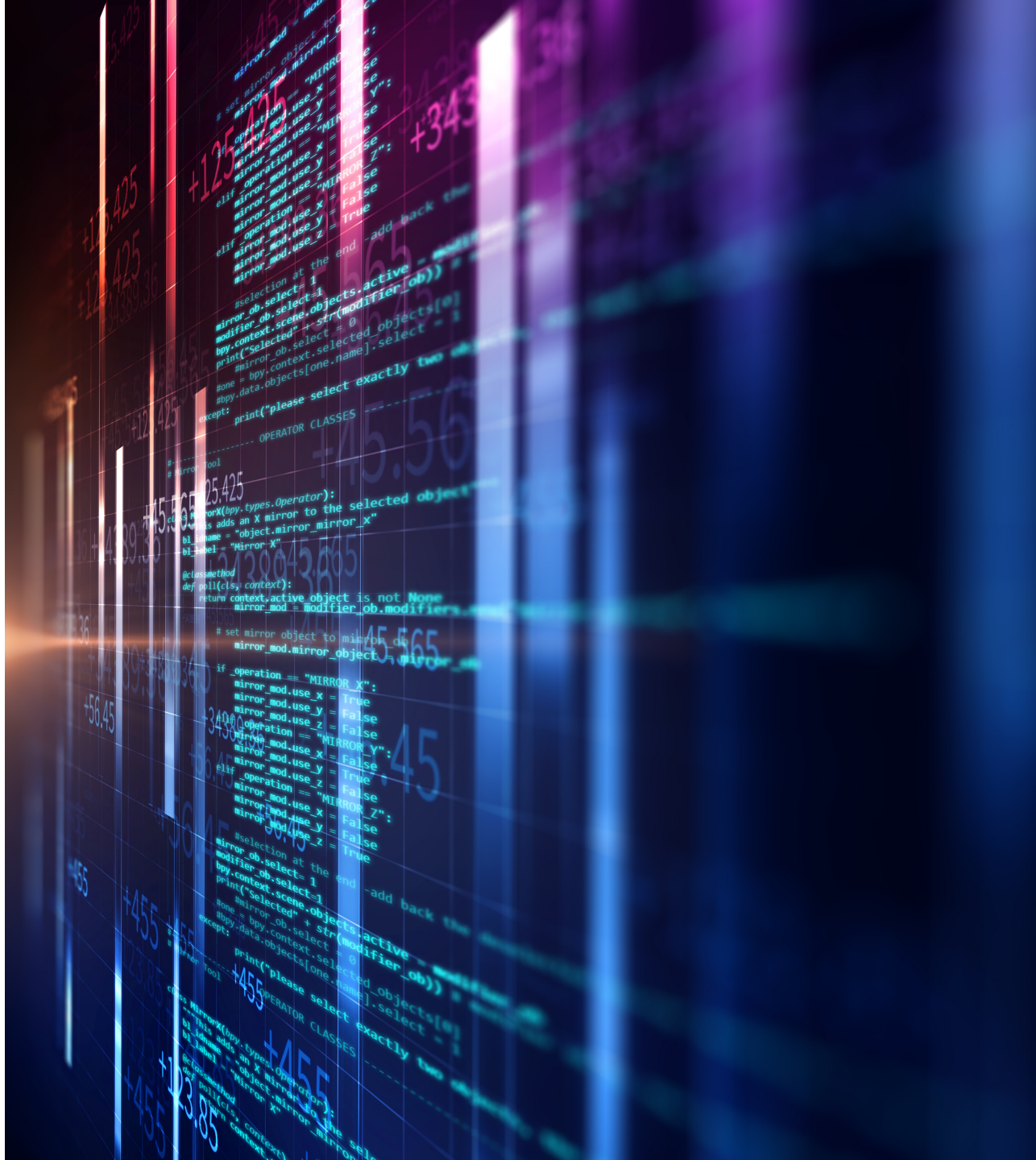
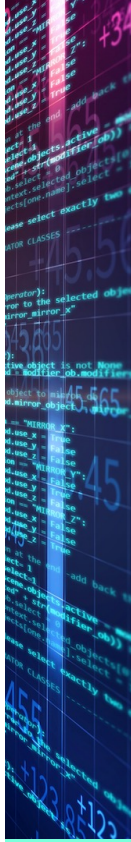
Abstract Classes

Brandon Krakowsky

Penn Engineering



Abstract Classes



Abstract Methods

- You can declare an Object without defining it:

