Java Fundamentals

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Agenda

- What is Inheritance?
- Inheritance Terminology
- Furniture Hierarchy
- java.lang.Object
- Polymorphism
  - Overloading
  - Overriding
    - toString
    - Constructor
- instanceof
- Constants

Agenda…

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  - Methods
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  - Methods
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- Abstract Vs final
- Interfaces
  - Abstract methods
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- Interfaces Vs Abstract classes

Inheritance

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Inheritance

- The Java programming language takes advantage of familiar, real life, ideas and concepts.
  - As we saw in the previous chapter, classes are the programming reflection of real world entities.
  - With the inheritance notion we continue this analogy.
- Just like a child inherits its parents' (and their ancestors') genetic characteristics, a class inherits its parent state and behavior.
  - State – data members.
  - Behavior – methods.

Inheritance Terminology

- Some terminology is needed to translate known concepts to Java programming concepts:
  - class – a data type.
  - superclass – the parent, also referred to as the "base" class.
  - extends – the inheritance relation
  - subclass – the child, the class that inherits (extends) the superclass.

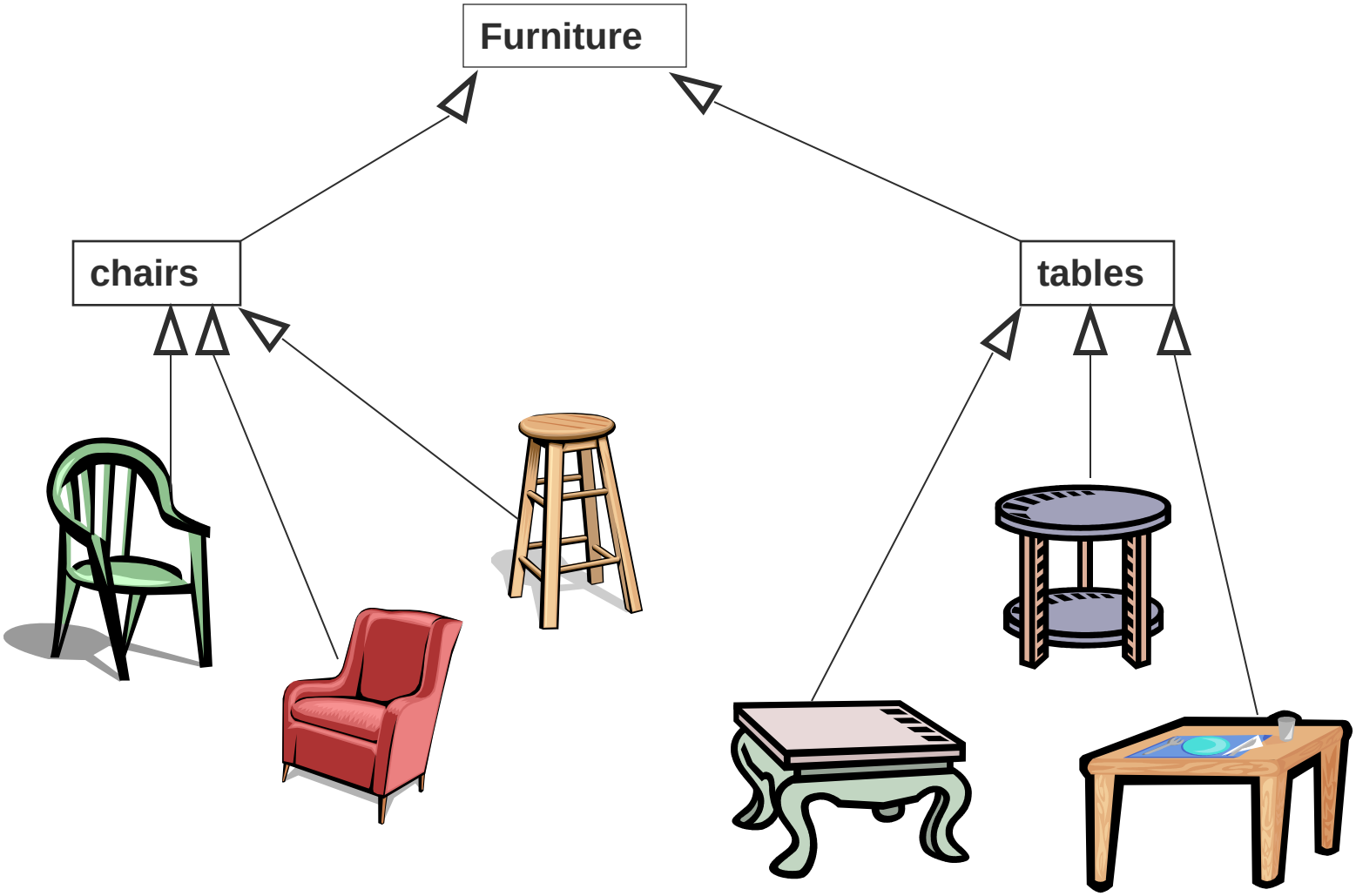
- Java Syntax:

subclass

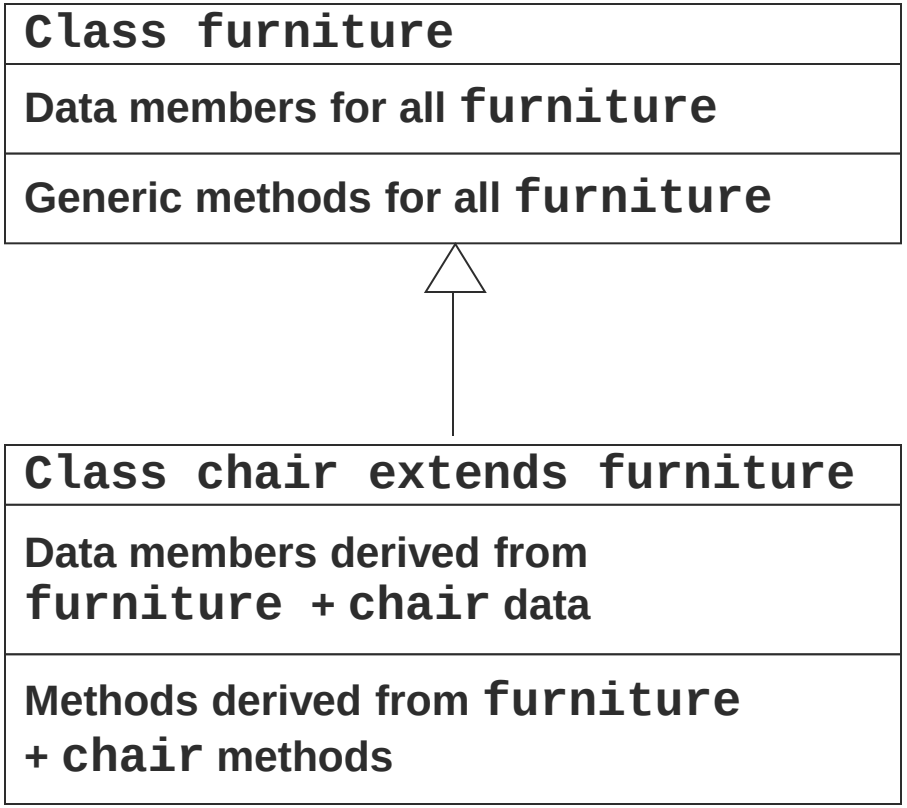
```
class chair extends furniture
{
}
```

superclass

The Furniture Dynasty



Furniture and Chair



Family Ties

```
class Furniture
int       m_nWidth
int       m_nHeight
String    m_sColor
int       m_nPrice
void setPrice(int price)
int  getPrice()
```

Unlike in real life, a class can (usually) choose its parent.

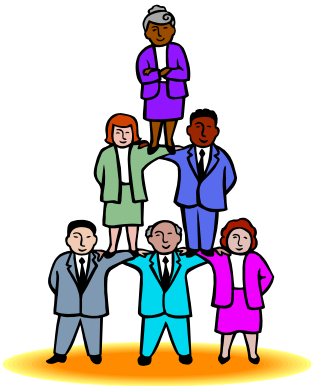
```
class Chair extends Furniture

int       m_nlegs
void adjustHeight(int num);
```

Class chair does not need to redefine `m_nWidth, m_nHeight` or any other data member or method belonging to its parent, furniture. Nevertheless, it is free to use them.

Inheritance Hierarchy

- Java is an Object-Oriented language so it uses inheritance to create a hierarchy model of the conceptual spectrum of the application.
  - As you go deeper inside the inheritance tree, specialization increases.
  - Sticking to the furniture example:
    - An adjustable student chair class will have a lot more features defining it that a mere furniture class.



Inheritance Advantages / Disadvantages

- Inheritance advantages:
  - Avoiding code cloning.
    - No need to re-implement furniture identifiers (Height, Width, etc.) in class chair.
  - Every change in the base class is being immediately reflected in all the classes derived from it.
- Inheritance disadvantages:
  - You may also inherit BUGS.
    - Before software can be reusable it first has to be usable- J

java.lang.Object

- No class is an orphan.
  - Every class has a parent class.
- When the term **`extends`** is omitted, the class is not parent-less, it inherits **`java.lang.Object`**.
- Class **`java.lang.Object`** is located at the root of the class hierarchy.
  - Every class has **`Object`** as a superclass either immediately (a parent) or mastering its ancestors hierarchy.
- Example class TextArea:

```
java.lang.Object
  |
  +--java.awt.Component
        |
        +--java.awt.TextComponent
              |
              +--java.awt.TextArea
```

Everyone Inherits Object

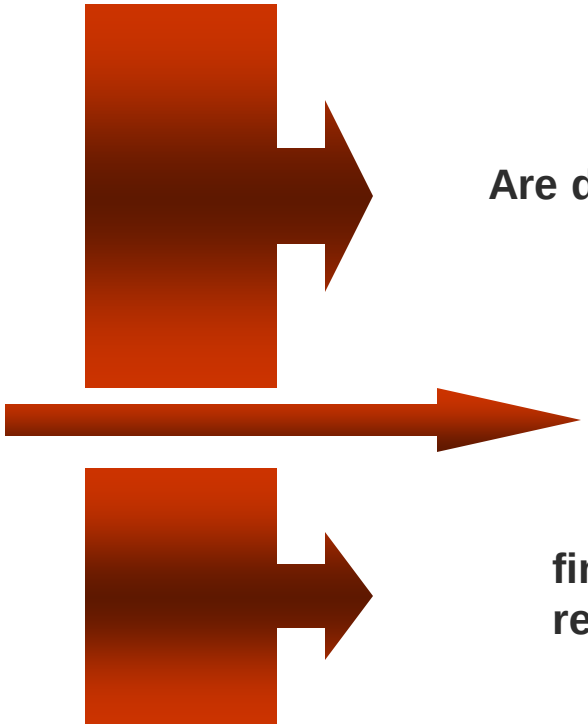
- The next example is a snippet of the output of the javap utility running the following code:

```
class Child
{
  public static void main(String args[])
   {
    System.out.println("I'm the direct child of Object");
   }
}
```

```
C:\Temp\JavaExamples\chapter4>javap -c Child
Compiled from child.java
class Child extends java.lang.Object {
    Child();
    public static void main(java.lang.String[]);
}
```

