Topic #7:
Classes, Interfaces, Inheritance

CSE 413, Autumn 2004

Programming Languages

http://www.cs.washington.edu/education/courses/413/04au/

Readings and References

- Reading in Java tutorial
  - » Object Basics and Simple Data Objects
  - » Classes and Inheritance
  - » Interfaces and Packages
  - » http://java.sun.com/docs/books/tutorial/java/TOC.html#concepts

Recall: Objects and Classes

- A class is a definition of a *type of thing*
  1. State
  2. Behavior
- An object is a *particular thing*
  - » An object is an *instance* of a class

Example : java.util.Random

```
package java.util;
public class Random implements java.io.Serializable {
   static final long serialVersionUID = 3905348978240129619L;
   private long seed;
   private final static long multiplier = 0x5DEECE66DL;
   private final static long addend = 0xBL;
   private final static long mask = (1L << 48) - 1;
   public Random() {...}
   public Random(long seed) {...}
   synchronized public void setSeed(long seed) {...}
   synchronized protected int next(int bits) {...}
   private static final int BITS_PER_BYTE = 8;
   private static final int BYTES_PER_INT = 4;
   public void nextBytes(byte[] bytes) {...}
   public int nextInt() {...}
   public int nextInt(int n) {...}
   public long nextLong() {...}
   public boolean nextBoolean() {...}
   public float nextFloat() {...}
   public double nextDouble() {...}
   private double nextNextGaussian;
   private boolean haveNextNextGaussian = false;
   synchronized public double nextGaussian() {...}
}
```

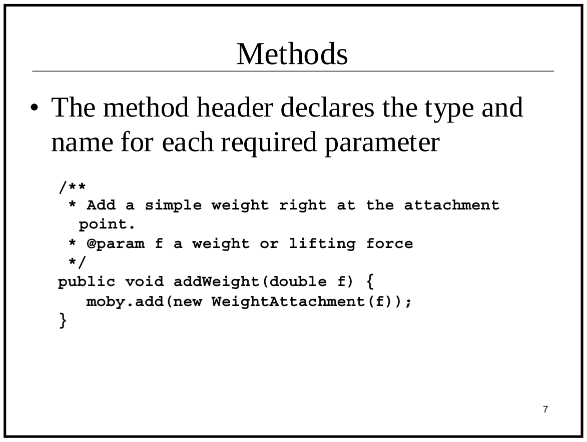
Constructors

- Constructors are special methods that get called with the **`new`** operator

  `Mobile m12 = new Mobile(10);`
- The name of a constructor is the same as the name of the class
- What does it do?
- What if there is no constructor?

Multiple Constructors

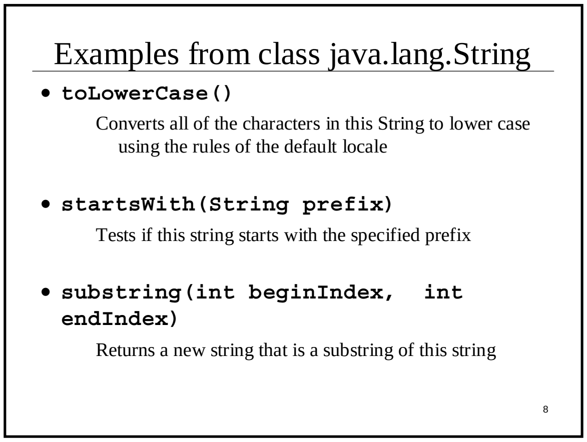
- There are often several constructors for any one class
- They all have the same name (the name of the class)
- They must differ in their parameter lists
  - » **`Mobile m10 = new Mobile();`**
  - » **`Mobile m12 = new Mobile(10);`**
- Return value?



Methods

- The method header declares the type and name for each required parameter

```
/**
 * Add a simple weight right at the attachment
   point.
 * @param f a weight or lifting force
 */
public void addWeight(double f) {
   moby.add(new WeightAttachment(f));
}
```



Examples from class java.lang.String

- **`toLowerCase()`**

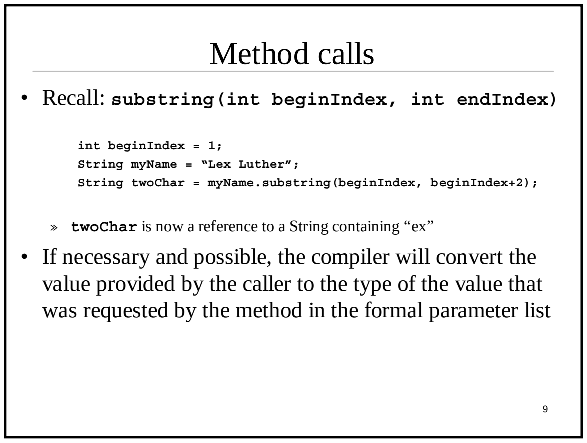
  Converts all of the characters in this String to lower case using the rules of the default locale

