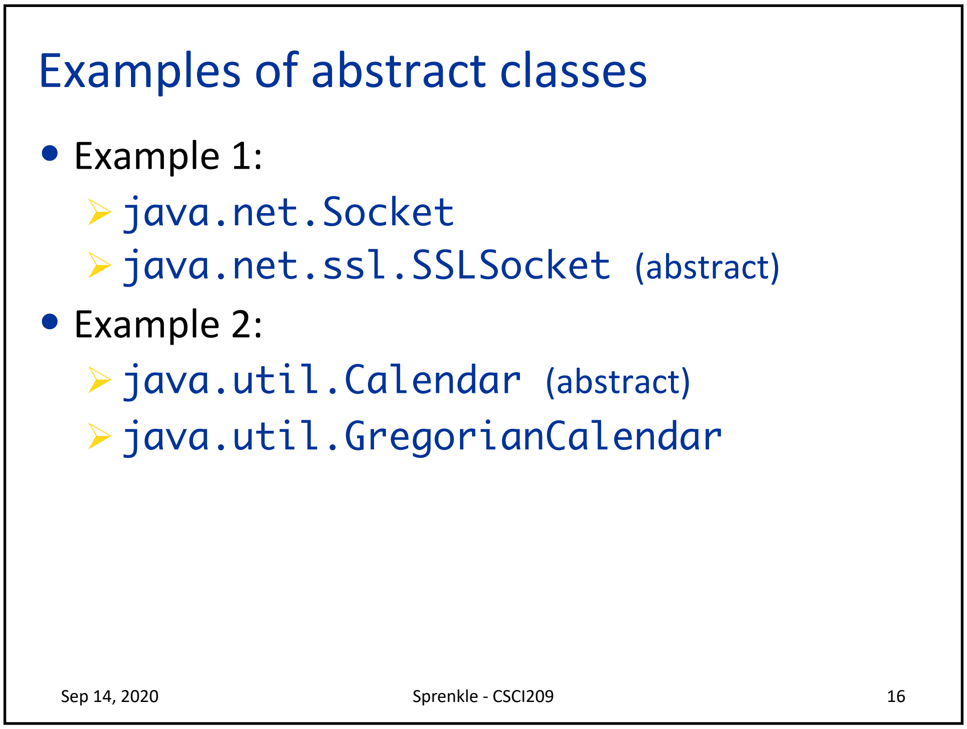
Abstract Classes

- static, private, and final methods cannot be abstract
  - B/c cannot be overridden by a child class
- final class cannot contain abstract methods

Why?

- A class can be abstract even if it has no abstract methods
  - Use when implementation is incomplete and is meant to serve as a parent class for class(es) that complete the implementation
- Can have array of objects of abstract class
  - JVM will do dynamic dispatch for methods

```
ZooAnimal[] animals = new ZooAnimals[10];
```



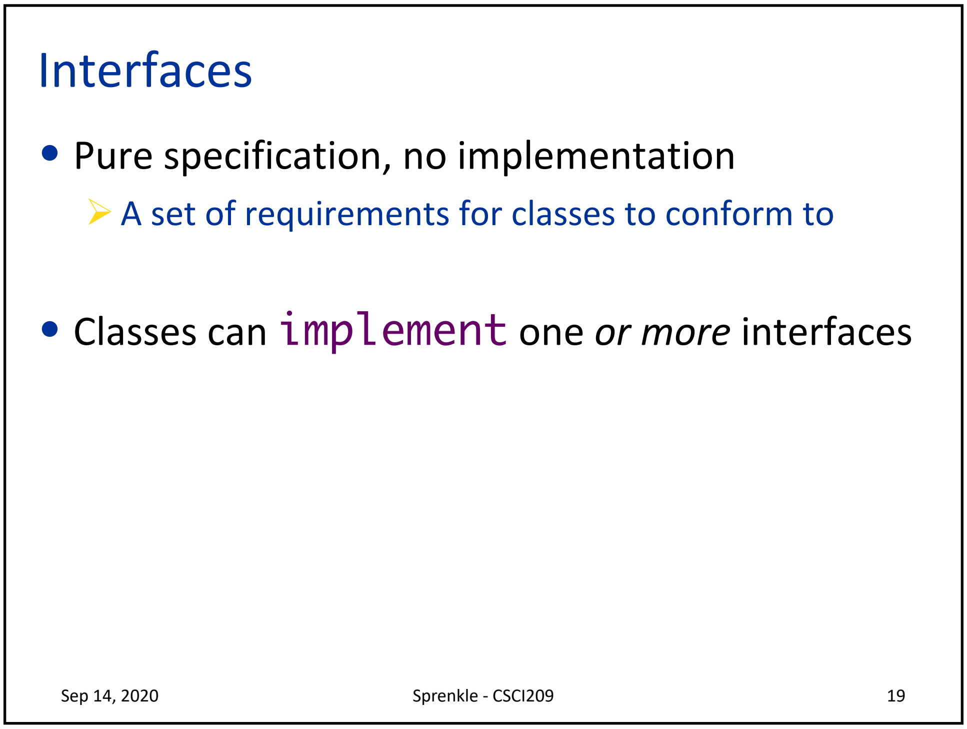
Examples of abstract classes

- Example 1:
  - java.net.Socket
  - java.net.ssl.SSLSocket (abstract)
- Example 2:
  - java.util.Calendar (abstract)
  - java.util.GregorianCalendar