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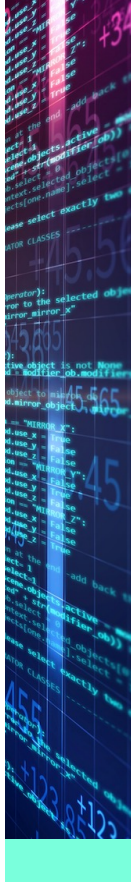
Person p; //declares variable p
```



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

```
public abstract void draw(int size); //declares method draw
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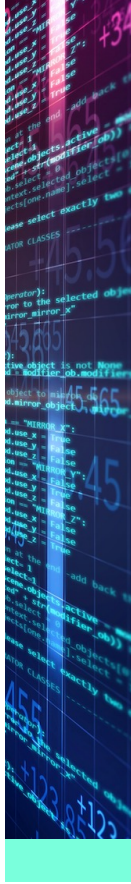
  - Declares the method with the keyword *abstract*



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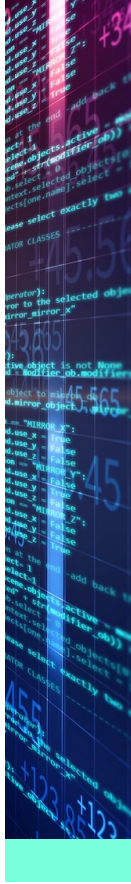
- Notice that the body of the method is missing
  - Instead of curly braces { } you just have a semi-colon ending the statement



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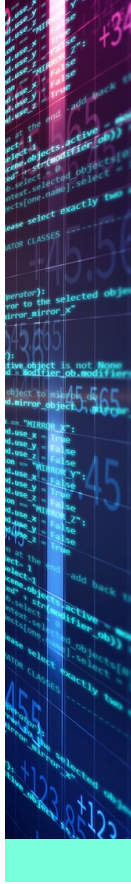
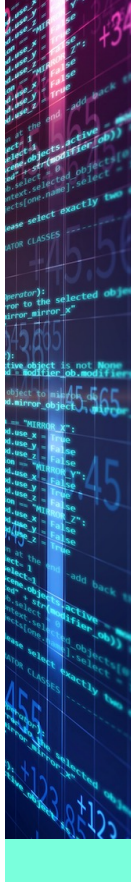
- A method that has been declared but not defined is an abstract method



Abstract Classes

- Any class containing an abstract method is an abstract class



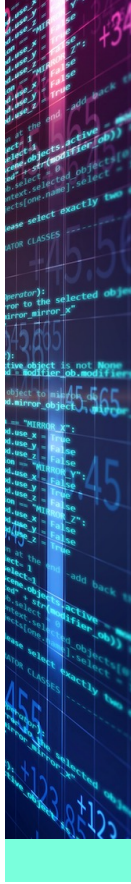
Abstract Classes

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

```
public abstract class Shape { //abstract class

    public abstract void draw(int size); //abstract method WITHOUT body

}
```



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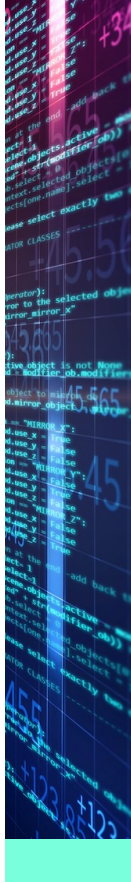
- You must declare the class with the keyword *abstract*:

```
public abstract class Shape { //abstract class

    public abstract void draw(int size); //abstract method WITHOUT body

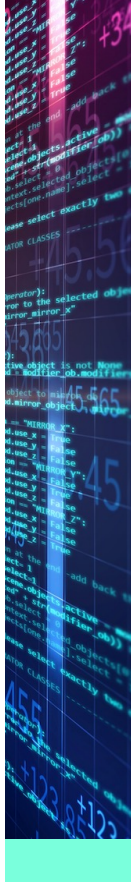
}
```

- You cannot instantiate (create a new instance of) an abstract class
  - You CANNOT do this:
    `Shape shape = new Shape();`



Extending Abstract Classes

- You can (and usually do) extend (or subclass) an abstract class
  - If the subclass defines all of the inherited abstract methods, it is “complete” and can be instantiated
    - This is also known as a “concrete” class
  - If the subclass does not define all the inherited abstract methods, it too must be abstract



