Lecture Notes
Chapter #11
Abstract Classes & Interfaces

Abstract Classes

- parent class, more abstract ➔ child class, more concrete, i.e., less abstract

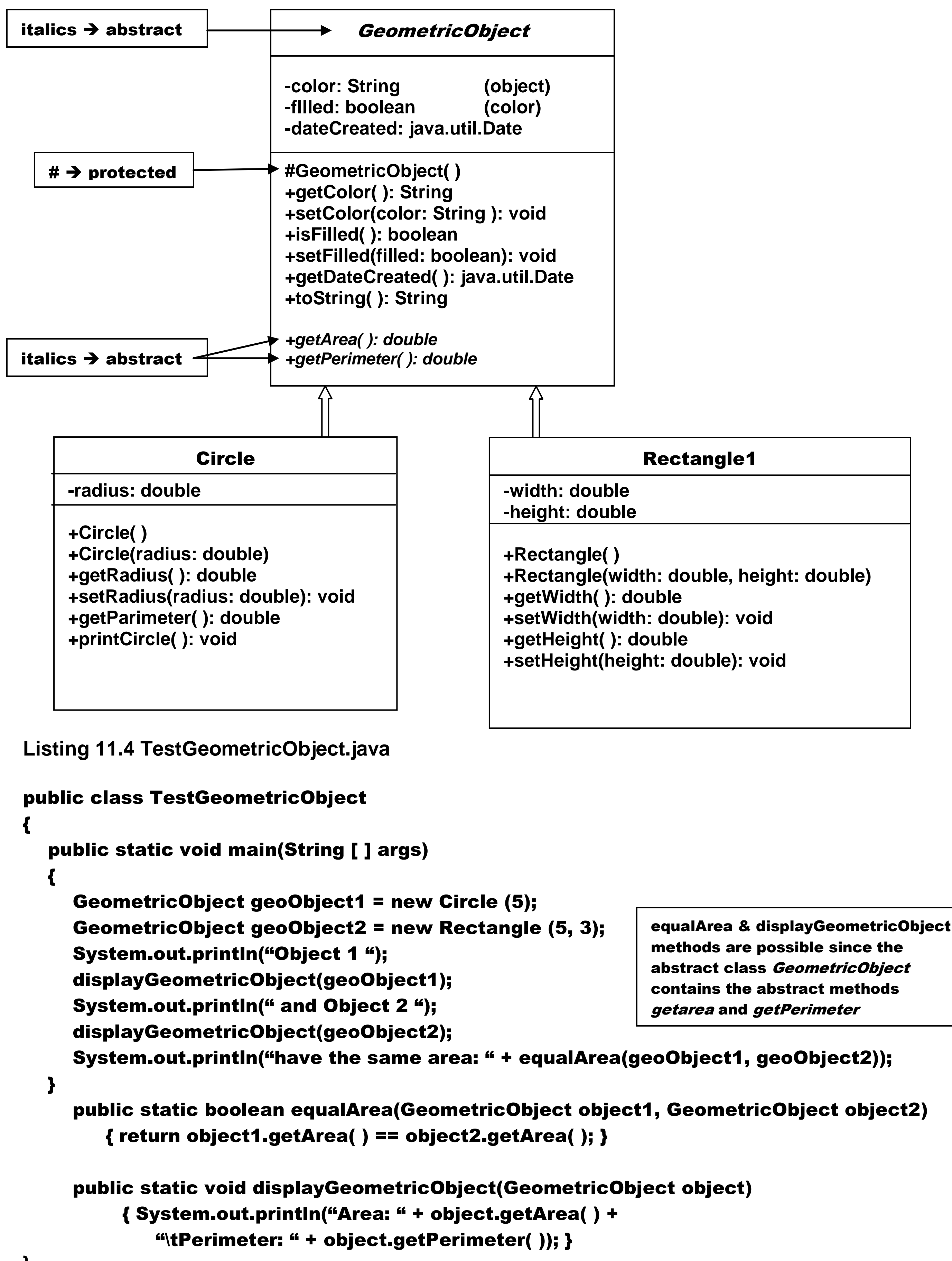
- abstract class
  - class with an abstract modifier
  - class containing abstract methods
  - cannot create instances, i.e., objects, with the **new** operator

Listing 11.1 GeometricObject.java

```
public abstract class GeometricObject
{

    private String color = "white";
    private boolean filled;
    private java.util.Date dateCreated;

    protected geometricObject( ){ dateCreated = new java.util.Date( ); }

    public String getColor( ){ return color };

    public void setColor(String color){ this.color = color;}

    public boolean isFilled( ){ return filled; }

    public void setFilled( boolean filled ){ this.filled = filled; }

    public java.util.Date getDateCreated( ){ return dateCreated; }

    public String toString( )
    { return "date created: " + dateCreated + "\ncolor: " + color + "filled: " + filled; }

    // Abstract Methods

    public abstract double getArea( );
    public abstract double getPerimeter( );
}
```

geometricObject constructor can only be used by subclasses (→ protected geometricObject( ))

method signatures without bodies (→ getArea( ), getPerimeter( ))



