Inheritance, Polymorphism, and Interfaces

Chapter 8

*JAVA: An Introduction to Problem Solving & Programming, 6*th Ed. By Walter Savitch
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Objectives

- Describe polymorphism and inheritance in general
- Define interfaces to specify methods
- Describe dynamic binding
- Define and use derived classes in Java

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Inheritance Basics: Outline

- Derived Classes
- Overriding Method Definitions
- Overriding Versus Overloading
- Private Instance Variables and Private Methods of a Base Class
- UML Inheritance Diagrams

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Inheritance Basics

- Download from SavitchSrc link:
- ch08/
  - `InheritanceDemo.java`
  - `Person.java`
  - `Student.java`
  - `Undergraduate.java`
  - `UndergraduateDemo.java`

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Inheritance Basics

- Inheritance allows programmer to define a general class
- Later you define a more specific class
  - Adds new details to general definition
- New class inherits all properties of initial, general class
- View **`Person.java`**

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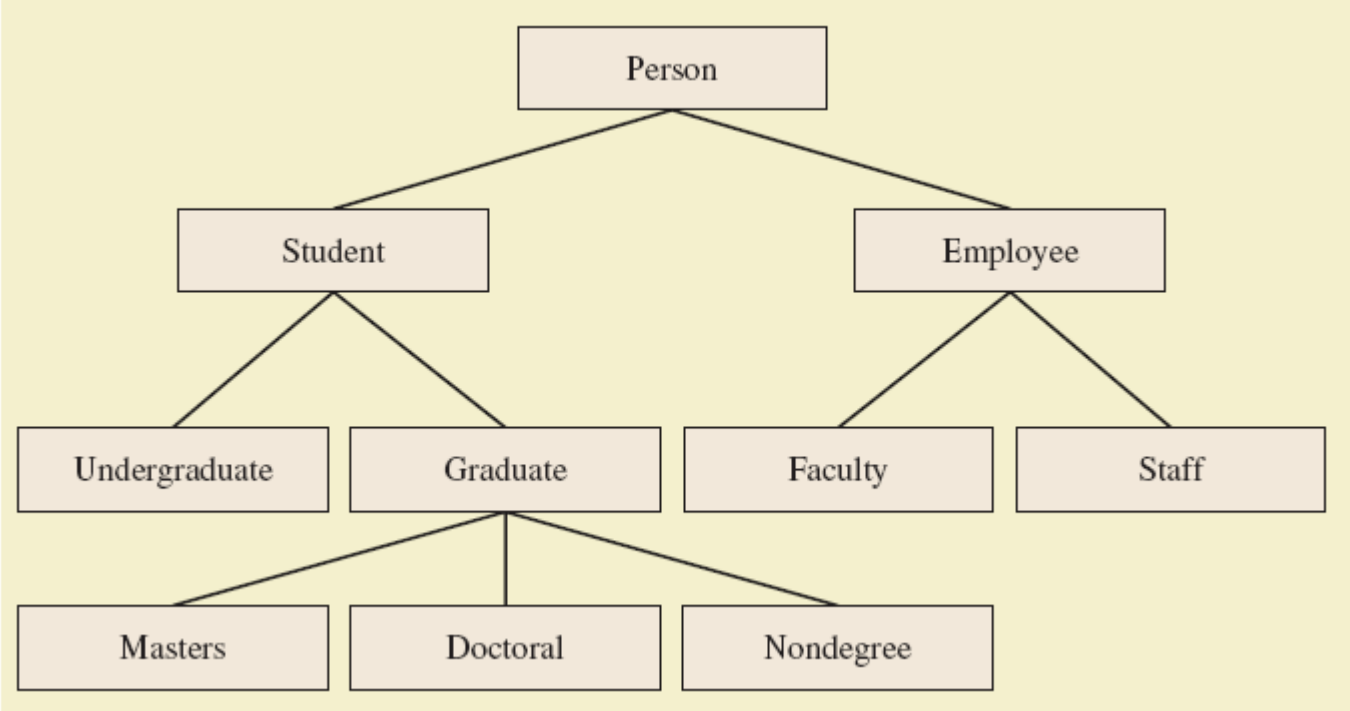
Derived Classes