Summary: Defining Abstract Classes

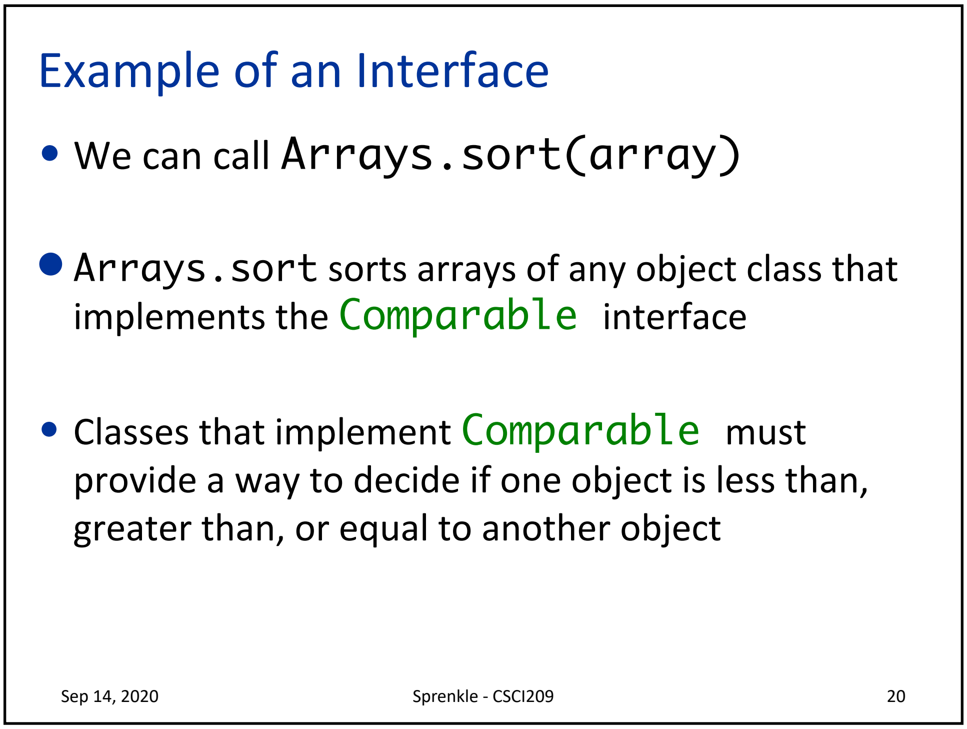
➡Define a class as `abstract` when class has *partial implementation*

INTERFACES



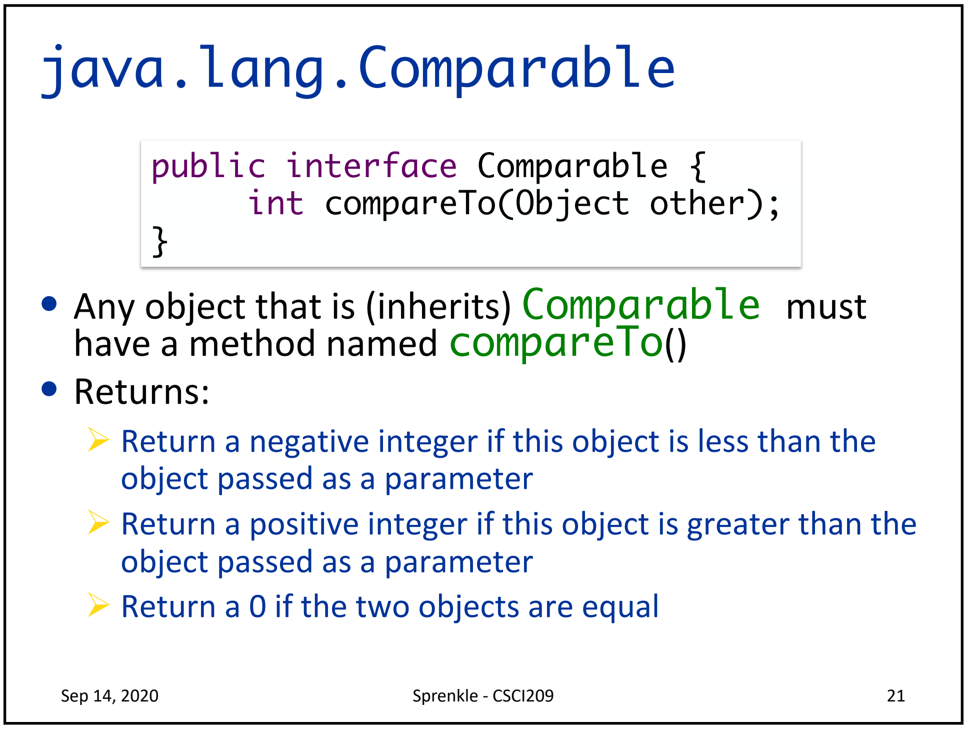
Interfaces

- Pure specification, no implementation
  - A set of requirements for classes to conform to
- Classes can `implement` one *or more* interfaces



