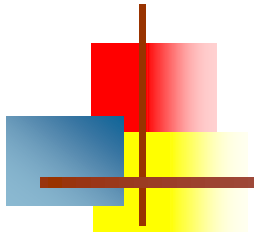
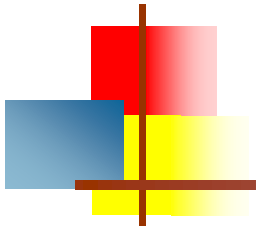
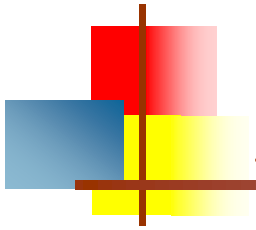


Abstract Classes and Interfaces



Java is “safer” than Python

- Python is very *dynamic*—classes and methods can be added, modified, and deleted as the program runs
  - If you have a call to a function that doesn't exist, Python will give you a **runtime** error *when you try to call it*
- In Java, everything has to be defined before the program begins to execute
  - If you have a call to a function that doesn't exist, the compiler marks it as a **syntax error**
  - Syntax errors are far better than runtime errors
    - Among other things, they won’t make it into distributed code
  - To achieve this, Java requires some additional kinds of classes



Abstract methods

- You can *declare* an object without *defining* it:

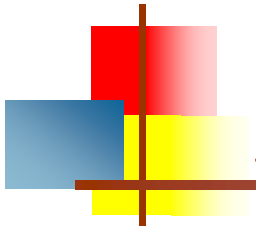
  ```
  Person p;
  ```

- Similarly, you can declare a *method* without defining it:

  ```
  public abstract void draw(int size);
  ```

  - Notice that the body of the method is missing

- A method that has been declared but not defined is an abstract method

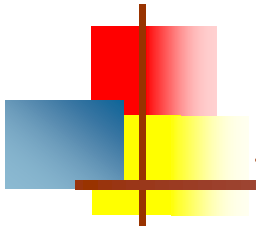


Abstract classes I

- Any class containing an abstract method is an abstract class
- You must declare the class with the keyword abstract:

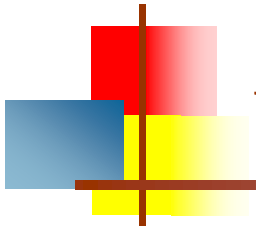
```
abstract class MyClass {...}
```

- An abstract class is *incomplete*
  - It has "missing" method bodies
- You cannot instantiate (create a new instance of) an abstract class



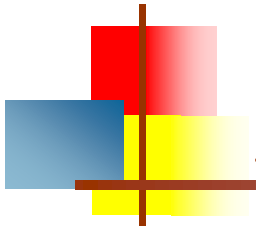
Abstract classes II

- You can extend (subclass) an abstract class
  - If the subclass defines all the inherited abstract methods, it is “complete” and can be instantiated
  - If the subclass does *not* define all the inherited abstract methods, it too must be abstract
- You can declare a class to be `abstract` even if it does not contain any abstract methods
  - This prevents the class from being instantiated



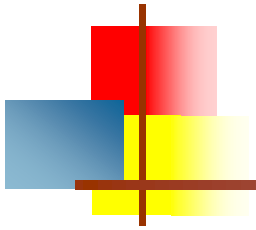
Why have abstract classes?

- Suppose you wanted to create a class Shape, with subclasses Oval, Rectangle, Triangle, Hexagon, etc.
- You don't want to allow creation of a "Shape"
  - Only *particular* shapes make sense, not *generic* ones
  - If Shape is abstract, you can't create a new Shape
  - You *can* create a new Oval, a new Rectangle, etc.
- Abstract classes are good for defining a general category containing specific, "concrete" classes



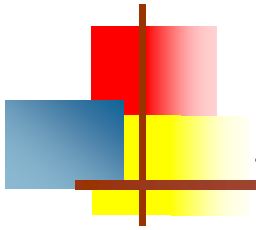
An example abstract class

- public abstract class Animal {
  abstract int eat();
  abstract void breathe();
  }
- This class cannot be instantiated
- Any non-abstract subclass of Animal must provide the eat() and breathe() methods



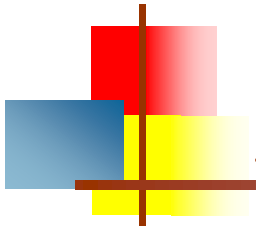
Why have abstract methods?

