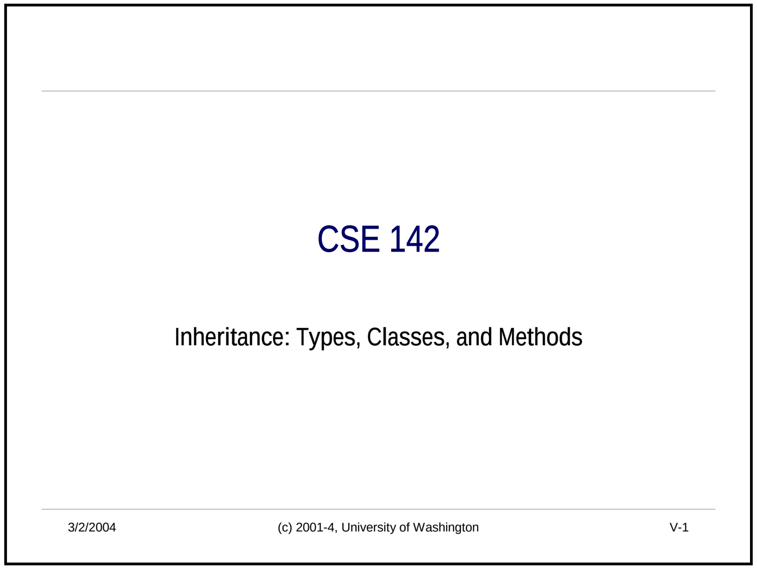
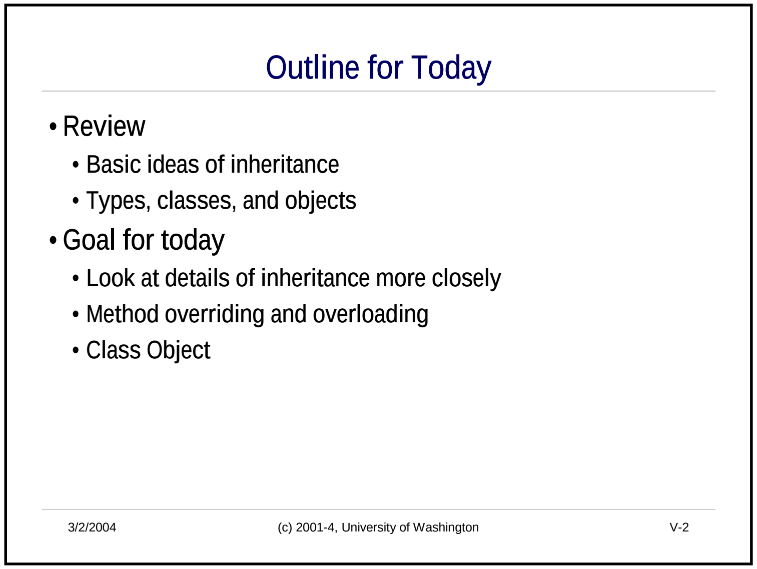


