Object-Oriented Programming

- OOP uses a number of techniques to achieve **reusability and adaptability** (able to be modified; adjusting quickly) including:

abstraction, encapsulation, inheritance, and polymorphism

Defining Object Composition

- Objects can be composed of other objects.
- Objects can be part of other objects.
- This relationship between objects is known as *aggregation*.

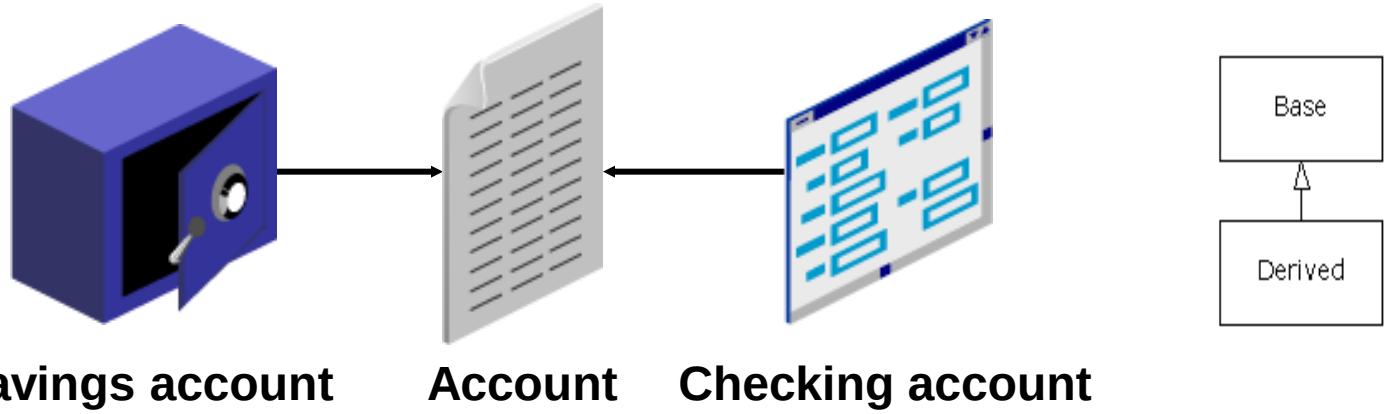
A PC may be an object.

A PC may have a keyboard, mouse, and network card, all of which may be objects.

A PC may have a CD drive, which may be an object.

What Is Inheritance?

- There may be a commonality between different classes.
- Define the common properties in a superclass.



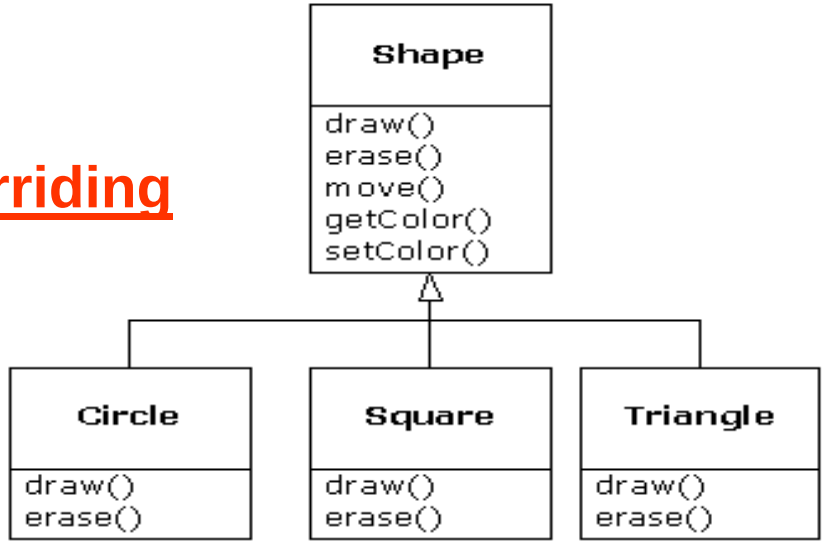
- The subclasses use inheritance to include those properties.

Using the "Is-a-Kind-of" Relationship

You have two ways to differentiate your new derived class from the original base class it inherits from.