Extending Abstract Classes

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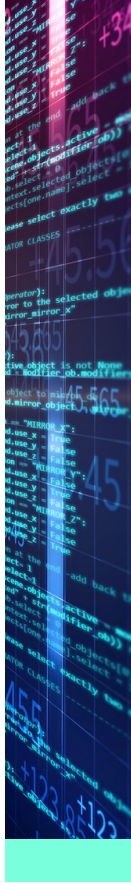
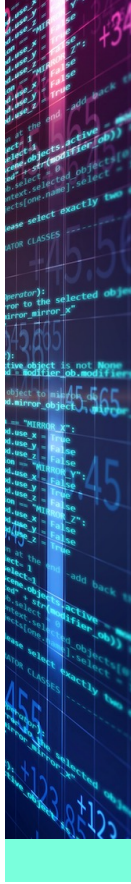
  - If the subclass does not define all the inherited abstract methods, it too must be abstract
- You can declare a class to be abstract even if it does not contain any abstract methods
  - This prevents the class from being instantiated



Example Abstract Class

- An abstract class can contain both *abstract* and *non abstract* (or concrete) methods



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- An abstract class can contain both *abstract* and *non abstract* (or concrete) methods
- Here's a sample abstract class for Pet
  - It contains an abstract method WITHOUT a body and a non abstract (concrete) method WITH a body

```
public abstract class Pet { //abstract class

        protected double weight;

        public abstract String makeSound(); //abstract method WITHOUT body

        public void eat(Food food) { //non abstract (concrete) method WITH body
            this.weight += (food.getCalories() / 100);
        }
    }
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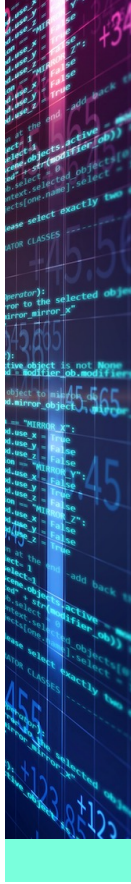

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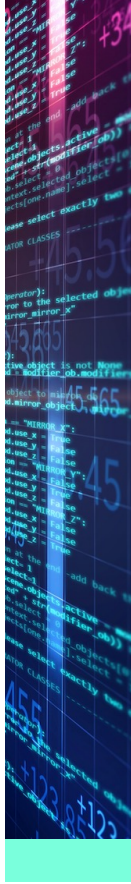
- This class cannot be instantiated because it's abstract



Example Abstract Class

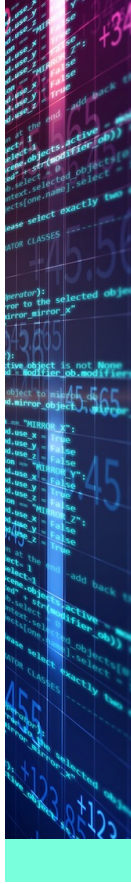
- Subclasses of Pet must provide an implementation of the makeSound method

```
public class Dog extends Pet {

    @Override
    public String makeSound() { //implementation of abstract method
        return “Bark!”;
    }

