JAVA BASICS

Primitive data types are like C

- Main data types are `int`, `double`, `boolean`, `char`
- Also have `byte`, `short`, `long`, `float`
- `boolean` has values `true` and `false`
- Declarations look like C, for example,
  - `double x, y;`
  - `int count = 0;`

Comments are almost like C++

- `/* This kind of comment can span multiple lines */`
- `// This kind is to the end of the line`
- ```
  /**
    * This kind of comment is a special
    * 'javadoc' style comment
    */
  ```

  The javadoc program generates HTML API documentation from the "javadoc" style comments in your code.

Expressions are like C

- Assignment statements mostly look like those in C; you can use `=`, `+=`, `*=` etc.
- Arithmetic uses the familiar `+ - * / %`
- Java also has `++` and `--`
- Java has boolean operators `&& || !`
- Java has comparisons `< <= == != >= >`
- Java does *not* have pointers or pointer arithmetic
  ```

Control statements are like C

- `if (x < y) smaller = x;`
- `if (x < y) { smaller = x; sum += x; }`
  `else { smaller = y; sum += y; }`
- `while (x < y) { y = y - x; }`
- `do { y = y - x; } while (x < y)`
- `for (int i = 0; i < max; i++) sum += i;`
- BUT: conditions must be `boolean` !

Control statements II

```
switch (n + 1) {
  case 0: m = n - 1; break;
  case 1: m = n + 1;
  case 3: m = m * n; break;
  default: m = -n; break;
}
```

- Java also introduces the `try` statement, about which more later

Java isn't C!

- In C, almost everything is in functions
- In Java, almost everything is in classes
- Typically, there is only one class per file
- There *must* be only *one* `public` class per file
- The file name *must* be the same as the name of the public class, but with a `.java` extension

Java program layout

- A typical Java file looks like:

```
import java.awt.*;
import java.util.*;

public class SomethingOrOther {
  // field and method definitions go here
  . . .
}
```

This must be on a file named `SomethingOrOther.java` !

What is a class?

- Early languages had only arrays
  - all elements had to be of the same type
- Then languages introduced structures (called `records`, or `structs`)
  - allowed different data types to be grouped
- Then Abstract Data Types (ADTs) became popular
  - grouped operations along with the data

So, what is a class?

- A class consists of
  - a collection of *fields*, or *variables*, very like the named fields of a struct
  - all the operations (called *methods*) that can be performed on those fields
- A class is like a type; it describes objects
- The objects are like values of that type

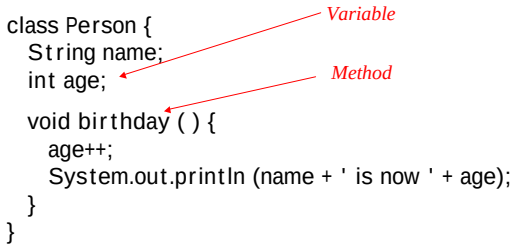
Name Conventions

- Java is case-sensitive; `maxval`, `maxVal`, and `MaxVal` are three different names
- Class names begin with a capital letter
- All other names begin with a lowercase letter
- Subsequent words are capitalized: `theBigOne`
- Underscores are not used in names
- These are *very strong* conventions!

The Java class hierarchy

- Classes are arranged in a hierarchy
- The root, or topmost, class is `Object`
  All classes descend from this single root.
- Every class but `Object` has a (one) superclass
  No multiple inheritance
- A class may have subclasses
- Each class *inherits* all the fields and methods of its superclasses

An example of a class




```
class Person {
   String name;
   int age;

   void birthday ( ) {
      age++;
      System.out.println (name + ' is now ' + age);
   }
}
```


Another example of a class

```
class Driver extends Person {
   long driversLicenseNumber;
   Date expirationDate;
}
```


Scoping

- As in C/C++, scope is determined by the placement of curly braces {}.
- A variable defined within a scope is available only to the end of that scope.

```
{  int x = 12;
   /* only x available */
      { int q = 96;
         /* both x & q available */
      }
      /* only x available */
      /* q "out of scope" */
   }
```

This is ok in C/C++ but not in Java.

