These notes are intended for students familiar with C++
Originally from Bruce Char & Vera Zaychik
Intro
Java is Object-Oriented

Inheritance in Java is rather like inheritance in C++. Some differences to note:

- No multiple inheritance
  - We use Java Interfaces
- All methods are virtual
  - All variables of type Object are references, so...
- There is no destructor
  - finalize() is called when object is released back to the heap
  - So, not reliably called
- Java allows static attributes of any type to be initialised at the declaration
- Java allows classes to be defined inside a class
- Java allows unnamed classes
Java Classes
The Math class, e.g., is simply a container for methods and constants.

- Can’t be instantiated
  - The default constructor is made private
- The class is final – can’t be subclassed
- All methods are public static
  - Math.sin( a ) ;
  - Math.exp( x ) ;
- Constants are public static attributes
Inheritance
Inheritance vs. Aggregation

- **Inheritance** is the *is-a* relationship:
  - A square is a shape
  - An employee is a person
  - A professor is an employee
  - So, a professor is a person
  - It’s not perfect

- **Aggregation** is the *has-a* relationship:
  - A square has a color
  - An employee has an address
  - A car has an engine
    - And 4 tires
Inheritance

Given a simple class:

```java
public class Person {
    protected String _name ;
    public Person( String n ) { _name = n ; }
    public String getName() { return _name ; }
}
```

We can define a subclass:

```java
public class Professor extends Person {
    protected String _id ;
    public Professor( String n, string i )
    { super(n) ; _id = i ; }
    public String getName()
    { return "Prof. " + _name ; }
}
```
An abstract class can not be instantiated

It typically contains method declarations, w/out definitions

- These are behaviors that subclasses must provide to be meaningfull objects
- Use the @Override annotation

E.g., a closed shape might well know its color, and declare a method to compute its area

- All closed shapes have an area
- Computed differently for each shape
- Area of an abstract shape is meaningless
Abstract Superclass – example

```java
public abstract class ClosedShape {
    protected Color _fill ;
    public ClosedShape( Color c ) { _fill = c ; }
    public Color color() { return _fill ; }
    public abstract double getArea() ;
}
```

We create an actual shape

```java
public class Circle extends ClosedShape {
    protected double _radius ;

    public Circle( Color c, double r )
    { super(c) ; _radius = r ; }

    @Override
    public double getArea()
    { return Math.Pi * _radius * _radius ; }

    public double getRadius() { return _radius ; }
}
```
Casting

- Objects can be cast up the tree
  - Always safe
  - Explicit cast not needed
  - Only methods from ancestor may be called
  - Remember, all methods are virtual

```java
ClosedShape s = new Circle(Color.BLUE, 3);
```

- Objects can be cast down the tree
  - Might throw `ClassCastException`
  - Remember, all methods are virtual

```java
Circle c = (Circle)s; // This works fine
Square q = (Square)s; // This throws exception
```
We can test objects

An object of a subclass is always an instance of an ancestor

An object of a class is not, generally, an instance of a descendant

```java
ClosedShape c = new Circle( Color.PURPLE, 8 );
...
if( c instanceof Square ) System.out.println( "c is a Square" );
if( c instanceof Circle ) System.out.println( "c is a Circle" );
if( c instanceof ClosedShape )
   System.out.println( "c is a ClosedShape" );
```

c is a Circle
c is a ClosedShape
We can create containers of shapes:

```java
public static void main( String [] args )
{
    GridLoc l = new GridLoc( 1, 2 ) ;
    ArrayList<Shape> zoo = new ArrayList<Shape>() ;
    zoo.add( new Circle( 3, l ) ) ;
    zoo.add( new Square( 5, l ) ) ;

    for( Shape s : zoo )
    {
        System.out.printf( "Area: %.2f\n", s.getArea() ) ;
    }
}
```

Area: 28.27
Area: 25.00
Java does not support multiple inheritance
- This is not a bad thing
- Multiple inheritance is messy, both in design and implementation

An interface describes behaviors which must be supplied by any implementing class
- It *declares* methods
- It does not *define* any
- Attributes, however, *can* be defined
An interface can “inherit” from one or more other interfaces:

```java
public interface Stealthy
{
    public void stalk();
}
```

```java
public interface Predator extends Stealthy
{
    public void pounce();
}
```

A class might implement multiple interfaces:

```java
public class Cat extends Animal implements Predator, Yowler
{
    ... 
}
Instances of an class implementing an interface can be viewed as objects of that type

- A `KeyListener` object, whatever else it is, has methods `keyTyped`, `keyPressed`, and `keyReleased`
- All Animals that implement the `Yowler` interface can be contained together:

```java
public static void main( String [] args )
{
    ArrayList<Yowler> zoo = new ArrayList<Yowler>() ;
zoo.add( new Cat( "Sylvester" )) ;
zoo.add( new Wolf( "Nighteyes" )) ;
...
    for( Yowler y : zoo )
    {
        y.singAncientSongOfYourPeople() ;
    }
}
```
Exceptions
These are the exceptions in the Java standard library.

Exceptions in darker boxes are *checked* exceptions:

- Must be caught, or listed in a `throws` statement
- All *should* be so listed

Inherit off of any of these to make your own exceptions:

- No behavior need be defined
- Its value is its type

Taken from Cay Horstmann's *Big Java, 4th ed.*
User-Defined Exceptions

```java
public class ThatsOdd extends IllegalArgumentException {
    public ThatsOdd( String s ) { super( s ); }
}
```

Can be used as any other exception:

```java
public static void foo( int i ) throws ThatsOdd {
    if ( i%2==1 )
        throw new ThatsOdd( "We’re partial to evens, in this method." ) ;
...
}

public static void bar( int n ) {
    try {
        foo( n/2 ) ;
        ...
    } // try
    catch( ThatsOdd e ) {
        System.err.printf( "bar> caught ThatsOdd: %s\n", e.toString() ) ;
        e.printStackTrace() ;
    }
}
```
Nested Classes
Nested Classes in Java

- Java allows classes to be defined inside other classes
  - Even inside methods
  - Even unnamed
- We’ll briefly look at these, describe common uses
  - We will not discuss nuances of design in this course
Types of Nested Classes

- The possibilities are:
  - Static nested class
  - Non-static inner class
    - Need an instance of outer class to instantiate
    - Defined inside a method (*method-local*)
      - Can only be instantiated in that method
      - Object can be returned from method
  - Do not confuse visibility (scope) with access
    - A private member is not accessible, outside of that class
Just a container for similar classes

```java
public class Public {
    public static class Inner1 {
        public void talk() {
            System.out.println( "In Public.Inner1.talk" );
        }
    } // class Inner1

    public static class Inner2 {
        public void talk() {
            System.out.println( "In Public.Inner2.talk" );
        }
    } // class Inner1
} // class Public
```
Public Static Nested Classes (cont.)

- Used like any other class
- Note the scope

```java
public static void main( String [] args )
{
    Public.Inner1 i1 = new Public.Inner1();
    Public.Inner2 i2 = new Public.Inner2();

    i1.talk();
    i2.talk();
}
```

// class Inner1
Non-Static Nested Classes

- Also called *inner* classes
- About all Java offers in the way of a *closure*
  - Needs an instance of outer class
  - These objects capture their surrounding scope, even if the containing object is no longer accessible
- Can be an alternative to exposing outer class’ attributes to entire package (or world)
- An inner class may be *unnamed*
  - Commonly used to install event handlers
E.g., inside a Dialog we might have event handlers for some controls

```java
buttonYes = new JButton() ;
buttonNo = new JButton() ;
...
buttonYes.addActionListener(
    new java.awt.ActionEvent() // class definition here
    {
        public void actionPerformed( java.awt.event.ActionEvent e )
        {
            doSomething() ;
        }
    }
)
```
Object creation is abstracted
- Class will choose which subclass to create
- Subclasses are hidden (can’t be instantiated directly)
  - Private static nested class, OR
  - Method local (defined inside the factory method)
- Consider the Sorting Hat, from Hogwarts
  - It decides which House a student belongs to
  - All houses have same i/f:

```java
public abstract class House {
    ...
    public abstract represent() ;
}
```
Inside we could define our subclasses:

```java
private static class Gryffyndor extends House {
    @Override
    public void represent() {
        System.out.println( "Gryffyndor!" );
    }
}

private static class Slytherin extends House {
    @Override
    public void represent() {
        System.out.println( "Slytherin!" );
    }
}

private static class RavenClaw extends House {
    @Override
    public void represent() {
        System.out.println( "RavenClaw!" );
    }
}
```
Hogwarts (cont.)

- Here’s our factory method, with exclusive access to the subclasses:

```java
public static House SortingHat( int i )
{
    House rv = null;
    switch( i%3 ) {
        case 0 : rv = new Gryffyndor(); break;
        case 1 : rv = new Slytherin(); break;
        case 2 : rv = new RavenClaw(); break;
    }
    return rv;
}
```

- We let the factory decide the proper subclass to use:

```java
public static void main( String [] args )
{
    House h = House.SortingHat( 27 );
    h.represent();
}
```