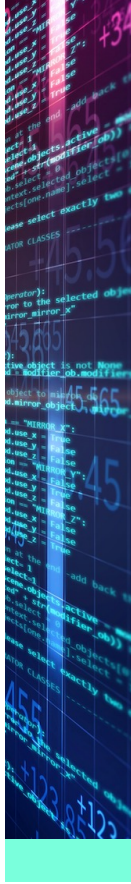
}

Dog myDog = new Dog();
System.out.println(myDog.makeSound()); //prints “Bark!”
```



Why Have Abstract Classes?

- For this example, we know that all Pets eat
  - The effect on the food is always the same
  - Instead of implementing the eat method for each subclass of Pet, we can implement it once and inherit it



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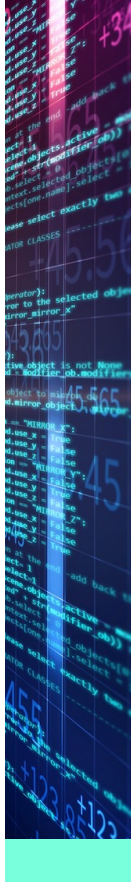

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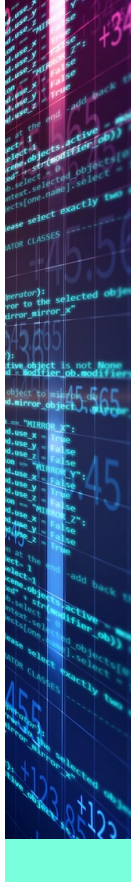
- We don’t want to instantiate a Pet object because we don’t know what it is (it’s abstract!)



Common Syntax Error with Subclasses

- Suppose we have a Shape class

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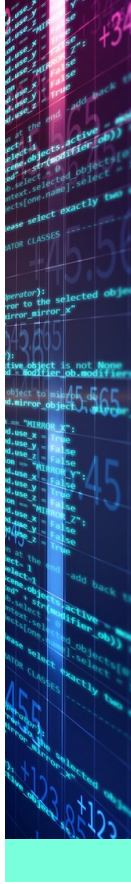


Common Syntax Error with Subclasses

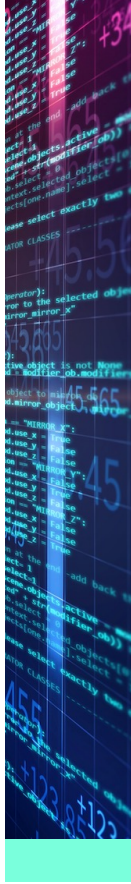
- Suppose we have a Shape class

```
class Shape { ... }
```

- And things (“shapes”) that extend Shape

```
class Star extends Shape {
    void draw() { ... }
    ...
}

class Crescent extends Shape {
    void draw() { ... }
    ...
}
```



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- Then we CAN actually do this, because a Star is a Shape

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//declare variable of type Shape to store object of type Star
Shape myShape = new Star();
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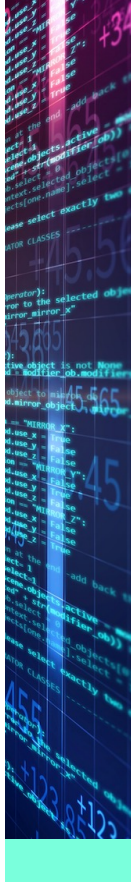

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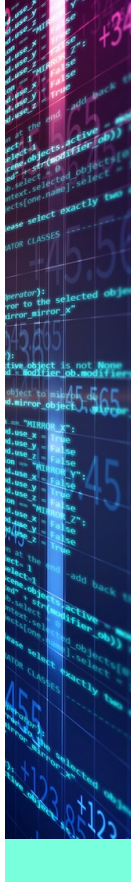

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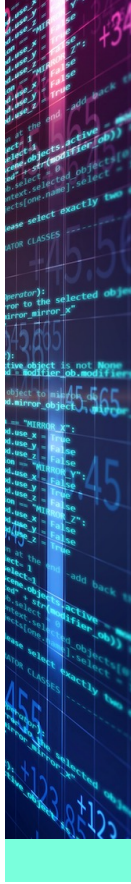
- So how can we call draw on every thing (or "shape")?
  - Use an abstract class!



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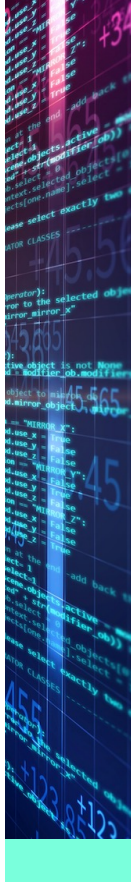

Common Syntax Error with Subclasses

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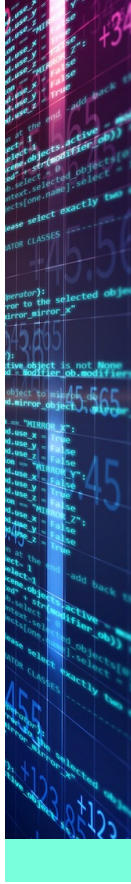

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for (Shape s : shapes)
    s.draw(); //try to call draw on each type Shape
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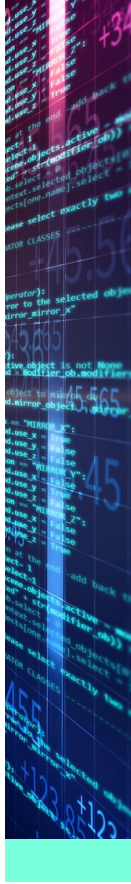
  - Again, this is not legal, because each s (of type Shape) does not have a draw method



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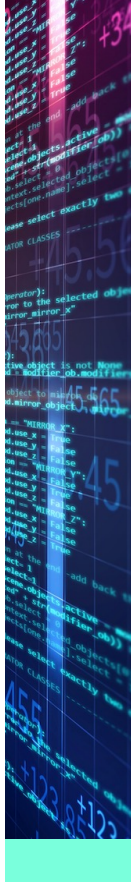
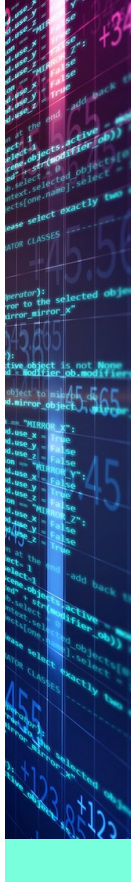
```
for (Shape s : shapes)
    s.draw(); //try to call draw on each type Shape
```

  - Again, this is not legal, because each s (of type Shape) does not have a draw method
- Rule: Every class “knows” its superclass, but a class doesn’t “know” its subclasses
  - *You* may know that every subclass of Shape has a draw method, but *Java* does not!



Possible Solutions to the Syntax Problem

- Solution 1: Put a draw method in the Shape class itself
  - This method will be inherited by all subclasses
  - Then you can call draw method for each shape
  - But what will it actually draw? It will be defined the same way for every subclass.



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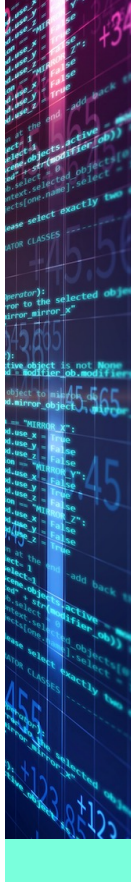
  - Then you can call draw method for each shape
  - But what will it actually draw? It will be defined the same way for every subclass.

- Solution 2: Put an abstract draw method in the Shape class
  - This will also be inherited by all subclasses, but you won't have to define it in the Shape class
  - You do, however, have to make the Shape class abstract
  - And implement draw in each subclass
  - This way, Java knows that each subclass has a draw method



Use Case for Abstract Class

- Make the Shape class abstract and add the abstract draw method with no body
  - Every subclass of Shape will HAVE TO implement draw

