Announcements/Follow-ups

- Midterm #2 Friday
  - Everything up to and including today
  - Review section tomorrow
  - Study set # 6 online
    - answers posted later today
- P5 due next Tuesday
  - A good way to study
  - Style – omit “this” when unnecessary
- Lab 07 questions?
  - Returning a reference to the current object
- Immutability and shallow copies

When to use `this`

- In a constructor:

```
public MyObj(int dat) { //Constructor
        data = dat;
}
```

VS

```
public MyObj(int data) { //Constructor
        this.data = data;
}
```

When to use `this`

- To return the object at the end.
  Compare:

```
public void grow(int more) {
      data = data + more;
}
…

//Somewhere else
obj1.grow(3)
System.out.println(obj1);
```

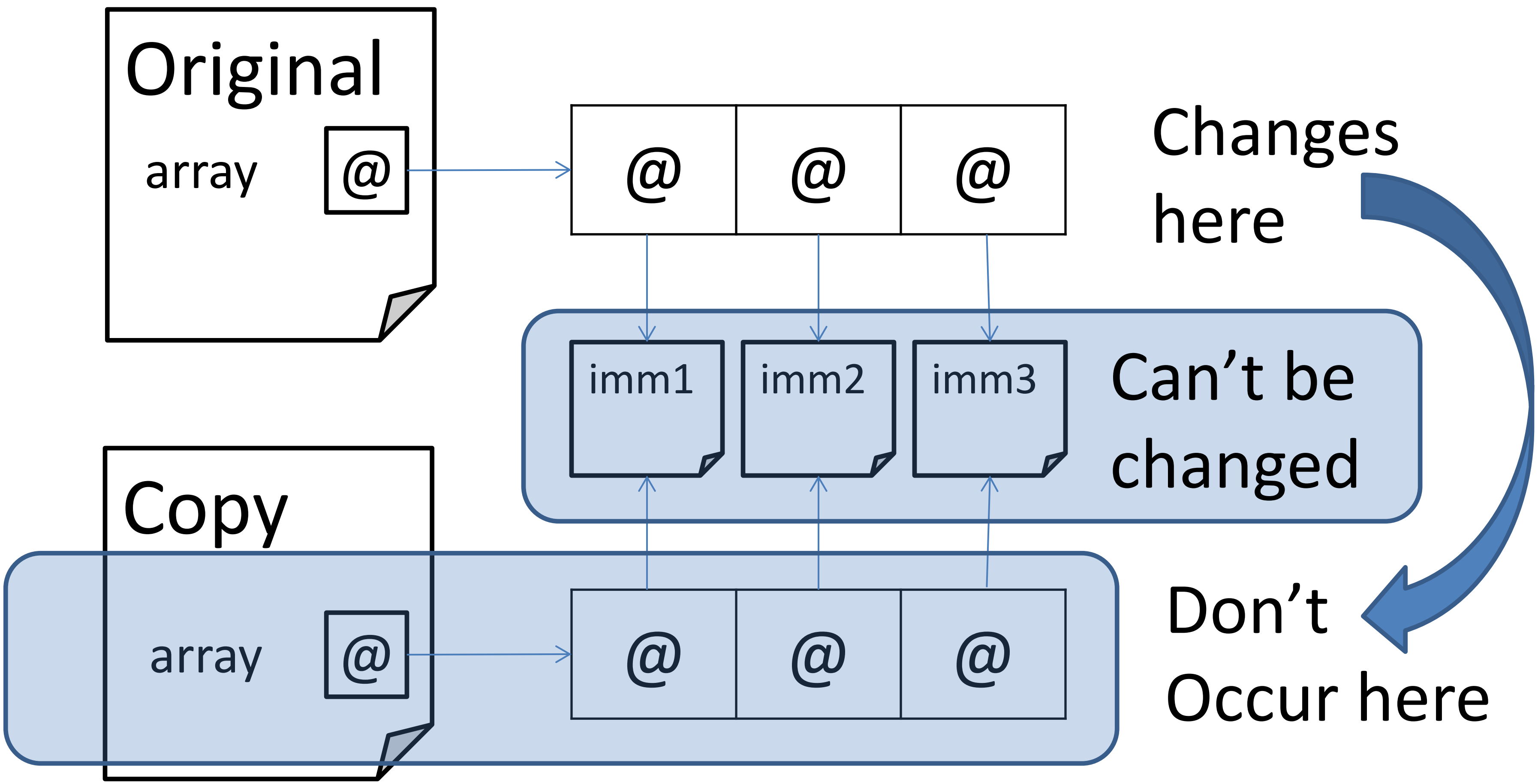
When to use `this`

- To return the object at the end.
  With:

```
public MyObj grow(int more) {
        data = data + more;
        return this;
}
…

//Somewhere else
System.out.println(obj1.grow(3));
```

Immutables and shallow copy



Built-in interfaces

- CharSequence
  - Declares charAt(…), length(), and more
  - Implemented by String, StringBuffer, and more
- Comparable
  - Declares compareTo()
  - Implemented by Integer, Boolean, String, and many more
  - Any array whose elements implement Comparable can be automatically sorted with Arrays.sort()

Built-in interfaces

- List
  - Declares get(), set(), indexOf(), and many more
  - Implemented by many "Collections" (next week)
  - "Optional" methods?? (e.g. set())
    - Must be implemented, but may throw "UnsupportedOperationException"
    - The other alternative would be no optional methods, but many more built-in interfaces
    - "Optional" methods not advised in your own interfaces
    - http://stackoverflow.com/questions/10572643/optional-methods-in-java-interface