The first is: you simply add new functions to the derived class.

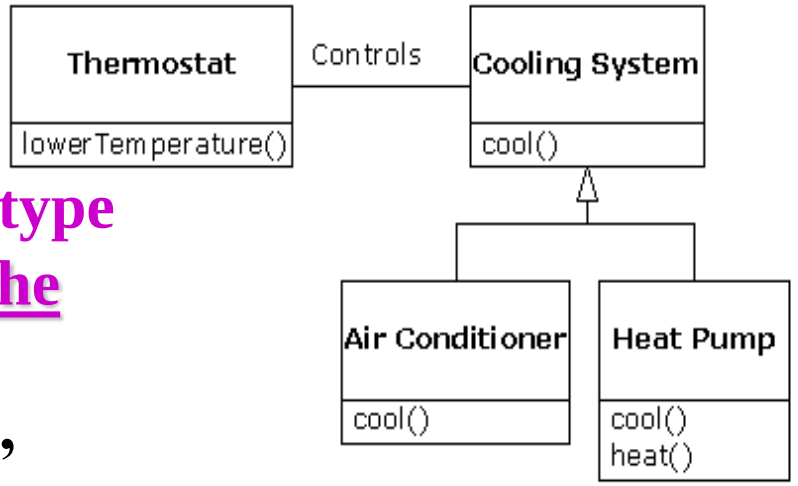
The second way is: to change the behavior of an existing base-class function. This is referred to as overriding that function.



Is-a vs. is-like-a relationships

Is-a

override *only* base-class functions



The derived type is *exactly* the same type as the base class since it has exactly the same interface.

"a circle *is a* shape."

is-like-a

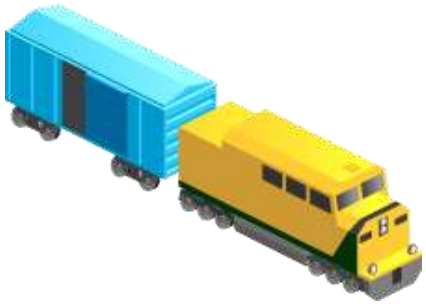
Add new interface elements to a derived type, thus extending the interface and creating a new type.

heat pump *is-like-an* air conditioner

What Is Polymorphism?

Polymorphism refers to:

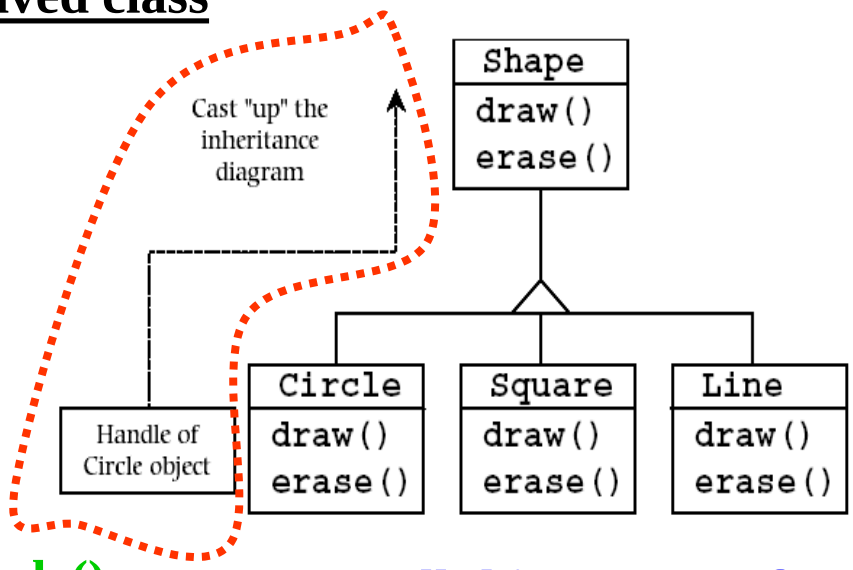
- **Many forms of the same operation**
- **The ability to request an operation with the same meaning to different objects. However, each object implements the operation in a unique way.**
- **The principles of inheritance and object substitution.**



Load passengers

One of the most important things you do with such a family of classes is to treat an object of a derived class as an object of the base class.

