UNIT - III

Inheritance

[Reusable Properties]

Inheritance - *Reusable Properties*

INHERITANCE: Super class & subclasses including multilevel hierarchy, process of constructor calling in inheritance, use of 'super' and 'final' keywords with super() method, dynamic method dispatch, use of abstract classes & methods, Method call binding, Overriding vs. overloading, Abstract classes and methods, Constructors and polymorphism, Order of constructor calls.

Inheritance

- Inheritance is one of the cornerstones of object-oriented programming because it allows the creation of hierarchical classifications.
- Using inheritance, you can create a general class that defines traits common to a set of related items. This class can then be inherited by other, more specific classes, each adding those things that are unique to it.
- In the terminology of Java, a class that is inherited is called a *superclass*. The class that does the inheriting is called a *subclass*.
- Therefore, a *subclass* is a specialized version of a *superclass*. It inherits all of the instance variables and methods defined by the superclass and adds its own, unique elements.

Inheritance

- **Inheritance Basics**
- To inherit a class, you simply incorporate the definition of one class into another by using the ***extends*** keyword.
- The general form of a **class** declaration that inherits a superclass:

```
class subclass-name extends superclass-name {
    // body of class
}
```

- You can only specify one superclass for any subclass that you create. Java does not support the inheritance of multiple superclasses into a single subclass. You can, as stated, create a hierarchy of inheritance in which a subclass becomes a superclass of another subclass. However, no class can be a superclass of itself.

Inheritance

- **Inheritance Basics ...**

```
// A simple example of inheritance.

// Create a superclass.
class A {
  int i, j;

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

// Create a subclass by extending class A.
class B extends A {
  int k;

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

```
class SimpleInheritance {
  public static void main(String args[]) {
    A superOb = new A();
    B subOb = new B();

    // The superclass may be used by itself.
    superOb.i = 10;
    superOb.j = 20;
    System.out.println("Contents of superOb: ");
    superOb.showij();
    System.out.println();

    /* The subclass has access to all public members of
       its superclass. */
    subOb.i = 7;
    subOb.j = 8;
    subOb.k = 9;
    System.out.println("Contents of subOb: ");
    subOb.showij();
    subOb.showk();
    System.out.println();

    System.out.println("Sum of i, j and k in subOb:");
    subOb.sum();
  }
}
```

Inheritance

- **Inheritance Basics ...**
- **Member Access and Inheritance:** Although a subclass includes all of the members of its superclass, it cannot access those members of the superclass that have been declared as **private.**

```
/* In a class hierarchy, private members remain
   private to their class.

   This program contains an error and will not
   compile.
*/

// Create a superclass.
class A {
  int i; // public by default
  private int j; // private to A

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

```
// A's j is not accessible here.
class B extends A {
  int total;
  void sum() {
    total = i + j; // ERROR,
  }
}
```

REMEMBER *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.*

Inheritance

- **Inheritance Basics ...** ***More Practical Example***

```
// This program uses inheritance to extend Box.
class Box {
  double width;
  double height;
  double depth;

  // construct clone of an object
  Box(Box ob) { // pass object to constructor
    width = ob.width;
    height = ob.height;
    depth = ob.depth;
  }

  // constructor used when all dimensions specified
  Box(double w, double h, double d) {
    width = w;
    height = h;
    depth = d;
  }

  // constructor used when no dimensions specified
  Box() {
    width = -1;  // use -1 to indicate
    height = -1; // an uninitialized
    depth = -1;  // box
  }

  // constructor used when cube is created
  Box(double len) {
    width = height = depth = len;
  }

  // compute and return volume
  double volume() {
    return width * height * depth;
  }
}
```

```
// Here, Box is extended to include weight.
class BoxWeight extends Box {
  double weight; // weight of box

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

class DemoBoxWeight {
  public static void main(String args[]) {
    BoxWeight mybox1 = new BoxWeight(10, 20, 15, 34.3);
    BoxWeight mybox2 = new BoxWeight(2, 3, 4, 0.076);
    double vol;

    vol = mybox1.volume();
    System.out.println("Volume of mybox1 is " + vol);
    System.out.println("Weight of mybox1 is " + mybox1.weight);
    System.out.println();

    vol = mybox2.volume();
    System.out.println("Volume of mybox2 is " + vol);
    System.out.println("Weight of mybox2 is " + mybox2.weight);
  }
}
```