Purposes of Interfaces

- Organization
  - Enforces encapsulation at compile-time
  - Provides a contract for users (other programmers)
  - Interfaces should be designed carefully
    - Many classes may eventually implement the interface
    - Changes to the interface requires changes to all classes that implement it
- Polymorphism

Polymorphism

- "Poly-morphism" $\leftrightarrow$ "Many-forms"
- Informally: The ability to type-cast non-primitive data

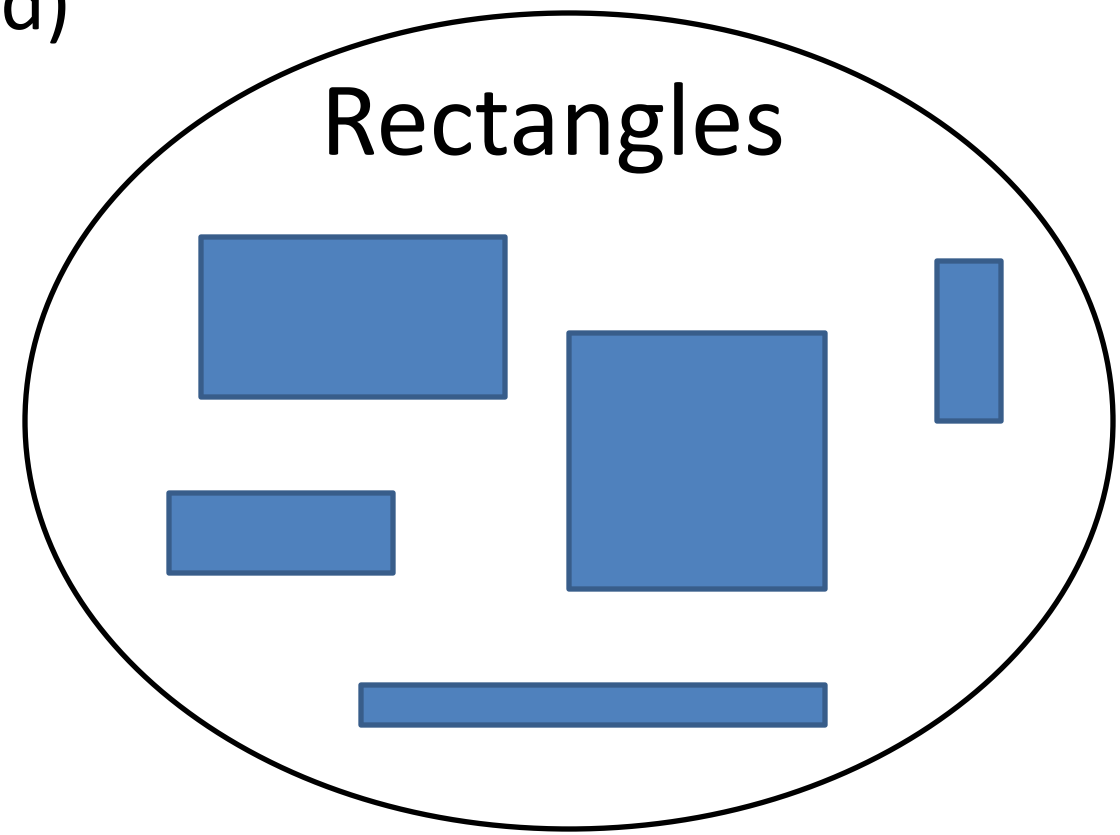
```
int i = 3;
float f = (float) i;

Circle c = new Circle(3);
Shape s = (Shape) c;
```

- Inheritance also facilitates polymorphism (more later)
- Set theory basics

Set Theory

- Set: A collection of distinct elements (unordered)



Set Theory

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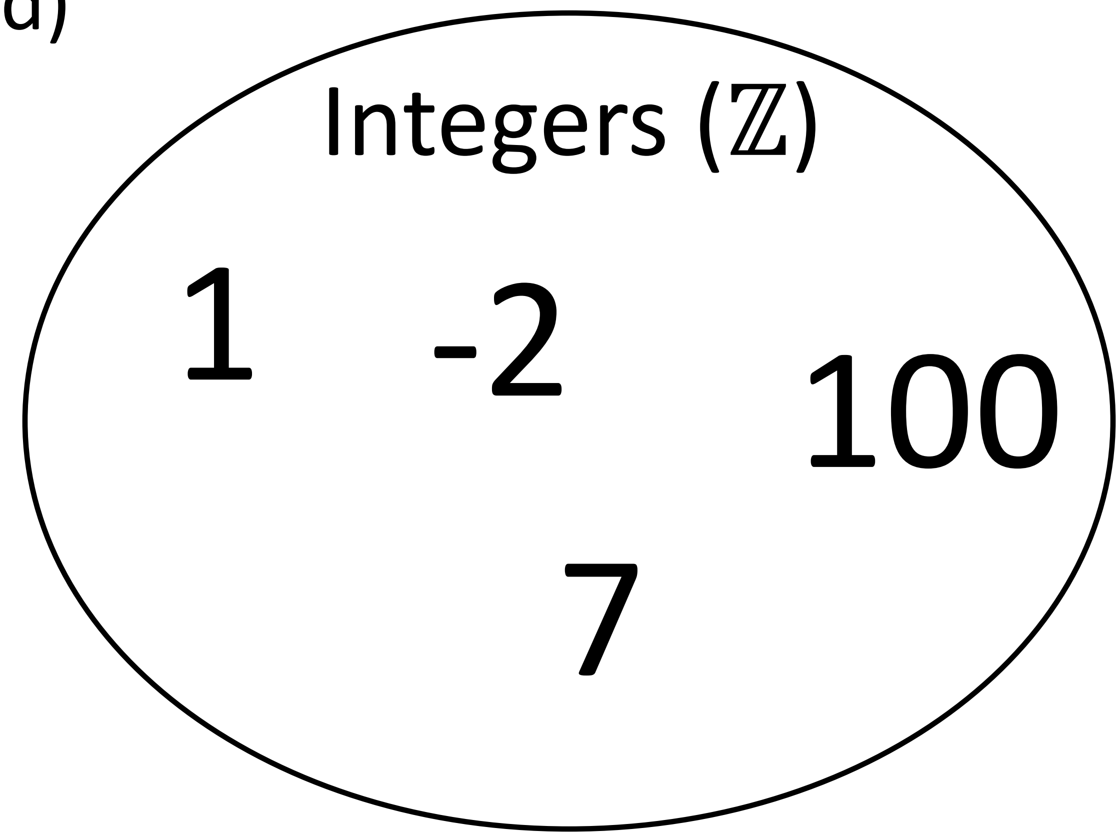

