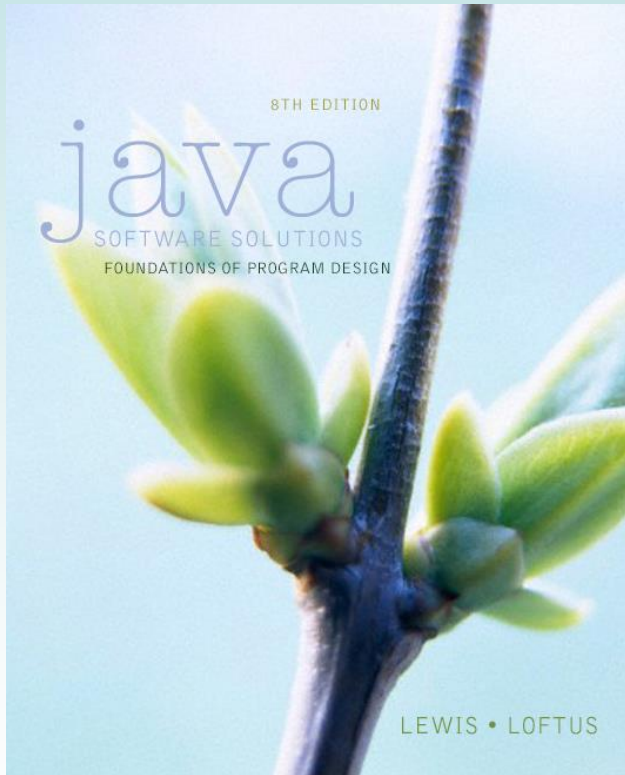


Chapter 7

Object-Oriented Design



Java Software Solutions

Foundations of Program Design

8th Edition

John Lewis
William Loftus

Addison-Wesley
is an imprint of

PEARSON

Copyright © 2014 Pearson Education, Inc.

Object-Oriented Design

- Discussion of the design of classes and objects
- Chapter 7 focuses on:
 - software development activities
 - determining the classes and objects that are needed for a program
 - the relationships that can exist among classes
 - the static modifier
 - writing interfaces
 - ☺ the design of enumerated type classes
 - method design and method overloading
 - ☺ GUI design and layout managers

Outline



Software Development Activities

Identifying Classes and Objects

Static Variables and Methods

Class Relationships

Interfaces

😊 **Enumerated Types Revisited**

Method Design

Testing

😊 **GUI Design and Layout**

Program Development

The creation of software involves four activities:

1. establishing the requirements
2. designing
3. implementation (writing code)
4. testing

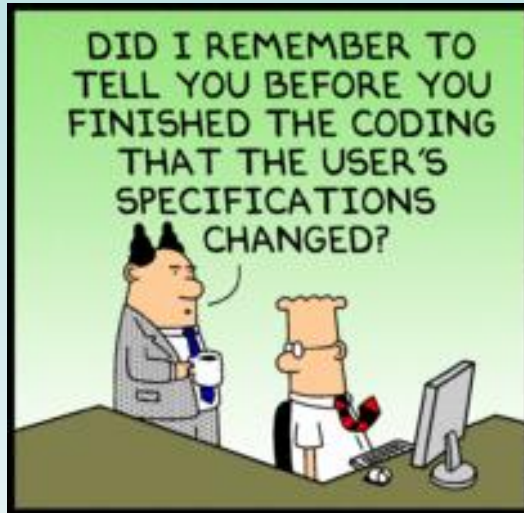
These activities are not strictly linear – they overlap and interact and may be repeated.

1. Requirements

- *Software requirements* specify the tasks that a program must accomplish
 - what you want, not how to do it
 - requirements should be specified before coding begins
- Often an initial set of requirements is provided, but they should be critiqued and expanded
 - 50% of software projects fail
 - 50% of small businesses fail in their first year

1. Requirements

- It is difficult to establish detailed, unambiguous, and complete requirements
 - Often requirements change as the project develops
 - Often a complete prototype is written only to discover what the requirements should have been
 - “prototyping languages”
 - after studying the prototype, the real program is written
- Careful attention to the requirements can save significant time and expense in the overall project



Dilbert.com DilbertCartoonist@gmail.com



5-16-11 © 2011 Scott Adams, Inc. Dist. by Universal Uclick



2. Design

- A *software design* specifies how a program will accomplish its requirements
- A software design specifies how the solution can be broken down into **manageable pieces** and what each piece will do
- An object-oriented design determines which **classes** and **objects** are needed, and specifies how they will interact
- Low level design describes how individual methods will accomplish their tasks
 - Possibly done with language-independent tools (sometimes flowcharts, sometimes UML diagrams)

3. Implementation

- *Implementation* is the process of translating a design into source code
 - Coding might be as little as 10% of the time spent on a software project
- Novice programmers often think that writing code is the heart of software development, but actually it should be the least creative step
 - “architecture” vs. “hammering nails”

3. Implementation

- Almost all important decisions are made during requirements and design stages
- Implementation should focus on coding details, including style guidelines and documentation
 - ideally, coding should be nearly “mechanical”
 - entry-level jobs are often coding (or testing)
 - top-level jobs are analysis and design

4. Testing

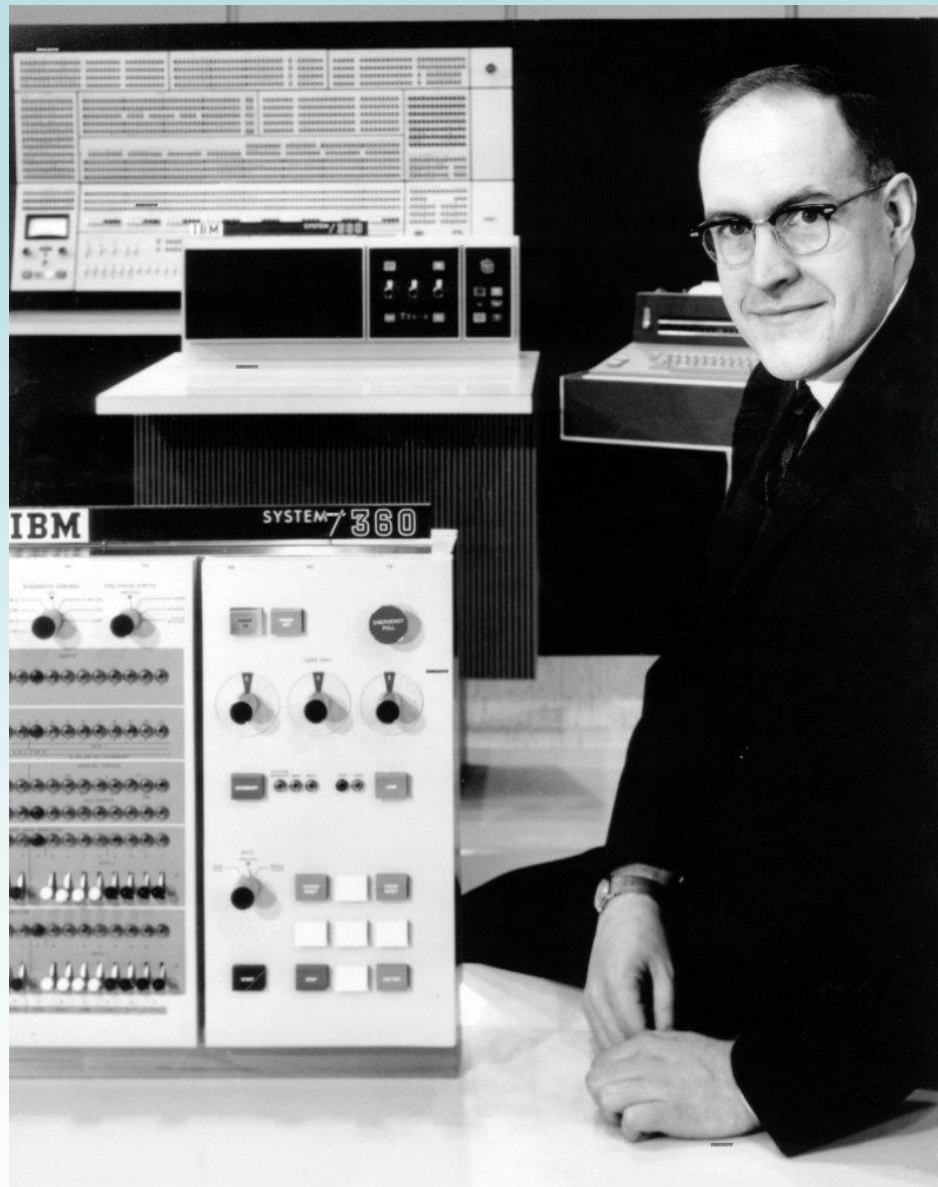
- *Testing* attempts to ensure that a program will solve the intended problem under all the constraints specified in the requirements
- *Debugging* is the process of determining the cause of a problem and fixing it

4. Testing

- A program should be thoroughly tested with the goal of finding errors
 - various data sets used:
 - typical, random, extreme cases
 - look at the “boundaries” check for off-by-one
 - testers are often not the programmers

Fred Brooks

- “The ... question ... is not *whether* to build a pilot system and throw it away. You *will* do that. Hence *plan to throw one away; you will, anyhow.*”
- “Well over half of the time you spend working on a project (on the order of 70 percent) is spent thinking...”
- http://en.wikiquote.org/wiki/Fred_Brooks



Fred Brooks (ca. 1965)

Outline

Software Development Activities



Identifying Classes and Objects

Static Variables and Methods

Class Relationships

Interfaces

😊 **Enumerated Types Revisited**

Method Design

Testing

😊 **GUI Design and Layout**

Identifying Classes and Objects

- The core activity of object-oriented **design** is determining the classes and objects that will make up the solution
- The classes may be part of a class library, reused from a previous project, or newly written
- One way to identify potential classes is to identify the real-world objects discussed in the requirements
- Objects are generally nouns, and the services that an object provides are generally verbs

Identifying Classes and Objects

- A partial requirements document:

The **user** must be allowed to specify each **product** by its primary **characteristics**, including its **name** and **product number**. If the **bar code** does not match the **product**, then an **error** should be generated to the **message window** and entered into the **error log**. The **summary report** of all **transactions** must be structured as specified in section 7.A.

- Of course, not all nouns will correspond to a class or object in the final solution

Identifying Classes and Objects

- A class represents a group (classification) of objects with the same behaviors
- Generally, classes that represent objects should be given names that are singular nouns
- Examples: `Coin`, `Student`, `Message`
- A class represents the concept of one such object
- We are free to instantiate as many of each object as needed

☺ Identifying Classes and Objects

- Sometimes it is challenging to decide whether something should be represented as a class
- For example, should an employee's address be represented as a set of instance variables or as an `Address` object
- The more you examine the problem and its details the more clear these issues become
- When a class becomes too complex, it often should be decomposed into multiple smaller classes to distribute the responsibilities

☺ Identifying Classes and Objects

- We want to define classes with the proper amount of detail
- For example, it may be unnecessary to create separate classes for each type of appliance in a house
- It may be sufficient to define a more general `Appliance` class with appropriate instance data
- It all depends on the details of the problem being solved

☺ Identifying Classes and Objects

- Part of identifying the classes we need is the process of *assigning responsibilities* to each class
- Every activity that a program must accomplish must be represented by one or more methods in one or more classes
- We generally use verbs for the names of methods
- In early stages it is not necessary to determine every method of every class – begin with primary responsibilities and evolve the design

Outline

Software Development Activities

Identifying Classes and Objects



Static Variables and Methods

Class Relationships

Interfaces

😊 **Enumerated Types Revisited**

Method Design

Testing

😊 **GUI Design and Layout**

Static Class Members

- A **static** method is one that is invoked through its class name
 - no object needed
- For example, the methods of the `Math` class are static:

```
result = Math.sqrt(25)
```

- Variables can be static as well

The static Modifier

- Declare static methods and variables using the **static** modifier
 - It associates the method or variable with the class rather than with an object of that class
- Static methods are sometimes called *class methods*
- static variables are sometimes called *class variables*

Static Variables

- Normally, each object has its own collection of instance variables, but if a variable is declared as static, **only one copy** of the variable exists

```
private static float price;
```

- Memory space for a static variable is created when the class is first referenced
- **All objects** instantiated from the class **share** its static variables
- Changing the value of a static variable in one object changes it for all others

Static Methods

```
public class Helper
{
    public static int cube(int num)
    {
        return num * num * num;
    }
}
```

Because it is declared as static, the `cube` method can be invoked through the class name:

```
value = Helper.cube(4);
```

```
public class Helper
{
    public static int cube(int num)
    {
        return num * num * num;
    }
}

public class Demo
{
    public static void main(String[] args)
    {
        int val = 2, val3;
        val3 = Helper.cube( val );
        System.out.println( val + " cubed: " + val3 );
    }
}
```

```
public class Helper
{
    public int cube(int num)    // not static
    {
        return num * num * num;
    }
}
```

```
public class Demo
{
    public static void main(String[] args)
    {
        int val = 2, val3;
        Helper help = new Helper(); // need an object
        val3 = help.cube( val );
        System.out.println( val + " cubed: " + val3 );
    }
}
```