```
{   int x = 12;
    { int x = 96; /* illegal */
     }
 }
```


Creating and using an object

- Person john;
  john = new Person ( );
  john.name = "John Smith";
  john.age = 37;
- Person mary = new Person ( );
  mary.name = "Mary Brown";
  mary.age = 33;
  mary.birthday ( );

An array is an object

- `Person mary = new Person ( );`
- `int myArray[ ] = new int[5];`
- `int myArray[ ] = {1, 4, 9, 16, 25};`
- `String languages [ ] = {"Prolog", "Java"};`
- Since arrays are objects they are not allocated on stack, but dynamically
- Arrays, like all objects, are subject to garbage collection when no more references remain
  - so fewer memory leaks
  - Java doesn't have pointers!

Scope of Objects

- Java objects don't have the same lifetimes as primitives.
- When you create a Java object using **new**, it hangs around past the end of the scope.
- Here, the scope of name s is delimited by the {}s but the String object hangs around until GC'd

```
{
  String s = new String("a string");
} /* end of scope */
```


Methods, arguments and return values

- Java methods are like functions. General case:

returnType methodName (*arg1, arg2, … argN*) {
  methodBody
}

The return keyword exits a method optionally with a value

```
int storage(String s) {return s.length() * 2;}
boolean flag() { return true; }
float naturalLogBase() { return 2.718f; }
void nothing() { return; }
void nothing2() {}
```


The static keyword

- Java methods and variables can be declared static
- These exist **independent of any object**
- This means that a Class's
  - static methods can be called even if no objects of that class have been created and
  - static data is "shared" by all instances (I.e., one rvalue per class instead of one per instance

```
class StaticTest {static int i = 47;}
StaticTest st1 = new StaticTest();
StaticTest st2 = new StaticTest();
// st1.i == st2.i == 47
StaticTest.i++;         // or st1.i++ or st2.i++
// st1.i == st2.i == 48
```

Array Operations

- Subscripts always start at 0 as in C
- Subscript checking is done automatically
- Certain operations are defined on arrays of objects, as for other classes
  - e.g. myArray.length == 5

Example Programs

Echo.java

```
C:\UMBC\331\java>type echo.java
//  This is the Echo example from the Sun tutorial
class echo {
  public static void main(Stringargs[]) {
    for (int i=0; i < args.length; i++) {
      System.out.println( args[i] );
    }
  }
}

C:\UMBC\331\java>javac echo.java

C:\UMBC\331\java>java echo this is pretty silly
this
is
pretty
silly

C:\UMBC\331\java>
```

Factorial Example

From Java in a Nutshell

```
/**
 * This program computes the factorial of a number
 */
public class Factorial {                    // Define a class
  public static void main(String[]args) { // The program starts here
    int input = Integer.parseInt(args[0]); // Get the user's input
    double result = factorial(input);      // Compute the factorial
    System.out.println(result);            // Print out the result
  }                                         // The main() method ends here

  public static double factorial(int x) {  // This method computes x!
    if (x < 0)                              // Check for bad input
      return 0.0;                           //   if bad, return 0
    double fact = 1.0;                      // Begin with an initial value
    while(x > 1) {                          // Loop until x equals 1
      fact = fact * x;                      //   multiply by x each time
      x = x - 1;                            //   and then decrement x
    }                                       // Jump back to the top of loop
    return fact;                            // Return the result
  }                                         // factorial() ends here
}                                           // The class ends here
```

JAVA Classes

- The *class* is the fundamental concept in JAVA (and other OOPLs)
- A class describes some data object(s), and the operations (or methods) that can be applied to those objects
- Every object and method in Java belongs to a class
- Classes have data (fields) and code (methods) and classes (member classes or inner classes)
- Static methods and fields belong to the class itself
- Others belong to instances

Example

```
public class Circle {
  // A class field
  public static final double PI= 3.14159;     // A useful constant

  // A class method: just compute a value based on the arguments
  public static double radiansToDegrees(double rads) {
    return rads * 180 / PI;
  }

  // An instance field
  public double r;                  // The radius of the circle