Set Theory

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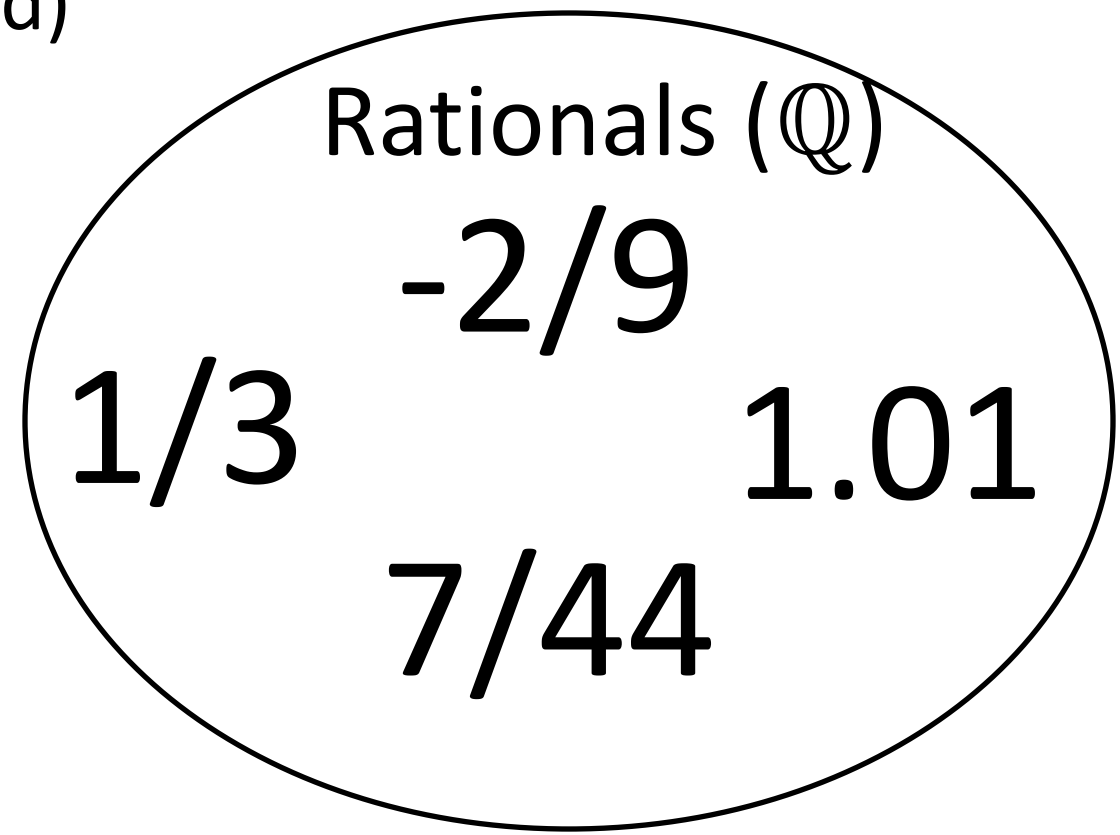
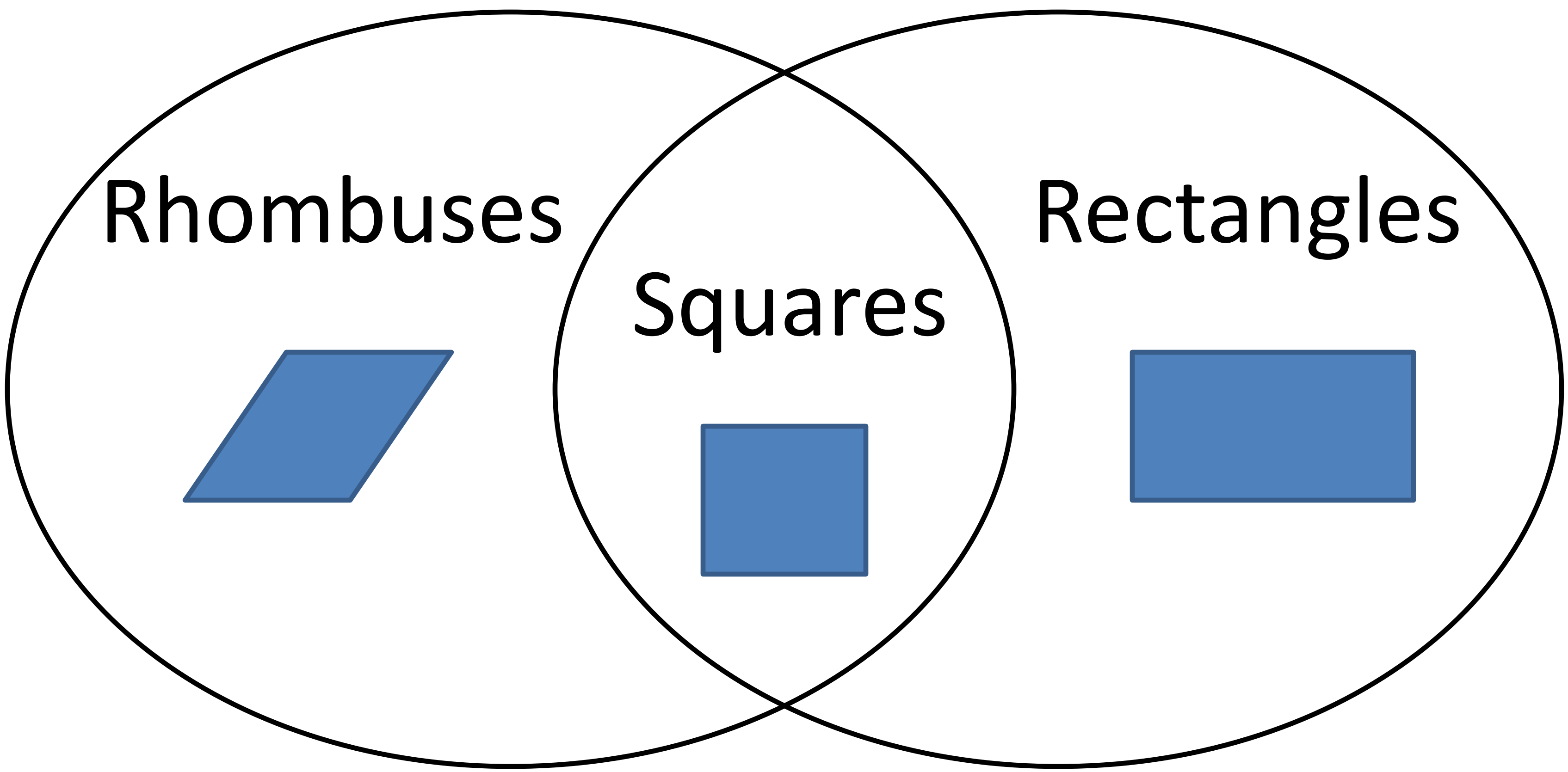


