Inheritance

Outlines

BASIC CONCEPTS

- Introduction
- Extend classes & instanceof
- Method overriding
- Keyword ‘super’
- Creation mechanism
- Access control
- Methods you cannot override

ADVANCED CONCEPTS

- Dynamic binding
  - Create a single method that has one or more parameters that might be one of several types
  - Create a single array of superclass object references but store multiple subclass instances in it.

Introduction

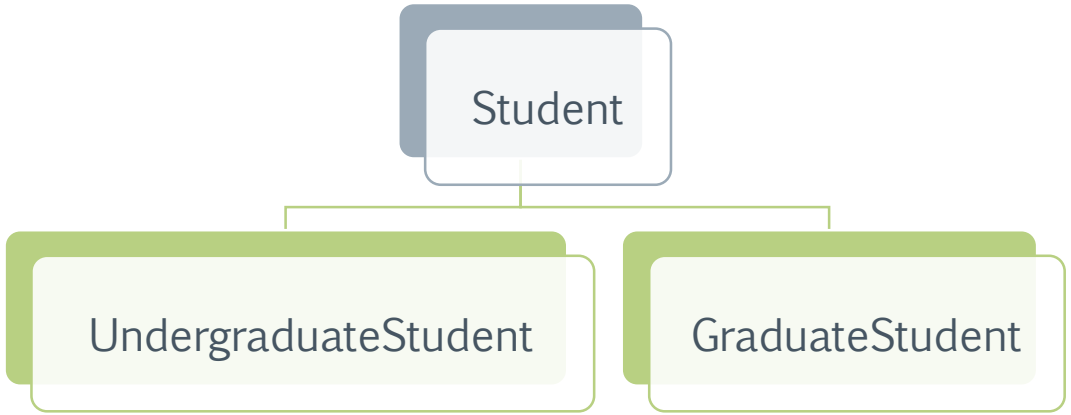
› Inheritance makes it possible to build new classes from existing classes thus facilitating the reuse of methods and data from one class in another.

› Inheritance allows data of one type to be treated as data of a more general type.

› Use inheritance to create derived class
  – Save time
  – Reduce errors
  – Reduce amount of new learning required to use new class

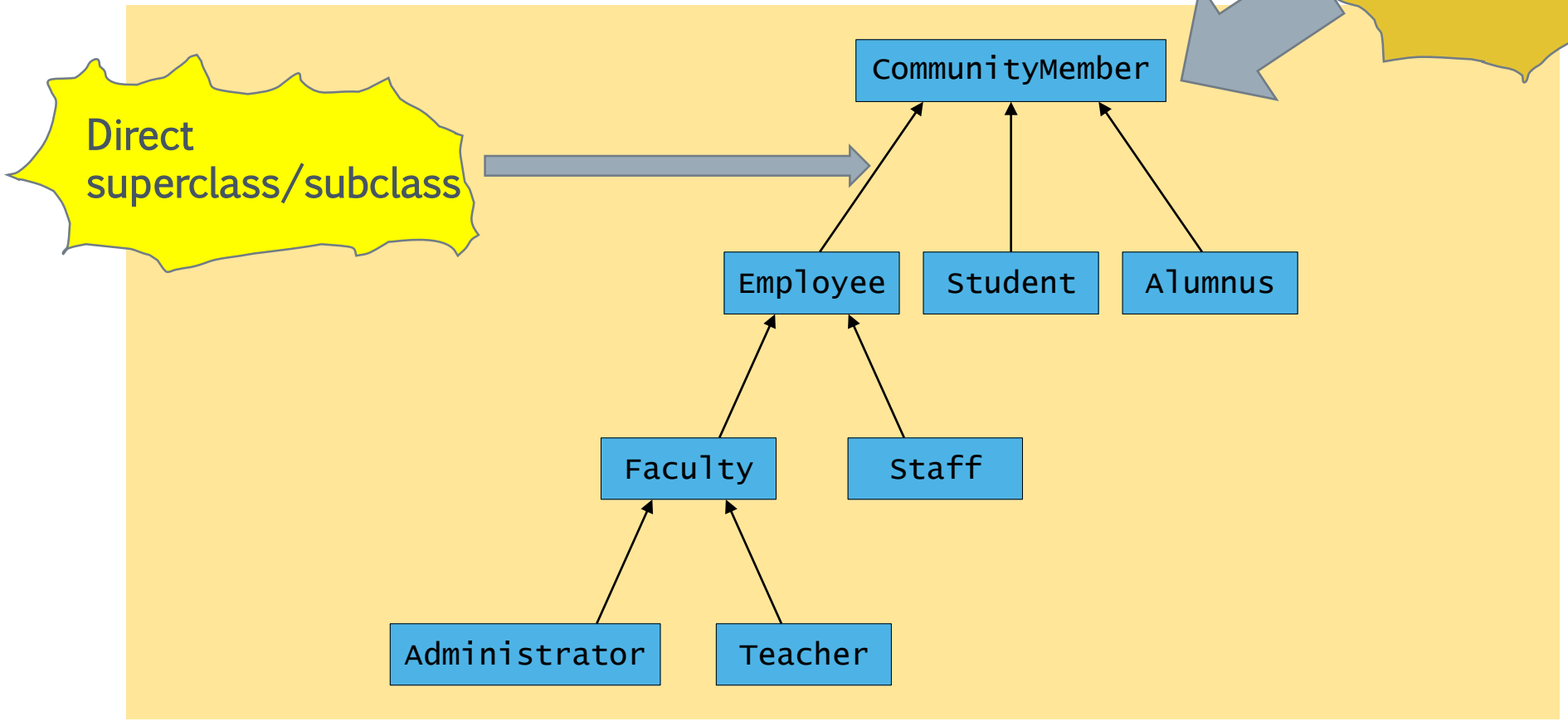
Introduction (cont.)