Class Object Methods

- All Java's objects implement class Object's methods:
  - `equals`
  - `hashCode`
  - `toString`
  - `clone`
  - `finalize`
  - `getClass`
  - `wait`
  - `notify`
  - `notifyAll`



Are designed to be overridden

Will be discussed in relation to reflection

final methods - will be discussed in relation to threads

Polymorphism

- Polymorphism is a complicated and impressive name meant to describe a very simple idea:
  - Using the same method name for different kinds of behavior.
- There are two types of polymorphism in Java:
  - Overloading – was preliminary discussed in the previous chapter.
  - Overriding

Overloading

- Overloading is about declaring some methods, in the same class, with the same name but with a different signature.
  - The signature is determined by the type, number and order of the arguments passed to the method.
- It is highly recommended that you will only overload methods performing related behavior.
- Class String contains a couple of examples for overloading:

```
public String substring(int beginIndex)

public String substring(int beginIndex, int endIndex)
```

Both method are called `subString`. they differ in their signature.

The compiler tests the parameters to decide which method is intended to be used.

Overloading in Class Furniture

```
class Furniture
{
 int m_nWidth;
 int m_nHeight;
 int m_nPrice;
 public void setPrice(int price)
 {
    m_nPrice = price;
 }
 public void setPrice(int price,int discount)
 {
    m_nPrice = price-(price * discount)/100;
 }
```

Overriding

- Overriding is a bit more complicated.
  - A sub class can own a method with the same signature (name and arguments) as its super class.
  - The method in the sub class is overriding, taking the place, of the one in the super class.
- The correct method is invoked at run time depending on the object's type.
  - The run time environment is performing dynamically binding (also called late or delayed binding) which allows it to act according to the object it handles.

Overriding `setPrice`

```
class Chair extends Furniture
{
  private int   m_nlegs;
  private boolean m_bUpholstery;
  private boolean m_bClubMember;
  public void setPrice(int price) {
   if (bClubMember)
     m_nPrice = price – 10;
   else
     m_nPrice = price
  }
  void adjustHeight(int num) {
    m_nHeight+=num;
  }
}
```

Overriding `Object`'s `toString()`

- Although **`java.lang.Object`** provides an implementation to the **`toString`** method, it is highly recommended to override it.
  - The original implementation consists of the class's name followed by the "at" sign (@) and the class's hexadecimal hash code.
    - Something like: "course@f032585a"
  - There is nothing wrong with this, except for it not being very user-friendly or informative.
    - Getting something like: "Java course for C++ programmers" is much more helpful for a class user.

Overriding `Object`'s `toString()`

- The return value of the overridden **`toString`** should be self-explanatory.
  - It should return all (or most) of the important information contained in the class.
- It is also recommended that you not force the class users to solely depend on that method for gathering information about your class.
  - Don't forget to provide your class with access methods for these important members.
- To invoke the **`toString()`** methods, you can explicitly call it or just pass your object into **`System.out.println`**.

toString Example

```
class Course
{
  String m_sName;
  String m_sDesc;
  public Course(String name,String desc)
  {
     m_sName = name;
     m_sDesc= desc;
  }
  public String getName()
  {
     return m_sName;
  }
  public String getDesc()
  {
     return m_sDesc;
  }
  public String toString()  {
    return m_sName +
         " course " + m_sDesc;
  }
}
```

```
class Main
{
  public static void main(String args[])
  {
    Course c = new Course("Java","c++
    programmers");
    System.out.println("registering to: "
    + c);
  }
}
```

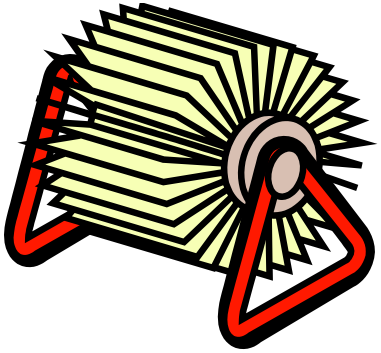
Overriding `equals`

- We have already used it with the `String` object.
- The equals method's role is to indicate whether some other object is "equal to" this one.
- The implementation supplied by **`java.lang.Object`** returns true if, and only if, the two compared referenced checked refer to the same object.
- It is recommended to override equals when the class user is interested to know whether the referenced classes are logically equivalent and whether or not they refer to the same object.

```
public boolean equals(Object obj)
```

Overriding Exercise

- Create a class named Contact with the following members:
  - String m_sFirstName
  - String m_sLastName
  - String m_sPhone
  - Address m_address
    - String m_sStreet
    - String m_sHouseNum
    - String m_sCity
- Override **`equals`** and compare instances of class Contact.



