Session 05
Interface and Inheritance

(https://docs.oracle.com/javase/tutorial/java/IandI/)

Objectives

- Benefits of OO implementation: Inheriatnce, Polymorphism
- Working with Interfaces.
- Working with Abstract Methods and Classes.
- Anonymous Classes
- Enum Type
- Practice walkthroughs

Implementing Object-Oriented Relationships

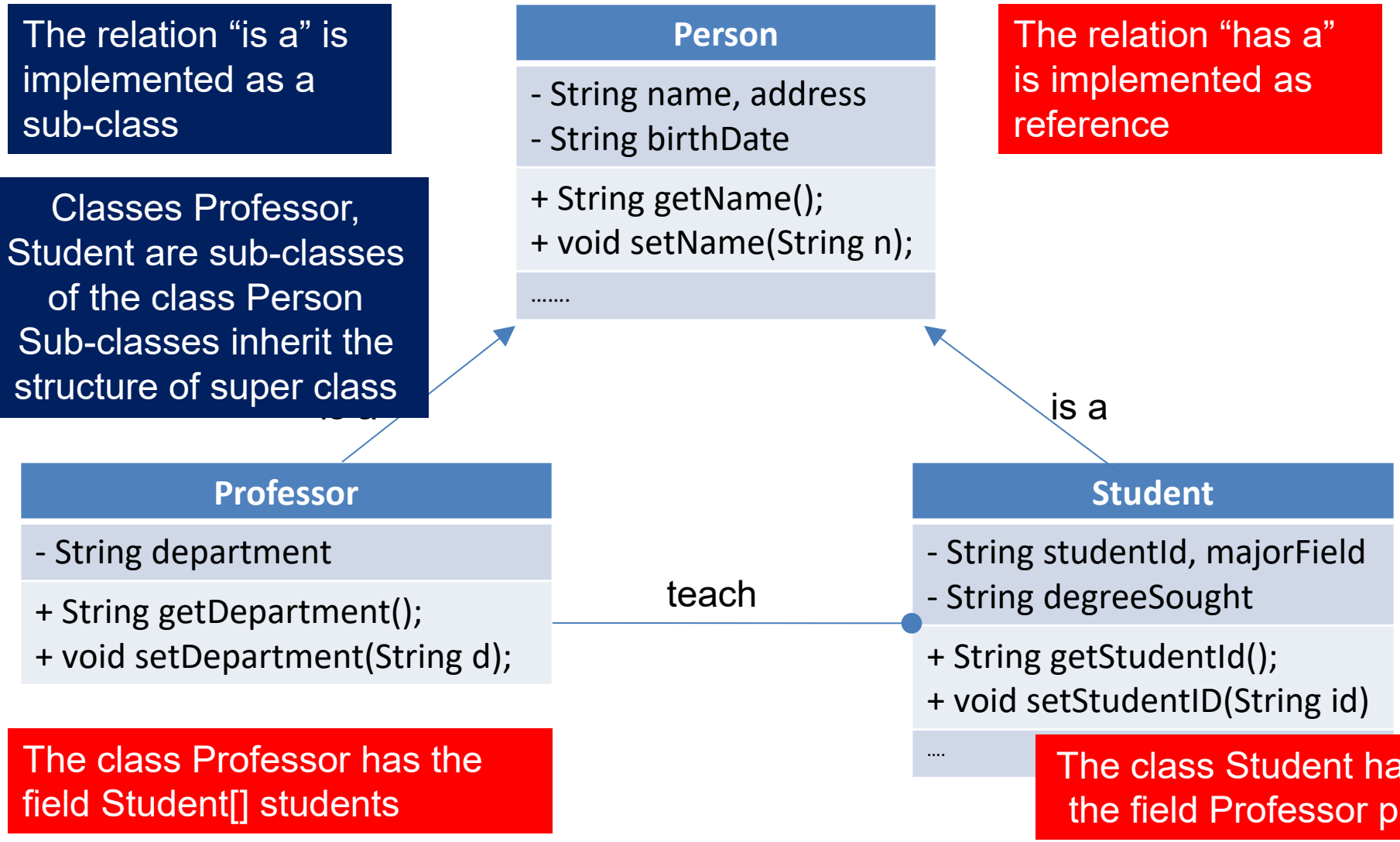
- 3 common relations in classes:
  - “is a/ a kind of”
  - “has a”
  - association
- Examples:
  - Student is a person
  - “A home is a house that has a family and a pet.”
  - An invoice contains some product and a products can be contained in one invoice

Implementing Object-Oriented Relationships…

The relation “is a” is implemented as a sub-class

Classes Professor, Student are sub-classes of the class Person Sub-classes inherit the structure of super class