Static Class Members

- The order of the modifiers can be reversed, but by convention visibility modifiers come first
- Recall that the `main` method is static – it is invoked by the Java interpreter without creating an object
- Static methods cannot use instance variables because instance variables don't exist until an object exists
- However, a static method can reference static variables or its own local variables

Static Class Members

- Static methods and static variables often work together
- The following example keeps track of how many `Slogan` objects have been created using a static variable, and makes that information available using a static method
- See `SloganCounter.java`
- See `Slogan.java`

```
//*****
//  SloganCounter.java          Author: Lewis/Loftus
//
//  Demonstrates the use of the static modifier.
//*****
```

```
public class SloganCounter
```

```
{
```

```
    //-----
```

```
    //  Creates several Slogan objects and prints the number of
```

```
    //  objects that were created.
```

```
    //-----
```

```
public static void main(String[] args)
```

```
{
```

```
    Slogan obj;
```

```
    obj = new Slogan("Remember the Alamo.");
```

```
    System.out.println(obj);
```

```
    obj = new Slogan("Don't Worry. Be Happy."); // Alamo is now garbage
```

```
    System.out.println(obj);
```

```
obj = new Slogan("Live Free or Die."); // Happy is now garbage
System.out.println(obj);

obj = new Slogan("Talk is Cheap."); // Live is now garbage
System.out.println(obj);

obj = new Slogan("Write Once, Run Anywhere."); // Talk is garbage
System.out.println(obj);

obj = new Slogan("Plan to throw one away."); // Write is garbage
System.out.println(obj);

System.out.println();
System.out.println("Slogans created: " + Slogan.getCount());
}
}
```


continue

```
obj = new Slogan("Remember the Alamo.");
System.out.println(obj);

obj = new Slogan("Don't Worry. Be Happy.");
System.out.println(obj);

obj = new Slogan("Live Free or Die.");
System.out.println(obj);

obj = new Slogan("Talk is Cheap.");
System.out.println(obj);

obj = new Slogan("Write Once, Run Anywhere.");
System.out.println(obj);

obj = new Slogan("Plan to throw one away.");
System.out.println(obj);

System.out.println("Slogans created: " + Slogan.getCount());
}
```

Output

```
Remember the Alamo.
Don't Worry. Be Happy.
Live Free or Die.
Talk is Cheap.
Write Once, Run Anywhere.
Plan to throw one away.

Slogans created: 6
```

```

//*****
//  Slogan.java          Author: Lewis/Loftus
//
//  Represents a single slogan string.
//*****

public class Slogan
{
    private String phrase;
    private static int count = 0;

    //-----
    //  Constructor: Sets up the slogan and counts the number of
    //  instances created.
    //-----
    public Slogan(String str)
    {
        phrase = str;
        count++;
    }
}

```

```
//-----  
// Returns this slogan as a string.  
//-----  
public String toString()  
{  
    return phrase;  
}  
  
//-----  
// Returns the number of instances of this class that have been  
// created, even if many of them are now garbage. The static  
// variable is part of the class, and exists as long as the  
// program runs.  
//-----  
public static int getCount()  
{  
    return count;  
}  
}
```

Quick Check

Why can't a static method reference an instance variable?

Quick Check

Why can't a static method reference an instance variable?

Because instance data is created only when an object is created.

You don't need an object to execute a static method.

And even if you had an object, which object's instance data would be referenced? (remember, the method is invoked through the class name)

Outline

Software Development Activities

Identifying Classes and Objects

Static Variables and Methods



Class Relationships

Interfaces

😊 **Enumerated Types Revisited**

Method Design

Testing

😊 **GUI Design and Layout**

Class Relationships

- Classes in a software system have various types of relationships to each other
- Three of the most common relationships:
 - Dependency: A **uses** B
 - Aggregation: A **has-a** B
 - Inheritance: A **is-a** B
- Inheritance is discussed in Chapter 9

Dependency

- A *dependency* exists when one class **uses** another in some way, usually by invoking the methods of the other
- We don't want numerous or complex dependencies among classes
- Nor do we want complex classes that don't depend on others
- A good design strikes the right balance

Dependency

- Some dependencies occur between objects of the same class
- A method of the class may accept an object reference of the same class as a parameter
- For example, the `concat` method of the `String` class takes as a parameter another `String` object

```
str3 = str1.concat(str2);
```

Dependency

- **Example:** `RationalNumber`
- A rational number is a value that can be represented as the ratio of two integers
- Several methods of the `RationalNumber` class accept another `RationalNumber` object reference as a parameter
- **See** `RationalTester.java`
- **See** `RationalNumber.java`

```

//*****
//  RationalTester.java          Author: Lewis/Loftus
//
//  Driver to exercise the use of multiple Rational objects.
//*****

public class RationalTester
{
    //-----
    //  Creates some rational number objects and performs various
    //  operations on them.
    //-----
    public static void main(String[] args)
    {
        RationalNumber r1 = new RationalNumber(6, 8);
        RationalNumber r2 = new RationalNumber(1, 3);
        RationalNumber r3, r4, r5, r6, r7;

        System.out.println("First rational number: " + r1);
        System.out.println("Second rational number: " + r2);
    }
}

```

```
if (r1.isLike(r2))
    System.out.println ("r1 and r2 are equal.");
else
    System.out.println ("r1 and r2 are NOT equal.");

r3 = r1.reciprocal();
System.out.println ("The reciprocal of r1 is: " + r3);

r4 = r1.add(r2);
r5 = r1.subtract(r2);
r6 = r1.multiply(r2);
r7 = r1.divide(r2);

System.out.println("r1 + r2: " + r4);
System.out.println("r1 - r2: " + r5);
System.out.println("r1 * r2: " + r6);
System.out.println("r1 / r2: " + r7);
}
}
```

Output

First rational number: 3/4
Second rational number: 1/3
r1 and r2 are NOT equal.
The reciprocal of r1 is: 4/3
r1 + r2: 13/12
r1 - r2: 5/12
r1 * r2: 1/4
r1 / r2: 9/4

```

//*****
//  RationalNumber.java      Author: Lewis/Loftus
//
//  Represents one rational number with a numerator and denominator.
//*****

public class RationalNumber
{
    private int numerator, denominator;

    //-----
    //  Constructor: Sets up the rational number by ensuring a nonzero
    //  denominator and making only the numerator signed.
    //-----
    public RationalNumber(int numer, int denom)
    {
        if (denom == 0)
            denom = 1;

        // Make the numerator "store" the sign
        if (denom < 0)
        {
            numer = numer * -1;
            denom = denom * -1;
        }
    }
}

```

```
    numerator = numer;
    denominator = denom;

    reduce();
}

//-----
// Returns the numerator of this rational number.
//-----
public int getNumerator()
{
    return numerator;
}

//-----
// Returns the denominator of this rational number.
//-----
public int getDenominator()
{
    return denominator;
}
```

```
//-----  
// Returns the reciprocal of this rational number.  
//-----  
public RationalNumber reciprocal()  
{  
    return new RationalNumber(denominator, numerator);  
}  
  
//-----  
// Adds this rational number to the one passed as a parameter.  
// A common denominator is found by multiplying the individual  
// denominators.  
//-----  
public RationalNumber add(RationalNumber op2)  
{  
    int commonDenominator = denominator * op2.getDenominator();  
    int numerator1 = numerator * op2.getDenominator();  
    int numerator2 = op2.getNumerator() * denominator;  
    int sum = numerator1 + numerator2;  
  
    return new RationalNumber(sum, commonDenominator);  
}
```

```
//-----  
//  Subtracts the rational number passed as a parameter from this  
//  rational number.  
//-----  
public RationalNumber subtract(RationalNumber op2)  
{  
    int commonDenominator = denominator * op2.getDenominator();  
    int numerator1 = numerator * op2.getDenominator();  
    int numerator2 = op2.getNumerator() * denominator;  
    int difference = numerator1 - numerator2;  
  
    return new RationalNumber(difference, commonDenominator);  
}  
  
//-----  
//  Multiplies this rational number by the one passed as a  
//  parameter.  
//-----  
public RationalNumber multiply(RationalNumber op2)  
{  
    int numer = numerator * op2.getNumerator();  
    int denom = denominator * op2.getDenominator();  
  
    return new RationalNumber(numer, denom);  
}
```



```
//-----  
// Divides this rational number by the one passed as a parameter  
// by multiplying by the reciprocal of the second rational.  
//-----  
public RationalNumber divide(RationalNumber op2)  
{  
    return multiply(op2.reciprocal());  
}  
  
//-----  
// Determines if this rational number is equal to the one passed  
// as a parameter. Assumes they are both reduced.  
//-----  
public boolean isLike(RationalNumber op2)  
{  
    return ( numerator    == op2.getNumerator() &&  
            denominator == op2.getDenominator() );  
}
```

```
//-----  
// Returns this rational number as a string.  
//-----  
public String toString()  
{  
    String result;  
    if (numerator == 0)  
        result = "0";  
    else  
        if (denominator == 1)  
            result = numerator + "";  
        else  
            result = numerator + "/" + denominator;  
    return result;  
}
```

```
//-----  
//  Reduces this rational number by dividing both the numerator  
//  and the denominator by their greatest common divisor  
//  (which might be 1).  
//-----  
private void reduce()  
{  
    if (numerator != 0)  
    {  
        int common = gcd( Math.abs(numerator), denominator );  
  
        numerator    = numerator    / common;  
        denominator  = denominator / common;  
    }  
}
```

```
//-----  
// Computes and returns the greatest common divisor of the two  
// positive parameters. Uses Euclid's algorithm.  
//-----  
private int gcd(int num1, int num2)  
{  
    while (num1 != num2)  
    {  
        if (num1 > num2)  
            num1 = num1 - num2;  
        else  
            num2 = num2 - num1;  
    }  
  
    return num1;  
}  
}
```

Euclid's Algorithm

- If two integers have a common divisor, the difference of the two integers has the same divisor.
- To find the common divisor, keep subtracting one integer from the other until a common value is reached.
- The common value might be 1 if the integers are relatively prime.

Euclid's Algorithm

- Say x and y have a common divisor, say d .
 - Then $x = md$ and $y = nd$
 - Then $(x - y) = md - nd = (m - n)d = kd$
 - So the difference kd has the same divisor d
- $7*5$ and $3*5$. $\{35 \text{ and } 15\}$
 $7*5 - 3*5 = (7-3)*5 = 4*5$ $\{20\}$

Example:

Say x is 35 and y is 15

35 and 15: subtract smaller from larger: 20
replace the larger with the result

20 and 15: subtract smaller from larger: 5
replace the larger with the result

5 and 15: subtract smaller from larger: 10
replace the larger with the result

5 and 10: subtract smaller from larger: 5
replace the larger with the result

5 and 5: are equal, so: $\text{gcd} = 5$

Example:

Say x is 23 and y is 8

23 and 8: subtract smaller from larger: 15
 replace the larger with the result

15 and 8: subtract smaller from larger: 7
 replace the larger with the result

8 and 7: subtract smaller from larger: 1
 replace the larger with the result

7 and 1: subtract smaller from larger: 6
 replace the larger with the result

6 and 1: subtract smaller from larger: 5
 replace the larger with the result

5 and 1: subtract smaller from larger: 4
 replace the larger with the result

4 and 1: subtract smaller from larger: 3
 replace the larger with the result

3 and 1: subtract smaller from larger: 2
 replace the larger with the result

2 and 1: subtract smaller from larger: 1
 replace the larger with the result

1 and 1: are equal, so: $\text{gcd} = 1$

Example:

Say x is 51 and y is 39

51 and 39: subtract smaller from larger: 12
replace larger with the result

39 and 12: subtract smaller from larger: 27
replace larger with the result

27 and 12: subtract smaller from larger: 15
replace larger with the result

15 and 12: subtract smaller from larger: 3
replace larger with the result

3 and 12: subtract smaller from larger: 9
replace larger with the result

3 and 9: subtract smaller from larger: 6
replace larger with the result

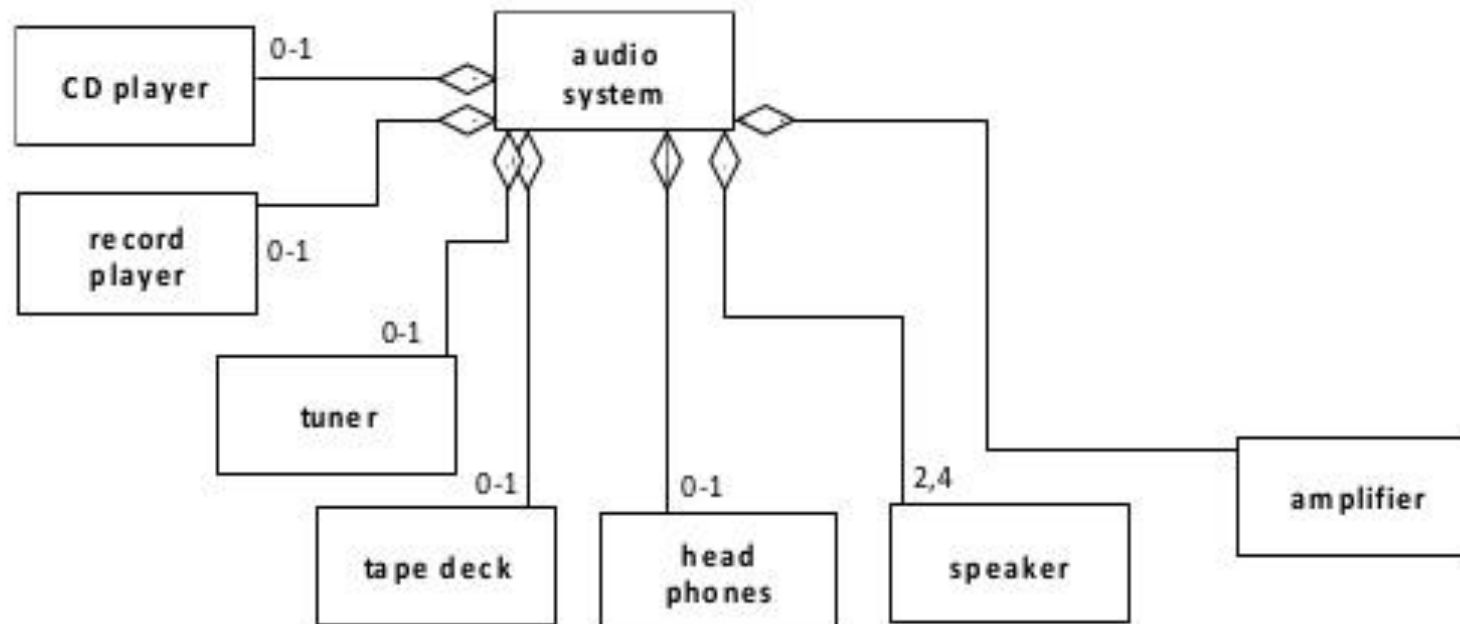
3 and 6: subtract smaller from larger: 3
replace larger with the result

3 and 3: are equal, so: $\text{gcd} = 3$

Aggregation

- An *aggregate* is an object that is made up of other objects
- Therefore **aggregation** is a *has-a* relationship
 - A car *has a* chassis
- An aggregate object **contains references** to other objects as its instance data

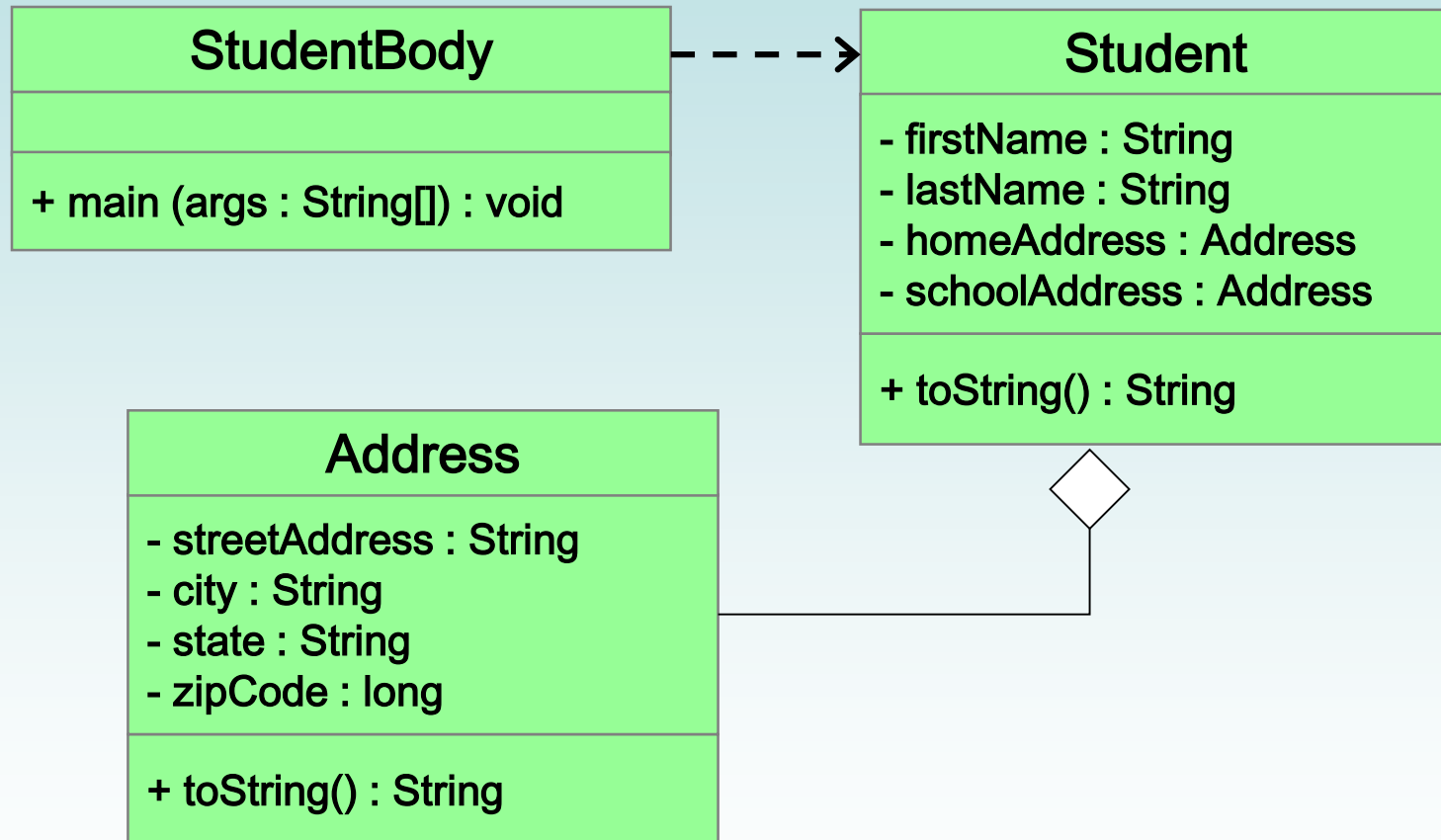
Notation for aggregation



Aggregation

- In the following example, a `Student` object is composed, in part, of `Address` objects
- A student has an address (in fact each student has two addresses)
- **See** `StudentBody.java`
- **See** `Student.java`
- **See** `Address.java`

Aggregation in UML



```

//*****
//  StudentBody.java          Author: Lewis/Loftus
//
//  Demonstrates the use of an aggregate class.
//*****

public class StudentBody
{
    //-----
    //  Creates some Address and Student objects and prints them.
    //-----
    public static void main(String[] args)
    {
        Address school = new Address("800 Lancaster Ave.", "Villanova",
                                     "PA", 19085);
        Address jHome  = new Address("21 Jump Street", "Lynchburg",
                                     "VA", 24551);
        Student john    = new Student("John", "Smith", jHome, school);

        Address mHome  = new Address("123 Main Street", "Euclid", "OH",
                                     44132);
        Student marsha = new Student("Marsha", "Jones", mHome, school);

        System.out.println(john);    // uses toString() method of john
        System.out.println();
        System.out.println(marsha);  // uses toString() method of marsha
    }
}

```



```
//*****
//  StudentBody.java
//
//  Demonstrates the
//*****
```

```
public class StudentB
{
    //-----
    //  Creates some A
    //-----
    public static void
    {
        Address school :
        Address jHome =
        Student john =
        Address mHome =

        Student marsha = new Student("Marsha", "Jones", mHome, school);

        System.out.println(john);
        System.out.println();
        System.out.println(marsha);
    }
}
```

Output

```
John Smith
Home Address:
21 Jump Street
Lynchburg, VA  24551
School Address:
800 Lancaster Ave.
Villanova, PA  19085

Marsha Jones
Home Address:
123 Main Street
Euclid, OH  44132
School Address:
800 Lancaster Ave.
Villanova, PA  19085
```

```
44132);
```

```
Student marsha = new Student("Marsha", "Jones", mHome, school);
```

```
System.out.println(john);
```

```
System.out.println();
```

```
System.out.println(marsha);
```

```
*****
```

```
*****
```

```
-----
and prints them.
-----
```

```
er Ave.", "Villanova",
;
et", "Lynchburg",
", jHome, school);
eet", "Euclid", "OH",
```

```
//*****
//  Student.java          Author: Lewis/Loftus
//
//  Represents a college student.
//*****

public class Student
{
    private String firstName, lastName;
    private Address homeAddress, schoolAddress;

    //-----
    //  Constructor: Sets up this student with the specified values.
    //-----
    public Student(String first, String last, Address home,
                    Address school)
    {
        firstName = first;
        lastName = last;
        homeAddress = home;
        schoolAddress = school;
    }
}
```

```
//-----  
// Returns a string description of this Student object.  
//-----  
public String toString()  
{  
    String result;  
  
    result = firstName + " " + lastName + "\n";  
    result += "Home Address:\n" + homeAddress + "\n";  
    result += "School Address:\n" + schoolAddress;  
  
    return result;  
}  
}
```

```

//*****
//  Address.java          Author: Lewis/Loftus
//
//  Represents a street address.
//*****

public class Address
{
    private String streetAddress, city, state;
    private long zipCode;

    //-----
    //  Constructor: Sets up this address with the specified data.
    //-----
    public Address(String street, String town, String st, long zip)
    {
        streetAddress = street;
        city = town;
        state = st;
        zipCode = zip;
    }
}

```

```
//-----  
// Returns a description of this Address object.  
//-----  
public String toString()  
{  
    String result;  
  
    result = streetAddress + "\n";  
    result += city + ", " + state + "  " + zipCode;  
  
    return result;  
}  
}
```

The **this** Reference

- The `this` reference allows an object to **refer to itself**
- The `this` reference, used inside a method, refers to the object that contains the method
- Suppose the `this` reference is used inside a method called `tryMe`, which is invoked as follows:

```
obj1.tryMe();  
obj2.tryMe();
```

- In the first invocation, the `this` reference refers to `obj1`; in the second it refers to `obj2`

The `this` reference

- The `this` reference can be used to distinguish the instance variables of a class from corresponding method parameters with the same names
- The constructor of the `Address` could have been written:

```
public Address(String streetAddress, String city,  
               String state, long zipCode )  
{  
    this.streetAddress = this.streetAddress ;  
    this.city          = city ;  
    this.state         = state ;  
    this.zipCode       = zipCode ;  
}
```

Outline

Software Development Activities

Identifying Classes and Objects

Static Variables and Methods

Class Relationships



Interfaces

😊 **Enumerated Types Revisited**

Method Design

Testing

😊 **GUI Design and Layout**

Interfaces

- A Java *interface* is a collection of **abstract methods** and **constants**
 - it is a description of what will be in some class
(a description of a description. “meta”)
 - a set of requirements for a blueprint
 - like saying a blueprint for a house must include kitchen, bathroom, room, living room
 - but the details of implementation are not specified
- An *abstract method* is a method header without a method body


Interfaces

- An abstract method is declared using the modifier `abstract`, but because all methods in an interface are abstract, usually it is left off.
- An interface is used to establish a set of methods that a class will implement.