Constructors and Inheritance

- When a sub class is instantiated, it always invokes the constructor of its super class.
  - It does so even before invoking its own constructor.
- Sometimes this default behavior is not enough, and you might wish to invoke your super class constructor explicitly.
  - This is essential when arguments are to be passed to it!
  - If this is the case, you will do so using the keyword **`super`**.

Invoking a Super-class Constructor

```
class Chair extends Furniture
{
  private int     m_nlegs;
  private boolean m_bUpholstery;
  public chair()
  {
     super("wood"); // Call the parent's Ctor
     System.out.println("Inside chair constructor");
  }
  void adjustHeight(int num)
  {
    m_nHeight+=num;
  }
}
```

Class `Chair` is now invoking a `Furniture` constructor that expects a string.

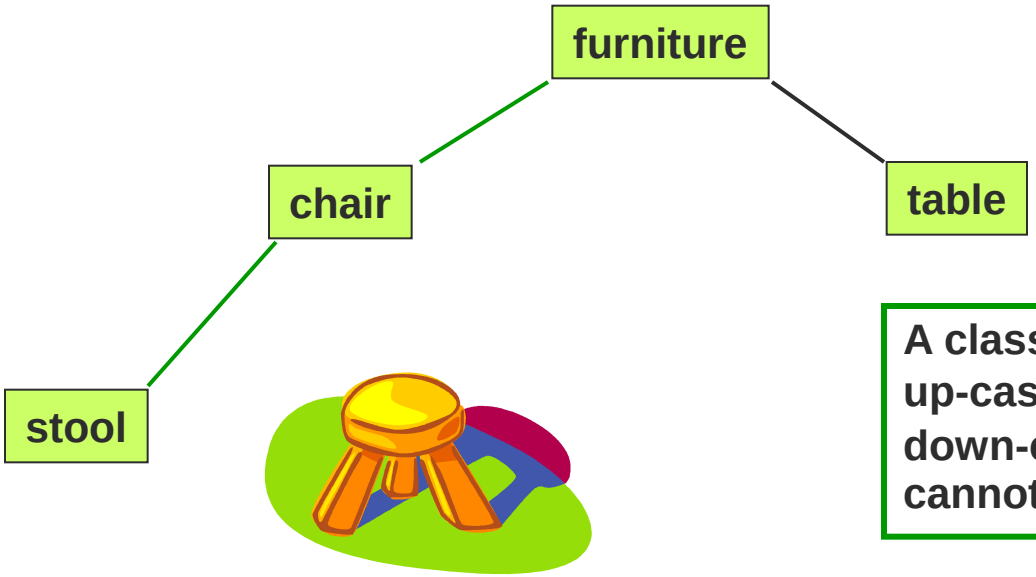
`super` should be the first line in the child class constructor.

Unveiling the Shadows

- The **`super`** keyword is also used to approach fields declared in the super class.
  - Class **`Chair`** can access the data members of class **`Furniture`** using the following syntax:
    - **`super.m_nHeight = 5;`**
  - The statement shown here is correct but yet verbose.
    - Class **`Furniture`** contains a data member by this name but class **`Chair`** does not, so it can be accessed without using **`super`**.
  - The use of **`super`** is unavoidable when a sub class is using an identically named data member as its parent or one of its ancestors.
    - Note that you cannot use **`super.super.super.member-name`** **……**

Casting

- Performing a casting action on an object means that you convert that object to another kind of object.
  - Casting can only be performed along the hierarchy tree, you cannot cast it "to the sides“.



A class of type `Chair` can be up-cast to `Furniture` and down-cast to stool, but it cannot be cast to a `Table` .....

Up - casting

- **Up-casting** is performed when a general object holds a more specialized one.
- It is completely legal to do the following casting:

```
Furniture MyFurniture = new Chair();
```

  - In this case we can only access, through **`MyFurniture`**, methods and data members declared in the super class, **`Furniture`**.
  - This kind of casting is very useful when you cannot be sure, in advance, exactly which one of **`furniture`** descents you will be instantiating.
- The other way around is, of course, illegal:

```
Chair MyChair = new Furniture();
```

Up – casting Example

```
class MyCast
{
  public static void main(String args[])
  {
     Furniture f = new Chair();
     f.setPrice(5);
     //f.adjustHeight(5);
  }
}
```

Up-casting: you can always simply do parent = child. (The other way around is a little more complicated.)

`setPrice()` is declared in class `Furniture` (the super class) so it can be accessed.

`adjustHeight(..)` cannot be accessed because it is not declared in the general class.

Down - casting

- **Down-casting** is a bit more complicated than up-casting:
  - It means to convert a general object to a more specialized one.
    - Note that both of them must be on the same hierarchy tree.
- In other words:
  - We expect that when we cast an object of type **`Furniture`** to **`Chair`**, it will have access to class **`Chair`** methods and data members.
  - This is only possible if is was initially referring to **`Chair`**:

```
Furniture F = new Chair();
Chair C = (Chair)F;
```

Down-cast Example

```
class MyCast
{
  public static void main(String args[])
  {
     Furniture F = new Chair();
     //F.adjustHeight(3);
     Chair C = (Chair)F;
     C.adjustHeight(3);
  }
}
```

Will not compile …

F can only access Furniture properties

After the down-cast, to Chair, the new reference can be used to freely access class Chair properties

No Sideways Casting

- As depicted a few slides ago, there are two classes that extend class **`Furniture`**: **`Chair`** and **`Table`**.
  - Casting can be made between **`Furniture`** and **`Chair`** but a **`Chair`** (as hard as it tries) will never become a **`Table`**.

```
Furniture F = new Table();

Chair C = (Chair)F;
```

Is legal and will compile.