The relation “has a” is implemented as reference



The class Professor has the field Student[] students

The class Student has the field Professor pr

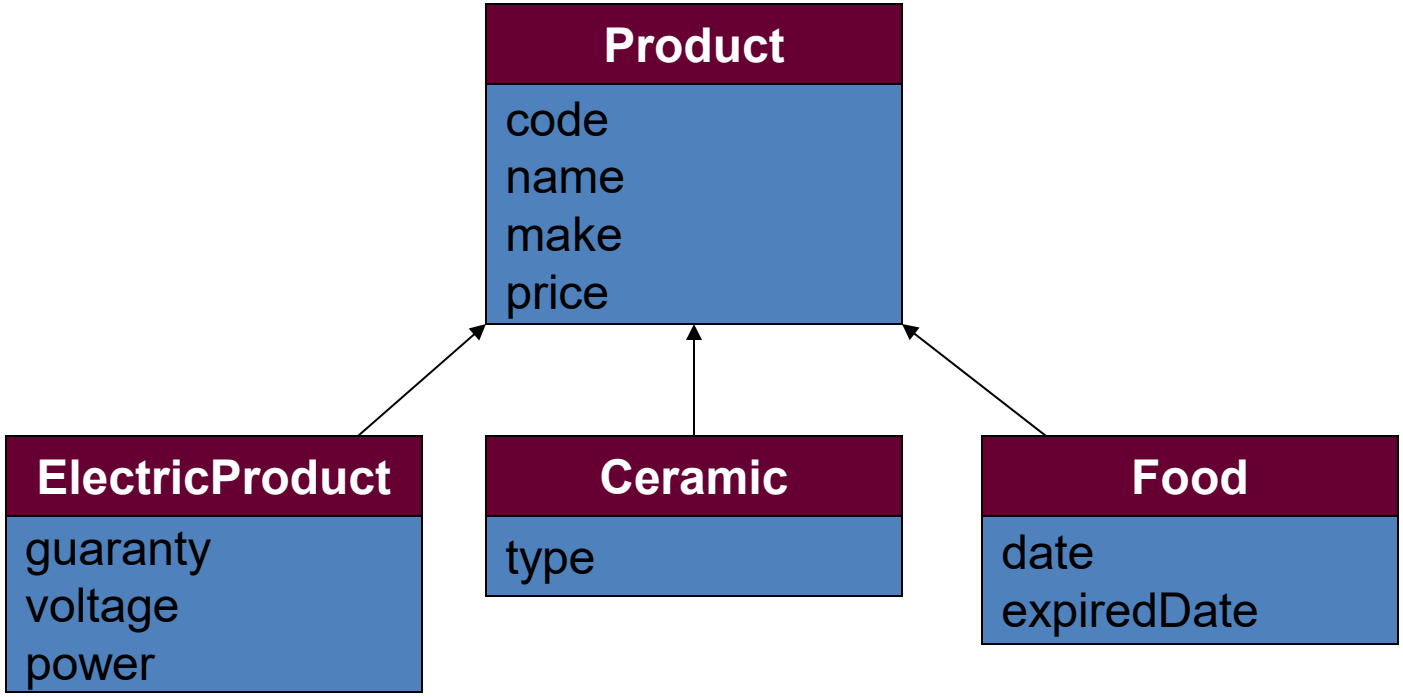
Inheritance

- There are some sub-classes from one super class ➔ An inheritance is a relationship where objects share a common structure: the structure of one object is a sub-structure of another object.
- The extends keyword is used to create sub-class.
- A class can be directly derived from only one class (Java is a single-inherited OOP language).
- If a class does not have any superclass, then it is implicitly derived from Object class.
- Unlike other members, constructor cannot be inherited (constructor of super class can not initialize sub-class objects)

Inheritance…

- **How to construct a class hierarchy? → Intersection**

- Electric Products< code, name, make, price, guaranty, voltage, power>
- Ceramic Products < code, name, make, price, type >
- Food Products < code, name, make, price , date, expiredDate >



Inheritance…: "super" Keyword

- Constructors Are **Not** Inherited
- super(...) for Constructor Reuse
  - super(arguments); *//invoke a superclass constructor*
  - The call ***must*** **be the** ***first*** **statement in the subclass constructor**
- Replacing the Default Parameterless Constructor

Inheritance…: "super" Keyword

- We use the Java keyword super as the qualifier for a method call:
  super. methodName(arguments);
- Whenever we wish to invoke the version of method methodName that was defined by our superclass.
- **super()** is used to access the superclass's constructor. And It must be the first statement in the constructor of the subclass.