Interfaces

interface is a reserved word

None of the methods in
an interface are given
a definition (body)



```
public interface Doable
{
    public void doThis();
    public int doThat();
    public void doThis2(double value, char ch);
    public boolean doTheOther(int num);
}
```



A semicolon immediately
follows each method header

Interfaces

- An interface cannot be instantiated
- Methods in an interface have **public visibility** by default
- A class formally implements an interface by:
 - stating so in the class header
 - providing implementations for every abstract method in the interface
- If a class implements an interface, it must define all methods in the interface

Interfaces

implements is a
reserved word



```
public class CanDo implements Doable
{
    public void doThis()
    {
        // whatever
    }

    public void doThat()
    {
        // whatever
    }

    // etc.
}
```

Each method listed
in Doable is
given a definition

Interfaces

- In addition to abstract methods, an interface can contain constants
- When a class implements an interface, it gains access to all its constants
- A class that implements an interface can implement methods not in the interface, as well
- **See** `Complexity.java`
- **See** `Question.java`
- **See** `MiniQuiz.java`

```
//*****  
// Complexity.java          Author: Lewis/Loftus  
//  
// Represents the interface for an object that can be assigned an  
// explicit complexity.  
//*****  
  
public interface Complexity  
{  
    public void setComplexity(int complexity);  
    public int getComplexity();  
}
```

```

//*****
//  Question.java          Author: Lewis/Loftus
//
//  Represents a question (and its answer).
//*****

public class Question implements Complexity
{
    private String question, answer;
    private int complexityLevel;

    //-----
    //  Constructor: Sets up the question with a default complexity.
    //-----
    public Question(String query, String result)
    {
        question = query;
        answer = result;
        complexityLevel = 1;
    }
}

```



```
//-----  
//  Sets the complexity level for this question.  
//-----  
public void setComplexity(int level)  
{  
    complexityLevel = level;  
}  
  
//-----  
//  Returns the complexity level for this question.  
//-----  
public int getComplexity()  
{  
    return complexityLevel;  
}  
  
//-----  
//  Returns the question.  
//-----  
public String getQuestion()  
{  
    return question;  
}
```

```
//-----  
// Returns the answer to this question.  
//-----  
public String getAnswer()  
{  
    return answer;  
}  
  
//-----  
// Returns true if the candidate answer matches the answer.  
//-----  
public boolean answerCorrect(String candidateAnswer)  
{  
    return answer.equals(candidateAnswer);  
}  
  
//-----  
// Returns this question (and its answer) as a string.  
//-----  
public String toString()  
{  
    return question + "\n" + answer;  
}  
}
```

```

//*****
//  MiniQuiz.java          Author: Lewis/Loftus
//
//  Demonstrates the use of a class that implements an interface.
//*****

import java.util.Scanner;

public class MiniQuiz
{
    //-----
    //  Presents a short quiz.
    //-----
    public static void main(String[] args)
    {
        Question q1, q2;
        String possible;

        Scanner scan = new Scanner(System.in);

        q1 = new Question("What is the capital of Jamaica?",
                           "Kingston");

        q1.setComplexity(4);

        q2 = new Question("Which is worse, ignorance or apathy?",
                           "I don't know and I don't care");
        q2.setComplexity(10);
    }
}

```

```
System.out.print(q1.getQuestion());  
System.out.println(" (Level: " + q1.getComplexity() + ")");  
possible = scan.nextLine();  
if (q1.answerCorrect(possible))  
    System.out.println("Correct");  
else  
    System.out.println("No, the answer is " + q1.getAnswer());  
  
System.out.println();  
System.out.print(q2.getQuestion());  
System.out.println(" (Level: " + q2.getComplexity() + ")");  
possible = scan.nextLine();  
if (q2.answerCorrect(possible))  
    System.out.println("Correct");  
else  
    System.out.println("No, the answer is " + q2.getAnswer());  
}  
}
```

```

System.out.print (q1.getQuestion());
System.out.println (" (Level: " + q1.getComplexity() + ")");
possible = scan.nextLine();
if (q1.answerCorrect(possible))
    System.out.println ("Correct");
else
    System.out.println ("No, the answer is " + q1.getAnswer());

System.out.println();
System.out.print(q2.getQuestion());
System.out.println(" (Level: " + q2.getComplexity() + ")");
possible = scan.nextLine();
if (q2.answerCorrect(possible))
    System.out.println("Correct");
else
    System.out.println("No, the answer is " + q2.getAnswer());
}
}

```

Sample Run

What is the capital of Jamaica? (Level: 4)

Kingston

Correct

Which is worse, ignorance or apathy? (Level: 10)

apathy

No, the answer is I don't know and I don't care

Implementing Interfaces

- A class can implement multiple interfaces
- The interfaces are listed in the `implements` clause
- The class must implement all methods in all interfaces listed in the header

```
class ManyThings implements interface1, interface2
{
    // all methods of both interfaces
}
```

API Interfaces

- The Java API contains many helpful interfaces
- The `Comparable` interface contains one abstract method called `compareTo`, which compares two objects
- The `String` class implements `Comparable`, which uses lexicographic order
 - We discussed the `compareTo` method of the `String` class in Chapter 5

The Comparable Interface

- Any class can implement `Comparable` to provide a mechanism for comparing objects of that type

```
if ( obj1.compareTo(obj2) < 0 )  
    System.out.println ( "obj1 is less than obj2" );
```

- The value returned from `compareTo` should be
 - negative if `obj1` is less than `obj2`,
 - 0 if they are equal,
 - and positive if `obj1` is greater than `obj2`
- It's up to the programmer to determine what makes one object less than another

The Iterator Interface

- As in Chapter 5, an iterator is an object that can process a collection of objects one at a time
- An iterator implements the `Iterator` interface, which contains three methods
 - The `hasNext` method returns a boolean result – true if there are items left to process
 - The `next` method returns the next object in the iteration
 - The `remove` method removes the object most recently returned by the `next` method

The Iterable Interface

- Another interface, `Iterable`, says that an object **provides an iterator**
- The `Iterable` interface has one method, `iterator`, that returns an `Iterator` object
- Any `Iterable` object can be processed using the for-each version of the `for` loop
- Note the difference:
 - an `Iterator` performs an iteration;
 - an `Iterable` object provides an iterator on request

☺ Interfaces

- You could write a class that implements certain methods (such as `compareTo`) without formally implementing the interface (`Comparable`)
- However, formally establishing the relationship between a class and an interface allows Java to deal with an object in certain ways
- Interfaces are a key aspect of object-oriented design in Java
- We discuss this idea further in Chapter 10

Outline

Software Development Activities

Identifying Classes and Objects

Static Variables and Methods

Class Relationships

Interfaces



😊 Enumerated Types Revisited

Method Design

Testing

😊 GUI Design and Layout

☺ Enumerated Types

- In Chapter 3 we introduced enumerated types, which define a new data type and list all possible values of that type:

```
enum Season {winter, spring, summer, fall}
```

- Once established, the new type can be used to declare variables

Season time;

- The only values this variable can be assigned are the ones established in the `enum` definition

☺ Enumerated Types

- An enumerated type definition is a special kind of class
- The values of the enumerated type are objects of that type
- For example, `fall` is an object of type `Season`
- That's why the following assignment is valid:

```
time = Season.fall;
```

☺ Enumerated Types

- An enumerated type definition can be more interesting than a simple list of values
- Because they are like classes, we can add additional instance data and methods
- We can define an `enum` constructor as well
- Each value listed for the enumerated type calls the constructor
- **See** `Season.java`
- **See** `SeasonTester.java`

```
//*****  
// Season.java          Author: Lewis/Loftus  
//  
// Enumerates the values for Season.  
//*****
```

```
public enum Season  
{  
    winter ("December through February"),  
    spring ("March through May"),  
    summer ("June through August"),  
    fall ("September through November");  
  
    private String span;
```

continue

continue

```
//-----  
//  Constructor: Sets up each value with an associated string.  
//-----  
Season(String months)  
{  
    span = months;  
}  
  
//-----  
//  Returns the span message for this value.  
//-----  
public String getSpan()  
{  
    return span;  
}  
}
```

```
//*****  
// SeasonTester.java          Author: Lewis/Loftus  
//  
// Demonstrates the use of a full enumerated type.  
//*****  
  
public class SeasonTester  
{  
    //-----  
    // Iterates through the values of the Season enumerated type.  
    //-----  
    public static void main(String[] args)  
    {  
        for (Season time : Season.values())  
            System.out.println(time + "\t" + time.getSpan());  
    }  
}
```

Output

```
//*****  
// SeasonTest  
//  
// Demonstrates  
//*****  
winter  December through February  
spring  March through May  
summer  June through August  
fall    September through November  
*****  
*****  
  
public class  
{  
    //-----  
    // Iterates through the values of the Season enumerated type.  
    //-----  
    public static void main(String[] args)  
    {  
        for (Season time : Season.values())  
            System.out.println(time + "\t" + time.getSpan());  
    }  
}
```

☺ Enumerated Types

- Every enumerated type contains a static method called `values` that returns a list of all possible values for that type
- The list returned from `values` can be processed using a for-each loop
- An enumerated type cannot be instantiated outside of its own definition
- A carefully designed enumerated type provides a versatile and type-safe mechanism for managing data

Outline

Software Development Activities

Identifying Classes and Objects

Static Variables and Methods

Class Relationships

Interfaces

😊 **Enumerated Types Revisited**



Method Design

😊 **Testing**

😊 **GUI Design and Layout**

Method Design

- High-level design includes:
 - identifying classes and objects
 - assigning responsibilities
- After doing high-level design, you need to address low-level issues such as the design of methods
- Careful planning is needed to make sure methods contribute to an efficient and elegant system design

Method Decomposition

- A method should be relatively small, so that it can be understood as a single entity
- A large method should be decomposed into several smaller methods as needed for clarity
- A public service method of an object may call one or more private support methods to help it accomplish its goal
- Support methods might call other support methods as needed

Method Decomposition

- Let's look at an example of method decomposition – translating English into Pig Latin
- Pig Latin is a language in which each word is modified by moving the initial sound of the word to the end and adding "ay"
- Words that begin with vowels have the "yay" sound added on the end

book → ookbay

table → abletay

item → itemyay

chair → airchay

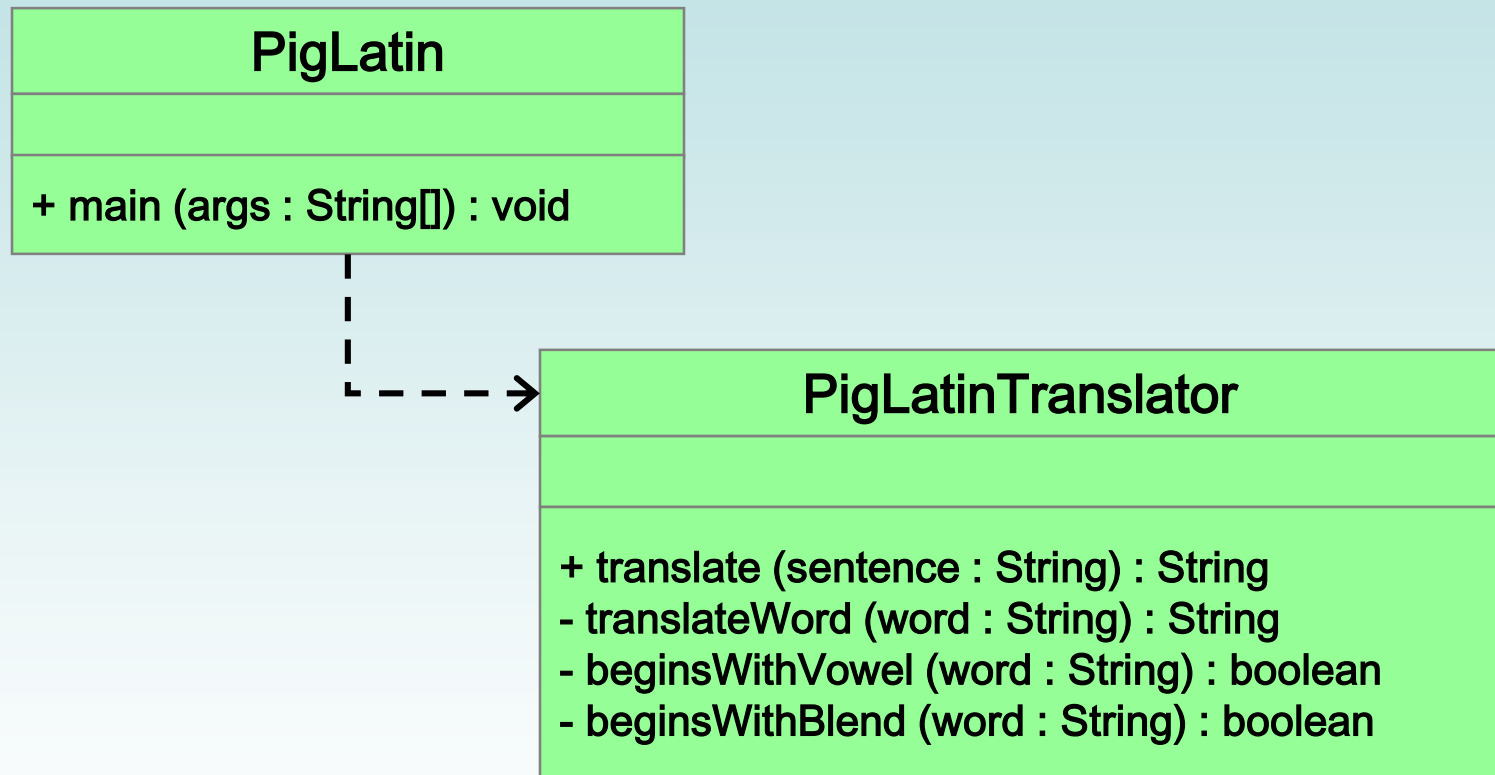
Method Decomposition

- Translating a sentence is too complicated for one method to accomplish
- Look for ways to decompose the solution into pieces
- Translating a sentence can be decomposed into the process of translating each word
- The process of translating a word can be separated into translating words that:
 - begin with vowels
 - begin with consonant blends (sh, cr, th, etc.)
 - begin with single consonants