This is important because it means you can write a single piece of code that ignores the specific details of type and talks just to the base class.




```
void doStuff(Shape s)
{
s.erase();
// ...
s.draw();
}
```

```
Circle c = new Circle();
Triangle t = new Triangle();
Line l = new Line();

doStuff(c);
doStuff(t);
doStuff(l);
```

We call this process of treating a derived type as though it were its base type *upcasting*

Specifying Inheritance in Java

- Inheritance is achieved by specifying which superclass the subclass extends.

```
public class InventoryItem {
   ...
}
```

```
public class Movie extends InventoryItem {
   ...
}
```

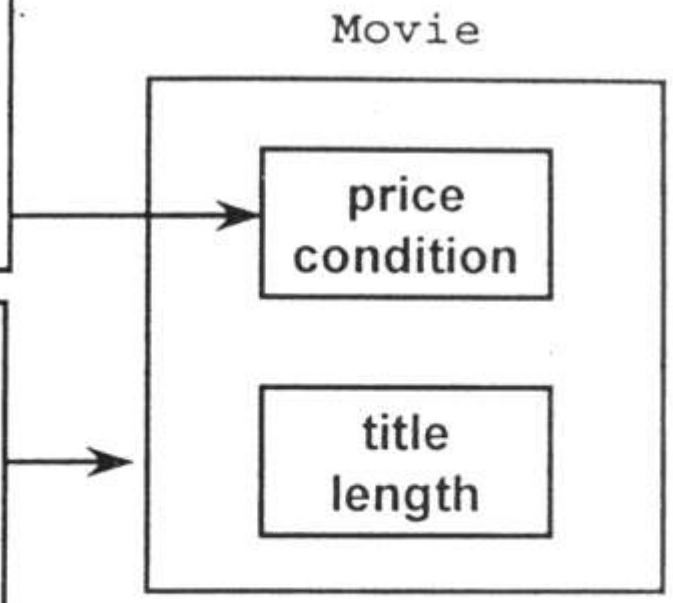
- `Movie` inherits all the variables and methods of `InventoryItem`.

What Does a Subclass Object Look Like?

A subclass inherits all the instance variables of its superclass.

```
public class InventoryItem {
  private float price;
  private String condition; …
}
```

```
public class
 Movie extends InventoryItem {
  private String title;
  private int length; …
}
```

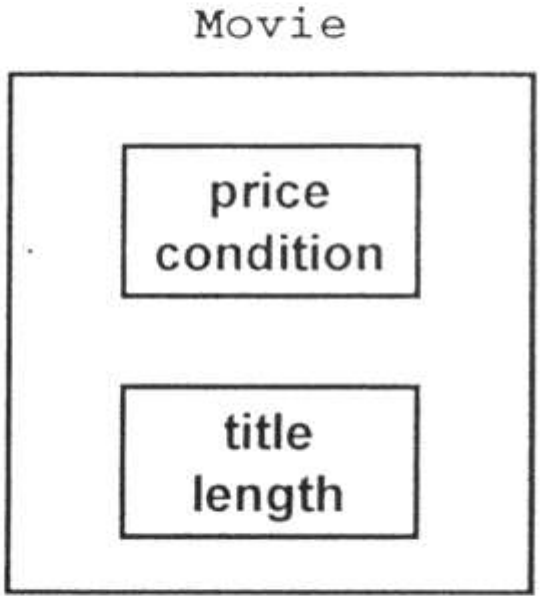


also private variables was inherited.

Default Initialization

- What happens when a subclass object is created?

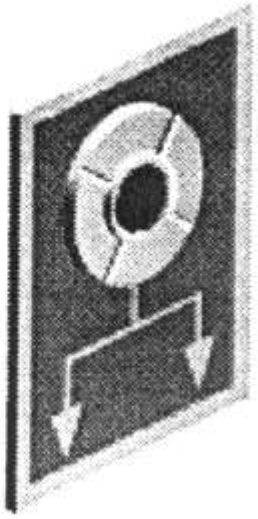
```
Movie movie1 = new Movie();
```



- If no constructors are defined:
  - First, the default no-arg constructor is called in the superclass.
  - Then, the default no-arg constructor is called in the subclass.