- Figure 8.1 A class hierarchy



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Derived Classes

- Class **`Person`** used as a *base* class
  - Also called *superclass*
- Now we declare *derived* class **`Student`**
  - Also called *subclass* also childclass
  - Inherits methods from the superclass
- View **`Student.java`**

```
class Student extends Person
```

- View **`InheritanceDemo.java`**

Sample screen output

```
Name: Warren Peace
Student Number: 1234
```


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Overriding Method Definitions

- Note method **`writeOutput`** in class **`Student`**
  - Class Person also has method with that name
- Method in subclass with same signature overrides method from base class
  - Overriding method is the one used for objects of the derived class
- Overriding method must return same type of value

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Overriding Versus Overloading

- Do not confuse overriding with overloading
  - Overriding takes place in subclass – new method with **same signature**
- Overloading
  - New method in same class with different signature

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Private Instance Variables, Methods

- Consider private instance variable in a base class
  - It is not inherited in subclass
  - It can be manipulated only by public accessor, modifier methods
- Similarly, private methods in a superclass not inherited by subclass

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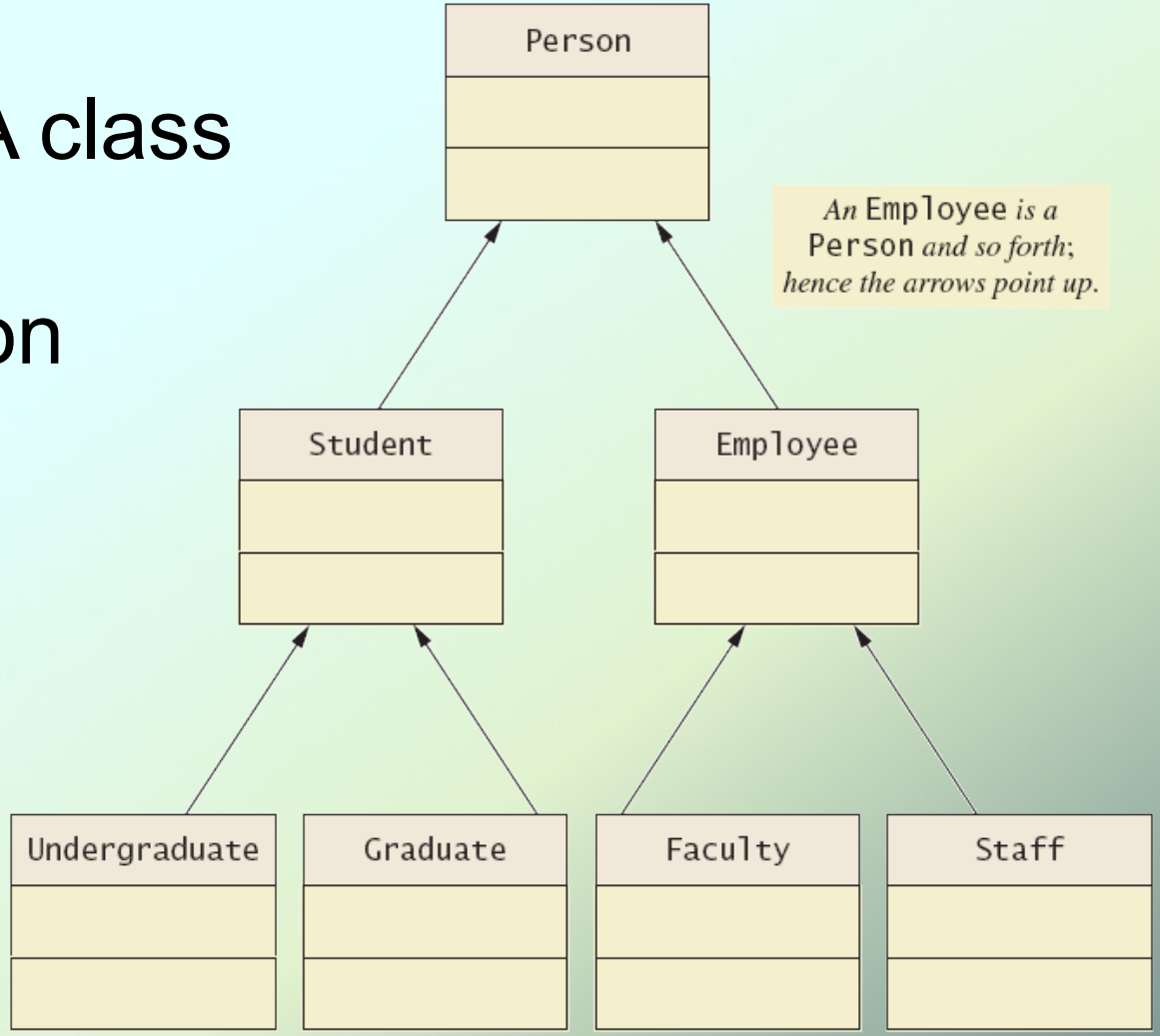
UML Inheritance Diagrams