- Suppose you have a class Shape, but it *isn't* abstract
  - Shape should *not* have a draw() method
  - Each subclass of Shape *should* have a draw() method
- Now suppose you have a variable Shape figure; where figure contains some subclass object (such as a Star)
  - It is *a syntax error* to say figure.draw(), because the Java compiler can't tell in advance what kind of value will be in the figure variable
  - A class "knows" its superclass, but doesn't know its subclasses
  - An object knows its class, but a class doesn't know its objects
- **Solution:** Give Shape an *abstract* method draw()
  - Now the class Shape is abstract, so it can't be instantiated
  - The figure variable cannot contain a (generic) Shape, because it is impossible to create one
  - Any object (such as a Star object) that *is* a (kind of) Shape *will* have the draw() method
  - The Java compiler can depend on figure.draw() being a legal call and does not give a syntax error



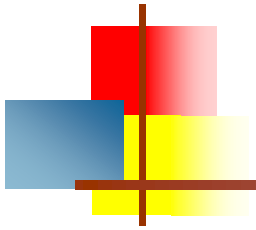
A problem

- class Shape { … }
- class Star extends Shape {
  void draw() { … }
  …
  }
- class Crescent extends Shape {
  void draw() { … }
  …
  }
- Shape someShape = new Star();
  - This is legal, because a Star ***is*** a Shape
- someShape.draw();
  - This is a syntax error, because *some* Shape might not have a draw() method
  - Remember: ***A class knows its superclass, but not its subclasses***



A solution

- abstract class Shape {
  void draw();
  }
- class Star extends Shape {
  void draw() { … }
  …
  }
- class Crescent extends Shape {
  void draw() { … }
  …
  }
- Shape someShape = new Star();
  - This is legal, because a Star ***is*** a Shape
  - However, Shape someShape = new Shape(); is *no longer* legal
- someShape.draw();
  - This is legal, because every actual instance *must* have a draw() method

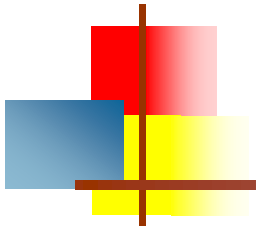


Interfaces

- An interface declares (describes) methods but does not supply bodies for them

```
interface KeyListener {
    public void keyPressed(KeyEvent e);
    public void keyReleased(KeyEvent e);
    public void keyTyped(KeyEvent e);
}
```

- All the methods are implicitly public and abstract
  - You can add these qualifiers if you like, but why bother?
- You cannot instantiate an interface
  - An interface is like a *very* abstract class—*none* of its methods are defined
- An interface may also contain constants (final variables)

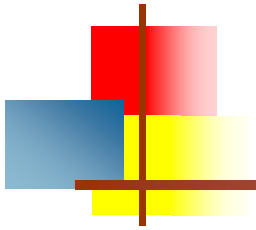


Designing interfaces

- Most of the time, you will use Sun-supplied Java interfaces
- Sometimes you will want to design your own
- You would write an interface if you want classes of various types to all have a certain set of capabilities
- For example, if you want to be able to create animated displays of objects in a class, you might define an interface as:

```
public interface Animatable {
    install(Panel p);
    display();
}
```

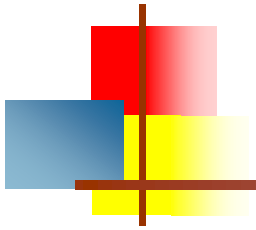
- Now you can write code that will display *any* Animatable class in a Panel of your choice, simply by calling these methods



Implementing an interface I

- You extend a class, but you implement an interface
- A class can only extend (subclass) one other class, but it can implement as many interfaces as you like
- Example:

```
class MyListener
        implements KeyListener, ActionListener { … }
```

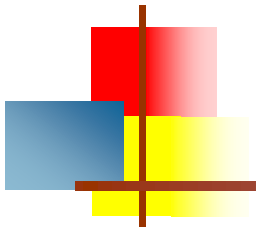


Implementing an interface II

- When you say a class implements an interface, you are promising to *define* all the methods that were *declared* in the interface
- Example:

```
class MyKeyListener implements KeyListener {
        public void keyPressed(KeyEvent e) {...};
        public void keyReleased(KeyEvent e) {...};
        public void keyTyped(KeyEvent e) {...};
}
```

  - The "…" indicates actual code that you must supply
- Now you can create a new MyKeyListener

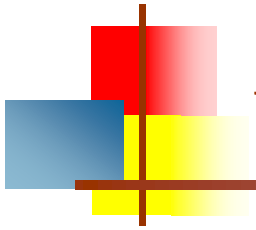


Partially implementing an Interface

- It is possible to define some but not all of the methods defined in an interface:

```
abstract class MyKeyListener implements KeyListener {
    public void keyTyped(KeyEvent e) {...};
}
```

- Since this class does not supply all the methods it has promised, it is an abstract class
- You must label it as such with the keyword abstract
- You can even *extend* an interface (to add methods):
  - interface FunkyKeyListener extends KeyListener { ... }

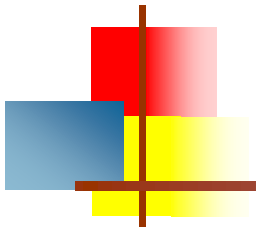


What are interfaces for?