The `super` Reference

- Refers to the base, top-level class
- Is useful for calling base class constructors
- Must be the first line in the derived class constructor
- Can be used to call any base class methods



The super Reference Example

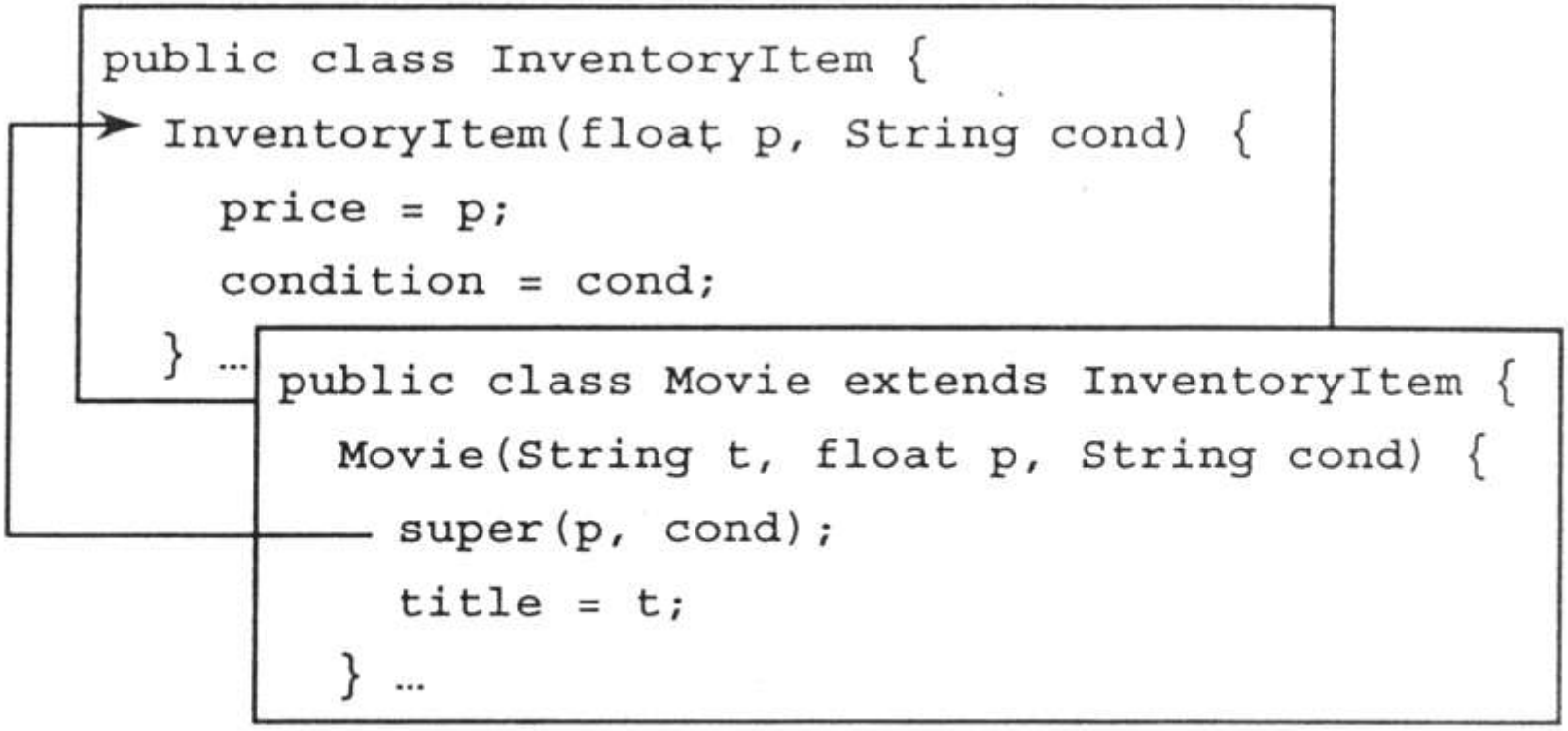
```
public class InventoryItem {
 InventoryItem(String cond) {
    System.out.println("InventoryItem");
    ...
  }
}
class Movie extends InventoryItem {
  Movie(String title) {
    super(title);
    ...
    System.out.println("Movie");
  }
}
```