```
abstract class Shape {
    abstract void draw();
}

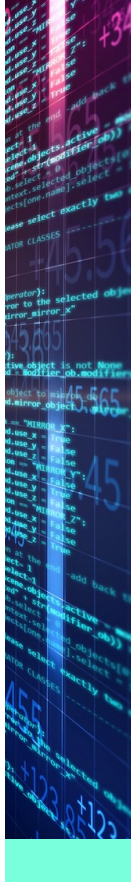
class Star extends Shape {
    @Override
    void draw() { ... } //implement abstract draw method
    ...
}

class Crescent extends Shape {
    @Override
    void draw() { ... } //implement abstract draw method
    ...
}

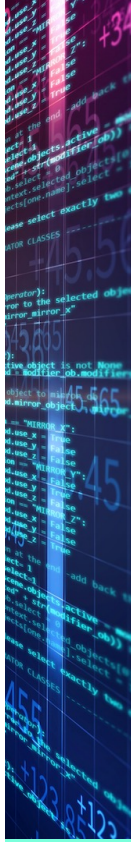
Shape myShape = new Star();
```

- This is legal, because a Star is a Shape
- However, Shape myShape = new Shape(); is no longer legal

```
myShape.draw(); //call draw method on type Shape
```



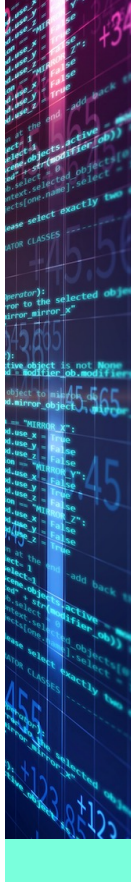
Abstract Pet Project



Pet Class

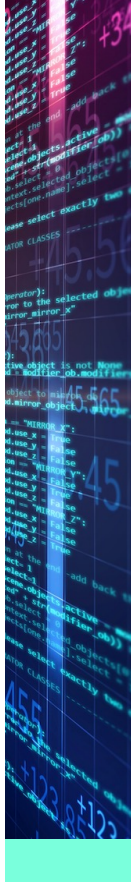
Pet.java

```java
package pet;

import java.util.ArrayList;

/**
 * Abstract class Pet to represent a generic (or abstract) pet.
 * @author wcauser
 *
 */
public abstract class Pet {