Inheritance

- **Inheritance Basics ...** ***More Practical Example***
- A major advantage of inheritance is that once you have created a superclass that defines the attributes common to a set of objects, it can be used to create any number of more specific subclasses. Each subclass can precisely tailor its own classification. For example, the following class inherits **Box and adds a color attribute:**

```
// Here, Box is extended to include color.
class ColorBox extends Box {
  int color; // color of box

  ColorBox(double w, double h, double d, int c) {
    width = w;
    height = h;
    depth = d;
    color = c;
  }
}
```

- **Remember:** Once you have created a superclass that defines the general aspects of an object, that superclass can be inherited to form specialized classes. Each subclass simply adds its own unique attributes. This is the essence of inheritance.

Inheritance

- **Inheritance Basics ...**
- **A Superclass Variable Can Reference a Subclass Object:**
- A reference variable of a superclass can be assigned a reference to any subclass derived from that superclass.
- It is important to understand that it is the type of the reference variable — not the type of the object that it refers to — that determines what members can be accessed. That is, when a reference to a subclass object is assigned to a superclass reference variable, you will have access only to those parts of the object defined by the superclass, *because the superclass has no knowledge of what a subclass adds to it.*

Inheritance

- **Inheritance Basics ...**
- **A Superclass Variable Can Reference a Subclass Object: ...**

```
class RefDemo {
  public static void main(String args[]) {
    BoxWeight weightbox = new BoxWeight(3, 5, 7, 8.37);
    Box plainbox = new Box();
    double vol;

    vol = weightbox.volume();
    System.out.println("Volume of weightbox is " + vol);
    System.out.println("Weight of weightbox is " +
                       weightbox.weight);
    System.out.println();

    // assign BoxWeight reference to Box reference
    plainbox = weightbox;

    vol = plainbox.volume(); // OK, volume() defined in Box
    System.out.println("Volume of plainbox is " + vol);

    /* The following statement is invalid because plainbox
       does not define a weight member. */
//  System.out.println("Weight of plainbox is " + plainbox.weight);
  }
}
```

Inheritance

- Using **super**
- Whenever a subclass needs to refer to its immediate superclass, it can do so by use of the keyword **super.**
- **super** has two general forms.
  - The first calls the superclass' constructor.
  - The second is used to access a member of the superclass that has been hidden by a member of a subclass.

Inheritance

- Using **super ...**

Using super to Call Superclass Constructors

- A subclass can call a constructor defined by its superclass by use of the following form of **super:**

super(*arg-list*);

- Here, *arg-list* specifies any arguments needed by the constructor in the superclass. **super( )** must always be the first statement executed inside a subclass' constructor.

```
// BoxWeight now uses super to initialize its Box attributes.
class BoxWeight extends Box {
  double weight; // weight of box

  // initialize width, height, and depth using super()
  BoxWeight(double w, double h, double d, double m) {
    super(w, h, d); // call superclass constructor
    weight = m;
  }
}
```

Inheritance

- Using **super ...**

Using super to Call Superclass Constructors...

- Since constructors can be overloaded, **super( )** can be called using any form defined by the superclass.
- **The** constructor executed will be the one that matches the arguments.

Inheritance

- Using **super ...**

Using super to Call Superclass Constructors...

```
// A complete implementation of BoxWeight.
class Box {
  private double width;
  private double height;
  private double depth;

  // construct clone of an object
  Box(Box ob) { // pass object to constructor
    width = ob.width;
    height = ob.height;
    depth = ob.depth;
  }

  // constructor used when all dimensions specified
  Box(double w, double h, double d) {
    width = w;
    height = h;
    depth = d;
  }

  // constructor used when no dimensions specified
  Box() {
    width = -1;  // use -1 to indicate
    height = -1; // an uninitialized
    depth = -1;  // box
  }

  // constructor used when cube is created
  Box(double len) {
    width = height = depth = len;
  }

  // compute and return volume
  double volume() {
    return width * height * depth;
  }
}
```

```
// BoxWeight now fully implements all constructors.
class BoxWeight extends Box {
  double weight; // weight of box

  // construct clone of an object
  BoxWeight(BoxWeight ob) { // pass object to constructor
    super(ob);
    weight = ob.weight;
  }

  // constructor when all parameters are specified
  BoxWeight(double w, double h, double d, double m) {
    super(w, h, d); // call superclass constructor
    weight = m;
  }

  // default constructor
  BoxWeight() {
    super();
    weight = -1;
  }

  // constructor used when cube is created
  BoxWeight(double len, double m) {
    super(len);
    weight = m;
  }
}
```