- Base class
  - Used as a basis for inheritance
  - Also called:
    - Superclass
    - Parent class
  - For example:
    - Student



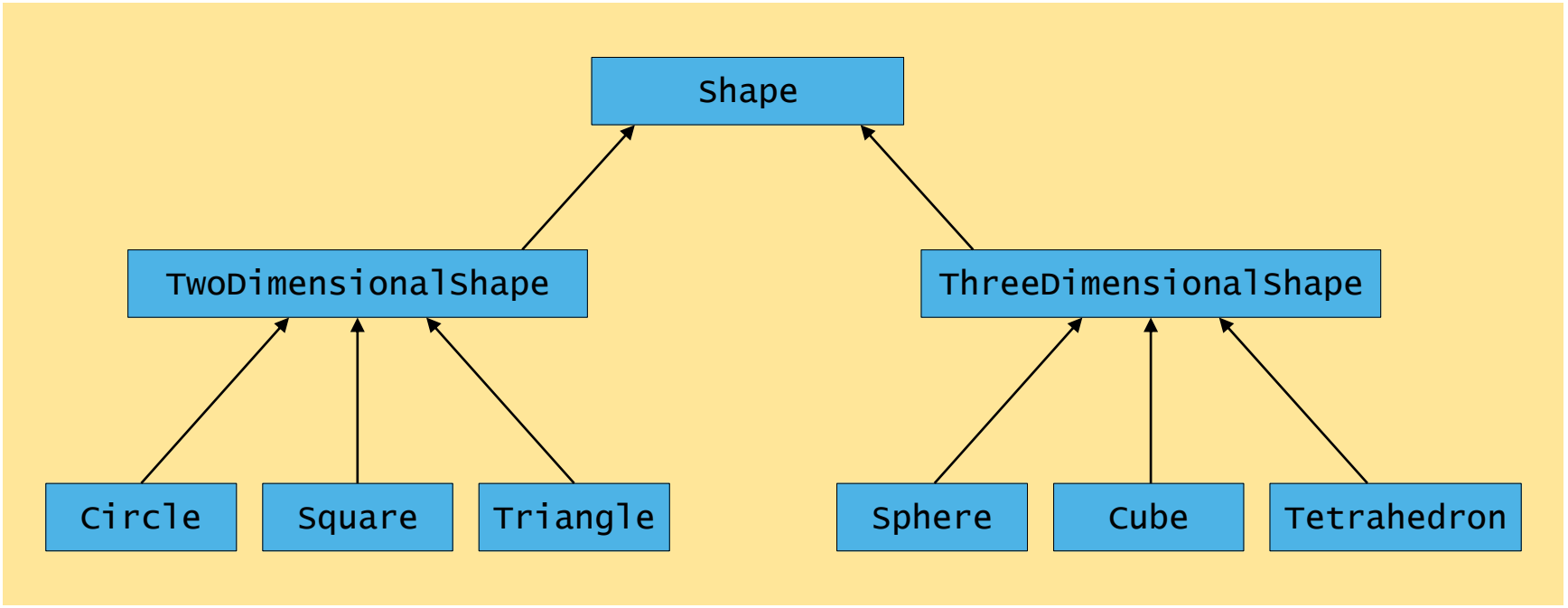
- Derived class
  - Inherits from a base class
  - Always "is a" case or example of more general base class
  - Also called:
    - Subclass
    - Child class
  - For example:
    - UndergraduateStudent
    - GraduateStudent