Inheritance…

```
1   public class Rectangle {
2        private int length = 0;
3        private int width = 0;
4       // Overloading constructors
5       public Rectangle() // Default constructor
6       {    }
7       public Rectangle(int l, int w)
8       {  length = l>0? l: 0;    width= w>0? w: 0;
9       }
10      // Overriding the toString method of the java.lang.Object class
        public String toString()
12      {  return "[" + getLength() + "," + getWidth() + "]}";
13      }
14      // Getters, Setters
15       public int getLength() { return length;  }
16       public void setLength(int length) { this.length = length;  }
17       public int getWidth() {  return width;  }
18       public void setWidth(int width) { this.width = width;  }
19       public int area() {  return length*width;    }
20  }
```

Inheritance…

```
1  public class Box extends Rectangle {
2    private int height=0; // additional data
3    public Box()   {  super(); }
4    public Box (int l, int w, int h)
5    {  super(l, w); // Try swapping these statements
6       height = h>0? h: 0;
7    }
8    // Additional Getter, Setter
9    public int getHeight() { return height; }
10   public void setHeight(int height)
11         {  this.height = height; }
12   // Overriding methods
     public String toString()
14   { return "[" + getLength() + "," +
15         getWidth() + "," + getHeight() + "]";
16   }
     public int area(){
18       int l = this.getLength();
19       int w = this.getWidth();
20       int h = this.getHeight();
21       return 2*(l*w + w*h + h*l);
22   }
23   // additional method
24   public int volumn(){
25       return this.getLength()*this.getWidth()*height;
26   }
27 }
```

```
1  public class Demo_1 {
2    public static void main  (String[] args)
3    {  Rectangle r= new Rectangle(2,5);
4       System.out.println("Rectangle: " + r.toString());
5       System.out.println("   Area: " + r.area());
6       Box b= new Box(2,2,2);
7       System.out.println("Box " + b.toString());
8       System.out.println("  Area: " + b.area());
9       System.out.println("  Volumn: " + b.volumn());
10   }
11 }
```

Output - Chapter06 (run)

```
run:
Rectangle: [2,5]}
   Area: 10
Box [2,2,2]
  Area: 24
  Volumn: 8
BUILD SUCCESSFUL (total time: 0 seconds)
```

Overriding and Hiding Methods (1)

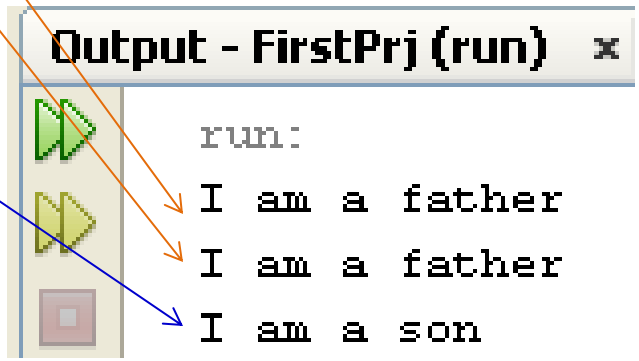
- **Overriding a method**: An instance method in a subclass with the same signature (name, plus the number and the type of its parameters) and return type as an instance method in the superclass overrides the superclass's method.
  - Use the **@Override** annotation that instructs the compiler that you intend to override a method in the superclass (you may not use it because overriding is default in Java).
- **Hiding a method**: Re-implementing a static method implemented in super class

Overriding and Hiding Methods (2)

```
class Father1 {
    public static void m(){
        System.out.println("I am a father");
    }
}
class Son1 extends Father1{
    public static void m(){
        System.out.println("I am a son");
    }
}
public class HidingMethodDemo {
    public static void main(String args[]){
        Father1 obj= new Father1();
        obj.m();
        obj= new Son1();
        obj.m();
        Son1 obj2= new Son1();
        obj2.m();

    }
}
```