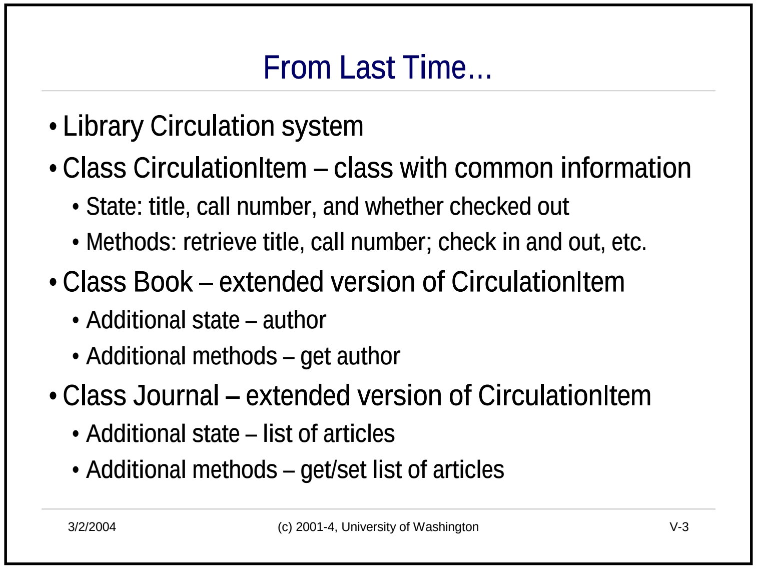
CSE 142

Inheritance: Types, Classes, and Methods



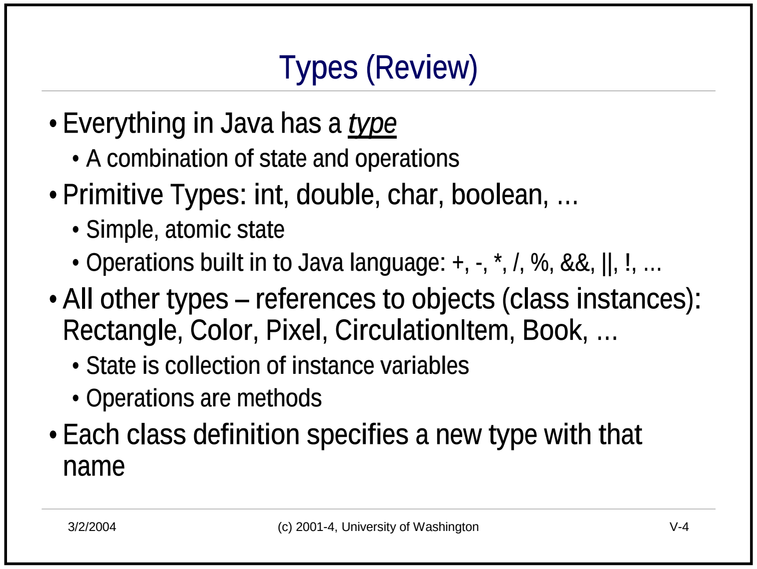
Outline for Today

- Review
  - Basic ideas of inheritance
  - Types, classes, and objects
- Goal for today
  - Look at details of inheritance more closely
  - Method overriding and overloading
  - Class Object



From Last Time…

- Library Circulation system
- Class CirculationItem – class with common information
  - State: title, call number, and whether checked out
  - Methods: retrieve title, call number; check in and out, etc.
- Class Book – extended version of CirculationItem
  - Additional state – author
  - Additional methods – get author
- Class Journal – extended version of CirculationItem
  - Additional state – list of articles
  - Additional methods – get/set list of articles



Types (Review)

- Everything in Java has a ***type***
  - A combination of state and operations
- Primitive Types: int, double, char, boolean, …
  - Simple, atomic state
  - Operations built in to Java language: +, -, *, /, %, &&, ||, !, …
- All other types – references to objects (class instances): Rectangle, Color, Pixel, CirculationItem, Book, …
  - State is collection of instance variables
  - Operations are methods
- Each class definition specifies a new type with that name

Types and Inheritance (1)

- When we define

  ```
  class Book extends CirculationItem { … }
  ```

  we create a new type, Book
- Instances of class Book have type Book, and also…
- …have type CirculationItem
  - Not so odd if you think about it. Many things in the real world have multiple "types" or roles. A person can be a student, employee, partner, child, parent, ….
  - Same as when a class implements 1 or more interfaces – it has multiple types

Types and Inheritance (2)

```
class Book extends CirculationItem { … }
```

- Rule: every Book object is also a CirculationItem object
  - Can be used in any situation where either a Book or CirculationItem is expected

```
Book b = new Book(…);
Book x = b;
CirculationItem c = b;
```

- The reverse is not true: there are CirculationItems that are not Books (plain CirculationItems, Journals)
  - So this is not allowed

```
CirculationItem c = new CirculationItem(…);        // ok
Book b1 = c;                                      // compile-time type error
Book b2 = (Book) c;                               // run time class cast exception error
```

Dynamic and Static Types

- The ***static type*** (or declared type) of a variable is the type in it's declaration

  ```
  Book b = …
  Journal m = …
  CirculationItem c = …
  ```

- The ***dynamic type*** of a variable is the type of the object it currently refers to
  - Either the variable's static type or a type that extends it
  - Can change during execution