Example of an Interface

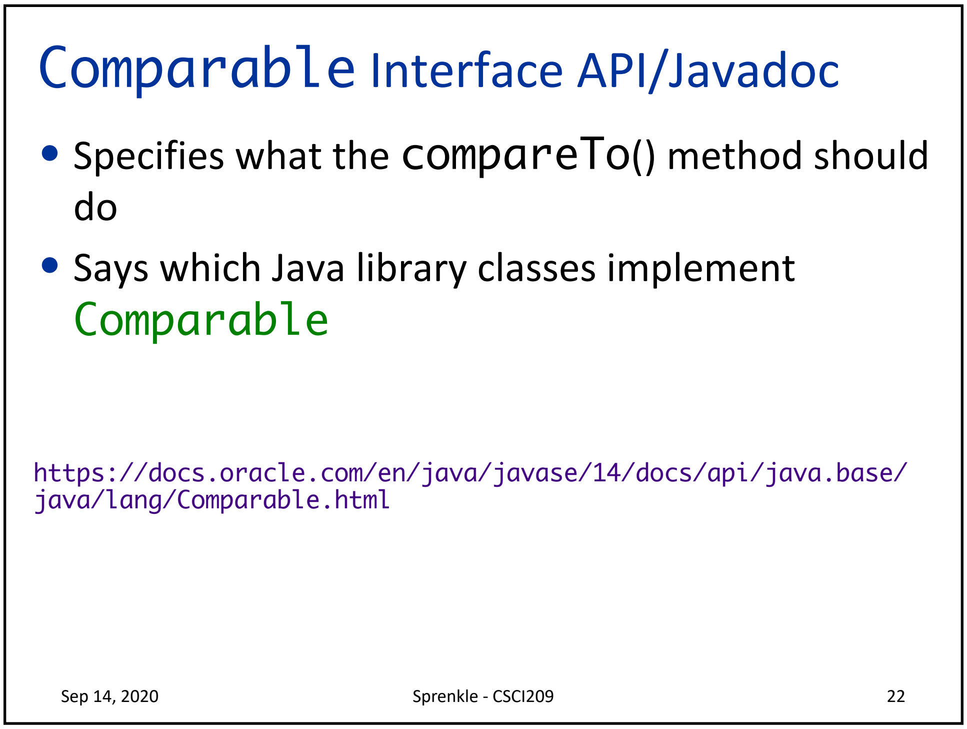
- We can call `Arrays.sort(array)`
- `Arrays.sort` sorts arrays of any object class that implements the `Comparable` interface
- Classes that implement `Comparable` must provide a way to decide if one object is less than, greater than, or equal to another object



java.lang.Comparable

```
public interface Comparable {
     int compareTo(Object other);
}
```

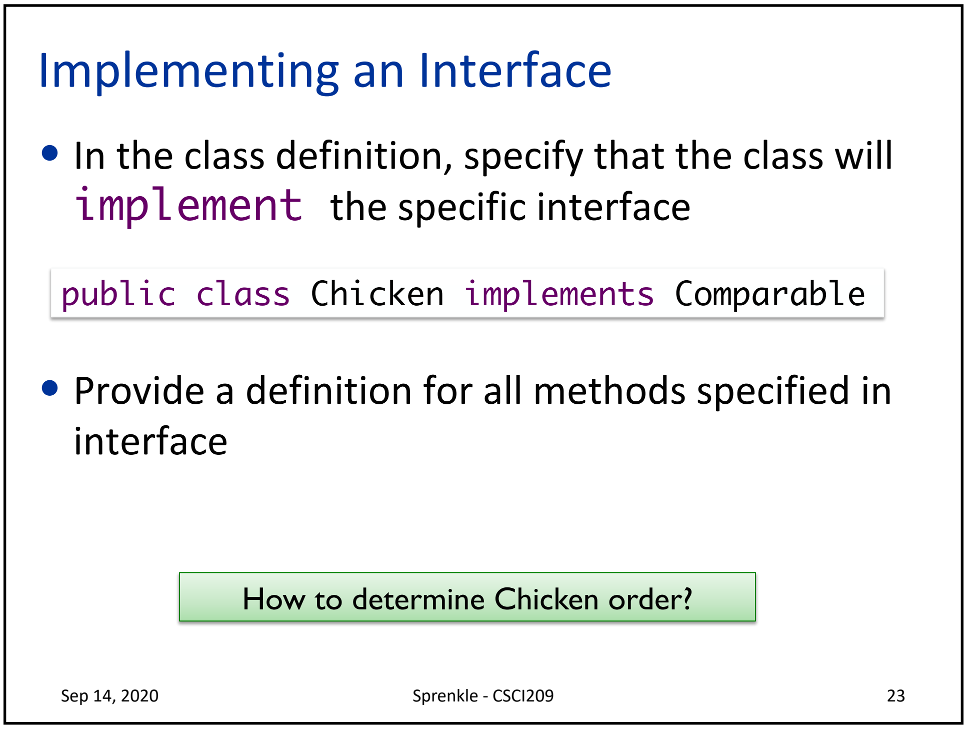
- Any object that is (inherits) Comparable must have a method named compareTo()
- Returns:
  - Return a negative integer if this object is less than the object passed as a parameter
  - Return a positive integer if this object is greater than the object passed as a parameter
  - Return a 0 if the two objects are equal



Comparable Interface API/Javadoc

- Specifies what the compareTo() method should do
- Says which Java library classes implement Comparable

https://docs.oracle.com/en/java/javase/14/docs/api/java.base/java/lang/Comparable.html