Introduction (cont.): More example



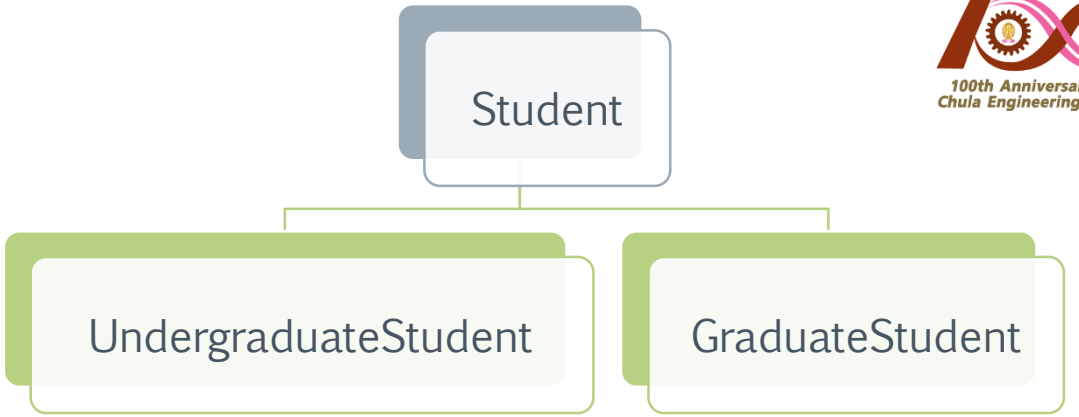
Inheritance hierarchy for university CommunityMembers.

Introduction (cont.): More example



Inheritance hierarchy for Shapes.

Extending classes



- Keyword `extends`
  - Achieve inheritance in Java
  - Can extends from only one superclass
  - Example:
    - public class UndergraduateStudent extends Student
    - public class GraduateStudent extends Student
- Inheritance one-way proposition
  - Child inherits from parent, not the other way round.

Student Case Study

Package "Student"

- What are subclasses inherited from superclass?
- Are there anything in subclasses that do not have in superclass?

Student

#name : string
#test[] : int
#courseGrade : string

+Student()
+Student(in studentName : string)
+setName(in name : string)
+getName() : string
+setCourseGrade(in courseGrade : string)
+getCourseGrade() : string
+setTestScore(in testNumber : int, in testScore : int)
+getTestScore(in testNumber : int)
+printName()

UndergraduateStudent

+UndergraduateStudent(in studentName : string)
+computeCourseGrade()
+printName()

GraduateStudent

#advisorName : string

+GraduateStudent(in studentName : string)
+GraduateStuden(in studentName : string, in advisorName : string)
+setAdvisorName(in advisorName : string)
+getAdvisorName() : string
+computeCourseGrade()
+printName()

Generalization Concept

- Subclasses can be considered as superclass since they inherit everything from superclass.
- But, superclass cannot be considered as subclasses.
- Undergraduate & graduate students are student!