Base class constructor

Calls base class constructor

Using Superclass Constructors

Use `super()` to call a superclass constructor:



Overriding Superclass Methods

- A subclass inherits all the methods of its superclass.
- The subclass can override a method with its own specialized version.
  - The subclass method must have the same signature and semantics as the superclass method.

```
public class InventoryItem {
  public float calcDeposit(int custId) {
  if …
    retur
  }
```

```
public class Vcr extends InventoryItem {
  public float calcDeposit(int custId) {
    if …
      return itemDeposit;
  }
```

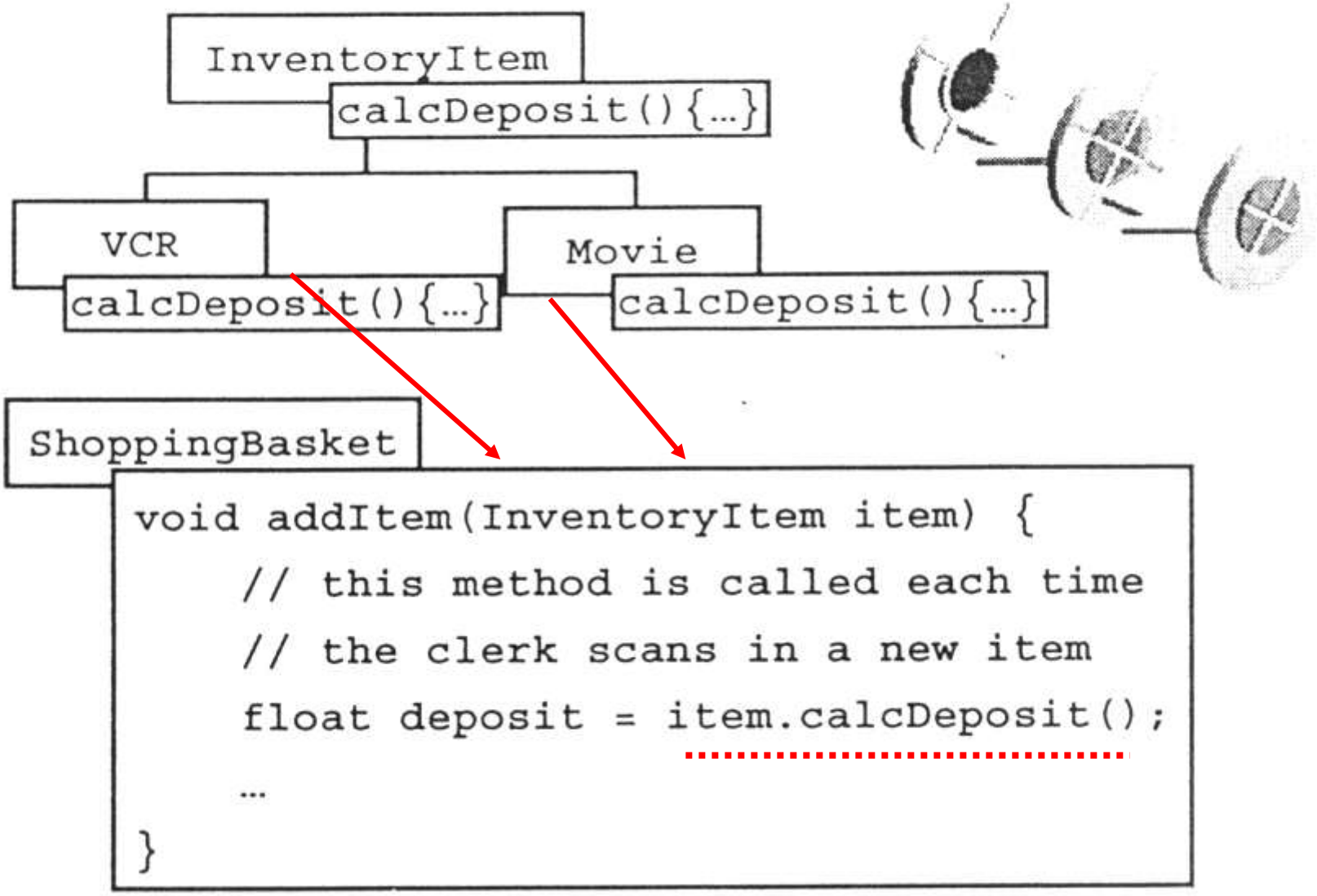
Invoking Superclass Methods

- If a subclass overrides a method, then it can still call the original superclass method.
- Use `super.method()` to call a superclass method from the subclass.

```
public class InventoryItem {
  public float calcDeposit(int custId) {
    if
    re
  }
```

```
public class Vcr extends InventoryItem {
 public float calcDeposit(int custId) {
    itemDeposit = super.calcDeposit(custId);
    return (itemDeposit + vcrDeposit);
}
```

Using Polymorphism for Acme Video



Using the `instanceof` Operator

- You can determine the true type of an object by using an `instanceof` operator. **(At run time)**
- An object reference can be downcast to the correct type, if necesary.

```
public void aMethod(InventoryItem i) {
   ...
   if (i instanceof Vcr)
      ((Vcr)i).playTestTape();
}
```

```
class Cleanser {
  private String s = new String("Cleanser");
  public void append  (String a) { s += a; }
  public void dilute()        { append(" dilute(111)"); }
  public void apply ()        { append(" apply(2222)"); }
  public void scrub ()        { append(" scrub(333)"); }
  public String toString ()     { return s; }
  public static void   main   (String[] args) {
    Cleanser x = new Cleanser();         x.dilute();    x.apply();     x.scrub();      System.out.println(x);
  } }
public class Detergent extends Cleanser {
  public void scrub() {
    append (" BM.scrub()");
    super.scrub();
  }
  public void foam() { append(" foam()"); }
  public static void main  (String[] args) {        System.out.println("----------");
    Detergent x = new Detergent();
    x.dilute();        x.apply();         x.scrub();     x.foam();
    System.out.println(x);
    System.out.println("Testing base class:");
    Cleanser.main(args);
  }  }
```

```
class Art {
  Art() {
    System.out.println("Art constructor");
  }
}
class Drawing extends Art {
  Drawing() {
    System.out.println("Drawing constructor");
  }
}
public class Cartoon extends Drawing {

  public Cartoon() {
    System.out.println("Cartoon constructor");
  }
  public static void main(String[] args) {