Inheritance

- Using **super ...**

Using super to Call Superclass Constructors...

```
class DemoSuper {
  public static void main(String args[]) {
    BoxWeight mybox1 = new BoxWeight(10, 20, 15, 34.3);
    BoxWeight mybox2 = new BoxWeight(2, 3, 4, 0.076);
    BoxWeight mybox3 = new BoxWeight(); // default
    BoxWeight mycube = new BoxWeight(3, 2);
    BoxWeight myclone = new BoxWeight(mybox1);
    double vol;

    vol = mybox1.volume();
    System.out.println("Volume of mybox1 is " + vol);
    System.out.println("Weight of mybox1 is " + mybox1.weight);
    System.out.println();

    vol = mybox2.volume();
    System.out.println("Volume of mybox2 is " + vol);
    System.out.println("Weight of mybox2 is " + mybox2.weight);
    System.out.println();

    vol = mybox3.volume();
    System.out.println("Volume of mybox3 is " + vol);
    System.out.println("Weight of mybox3 is " + mybox3.weight);
    System.out.println();

    vol = myclone.volume();
    System.out.println("Volume of myclone is " + vol);
    System.out.println("Weight of myclone is " + myclone.weight);
    System.out.println();

    vol = mycube.volume();
    System.out.println("Volume of mycube is " + vol);
    System.out.println("Weight of mycube is " + mycube.weight);
    System.out.println();
  }
}
```

This program generates the following output:

```
Volume of mybox1 is 3000.0
Weight of mybox1 is 34.3

Volume of mybox2 is 24.0
Weight of mybox2 is 0.076

Volume of mybox3 is -1.0
Weight of mybox3 is -1.0

Volume of myclone is 3000.0
Weight of myclone is 34.3

Volume of mycube is 27.0
Weight of mycube is 2.0
```

Inheritance

- Using **super ...**

Using super to Call Superclass Constructors...

```
// construct clone of an object
BoxWeight(BoxWeight ob) { // pass object to constructor
  super(ob);
  weight = ob.weight;
}
```

- Notice that **super( )** is passed an object of type **BoxWeight**—not of type **Box**. This still invokes the constructor **Box(Box ob)**. As mentioned earlier, *a superclass variable can be used to reference any object derived from that class.*
- Thus, we are able to pass a **BoxWeight** object to the **Box** constructor. *Of course, **Box** only has knowledge of its own members.*

- When a subclass calls **super( )**, it is calling the constructor of its immediate superclass. Thus, **super( )** always refers to the superclass immediately above the calling class.
- This is true even in a multileveled hierarchy. Also, **super( )** must always be the first statement executed inside a subclass constructor.

Inheritance

- Using **super ...**

A Second Use for *super*

- Acts somewhat like *this*, except that it always refers to the superclass of the subclass in which it is used. This usage has the following general form:

super.*member*

Here, *member can be either a method or an instance variable.*

- This second form of **super** is most applicable to situations in which member names of a subclass hide members by the same name in the superclass.

Inheritance

- Using **super ...**

A Second Use for *super* ...

- Although the instance variable **i** in **B** hides the **i** in **A**, **super** allows access to the **i** defined in the superclass.
- As you will see, **super** can also be used to call methods that are hidden by a subclass.

```
// Using super to overcome name hiding.
class A {
  int i;
}

// Create a subclass by extending class A.
class B extends A {
  int i; // this i hides the i in A

  B(int a, int b) {
    super.i = a; // i in A
    i = b; // i in B
  }

  void show() {
    System.out.println("i in superclass: " + super.i);
    System.out.println("i in subclass: " + i);
  }
}

class UseSuper {
  public static void main(String args[]) {
    B subOb = new B(1, 2);

    subOb.show();
  }
}
```

This program displays the following:

```
i in superclass: 1
i in subclass: 2
```

Inheritance

- **Creating a Multilevel Hierarchy**
- Builds hierarchies that contain as many layers of inheritance, uses a subclass as a superclass of another.