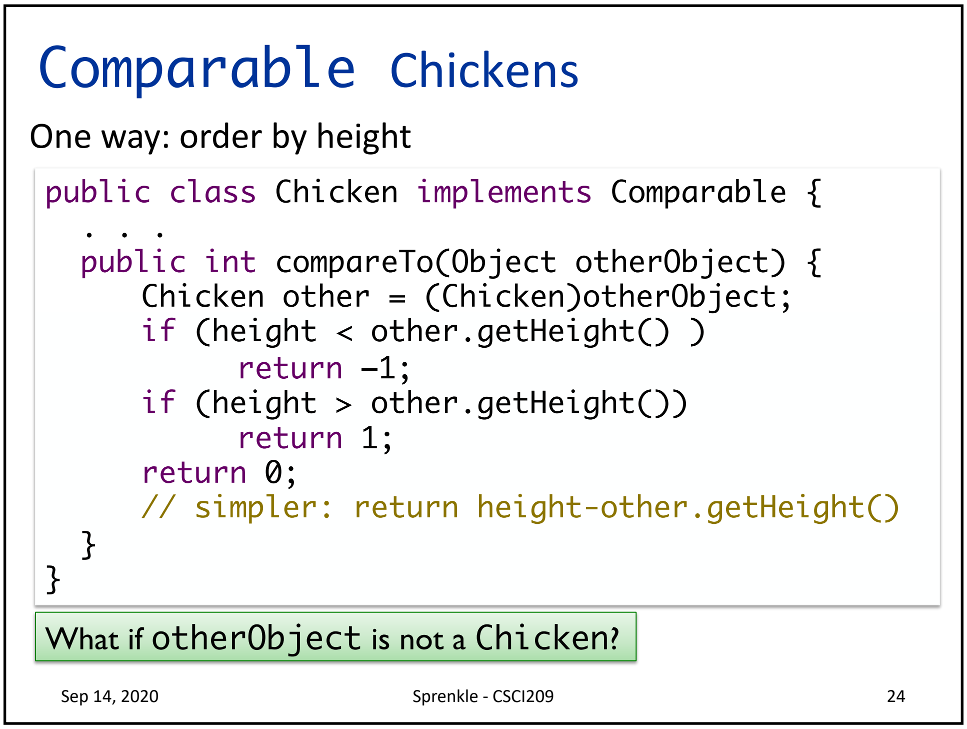
Implementing an Interface

- In the class definition, specify that the class will `implement` the specific interface

```
public class Chicken implements Comparable
```

- Provide a definition for all methods specified in interface

How to determine Chicken order?

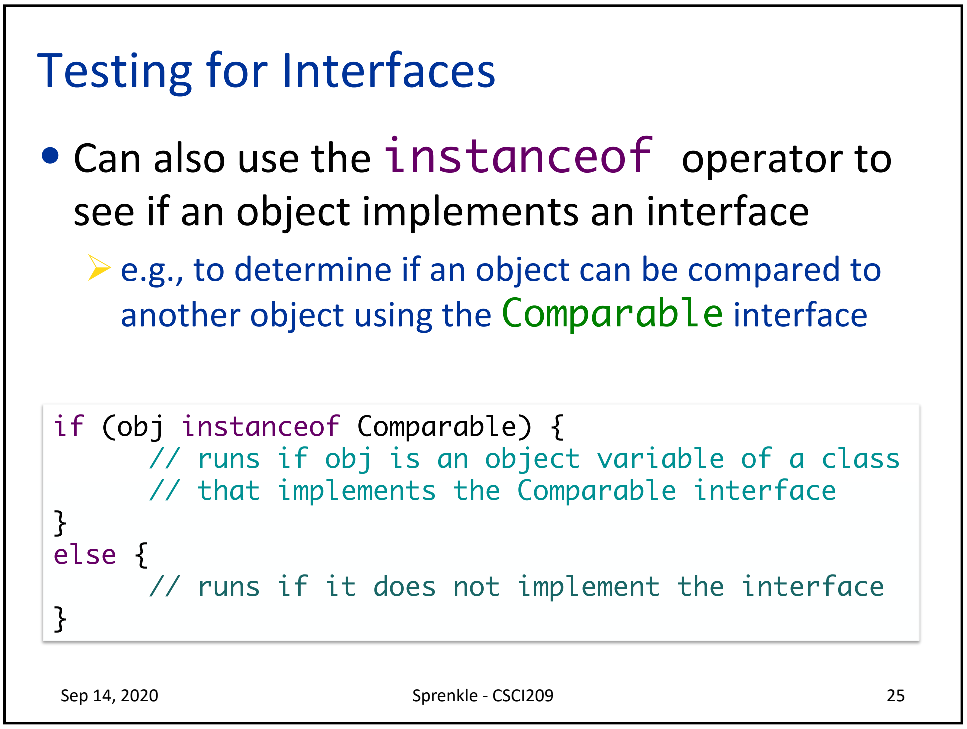


`Comparable` Chickens

One way: order by height

```
public class Chicken implements Comparable {
  . . .
  public int compareTo(Object otherObject) {
      Chicken other = (Chicken)otherObject;
      if (height < other.getHeight() )
            return -1;
      if (height > other.getHeight())
            return 1;
      return 0;
      // simpler: return height-other.getHeight()
  }
}
```

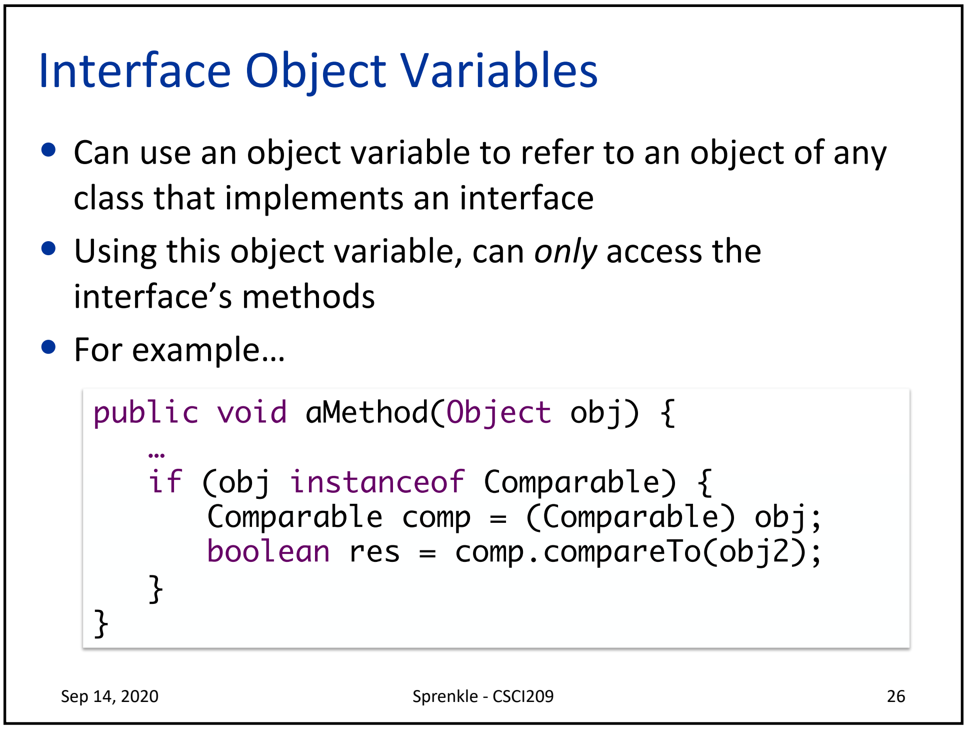
What if `otherObject` is not a `Chicken`?