    Cartoon x = new Cartoon();
  }
}
```

```
class Game {
  Game (int i){
    System.out.println("Game constructor");
  }
}
class BoardGame extends Game {
  BoardGame(int i) {
    super(i);
    System.out.println("BoardGame constructor");
  }
}
public class Chess extends BoardGame {
  Chess() {
    super(11);
    System.out.println("Chess constructor");
  }
  public static void main(String[] args) {
    Chess x = new Chess();
  }
}
```

```
class Homer {
  char doh(char c) {
    System.out.println("doh(char)");
    return 'd';
  }
  float doh(float f) {
    System.out.println("doh(float)");
    return 1.0f;
  }  }
class Milhouse {}
class Bart extends Homer {
  void doh(Milhouse m) {
    System.out.println("doh(Milhouse)");
  } }
public class Hide {
  public static void main(String[] args) {
    Bart b = new Bart();
    b.doh(1);       b.doh('x');       b.doh(1.0f);
    b.doh(new Milhouse());
  }}
```

```
class Engine {     //// Composition
  public void start() {}       public void rev() {}      public void stop() {}
}
class Wheel {
  public void inflate(int psi) {}
}
class Window {
  public void rollup() {}     public void rolldown() {}
}
class Door {
  public Window window = new Window();
  public void open() {}     public void close() {}
}
public class Car {
  public Engine engine = new Engine();      public Wheel[] wheel = new Wheel[4];
  public Door     left = new Door(),  right = new Door(); // 2-door
  public Car() {
    for(int i = 0; i < 4; i++)          wheel[i] = new Wheel();    }
  public static void main(String[] args) {
    Car car = new Car();
    car.left.window.rollup();       car.wheel[0].inflate(72);
  } }
```

```
import   java.util.*;
class Shape {    void draw() {}     void erase() {}        }
class Circle extends Shape {
  void draw()  { System.out.println("Circle.draw()");   }    void erase() {    System.out.println("Circle.erase()");
}
}
class Square extends Shape {
  void draw()  { System.out.println("Square.draw()");   }    void erase() { System.out.println("Square.erase()");
}
}
class Triangle extends Shape {
  void draw() { System.out.println("Triangle.draw()"); }  void erase() {System.out.println("Triangle.erase()");
}    }
class RandomShapeGenerator {
  private     Random     rand     =     new     Random();
  public   Shape   next(  ) {
   switch     (rand.nextInt(3))   {
   default:
   case 0: return new Circle();   case 1: return new Square(); case 2: return new Triangle(); }}}
public class Shapes {
  private static RandomShapeGenerator gen = new RandomShapeGenerator();
  public static void main(String[] args) {       Shape[] s = new Shape[9];
    for(int i = 0; i < s.length; i++)          s[i] = gen.next();
    for(int i = 0; i < s.length; i++)          s[i].draw();      } }
```