Will compile but when checked, at run time, will throw a `ClassCastException`.

The Ultimate Ancestor

- Since **`java.lang.Object`** is the ancestor of all Java objects it can be assigned each one of them.
- Class **`Vector`** is a container for objects.
  - It will be discussed in detail in later chapters.
  - Here we will use 2 of its methods to demonstrate casting.

```
public void addElement(Object obj)
```

Expects an `Object` so we can practically supply it with any type of object

```
public Object elementAt(int index)
```

The method returns an object of type `Object` that must be explicitly down-cast to be used

MyVector.java

```
import java.util.Vector;
 class MyVector
{
  Vector m_vChairVect;
  public static void main(String args[])
  {
     MyVector chairVec = new MyVector();
  }
public MyVector()
  {
    m_vChairVect = new Vector(); // Create a new collection
    buildVec();
    changeHeight();
  }
```

Up and Down Casting

```
public void buildVec()
  {
    for (int i=0;i<5;i++){
      Chair c = new Chair();
      m_vChairVect.addElement(c);  // Add a new element
    }
  }
public void changeHeight() {
    for (int i=0;i<m_vChairVect.size();i++)
    {
       // Get an element out of the collection:
       Chair c = (Chair)m_vChairVect.elementAt(i);
       c.adjustHeight(i);
       System.out.println("the chair height is: " +
                                c.getHeight());
    }
  }
}
```

Safe Casting

- When performing a down-cast, it is essential to know how the object was declared in the beginning.
- In the last slide, we created objects of type **`Chair`** and placed them inside a **`Vector`**.

```
Chair c = new Chair();
m_vChairVect.addElement(c);
```

  - When we took them out, we received objects of type **`Object`** and performed a down-cast.

```
Chair c = (Chair)m_vChairVect.elementAt(i);
```

  - Neglecting to perform the correct cast (anything but **`Chair`**) would have been ended in an exception being thrown.
    - The obvious conclusion is that we must perform safe casting.

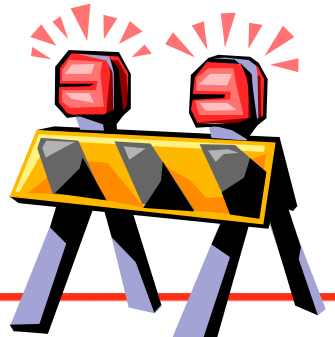
The `instanceof` Operator

- The `instanceof` operator is designed to compare a reference with a type.
  - So, in order to perform a safe cast, we have recoded the method **`changeHeight`**:

```
public void changeHeight()
  {
    for (int i=0;i<m_vChairVect.size();i++){
       Object obj = m_vChairVect.elementAt(i);
       if (obj instanceof Chair){  // Safe downcasting
         Chair c = (Chair)obj ;
          c.adjustHeight(i);
          System.out.println("the chair height is: " + c.getHeight());
         }
    }
  }
```

Blocking Inheritance

- A little earlier, we said that a class is lucky to pick its dream parent.
  - Well, it is time to add a little exception to this notion!
- When a class is declared **`final`** it cannot be extended.
  - If you try to extend it, you will end up with a run time error.
- What's the purpose of blocking inheritance?
  - When a class is being extended, the sub class does not only inherit data members and methods. It can also change them (a lot more about this will shortly follow).
    - There might be times when a class developer is not so liberal as to allow that.
    - Either the developer is restricted to some pattern or behavior that should not be changed – kind of a constant, really.



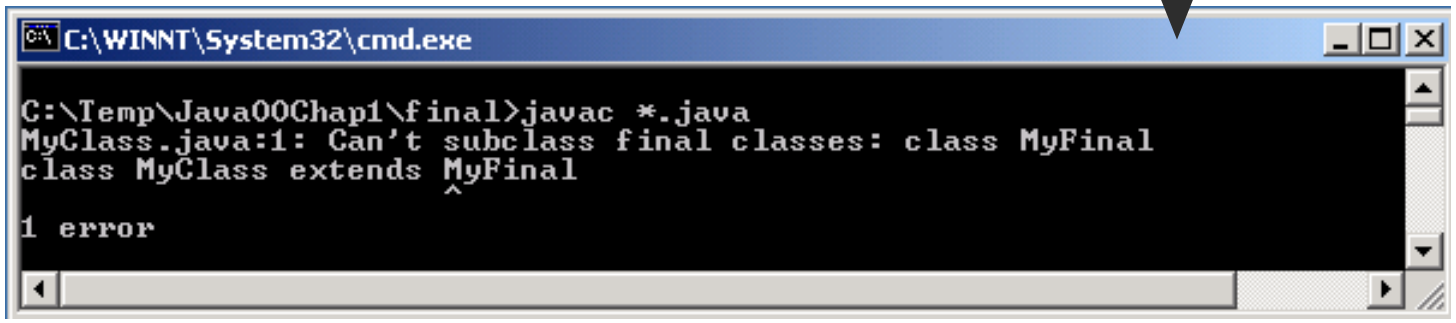
Final Classes

```
final class MyFinal
{
   public MyFinal()
  {
   System.out.println("I'm the ultimate class");
  }
}
```

This class is `final`

```
class MyClass extends MyFinal
{
}
```

This class tries to extend a `final` class. The result:



`final` Methods

- So, in order to prevent a class from being extended, we use the keyword **`final`**.
  - It is possible to apply a very similar behavior to a class's method.
  - When a method is declared **`final`** it cannot be overridden.
- Naturally, another type of methods that cannot be overridden are **`static`** methods.
  - Quite reasonable when you think about it:
    - A **`static`** method belongs to a class, not an instance, so there is never any ambiguity about its owner.