- Reason 1: A class can only extend one other class, but it can implement multiple interfaces
  - This lets the class fill multiple "roles"
  - In writing Applets, it is common to have one class implement several different listeners
  - Example:

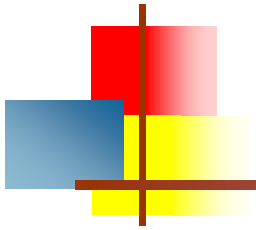
```
class MyApplet extends Applet
        implements ActionListener, KeyListener {
...
}
```

- Reason 2: You can write methods that work for more than one kind of class



How to use interfaces

- You can write methods that work with more than one class
- interface RuleSet { boolean isLegal(Move m, Board b);
  void makeMove(Move m); }
  - Every class that implements RuleSet must have these methods
- class CheckersRules implements RuleSet { // one implementation
  public boolean isLegal(Move m, Board b) { ... }
  public void makeMove(Move m) { ... }
  }
- class ChessRules implements RuleSet { ... } // another implementation
- class LinesOfActionRules implements RuleSet { ... } // and another
- RuleSet rulesOfThisGame = new ChessRules();
  - This assignment is legal because a rulesOfThisGame object *is* a RuleSet object
- if (rulesOfThisGame.isLegal(m, b)) { makeMove(m); }
  - This statement is legal because, *whatever* kind of RuleSet object rulesOfThisGame is, it *must* have isLegal and makeMove methods



instanceof

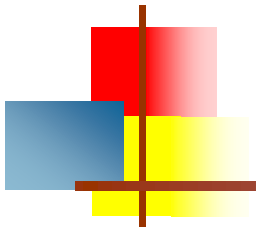
- instanceof is a keyword that tells you whether a variable "is a" member of a class or interface
- For example, if

```
class Dog extends Animal implements Pet {...}
Animal fido = new Dog();
```

  then the following are all true:

```
fido instanceof Dog
fido instanceof Animal
fido instanceof Pet
```

- instanceof is seldom used
  - When you find yourself wanting to use instanceof, think about whether the method you are writing should be moved to the individual subclasses

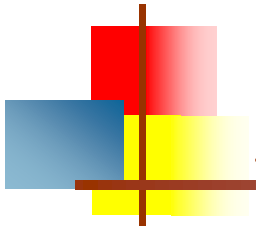


Interfaces, again

- When you implement an interface, you promise to define *all* the functions it declares
- There can be a *lot* of methods

```
interface KeyListener {
    public void keyPressed(KeyEvent e);
    public void keyReleased(KeyEvent e);
    public void keyTyped(KeyEvent e);
}
```

- What if you only care about a couple of these methods?

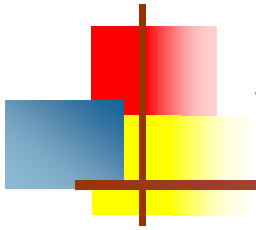


Adapter classes

- Solution: use an adapter class
- An adapter class implements an interface and provides empty method bodies

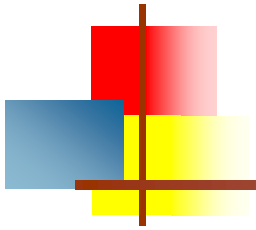
```
class  KeyAdapter implements KeyListener {
    public void keyPressed(KeyEvent e) { };
    public void keyReleased(KeyEvent e) { };
    public void keyTyped(KeyEvent e) { };
}
```

- You can override only the methods you care about
- This isn't elegant, but it does work
- Java provides a number of adapter classes



Vocabulary

- abstract method—a method which is declared but not defined (it has no method body)
- abstract class—a class which either (1) contains abstract methods, or (2) has been declared abstract
- instantiate—to create an instance (object) of a class
- interface—similar to a class, but contains only abstract methods (and possibly constants)
- adapter class—a class that implements an interface but has only empty method bodies



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