# CS/ENGRD 2110
# FALL 2016

Lecture 7: Interfaces and Abstract Classes
http://courses.cs.cornell.edu/cs2110

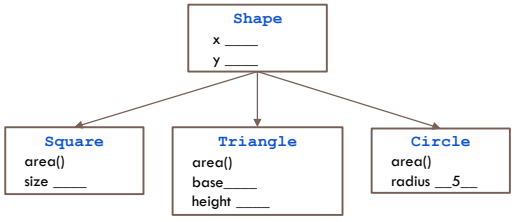
## Announcements



- Attendance for this week's recitation is mandatory!
- A2 is due Today
- Get started on A3 – a method every other day

## A Little Geometry!






## Demo 1: Complete this function



```
/** Return the sum of the areas of
  * the shapes in s */
static double sumAreas(Shape[] s) { }
```

1. Operator **instanceof** and casting are required
2. Adding new `Shape` subclasses breaks `sumAreas`

## A Partial Solution:



Add method area to class Shape:

```
public double area() {
        return 0;
}
```

```
public double area() {
        throw new RuntimeException("area not
overridden");
}
```

## Problems not solved



1. What is a Shape that isn't a Circle, Square, Triangle, etc? What is *only* a shape, nothing more specific?
   a. `Shape s= new Shape(...);` Should be disallowed
2. What if a subclass doesn't override area()?
   a. Can't force the subclass to override it!
   b. Incorrect value returned or exception thrown.

## Solution: Abstract classes



```
public abstract class Shape {

  public double area() {
      return 0;
   }
}
```

***Abstract class***
Means that it can't be instantiated.
`new Shape()` illegal

## Solution: Abstract methods



```
public abstract class Shape {

  public abstract double area();

}
```

***Abstract method***
Subclass must override.

- Can also have implemented methods
- Place abstract method only in abstract class.
- Semicolon instead of body.

## Demo 2: A better solution



We modify class Shape to be abstract and make `area()` an abstract method.

- Abstract class prevents instantiation of class Shape
- Abstract method forces all subclasses to override `area()`

## Abstract Classes, Abstract Methods



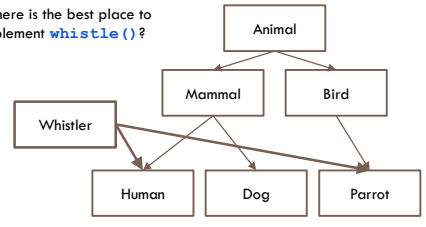
1. **Cannot instantiate an object of an abstract class.**
   (Cannot use new-expression)
2. **A subclass must override abstract methods.**

# Interfaces

## Problem



Where is the best place to implement `whistle()`?



## No multiple inheritance in Java!



```
class Whistler {
  void breathe() { … }
}
class Animal {
  void breathe() { … }
}
class Human extends Animal, Whistler {
}
```

```
new Human().breathe();
```

Which breathe() should java run in class Human?

## Why not make it fully abstract?



```
class abstract Whistler {
  abstract void breathe();
}
class abstract Animal {
  abstract void breathe();
}
class Human extends Animal, Whistler {
}
```

Java doesn't allow this, even though it would work. Instead, Java has another construct for this purpose, the interface

## Solution: Interfaces



```
public interface Whistler {
      void whistle();
      int MEANING_OF_LIFE= 42;
}

class Human extends Mammal implements Whistler {
}
```

- methods are automatically **public** and **abstract**
- fields are automatically **public**, **static**, and **final** (i.e. constants)

Must implement all methods in the implemented interfaces

## Multiple interfaces



```
public interface Singer {
      void singTo(Human h);
}

class Human extends Mammal implements Whistler, Singer {
}
```

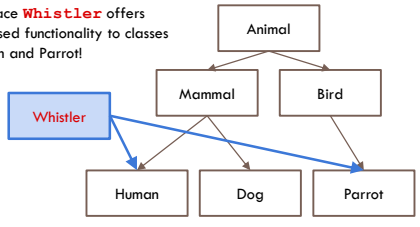
Classes can implement several interfaces!
They must implement all the methods in those interfaces they implement.

Must implement `singTo(Human h)` and `whistle()`

## Solution: Interfaces



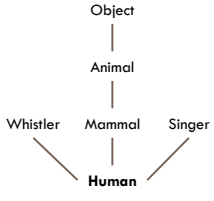
Interface **Whistler** offers promised functionality to classes Human and Parrot!




## Casting to an interface



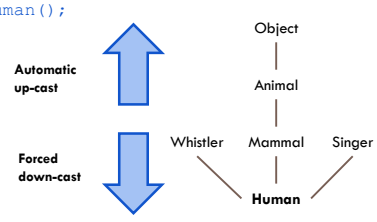
```
Human h=   new Human();
Object o= (Object) h;
Animal a= (Animal) h;
Mammal m= (Mammal) h;

Singer s= (Singer) h;
Whistler w= (Whistler) h;

All point to the same
  memory address!
```



## Casting to an interface



```
Human h=  new Human();
Object o= h;
Animal a= h;
Mammal m= h;
Singer s= h;
Whistler w= h;
```

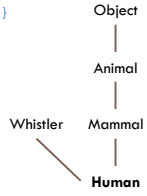



## Casting up to an interface automatically



```
class Human … implements Whistler {
     void listenTo(Whistler w) {...}
}
Human h = new Human(...);
Human h1= new Human(...);
h.listenTo(h1);
```

Arg h1 of the call has type Human. Its value is being stored in w, which is of type Whistler. Java does an upward cast automatically. It costs no time; it is just a matter of perception.




## Demo 3: Implement Comparable<T>

Implement interface Comparable in class Shape:

```
public interface Comparable<T> {
  /** = a negative integer if this object < c,
      = 0 if this object = c,
      = a positive integer if this object > c.
      Throw a ClassCastException if c can't
           be cast to the class of this object.
    */
  int compareTo(T c);
}
```

## Shape implements Comparable<T>

```
public class Shape implements Comparable<Shape> {
    ...
    /** … */
    public int compareTo(Shape s) {
       double diff= area() - s.area();
       return (diff == 0 ? 0 : (diff < 0 ? -1 : +1));
    }
}
```

## Beauty of interfaces

**Arrays.sort** sorts an array of *any* class C, as long as C implements interface **Comparable<T>** without needing to know any implementation details of the class.

Classes that implement Comparable:

| | | | |
|---|---|---|---|
| Boolean | Byte | Double | Integer |
| String | BigDecimal | BigInteger | Calendar |
| Time | Timestamp | and 100 others | |

## String sorting

**Arrays.sort(Object[] b)** sorts an array of *any* class C, as long as C implements interface **Comparable<T>**.

String implements Comparable, so you can write

```
String[] strings= ...;
...
Arrays.sort(strings);
```

During the sorting, when comparing elements, a String's compareTo function is used

## And Shape sorting, too!

**`Arrays.sort(Object[] b)`** sorts an array of *any* class C, as long as C implements interface **`Comparable<T>`**.

`Shape` implements `Comparable`, so you can write

```
Shape[] shapes= ...;  ...
Arrays.sort(shapes);
```

During the sorting, when comparing elements, a Shape's compareTo function is used

## Abstract Classes vs. Interfaces

- Abstract class represents something
- Sharing common code between subclasses

- Interface is what something can do
- A contract to fulfill
- Software engineering purpose

Similarities:

- Can't instantiate
- Must implement abstract methods
- Later we'll use interfaces to define "abstract data types"
  - (e.g. List, Set, Stack, Queue, etc)