23-0: **Drawing Example**

- Creating a drawing program
- Allow user to draw triangles, circles, rectanlges, move them around, etc.
- Need to store a list of shapes, each of which could be a circle, rectangle, or triangle
- Shape superclass, with Triangle, Rectangle, and Circle subclasses

23-1: **Shape Class**

```
class Shape
{
   public void draw()
   {

   }
}
class Rectangle extends Shape
{
   public void draw()
   {
     // code to draw a Rectangle
   }
}
class Circle extends Shape
{
   public void draw()
   {
     // code to draw a Circle
   }
}
```

```
in main
---------
Shape shapes[] = new Shape[3];
shapes[0] = new Circle();
shapes[1] = new Rectangle();
shapes[2] = new Circle();


for (int i = 0; i < shapes.length; i++)
{
    shapes[i].draw();
}
```

23-2: **Abstract Classes**

- Abstract Class:
  - How do you draw a generic shape?
    - Drawing a generic shape doesn't make sense!
  - Does it ever make sense to instantiate a generic Shape (instead of a circle, triangle, or rectange)?
    - No!
  - We can make the Shape class *abstract*
  - Prevents anyone from creating an instance of Shape
  - Shape *variables* are OK, as long as values are Circles, Triangles, etc

23-3: **Abstract Classes**

```
abstract class Shape
{
   public abstract void draw();
}
class Circle extends Shape
{
 // Needs to implement draw
}
class Triangle extends Shape
{
 // Needs to implement draw
}
class Rectangle extends Shape
{
 // Needs to implement draw
}
```

```
In main
-------
Shape s1, s2, s3;      // OK!

s1 = new Shape();     // NOT OK!
s2 = new Circle();    // OK!
s3 = new Triangle();  // OK!

s2.draw();            // OK!
s3.draw();            // OK!
```

23-4: **Abstract Classes**

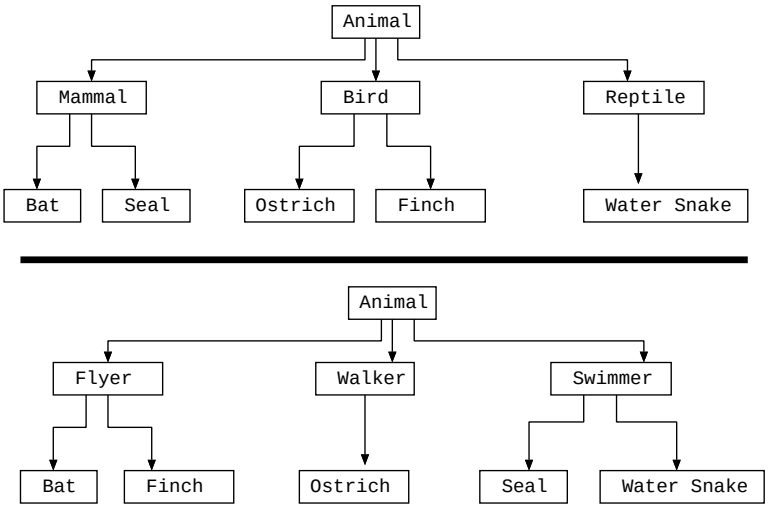
- We can make a class abstract by adding the abstract modifier to the class definition
  - Can't create instances of an abstract class
- If a class is abstract, we can define abstract methods

- Use the abstract modifier on method definition
- Don't give the method a body (use a ; instead of a method body)
- Subclasses of this class will need to either implement all abstract methods, or be abstract themselves

23-5: **Inheritance Heirarchies**

- More than one way to skin a cat
- Classes for animals:
  - Standard classification: Mammal, bird, reptile
  - Functional Classification: Flying Animal, Swimming animal Walking Animal
- How you design your classes depends upon the problem at hand

23-6: **Inheritance Heirarchies**



23-7: **Multiple Inheritance?**

- Might be nice to inheret from more than one thing
  - Bat is a mammal *and* a flying animal
  - Could inherit both mammalian qualities, and qualities of flying animals
    - Likely want to override methods specific to bats, but would be nice to get as much "for free" as possible
- Java *does not allow* multiple inheritance
  - C++ does, however

23-8: **Multiple Inheritance?**

- Multiple inheritance does have problems
  - Class A defines a method foo
  - Class B also defines a method foo
  - Class C inherits from both A and B (multiple inheritance)

    - Which foo does class C use?
- Java avoids these problems by only allowing single inheritance

23-9: **Interfaces**

- Multiple inheritance can be useful
    - Allows more than one heirarchy structure
    - Arrange our animal classes both structurally (mammal, reptile, etc) and functionally (swims, flies, runs, etc)
- We can get some of the advantages of multiple inheritance from interfaces

23-10: **Interfaces**

- A java interface is essentially a promise
    - Interface defines a number of methods
    - Classes that implement the interface promise to implement all of those methods

23-11: **Interfaces**

```
public interface Flyer
{
   public void fly();
}
```

- Any class that implements Flyer needs to implement the fly method

23-12: **Interfaces**

```
public interface Flyer
{
   public void fly();
}


public class Bat extends Mammal implements Flyer
{

  public void fly()
  {
     System.out.println("I'm flying");
  }
}
```