Method Decomposition

- In a UML class diagram, the visibility of a variable or method is shown by:
 - Public members are preceded by a plus sign +
 - Private members are preceded by a minus sign -
- See `PigLatin.java`
- See `PigLatinTranslator.java`

Class Diagram for Pig Latin



```
//*****
//  PigLatin.java      Author: Lewis/Loftus
//
//  Demonstrates the concept of method decomposition.
//*****

import java.util.Scanner;

public class PigLatin
{
    //-----
    //  Reads sentences and translates them into Pig Latin.
    //-----
    public static void main(String[] args)
    {
        String sentence, result, another = "y";

        Scanner scan = new Scanner(System.in);
```

```
while (another.equalsIgnoreCase("y"));
{
    System.out.println();
    System.out.println("Enter a sentence (no punctuation):");
    sentence = scan.nextLine();

    System.out.println();
    result = PigLatinTranslator.translate(sentence);
    System.out.println("That sentence in Pig Latin is:");
    System.out.println(result);

    System.out.println();
    System.out.print("Translate another sentence (y/n)? ");
    another = scan.nextLine();
}
}
```

```

while (another.equalsIgnoreCase("y"));
{
    System.out.println ();
    System.out.println ("Enter a sentence (no punctuation):");
    sentence = scan.nextLine();

    System.out.println ();
    result = PigLatinTranslat
    System.out.println ("That
    System.out.println (resul

    System.out.println ();
    System.out.print ("Transl
    another = scan.nextLine()

}
}
}

```

Sample Run

Enter a sentence (no punctuation):
Do you speak Pig Latin

That sentence in Pig Latin is:
 oday ouyay eakspay igpay atinlay

Translate another sentence (y/n)? **y**

Enter a sentence (no punctuation):
Play it again Sam

That sentence in Pig Latin is:
 ayplay ityay againyay amsay

Translate another sentence (y/n)? **n**

```
//*****
//  PigLatinTranslator.java          Author: Lewis/Loftus
//
//  Represents a translator from English to Pig Latin. Demonstrates
//  method decomposition.
//*****

import java.util.Scanner;

public class PigLatinTranslator
{
    //-----
    //  Translates a sentence of words into Pig Latin.
    //-----
    public static String translate(String sentence)
    {
        String result = "";
        sentence = sentence.toLowerCase();
        Scanner scan = new Scanner(sentence);

        while (scan.hasNext())
        {
            result += translateWord(scan.next());
            result += " ";
        }
        return result;
    }
}
```

```
//-----  
//  Translates one word into Pig Latin. If the word begins with a  
//  vowel, the suffix "yay" is appended to the word.  Otherwise,  
//  the first letter or two are moved to the end of the word,  
//  and "ay" is appended.  
//-----  
private static String translateWord(String word)  
{  
    String result = "";  
  
    if (beginsWithVowel(word))  
        result = word + "yay";  
    else  
        if (beginsWithBlend(word))  
            result = word.substring(2) + word.substring(0,2) + "ay";  
        else  
            result = word.substring(1) + word.charAt(0) + "ay";  
  
    return result;  
}
```



```
//-----  
//  Determines if the specified word begins with a vowel.  
//-----  
private static boolean beginsWithVowel(String word)  
{  
    String vowels = "aeiou";  
  
    char letter = word.charAt(0);  
  
    return (vowels.indexOf(letter) != -1);  
}
```

```

//-----
//  Determines if the specified word begins with a particular
//  two-character consonant blend.
//-----
private static boolean beginsWithBlend(String word)
{
    return ( word.startsWith("bl") || word.startsWith("sc") ||
             word.startsWith("br") || word.startsWith("sh") ||
             word.startsWith("ch") || word.startsWith("sk") ||
             word.startsWith("cl") || word.startsWith("sl") ||
             word.startsWith("cr") || word.startsWith("sn") ||
             word.startsWith("dr") || word.startsWith("sm") ||
             word.startsWith("dw") || word.startsWith("sp") ||
             word.startsWith("fl") || word.startsWith("sq") ||
             word.startsWith("fr") || word.startsWith("st") ||
             word.startsWith("gl") || word.startsWith("sw") ||
             word.startsWith("gr") || word.startsWith("th") ||
             word.startsWith("kl") || word.startsWith("tr") ||
             word.startsWith("ph") || word.startsWith("tw") ||
             word.startsWith("pl") || word.startsWith("wh") ||
             word.startsWith("pr") || word.startsWith("wr") );
}
}

```

Objects as Parameters

- Parameters in a Java method are *passed by value*
- A *copy* of the *actual parameter* (the value passed in) is stored into the *formal parameter* (listed in the method header)
- When an object is passed to a method, the actual parameter and the formal parameter become *aliases* of each other

Passing Objects to Methods

- What a method does with a parameter may or may not have a permanent effect (outside the method)
- Note the difference between changing the internal state of an object versus changing which object a reference points to
- **See** `ParameterTester.java`
- **See** `ParameterModifier.java`
- **See** `Num.java`

```

public class ParameterTester
{
    //-----
    //  Sets up three variables (one primitive and two objects) to
    //  serve as actual parameters to the changeValues method. Prints
    //  their values before and after calling the method.
    //-----
    public static void main(String[] args)
    {
        ParameterModifier modifier = new ParameterModifier();

        int a1 = 111;
        Num a2 = new Num(222);
        Num a3 = new Num(333);

        System.out.println(">>Before calling changeValues:<<");
        System.out.println("a1\ta2\ta3");
        System.out.println(a1 + "\t" + a2 + "\t" + a3 + "\n");

        modifier.changeValues(a1, a2, a3);

        System.out.println(">>After calling changeValues:<<");
        System.out.println("a1\ta2\ta3");
        System.out.println(a1 + "\t" + a2 + "\t" + a3 + "\n");
    }
}

```

Output

>>Before calling changeValues:<<

a1	a2	a3
111	222	333

Before changing the values:

f1	f2	f3
111	222	333

After changing the values:

f1	f2	f3
999	888	777

>>After calling changeValues:<<

a1	a2	a3
111	888	333

```

//*****
//  ParameterModifier.java          Author: Lewis/Loftus
//
//  Demonstrates the effects of changing parameter values.
//*****

public class ParameterModifier
{
    //-----
    //  Modifies the parameters, printing their values before and
    //  after making the changes.
    //-----
    public void changeValues(int f1, Num f2, Num f3)
    {
        System.out.println("Before changing the values:");
        System.out.println("f1\tf2\tf3");
        System.out.println(f1 + "\t" + f2 + "\t" + f3 + "\n");

        f1 = 999;                // change parameter (no change to main)
        f2.setValue(888);        // change the object (same one in main)
        f3 = new Num(777);       // point parameter to new object
                                // (object in main not affected)

        System.out.println("After changing the values:");
        System.out.println("f1\tf2\tf3");
        System.out.println(f1 + "\t" + f2 + "\t" + f3 + "\n");
    }
}

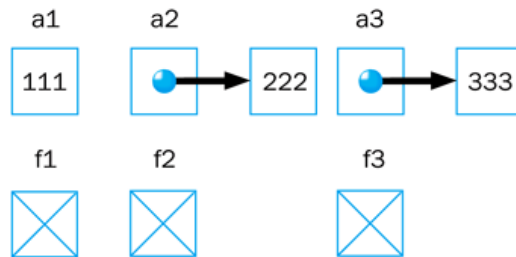
```

```
//*****  
//  Num.java          Author: Lewis/Loftus  
//  
//  Represents a single integer as an object.  
//*****
```

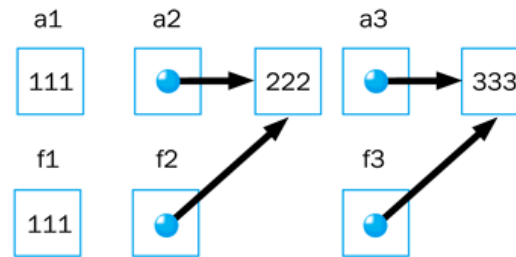
```
public class Num  
{  
    private int value;  
  
    public Num(int initialValue)  // constructor  
    {  
        value = initialValue;  
    }  
  
    public void setValue(int update)  
    {  
        value = update;  
    }  
  
    public String toString()  
    {  
        return value + "  
    }  
}
```


STEP 1

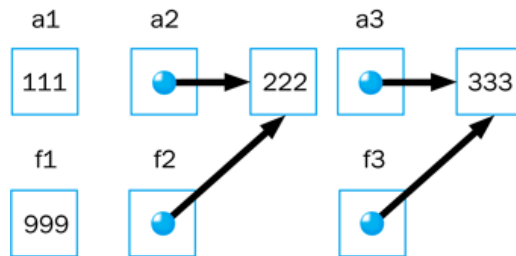
Before invoking changeValues

**STEP 2**

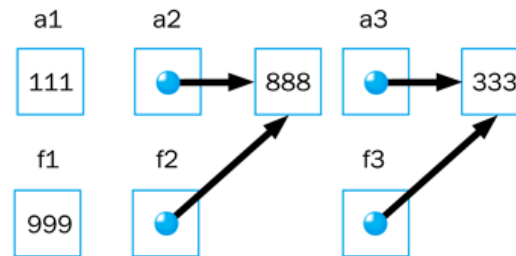
tester.changeValues (a1, a2, a3);

**STEP 3**

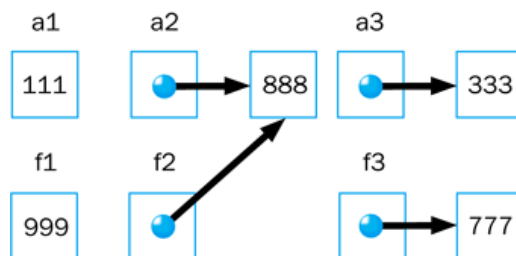
f1 = 999;

**STEP 4**

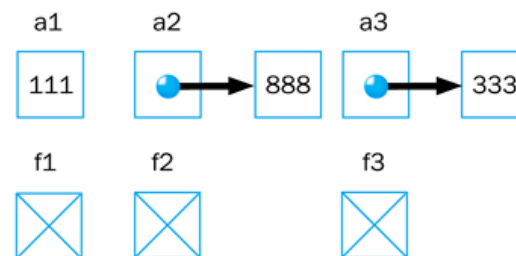
f2.setValue (888);

**STEP 5**

f3 = new Num (777);

**STEP 6**

After returning from changeValues



Method Overloading

- *Method overloading* is the process of giving a single method name **multiple definitions** in a class
- If a method is overloaded, the method name is not sufficient to determine which method is being called
- The ***signature*** of each overloaded method must be unique
 - sometimes called ***method header***
- The signature includes the number, type, and order of the parameters

Method Overloading

- The compiler determines which method is being invoked by analyzing the parameters

```
float tryMe(int x)
{
    return x + .375;
}
```

Invocation

```
result = tryMe(25, 4.32)
```

```
float tryMe(int x, float y)
{
    return x*y;
}
```



Method Overloading

- The `println` method is overloaded:

```
println(String s)
println(int i)
println(double d)
```

and so on...