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class Shape {
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class Circle extends Shape {
  void draw()  {    System.out.println("Circle.draw()");   }    void erase() {    System.out.println("Circle.erase()");  }    }
class Square extends Shape {
  void draw()  {     System.out.println("Square.draw()");   }    void erase() {     System.out.println("Square.erase()");  }  }
class Triangle extends Shape {
  void draw()  {     System.out.println("Triangle.draw()");   }   void erase() {   System.out.println("Triangle.erase()");  }  }
class RandomShapeGenerator {
  private Random rand = new Random();
  public   Shape  next( ) {
    switch  ( rand.nextInt(3) ) {
      default:
      case 0: return new Circle();    case 1: return new Square();   case 2: return new Triangle();
   }    }    }
public class Shapes {
  private static RandomShapeGenerator       gen     =     new RandomShapeGenerator();
  public static void main(String[] args) {
    Object[] s = new Shape[9];

    for(int i = 0; i < s.length; i++)
      s[i] = gen.next();
    for(int i = 0; i < s.length; i++)
          s[i].draw();
  } }
```

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class Square extends Shape {
  void draw()  {     System.out.println("Square.draw()");   }    void erase() {     System.out.println("Square.erase()");  }  }
class Triangle extends Shape {
  void draw()  {     System.out.println("Triangle.draw()");   }   void erase() {   System.out.println("Triangle.erase()");  }  }
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  private Random rand = new Random();
  public Shape next() {
    switch(rand.nextInt(3)) {
      default:
      case 0: return new Circle();   case 1: return new Square();  case 2: return new Triangle();       }    }
}
public class Shapes {
  private static RandomShapeGenerator gen = new RandomShapeGenerator();
  public static void main(String[] args) {
    Object[] s = new Shape[9];
    for(int i = 0; i < s.length; i++)
      s[i] = gen.next();
    for(int i = 0; i < s.length; i++)  {
      if  ( s[i]   instanceof    Circle)      ((Circle)      s[i]).draw();
      if  ( s[i]   instanceof    Square )     ((Square )     s[i]).draw();
      if  ( s[i]   instanceof    Triangle )   ((Triangle )  s[i]).draw();     }   } }
```

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  private Random rand = new Random();
  public Shape next() {
    switch(rand.nextInt(3)) {
      default:
      case 0: return new Circle();          case 1: return new Square();          case 2: return
new Triangle();        }    }    }
public class Shapes {
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  public static void main(String[] args) {
    Object[] s = new Shape[9];
    for(int i = 0; i < s.length; i++)
      s[i] = gen.next();
    for(int i = 0; i < s.length; i++)  {
      if  ( s[i]   instanceof   Shape )      ((Shape )      s[i]).draw();  }
  } }
```