Java

Inheritance

Inheritance

- Same inheritance concept of C++ in Java with some modifications
  - One class inherits the other using ***extends*** keyword
  - The classes involved in inheritance are known as ***superclass*** and ***subclass***
  - ***Multilevel*** inheritance but no ***multiple*** inheritance
  - There is a special way to call the superclass's ***constructor***
  - There is automatic ***dynamic method dispatch***
- Inheritance provides code reusability (code of any class can be used by extending that class)

Simple Inheritance

```java
class A {
    int i, j;

    void showij() {
        System.out.println(i+" "+j);
    }
}

class B extends A{
    int k;

    void showk() {
        System.out.println(k);
    }

    void sum() {
        System.out.println(i+j+k);
    }
}
```

```java
public class SimpleInheritance {
    public static void main(String[] args) {
        A superOb = new A();
        superOb.i = 10;
        superOb.j = 20;
        superOb.showij();
        B subOb = new B();
        subOb.i = 7;
        subOb.j = 8;
        subOb.k = 9;
        subOb.showij();
        subOb.showk();
        subOb.sum();
    }
}
```

Inheritance and Member Access

```java
class M {
    int i;
    private int j;

    void set(int x, int y) {
        i = x;
        j = y;
    }
}

class N extends M {
    int total;

    void sum() {
        total = i + j;
        // Error, j is not accessible here
    }
}
```

```java
public class SimpleInheritance2 {
    public static void main(String[] args) {
        N obj = new N();
        obj.set(10, 20);
        obj.sum();
        System.out.println(obj.total);
    }
}
```

- A class member that has been declared as private will remain private to its class
- It is not accessible by any code outside its class, including subclasses

Practical Example

```
3   class Box {
4       double width, height, depth;
5
6       Box(Box ob) {
7           width = ob.width; height = ob.height; depth = ob.depth;
8       }
9
10      Box(double w, double h, double d) {
11          width = w; height = h; depth = d;
12      }
13
14      Box() { width = height = depth = 1; }
17
18      Box(double len) { width = height = depth = len; }
21
22      double volume() { return width * height * depth; }
25  }
26
27  class BoxWeight extends Box {
28      double weight;
29
30      BoxWeight(double w, double h, double d, double m) {
31          width = w; height = h; depth = d; weight = m;
32      }
33  }
```

Superclass variable reference to Subclass object

```
34
35  public class RealInheritance {
36      public static void main(String[] args) {
37          BoxWeight weightBox = new BoxWeight( w: 3,  h: 5,  d: 7,  m: 8.37);
38          System.out.println(weightBox.weight);
39          Box plainBox = weightBox; // assign BoxWeight reference to Box reference
40          System.out.println(plainBox.volume()); // OK, volume() defined in Box
41          System.out.println(plainBox.weight); // Error, weight not defined in Box
42          Box box = new Box( w: 1,  h: 2,  d: 3); // OK
43          BoxWeight wbox = box; // Error, can't assign Box reference to BoxWeight
44      }
45  }
46
```

Constructors are not inherited

- Constructors are not members, so they are not inherited by subclasses
  - the constructor of the superclass can be invoked from the subclass

```
class BoxWeight extends Box {  4 usages
    double weight;  1 usage
}

public class RealInheritance {
    public static void main(String[] args) {
        BoxWeight weightBox1 = new BoxWeight();
        System.out.println(weightBox1.width);
        System.out.println(weightBox1.height);
        System.out.println(weightBox1.depth);
        System.out.println(weightBox1.weight);
        BoxWeight weightBox2 = new BoxWeight(3, 5, 7);
    }
}
```

```
class BoxWeight extends Box {  2 usages
    double weight;  1 usage

    BoxWeight(double w, double h, double d, double m) {
        width = w;
        height = h;
        depth = d;
        weight = m;
    }
}

public class RealInheritance {
    public static void main(String[] args) {
        BoxWeight weightBox1 = new BoxWeight();
    }
}
```

Using super to call Superclass Constructors

```
3  class BoxWeightNew extends Box {
4      double weight;
5
6      BoxWeightNew(BoxWeightNew ob) {
7          super(ob);
8          weight = ob.weight;
9      }
10
11     BoxWeightNew(double w, double h, double d, double m) {
12         super(w, h, d);
13         weight = m;
14     }
15
16     BoxWeightNew() {
17         super(); // must be the 1st statement in constructor
18         weight = 1;
19     }
20
21     BoxWeightNew(double len, double m) {
22         super(len);
23         weight = m;
24     }
25
26     void print() {
27         System.out.println("Box(" + width + ", " + height +
28                            ", " + depth + ", " + weight + ")");
29     }
30 }
```

super( ) must always be the first statement executed inside a subclass' constructor