- The following lines invoke different versions of the `println` method:

```
System.out.println("The total is:");
System.out.println(total);
```

Overloading Methods

- The return type of the method is not part of the signature
- That is, overloaded methods cannot differ only by their return type
- Constructors can be overloaded
- Overloaded constructors provide multiple ways to initialize a new object

Outline

Software Development Activities

Identifying Classes and Objects

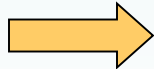
Static Variables and Methods

Class Relationships

Interfaces

😊 **Enumerated Types Revisited**

Method Design



Testing

😊 **GUI Design and Layout**

Testing

- Testing can mean many different things
- It certainly includes running a completed program with various inputs
- Some evaluations should occur before coding even begins
- The earlier we find an problem, the easier and cheaper it is to fix

Testing

- The goal of testing is to find errors
- As we find and fix errors, we raise our confidence that a program will perform as intended
- We can never really be sure that all errors have been eliminated
- So when do we stop testing?
 - Conceptual answer: Never
 - Cynical answer: When we run out of time
 - Better answer: When we are willing to risk undiscovered errors

Reviews

- A *review* is a meeting in which several people examine a design document or section of code
- It is a common and effective form of human-based testing
- Presenting a design or code to others:
 - makes us think more carefully about it
 - provides an outside perspective
- Reviews are sometimes called *inspections* or *walkthroughs*

Test Cases

- A *test case* is a set of input and user actions, coupled with the expected results
- Often test cases are organized formally into *test suites* which are stored and reused as needed
- For medium and large systems, testing must be a carefully managed process
- Many organizations have a separate Quality Assurance (QA) department to lead testing efforts

Defect and Regression Testing

- *Defect testing* is using test cases to uncover errors
- The act of fixing an error may introduce new errors
- After fixing a set of errors we should perform *regression testing* – running previous test suites to ensure new errors haven't been introduced
- It is not possible to create test cases for all possible input and user actions. (combinatorial explosion)
- Therefore we should design tests to maximize their ability to find problems

Black-Box Testing

- In *black-box testing*, test cases are developed without considering the internal logic
- They are based on the input and expected output
- Input can be organized into *equivalence categories*
- Two input values in the same equivalence category would produce similar results
- Therefore a good test suite will cover all equivalence categories and focus on the boundaries between categories

White-Box Testing

- *White-box testing* focuses on the internal structure of the code
- The goal is to ensure that every path through the code is tested
- Paths through the code are governed by any conditional or looping statements in a program
- A good testing effort will include both black-box and white-box tests

Outline

Software Development Activities

Identifying Classes and Objects

Static Variables and Methods

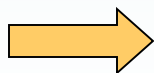
Class Relationships

Interfaces

☺ **Enumerated Types Revisited**

Method Design

Testing



☺ **GUI Design and Layout**

GUI Design

- We must remember that the goal of software is to help the user solve the problem
- To that end, the GUI designer should:
 - Know the user
 - Prevent user errors
 - Optimize user abilities
 - Be consistent
- Let's discuss each of these in more detail

Know the User

- Knowing the user implies an understanding of:
 - the user's true needs
 - the user's common activities
 - the user's level of expertise in the problem domain and in computer processing
- We should also realize these issues may differ for different users
- Remember, to the user, the interface is the program

Prevent User Errors

- Whenever possible, we should design user interfaces that minimize possible user mistakes
- We should choose the best GUI components for each task
- For example, in a situation where there are only a few valid options, using a menu or radio buttons would be better than an open text field
- Error messages should guide the user appropriately

😊 Optimize User Abilities

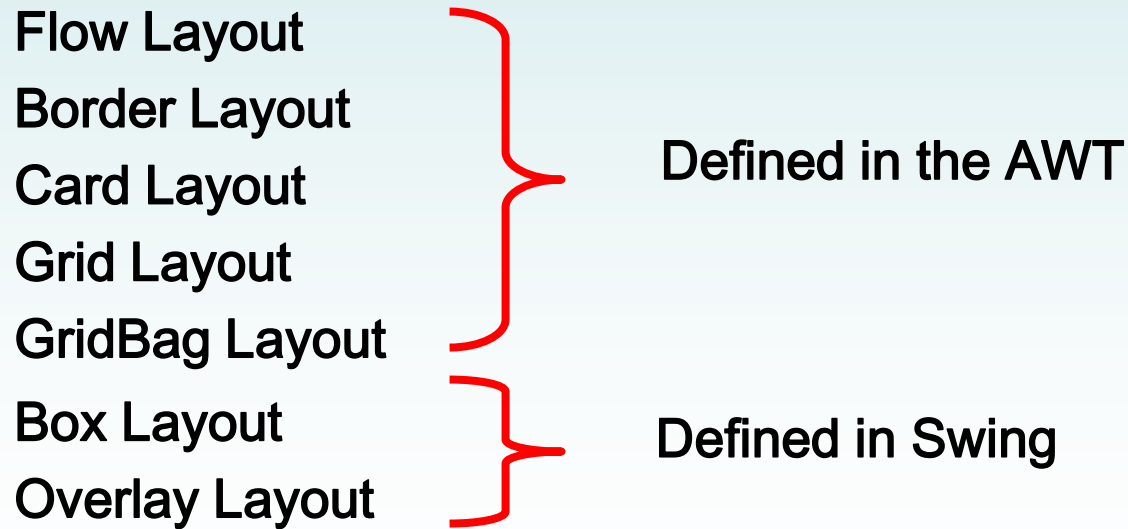
- Not all users are alike – some may be more familiar with the system than others
- Knowledgeable users are sometimes called *power users*
- We should provide multiple ways to accomplish a task whenever reasonable
 - "wizards" to walk a user through a process
 - short cuts for power users
- Help facilities should be available but not intrusive

Be Consistent

- Consistency is important – users get used to things appearing and working in certain ways
- Colors should be used consistently to indicate similar types of information or processing
- Screen layout should be consistent from one part of a system to another
- For example, error messages should appear in consistent locations

☺ Layout Managers

- A *layout manager* is an object that determines the way that components are arranged in a container
- There are several predefined layout managers defined in the Java API:



☺ Layout Managers

- Every container has a default layout manager, but we can explicitly set the layout manager as well
- Each layout manager has its own particular rules governing how the components will be arranged
- Some layout managers pay attention to a component's preferred size or alignment, while others do not
- A layout manager adjusts the layout as components are added and as containers are resized

☺ Layout Managers

- We can use the `setLayout` method of a container to change its layout manager:

```
JPanel panel = new JPanel();  
panel.setLayout(new BorderLayout());
```

- The following example uses a *tabbed pane*, a container which permits one of several panes to be selected
- See `LayoutDemo.java`
- See `IntroPanel.java`

```

//*****
//  LayoutDemo.java          Authors: Lewis/Loftus
//
//  Demonstrates the use of flow, border, grid, and box layouts.
//*****

import javax.swing.*;

public class LayoutDemo
{
    //-----
    //  Sets up a frame containing a tabbed pane. The panel on each
    //  tab demonstrates a different layout manager.
    //-----
    public static void main(String[] args)
    {
        JFrame frame = new JFrame("Layout Manager Demo");
        frame.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
    }
}

```

continue

continue

```
JTabbedPane tp = new JTabbedPane();
tp.addTab("Intro", new IntroPanel());
tp.addTab("Flow", new FlowPanel());
tp.addTab("Border", new BorderPanel());
tp.addTab("Grid", new GridPanel());
tp.addTab("Box", new BoxPanel());

frame.getContentPane().add(tp);
frame.pack();
frame.setVisible(true);
}
}
```



```

//*****
//  IntroPanel.java          Authors: Lewis/Loftus
//
//  Represents the introduction panel for the LayoutDemo program.
//*****

import java.awt.*;
import javax.swing.*;

public class IntroPanel extends JPanel
{
    //-----
    //  Sets up this panel with two labels.
    //-----
    public IntroPanel()
    {
        setBackground(Color.green);

        JLabel l1 = new JLabel("Layout Manager Demonstration");
        JLabel l2 = new JLabel("Choose a tab to see an example of " +
                                "a layout manager.");

        add(l1);
        add(l2);
    }
}

```

```
//*****  
//  IntroE  
//  
//  Repres  
//*****
```

```
import jav  
import jav
```

```
public cla  
{
```

```
//-----  
//  Sets up this panel with two labels.  
//-----
```

```
public IntroPanel()  
{
```

```
    setBackground(Color.green);
```

```
    JLabel l1 = new JLabel("Layout Manager Demonstration");
```

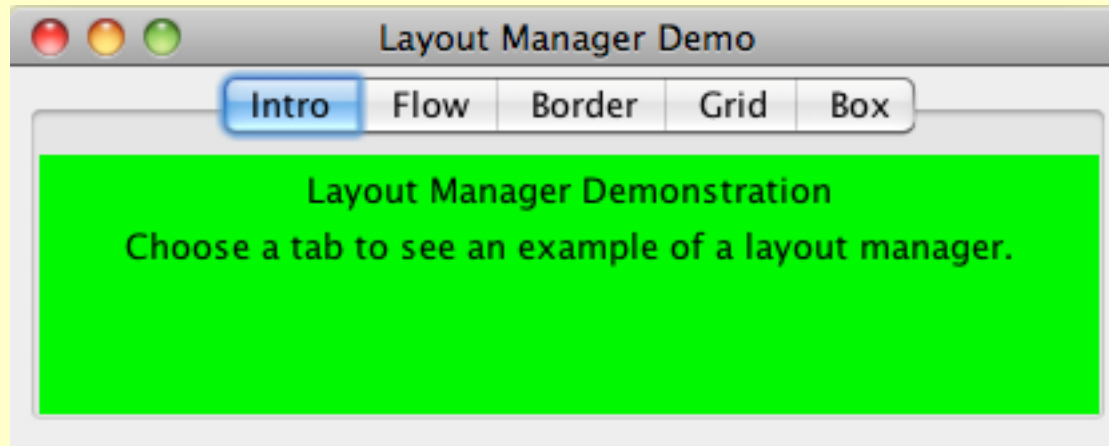
```
    JLabel l2 = new JLabel("Choose a tab to see an example of " +  
                           "a layout manager.");
```

```
    add(l1);
```

```
    add(l2);
```

```
}
```

```
}
```



```
*****  
m.  
*****
```

☺ Flow Layout

- *Flow layout* puts as many components as possible on a row, then moves to the next row
- Components are displayed in the order they are added to the container
- Each row of components is centered horizontally by default, but could also be aligned left or right
- The horizontal and vertical gaps between the components can be explicitly set
- See `FlowPanel.java`

```

//*****
//  FlowPanel.java      Authors: Lewis/Loftus
//
//  Represents the panel in the LayoutDemo program that demonstrates
//  the flow layout manager.
//*****

import java.awt.*;
import javax.swing.*;

public class FlowPanel extends JPanel
{
    //-----
    //  Sets up this panel with some buttons to show how flow layout
    //  affects their position.
    //-----
    public FlowPanel()
    {
        setLayout(new FlowLayout());

        setBackground(Color.green);
    }
}

```

continue

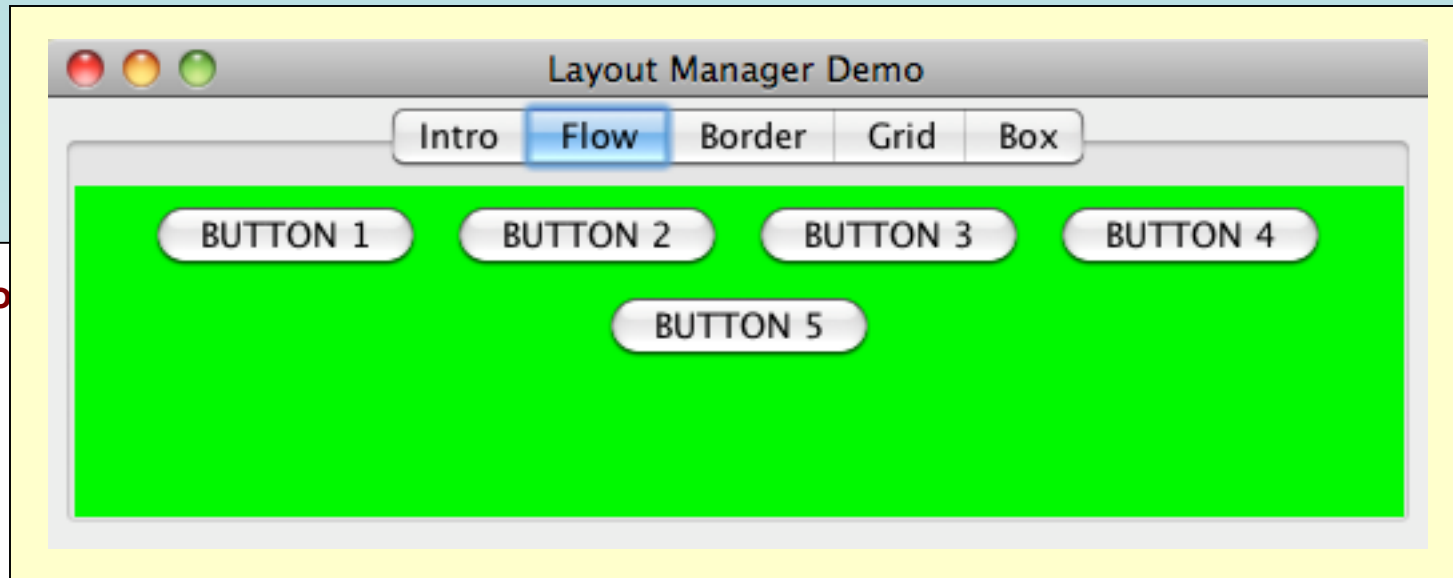
continue

```
JButton b1 = new JButton("BUTTON 1");  
JButton b2 = new JButton("BUTTON 2");  
JButton b3 = new JButton("BUTTON 3");  
JButton b4 = new JButton("BUTTON 4");  
JButton b5 = new JButton("BUTTON 5");
```

```
add(b1);  
add(b2);  
add(b3);  
add(b4);  
add(b5);
```

```
}
```