- Figure 8.2 A class hierarchy in UML notation



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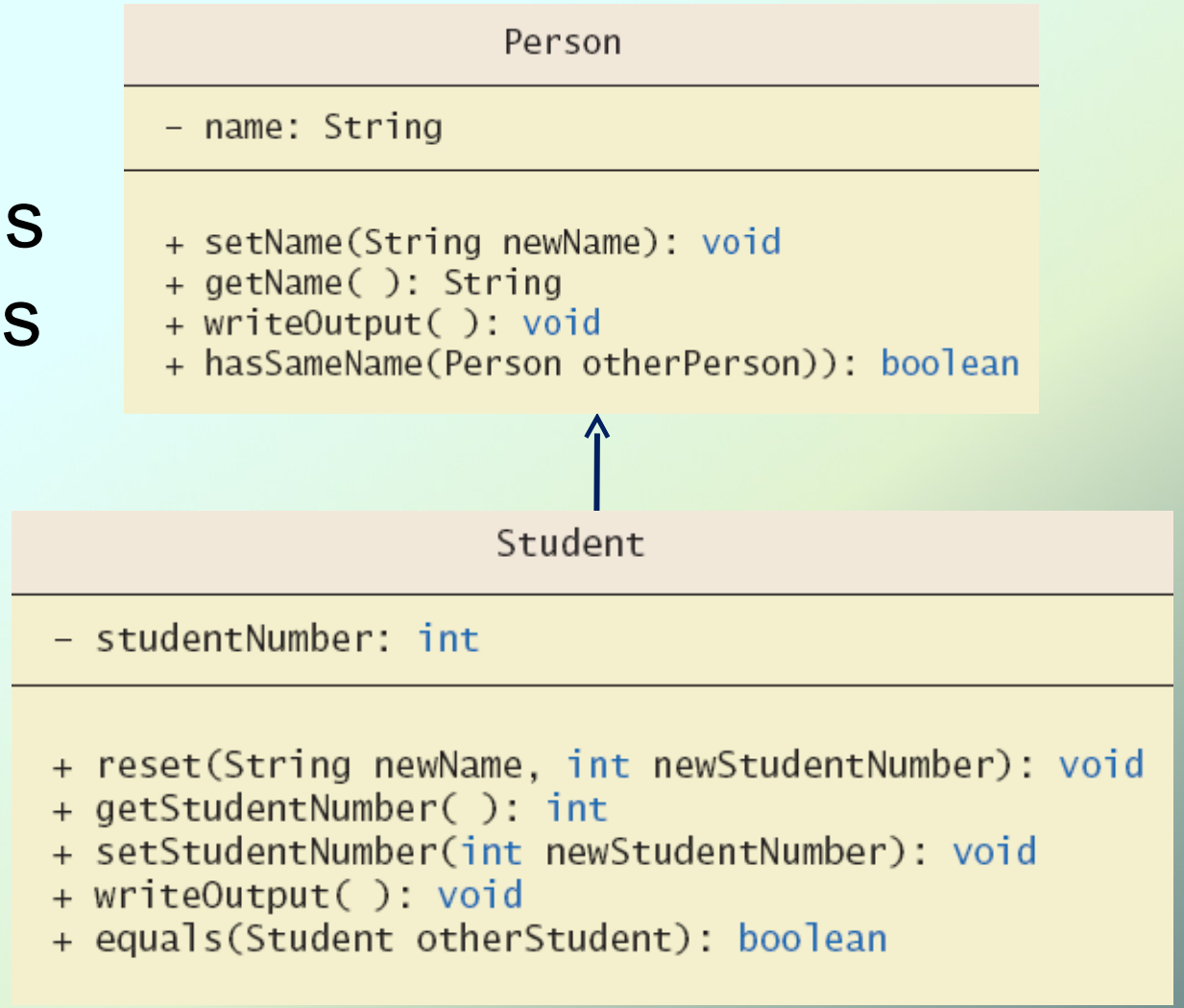
UML Inheritance Diagrams