Using super to call Superclass Constructors

```
31
32  public class SuperTest {
33      public static void main(String[] args) {
34          BoxWeightNew box1 = new BoxWeightNew(10, 20, 15, 34.3);
35          BoxWeightNew box2 = new BoxWeightNew(2, 3, 4, 0.076);
36          BoxWeightNew box3 = new BoxWeightNew();
37          BoxWeightNew cube = new BoxWeightNew(3, 2);
38          BoxWeightNew clone = new BoxWeightNew(box1);
39          box1.print();
40          box2.print();
41          box3.print();
42          cube.print();
43          clone.print();
44      }
45
46  }
47
```

Using super to access Superclass hidden members

```
3  class C {
4      int i;
5      void show() {
6      }
7  }
8
9  class D extends C {
10     int i; // this i hides the i in C
11
12     D(int a, int b) {
13         super.i = a; // i in C
14         i = b; // i in D
15     }
16
17     void show() {
18         System.out.println("i in superclass: " + super.i);
19         System.out.println("i in subclass: " + i);
20         super.show();
21     }
22 }
23
24 public class UseSuper {
25     public static void main(String[] args) {
26         D subOb = new D( a: 1,  b: 2);
27         subOb.show();
28     }
29 }
```

Multilevel Inheritance

```java
class X {
    int a;
    X() {
        System.out.println("Inside X's constructor");
    }
}

class Y extends X {
    int b;
    Y() {
        System.out.println("Inside Y's constructor");
    }
}

class Z extends Y {
    int c;
    Z() {
        System.out.println("Inside Z's constructor");
    }
}

public class MultilevelInheritance {
    public static void main(String[] args) {
        Z z = new Z();
        z.a = 10;
        z.b = 20;
        z.c = 30;
    }
}
```

Inside X's constructor
Inside Y's constructor
Inside Z's constructor

Method Overriding

```java
class Base {
    int a;
    Base(int a) {
        this.a = a;
    }
    void show() {
        System.out.println(a);
    }
}

class Child extends Base {
    int b;

    Child(int a, int b) {
        super(a);
        this.b = b;
    }

    // the following method overrides Base class's show()
    @Override // this is an annotation (optional but recommended)
    void show() {
        System.out.println(a + ", " + b);
    }
}
```

```java
public class MethodOverride {
    public static void main(String[] args) {
        Child o = new Child( a: 10,  b: 20);
        o.show();
        Base b = o;
        b.show(); // will call show of Override
    }
}
```

Dynamic Method Dispatch

```
3  class P {
4      void call() {
5          System.out.println("Inside P's call method");
6      }
7  }
8  class Q extends P {
9      void call() {
10         System.out.println("Inside Q's call method");
11     }
12 }
13 class R extends Q {
14     void call() {
15         System.out.println("Inside R's call method");
16     }
17 }
18
19 public class DynamicDispatchTest {
20     public static void main(String[] args) {
21         P p = new P(); // object of type P
22         Q q = new Q(); // object of type Q
23         R r = new R(); // object of type R
24         P  x;          // reference of type P
25         x = p;         // x refers to a P object
26         x.call();      // invoke P's call
27         x = q;         // x refers to a Q object
28         x.call();      // invoke Q's call
29         x = r;         // x refers to a R object
30         x.call();      // invoke R's call
31     }
32 }
```

For practical example please refer to **FindAreas.java**

Abstract Class

- ***abstract class A***
- contains abstract method ***abstract method f()***
- No instance can be created of an abstract class
- The subclass must implement the abstract method
- Otherwise the subclass will be a abstract class too

Abstract Class

```java
abstract class S {
    // abstract method
    abstract void call();
    // concrete methods are still allowed in abstract classes
    void call2() {
        System.out.println("This is a concrete method");
    }
}

class T extends S {
    void call() {
        System.out.println("T's implementation of call");
    }
}

class AbstractDemo {
    public static void main(String args[]) {
        //S s = new S(); // S is abstract; cannot be instantiated
        T t = new T();
        t.call();
        t.call2();
    }
}
```