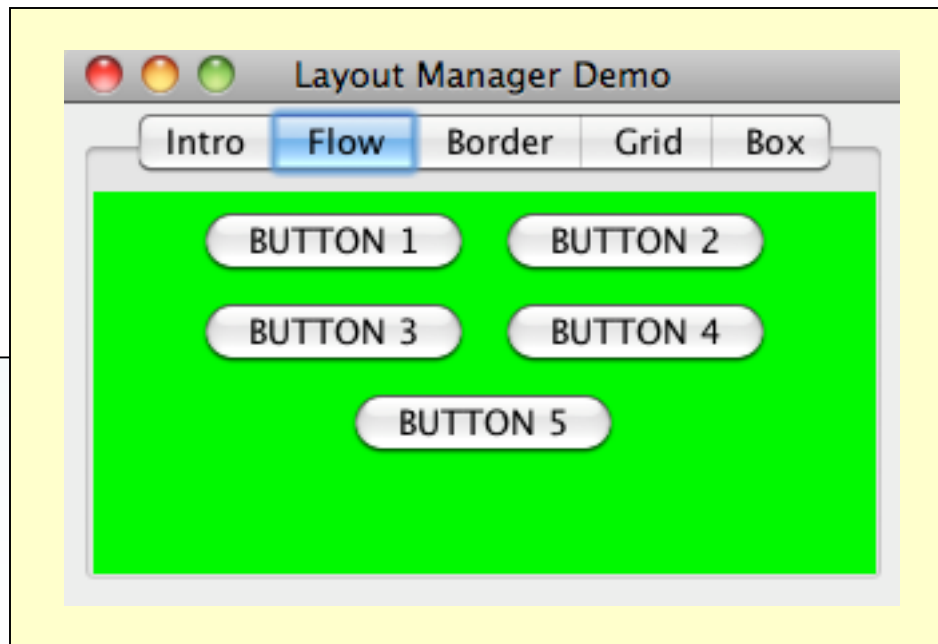
```
}
```



```
add(b1)
add(b2)
add(b3)
add(b4)
add(b5)
```

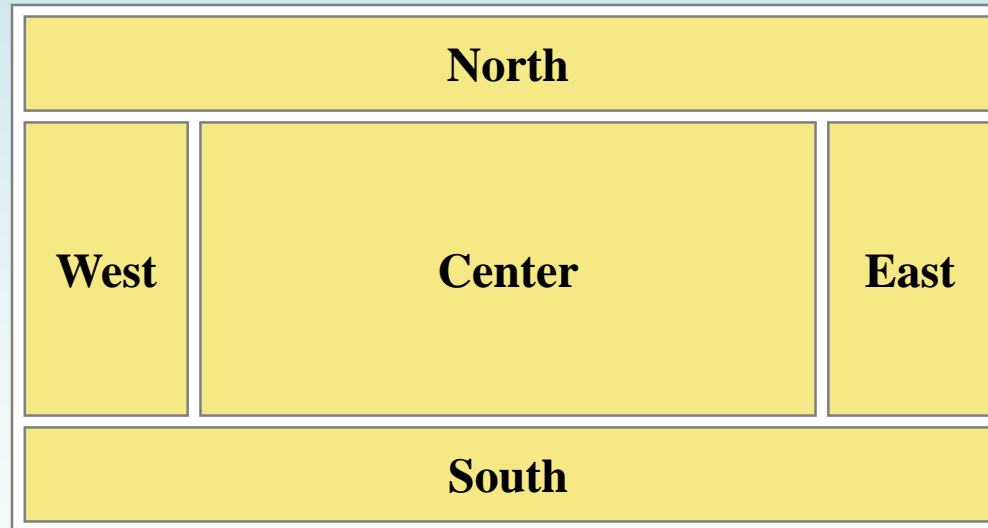
```
}
```

```
}
```



😊 Border Layout

- A *border layout* defines five areas into which components can be added



☺ Border Layout

- Each area displays one component (which could be a container such as a `JPanel`)
- Each of the four outer areas enlarges as needed to accommodate the component added to it
- If nothing is added to the outer areas, they take up no space and other areas expand to fill the void
- The center area expands to fill space as needed
- See `BorderPanel.java`


```

//*****
//  BorderLayout.java      Authors: Lewis/Loftus
//
//  Represents the panel in the LayoutDemo program that demonstrates
//  the border layout manager.
//*****

import java.awt.*;
import javax.swing.*;

public class BorderLayout extends JPanel
{
    //-----
    //  Sets up this panel with a button in each area of a border
    //  layout to show how it affects their position, shape, and size.
    //-----
    public BorderLayout()
    {
        setLayout(new BorderLayout());

        setBackground(Color.green);
    }
}

```

continue

continue

```
JButton b1 = new JButton("BUTTON 1");  
JButton b2 = new JButton("BUTTON 2");  
JButton b3 = new JButton("BUTTON 3");  
JButton b4 = new JButton("BUTTON 4");  
JButton b5 = new JButton("BUTTON 5");
```

```
add(b1, BorderLayout.CENTER);  
add(b2, BorderLayout.NORTH);  
add(b3, BorderLayout.SOUTH);  
add(b4, BorderLayout.EAST);  
add(b5, BorderLayout.WEST);
```

```
}
```

```
}
```

continue

JB

JB

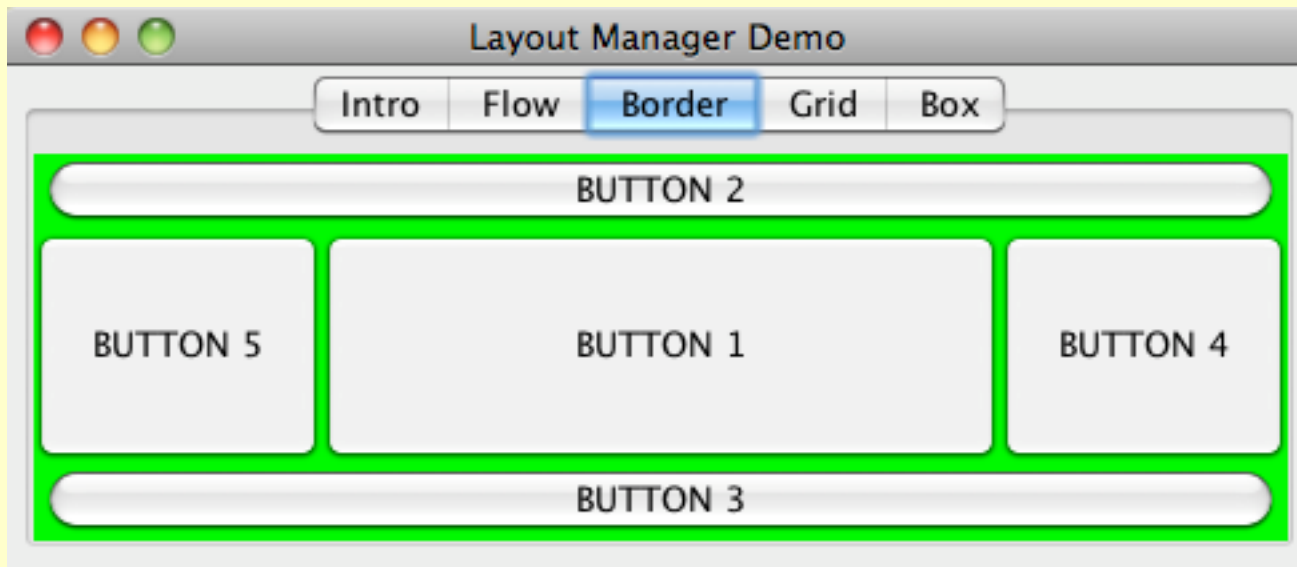
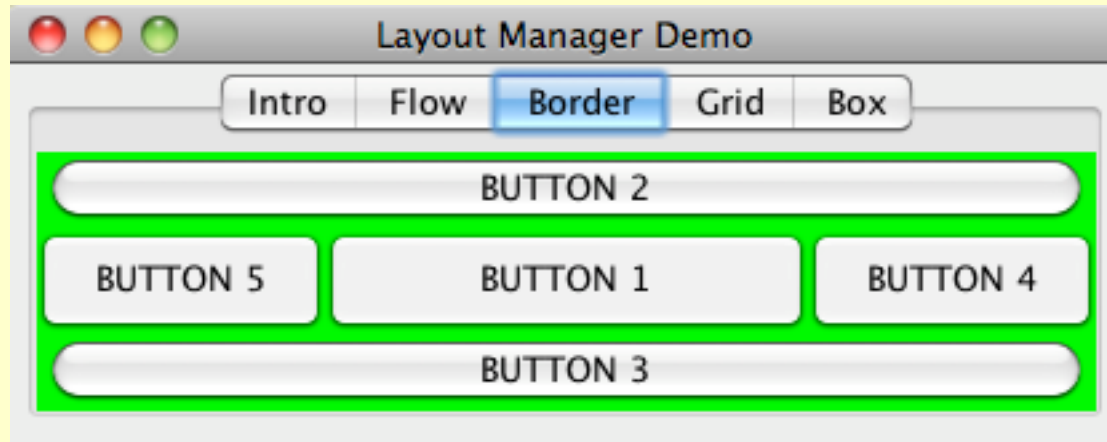
JB

JButton b4 = new JButton("BUTTON 4");

JButton b5 = new JButton("BUTTON 5");

}

}



☺ Grid Layout

- A *grid layout* presents a container's components in a rectangular grid of rows and columns
- One component is placed in each cell of the grid, and all cells have the same size
- Components fill the grid from left-to-right and top-to-bottom (by default)
- The size of each cell is determined by the overall size of the container
- See `GridPanel.java`

```

//*****
//  GridPanel.java      Authors: Lewis/Loftus
//
//  Represents the panel in the LayoutDemo program that demonstrates
//  the grid layout manager.
//*****

import java.awt.*;
import javax.swing.*;

public class GridPanel extends JPanel
{
    //-----
    //  Sets up this panel with some buttons to show how grid
    //  layout affects their position, shape, and size.
    //-----
    public GridPanel()
    {
        setLayout(new GridLayout(2, 3));

        setBackground(Color.green);
    }
}

```

continue

continue

```
JButton b1 = new JButton("BUTTON 1");  
JButton b2 = new JButton("BUTTON 2");  
JButton b3 = new JButton("BUTTON 3");  
JButton b4 = new JButton("BUTTON 4");  
JButton b5 = new JButton("BUTTON 5");
```

```
add(b1);  
add(b2);  
add(b3);  
add(b4);  
add(b5);
```

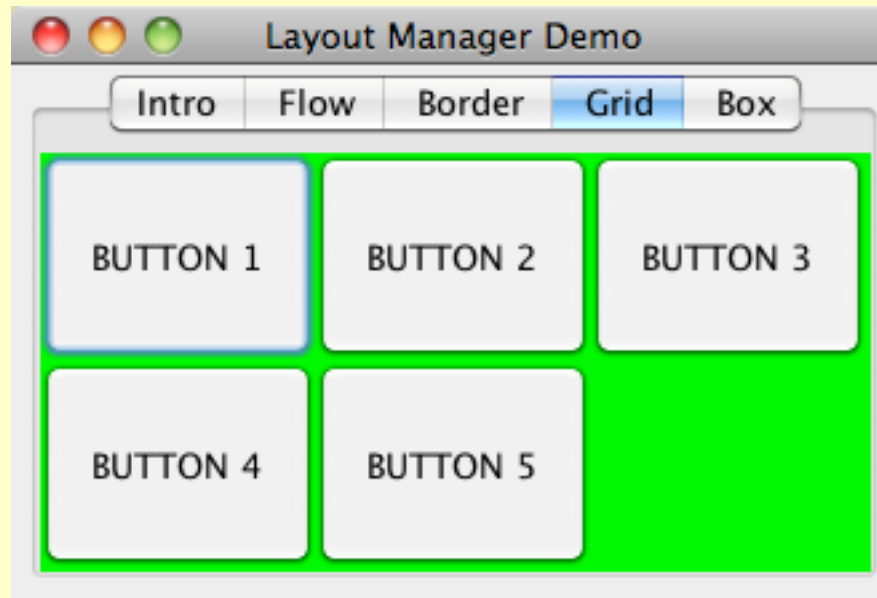
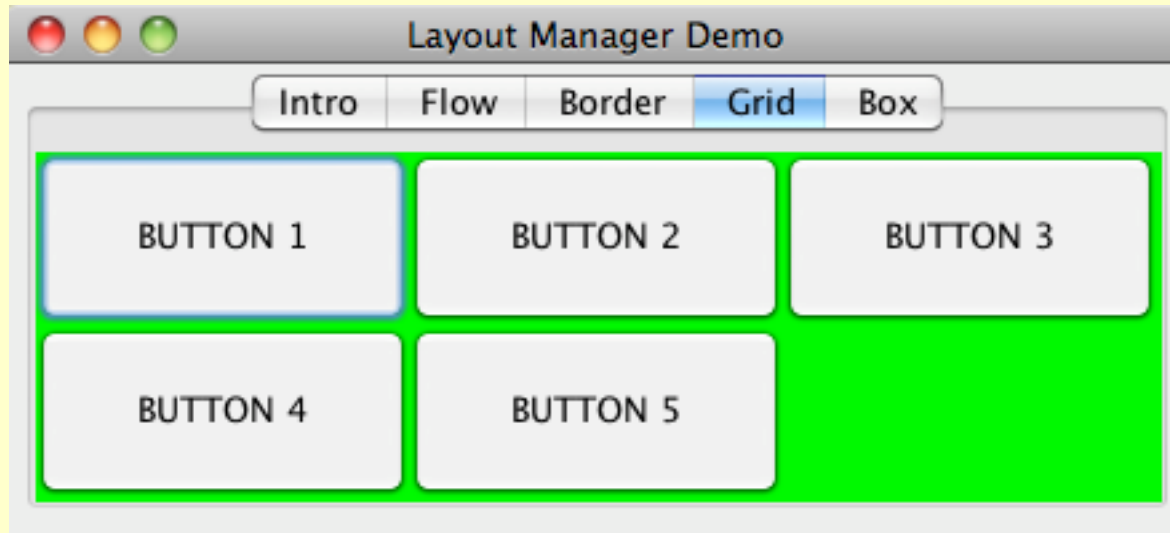
```
}
```

```
}
```

continue

JBt
JBt
JBt
JBt
JBt

```
add(b1) ;  
add(b2) ;  
add(b3) ;  
add(b4) ;  
add(b5) ;  
}  
}
```