- **`startsWith(String prefix)`**

  Tests if this string starts with the specified prefix

- **`substring(int beginIndex,  int endIndex)`**

  Returns a new string that is a substring of this string



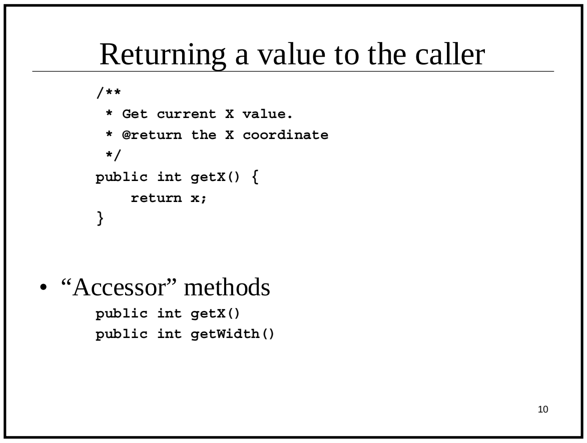
Method calls

- Recall: **`substring(int beginIndex, int endIndex)`**

```
int beginIndex = 1;
String myName = “Lex Luther”;
String twoChar = myName.substring(beginIndex, beginIndex+2);
```

  » **`twoChar`** is now a reference to a String containing “ex”

- If necessary and possible, the compiler will convert the value provided by the caller to the type of the value that was requested by the method in the formal parameter list

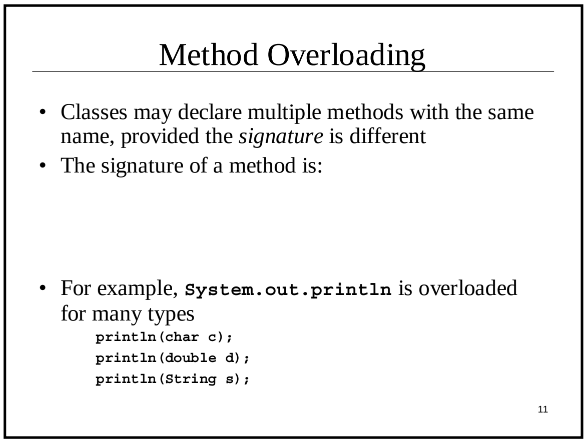


Returning a value to the caller

```
/**
 * Get current X value.
 * @return the X coordinate
 */
public int getX() {
    return x;
}
```

- “Accessor” methods

```
public int getX()
public int getWidth()
```

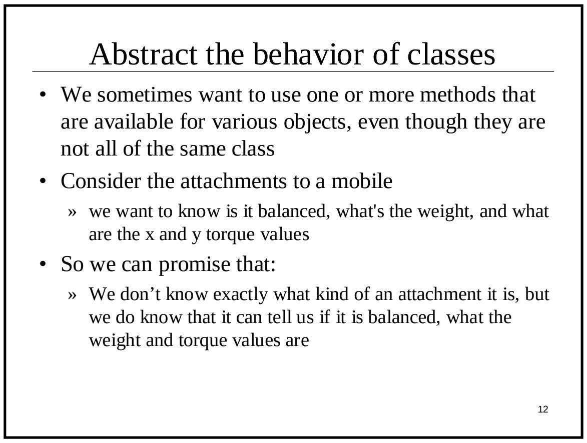


Method Overloading

- Classes may declare multiple methods with the same name, provided the *signature* is different
- The signature of a method is:

- For example, **`System.out.println`** is overloaded for many types

```
println(char c);
println(double d);
println(String s);
```



Abstract the behavior of classes

- We sometimes want to use one or more methods that are available for various objects, even though they are not all of the same class
- Consider the attachments to a mobile
  - » we want to know is it balanced, what's the weight, and what are the x and y torque values
- So we can promise that:
  - » We don’t know exactly what kind of an attachment it is, but we do know that it can tell us if it is balanced, what the weight and torque values are

Interface

- You can say that any class that claims to be an *Attachment* will guarantee that it has methods for all the things that any *Attachment* must do
- The definition of the interface shows exactly what the methods must look like

```
public interface Attachment {
     /**
     * Check to see if this Attachment is balanced.
     * An Attachment is balanced if all its constituent parts are balanced.
     * @return true if the Attachment is balanced, false if not.
     */
       public boolean isBalanced();
     /**
     * Return the total weight of this Attachment.
     * @return the total weight of this Attachment
     */
       public double getWeight();
     /**
     * Get the x-torque.  This is the torque applied around the x-axis by
     * the Attachment to the Mobile at the attachment point.
     * @return the torque around the x-axis.
     */
       public double getXTorque();
     /**
     * Get the y-torque.  This is the torque applied around the y-axis by
     * the Attachment to the Mobile at the attachment point.
     * @return the torque around the y-axis.
     */
       public double getYTorque();
}
```