Testing for Interfaces

- Can also use the `instanceof` operator to see if an object implements an interface
  - e.g., to determine if an object can be compared to another object using the `Comparable` interface

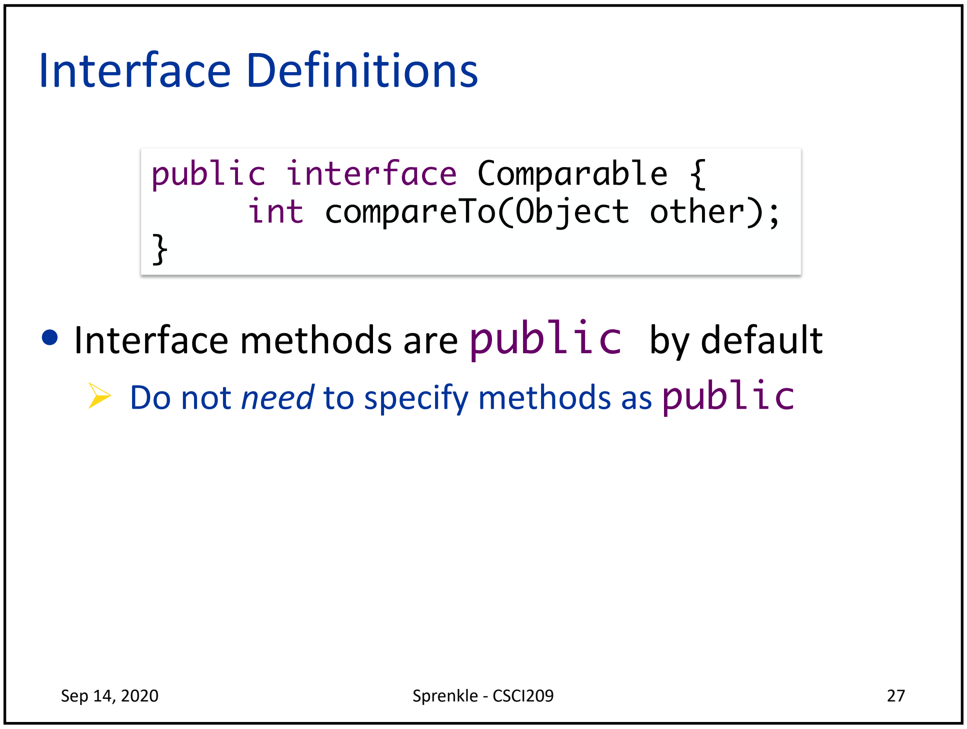
```
if (obj instanceof Comparable) {
      // runs if obj is an object variable of a class
      // that implements the Comparable interface
}
else {
      // runs if it does not implement the interface
}
```



Interface Object Variables

- Can use an object variable to refer to an object of any class that implements an interface
- Using this object variable, can *only* access the interface’s methods
- For example…

```
public void aMethod(Object obj) {
    …
    if (obj instanceof Comparable) {
        Comparable comp = (Comparable) obj;
        boolean res = comp.compareTo(obj2);
    }
}
```



Interface Definitions

```
public interface Comparable {
     int compareTo(Object other);
}
```

- Interface methods are `public` by default
  - Do not *need* to specify methods as `public`

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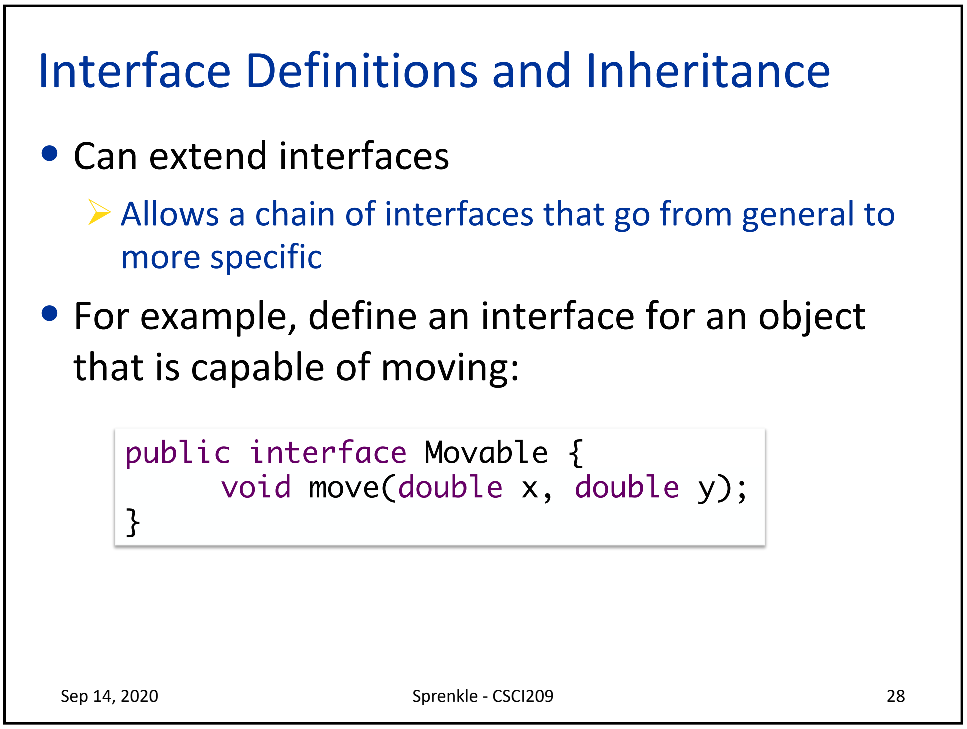