Inheritance

- **Creating a Multilevel Hierarchy:...**

```
// Start with Box.
class Box {
  private double width;
  private double height;
  private double depth;

  // construct clone of an object
  Box(Box ob) { // pass object to constructor
    width = ob.width;
    height = ob.height;
    depth = ob.depth;
  }

  // constructor used when all dimensions specified
  Box(double w, double h, double d) {
    width = w;
    height = h;
    depth = d;
  }

  // constructor used when no dimensions specified
  Box() {
    width = -1;  // use -1 to indicate
    height = -1; // an uninitialized
    depth = -1;  // box
  }

  // constructor used when cube is created
  Box(double len) {
    width = height = depth = len;
  }

  // compute and return volume
  double volume() {
    return width * height * depth;
  }
}
```

Inheritance

- **Creating a Multilevel Hierarchy:...**

```
// Add weight.
class BoxWeight extends Box {
  double weight; // weight of box

  // construct clone of an object
  BoxWeight(BoxWeight ob) { // pass object to constructor
    super(ob);
    weight = ob.weight;
  }
  // constructor when all parameters are specified
  BoxWeight(double w, double h, double d, double m) {
    super(w, h, d); // call superclass constructor
    weight = m;
  }

  // default constructor
  BoxWeight() {
    super();
    weight = -1;
  }
  // constructor used when cube is created
  BoxWeight(double len, double m) {
    super(len);
    weight = m;
  }
}
```

```
// Add shipping costs.
class Shipment extends BoxWeight {
  double cost;

  // construct clone of an object
  Shipment(Shipment ob) { // pass object to constructor
    super(ob);
    cost = ob.cost;
  }

  // constructor when all parameters are specified
  Shipment(double w, double h, double d,
           double m, double c) {
    super(w, h, d, m); // call superclass constructor
    cost = c;
  }

  // default constructor
  Shipment() {
    super();
    cost = -1;
  }

  // constructor used when cube is created
  Shipment(double len, double m, double c) {
    super(len, m);
    cost = c;
  }
}
```

Inheritance

- **Creating a Multilevel Hierarchy:...**

```
class DemoShipment {
  public static void main(String args[]) {
    Shipment shipment1 =
               new Shipment(10, 20, 15, 10, 3.41);
    Shipment shipment2 =
               new Shipment(2, 3, 4, 0.76, 1.28);

    double vol;

    vol = shipment1.volume();
    System.out.println("Volume of shipment1 is " + vol);
    System.out.println("Weight of shipment1 is "
                       + shipment1.weight);
    System.out.println("Shipping cost: $" + shipment1.cost);
    System.out.println();
    vol = shipment2.volume();
    System.out.println("Volume of shipment2 is " + vol);
    System.out.println("Weight of shipment2 is "
                       + shipment2.weight);
    System.out.println("Shipping cost: $" + shipment2.cost);
  }
}
```

```
Volume of shipment1 is 3000.0
Weight of shipment1 is 10.0
Shipping cost: $3.41

Volume of shipment2 is 24.0
Weight of shipment2 is 0.76
Shipping cost: $1.28
```

*The entire class hierarchy, including **Box, BoxWeight, and Shipment, is shown all in one file.** In Java, all three classes could have been placed into their own files and compiled separately. In fact, using separate files is the norm, not the exception, in creating class hierarchies.*

Inheritance

- In a class hierarchy, constructors are called in order of derivation, from superclass to subclass.
- Further, since **super( )** must be the first statement executed in a subclass' constructor, this order is the same whether or not **super( )** is used.
- If **super( )** is not used, then the default or parameterless constructor of each superclass will be executed.

Inheritance

```
// Demonstrate when constructors are called.

// Create a super class.
class A {
  A() {
    System.out.println("Inside A's constructor.");
  }
}
// Create a subclass by extending class A.
class B extends A {
  B() {
    System.out.println("Inside B's constructor.");
  }
}

// Create another subclass by extending B.
class C extends B {
  C() {
    System.out.println("Inside C's constructor.");
  }
}

class CallingCons {
  public static void main(String args[]) {
    C c = new C();
  }
}
```

The output from this program is shown here:

```
Inside A's constructor
Inside B's constructor
Inside C's constructor
```

The constructors are called in order of derivation, it makes sense that constructors are executed in order of derivation.

Because a superclass has no knowledge of any subclass, any initialization it needs to perform is separate from and possibly prerequisite to any initialization performed by the subclass. Therefore, it must be executed first.

Inheritance

Method Overriding:

- In a class hierarchy, when a method in a subclass has the same name and type signature as a method in its superclass, then the method in the subclass is said to *override the method in* the superclass.
- When an overridden method is called from within a subclass, it will always refer to the version of that method defined by the subclass. The version of the method defined by the superclass will be hidden.