Dynamic Types

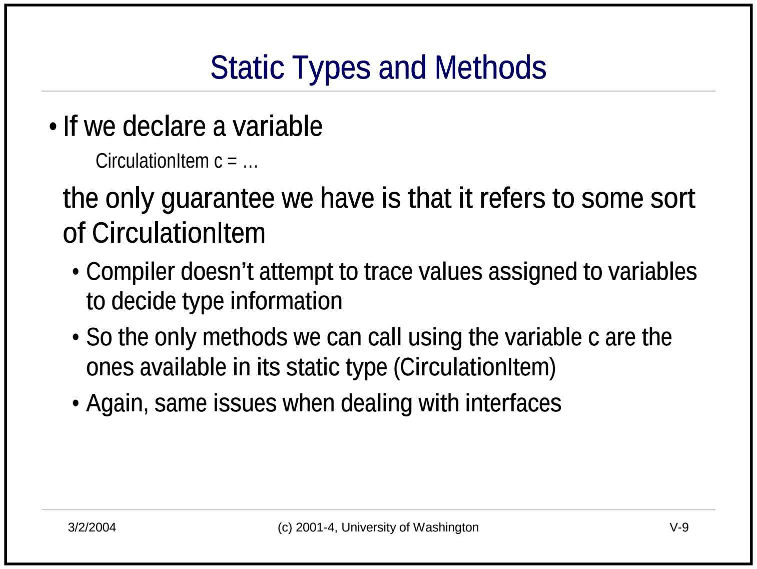
- What are the dynamic types of the variables in the following code?

```
Book b = new Book("Short Story", "A. U. Thor", "P34.56");

CirculationItem c = new CirculationItem("Rather Bland", "A1");

CirculationItem d = new Journal("Long 'n Boring", "Q45.367");

c = b;
```



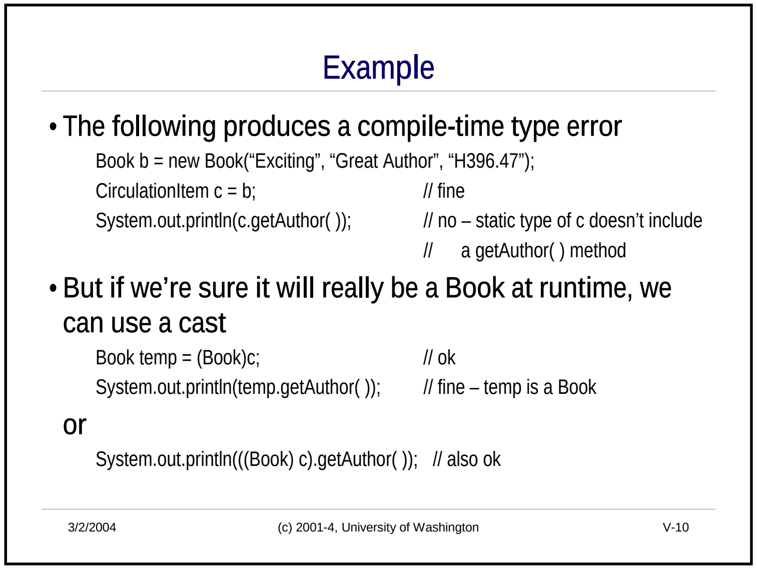
Static Types and Methods

- If we declare a variable

```
CirculationItem c = …
```

the only guarantee we have is that it refers to some sort of CirculationItem

  - Compiler doesn't attempt to trace values assigned to variables to decide type information
  - So the only methods we can call using the variable c are the ones available in its static type (CirculationItem)
  - Again, same issues when dealing with interfaces