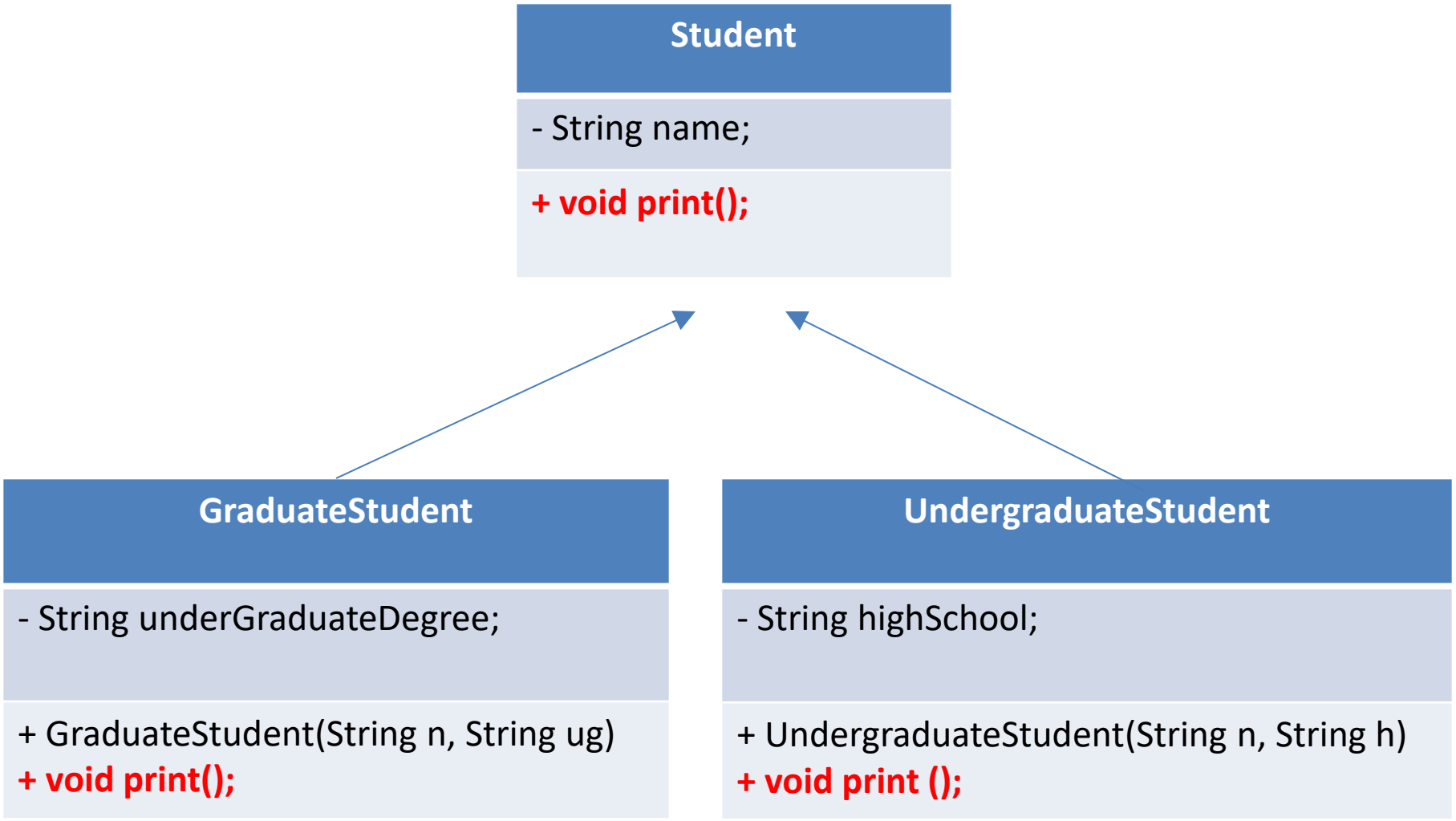
Hiding



Polymorphism

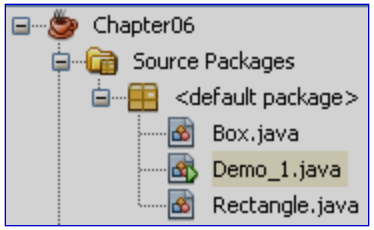
- The ability of two or more objects belonging to ***different*** classes to respond to exactly the ***same*** message (method call) in different class-specific ways**.**
- ***Inheritance combined with overriding facilitates polymorphism*****.**

Polymorphism…)



Overriding Inherited Methods

Overridden method: An inherited method is re-written




```
1   public class Box extends Rectangle {
2     int height=0;
3     public void set (int l, int w, int h)
4     {  super.setValue(l, w);
5        height = h>0? h: 0;
6     }
7     // Overriding the toString method
8     // of the Rectangle class
9     public String toString()
10    { return "[" + length + "," + width +
11                 "," + height + "]";
12    }
13  }
```

```
1   public class Rectangle {
2      protected int length=0, width=0;
3      // Overloading methods
4      public void setValue(int l)
5      {  length = l>0?l:0; }
6      public void setValue(int l, int w)
7      {  length = l>0? l: 0;
8         width= w>0? w: 0;
9      }
10     // Overriding the toString method of the java.lang.Object class
11     public String toString()
12     {  return "[" + length + "," + width + "]}";
13     }
14  }
15
```

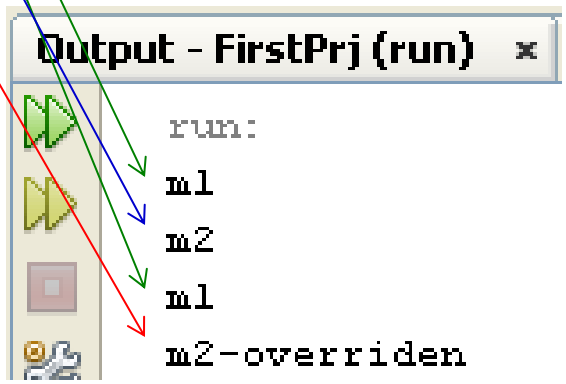
```
Output - Chapter06 (run)
run:
[5,0]}
[10,20]}
[5,10,15]
```

```
public class Demo_1 {
  public static void main  (String[] args)
  {  Rectangle r= new Rectangle();
     r.setValue(5);
     System.out.println(r.toString());
     r.setValue(10,20);
     System.out.println(r.toString());
     Box b= new Box();
     b.set(5,10,15);
     System.out.println(b.toString());
  }
}
```