Type	computeCourseGrade
Undergrad.	Pass if (test1+test2+test3)/3 >= 70
Grad.	Pass if (test1+test2+test3)/3 >= 80

```
public class Student {

        protected final static int NUM_OF_TESTS = 3;

        protected String name;
        protected int[]  test;
        protected String courseGrade;

...
```

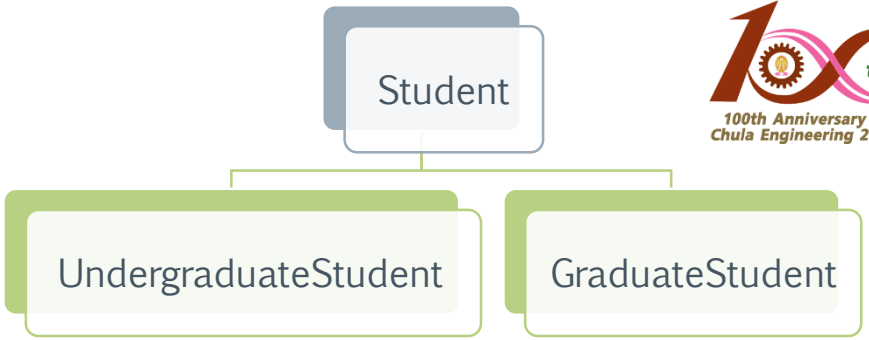
Additional variable

```
public class UndergraduateStudent extends Student {
        public UndergraduateStudent(String studentName) {
                super(studentName);
        }

        public void computeCourseGrade() {
            //calculation 1
        }
...
```

Additional Method

```
public class GraduateStudent extends Student {
        String advisorName;

        public void computeCourseGrade() {
                //calculation 2
        }
...
```

Save time & Reduce errors



- Is there anything wrong in the following code?
  - Is it possible to have "ArrayIndexOutOfBound"?
  - If yes, should this issue also happen in Student's subclasses?
  - How many method should we fix the issue?

Student.java (with ArrayIndexOutOfBound)

```
public int getTestScore(int testNumber) {
   return test[testNumber - 1];
}
```

Student.java (no error)

```
public int getTestScore(int testNumber) {
   return (testNumber <= NUM_OF_TESTS) ? test[testNumber - 1] : test[0];
}
```

Overriding Superclass Methods

- Create subclass by extending existing class
  - Subclass contains data and methods defined in original superclass
  - Sometimes superclass data fields and methods not entirely appropriate for subclass objects
- Polymorphism (in general)
  - Using same method name to indicate different implementations
- Polymorphism for superclass/subclasses
  - Override method in parent class
    - Create method in child class that has same name and argument list as method in parent class
  - Subtype polymorphism
    - Ability of one method name to work appropriately for different subclass objects of same parent class

Override method in parent class

```
class Student{
...
        public void printName() {
                System.out.println("Student [" + name + "]");
        }
...
```

Same signature!!!

```
class GraduateStudent extends Student {
...
        public void printName() {
                System.out.println("GraduateStudent [" + name + "]");
        }
...
```

Override method in parent class(cont.)

StudentTest1.java

```
public class StudentTest1 {
  public static void main(String[] args) {
    Student s1 = new UndergraduateStudent("Toey");
    Student s2 = new GraduateStudent("Nat");
    Student s3 = new Student("Jump");

    s1.printName();
    s2.printName();
    s3.printName();
  }
}
```

Result

```
UndergraduateStudent [Toey]
GraduateStudent [Nat]
Student [Jump]
```

Subtype polymorphism

instanceof

StudentTest2.java

```
public class StudentTest2 {
   public static void main(String[] args) {
      Student s1 = new UndergraduateStudent("Toey");
      Student s2 = new GraduateStudent("Nat");
      checkStatus(s1);
      checkStatus(s2);
   }
   public static void checkStatus(Student s) {
      if (s instanceof UndergraduateStudent) {
         System.out.println("You are undergraduate student.");
      } else if (s instanceof GraduateStudent) {
         System.out.println("You are graduate student.");
      }
   }
}
```

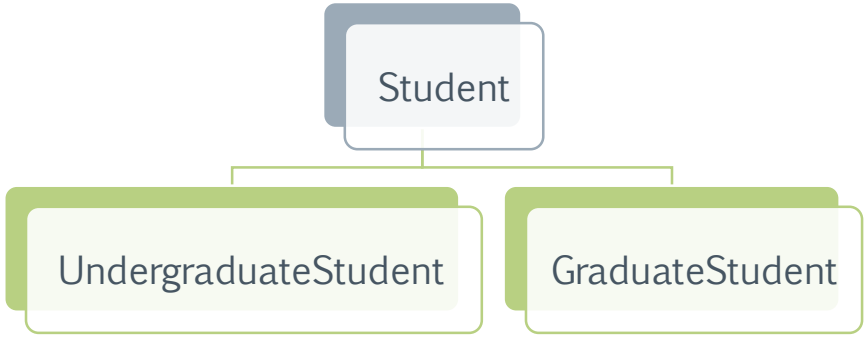
Result

```
You are undergraduate student.
You are graduate student.
```