Inheritance

Method Overriding:...

```
// Method overriding.
class A {
  int i, j;
  A(int a, int b) {
    i = a;
    j = b;
  }

  // display i and j
  void show() {
    System.out.println("i and j: " + i + " " + j);
  }
}
```

When show( ) is invoked on an object of type B, the version of show( ) defined within B is used. That is, the version of show( ) inside B overrides the version declared in A. To access the superclass version of an overridden method, you can do so by using super.

```
class B extends A {
  int k;

  B(int a, int b, int c) {
    super(a, b);
    k = c;
  }
  void show() {
    super.show(); // this calls A's show()
    System.out.println("k: " + k);
  }
}
```

```
class B extends A {
  int k;

  B(int a, int b, int c) {
    super(a, b);
    k = c;
  }

  // display k - this overrides show() in A
  void show() {
    System.out.println("k: " + k);
  }
}

class Override {
  public static void main(String args[]) {
    B subOb = new B(1, 2, 3);

    subOb.show(); // this calls show() in B
  }
}
```

Inheritance

Method Overriding:...

```
// Methods with differing type signatures are overloaded - not
// overridden.
class A {
  int i, j;

  A(int a, int b) {
    i = a;
    j = b;
  }

  // display i and j
  void show() {
    System.out.println("i and j: " + i + " " + j);
  }
}

// Create a subclass by extending class A.
class B extends A {
  int k;

  B(int a, int b, int c) {
    super(a, b);
    k = c;
  }

  // overload show()
  void show(String msg) {
    System.out.println(msg + k);
  }
}
```

```
class Override {
  public static void main(String args[]) {
    B subOb = new B(1, 2, 3);

    subOb.show("This is k: "); // this calls show() in B
    subOb.show(); // this calls show() in A
  }
}
```

- Method overriding occurs *only when the names and the type signatures of the two* methods are identical.
- If they are not, then the two methods are simply overloaded.

Inheritance

Dynamic Method Dispatch:

- Method overriding forms the basis for one of Java's most powerful concepts: *dynamic method dispatch.*
- *Dynamic method dispatch* is the mechanism by which a call to an overridden method is resolved at run time, rather than compile time.
- Dynamic method dispatch is important because this is how Java implements run-time polymorphism.
- **An important principle:** ***A superclass reference variable can refer to a subclass object.***
- ***Java uses this fact to resolve calls to overridden methods at run time.***

Inheritance

Dynamic Method Dispatch:...

- When an overridden method is called through a superclass reference, Java determines which version of that method to execute based upon the type of the object being referred to at the time the call occurs.
- Thus, this determination is made at run time. When different types of objects are referred to, different versions of an overridden method will be called.

Inheritance

Dynamic Method Dispatch:...

- **In other words, *it is the type of the object being referred to (not the type of the reference variable) that determines which version of an overridden method will be executed.***
- Therefore, if a superclass contains a method that is overridden by a subclass, then when different types of objects are referred to through a superclass reference variable, different versions of the method are executed.

Inheritance

Dynamic Method Dispatch:...

```
// Dynamic Method Dispatch
class A {
   void callme() {
     System.out.println("Inside A's callme method");
   }
}

class B extends A {
  // override callme()
  void callme() {
    System.out.println("Inside B's callme method");
  }
}

class C extends A {
  // override callme()
  void callme() {
    System.out.println("Inside C's callme method");
  }
}
```

```
class Dispatch {
  public static void main(String args[]) {
    A a = new A(); // object of type A
    B b = new B(); // object of type B
    C c = new C(); // object of type C
    A r; // obtain a reference of type A
    r = a; // r refers to an A object
    r.callme(); // calls A's version of callme

    r = b; // r refers to a B object
    r.callme(); // calls B's version of callme

    r = c; // r refers to a C object
    r.callme(); // calls C's version of callme
  }
}
```

Inheritance

Dynamic Method Dispatch:...

Why Overridden Methods?

- Overridden methods allow Java to support run-time polymorphism. Polymorphism is essential to object-oriented programming for one reason: ***It allows a general class to specify methods that will be common to all of its derivatives, while allowing subclasses to define the specific implementation of some or all of those methods.***
- Overridden methods are another way that Java implements the **"One interface, Multiple methods"** aspect of polymorphism.