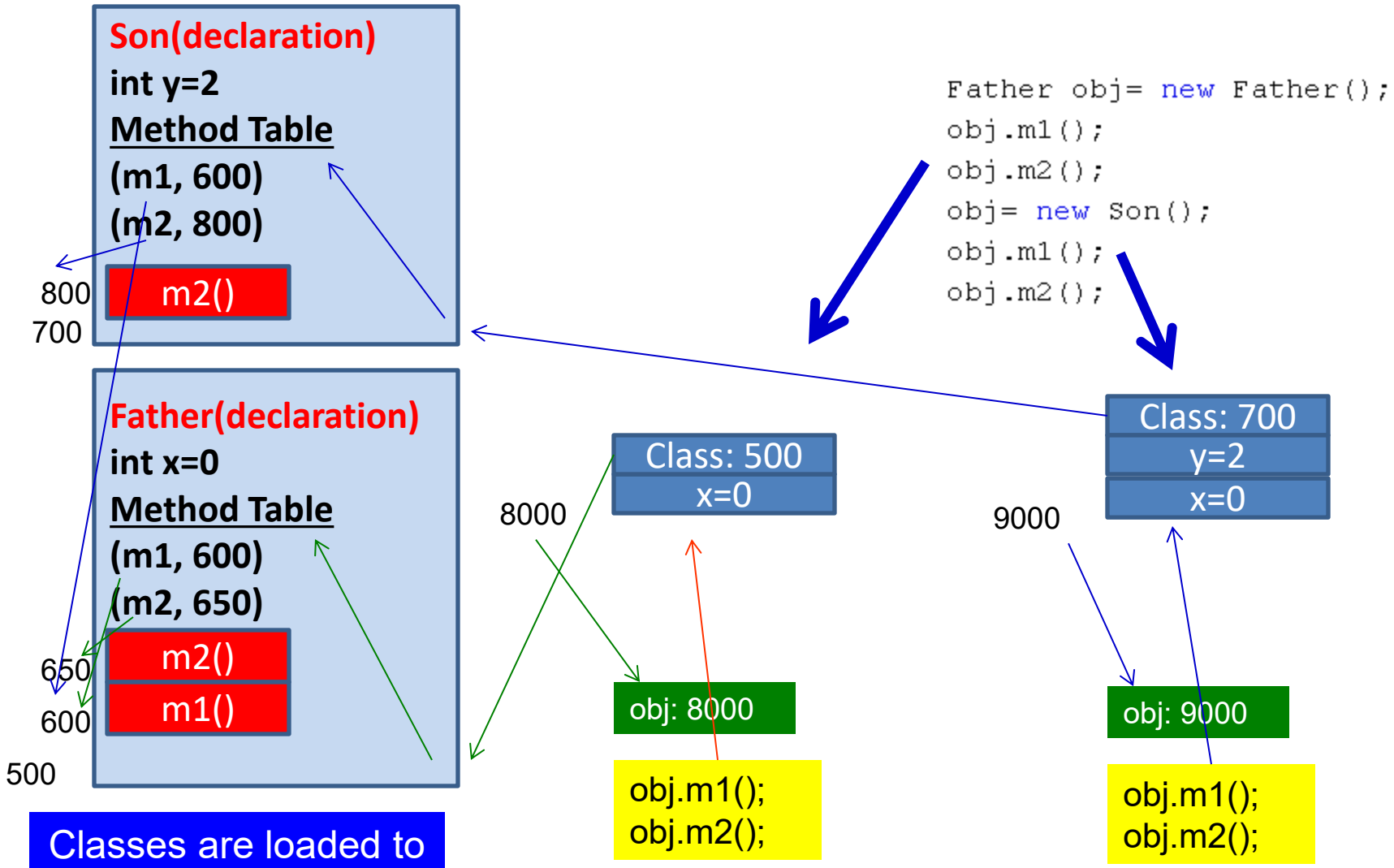
Overloaded methods: Methods have the same name but their parameters are different in a class

How Can Overridden Method be Determined?

```
class Father{
    int x=0;
    void m1() { System.out.println("m1");}
    void m2() { System.out.println("m2");}
}
class Son extends Father {
    int y=2;
    void m2() { System.out.println("m2-overriden");}
}
public class CallOverriddenMethod {
    public static void main(String[] args){
        Father obj= new Father();
        obj.m1();
        obj.m2();
        obj= new Son();
        obj.m1();
        obj.m2();
    }
}
```



How Can Overridden Methods be Determined?



Interfaces

- An *interface* is a reference type, similar to a class, that can contain *only* constants, initialized fields, static methods, prototypes (abstract methods, default methods), static methods, and nested types.
- It will be the **core** of some classes
- Interfaces cannot be instantiated because they have no-body methods.
- Interfaces can only be *implemented* by classes or *extended* by other interfaces.