For practical example please refer to **FindAreas2.java**

Anonymous Subclass

```
3  abstract class S {
4      // abstract method
5      abstract void call();
6      // concrete methods are still allowed in abstract classes
7      void call2() {
8          System.out.println("This is a concrete method");
9      }
10 }
11
12 class AbstractDemo {
13     public static void main(String args[]) {
14         //S s = new S(); // S is abstract; cannot be instantiated
15         S s = new S() {
16             void call() {
17                 System.out.println("Call method of an abstract class");
18             }
19         };
20         s.call();
21     }
22 }
```

Using final with Inheritance

To prevent overriding

```
class A {
    final void f() {
        System.out.println("This is a final method.");
    }
}

class B extends A {
    void f() { // Error! Can't override.
        System.out.println("Illegal!");
    }
}
```

To prevent inheritance

```
final class A {
    //...
}

// The following class is illegal.
class B extends A { // Error! Can't subclass A
    //...
}
```

Local Variable Type Inference and Inheritance

- A superclass reference can refer to a derived class object in Java
- When using local variable type inference, the inferred type of a variable is based on the declared type of its initializer
  - Therefore, if the initializer is of the superclass type, that will be the inferred type of the variable
  - It does not matter if the actual object being referred to by the initializer is an instance of a derived class

Local Variable Type Inference and Inheritance

```java
class A {
    int a;
}
class B extends A {
    int b;
}
class C extends B {
    int c;
}
public class InheritanceVarDemo {
    static A getObject(int type) {
        switch(type) {
            case 0: return new A();
            case 1: return new B();
            case 2: return new C();
            default: return null;
        }
    }
    public static void main(String[] args) {
        var x = getObject( type: 0);
        var y = getObject( type: 1);
        var z = getObject( type: 2);
        System.out.println(x.a);
        System.out.println(y.b);
                    // Error, A doesn't have b field
        System.out.println(z.c);
                    // Error, A doesn't have c field
    }
}
```

For detail example please refer to **InheritanceVarDemo.java**

The inferred type is determined by the return type of getObject( ), not by the actual type of the object obtained. Thus, all three variables will be of type A

Object Class

- There is one special class, ***Object***, defined by Java
- All other classes are subclasses of Object
- That is, Object is a superclass of all other classes
- This means that a reference variable of type Object can refer to an object of any other class
- Also, since arrays are implemented as classes, a variable of type Object can also refer to any array

Object's toString()

- The **toString**( ) method returns a string that contains a description of the object on which it is called
- Also, this method is automatically called when an object is output using println()
- Many classes override this method
- Doing so allows them to provide a description specifically for the types of objects that they create

Object's toString()

```
3   class Point {
4       int x, y;
5
6       Point(int x, int y) {
7           this.x = x;
8           this.y = y;
9       }
10
11      @Override
12      public String toString() {
13          return "(" + x + ", " + y + ")";
14      }
15  }
16
17  public class ObjectTest {
18      public static void main(String[] args) {
19          Point p1 = new Point( x: 10, y: 20);
20          // without override toString() method the
21          // following will print something like this
22          // Point@3cd1a2f1
23          System.out.println(p1);
24      }
25  }
26
```

Object's equals() and hashCode()

- **==** is a reference comparison, whether both variables refer to the same object
- Object's **equals**() method does the same thing
- String class override **equals**() to check contents
- If you want two different objects of a same class to be equal then you need to override **equals**() and **hashCode**() methods
  - **hashCode**() needs to return same value to work properly as keys in Hash data structures

Object's equals() and hashCode()

```java
import java.util.HashMap;
import java.util.Objects;

class Point {
    int x, y;
    Point(int x, int y) {
        this.x = x;
        this.y = y;
    }

    @Override
    public boolean equals(Object o) {
        if (o == this) return true;
        if (!(o instanceof Point)) {
            return false;
        }
        Point p = (Point) o;
        if (p.x == this.x && p.y == this.y) return true;
        return false;
    }

    @Override
    public int hashCode() {
        return Objects.hash(x, y);
    }
}
```

```java
public class ObjectTest {
    public static void main(String[] args) {
        Point p1 = new Point( x: 10, y: 20);
        Point p2 = new Point( x: 10,  y: 20);
        System.out.println(p1.equals(p2));
        System.out.println(p1 == p2);
        HashMap m = new HashMap();
        m.put(p1, "Hello");
        System.out.println(m.get(p2));
    }
}
```