Using an interface in a class definition

- Each of the classes that wants to be considered an Attachment must say so at the very beginning of the class definition

```
public class Branch implements Attachment {
```

Using Attachment Interface

```
public class Mobile {
    ...
    Attachment attachments[] = ...;

    public double getWeight() {
        double w = 0;
        for (int ii=0;ii<attachments.length;ii++) {
            Attachment a = attachments[ii];
            w += a.getWeight();
        }
        return w;
    }
    ...
}
```

Cast to Attachment

- Tell the compiler that the ArrayList contains objects that are Attachments

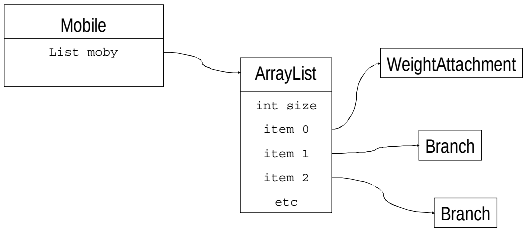
```
public class Mobile {
    ...
    ArrayList myList = ...;

   public double getWeight() {
        double w = 0;
        Iterator iter = myList.iterator();
        while (iter.hasNext()) {
            Attachment a = (Attachment)iter.next();
            w += a.getWeight();
        }
        return w;
   }
```

Relationships between classes

- Classes can be related via composition
  - » This is often referred to as the “has-a” relationship
  - » eg, a Mobile *has a* list in an ArrayList of Attachments
- Classes can also be related via inheritance
  - » This is often referred to as the “is-a” relationship
  - » eg, an ArrayList *is an* AbstractList

Mobile *has a* list of Attachments



Mobile

List moby

ArrayList

int size

item 0

item 1

item 2

etc

WeightAttachment

Branch

Branch

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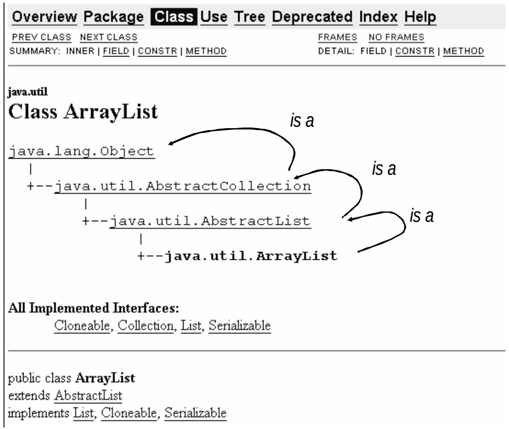

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FRAMES NO FRAMES
SUMMARY: INNER | FIELD | CONSTR | METHOD
DETAIL: FIELD | CONSTR | METHOD
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java.util

Class ArrayList

```
java.lang.Object
  |
  +--java.util.AbstractCollection
        |
        +--java.util.AbstractList
              |
              +--java.util.ArrayList
```

All Implemented Interfaces:

Cloneable, Collection, List, Serializable

public class **ArrayList**
extends AbstractList
implements List, Cloneable, Serializable

Why use inheritance?

- Code simplification
  - » Avoid doing the same operation in two places
  - » Avoid storing “matching state” in two places
- Code simplification
  - » We can deal with objects based on their common behavior, and don’t need to have special cases for each subtype
- Code simplification
  - » Lots of elegant code has already been written - use it, don’t try to rewrite everything from scratch

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Reduce the need for duplicated code

- Suppose we have two Attachments:
  - » Branch has **`getXTorque()`** method
  - » LiftingBranch has **`getXTorque()`** method
  - » and they are implemented exactly the same way
- We can implement this method once in a base class, and then extend it and add or replace implementations of other methods as we like

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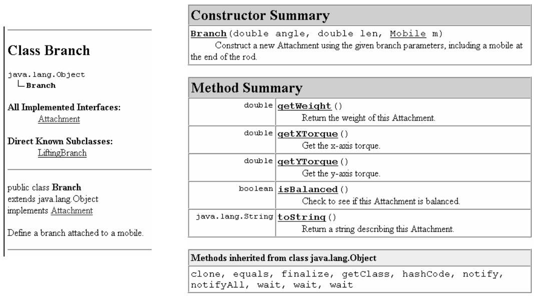
Branch class



Class Branch

```
java.lang.Object
  └Branch
```

All Implemented Interfaces:

Attachment

Direct Known Subclasses:

LiftingBranch

public class **Branch**
extends java.lang.Object
implements Attachment

Define a branch attached to a mobile.