Interfaces…

```
1   public interface InterfaceDemo {
2       final int MAXN=100; // constant
3       int n=0; // Fields in interface must be initialized
4       static public int sqr(int x){ return x*x;}
5       public abstract void m1(); // abstract methods
6       abstract public void m2();
7       void m3(); // default methods
8       void m4();
9   }
10
11  class UseIt{
12      public static void main(String args[]){
            InterfaceDemo obj= new InterfaceDemo();
14      }
15  }
```

Interfaces…

```
public interface InterfaceDemo {
    final int MAXN=100; // constant
    int n=0; // Fields in interface must be initialized
    static public int sqr(int x){ return x*x;}
    public abstract void m1(); // abstract methods
    abstract public void m2();
    void m3(); // default methods
    void m4();
}
class A implements InterfaceDemo{
    // overriding methods
    public void m1() { System.out.println("M1");}
    public void m2() { System.out.println("M2");}
    void m3() { System.out.println("M3");}
    void m4() { System.out.println("M4");}
}
```

m3(), m4() in A cannot implement m3(), m4() in InterfaceDemo, attempting to assign weaker access privileges, were public

Default methods of an interface must be overridden as public methods in concrete classes.

Interfaces

...

```
public interface InterfaceDemo {
    final int MAXN=100; // constant
    int n=0; // Fields in interface must be initialized
    static public int sqr(int x){ return x*x;}
    public abstract void m1(); // abstract methods
    abstract public void m2();
    void m3(); // default methods
    void m4();
}
```

```
class A implements InterfaceDemo{
    // overriding methods
    public void m1() { System.out.println("M1");}
    public void m2() { System.out.println("M2");}
    public void m3() { System.out.println("M3");}
    public void m4() { System.out.println("M4");}
}
```

```
class UseIt{
    public static void main(String args[]){
        InterfaceDemo obj= new A();
        obj.m1();
        obj.m2();
        obj.m3();
        obj.m4();
        int s= InterfaceDemo.sqr(5);
        System.out.println("5x5=" + s);
    }
}
```

```
Output - FirstPrj (run)
run:
M1
M2
M3
M4
5x5=25
```

Abstract Classes

- Used to define ***what*** **behaviors a class is required to perform without having to provide an explicit implementation.**
- **It is the result of so-high generalization**
- **Syntax to define a abstract class**
  - *public abstract class className{ ... }*
- It isn't necessary for all of the methods in an abstract class to be abstract.
- An abstract class can also declare implemented methods.

Abstract Classes…

```
1   package shapes;
2   public abstract class Shape {
3       abstract public double circumstance();
4       abstract public double area();
5   }
6   class Circle extends Shape {
7       double r;
8       public Circle (double rr) { r=rr; }
        public double circumstance() { return 2*Math.PI*r; }
        public double area() { return Math.PI*r*r; }
11  }
12  class Rect extends Shape {
13      double l,w;
14      public Rect(double ll, double ww){
15          l = ll; w = ww;
16      }
        public double circumstance() { return 2*(l+w); }
        public double area() { return l*w; }
19  }
20  class Program {
21      public static void main(String[] args) {
            Shape s = new Shape ();
23      }
24  }
```

```
20  class Program {
21      public static void main(String[] args) {
22          Shape s = new Circle(5);
23          System.out.println(s.area());
24      }
25  }
```

Modified

```
Output - Chapter06 (run)
run:
78.53981633974483
```

Abstract Classes…

```
1   public abstract class AbstractDemo2 {
2       void m1() // It is not abstract class
3       { System.out.println("m1");
4       }
5       void m2() // It is not abstract class
6       { // empty body
7       }
8       public static void main(String[] args)
        {   AbstractDemo2 obj = new AbstractDemo2();
10      }
11  }
```

This class have no abstract method but it is declared as an abstract class. So, we can not initiate an object of this class.

Abstract Classes…

Error. Why?

```
1  public abstract class AbstractDemo2 {
2      void m1() // It is not abstract class
3      { System.out.println("m1");
4      }
5      abstract void m2();
6  }
7  class Derived extends  AbstractDemo2
8  {   public void m1() // override
9      { System.out.println("m1");
10     }
11     public static void main(String[] args)
12     {   Derived obj = new Derived();
13     }
14 }
```

Implementing Abstract Methods

- Derive a class from an abstract superclass, the subclass will inherit all of the superclass's features, all of ***abstract* methods** included**.**
- To replace an inherited abstract method with a concrete version, the subclass need merely override it.
- Abstract classes ***cannot be instantiated***

Anonymous Classes

Anonymous classes are classes which are not named but they are identified automatically by Java compiler.

Where are they? They are identified at initializations of interface/abstract class object but abstract methods are implemented as attachments.

Why are they used?

- Enable you to make your code more concise.
- Enable you to declare and instantiate a class at the same time.
- They are like local classes except that they do not have a name.
- Use them if you need to use a local class only once.

