INHERITENCE, POLYMORPHISM, INTERFACES

cs2420 | Introduction to Algorithms and Data Structures | Spring 2015

administrivia…

-TA office hours posted

-assignment 1 due on Thursday at 5pm

-clickers start on Tuesday

last time…

- a **variable** is a piece of data in memory with:
  - an identifier (name)
  - a **type**

- what is a type?
  - a basic building block in a programming language
  - determines what kind of data a variable holds, and what operations can be performed on it

- Java defines eight primitive types
  - byte, short, int, long, float, double, char, boolean
  - each primitive type can hold a single value
    - `'r', 12, 2.64, true`

type conversion

-**widening conversions**

```
short -> int
int   -> long
int   -> float
```

-**narrowing conversions**

```
double -> float
float  -> int
```

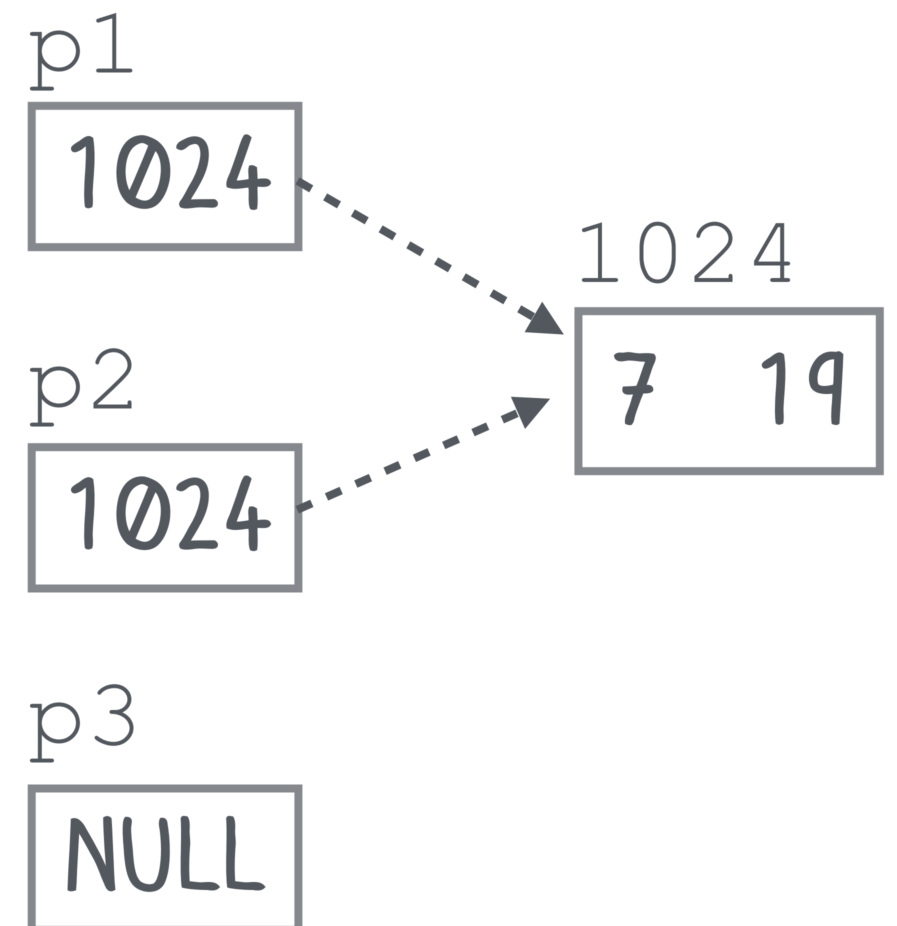
```
5 / 2 * 3.0  + 10 / 3      9.0

        "6+3=" + 6 + 3     "6+3=63"
```

- **control flow** determines how programs make decisions about what to do, and how many times to do it
  - decision making : `if-else, switch-case`
  - looping : `for, while, do-while`
  - jumping : `break, continue, return`
  - exceptions : `try-catch, throw`

-all non-primitive types are **reference types**

-a **reference** is a variable that stores the memory address where an object (a group of values) resides

```
Point p1, p2, p3;
p1 = new Point(7,19);
p2 = p1;
```



today…

-inheritance

-polymorphism

-abstract classes

-interfaces

object-oriented programming

-data is treated as encapsulated in **objects**

-objects contain data and define functions meaningful to that data

-objects are instantiations of **classes**

-actual written piece of code which is used to define the behavior of any given class