Interface Definitions and Inheritance

- Can extend interfaces
  - Allows a chain of interfaces that go from general to more specific
- For example, define an interface for an object that is capable of moving:

```
public interface Movable {
     void move(double x, double y);
}
```

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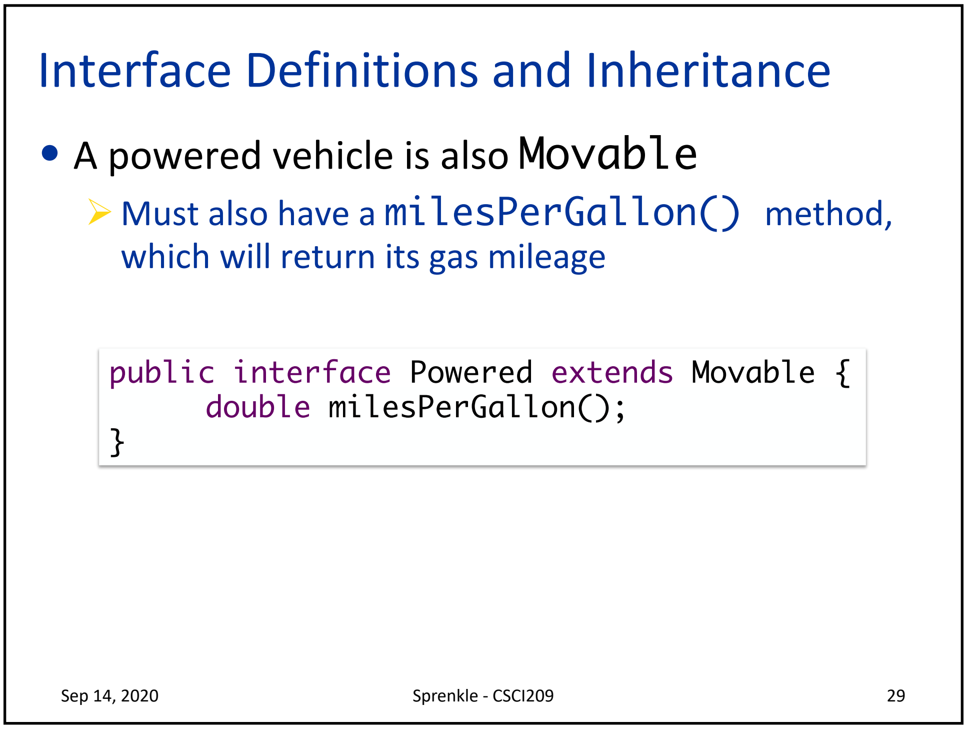
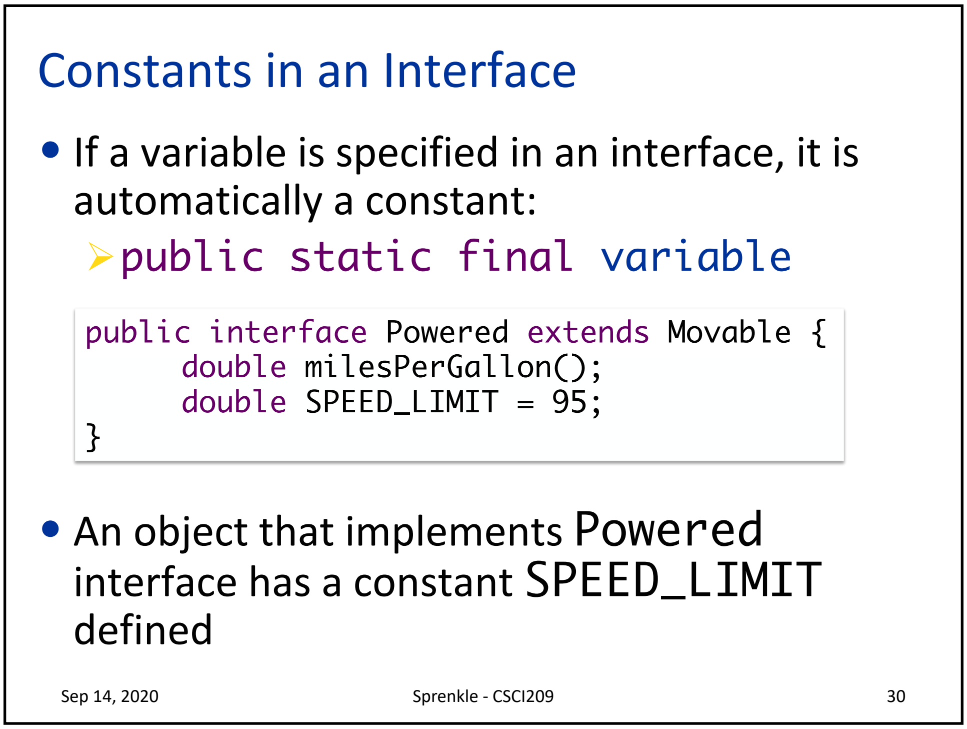


Interface Definitions and Inheritance

- A powered vehicle is also `Movable`
  - Must also have a `milesPerGallon()` method, which will return its gas mileage

```
public interface Powered extends Movable {
	double milesPerGallon();
}
```



Constants in an Interface

- If a variable is specified in an interface, it is automatically a constant:
  - `public static final variable`

```
public interface Powered extends Movable {
	double milesPerGallon();
	double SPEED_LIMIT = 95;
}
```

