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## CSE 142

### Inheritance: Types, Classes, and Methods

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## 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

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## 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

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## 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

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## 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, .....

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## 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
```

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## Types and Interfaces

- The rule works exactly as with inheritance

```
class BankAccount implements Comparable { ... }
```

- Rule: every **BankAccount** object is also a **Comparable** object

- Can be used in any situation where either a **Comparable** or **BankAccount** is expected

```
BankAccount myAccount = new BankAccount("Bill Gates", 1000000000.00);
```

```
Comparable comp1;
```

```
comp1 = myAccount;
```

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## Dynamic and Static Types

- The **static type** of a variable is the type in its declaration

```
Book b = ...
```

```
Journal m = ...
```

```
CirculationItem c1 = ...
```

```
BankAccount b = ...
```

```
Comparable c2 = ...
```

- 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 it extends or implements

- Can change during execution

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## 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;
```

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## 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`)

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## 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
```

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## 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()?
```

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## 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*

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## 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

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## 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) { ... }
```

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## 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()`

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## 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

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## 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 use depending on type of thing being printed

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## 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
  - Interfaces

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