Inheritance

Dynamic Method Dispatch:...*Applying Method Overriding*

```
// Using run-time polymorphism.
class Figure {
  double dim1;
  double dim2;

  Figure(double a, double b) {
    dim1 = a;
    dim2 = b;
  }

  double area() {
    System.out.println("Area for Figure is undefined.");
    return 0;
  }
}

class Rectangle extends Figure {
  Rectangle(double a, double b) {
    super(a, b);
  }

  // override area for rectangle
  double area() {
    System.out.println("Inside Area for Rectangle.");
    return dim1 * dim2;
  }
}

class Triangle extends Figure {
  Triangle(double a, double b) {
    super(a, b);
  }

  // override area for right triangle
  double area() {
    System.out.println("Inside Area for Triangle.");
    return dim1 * dim2 / 2;
  }
}
```

```
class FindAreas {
  public static void main(String args[]) {
    Figure f = new Figure(10, 10);
    Rectangle r = new Rectangle(9, 5);
    Triangle t = new Triangle(10, 8);
    Figure figref;

    figref = r;
    System.out.println("Area is " + figref.area());

    figref = t;
    System.out.println("Area is " + figref.area());

    figref = f;
    System.out.println("Area is " + figref.area());
  }
}
```

Inheritance

- **Using Abstract Classes:**
- There are situations in which you will want to define a superclass that declares the structure of a given abstraction without providing a complete implementation of every method.
- Sometimes you will want to create a superclass that only defines a generalized form that will be shared by all of its subclasses, leaving it to each subclass to fill in the details. Such a class determines the nature of the methods that the subclasses must implement.
- One way this situation can occur is when a superclass is unable to create a meaningful implementation for a method.

Inheritance

- **Using Abstract Classes:...**
- You can require that certain methods be overridden by subclasses by specifying the **abstract** type modifier. These methods are sometimes referred to as ***subclasser responsibility*** because they have no implementation specified in the superclass. Thus, a subclass must override them—it cannot simply use the version defined in the superclass.
- To declare an abstract method, use this general form:

abstract *type name(parameter-list);*

No method body is present.

Inheritance

- **Using Abstract Classes:...**
- ***Any class that contains one or more abstract methods must also be declared abstract.***
- To declare a class abstract, you simply use the **abstract** keyword in front of the class keyword at the beginning of the class declaration.
- There can be no objects of an abstract class. That is, an abstract class cannot be directly instantiated with the **new** operator. Such objects would be useless, because an abstract class is not fully defined. ***Also, you cannot declare abstract constructors, or abstract static methods.***
- Any subclass of an abstract class must either implement all of the abstract methods in the superclass, or be itself declared **abstract.**

Inheritance

- **Using Abstract Classes:...** ***An Example***

```
// A Simple demonstration of abstract.
abstract class A {
  abstract void callme();

  // concrete methods are still allowed in abstract classes
  void callmetoo() {
    System.out.println("This is a concrete method.");
  }
}

class B extends A {
  void callme() {
    System.out.println("B's implementation of callme.");
  }
}

class AbstractDemo {
  public static void main(String args[]) {
    B b = new B();

    b.callme();
    b.callmetoo();
  }
}
```

Abstract classes can include as much implementation as they see fit.

Although abstract classes cannot be used to instantiate objects, they can be used to create object references, because Java's approach to run-time polymorphism is implemented through the use of superclass references.

Thus, it must be possible to create a reference to an abstract class so that it can be used to point to a subclass object.

Inheritance

- **Using Abstract Classes:...** ***An Example***

```
// Using abstract methods and classes.
abstract class Figure {
  double dim1;
  double dim2;

  Figure(double a, double b) {
    dim1 = a;
    dim2 = b;
  }

  // area is now an abstract method
  abstract double area();
}

class Rectangle extends Figure {
  Rectangle(double a, double b) {
    super(a, b);
  }

  // override area for rectangle
  double area() {
    System.out.println("Inside Area for Rectangle.");
    return dim1 * dim2;
  }
}

class Triangle extends Figure {
  Triangle(double a, double b) {
    super(a, b);
  }

  // override area for right triangle
  double area() {
    System.out.println("Inside Area for Triangle.");
    return dim1 * dim2 / 2;
  }
}
```

```
class AbstractAreas {
  public static void main(String args[]) {
  // Figure f = new Figure(10, 10); // illegal now
    Rectangle r = new Rectangle(9, 5);
    Triangle t = new Triangle(10, 8);
    Figure figref; // this is OK, no object is created

    figref = r;
    System.out.println("Area is " + figref.area());
    figref = t;
    System.out.println("Area is " + figref.area());
  }
```

Inheritance

- **Using *final* with Inheritance:**
- The keyword **final** has three uses.
  - First, it can be used to create the equivalent of a named constant.
  - The other two uses of **final** apply to inheritance.

