CMSC 150
INTRODUCTION TO COMPUTING

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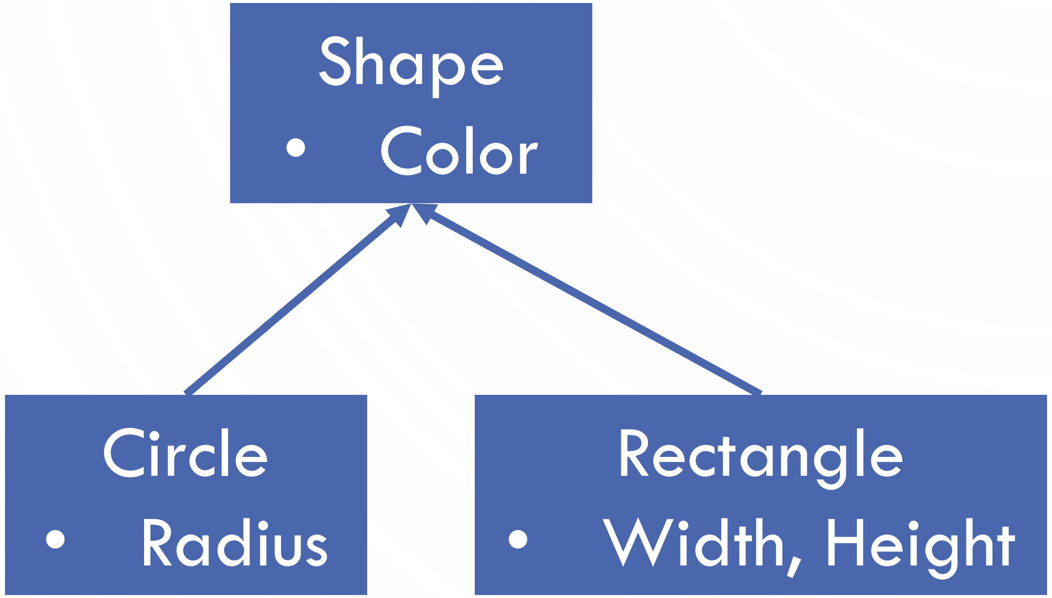
LECTURE 11

- POLYMORPHISM
- ABSTRACT CLASSES
- INTERFACES

REVIEW
DATA TYPES AND OBJECT-ORIENTED PROGRAMMING

- **Data type. Object.** Set of values and operations on those values.
- **Object-oriented Programming** – design principle for large programs
  - **Composition/Abstraction** – Modeling objects (HAS-A relationship)
  - **Encapsulation** – combining data and operations (methods); data hiding from misuse (private vs public)
  - **Inheritance** – Types and sub-types (IS-A relationship)
  - **Polymorphism** – Abstract types that can act as other types (for algorithm design)

EXAMPLE
SHAPES



- Recall our shape hierarchy
- Shape will have the functions
  - `double area();`
  - `double perimeter();`
- Specifics are defined in the sub classes

POLYMORPHISM

- Wikipedia – “the provision of a single interface to entities of different types”
- “one name, many forms”
- **Polymorphism** realistically implies that a variable of a superclass can refer to a value of a subclass

```
Shape circle = new Circle(5, Color.red);
System.out.println(circle.area());
```

WHY WOULD YOU EVER DO THIS?

- Allow types to be defined at runtime, instead of at compile time:

```
Scanner s = new Scanner(System.in);
Shape shape = null;
String tag = s.next();
if(tag.equals(“Circle”)) {                                  //user wants a circle
    double r = s.nextDouble();
    shape = new Circle(r, Color.red);
}
else if(tag.equals(“Rectangle”)) {                          //User wants a rectangle
    double w = s.nextDouble(), h = s.nextDouble();
    shape = new Rectangle(w, h, Color.red);
}
System.out.println(“Area: ” + shape.area());                //works no matter what!
```

WHY WOULD YOU EVER DO THIS?