Set Theory

- Set: A collection of distinct elements (unordered)
- Typically written as {element1, element2,…}
  - The positive, even numbers less than 10 (finite)
    - {2, 4, 6, 8}
    - {2, 6, 4, 8}
    - {8, 4, 6, 2}

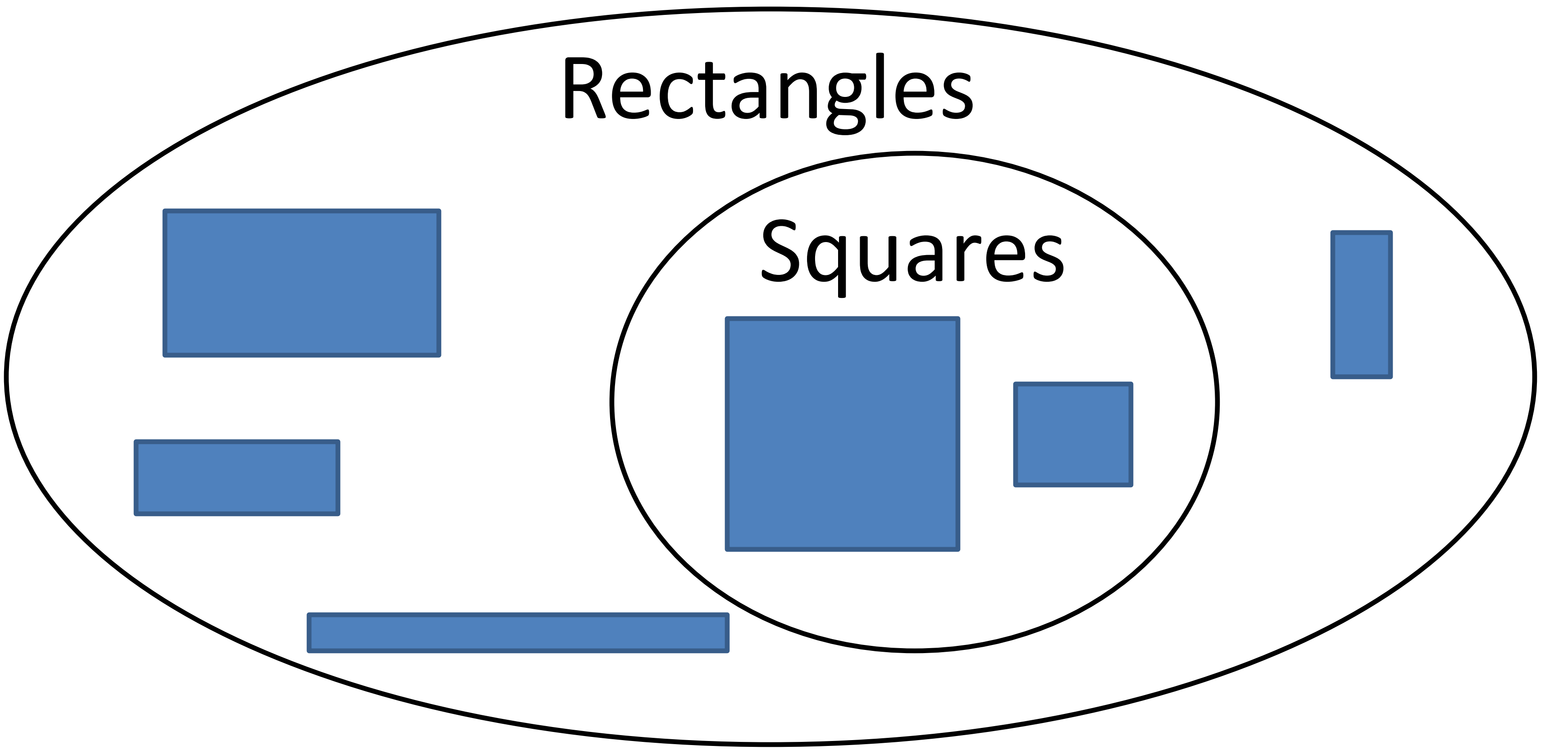
Set Theory

- Sets can overlap



Set operations

- Subset: One set entirely contained in another



Set operations

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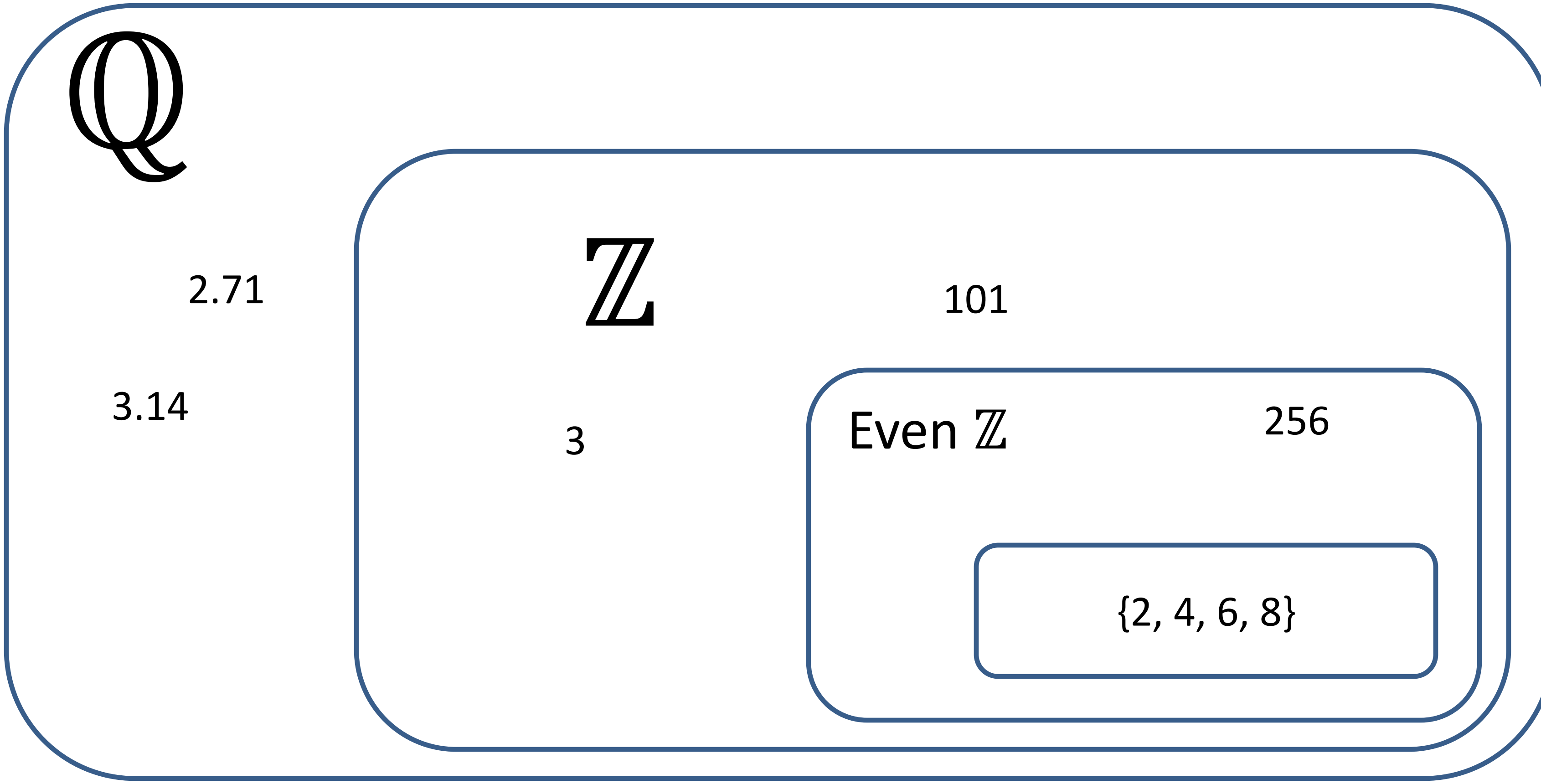