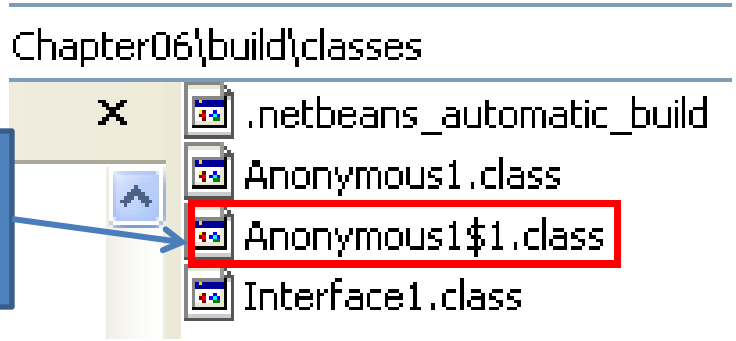
Anonymous Class…

```
1   // New - Java Interface
2   public interface Interface1 {
3     void M1();
4     void M2();
5   }
6   class Anonymous1{
7       public static void main(String[] args) {
8           Interface1 obj = new Interface1() {
9               public void M1()
10              { System.out.println("M1");}
11              public void M2()
12              { System.out.println("M2");}
13          };
14          obj.M1();
15          obj.M2();
16      }
17  }
18
```

```
Output - Chapter06 (run)
run:
M1
M2
BUILD SUCCESSFUL (total time: 0 seconds)
```

Anonymous class.

Class name is given by the compiler: **ContainerClass$Number**



Anonymous Class…

```
1   package adapters;
2   // abstract class contains all concrete methods
3   public abstract class MyAdapter {
4       public void M1() { System.out.println("M1");}
5       public void M2() { System.out.println("M2");}
6   }
7   class Program {
8       public static void main(String[] args) {
9           // Overriding one method
10          MyAdapter obj = new MyAdapter ()
            {   public void M1()
12              {   System.out.println("M1 overridden");
13              }
14          };
15          obj.M2();
16          obj.M1();
17      }
18  }
```

Concrete methods but they can not be used because the class is declared as abstract one.

The abstract class can be used only when at least one of it's methods is overridden

Output - Chapter06 (run)

```
run:
M2
M1 overridden
```

Anonymous class is a technique is commonly used to support programmer when only some methods are overridden only especially in event programming.

Enum Types (1)

- An *enum type* is a special data type that enables for a variable to be a set of predefined constants.
- We use enum types any time you need to represent a fixed set of named-constants (uppercase).

New/ Java Enum

```
public enum Day {
    SUNDAY, MONDAY, TUESDAY, WEDNESDAY,
    THURSDAY, FRIDAY, SATURDAY;// ; can be missed
}
```

Enum Types (2)

```
class DayInWeek{
    Day d; // Using the enum Day
    DayInWeek(Day d){
        this.d= d;
    }
    public void tellItLikeItIs() {
        switch (d) {
            case MONDAY:
                System.out.println("Mondays are bad.");
                break;
            case FRIDAY:
                System.out.println("Fridays are better.");
                break;
            case SATURDAY:
            case SUNDAY:
                System.out.println("Weekends are best.");
                break;
            default:
                System.out.println("Midweek days are so-so.");
                break;
        }
    }
}
```

```
Output - FirstPrj (run)
run:
Mondays are bad.
Midweek days are so-so.
```

```
class UseDay {
    public static void main(String[]args){
        DayInWeek obj= new DayInWeek(Day.MONDAY);
        obj.tellItLikeItIs();
        obj= new DayInWeek(Day.WEDNESDAY);
        obj.tellItLikeItIs();
    }
}
```

Enum Types (3)

```
public enum Planet { // Enum for some planets (mass, radius)
    MERCURY (3.303e+23, 2.4397e6), VENUS   (4.869e+24, 6.0518e6),
    EARTH   (5.976e+24, 6.37814e6), MARS    (6.421e+23, 3.3972e6),
    JUPITER (1.9e+27,   7.1492e7), SATURN  (5.688e+26, 6.0268e7),
    URANUS  (8.686e+25, 2.5559e7), NEPTUNE (1.024e+26, 2.4746e7);
    // Fields of a Planet object
    private final double mass;   // in kilograms
    private final double radius; // in meters
    // Create a planet, onstructor, public can not be used
    Planet(double mass, double radius) {
        this.mass = mass; // initialize mass
        this.radius = radius; // initialize radius
    }
    private double mass() { return mass; }
    private double radius() { return radius; }
    // universal gravitational constant  (m3 kg-1 s-2)
    public static final double G = 6.67300E-11;
    double surfaceGravity() {
        return G * mass / (radius * radius);
    }
    double surfaceWeight(double otherMass) {
        return otherMass * surfaceGravity();
    }
}
```

Enum Types (4)

```
26  class PlanetUse{
27      public static void main(String[] args) {
28          double yourWeightOnEarth = 60;// kg
29          double mass = yourWeightOnEarth/Planet.EARTH.surfaceGravity();
30          for (Planet p : Planet.values())
31             System.out.printf("Your weight(kg) on %s is %f%n",
32                               p, p.surfaceWeight(mass));
33      }
34  }
```