Listing 11.4 TestGeometricObject.java

```
public class TestGeometricObject
{
   public static void main(String [ ] args)
   {
      GeometricObject geoObject1 = new Circle (5);
      GeometricObject geoObject2 = new Rectangle (5, 3);
      System.out.println("Object 1 ");
      displayGeometricObject(geoObject1);
      System.out.println(" and Object 2 ");
      displayGeometricObject(geoObject2);
      System.out.println("have the same area: " + equalArea(geoObject1, geoObject2));
   }
      public static boolean equalArea(GeometricObject object1, GeometricObject object2)
          { return object1.getArea( ) == object2.getArea( ); }

      public static void displayGeometricObject(GeometricObject object)
            { System.out.println("Area: " + object.getArea( ) +
                "\tPerimeter: " + object.getPerimeter( )); }
}
```

equalArea & displayGeometricObject methods are possible since the abstract class *GeometricObject* contains the abstract methods *getarea* and *getPerimeter*

Remarks

- **abstract methods cannot be contained in non-abstract classes**
- **if a subclass of an abstract class does not implement all the abstract methods, that subclass must be declared to be abstract**
- **abstract methods cannot be static methods**
- **abstract classes cannot be instantiated by the new operator, but it can be invoked by the creation of an instantiation of a subclass object, hence it should be provided with constructors**
- **classes that contain abstract methods are abstract**
- **it is possible to declare a class which contains no abstract methods to be abstract**
- **a concrete superclass may have abstract subclasses, e.g., the Object class is concrete but all other classes, i.e., abstract classes, are subclasses of the Object class**
- **a subclass may override a concrete method from its superclass and declare it to be abstract; in this case the subclass must be declared to be abstract**
- **an abstract class can be used as a data type, e.g.,**
  GeometricObject [ ] objects = new GeometricObject [10];

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java.util.Date( ) is a concrete method that represents a specific instance in time

java.util.Calendar is an abstract base class which contains methods for extracting detailed calendar information, e.g., year, month, etc.

java.util.GregorianCalendar is a concrete class which implements the abstract methods inherited from the abstract base class java.util.Calendar

Interfaces

- class-like construct that contains only constants and abstract methods
- used to specify common behaviors for objects
- each interface is compiled into a separate ByteCode file
- interface inheritance – multiple interfaces possible

```
public interface Edible
{
   public abstract String howToEat( );
}
```

abstract method

Listing 11.6 TestEdible.java

```
public class TestEdible
{
    public static void main(String [ ] args)
    {
        Object[ ] objects = {new tiger( ), new Chicken( ), new Apple( ) };
        for ( int i = 0; i < objects.length; i++)
            if ( objects[ i ] instanceof edible )
                    System.out.println(((Edible)objects[ i ]).howToEat( ));
    }
}

class Animal { }

class Chicken extends Animal implements Edible
{
  public String howToEat( ) { return "Chicken: Fry it"; }
}

class Tiger extends Animal { }

abstract class Fruit implements Edible { }

class Apple extends Fruit
{
  public String howToEat( ) { return "Apple: Make Apple Cider"; }
}

class Orange extends Fruit
{
  public String howToEat( ) { return "Orange: Make Orange Juice"; }
}
```

Fruit does not implement howToEat method; thus it must be declared to be abstract

Concrete classes Apple & Orange need to implement the howToEat method

Remark: Since

- all data fields specified in interfaces are public final static
- all methods specified in interfaces are public abstract

Java allows these modifiers to be omitted

```
public interface T
{
  public static final int K = 1;
  public abstract void p( );
}
```

↔

```
public interface T
{
  int K = 1;
  void p( );
}
```

The constant K defined in the interface T can be accessed by T.K

Comparable Interface

- **interface Comparable is defined in java.lang, e.g.,**

```
package java.lang;

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

compareTo( ) determines the order of this object with the specified object and returns a negative integer, zero, or a positive integer depending upon the rank order of the objects

Remark: Java Library objects often implement the Comparable interface to define a natural order for the objects, e.g.,

```
public class String extends Object implements Comparable { }
```

```
public class Date extends Object implements Comparable { }
```

Generic Max Methods

```
public class Max
{
  public static Comparable max(Comparable o1, Comparable o2)
  {
     if(o1.compareTo(o2)  >  0)
        return o1;
     else
        return o2;
  }
}
```

preferable
- **simpler, more robust**
- **restricted to Comparable objects** → **compiler detects violations**