Set operations

- Subset: Mathematical symbol is $\subset$
  - Squares $\subset$ Rectangles (Four right angles)
  - Squares $\subset$ Rhombuses (Four equal sides)
  - $\mathbb{Z} \subset \mathbb{Q}$
- Set union: Everything in either set
  - Rectangles $\cup$ Rhombuses = Parallelograms(?)
  - $\mathbb{Z} \cup \mathbb{Q} = \mathbb{Q}$
- Set intersection: Everything in both sets
  - Rectangles $\cap$ Rhombuses = Squares
  - $\mathbb{Z} \cap \mathbb{Q} = \mathbb{Z}$

Explicit/implicit casting

The rules of type-casting depend on the “is-a” (subset) relationship

- $\mathbb{Z} \subset \mathbb{Q}$:
  - An integer ***IS A*** rational number
  - A rational number is not necessarily an integer
- Circles $\subset$ Shapes
  - A circle ***IS A*** shape
  - A shape is not necessarily a circle
- A String is never a shape
- Polymorphism examples

Explicit/implicit casting

Which type-casts are necessary?

- `int i = (int) 3.0;`
- `float f = (float) 3;`
- `Shape s = (Shape) new Circle(3);`
- `Circle c = (Circle) s;`
- `String str = (String) c;`

Explicit/implicit casting

Which type-casts are necessary?

- `int i = (int) 3.0; //Yes`
- `float f = (float) 3; //No`
- `Shape s = (Shape) new Circle(3); //No`
- `Circle c = (Circle) s; //Yes`
- `String str = (String) c; //Error`

"is-a" relationship gives the correct answer ("hiding/destroying data" does not)

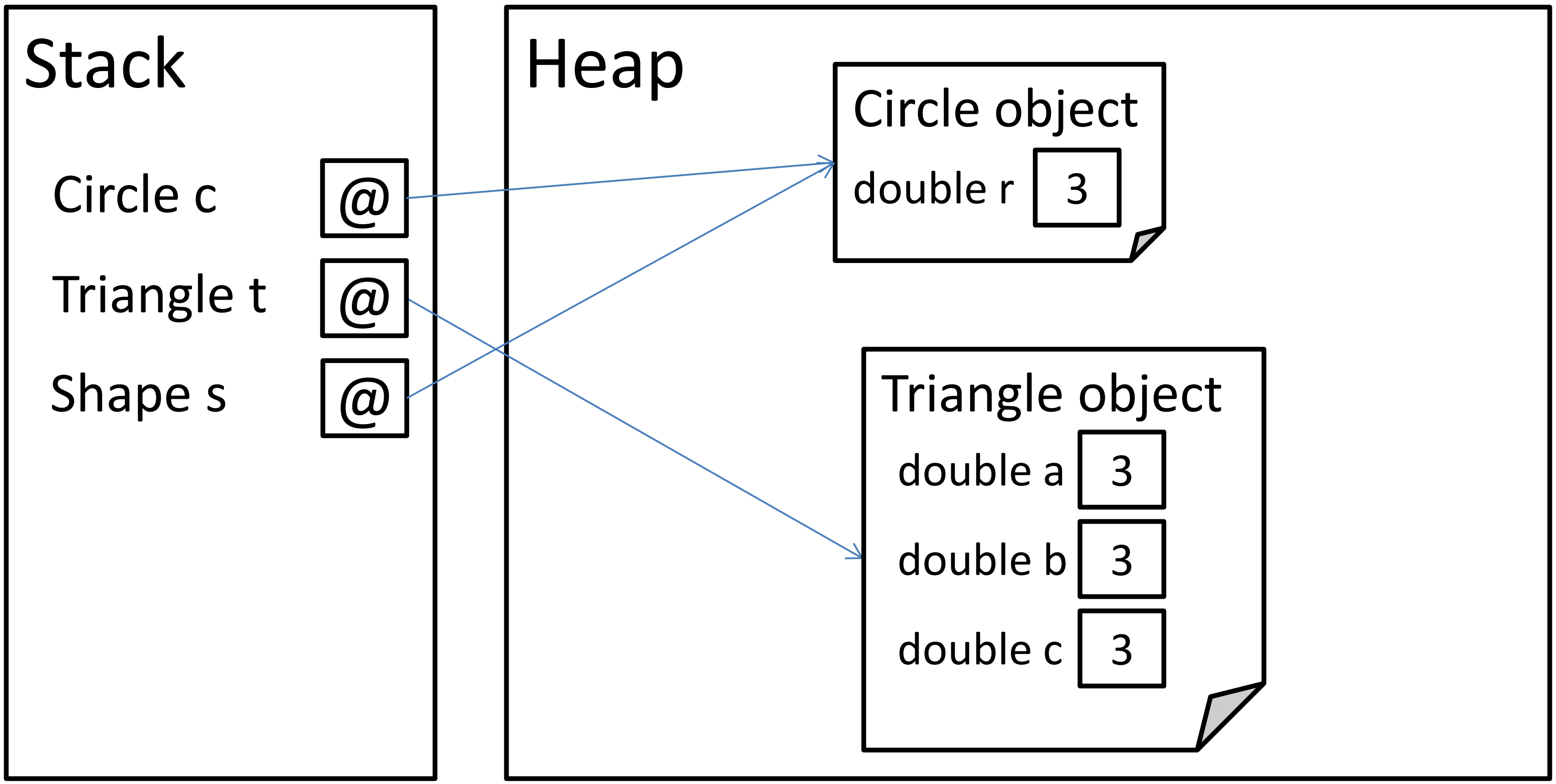
Polymorphic references

- As long as the underlying object implements Shape, it can be referenced by a Shape variable.

```
//Casts are not necessary here
Shape s = (Shape) new Circle(3);
s = (Shape) new Triangle(3);
s = (Shape) new Square(3);
```