23-13: **Interfaces**

```
public interface Comparable
{
   public int compareTo(Object o);
}
```

- Any class that implements Comparable needs to implement the compareTo method
- (Note – recent versions of Java use Generics in Comparable interface, but the basic idea is the same

23-14: **Interfaces**

```
class Student implements Comparable
{
    public int studentID;
    public String name;

    public int compareTo(Object other)
    {
        // How can we compare an Object to a Student?
        // Really only want to compare students to other students!

        // Need a way to check if "other" is really a student
        //   If it is a student, we need to get at "student"
        //   instance variables (studentID, name)
    }
}
```

23-15: **Casting**

- (<Type>) f
  - If f is not of type <Type>, runtime error
  - If f is of type <Type>, we can assign to a variable of type <Type>

```
Object o1 = new String("Hello!");
Object o2 = new Integer(3);

String s;
Integer i;
i = o1;   // Not legal!  Won't even compile
i = o2;   // Not legal!  Won't even compile
s = o1;   // Not legal!  Won't even compile
s = o2;   // Not legal!  Won't even compile
```

23-16: **Casting**

- (<Type>) f
  - If f is not of type <Type>, runtime error
  - If f is of type <Type>, we can assign to a variable of type <Type>

```
Object o1 = new String("Hello!");
Object o2 = new Integer(3);

String s;
Integer i;
i = (Integer) o1;  // Compiles, gives runtime error
i = (Integer) o2;  // Compiles & runs OK
s = (String) o1;   // Compiles & runs OK
s = (String) o2;   // Compiles, gives runtime error
```

23-17: **Casting**

- Of course, we can always assign a subclass value to a superclass variable, without casting.
  - Never gives us a runtime error
- If we assign a subclass value to a superclass variable, we can get the subclass value out of the variable by casting
  - Will give us a runtime error if the superclass variable does not hold a subclass value

23-18: **Interfaces**

```
class Student implements Comparable
{
    public int studentID;
    public String name;

    public int compareTo(Object other)
    {
        // Following will cause runtime exception if we try to
        //   compare a Student with a non-student.
        int otherID = ((Student) other).studentID;
        if (studentID < otherID)
            return -1;
        else if (studentID > otherID)
            return 1;
        else
            return 0;
    }
}
```

23-19: **Using Interfaces**

- We can declare a variable of type "Comparable"
- Can assign any comparable value to type Comparable

```
Comparable c1, c2, c3;
c1 = new Student();
c2 = Integer(4);  // Integer class implements Comparable
c3 = "Hello";     // String class does, too
```

23-20: **Using Interfaces**

- Creating a comparable variable seems a little silly
- However, write a function that takes a Comparable variable as a parameter makes perfect sense
- Even better, a function that takes an array of Comparable objects as an input parameter

23-21: **Using Interfaces**

- Write a method that takes as input an array of “Comparable”
  - That is, we can pass in an array of anything, as long as elements of that array implement Comparable
- Returns the smallest element in the array

23-22: **Using Interfaces**

```
Comparable minValue(Comparable array[])
{
}
```

- Return the smallest element in the array
- If the array is empty, return null

23-23: **Using Interfaces**

```
Comparable minValue(Comparable array[])
{
   if (array.length == 0)
      return null;
   Comparable smallest = array[0];
   for (int i = 1; i < array.length; i++)
   {
      if (array[i].comparTo(smallest) < 0)
          smallest = array[i];
   }
   return smallest;
}
```

23-24: **Using Interfaces**

```
   Integer intArray[] = new Integer[10];
   // fill up intArray with Integers

   Student studentArray[] = new Student[20];
   // fill up student array with Students

   Integer smallestInteger = smallest(intArray);  // BAD!! Why?
   Student smallestStudent = smallest(studentArray);  // BAD!! Why?
```

23-25: **Using Interfaces**

```
   Integer intArray = new Integer[10];
   // fill up intArray with Integers

   Student studentArray = new Student[20];
   // fill up student array with Students

   Integer smallestInteger = (Integer) smallest(intArray);
   Student smallestStudent = (Student) smallest(studentArray);
```

23-26: **Sorting**

- Want to sort an array if integers

- Break the list into a sorted portion and an unsorted portion
- Repeatedly insert the next element in the unsorted portion of the list into the sorted portion of the list (exmaples on board)

23-27: **Sorting**

```
public static void sort(Comparable data[])
{
  for (int i = 1; i < data.length; i++)
  {
    Comparable nextElem = data[i];
    int j;
    for (j=i-1; j >= 0 && data[j].compareTo(nextElem)  > 0; j--)
    {
      data[j+1] = data[j];
    }
    data[j+1] = nextElem;
  }
}
```

23-28: **Sorting**

- This sorting method can sort any array of comparables
  - Integers
  - Strings
  - Students
  - ... anything that implements the comparable interface

23-29: **MiniLab**

- Create an interface Audible that contains the method speak, that takes no parameters and retuns no value
- Create two classes Dog and Cat that both implement the Audible interface
  - Dog speak method prints out “woof”
  - Cat speak method prints out “meow”
- In a separate driver class, create an array of Audibles, fill it with Dogs and Cats, and then have each element in the array speak.