- Figure 8.3 Some details of UML class hierarchy from figure 8.2



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Programming with Inheritance: Outline

- Constructors in Derived Classes
- The `this` Method – Again
- Calling an Overridden Method
- Derived Class of a Derived Class
- Type Compatibility
- The class `Object`
- A Better `equals` Method
- Abstract Classes
- Dynamic Binding and Inheritance

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Constructors in Derived Classes

- A derived class does not inherit constructors from base class
  - Constructor in a subclass must invoke constructor from base class
- Use the reserve word **`super`**

```
public Student(String initialName, int initialStudentNumber)
{
    super(initialName);
    studentNumber = initialStudentNumber;
}
```

  - Must be first action in the constructor

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The `this` Method – Again

- Also possible to use the **`this`** keyword
  - Use to call any constructor in the class

```
public Person()
{
    this("No name yet");
}
```

- When used in a constructor, **`this`** calls constructor in same class
  - Contrast use of **`super`** which invokes constructor of base class

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Calling an Overridden Method

- Reserved word **`super`** can also be used to call method in overridden method

```
public void writeOutput()
{
   super.writeOutput(); //Display the name
   System.out.println("Student Number: " + studentNumber);
}
```

- Calls method by same name in base class

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Programming Example

- A derived class of a derived class
- View **`Undergraduate.java`**
- Has all public members of both
  - **`Person`**
  - **`Student`**
- This reuses the code in superclasses

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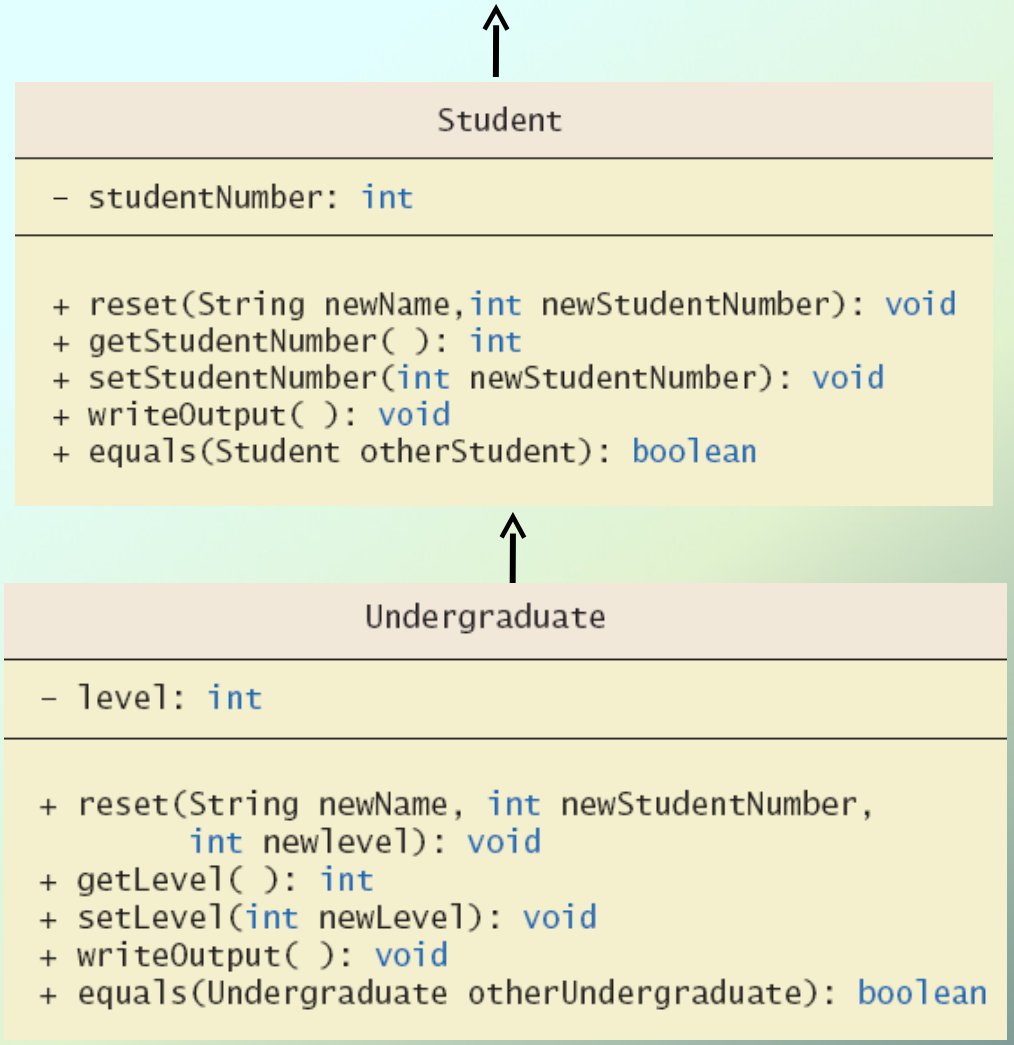
Programming Example