Constructor Summary
Branch(double angle, double len, Mobile m) Construct a new Attachment using the given branch parameters, including a mobile at the end of the rod.

Method Summary	
double	**getWeight**() Return the weight of this Attachment.
double	**getXTorque**() Get the x-axis torque.
double	**getYTorque**() Get the y-axis torque.
boolean	**isBalanced**() Check to see if this Attachment is balanced.
java.lang.String	**toString**() Return a string describing this Attachment.

Methods inherited from class java.lang.Object
clone, equals, finalize, getClass, hashCode, notify, notifyAll, wait, wait, wait

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Syntax of inheritance

- Specify inheritance relationship using **`extends`**

```
public class LiftingBranch extends Branch { …
```

```
public class Branch implements Attachment {
        …
        public double getXTorque() {
          return getWeight()*length*Math.sin(theta);
        }
}
```

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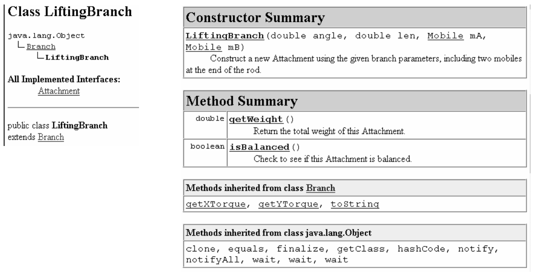
LiftingBranch : subclass of Branch



Class LiftingBranch

```
java.lang.Object
  └Branch
      └LiftingBranch
```

All Implemented Interfaces:
Attachment

public class **LiftingBranch**
extends Branch

Constructor Summary
LiftingBranch(double angle, double len, Mobile mA, Mobile mB) Construct a new Attachment using the given branch parameters, including two mobiles at the end of the rod.

Method Summary	
double	**getWeight**() Return the total weight of this Attachment.
boolean	**isBalanced**() Check to see if this Attachment is balanced.

Methods inherited from class Branch
getXTorque, getYTorque, toString

Methods inherited from class java.lang.Object
clone, equals, finalize, getClass, hashCode, notify, notifyAll, wait, wait, wait

Using the superclass constructor

- Constructor of the superclass is called to do much (or all) of the initialization for the subclass

```
public class LiftingBranch extends Branch {
    public LiftingBranch(double angle, double len, Mobile mA,Mobile mB) {
        super(angle,len,mA);
        this.lift = mB;
    }
...
```

```
public class Branch implements Attachment {
    public Branch(double angle, double len, Mobile m) {
        theta = angle;
        length = len;
        structure = m;
    }
...
```

this() and super() as constructors

- You can use an alias to call another constructor
  - » `super(...)` to call a superclass constructor
  - » `this(…)` to call another constructor from same class
- The call to the other constructor must be the first line of the constructor
  - » If neither this() nor super() is the first line in a constructor, a call to super() is inserted automatically by the compiler. This call takes no arguments. If the superclass has no constructor that takes no arguments, the class will not compile.

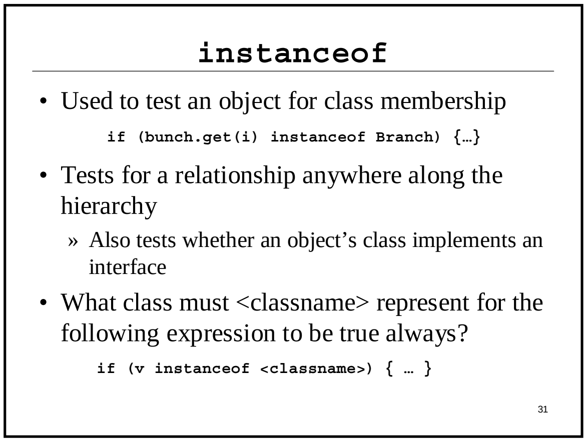
Overriding methods

- Overriding methods is how a subclass refines or extends the behavior of a superclass method
- Manager and Executive classes extend Employee
  - » Employee:

    double pay() {return hours*rate + overtime*(rate+5.00);}
- How do we specify different behavior for Managers and Executives?

Overriding methods

```
public class Employee {
  // other stuff
  public float pay() {
      return hours*rate + overtime*(rate+5.00);
  }
}
public class Manager extends Employee {
  // other stuff
  public float pay() {
      return hours*rate;
  }
}
```



instanceof

- Used to test an object for class membership

```
if (bunch.get(i) instanceof Branch) {…}
```

- Tests for a relationship anywhere along the hierarchy
  - » Also tests whether an object’s class implements an interface
- What class must <classname> represent for the following expression to be true always?

```
if (v instanceof <classname>) { … }
```

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