  // Two instance methods: they operate on the instance fields of an
  object
  public double area() {            // Compute the area of the
  circle
    return PI * r * r;
  }
  public double circumference() {   // Compute the circumference of
  the circle
    return 2 * PI * r;
  }
}
```


Constructors

- Classes should define one or more methods to create or construct instances of the class
- Their name is the same as the class name
  - note deviation from convention that methods begin with lower case
- Constructors are differentiated by the number and types of their arguments
  - An example of overloading
- If you don't define a constructor, a default one will be created.
- Constructors automatically invoke the zero argument constructor of their superclass when they begin (note that this yields a recursive process!)

Constructor example

```
public class Circle {
    public static final double PI = 3.14159;  // A constant
    public double r;   // instance field holds circle's radius

    // The constructor method: initialize the radius field
    public Circle(double r) { this.r = r; }

    // Constructor to use if no arguments
    public Circle() { r = 1.0; }
    // better: public Circle() { this(1.0); }

    // The instance methods: compute values based on radius
    public double circumference() { return 2 * PI * r; }
    public double area() { return PI * r*r; }
}
```

this.r refers to the r field of the class

This() refers to a constructor for the class

Extending a class

- Class hierarchies reflect subclass-superclass relations among classes.
- One arranges classes in hierarchies:
  - A class inherits instance variables and instance methods from all its superclasses.
  - You can specify only ONE superclass for any class.
- When a subclass-superclass chain contains multiple instance methods with the same signature (name, arity, and argument types), the one **closest** to the target instance in the subclass-superclass chain is the one executed.
  - All others are shadowed/overridden.
- Something like multiple inheritance can be done via interfaces (more on this later)
- What's the superclass of a class define w/o an extends clause?

Extending a class

```
public class PlaneCircle extends Circle {
  // We automatically inherit the fields and methods of Circle,
  // so we only have to put the new stuff here.
  // New instance fields that store the center point of the circle
  public double cx, cy;

  // A new constructor method to initialize the new fields
  // It uses a special syntax to invoke the Circle() constructor
  public PlaneCircle(double r, double x, double y) {
    super(r);     // Invoke the constructor of the superclass, Circle()
    this.cx = x;  // Initialize the instance field cx
    this.cy = y;  // Initialize the instance field cy
  }

  // The area() and circumference() methods are inherited from Circle
  // A new instance method that checks whether a point is inside the circle
  // Note that it uses the inherited instance field r
  public boolean isInside(double x, double y) {
    double dx = x - cx, dy = y - cy;          // Distance from center
    double distance = Math.sqrt(dx*dx + dy*dy);  // Pythagorean theorem
    return (distance < r);                    // Returns true or false
  }
}
```


Overloading, overwriting, and shadowing

- **Overloading** occurs when Java can distinguish two procedures with the same name by examining the number or types of their parameters.
- **Shadowing** or **overriding** occurs when two procedures with the same signature (name, the same number of parameters, and the same parameter types) are defined in different classes, one of which is a superclass of the other.

On designing class hierarchies

- Programs should obey the *explicit-representation principle*, with classes included to reflect natural categories.
- Programs should obey the *no-duplication principle*, with instance methods situated among class definitions to facilitate sharing.
- Programs should obey the *look-it-up principle*, with class definitions including instance variables for stable, frequently requested information.
- Programs should obey the *need-to-know principle*, with public interfaces designed to restrict instance-variable and instance-method access, thus facilitating the improvement and maintenance of nonpublic program elements.
- If you find yourself using the phrase *an X is a Y* when describing the relation between two classes, then the X class is a subclass of the Y class.
- If you find yourself using *X has a Y* when describing the relation between two classes, then instances of the Y class appear as parts of instances of the X class.

Data hiding and encapsulation

- Data-hiding or encapsulation is an important part of the OO paradigm.
- Classes should carefully control access to their data and methods in order to
  - Hide the irrelevant implementation-level details so they can be easily changed
  - Protect the class against accidental or malicious damage.
  - Keep the externally visible class simple and easy to document
- Java has a simple access control mechanism to help with encapsulation
  - Modifiers: public, protected, private, and package (default)

Example

encapsulation