A **CLASS** IS A GENERAL CONCEPT, WHILE AN **OBJECT** IS A VERY SPECIFIC EMBODIMENT OF THAT CLASS

-OOP supports and enables…

-modularity

-code re-use

-better code design

-…

- **inheritance** is one of the most powerful features of OOP
  - allows a class to *inherent* properties from another class
  - used when multiple types of data have something in common
  - avoid duplication of code

```
NullPointerException
IndexOutOfBoundsException
ArithmeticException
```

example…

`shape` class

- a `shape` has (fields):
  - a color (`String`)
  - an area (`double`)

- different shapes:
  - `circle`
  - `triangle`
  - `rectangle`
  - `square`

```
public class Triangle{
  String color;
  double area;
}

public class Circle{
  String color;
  double area;
}

public class Rectangle{
  String color;
  double area;
}

public class Square{
  String color;
  double area;
}
```

WHAT IF I WANT TO REDFINE COLOR AS AN INTEGER ARRAY (R,G,B)?

WHAT IF I WANT TO GIVE EACH SHAPE AN OUTLINE COLOR?

WHAT CAN I DO?

`extends`

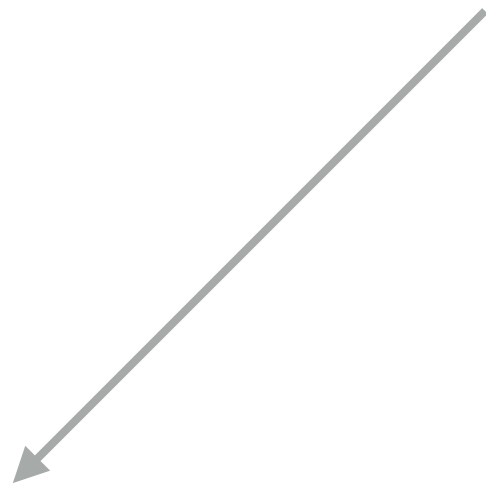
```
public class Shape{
  String color;
  double area;
}
```

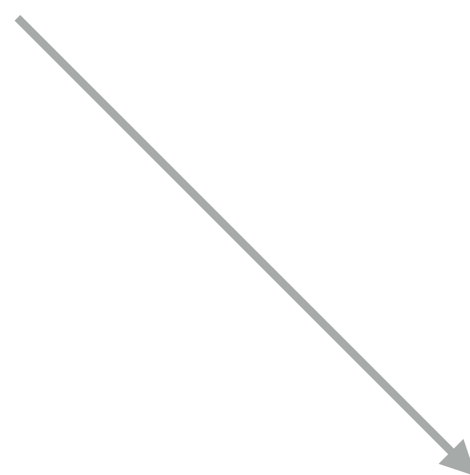
CALLED A **BASE CLASS** (OR SUPERCLASS)

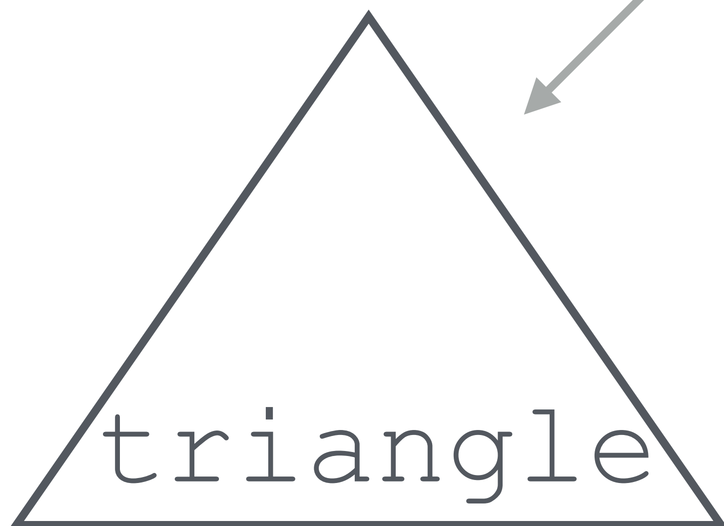
```
public class Triangle extends Shape{
}

public class Circle extends Shape{
}

public class Rectangle extends Shape{
}

public class Square extends Shape{
}
```

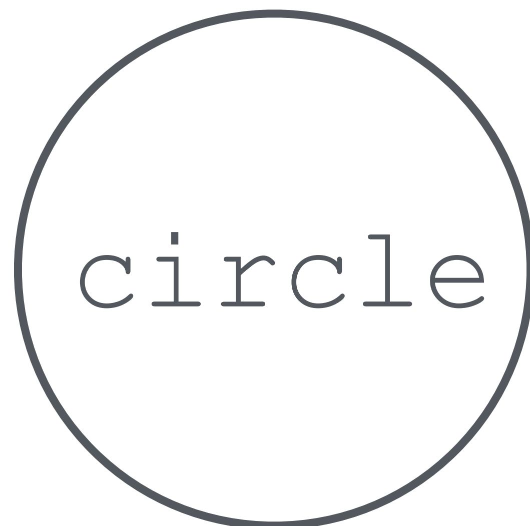
inherit all public fields and methods of `Shape`