Polymorphic references

- A reference variable is a *memory address*
- An object is a data structure on the heap



Polymorphic references

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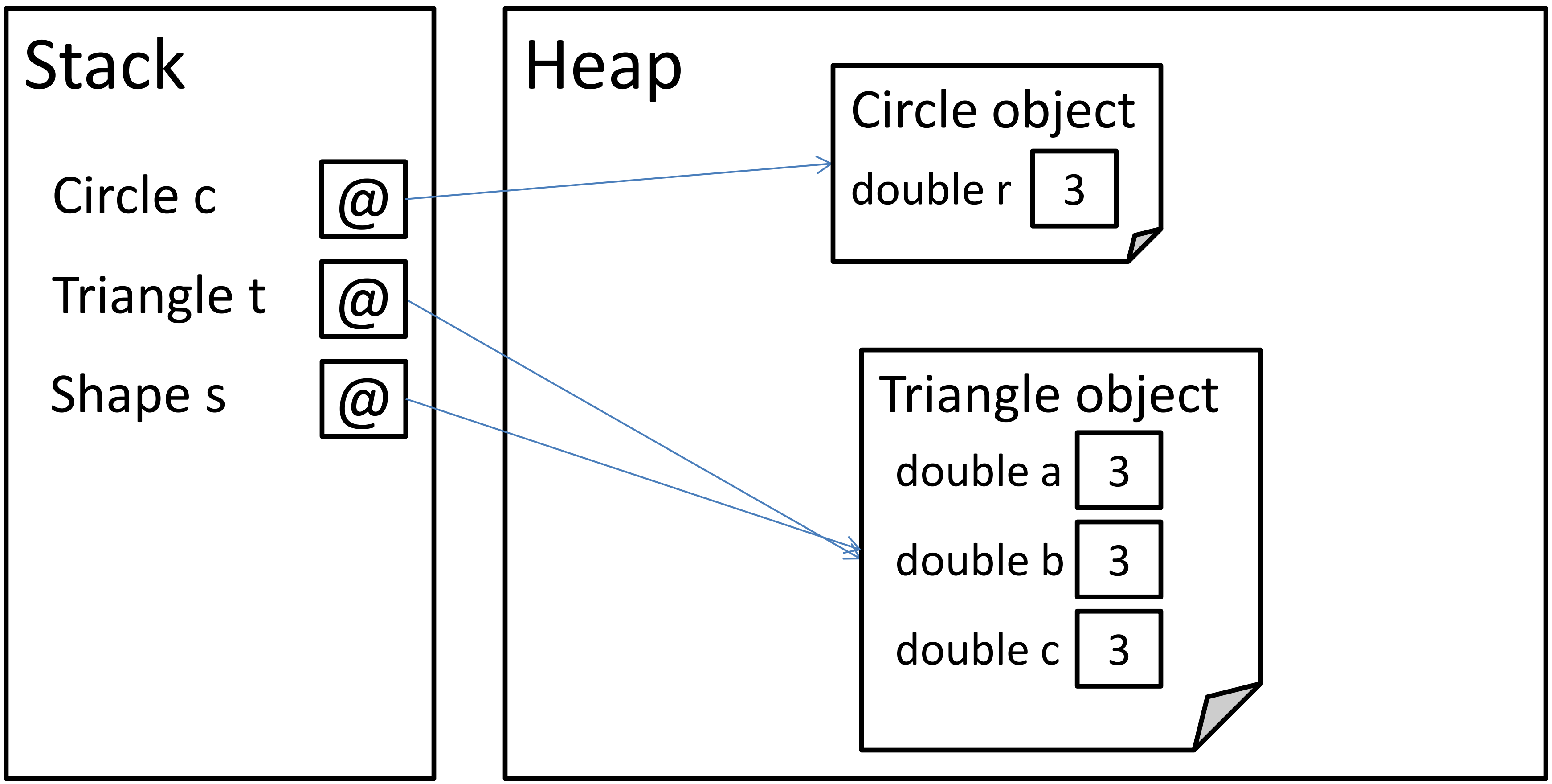


Polymorphic references

- The Shape variable can call all of (and only) the methods in the Shape interface

```
s.area(); //Valid
s.dilate(3.0); //Valid
s.toString(); //Valid
s.circumference(); //Invalid
```