Abstract Class

- We have previously seen how a class author can block its creation from being extended.
- The keyword `abstract` is used to do the opposite:
  - An abstract class must be extended in order to create an instance.
  - An abstract class cannot be instantiated.
- You can think about an abstract class as a concept.
  - This does not prevent it from containing methods and data members.

Food and Omelet

```
abstract class Food
{
 int     m_nCalories;
 public int CaloriesPerAmount(int amount)
 {
  return (m_nCalories*amount)/100;
 }
 public void setCaloriesPer100gram(int cal)
 {
  m_nCalories = cal;
 }
}
```

```
class Omelet extends Food
{
}
```

Only `Omelet` can be instantiated, invoke class Food methods and use its data members.

Abstract Method

- An abstract method is an empty one, it does not include implementation.
  - A class containing at least one abstract method must be declared abstract.
  - However, an abstract class doesn’t have to make all its methods abstract !
- The extending class must handle it in one of two ways:
  - Implement the method.
  - Declare it the same way its super class has done, which will make it an abstract class too.
- A class extending an abstract class must be careful to implement all its super's abstract methods or else it would itself become abstract.

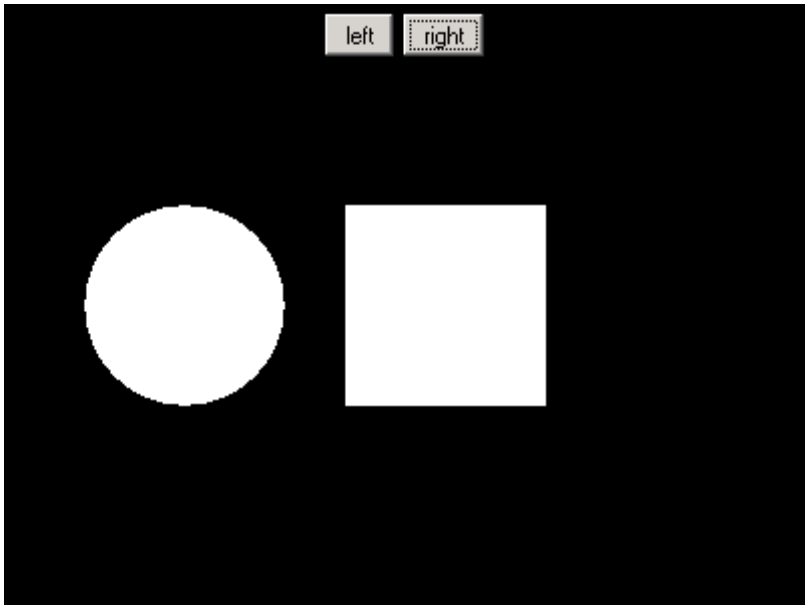
Abstract Method Example

```
abstract class Food
{
 abstract public void importantInfo();
}
```

```
class Omelet extends Food
{
  public void importantInfo()
  {
      System.out.println("Just throw some eggs,
       oil and salt into a frying pan");
  }
}
```

Abstract Class Example

- The following example contains one abstract class: **`Shape`** and two classes that inherit it: **`Cycle and Rectangle.`**
- Class Shape has two methods:
  - An abstract method **`draw`**.
    - Which is implemented in the extending classes.
  - A real method to **`move`** which is responsible for moving a shape left and right.



Class Board

```
import java.applet.*;
import java.awt.*;
import java.awt.event.*;
public class Board extends Applet
{
    Shape sArr[]=new Shape[2];
    Board brd;
    public void init()
    {
        brd=this;
        Implementor imp=new Implementor();
        this.setBackground(Color.black);
        this.setForeground(Color.white);
        Button bLeft=new Button(" left ");
        bLeft.addActionListener(imp);
        Button bRight=new Button(" right ");
        bRight.addActionListener(imp);
        this.add(bLeft);
        this.add(bRight);
```

The Action Listener

```
20.                 //creating the shapes that will be draw on the applet
21.                 sArr[0]=new Circle(120,100,100,100);
22.                 sArr[1]=new Rectangle(250,100,100,100);
23.         }
24.         public void paint(Graphics g){
25.                 for(int i=0;i<sArr.length;i++)
26.                 {
27.                         sArr[i].draw(g);
28.                 }
29.         }
30.         private class Implementor implements ActionListener  {
31.                 public void actionPerformed(ActionEvent e)
32.                 {
33.                         if(e.getActionCommand().equals(" left "))
34.                         {
35.                                 for(int i=0;i<sArr.length;i++)
36.                                 {
37.                                         sArr[i].move("left",brd);
38.                                 }
```

Class Board - cont'd

```
                        }
                       else
                       {
                               for(int i=0;i<sArr.length;i++)
                               {
                                   sArr[i].move("right",brd);
                               }
                       }
               }
      }
}
```