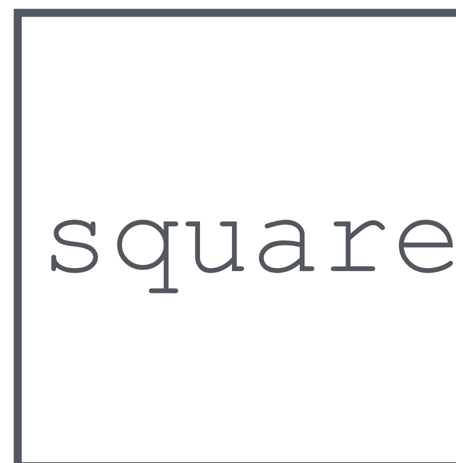
shape











-now we have several shape classes, all with common fields associated with every shape

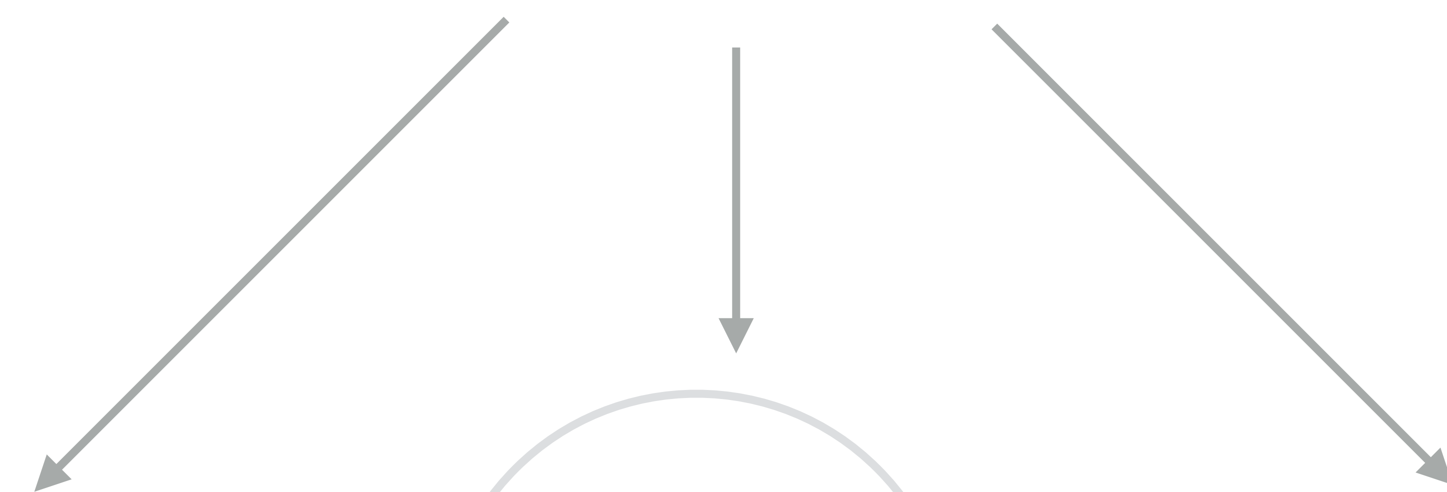
-but…

- -circles have a `radius`
- -rectangles have a `width` and `height`
- -triangles have three `Points`

-does it make sense for all shapes to have a `radius`? a `width` and `height`? three `Points`?

-can inherited classes add their own fields and methods?

```
Shape
String color
double area
```



```
Triangle
Point p1
Point p2
Point p3
```

```
Circle
int radius
Point center
```

```
Rectangle
int width
int height
```

```
Square
if (width!=height)
  error
```

HOW MANY FIELDS DOES A **TRIANGLE** HAVE?

HOW MANY FIELDS DOES A **SQUARE** HAVE?

inherited classes also inherit methods

```
public class Shape{
  String color;
  double area;

  public String toString(){
    return color + “ shape”;
  }
}


Triangle t = new Triangle();
t.color = “red”;
System.out.println(t.toString());
```

→ **red shape**

what can('t) inherited classes do?