Using final to Prevent Overriding

- To disallow a method from being overridden, specify **final** as a modifier at the start of its declaration. Methods declared as **final** cannot be overridden.

Inheritance

- **Using *final* with Inheritance:...**

Using final to Prevent Overriding

- To disallow a method from being overridden, specify **final** as a modifier at the start of its declaration. Methods declared as **final** cannot be overridden.

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

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

Inheritance

- **Using *final* with Inheritance:...**

Using final to Prevent Overriding...

- Methods declared as **final** can sometimes provide a performance enhancement: The compiler is free to *inline* calls to them because it "knows" they will not be overridden by a subclass. When a small **final** method is called, often the Java compiler can copy the bytecode for the subroutine directly inline with the compiled code of the calling method, thus eliminating the costly overhead associated with a method call.
- Inlining is only an option with **final** methods. Normally, Java resolves calls to methods dynamically, at run time. This is called *late binding*. However, since **final** methods cannot be overridden, a call to one can be resolved at compile time. This is called *early binding*.

Inheritance

- **Using *final* with Inheritance:...**

Using final to Prevent Inheritance

- Sometimes you will want to prevent a class from being inherited. To do this, precede the class declaration with **final.** Declaring a class as **final** implicitly declares all of its methods as **final**, too.
- It is illegal to declare a class as both **abstract** and **final** since an abstract class is incomplete by itself and relies upon its subclasses to provide complete implementations.

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

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

Inheritance

- **The 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.

Inheritance

- **The Object Class:...**
- **Object** defines the following methods, which means that they are available in every object.

Method	Purpose
Object clone( )	Creates a new object that is the same as the object being cloned.
boolean equals(Object *object*)	Determines whether one object is equal to another.
void finalize( )	Called before an unused object is recycled.
Class getClass( )	Obtains the class of an object at run time.
int hashCode( )	Returns the hash code associated with the invoking object.
void notify( )	Resumes execution of a thread waiting on the invoking object.
void notifyAll( )	Resumes execution of all threads waiting on the invoking object.
String toString( )	Returns a string that describes the object.
void wait( ) void wait(long *milliseconds*) void wait(long *milliseconds*, int *nanoseconds*)	Waits on another thread of execution.

Inheritance

- **Additional Coverage:**
- **Inheritance in java** is a mechanism in which one object acquires all the properties and behaviors of parent object.
- The idea behind inheritance in java is that you can create new classes that are built upon existing classes. When you inherit from an existing class, you can reuse methods and fields of parent class, and you can add new methods and fields also.
- Inheritance represents the **IS-A relationship**, also known as parent-child relationship. **IS-A is a way of saying: This object *is a* type of that object.**

Inheritance

- **Additional Coverage:...**
- The **extends** keyword is used to achieve inheritance.

```
public class Animal{

}
    public class Mammal extends Animal{

    }
    public class Reptile extends Animal{

    }
        public class Dog extends Mammal{

        }
```

Inheritance

- **Additional Coverage:...*Example***

```
public class Animal{
}
public class Mammal extends Animal{
}
public class Dog extends Mammal{

  public static void main(String args[]){

    Animal a = new Animal();
    Mammal m = new Mammal();
    Dog d = new Dog();

    System.out.println(m instanceof Animal);
    System.out.println(d instanceof Mammal);
    System.out.println(d instanceof Animal);
  }
}
```

