Building Java Programs

Interfaces

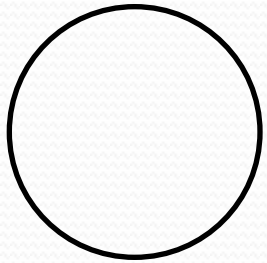
reading: 9.5 - 9.6, 16.4

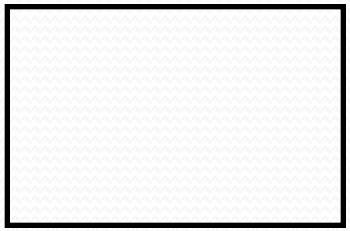
Shapes

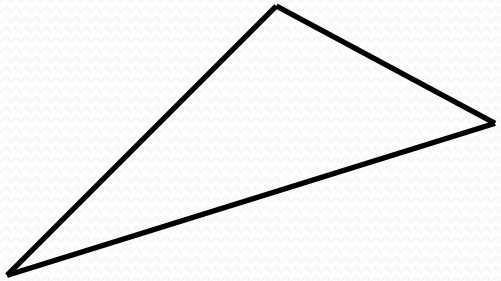
- Consider the task of writing classes to represent 2D shapes such as `Circle`, `Rectangle`, and `Triangle`.

- Certain operations are common to all shapes:
  - perimeter: distance around the outside of the shape
  - area: amount of 2D space occupied by the shape

  - Every shape has these, but each computes them differently.





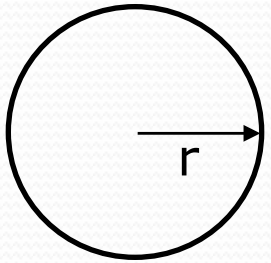


Shape area and perimeter

- Circle (as defined by radius r):

  area $= \frac{1}{2} \pi r^2$

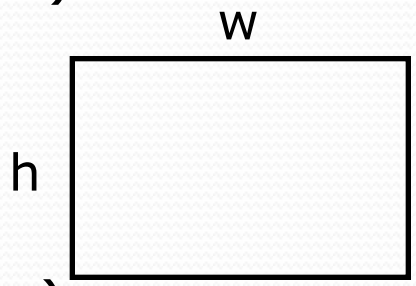
  perimeter $= 2 \pi r$



- Rectangle (as defined by width w and height h):

  area $= w h$

  perimeter $= 2w + 2h$

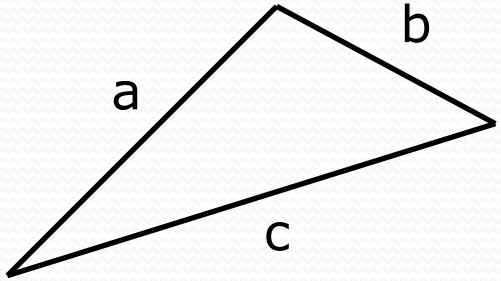


- Triangle (as defined by side lengths a, b, and c)

  area $= \sqrt{(s\,(s - a)\,(s - b)\,(s - c))}$

  where $s = \frac{1}{2}\,(a + b + c)$

  perimeter $= a + b + c$



Common behavior

- Suppose we have 3 classes `Circle`, `Rectangle`, `Triangle`.
  - Each has the methods `perimeter` and `area`.

- We'd like our client code to be able to treat different kinds of shapes in the same way:
  - Write a method that prints any shape's area and perimeter.
  - Create an array to hold a mixture of the various shape objects.
  - Write a method that could return a rectangle, a circle, a triangle, or any other kind of shape.
  - Make a `DrawingPanel` display many shapes on screen.

Interfaces (9.5)

- **interface**: A list of methods that a class can promise to implement.
  - Inheritance gives you an is-a relationship *and* code sharing.
    - A `Lawyer` can be treated as an `Employee` and inherits its code.
  - Interfaces give you an is-a relationship *without* code sharing.
    - A `Rectangle` object can be treated as a `Shape` but inherits no code.
  - Analogous to non-programming idea of roles or certifications:
    - "I'm certified as a CPA accountant.
      This assures you I know how to do taxes, audits, and consulting."
    - "I'm 'certified' as a Shape, because I implement the Shape interface.
      This assures you I know how to compute my area and perimeter."

Interface syntax

```
public interface name {
    public type name(type name, ..., type name);
    public type name(type name, ..., type name);
    ...
    public type name(type name, ..., type name);
}
```

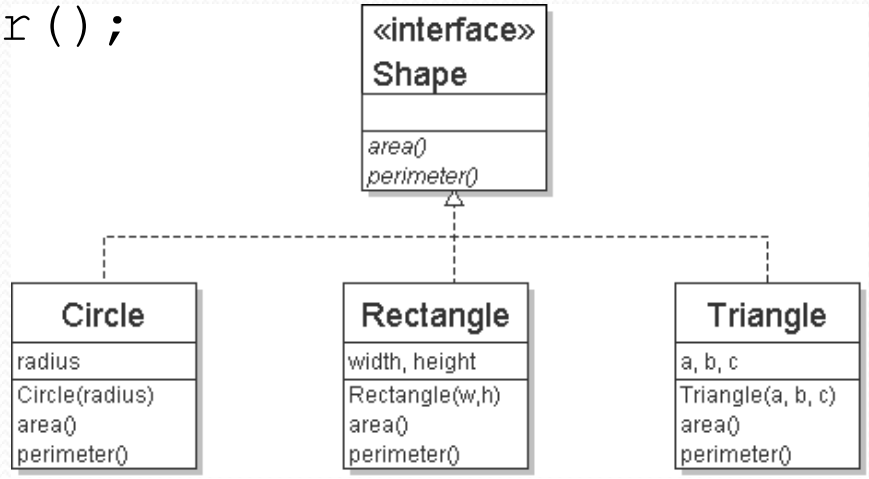
Example:

```
public interface Vehicle {
    public int getSpeed();
    public void setDirection(int direction);
}
```

Shape interface

```
// Describes features common to all shapes.
public interface Shape {
    public double area();
    public double perimeter();
}
```

- Saved as `Shape.java`



- **abstract method**: A header without an implementation.
  - The actual bodies are not specified, because we want to allow each class to implement the behavior in its own way.