- Figure 8.4 More details of the UML class hierarchy



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Type Compatibility

- In the class hierarchy
  - Each **`Undergraduate`** is also a **`Student`**
  - Each **`Student`** is also a **`Person`**
- An object of a derived class can serve as an object of the base class
  - Note this is not typecasting
- An object of a class can be referenced by a variable of an ancestor type

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Type Compatibility

- Be aware of the "is-a" relationship
  - A **`Student`** *is a* **`Person`**
- Another relationship is the "has-a"
  - A class can contain (as an instance variable) an object of another type
  - If we specify a date of birth variable for **`Person`** – it "has-a" **`Date`** object

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Type Compatibility

- An object can have more than one type
- In an assignment statement where **`left`** and **`right`** are object references:

```
left = right;  // ok if right "is-a" left
```

- Example:

```
Student s = new Student();
Person p = new Person();
p = s;  // ok – a Student "is-a" Person
s = p;  // illegal – a Person is not a Student
```


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The Class `Object`

- Java has a class that is the ultimate ancestor of every class ("Eve class")
  - The class `Object`
- Thus possible to write a method with parameter of type `Object`
  - Actual parameter in the call can be object of any type
- Example: method

```
println(Object theObject)
```


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The Class `Object`

- Class `Object` has some methods that every Java class inherits
- Examples
  - Method `equals`
  - Method `toString`
- Method `toString` called when `println(theObject)` invoked
  - Best to define your own `toString` to handle this

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A Better `equals` Method

- Download examples:
  `Parent.java Child.java`
- Programmer of a class should override method `equals` from `Object`
- Use `equals` method in `Student.java` as a model for writing your own.
- View `equals` method in `Student.java`:
  `public boolean equals(Object theObject)`

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Polymorphism: Outline

- Class interfaces
- Java interfaces
- Implementing an interface
- An interface as a type

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Polymorphism

- Inheritance allows you to define a base class and derive classes from the base class
- Polymorphism allows you to make changes in the method definition for the derived classes and have those changes apply to methods written in the base class

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An Inheritance as a Type

- A method can substitute one object for another
  - Called *polymorphism*
- This is made possible by mechanism
  - *Dynamic binding*
  - Also known as *late binding*

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Dynamic Binding and Inheritance

- When an overridden method invoked
  - Action matches method defined in class used to create object using **`new`**
  - Not determined by type of variable naming the object
- Variable of any ancestor class can reference object of descendant class
  - Object always remembers which method actions to use for each method name