    //instance variables

    /**
     * Age of pet.
     * Default (package-private) access.  Accessible anywhere in same package.
     */
    int age;

    /**
     * Name of pet.
     * Default (package-private) access.  Accessible anywhere in same package.
     */
    String name;

    /**
     * Weight of pet.
     * Default (package-private) access.  Accessible anywhere in same package.
     */
    double weight;
```



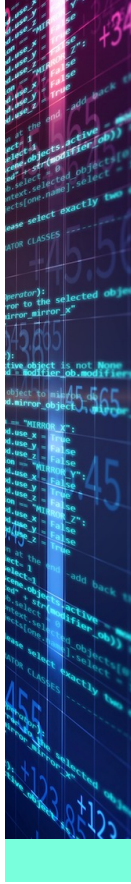
Pet Class

```
31
32      //constructor(s)
33
34      /**
35       * Called by subclasses of Pet to create instances of different types of pets.
36       * @param name of pet
37       * @param age of pet
38       * @param weight of pet
39       */
40      public Pet(String name, int age, double weight) {
41          this.name = name;
42          this.age = age;
43          this.weight = weight;
44      }
45
46      //getters and setters
47
48      /**
49       * @return the weight
50       */
51      public double getWeight() {
52          return this.weight;
53      }
54
55      /**
56       * @param weight the weight to set
57       */
58      public void setWeight(double weight) {
59          this.weight = weight;
60      }
61
```



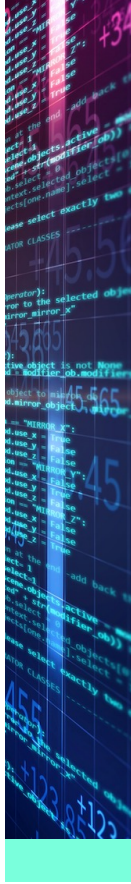
Pet Class

```
62      //non-abstract method(s)
63
64      /**
65       * Tells pet to eat given food.
66       * @param food to eat
67       */
68      public void eat(Food food) {
69          this.weight += (food.getCalories() / 100);
70      }
71
```



Pet Class

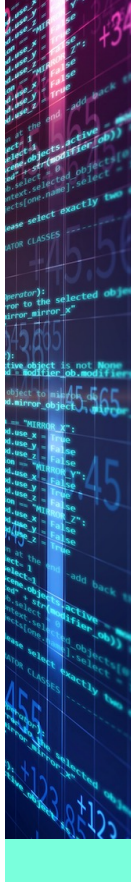
```
72      //abstract method(s)
73
74      /**
75       * Forces all pets to make their own sound.
76       * All subclasses of Pet MUST implement this method.
77       */
78      public abstract void makeSound();
79
80      /**
81       * Every subclass must implement toString for printing/debugging.
82       */
83      @Override
84      public abstract String toString();
85
```



Food Class

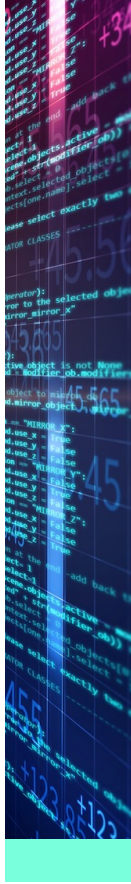
Pet.java | Food.java

```
1  package pet;
2
3  /**
4   * Represents generic food for pet.
5   * @author lbrandon
6   *
7   */
8  public class Food {
9
10     //instance variables
11
12     /**
13      * Calories for food.
14      */
15     private int calories;
16
```



Food Class

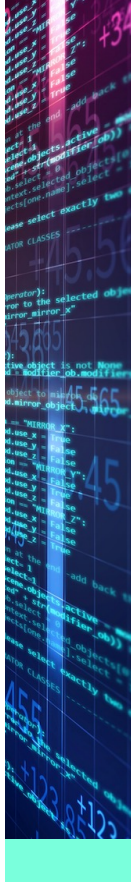
```
16
17      //constructor(s)
18
19      /**
20       * Creates instance of Food.
21       * @param calories for food
22       */
23      public Food(int calories) {
24          this.calories = calories;
25      }
26
27      //getters/setters
28
29      /**
30       * @return the calories
31       */
32      public int getCalories() {
33          return calories;
34      }
35
36      /**
37       * @param calories the calories to set
38       */
39      public void setCalories(int calories) {
40          this.calories = calories;
41      }
42
```



Cat Class

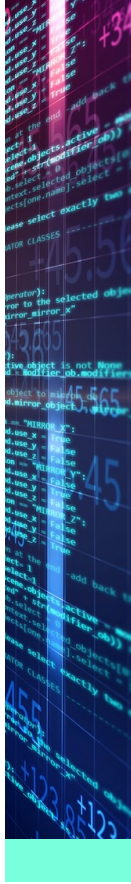
Pet.java | Cat.java