-a **derived** class can:
- -add new fields
- -add new methods

-a **derived** class cannot:
- -remove fields
- -remove methods
- -inherit private fields
- -inherit private methods

overriding a method

-ability of a class to **override** a method allows a class to inherit from a base class whose behavior is close enough, then modify behavior as needed

- -method must have the same **signature**
  - -*same name, parameters, return type*

```
public class Circle extends Shape{
  int radius;
  Point center;

  // override
  public String toString(){
    return color + " circle with radius:" + radius;
  }
}
```

why override?

-there may be a method that makes sense for all shapes to have, but with drastically different implementations

```
public double getArea(){
   …
}
```

IS THE AREA COMPUTATION THE SAME FOR A `Circle` AND A `Square`?

partial overriding

-derived classes can explicitly invoke the base class's version of a method using super

```
public void doSomething(){
  super.doSomething();
  // then do a little more
}
```

WHY WOULD WE DO THIS?

in case we want to do something just slightly different than the base class, but most of the code is done for us…

option 1

-copy/paste implementation of `Circle`, modify slightly for `Triangle`, `Rectangle`, and `Square`

- -debug same code in several places
- -extend/modify same code several times
- -no relationship between classes
  - *-can't pass a* `Circle` *to a method that expects a* `Shape`

option 2

-base class `Shape`, others extend

- -can write one function that operates on any `Shape`
- -automatic code reuse through inheritance

a more interesting example…

suppose you are making a video game about skiing

```
public class Ski{
  public void turn();
}

public class AlpineSki extends Ski{
  // override
  public void turn(){
    //how to turn on alpine skis
  }
}

public class TelemarkSki extends Ski{
  //override
  public void turn(){
    //how to turn on tele skis
  }
}
```

suppose you are making a video game about skiing

WITHOUT INHERITANCE:

```
switch(skier.ski_type)
{
  case ALPINE:
    turnAlpine();
  break;
  case TELEMARK:
    turnTelemark();
  break;
  …
}
```

WITH INHERITANCE:

```
skier.ski.turn();
```

polymorphism

type compatibility

-a derived class is compatible with its base class

```
public static boolean isLarger(Shape s1, Shape s2){
  return s1.getArea() > s2.getArea();
}

Triangle t = new Triangle(…);
Circle c = new Circle(…);

if (isLarger(t,c)){
  …
}
```

WHY CAN I PASS `isLarger` A `Circle` AND A `Triangle`?

-**polymorphism** is a fancy word for automatically determining an object's type at runtime

-the most specific type possible is used

```
Shape s1 = new Circle();
Shape s2 = new Triangle();

s1.getArea();
s2.getArea();
```

WHAT TYPE IS `s1` TREATED AS?

WHAT TYPE IS `s2` TREATED AS?

-suppose `Triangle` does not override `toString()`

```
s2.toString();
```

WHAT TYPE IS `s2` TREATED AS?

-Java takes OOP to the extreme

-every reference type is polymorphic

- -every reference type inherits from `Object`

-when you write your own `toString()` or `equals(Object o)` methods, you are overriding `Object's` version

```
Matrix m = new Matrix(4,2);
System.out.println(m.toString());
```

IS POLYMORPHISM HAPPENING?

```
Shape shape_array = new Shape[5];

shape_array[0] = new Triangle();
shape_array[1] = new Circle();
shape_array[2] = new Rectangle();
…

//find the total area of all the shapes
int total_area = 0;
for(int i=0; i<5; i++)
  total_area += shape_array[i].getArea();
```

abstract classes

-we never intend for anyone to call the `Shape` class's `getArea()` method directly

-meant to be called from a specific shape

-we don't have to provide an implementation in the base class if we make the method `abstract`

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

-semicolon immediately following definition!

-remove `abstract` keyword in derived class's definition

-a class with at least one `abstract` method is an **`abstract` class**

-derived classes **MUST** implement `abstract` methods

-`abstract` classes cannot be instantiated

```
Shape s = new Shape();
Shape s = new Triangle();
```

} WHICH OF THESE IS ILLEGAL?

-`abstract` classes are **ONLY** designated as base classes

interfaces

-an **interface** is the ultimate abstract class

- -every method is `abstract`
- -can contain only `public static final` fields
- -declared with the `interface` keyword instead of `class`

-derived classes use keyword `implements` instead of `extends`

-subclasses can implement multiple interfaces, but can only extend one base class

interfaces

- provide a contract that guarantees objects of a certain type can do specific things
  - `java.lang.Comparable` interface has one method: `compareTo()`
  - classes that implement `Comparable` have a natural ordering
    - *can be sorted without knowing any details about the class (just use the* `compareTo()` *method!)*

next time…

-reading

  -chapters 3 & 4

-homework

  -assignment 1 due next Thursday at 5pm

    -must complete on your own!

-clickers start next Tuesday