Output - FirstPrj (run)

```
run:
Your weight(kg) on MERCURY is 22.665457
Your weight(kg) on VENUS is 54.299946
Your weight(kg) on EARTH is 60.000000
Your weight(kg) on MARS is 22.724231
Your weight(kg) on JUPITER is 151.833452
Your weight(kg) on SATURN is 63.960932
Your weight(kg) on URANUS is 54.307632
Your weight(kg) on NEPTUNE is 68.299684
```

Test

```
1  /* What is the output of the following program */
2  class Study_1A{
3      void M() { System.out.println("A");}
4  }
5  class Study_1B extends Study_1A{
6      void M() { System.out.println("B"); }
7  }
8  class Study_1C{
9      void M() { System.out.println("C"); }
10 }
11 public class Study_1 {
12   public static void main(String[] args)   {
13     Study_1A obj= new Study_1A();
14     obj.M();
15     obj=new Study_1B();
16     obj.M();
17     obj= new Study_1C();
18     obj.M();
19   }
20 }
```

a) ABC

b) AAC

c) ABA

d) Compile-time error

Study_1A and Study_1C are inconvertible

Test

```
/* What is the output of the following program */
class Study_1A{
   void M() { System.out.println("A");}
}
class Study_1B extends Study_1A{
   void M() { System.out.println("B"); }
}
class Study_1C{
   void M() { System.out.println("C"); }
}
public class Study_1 {
  public static void main(String[] args)  {
    Object obj= new Study_1A();
    obj.M();
    obj=new Study_1B();
    obj.M();
    obj= new Study_1C();
    obj.M();
  }
}
```

a) ABC

b) AAC

c) ABA

d) Compile-time error

The java.lang.Object class does not have the M() method

Test

```
/* What is the output of the following program */
class Study_1A{
   void M() { System.out.print("A");}
}
class Study_1B extends Study_1A{
   void M() { System.out.print("B"); }
}
class Study_1C{
   void M() { System.out.print("C"); }
}
public class Study_1 {
  public static void main(String[] args)  {
    Study_1A obj= new Study_1A();
    obj.M();
    obj=new Study_1B();
    obj.M();
    Object obj2= new Study_1C();
    ((Study_1A)obj2).M();
  }
}
```

a) ABC

b) AAA

c) ABA

d) None of the others

AB and a ClassCastException

Test

```
/* What is the output of the following program */
class Study_1A{
   void M() { System.out.print("A");}
}
class Study_1B extends Study_1A{
   void M() { System.out.print("B"); }
}
class Study_1C extends Study_1B {
   void M() { System.out.print("C"); }
}
public class Study_1 {
  public static void main(String[] args)  {
    Study_1A obj= new Study_1A();
    obj.M();
    obj=new Study_1B();
    obj.M();
    obj= new Study_1C();
    obj.M();
  }
}
```

a) AAA

b) ACB

c) None of the others

d) ABC

Test

```
/* What is the output of the following program */
class Study_1A{
   void M() { System.out.print("A");}
}
class Study_1B extends Study_1A{
   void M() { System.out.print("B"); }
}
class Study_1C extends Study_1B {
   void M() { System.out.print("C"); }
}
public class Study_1 {
  public static void main(String[] args)  {
    Study_1C obj= new Study_1C();
    obj.M();
    obj=new Study_1B();
    obj.M();
    obj= new Study_1A();
    obj.M();
  }
}
```

a) ABC

b) AAA

c) ABA

d) None of the others

Compile-time error
(Type conformity violation)

Test

```
public class Study_2 {
   static int N =10;
   int x = 120;
   static{
        N = 50;
        System.out.print("A");
   }
   public void M(){
        System.out.print(x);
   }
   public static void main(String [] args){
        Study_2 obj = new Study_2();
        obj.M();
   }
}
```

a) 120

b) 120A

c) None of the others

d) A120

Test

```
public class Study_2 {
   static int N =10;
   int x = 120;
   static{
        N = 7;
        System.out.print("A" + N );
        x = 500;
   }
   public void M(){
        System.out.print( x );
   }
   public static void main(String [] args){
        Study_2 obj = new Study_2();
        obj.M();
   }
}
```

a) A7500

b) 500A7

c) 500

d) None of the others

Compile-time error
(static code can not access instance variables)

Test

```
public class Study_2 {
   static int N = 2;
   int x = 10;
   static{
        N = 5;
        int y = 7;
        System.out.print("A" + (N + y) );
   }
   public void M(){
        System.out.print( x + y );
   }
   public static void main(String [] args){
        Study_2 obj = new Study_2();
        obj.M();
   }
}
```

a) A1210

b) 10A12

c) 17

d) None of the others

Compile-time error
(The y variable is out of scope)

Summary

- Benefits of OO implementation: Inheriatance ans Polymorphism
- Working with Interfaces.
- Working with Abstract Methods and Classes.
- Anonymous Classes
- Enum Type