- Arrays can only store one type

```
1. Circle[] circles; //all circles
2. Rectangle[] rects; //all rectangles
3. Shape[] shapes; //depends on subtypes! Can have
   some circles and some rectangles.
```

WHY WOULD YOU EVER DO THIS?

- Lets say we have an array of Shape shapes then we can do something like:

```
double total = 0;
for(int i = 0; i < shapes.length; ++i)
    total += shapes[i].area(); //Uses specific instance’s subtype’s function
return total;
```

DYNAMIC BINDING

- When defining a variable of a super type as a sub type, e.g.,

  ```
  Shape s = new Circle(5, Color.red);
  ```

  - Shape is the **declared type**
  - Circle is the **actual type**
  - **Dynamic binding** relates the correct implementation of the functions to the variable
  - The declared type says what functions and public entities can be accessed
    - Note that by declaring `s` as **`Shape`**, all of the additional public API functions/data cannot be accessed, e.g., `getRadius()`. Lucky for us though…

TYPE CASTING

- Can use casting to get back to the actual type:

  ```java
  Shape s = new Circle(5, Color.red);
  Circle c = (Circle)s; //Only the pointer is copied
  c.specificFunctionInCircleOnly();
  ```

- Casting to a subclass is referred to as **downcasting** and must be done explicitely
- Casting to a superclass is referred to as **upcasting** and will be done implicitely
- Determining if an instance can be downcast is often necessary. Can use the **instanceof** keyword

ABSTRACT CLASSES

- In modeling, sometimes we don’t want to allow types to be defined:

  ```
  Shape s = new Shape(Color.red); //Makes no sense. What is s really?
  ```

- We can use abstract classes to facilitate this to provide better protection to other software developers on our team. Also specified interface (API) requirements of subtypes.

```
public abstract class Shape {   //Abstract here disbars the code above.
                                //No “new” is allowed on this type.
   protected Shape(Color c) {…} //Constructor is protected because
                                //nothing but subtypes will access it
   …
   public abstract double area(); //If a function is abstract no
                                  //definition needs to be provided
   public abstract double perimeter(); //Also subtypes are now required
                                       //to define them!
}
```

SOME INTERESTING POINTS ON ABSTRACT

- An abstract method cannot be contained in a non abstract class
- If a subclass of an abstract superclass does not implement all of the abstract methods, then it must also be declared as abstract
- Cannot use new on an abstract type, but constructors can be defined (for use with super). Also can still use the abstract type for polymorphism!
- An abstract class does not require abstract methods
- A subclass can be abstract even if the superclass is concrete (non abstract)

INTERFACES

- An interface is a class-like construct that contains only constants and abstract methods (almost like a purely abstract class).

```
public interface AreaComputation {  //Note “interface”
                                    //not “class”
    public static final double PI = Math.PI;
    public abstract area();
}
```

INTERFACES

- Cannot have constructors
- All variables must be `public static final`
- All methods must be `public abstract`
- Useful for writing algorithms for searching or sorting (these need comparison), i.e., Comparable things (any object “implementing” the Comparable interface)
- Used to support multiple inheritance

INTERFACES

- To inherit an interface:

```
public class Shape implements AreaComputation,
PerimeterComputation {
… }
```

- Implementing an interface requires implementation of all of the abstract methods, or declaring as an abstract class.
- Interfaces commonly used as a weaker is-a relationship, specifically is-kind-of referring to possessing certain properties only
- Oddly, interfaces can “extend” other interfaces

SUMMARY OF OOP

- OOP is a methodology to model things in our world and their interactions
    - Used for solving problems
    - Used in creating useful applications
- Do not think this is the end of the story…
    - We only went over the core principles of OOP
    - There are more advanced programming techniques
    - There are many differences in OOP between languages

With object-oriented programming, we can resurrect old classes and use them again.
Yes?
Isn't that suspiciously like necromancy?
...No.
Damn! They're onto me.

```
public static void main(String[] args)
{
    Arraylist<Person> people;
    try
    {
```