```
1  package pet;
2
3  /**
4   * Represents a Cat, subclass of abstract class Pet.
5   * @author lbrandon
6   *
7   */
8  public class Cat extends Pet {
9
10     //static variables
11
12     /**
13      * Default sound for all cats.
14      * Private access.  Only accessible within this class.
15      */
16     private static String SOUND = "Meow!";
17
18     //instance variables
19
20     /**
21      * Type of this cat.
22      * Private access.  Only accessible within this class.
23      */
24     private String type;
25
```



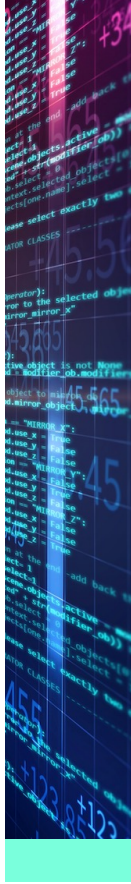
Cat Class

```
26      //constructor(s)
27
28      /**
29       * Creates cat with given name, age, weight, and type.
30       * @param name for cat
31       * @param age for cat
32       * @param weight for cat
33       * @param type for cat
34       */
35      public Cat(String name, int age, double weight, String type) {
36          //must call constructor in superclass Pet
37          super(name, age, weight);
38
39          //set type
40          this.type = type;
41      }
42
43      //getters/setters
44
45      /**
46       * @return the type
47       */
48      public String getType() {
49          return type;
50      }
51
52      /**
53       * @param type the type to set
54       */
55      public void setType(String type) {
56          this.type = type;
57      }
```



Cat Class

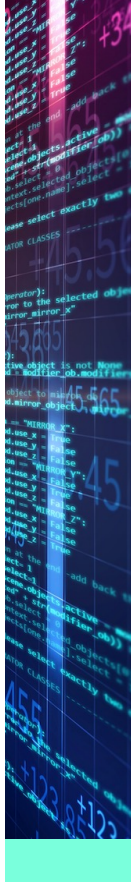
```
59      //inherited abstract methods
60      //MUST override and implement these (provide bodies)
61
62      /**
63       * Makes cat sound.
64       */
65      @Override
66      public void makeSound() {
67          System.out.println(Cat.SOUND);
68      }
69
70      /**
71       * Returns string for printing/debugging this cat.
72       */
73      @Override
74      public String toString() {
75          return this.name + " is a " + this.type;
76      }
```



Dog Class

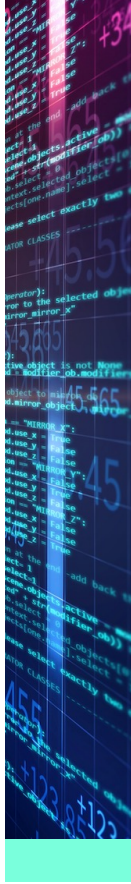
Pet.java | Cat.java | Dog.java

```
1  package pet;
2
3  /**
4   * Represents a Dog, subclass of abstract class Pet.
5   * @author lbrandon
6   *
7   */
8  public class Dog extends Pet {
9
10     //static variables
11
12     /**
13      * Default sound for all dogs.
14      * Private access.  Only accessible within this class.
15      */
16     private static String SOUND = "Bark!";
17
18     //instance variables
19
20     /**
21      * Breed for this dog.
22      * Private access.  Only accessible within this class.
23      */
24     private String breed;
25
```



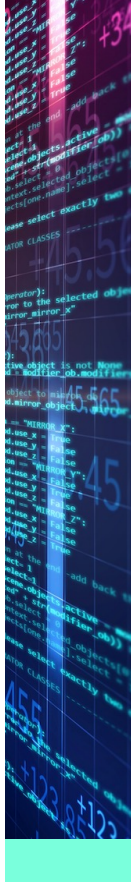
Dog Class