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Polymorphism

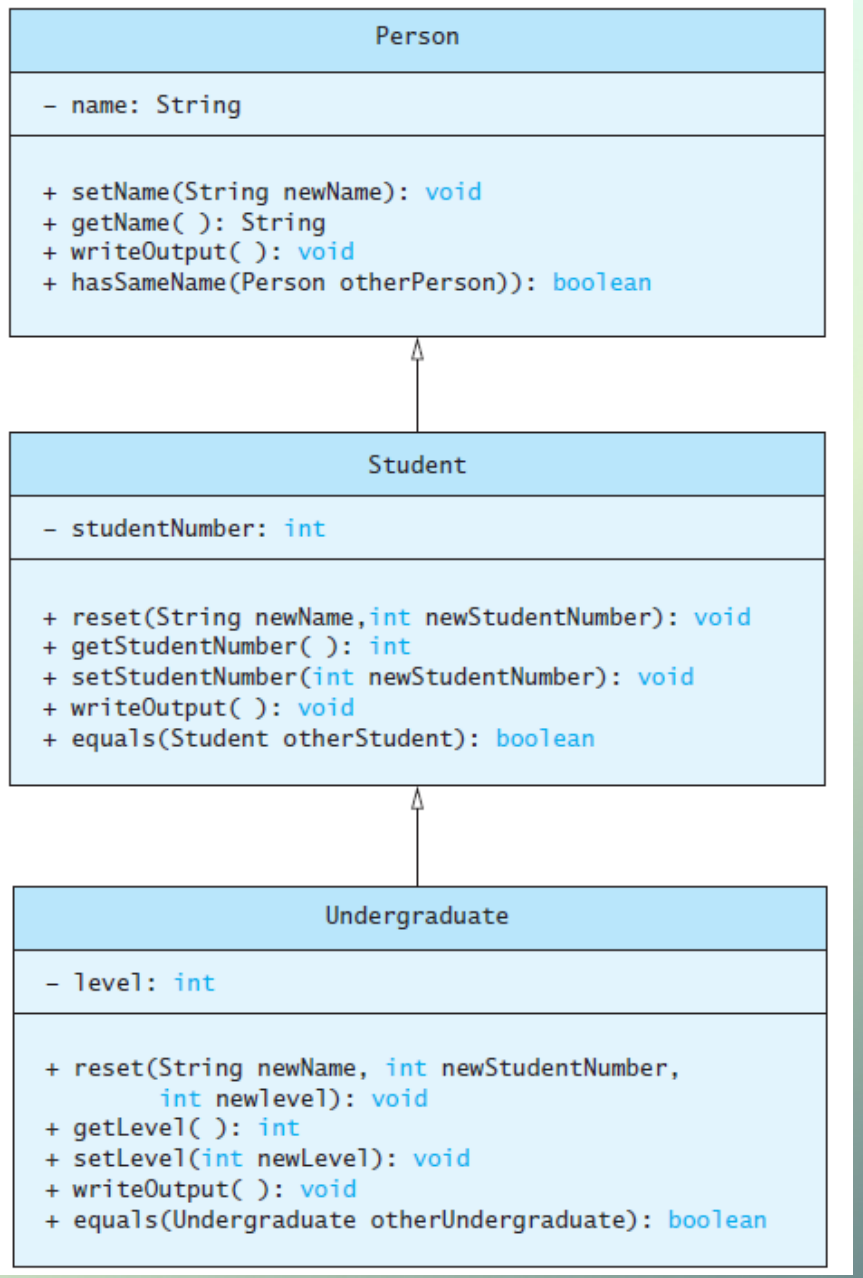
- Consider an array of **Person**

```
Person[] people = new
   Person[4];
```

- Since **Student** and **Undergraduate** are types of **Person**, we can assign them to **Person** variables

```
people[0] = new
   Student("DeBanque, Robin",
   8812);

people[1] = new
   Undergraduate("Cotty, Manny",
   8812, 1);
```



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Polymorphism

- Given:

```
Person[] people = new Person[4];
people[0] = new Student("DeBanque, Robin",
   8812);
```

- When invoking `people[0].writeOutput();`
- Which `writeOutput()` is invoked, the one defined for `Student` or the one defined for `Person`?
- Answer: The one defined for **`Student`**

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Polymorphism Example

- Download **`PolymorphismDemo.java`**
- Output:

```
Name: Cotty, Manny
Student Number: 4910
Student Level: 1

Name: Kick, Anita
Student Number: 9931
Student Level: 2

Name: DeBanque, Robin
Student Number: 8812

Name: Bugg, June
Student Number: 9901
Student Level: 4
```