Class Shape

```
import java.awt.*;
abstract public class Shape
{
        int x,y,width,height;

        abstract public void draw(Graphics g);

        public void move(String direction,Board brd){
                if(direction.equals("right")&& x<=390)
                {
                        x+=10;
                }
                else{
                        if(direction.equals("left")&& x>=10)
                                x-=10;
                }
                brd.repaint();
        }
}
```

Class Circle

```
import java.awt.*;
public class Circle extends Shape
{
        public Circle(int x,int y,int width,int height)
        {
                this.x=x;
                this.y=y;
                this.width=width;
                this.height=height;
        }
        public void draw(Graphics g)
        {
                g.fillOval(x,y,width,height);
        }
}
```

Class Rectangle

```
import java.awt.*;
public class Rectangle extends Shape
{
        public Rectangle(int x,int y,int width,int height)
        {
                this.x=x;
                this.y=y;
                this.width=width;
                this.height=height;
        }
        public void draw(Graphics g)
        {
                g.fillRect(x,y,width,height);
        }
}
```

Summary

- Just like a child inherits its parents' (and their ancestors') genetic characteristics, a class inherits its parent state and behavior
- Inheritance Terminology
  - Super class
  - Sub Class
- java.lang.Object is ancestor for all
- Overloading
  - add(int a, int b)
  - add(String a, String b)
- Overriding
    - toString
- Calling super class Constructor using super
- final static String COLOR="RED"

Summary…

- Abstract
  - Methods
    - Only declaration
  - Classes
    - Can’t be instantiated
- Final
  - Classes
    - Cant be inherited
  - Methods
    - Cant be overridden
  - Data
    - Can’t be changed
- Abstract Vs final

A Single Parent

- Java does not support multiple inheritance.
  - Every sub class may have exactly one direct super class.
- The language designers have decided to leave out multiple inheritance because of the difficulties and complications it creates.
- Java has an elegant bypass to this matter, called **interface**.
  - By using interfaces you can gain some of the benefits of a super class, without having to deal with complications.

~~**class Chair extends Furniture , office-stuff**~~

Interfaces

- An **interface** is a skeleton of a class, it specifies a set of unimplemented methods and class variables.
  - The classes making use of the interface are responsible for implementing these methods.

The keyword `implements` is used to specify a connection between a class and an interface.

```
Class MyClass implements IMyInterface
{
   public void work() {
    System.out.println("I'm working very hard");
   }
 }
```

```
interface IMyInterface {
   public void work();
}
```

Multiple Interfaces

- The fact that the interface's methods are abstract (lack implementation) creates an elegant round-about to the multiple inheritance problem.
  - A class may extend only one class but may implement as many interfaces as it likes without worrying about names collision.

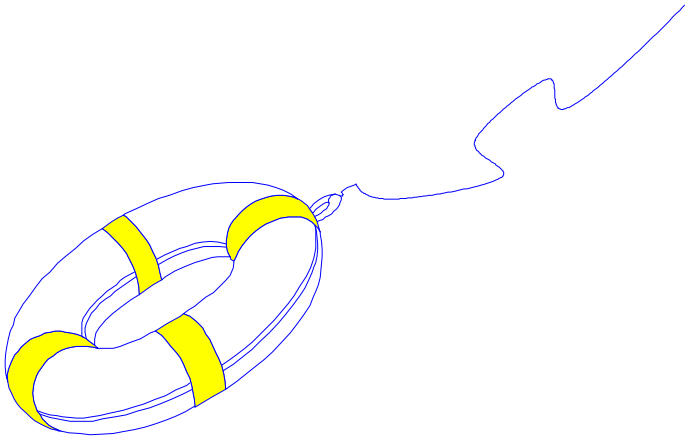
```
class MyClass extends YourClass implements IMyInterface,
IHerInterface, IHisInterface
 {
   . . . . . .
 }
```

Reusing Interfaces

- An interface may extend other interfaces.

```
interface IMyInterface extends Runnable, Serializable
```

Both Runnable and Serializable belong to the Java API



Named Constants

- The methods and the data members of an interface are actually constants, they are always **`public`**, **`static`** and **`final`**.
  - You don't need to include any of those keywords in the interface's code to make them like that.
- You can use an interface to declare a set of named constants:

```
class MyClass implements Isalaries {
   public static void main(String args[])
   {
      System.out.println("My salary is: "+ 2*minSalary);
   }
}
```

```
interface ISalaries {
    int minSalary = 500;
    int maxSalary = 50000;
}
```

Implementing Multiple Interfaces

```
class Person implements ISleep, IWork
{
  public Person()
  {
    TaskList task = new TaskList();
    task.add(this);
  }
  public void sleep()
  {
    System.out.println("I'm sleeping 12 hours a day");
  }
  public void work()
  {
    System.out.println("I'm working 4 hours a day");
  }
}
```

```
interface ISleep
{
  public void sleep();
}
```

```
interface IWork
{
  public void work();
}
```

The whole `Person` object is being sent to the `TaskList` object.