```
27
28      /**
29       * Creates dog with given name, age, weight, and breed.
30       * @param name of dog
31       * @param age of dog
32       * @param weight of dog
33       * @param breed of dog
34       */
35      public Dog(String name, int age, double weight, String breed) {
36          //must call constructor in superclass Pet
37          super(name, age, weight);
38
39          //set breed
40          this.breed = breed;
41      }
42
43      //getters/setters
44
45      /**
46       * @return the breed
47       */
48      public String getBreed() {
49          return breed;
50      }
51
52      /**
53       * @param breed the breed to set
54       */
55      public void setBreed(String breed) {
56          this.breed = breed;
57      }
```



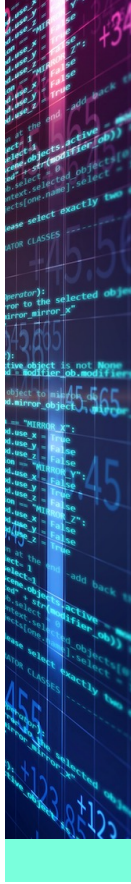
Dog Class

```
59      //inherited abstract methods
60      //MUST override and implement these (provide bodies)
61
62      /**
63       * Makes dog sound.
64       */
65      @Override
66      public void makeSound() {
67          System.out.println(Dog.SOUND);
68      }
69
70      /**
71       * Returns string for printing/debugging this dog.
72       */
73      @Override
74      public String toString() {
75          return this.name + " is a " + this.breed;
76      }
```



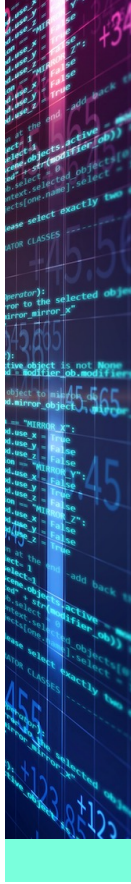
Pet Class

```
86
87      public static void main(String[] args) {
88
89          //create list of pets
90          ArrayList<Pet> pets = new ArrayList<Pet>();
91
92          //create a dog
93          Dog dog = new Dog("Buster", 14, 100, "German Shepherd");
94
95          //create a cat
96          Cat cat = new Cat("Snuggles", 3, 40, "House Cat");
97
98          //add pets to list
99          pets.add(dog);
100         pets.add(cat);
101
```



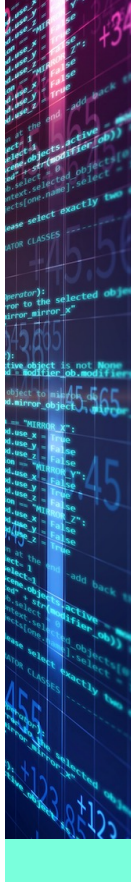
Pet Class

```
102         //iterate over list of pets
103         for (Pet p : pets) {
104             //call makeSound, abstract method in pet class
105             //every subclass of pet MUST have this defined
106             p.makeSound();
107         }
108
109         //iterate over list of pets
110         for (Pet p : pets) {
111             //print each pet
112             //calls toString method implemented in each subclass of pet
113             System.out.println(p);
114         }
115
116         //call specific method in dog class
117         String breed = dog.getBreed();
118         System.out.println("dog breed: " + breed);
119
120         //call specific method in cat class
121         String type = cat.getType();
122         System.out.println("cat type: " + type);
123
```

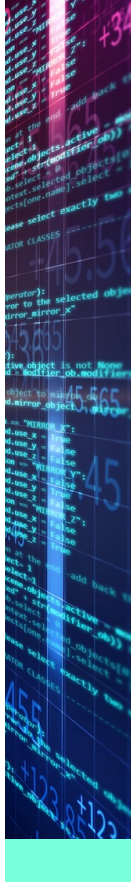


Pet Class

```
123
124         //get dog weight before eating
125         //getWeight defined as non-abstract method in pet class
126         System.out.println(dog.getWeight());
127
128         //create some food
129         Food food = new Food(1000);
130
131         //dog will eat
132         //eat defined as non-abstract method in pet class
133         dog.eat(food);
134
135         //get dog weight after eating
136         System.out.println(dog.getWeight());
137
```



Homework 7



Homework 7

Will be assigned by tonight, Wednesday, November 2nd at midnight and due Friday, November 18th at midnight

- For this HW, **you may work as a group (no more than 2 students)**
- In this HW, you will program a simple version of either the classic game **Battleship**
- This HW deals with the following topics:
  - Inheritance & overriding
  - Access modifiers (see the provided reading)
  - Abstract classes
  - 2-dimensional arrays
- To complete the assignment:
  - Submit all the classes in your entire Java project. This will include everything in your "src" folder.