☺ Box Layout

- A *box layout* organizes components horizontally (in one row) or vertically (in one column)
- Components are placed top-to-bottom or left-to-right in the order in which they are added to the container
- By combining multiple containers using box layout, many different configurations can be created
- Multiple containers with box layouts are often preferred to one container that uses the more complicated gridbag layout manager

☺ Box Layout

- *Invisible components* can be added to a box layout container to take up space between components
 - *Rigid areas* have a fixed size
 - *Glue* specifies where excess space should go
- Invisible components are created using these methods of the `Box` class:
 - `createRigidArea(Dimension d)`
 - `createHorizontalGlue()`
 - `createVerticalGlue()`
- See `BoxPanel.java`

```

//*****
//  BoxPanel.java          Authors: Lewis/Loftus
//
//  Represents the panel in the LayoutDemo program that demonstrates
//  the box layout manager.
//*****

import java.awt.*;
import javax.swing.*;

public class BoxPanel extends JPanel
{
    //-----
    //  Sets up this panel with some buttons to show how a vertical
    //  box layout (and invisible components) affects their position.
    //-----
    public BoxPanel()
    {
        setLayout(new BoxLayout(this, BoxLayout.Y_AXIS));

        setBackground(Color.green);
    }
}

```

continue

continue

```
    JButton b1 = new JButton("BUTTON 1");
    JButton b2 = new JButton("BUTTON 2");
    JButton b3 = new JButton("BUTTON 3");
    JButton b4 = new JButton("BUTTON 4");
    JButton b5 = new JButton("BUTTON 5");

    add(b1);
    add(Box.createRigidArea(new Dimension(0, 10)));
    add(b2);
    add(Box.createVerticalGlue());
    add(b3);
    add(b4);
    add(Box.createRigidArea(new Dimension(0, 20)));
    add(b5);
}
}
```

continue

```
JB  
JB  
JB  
JB  
JB
```

```
ad  
ad  
ad  
ad  
ad  
ad  
ad  
ad  
ad
```

```
}
```

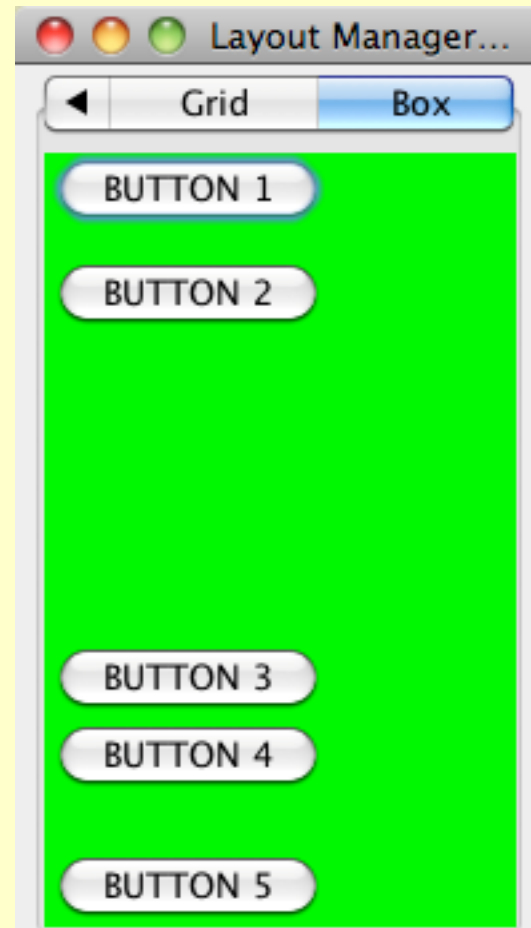
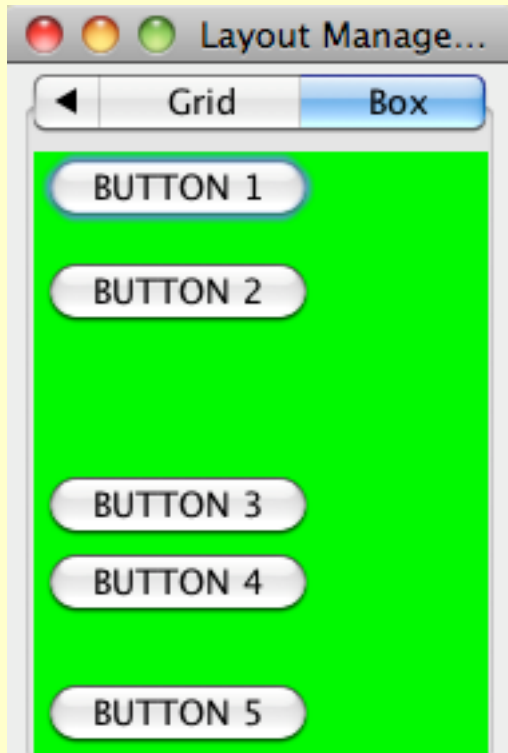
```
}
```

```
UT  
UT  
UT  
UT  
UT
```

```
w
```

```
) )
```

```
w
```



Borders

- A *border* can be put around any Swing component to define how the edges of the component should be drawn
- Borders can be used effectively to group components visually
- The `BorderFactory` class contains several static methods for creating border objects
- A border is applied to a component using the `setBorder` method

😊 Borders

- *An empty border*
 - buffers the space around the edge of a component
 - otherwise has no visual effect
- *A line border*
 - surrounds the component with a simple line
 - the line's color and thickness can be specified
- *An etched border*
 - creates the effect of an etched groove around a component
 - uses colors for the highlight and shadow

Borders

- *A bevel border*
 - can be raised or lowered
 - uses colors for the outer and inner highlights and shadows
- *A titled border*
 - places a title on or around the border
 - the title can be oriented in many ways
- *A matte border*
 - specifies the sizes of the top, left, bottom, and right edges of the border separately
 - uses either a solid color or an image

😊 Borders

- *A compound border*
 - is a combination of two borders
 - one or both of the borders can be a compound border
- **See** `BorderDemo.java`


```

//*****
//  BorderDemo.java          Authors: Lewis/Loftus
//
//  Demonstrates the use of various types of borders.
//*****

import java.awt.*;
import javax.swing.*;
import javax.swing.border.*;

public class BorderDemo
{
    //-----
    //  Creates several bordered panels and displays them.
    //-----
    public static void main(String[] args)
    {
        JFrame frame = new JFrame("Border Demo");
        frame.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);

        JPanel panel = new JPanel();
        panel.setLayout(new GridLayout(0, 2, 5, 10));
        panel.setBorder(BorderFactory.createEmptyBorder(8, 8, 8, 8));

        JPanel p1 = new JPanel();
        p1.setBorder(BorderFactory.createLineBorder(Color.red, 3));
        p1.add(new JLabel("Line Border"));
        panel.add(p1);
    }
}

```

continue

continue

```
JPanel p2 = new JPanel();  
p2.setBorder(BorderFactory.createEtchedBorder());  
p2.add(new JLabel("Etched Border"));  
panel.add(p2);
```

```
JPanel p3 = new JPanel();  
p3.setBorder(BorderFactory.createRaisedBevelBorder());  
p3.add(new JLabel("Raised Bevel Border"));  
panel.add(p3);
```

```
JPanel p4 = new JPanel();  
p4.setBorder(BorderFactory.createLoweredBevelBorder());  
p4.add(new JLabel("Lowered Bevel Border"));  
panel.add(p4);
```

```
JPanel p5 = new JPanel();  
p5.setBorder(BorderFactory.createTitledBorder("Title"));  
p5.add(new JLabel("Titled Border"));  
panel.add(p5);
```

```
JPanel p6 = new JPanel();  
TitledBorder tb = BorderFactory.createTitledBorder("Title");  
tb.setTitleJustification(TitledBorder.RIGHT);  
p6.setBorder(tb);  
p6.add(new JLabel("Titled Border(right)"));  
panel.add(p6);
```

continue

continue

```
JPanel p7 = new JPanel();  
Border b1 = BorderFactory.createLineBorder(Color.blue, 2);  
Border b2 = BorderFactory.createEtchedBorder();  
p7.setBorder (BorderFactory.createCompoundBorder(b1, b2));  
p7.add (new JLabel("Compound Border"));  
panel.add(p7);
```

```
JPanel p8 = new JPanel();  
Border mb = BorderFactory.createMatteBorder(1, 5, 1, 1,  
                                           Color.red);  
  
p8.setBorder(mb);  
p8.add(new JLabel("Matte Border"));  
panel.add(p8);
```

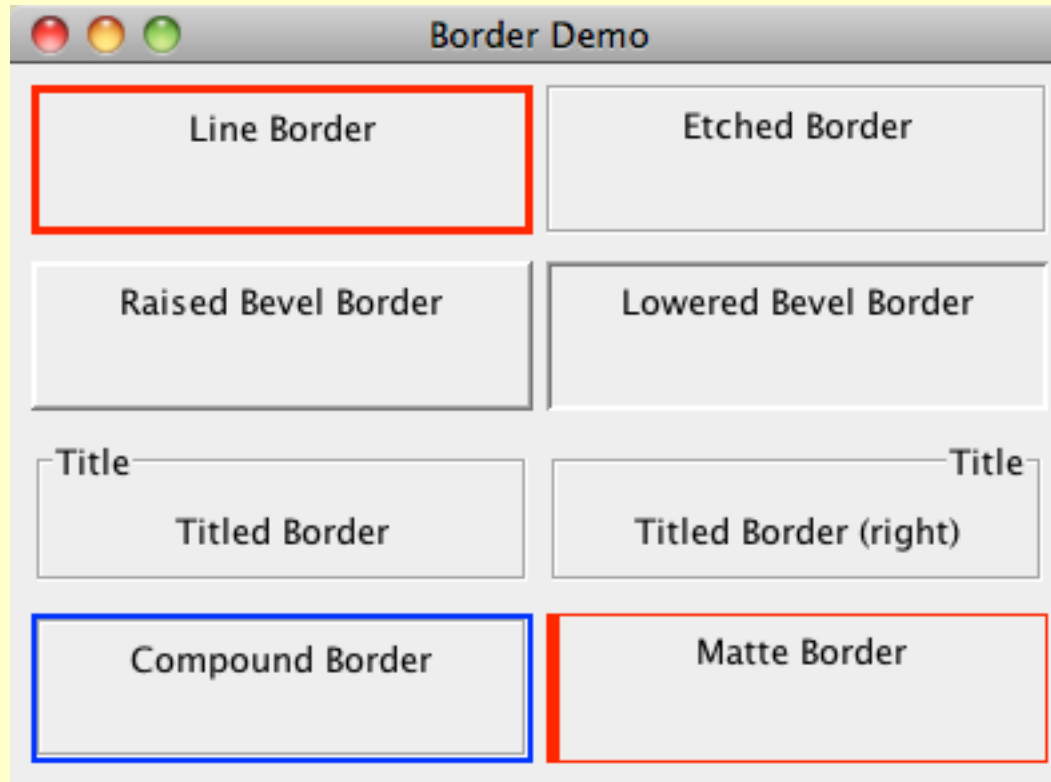
```
frame.getContentPane().add(panel);  
frame.pack();  
frame.setVisible(true);
```

```
}
```

```
}
```

continue

```
JPanel  
Border  
Border  
p7.s  
p7.a  
pane  
  
JPanel  
Border  
  
p8.s  
p8.a  
pane  
  
frame  
frame  
frame.setVisible(true);  
}  
}
```



```
2) ;  
)) ;
```

Summary

- Chapter 7 has focused on:
 - software development activities
 - determining the classes and objects that are needed for a program
 - the relationships that can exist among classes
 - the static modifier
 - writing interfaces
 - 😊 the design of enumerated type classes
 - method design and method overloading
 - 😊 GUI design and layout managers