```
public class Max
{
  public static Object max(Object o1, Object o2)
  {
     if(((Comparable)o1).compareTo(o2) > 0)
        return o1;
     else
        return o2;
  }
}
```

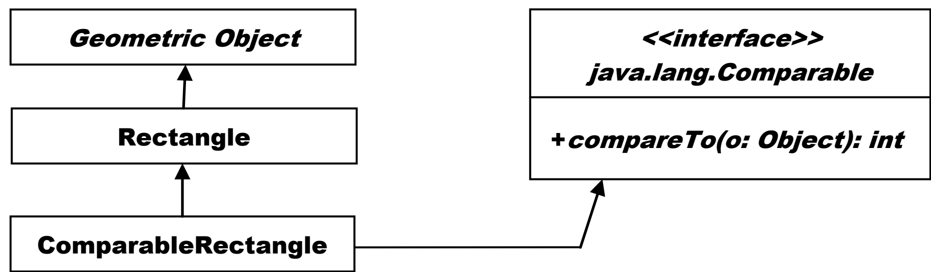
complex, less robust method

may be invoked by objects that have not implemented the Comparable interface hence the compiler does not detect violations; violations are detected at runtime producing the ClassCastException

Listing 11.7 ComparableRectangle.java

```
public class ComparableRectangle extends Rectangle implements Comparable
{
   public class ComparableRectangle(double width, double height)
   {
      super(width, height);
   }

   public int compareTo(Object o)
   {
      if (getArea( ) > ((CompareRectangle)o).getArea( ))
         return 1;
      else if (getArea( ) < ((CompareRectangle)o).getArea( ))
         return -1;
     else
         return 0;
   }
}
```



Remark:

- **Object class contains the equals method**
- **Comparable interface provides the compareTo method**
- **Strong Recommendation: the implementation of the compareTo method should be consistent with the equals method,i.e.,**
  o1.compareTo(o2) == 0 ←→ o1.equals(o2) is true

Cloneable Interface

```
package java.lang;

public interface Cloneable { }
```

Remarks:

- marker interface – empty interface – method has an empty body
- objects created from classes that implement the Cloneable interface can be copied by the **clone( )** method
- Java Library objects often implement the Cloneable interface, e.g., Date, Calendar, ArrayList

```
Calendar calendar = new GregorianCalendar(2003, n2, 1);
Calendar calendarCopy = (calendar)calendar.clone( );

    calendar == calendarCopy ➔ false
    calendar.equals(calendarCopy) ➔ true
```

two different objects with identical contents

Implementing the Cloneable Interface

```
public class House implements Cloneable, Comparable
{
  private int id;
  private double area;
  private java.util.Date whenBuilt;

  public House(int id, double area)
  {
    this.id = id;
    this.area = area;
    whenBuilt = new java.util.Date( );
  }

  public double getId( ) { return id; }
  public double getArea( ) { return area; }
  public java.lang.Date getWhenBuilt( ) { return whenBuilt; }

  public Object clone( ) throws CloneNotSupportedException { return super.clone( ); }

  public int compareTo(Object o)
  {
    if (area > ((House)o).area)
        return 1;
    else if (area < ((House)o).area)
        return -1;
     else
        return 0;
  }
}
```

Override the protected clone method defined in the Object class, i.e.,

protected native Object clone( ) throws CloneNotSupportedException

native ➔ implemented in the native platform, i.e., not written in Java

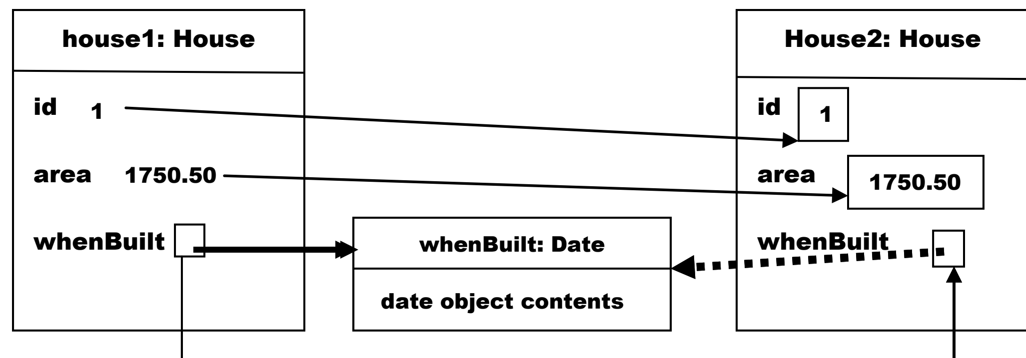
protected ➔ restricts method to same package or subclass access

override ➔ changes the visibility to public

Shallow Copy

```
House house1 = new House(1, 1750.50);
House house2 = (House)house1.clone( );
```

clone( ) copies the data value of each field in the original object to the equivalent field in the target object



Deep Copy

override the clone method with custom cloning operations after the super.clone( ) constructor has been invoked

	Variables	Constructors	Methods
Abstract Class	no restrictions	invoked by subclasses via constructor chaining; cannot be invoked directly via the new operator	no restrictions
Interface	public static final variables	do not exist; cannot be instantiated via the new operator	public abstract instance methods

public class NewClass extends BaseClass implements Interface1, Interface2, ..., InterfaceN { ... }

SubInterfaces

public interface NewInterface extends Interface1, Interface2, ..., InterfaceN { ... }

Class Names -- Nouns
Interface Names -- Nouns or Adjectives