Main and TaskList Classes

```
class Main
{
  public static void main(String args[])
  {
    Person person = new Person();
  }
}
```

```
class TaskList
{
   IWork m_work;
   public void add(IWork work)
   {
     m_work = work;
     m_work.work();
   }
}
```

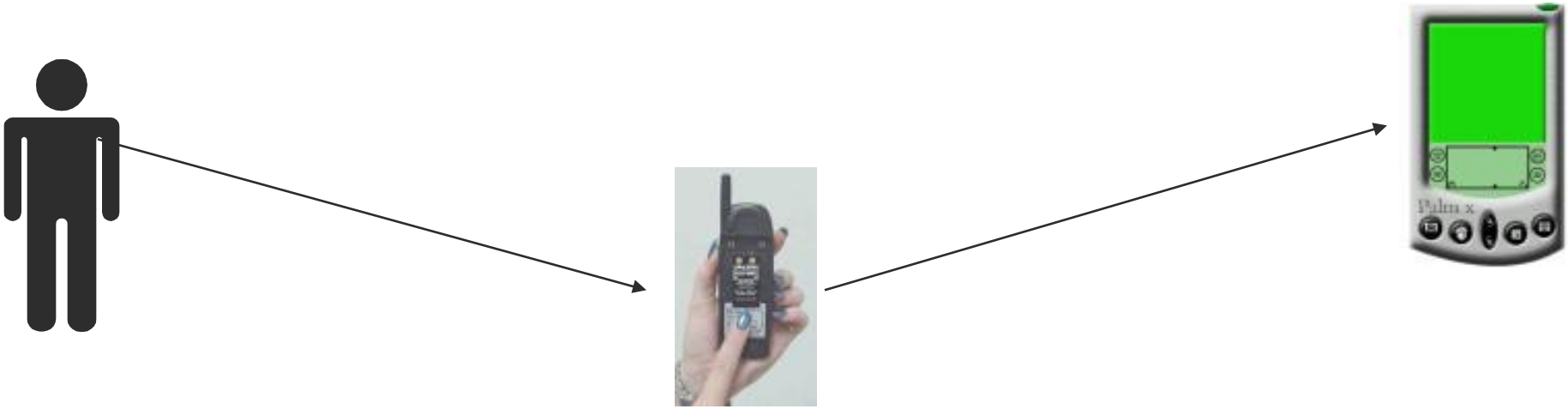
Inside `TaskList` we recognize only the part of `Person` which implements `Iwork`.

Interfaces vs. Abstract Classes

- Interfaces and abstract classes have a lot in common:
  - Specify a set of methods for an object.
  - Cannot be instantiated.

- However, don’t forget they also have 2 important differences:
  - While an interface can’t implement any of its declared methods, an abstract class may offer implementation.
  - Naturally, and abstract class prevents you from extending another class in the future.

Interfaces – Another Perspective



An interface is a named collection of method definitions (without implementations).

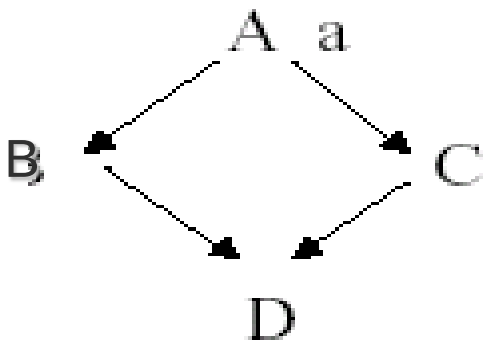
An interface defines a protocol of behavior that can be implemented by any class anywhere in the class hierarchy.

An interface defines a set of methods but does not implement them.

Interfaces…

A technique to obtain multiple inheritance without problems of inheriting the same instance variable twice

- Contain only specifications, not code
- Can be implemented by many classes
- Provides for shared functionality
- All methods are public
- Also can be used to inherit constants



Example

```
class Circle extends Shape
        {       Point center;
                Integer radius;
        }
        public interface Scalable
        {       public void changeScale(int percent);}

class ScalableCircle extends Circle implements Scalable
                {
                                // changeScale() method must be implemented here
                                public void changeScale(int percent){. . .};
                }
```

(similarities)

A variable can be declared using *either* its **class** type *or* its **interface** type:

Scalable c = new ScalableCircle();

- Both can be extended:

```
public interface Readable
{
public String read();
}
public interface Searchable extends Readable
{
public int findPosition();
}
```

Differences

Interfaces cannot specify static methods

Interfaces cannot have instance variables

Interfaces cannot be instantiated using new

One class may implement multiple interfaces

```
public class Word implements Searchable, Replaceable
{
public int findPosition(Searchable s) {...}
public void replace(Replaceable w1,
Replaceable w2) {...}
}
```

}

Packages

Packages are

- Mechanism for partitioning the class name space into more manageable chunks
- Containers for classes that are used to keep the class name space compartmentalized
- Naming and visibility control mechanism

Defining Package

- Include *package* Command
- *It should be the first statement of java source file*.

File System Directories are used to store a package

Hence….

Folder should be created to store .class files with same name as of package Name

```
package myPackage;

public class ProtectionDemo
{
        ……
} // end class

subclass inside myPackage:

package myPackage;
public class subDemo extends ProtectionDemo
{
        public class User
                {
                        public void printStuff() {
                        ProtectionDemo d = new ProtectionDemo();
                        ….
                } end printStuff
} // end
```

}

Executing the package

Java mypack.user

Importing Packages

- To bring the certain classes or entire packages into visibility.

```
Import package.classname
```

}

Access Levels

Modifier	Class	Package	Subclass	World
public	Y	Y	Y	Y
protected	Y	Y	Y	N
no modifier	Y	Y	N	N
private	Y	N	N	N

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