Up/down casting

StudentTest3.java

```
public class StudentTest3 {

   public static void main(String[] args) {

      // upcasting (automatically)

      Student s1 = new GraduateStudent("Nat");

      s1.printName();


      // downcasting (manually) – may have problem

      Student s = new Student("Luck");

      UndergraduateStudent s2 = (UndergraduateStudent) s;

   }

}
```



Result

```
GraduateStudent [Nat]

Exception in thread "main" java.lang.ClassCastException: Student.Student cannot
be cast to Student.UndergraduateStudent

at Student.StudentTest3.main(StudentTest3.java:12)
```

Keyword 'super'

- The super is a reference variable that is used to refer to parent class object.
- Whenever you create the instance of subclass, an instance of parent class is created implicitly, i.e. referred by super reference variable.
- Usage of keyword 'super'
  - super is used to refer to parent class instance variable.
  - super() is used to invoke parent class constructor.
  - super is used to invoke parent class method.


Bike1.java


Bike2.java


Student1.java


Student2.java

Package 'Super'

'super' examples

```
class Vehicle1 {
        int speed = 50;
}

class Bike1 extends Vehicle1 {
        int speed = 100;

        void display() {
                System.out.println(super.speed);
        }
...
```

```
class Vehicle2 {
        Vehicle2() {
                System.out.println("Vehicle is created");
        }
}

public class Bike2 extends Vehicle2 {
        Bike2() {
                super();//  parent class constructor
                System.out.println("Bike is created");
        }
...
```

'super' examples (cont).

```
class Person1 {
        void message() {
                System.out.println("welcome");
        }
}

public class Student1 extends Person1 {
        void message() {
                System.out.println("welcome to java");
        }

        void display() {
                message();//  will invoke current class message() method
                super.message();//  will invoke parent class message() method
        }
...
```

If this method does not exist, a call to message() simply calls message() of the superclass!

Instance Creation Mechanism

Result

```
class A
class B, value=5
class C, value=5
```

ClassCreation.java

```
public class ClassCreation {
   public static void main(String[] args){
      C c1 = new C(5);
   }
}

class A {
   A() {
      System.out.println("class A");
   }
}
```

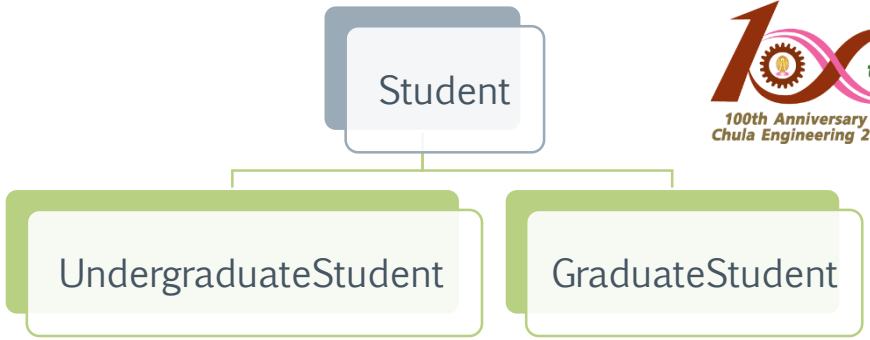
```
class B extends A {
   B(int val) {
      // super();
      System.out.println("class B, value=" + val);
   }
}
class C extends B {
   C(int val) {
      super(val);
      System.out.println("class C, value="+ val);
    }
}
```

Instance Creation Mechanism (cont.)