- An object that implements `Powered` interface has a constant `SPEED_LIMIT` defined

Interface Definitions and Inheritance

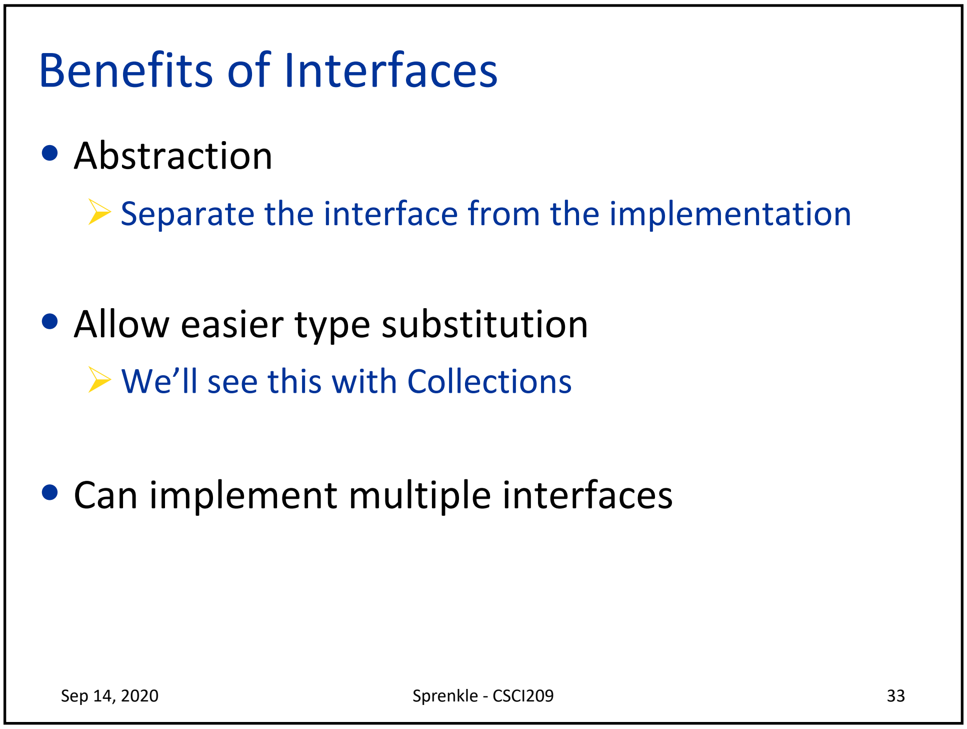
- `Powered` interface extends `Movable` interface
- An object that implements `Powered` interface must satisfy all requirements of that interface as well as the parent interface.
  - A `Powered` object must have a `milesPerGallon()` and `move()` method

Multiple Interfaces

- A class can implement *multiple* interfaces
  - Must fulfill the requirements of each interface

```
public final class String implements
     Serializable, Comparable, CharSequence { …
```

- But NOT possible with inheritance
  - A class can only extend (or inherit from) **one** class



Benefits of Interfaces

- Abstraction
  - Separate the interface from the implementation
- Allow easier type substitution
  - We’ll see this with Collections
- Can implement multiple interfaces

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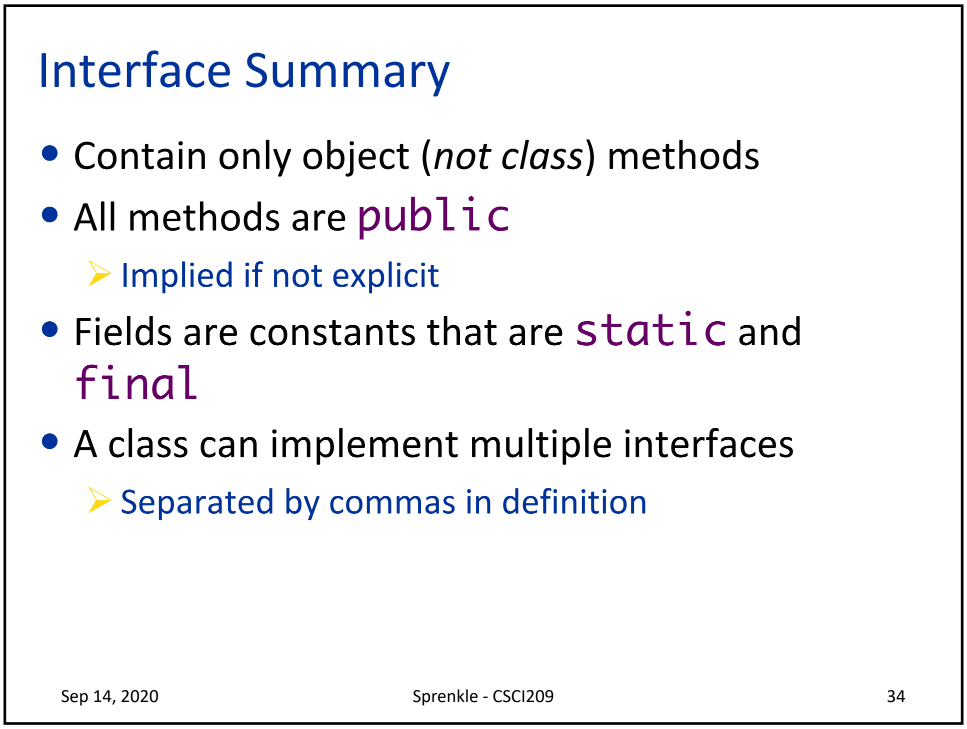

Interface Summary

- Contain only object (*not class*) methods
- All methods are `public`
  - Implied if not explicit
- Fields are constants that are `static` and `final`
- A class can implement multiple interfaces
  - Separated by commas in definition