```
package shapes;           // Specify a package for the class
public class Circle {     // The class is still public
  // This is a generally useful constant, so we keep it public
  public static final double PI = 3.14159;

  protected double r;     // Radius is hidden, but visible to subclasses

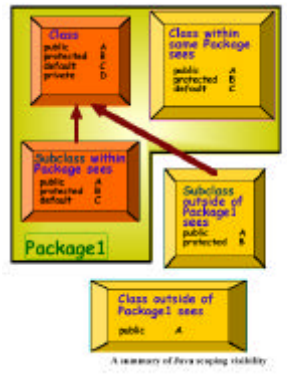
  // A method to enforce the restriction on the radius
  // This is an implementation detail that may be of interest to subclasses
  protected checkRadius(double radius) {
    if (radius < 0.0)
      throw new IllegalArgumentException("radius may not be negative.");
  }
  // The constructor method
  public Circle(double r) { checkRadius(r); this.r = r; }

  // Public data accessor methods
  public double getRadius() { return r; };
  public void setRadius(double r) { checkRadius(r); this.r = r;}

  // Methods to operate on the instance field
  public double area() { return PI * r * r; }
  public double circumference() { return 2 * PI * r; }
}
```


Access control

- Access to packages
  - Java offers no control mechanisms for packages.
  - If you can find and read the package you can access it
- Access to classes
  - All top level classes in package P are accessible anywhere in P
  - All public top-level classes in P are accessible anywhere
- Access to class members (in class C in package P)
  - Public: accessible anywhere C is accessible
  - Protected: accessible in P and to any of C's subclasses
  - Private: only accessible within class C
  - Package: only accessible in P (the default)



A summary of Java scoping visibility

Getters and setters

- A getter is a method that extracts information from an instance.
  - One benefit: you can include additional computation in a getter.
- A setter is a method that inserts information into an instance (also known as mutators).
  - A setter method can check the validity of the new value (e.g., between 1 and 7) or trigger a side effect (e.g., update a display)
- Getters and setters can be used even w/o underlying matching variables
- Considered good OO practice
- Essential to javabeans
- Convention: for variable fooBar of type fbtype, define
  - getFooBar()
  - setFooBar(fbtype x)

Example

getters and setters

```
package shapes;           // Specify a package for the class

public class Circle {     // The class is still public
  // This is a generally useful constant, so we keep it public
  public static final double PI = 3.14159;

  protected double r;     // Radius is hidden, but visible to subclasses

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    if (radius < 0.0)
      throw new IllegalArgumentException("radius may not be negative.");
  }

  // The constructor method
  public Circle(double r) {checkRadius(r); this.r = r;}

  // Public data accessor methods
  public double getRadius() { return r; };
  public void setRadius(double r) { checkRadius(r); this.r = r;}

  // Methods to operate on the instance field
  public double area() { return PI * r * r; }
  public double circumference() { return 2 * PI * r; }
}
```


Abstract classes and methods

- Abstract vs. concrete classes
- Abstract classes can not be instantiated

  public abstract class shape { }
- An abstract method is a method w/o a body

  public abstract double area();
- (Only) Abstract classes can have abstract methods
- In fact, any class with an abstract method is automatically an abstract class

Example

abstract class

```
public abstract class Shape {
  public abstract double area();  // Abstract methods: note
  public abstract double circumference();// semicolon instead of body.
}

class Circle extends Shape {
  public static final double PI = 3.14159265358979323846;
  protected double r;                                  // Instance data
  public Circle(double r) { this.r = r; }              // Constructo
  public double getRadius() { return r; }             // Accessor
  public double area() { return PI*r*r; }              // Implementations of
  public double circumference() { return 2*PI*r; } // abstract methods.
}

class Rectangle extends Shape {
  protected double w, h;                                // Instance data
  public Rectangle(double w, double h) {               // Constructor
    this.w = w;  this.h = h;
  }
  public double getWidth() { return w; }               // Accessor method
  public double getHeight() { return h; }              // Another accessor
  public double area() { return w*h; }                 // Implementations of
  public double circumference() { return 2*(w + h); }  // abstract methods.
}
```

Syntax Notes

- No global variables
  - class variables and methods may be applied to any instance of an object
  - methods may have local (private?) variables
- No pointers
  - but complex data objects are "referenced"
- Other parts of Java are borrowed from PL/I, Modula, and other languages