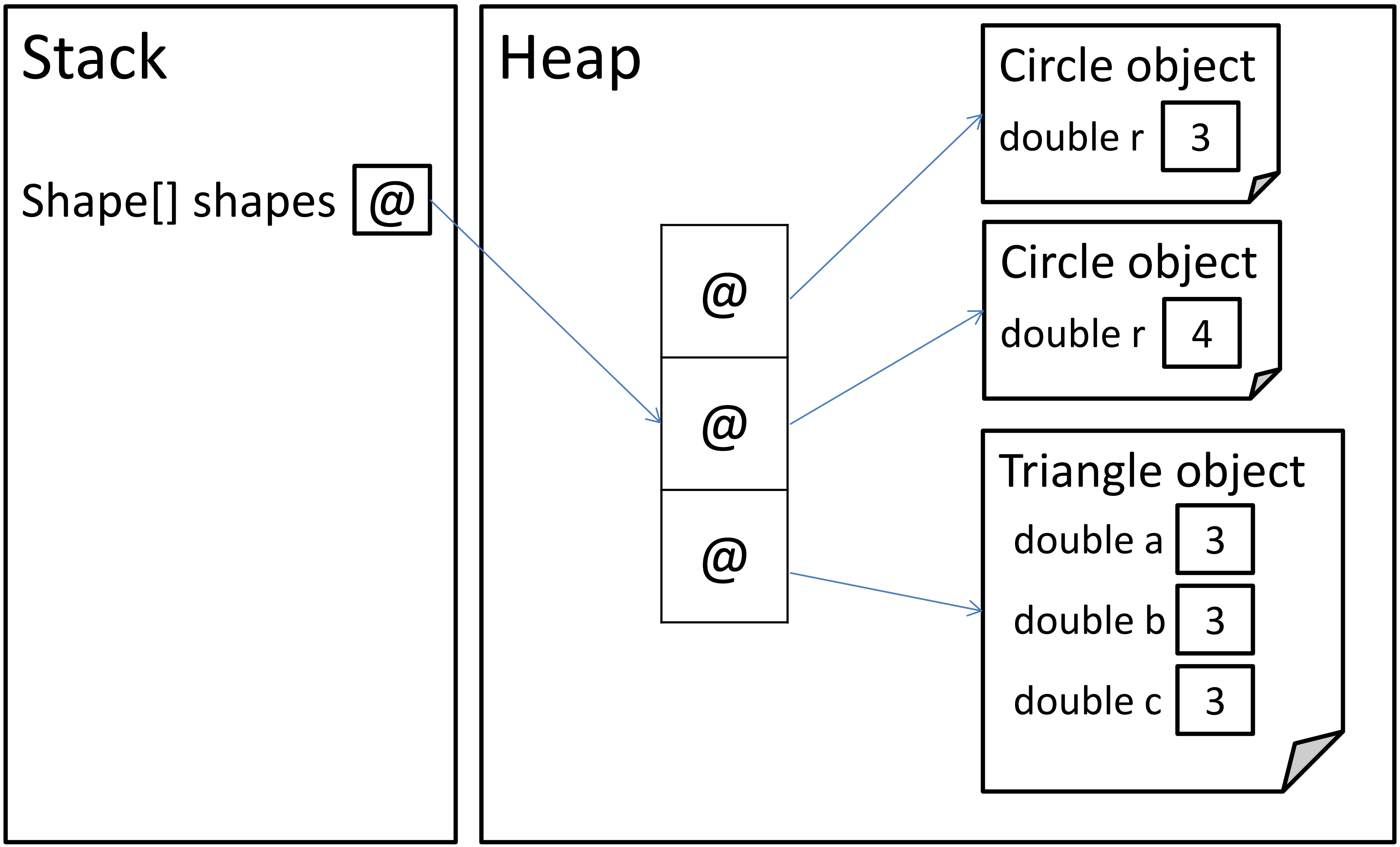
- But the underlying object determines which method gets called:

```
s.area(); //Circle or triangle area?
//Depends on the underlying object
```

Dynamic binding

- Different classes can have methods with the same name, so method calls must be “bound” to objects before they are executed
  - “Early”/ “Static” binding: at compile time
  - “Late”/ “Dynamic” binding: at run time
- Java uses late binding
  - With interfaces and polymorphic references, the class of the underlying object is not necessarily known until run-time
  - Late binding allows this sort of polymorphism, but at the cost of efficiency

Heterogenous arrays



Heterogenous Arrays

- Polymorphism allows us to create “heterogenous” arrays
  - Different classes in a single array
- If we stick to interface methods, we can manipulate heterogenous arrays the same way as usual:

```
Shape[] shapes = new Shape[6];
shapes[3] = new Circle(3);
shapes[4] = new Triangle(3,4,5);
System.out.println(shapes[3].area());
System.out.println(shapes[4].area());
```

- Array example

The Object class

- “Object” is an umbrella class that contains all other classes
- Any object can be stored in a variable of type Object
  - `Object obj = new Integer(3);`
  - `Object obj = new Scanner(System.in);`
  - ObjectExample

The Object class

- Object has its own set of methods:
  - Equals
  - toString
  - hashCode
  - **getClass**
  - And more: http://docs.oracle.com/javase/7/docs/api/java/lang/Object.html
- Every class has access to these methods by default (unless they get overriden)
  - MyObject example

The getClass() method

- GetClassExample
  - Shape is an interface
  - Shape shape is a reference variable
    - It points to an object with a specific class at run time
  - How do we determine the runtime class?
    - Calling the getClass() method.
  - “Dummy” objects: allocated simply for calling getClass()
  - buggingMe method
- Class, get getClass()?

Using getClass()

- The return type of getClass() is Class
  - “Class” is a class that represents classes (ugh…)
- You can declare variables of type Class:
  - Class c = obj1.getClass();
  - Warnings related to “generics” (next week)
- But typically you compare the Classes of two objects:
  - obj1.getClass().equals(obj2.getClass())

The standard equals method

- There is a standard way of defining equals that is widely accepted and expected

Warning
ComplexNumber defines equals(ComplexNumber) method and uses Object.equals(Object)

The standard equals method

- What if we want to compare our object to ***any*** other object, not just others of the same type?
  - `public boolean equals(Square other);`
  - `public boolean equals(Shape other);`
  - `public boolean equals(Object other);`
- Square example – standard equals

Standard equals

- Public boolean equals(Object other) should contain:
  - Null check (is other null?)
  - Type check (is other the correct run-time type?)
  - Your checks
    - Typically, check that all the fields are the same. This will require a type-cast: (*this.getClass()*) other.
    - Application may have different requirements – for example, two equal “Set” objects may contain arrays with the same elements, but in different orders.