Implementing an interface

```
public class name implements interface {
    ...
}
```

- A class can declare that it "implements" an interface.
  - The class must contain each method in that interface.

```
public class Bicycle implements Vehicle {
    ...
}
```

(Otherwise it will fail to compile.)

```
Banana.java:1: Banana is not abstract and does not
override abstract method area() in Shape
public class Banana implements Shape {
                ^
```

Interface requirements

```
public class Banana implements Shape {
    // haha, no methods! pwned
}
```

- If we write a class that claims to be a `Shape` but doesn't implement `area` and `perimeter` methods, it will not compile.

```
Banana.java:1: Banana is not abstract and does not
override abstract method area() in Shape
public class Banana implements Shape {
                ^
```

Interfaces + polymorphism

- Interfaces benefit the *client code* author the most.
  - They allow **polymorphism**.
    (the same code can work with different types of objects)

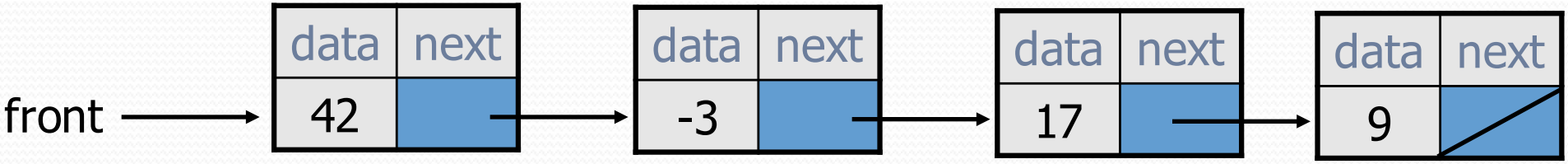
```
public static void printInfo(Shape s) {
    System.out.println("The shape: " + s);
    System.out.println("area : " + s.area());
    System.out.println("perim: " + s.perimeter());
    System.out.println();
}
...
Circle circ = new Circle(12.0);
Triangle tri = new Triangle(5, 12, 13);
printInfo(circ);
printInfo(tri);
```

Linked vs. array lists

- We have implemented two collection classes:
  - `ArrayIntList`

index	0	1	2	3
value	42	-3	17	9

  - `LinkedIntList`



  - They have similar behavior, implemented in different ways. We should be able to treat them the same way in client code.

Redundant client code

```
public class ListClient {
    public static void main(String[] args) {
        ArrayIntList list1 = new ArrayIntList();
        list1.add(18);
        list1.add(27);
        list1.add(93);
        System.out.println(list1);
        list1.remove(1);
        System.out.println(list1);

        LinkedIntList list2 = new LinkedIntList();
        list2.add(18);
        list2.add(27);
        list2.add(93);
        System.out.println(list2);
        list2.remove(1);
        System.out.println(list2);
    }
}
```

An `IntList` interface

```
// Represents a list of integers.
public interface IntList {
    public void add(int value);
    public void add(int index, int value);
    public int get(int index);
    public int indexOf(int value);
    public boolean isEmpty();
    public int remove(int index);
    public void set(int index, int value);
    public int size();
}
```

```
public class ArrayIntList implements IntList { ...
public class LinkedIntList implements IntList { ...
```

Client code w/ interface

```
public class ListClient {
    public static void main(String[] args) {
        IntList list1 = new ArrayIntList();
        process(list1);

        IntList list2 = new LinkedIntList();
        process(list2);
    }

    public static void process(IntList list) {
        list.add(18);
        list.add(27);
        list.add(93);
        System.out.println(list);
        list.remove(1);
        System.out.println(list);
    }
}
```

ADTs as interfaces (11.1)

- **abstract data type (ADT)**: A specification of a collection of data and the operations that can be performed on it.
  - Describes *what* a collection does, not *how* it does it.

- Java's collection framework uses interfaces to describe ADTs:
  - `Collection`, `Deque`, `List`, `Map`, `Queue`, `Set`

- An ADT can be implemented in multiple ways by classes:
  - `ArrayList` and `LinkedList` implement `List`
  - `HashSet` and `TreeSet` implement `Set`
  - `LinkedList`, `ArrayDeque`, etc. implement `Queue`
    - They messed up on `Stack`; there's no `Stack` interface, just a class.

Using ADT interfaces

When using Java's built-in collection classes:

- It is considered good practice to always declare collection variables using the corresponding ADT interface type:

```
List<String> list = new ArrayList<String>();
```

- Methods that accept a collection as a parameter should also declare the parameter using the ADT interface type:

```
public void stutter(List<String> list) {
    ...
}
```

Why use ADTs?

- Why would we want more than one kind of list, queue, etc.?

- Answer: Each implementation is more efficient at certain tasks.
  - `ArrayList` is faster for adding/removing at the end; `LinkedList` is faster for adding/removing at the front/middle. Etc.

  - You choose the optimal implementation for your task, and if the rest of your code is written to use the ADT interfaces, it will work.