Example

- The following produces a compile-time type error

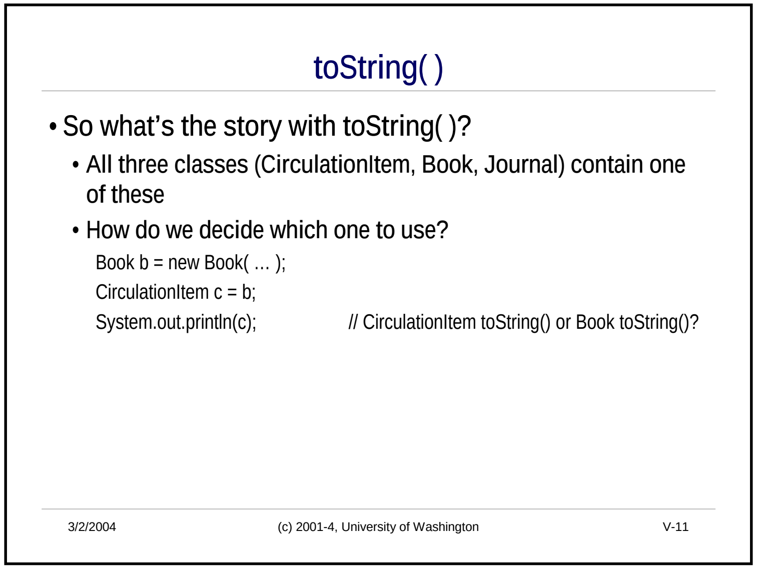
```
Book b = new Book("Exciting", "Great Author", "H396.47");
CirculationItem c = b;                  // fine
System.out.println(c.getAuthor( ));     // no – static type of c doesn't include
                                        //     a getAuthor( ) method
```

- But if we're sure it will really be a Book at runtime, we can use a cast

```
Book temp = (Book)c;                    // ok
System.out.println(temp.getAuthor( ));  // fine – temp is a Book
```

or

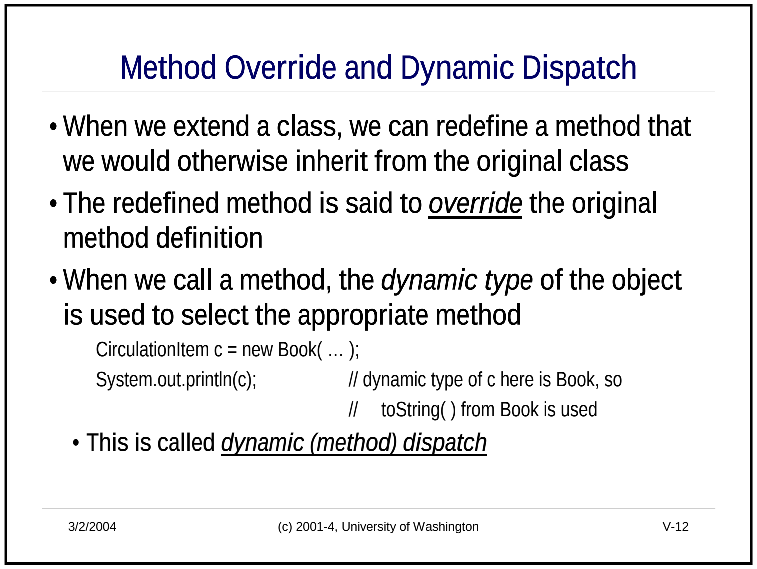
```
System.out.println(((Book) c).getAuthor( ));   // also ok
```



toString( )

- So what's the story with toString( )?
  - All three classes (CirculationItem, Book, Journal) contain one of these
  - How do we decide which one to use?

```
Book b = new Book( … );
CirculationItem c = b;
System.out.println(c);          // CirculationItem toString() or Book toString()?
```



Method Override and Dynamic Dispatch

- When we extend a class, we can redefine a method that we would otherwise inherit from the original class
- The redefined method is said to ***override*** the original method definition
- When we call a method, the *dynamic type* of the object is used to select the appropriate method

```
CirculationItem c = new Book( … );
System.out.println(c);          // dynamic type of c here is Book, so
                                //     toString( ) from Book is used
```

  - This is called ***dynamic (method) dispatch***

Dynamic Dispatch and Class Hierarchy Design

- Overriding and dynamic dispatch are powerful design tools
- Idea: when designing a class hierarchy, define in the original class methods which we want to be available for all objects in the hierarchy
- Use overriding to provide specialized implementations in extended classes
- Dynamic dispatch guarantees that the appropriate overriding methods will be called

Class Object

- The Java class structure has a root class: Object
- All Java classes implicitly extend Object if they don't explicitly extend some other class (which itself extends Object directly or indirectly)

```
class CirculationItem { … }
```

means exactly the same thing as

```
class CirculationItem extends Object { … }
```

- Classes like ArrayList have parameters and results of type Object, so will handle any non-primitive type

```
public void add(Object obj) { … }
public Object get(int position) { … }
```

What's in Class Object?