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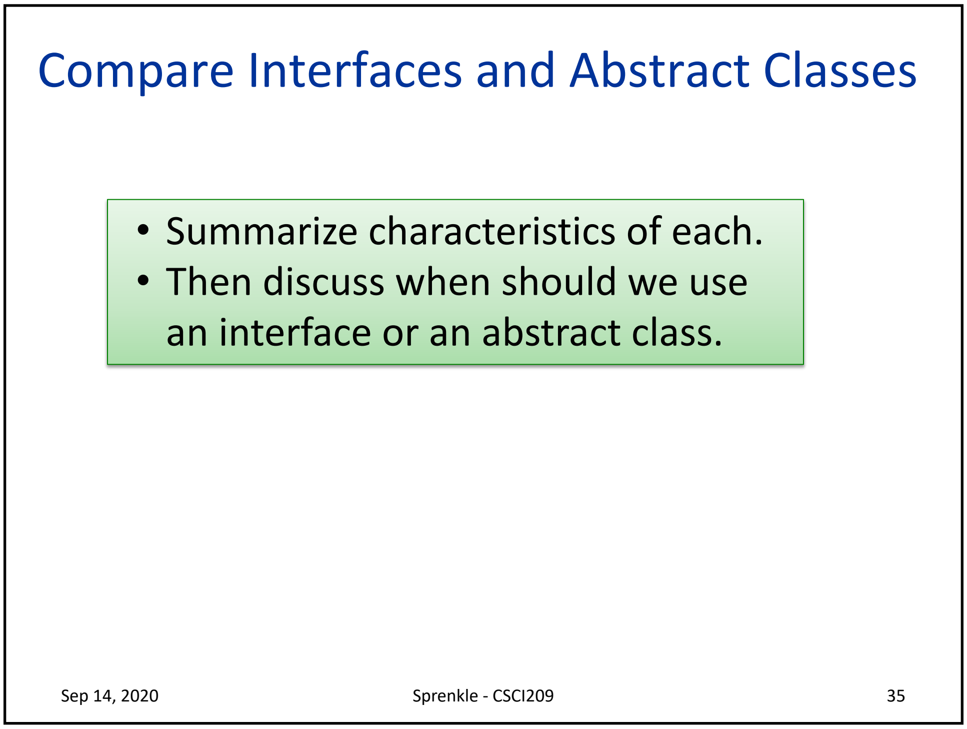

Compare Interfaces and Abstract Classes

- Summarize characteristics of each.
- Then discuss when should we use an interface or an abstract class.

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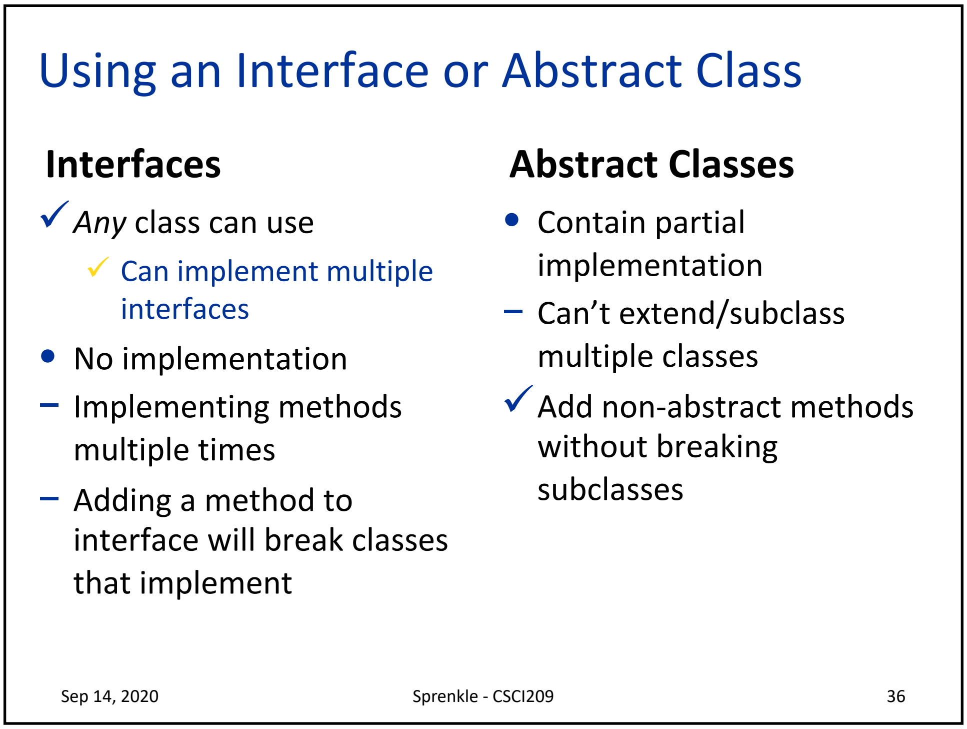

Using an Interface or Abstract Class

Interfaces

✓ *Any* class can use
  - ✓ Can implement multiple interfaces

● No implementation

– Implementing methods multiple times

– Adding a method to interface will break classes that implement

Abstract Classes

● Contain partial implementation

– Can't extend/subclass multiple classes

✓ Add non-abstract methods without breaking subclasses

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One Option: Use Both!

- Define interface, e.g., `MyInterface`
- Define abstract class, e.g., `AbstractMyInterface`
  - Implements interface
  - Provides implementation for some methods

Abstract Classes and Interfaces

- Important structures in Java
  - Make code easier to change
- Will return to/apply these ideas throughout the course
- Concepts are used in many languages besides Java

Looking Ahead

- Assignment 6: Goblin Game
  - Can now do the refactoring part
  - Due Wednesday before class