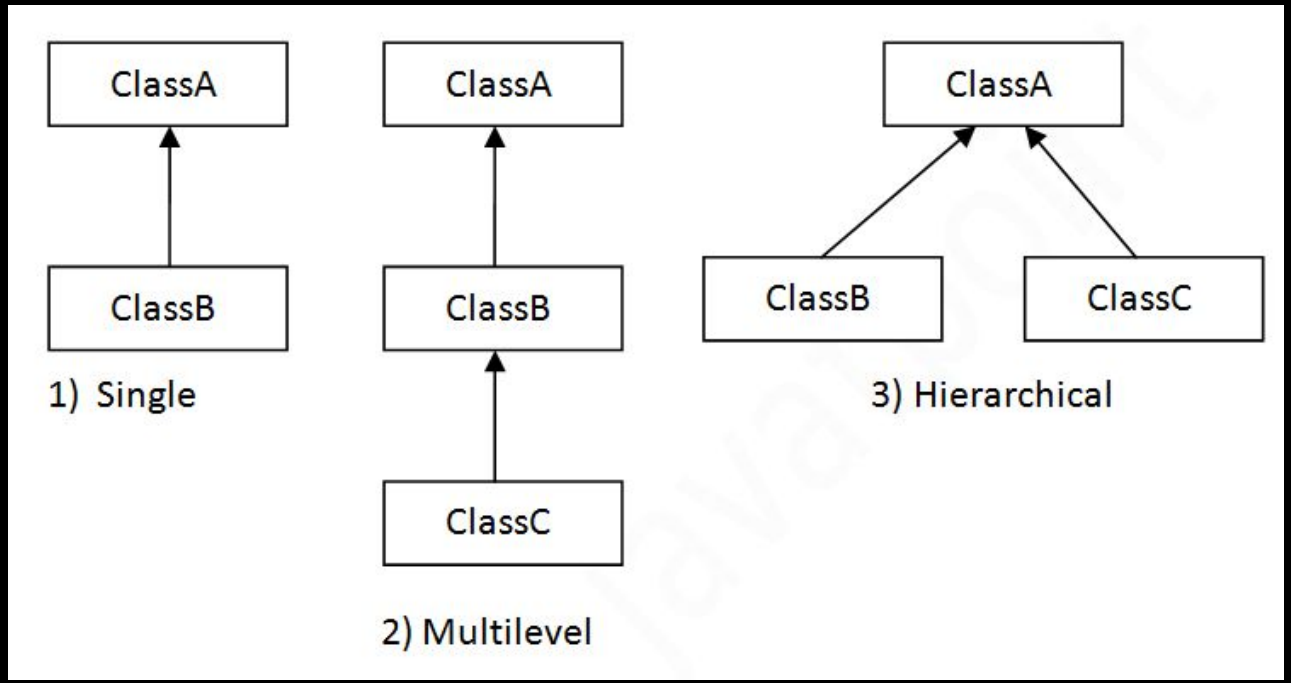
Inheritance

- **Additional Coverage:...**

Why use inheritance in java?

- ✔ For Method Overriding (so runtime polymorphism can be achieved).
- ✔ For Code Reusability.

- **Types:**



Inheritance

- **Additional Coverage:...*Examples***

```
class Parent
{
    public void p1()
    {
        System.out.println("Parent method");
    }
}
public class Child extends Parent {
    public void c1()
    {
        System.out.println("Child method");
    }
    public static void main(String[] args)
    {
        Child cobj = new Child();
        cobj.c1();    //method of Child class
        cobj.p1();    //method of Parent class
    }
}
```

```
class Vehicle
{
    String vehicleType;
}
public class Car extends Vehicle {

    String modelType;
    public void showDetail()
    {
        vehicleType = "Car";          //accessing Vehicle class member
        modelType = "sports";
        System.out.println(modelType+" "+vehicleType);
    }
    public static void main(String[] args)
    {
        Car car =new Car();
        car.showDetail();
    }
}
```

Inheritance

- **Additional Coverage:...*Examples***

Example of Child class refering Parent class `property` using `super` keyword

```
class Parent
{
    String name;

}
public class Child extends Parent {
    String name;
    public void details()
    {
        super.name = "Parent";      //refers to parent class member
        name = "Child";
        System.out.println(super.name+" and "+name);
    }
    public static void main(String[] args)
    {
        Child cobj = new Child();
        cobj.details();
    }
}
```

Inheritance

- **Additional Coverage:...*Examples***

Example of Child class calling Parent class `constructor` using `super` keyword

```
class Parent
{
    String name;

    public Parent(String n)
    {
        name = n;
    }

}
public class Child extends Parent {
    String name;

    public Child(String n1, String n2)
    {

        super(n1);        //passing argument to parent class constructor
        this.name = n2;
    }
    public void details()
    {
        System.out.println(super.name+" and "+name);
    }
     public static void main(String[] args)
    {
        Child cobj = new Child("Parent","Child");
        cobj.details();
    }
}
```