- Object contains methods (not many) that are suitable for all classes
- Class definitions can override these to provide more appropriate, specific versions
- Examples we've seen frequently
  - toString( )
  - equals( )

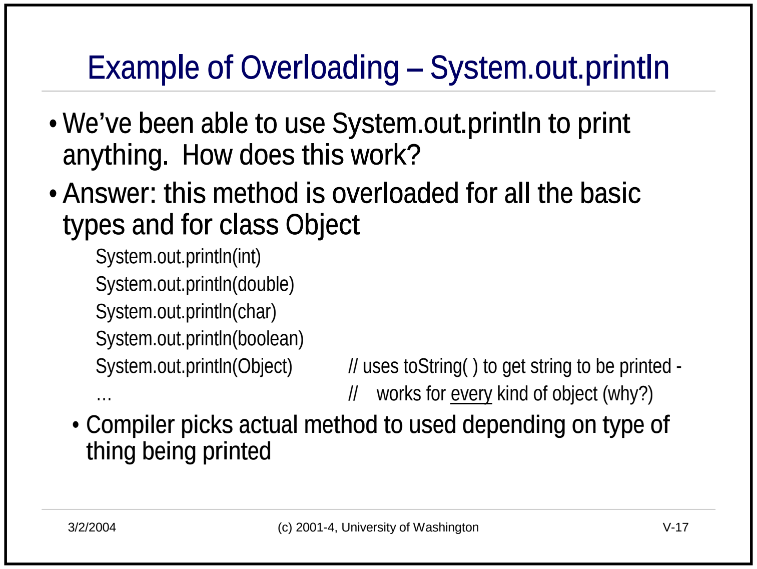
Overloading

- In a class, it is possible to define more than one method with the same name

```
class Thing {
    /** do something interesting with a Rectangle */
    public void doIt(Rectangle r) { … }
    /** do something interesting with an int */
    public void doIt(int n) { … }
```

- This is called method ***overloading***
  - Not the same thing as method overriding

    (overriding is substituting a new method for one that would otherwise be inherited when we extend a class)
- Compiler picks right method to use by comparing call argument types with parameters of available methods

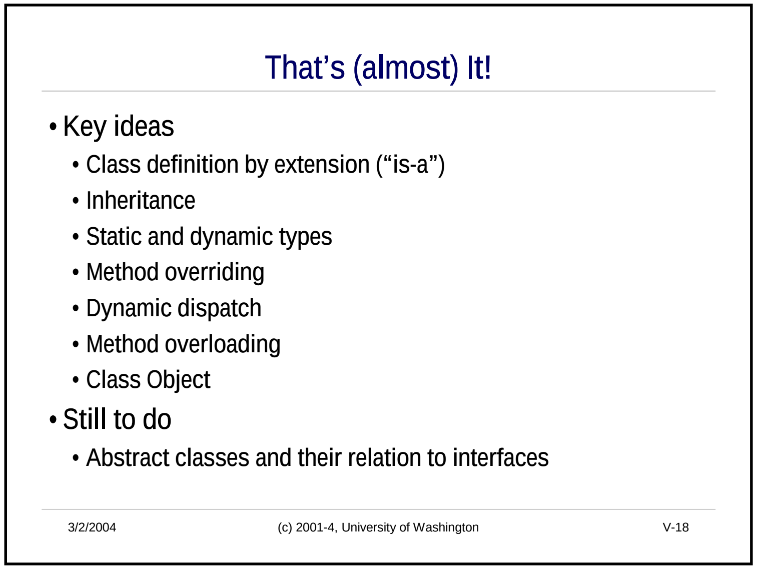


Example of Overloading – System.out.println

- We've been able to use System.out.println to print anything. How does this work?
- Answer: this method is overloaded for all the basic types and for class Object

```
System.out.println(int)
System.out.println(double)
System.out.println(char)
System.out.println(boolean)
System.out.println(Object)        // uses toString( ) to get string to be printed -
…                                 //    works for every kind of object (why?)
```

  - Compiler picks actual method to used depending on type of thing being printed



That's (almost) It!

- Key ideas
  - Class definition by extension ("is-a")
  - Inheritance
  - Static and dynamic types
  - Method overriding
  - Dynamic dispatch
  - Method overloading
  - Class Object
- Still to do
  - Abstract classes and their relation to interfaces