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Class Interfaces

- Consider a set of behaviors for pets
  - Be named
  - Eat
  - Respond to a command
- We could specify method headings for these behaviors
- These method headings can form a class interface

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Class Interfaces

- Now consider different classes that implement this interface
  - They will each have the same behaviors
  - Nature of the behaviors will be different
- Each of the classes implements the behaviors/methods differently

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Java Interfaces

- A program component that contains headings for a number of public methods
  - Will include comments that describe the methods
- Interface can also define public named constants
- Download all source files from the SavitchSrc link: ch08/polymorphism
- View **`Measurable.java`**

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Java Interfaces

- Interface name begins with uppercase letter
- Stored in a file with suffix `.java`
- Interface does not include
  - Declarations of constructors
  - Instance variables
  - Method bodies

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Implementing an Interface

- To implement an interface, a class must
  - Include the phrase

    `implements` *`Interface_name`*
  - Define each specified method
- View **`Rectangle.java`**:

  `class Rectangle implements Measurable`
- View another class, **`Circle.java`**, which also implements **`Measurable`**

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An Inheritance as a Type

- Possible to write a method that has a parameter as an interface type
  - An interface is a reference type
- Program invokes the method passing it an object of any class which implements that interface
- See **`Driver.java`**, **`Driver2.java`**, **`Driver3.java`**
  - **`box`** has 2 types: **`Rectangle`** and **`Measurable`**
  - **`disc`** has 2 types: **`Circle`** and **`Measurable`**

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Abstract Classes

- Classes can be designed to be a base class for other classes
  - Some methods must be redefined for each subclass
  - These methods should be declared *abstract* – a method that has no body
- This makes the class abstract
- You cannot create an object of an abstract class – thus its role as base class

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Abstract Classes

- Not all methods of an abstract class are abstract methods
- Abstract class makes it easier to define a base class
  - Specifies the obligation of designer to override the abstract methods for each subclass

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Abstract Classes

- Cannot have an instance of an abstract class
  - But OK to have a parameter of that type
- Think of an abstract class as something between an **interface** (no methods implemented) and a **complete class definition** (all methods implemented)

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Dynamic Binding – Quiz

- Download **`Examples/PeopleDemo.java`**
- What gets printed when calling
  - **`einTest(peter);`**
  - **`einTest(hans);`**
  - **`einTest(maria);`**

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Dynamic Binding – Quiz

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Dynamic Binding – Quiz

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  - **`einTest(hans);`**

    → Object "Person's name: Hans" is a Person :: class Person
  - **`einTest(maria);`**

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Dynamic Binding – Quiz

- Download **`Examples/PeopleDemo.java`**
- What gets printed when calling
  - **`einTest(peter);`**

    → Object "Student's name: Peter" is a Student :: class Student
  - **`einTest(hans);`**

    → Object "Person's name: Hans" is a Person :: class Person
  - **`einTest(maria);`**

    → Object "Student's name: Maria" is a Person :: class Student

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Summary

- Derived class obtained from base class by adding instance variables and methods
  - Derived class inherits all public elements of base class
- Constructor of derived class must first call a constructor of base class
  - If not explicitly called, Java automatically calls default constructor

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Summary

- Within constructor
  - **`this`** calls constructor of same class
  - **`super`** invokes constructor of base class
- Method from base class can be overridden
  - Must have same signature
- If signature is different, method is overloaded

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Summary

- Overridden method can be called with preface of **`super`**
- Private elements of base class cannot be accessed directly by name in derived class
- Object of derived class has type of both base and derived classes
- Legal to assign object of derived class to variable of any ancestor type
- Every class is descendant of class **`Object`**

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Summary

- An interface contains
  - Headings of public methods
  - Definitions of named constants
  - No constructors, no private instance variables
- Class which implements an interface must
  - Define a body for every interface method specified
- Interface enables designer to specify methods for another programmer

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Summary

- Interface is a reference type
  - Can be used as variable or parameter type
- Dynamic (late) binding enables objects of different classes to substitute for one another
  - Called polymorphism

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