- When superclass contains default constructor
  - Execution of superclass constructor transparent
  - For example, C → B → A

- Using superclass constructors that require arguments
  - When superclass has default constructor
    - Can create subclass with or without own constructor (automatically)
  - When there is no default constructor in superclass
    - Must include at least one constructor for each subclass you create
    - First statement within each constructor must call superclass constructor

Hiding Information



- Keyword `protected`
  - Provides intermediate level of security between `public` and `private` access
  - Can be used within own class or in any classes extended from that class
  - Cannot be used by "outside" classes
  - In UML, the symbol is "#".

Access Level	Accessing Class		
	current class	subclass	other
public	☑	☑	☑
protected	☑	☑	☒
default	☑	☒	☒
private	☑	☒	☒

Methods You Cannot Override

- `static` methods
- `final` methods
- Methods within `final` classes
  - They cannot be superclasses (be extended).

A Subclass Cannot Override `static` Methods in Its Superclass

- Subclass cannot override methods declared `static` in superclass
- Can hide `static` method in superclass
  - By declaring `static` method with same signature as `static` method in superclass
  - Call new `static` method from within subclass or in another class by using subclass object
  - Within `static` method of subclass
    - Cannot access parent method using `super` object
- Although child class cannot inherit parent's static methods
  - Can access parent's static methods in the same way any other class can -> SuperclassName.method()

Experiment!!

- What happen if the method "Student.printName()" is static?
- For the method "GraduateStudent.computeCourseGrade()", if it is static, can we use "super"?

Static method in super class : example

```
class A{
   static void m1(){

   }
}

class B extends A{
   static void m1(){

   }
}
```

Cannot use super in here!

```
class C{
   public static void main(String[]  a){
         B b = new B();
         b.m1();

         A c = new B();
         c.m1();
   }
}
```

It calls class A.

!

A Subclass Cannot Override `final` Methods in Its Superclass

- Subclass cannot override methods declared `final` in superclass
- `final` modifier
  - Does not allow method to be overridden
- Advantage to making method `final`
  - Compiler knows there is only one version of method
  - Compiler knows which method version will be used
  - Can optimize program's performance
    - By removing calls to final methods
    - Replacing them with expanded code of their definitions
    - At each method call location
    - Called inlining

- What happen if the method "Student.printName()" is final?

Using Dynamic Method Binding

- Static binding (Early binding) vs. Dynamic binding (Late binding)
  - In static binding, the method or variable version that is going to be called is resolved at compile time,
  - While in dynamic binding the compiler cannot resolve which version of a method or variable is going to bind.
- Every subclass object "is a" superclass member
  - Convert subclass objects to superclass objects
  - Can create reference to superclass object
    - Create variable name to hold memory address
    - Store concrete subclass object
    - Example:

```
Animal ref;
ref = new Cow();
```

- Dynamic method binding
  - Application's ability to select correct subclass method
  - Makes programs flexible
- When application executes
  - Correct method attached to application based on current one

Using Dynamic Method Binding (cont.)

StudentTest4.java

```
public class StudentTest4 {
   public static void main(String[] args) {
      Student s;
      GraduateStudent g = new GraduateStudent("Nat");
      UndergraduateStudent u = new UndergraduateStudent("Toey");
      // This is called Dynamic binding, as the compiler will never know
      // which version of printName() is going to called at runtime.
      s = g;
      s.printName();
      s = u;
      s.printName();
   }
}
```

Result

```
GraduateStudent [Nat]
UndergraduateStudent [Toey]
```

Using a Superclass as a Method Parameter Type (method argument)


```
public class TalkingAnimalDemo
{
   public static void main(String[] args)
   {
      Dog dog = new Dog();
      Cow cow = new Cow();
      dog.setName("Ginger");
      cow.setName("Molly");
      talkingAnimal(dog);
      talkingAnimal(cow);
   }
   public static void talkingAnimal(Animal animal)
   {
      System.out.println("Come one. Come all.");
      System.out.println
         ("See the amazing talking animal!");
      System.out.println(animal.getName() +
         " says");
      animal.speak();
      System.out.println("***************");
   }
}
```

Creating Arrays of Subclass Objects 2

- Create superclass reference
  - Treat subclass objects as superclass objects
    - Create array of different objects
    - Share same ancestry
- Creates array of three `Animal` references

```
Animal[] ref = new Animal[3];
```

  - Reserve memory for three `Animal` object references