1 Creating Cats

Given the `Animal` class, fill in the definition of the `Cat` class so that it makes a "Meow!" noise when `greet()` is called. Assume this noise is all caps for kittens (less than 2 years old).

```java
public class Animal {
    protected String name, noise;
    protected int age;
    public Animal(String name, int age) {
        this.name = name;
        this.age = age;
        this.noise = "Huh?";
    }
    public String makeNoise() {
        if (age < 2) {
            return noise.toUpperCase();
        }
        return noise;
    }
    public String greet() {
        return name + ": " + makeNoise();
    }
}

class Cat extends Animal {
    public Cat(String name, int age) {
        super(name, age);
        this.noise = "Meow!";
    }
}
```

Inheritance is powerful because it allows us to reuse code for related classes. With the `Cat` class here, we just have to re-write the constructor to get all the goodness of the `Animal` class.

A common question at this point may be, "Why is it necessary to call `super(name, age);` within the `Cat` constructor?" Great question! I’m glad you asked.

It turns out that a subclass’ constructor by default always calls the superconstructor. If we didn’t specify the call to the `Animal` superconstructor that takes in a `String` and a `int`, we’d get a compiler error. This is because the default superconstructor (`super();`) would have been called. Only problem is that the `Animal` class has no such zero-argument constructor!

By explicitly calling `super(name, age);` in the first line of the `Cat` constructor, we avoid calling the default superconstructor.
2 Impala-ments

a) We have two interfaces, BigBaller and ShotCaller. LilTroy, a concrete class, should implement BigBaller and ShotCaller. Fill out the blank lines below so that the code compiles correctly.

```java
interface BigBaller {
    void ball();
}

interface ShotCaller {
    void callShots();
}

public class LilTroy implements BigBaller, ShotCaller {
    public void ball() {
        System.out.println("Wanna be a, baller");
    }
    public void callShots() {
        System.out.println("Shot caller");
    }
    public void rap() {
        System.out.println("Say: Twenty inch blades on the Impala");
    }
}
```

b) We have a BallCourt where ballers should be able to come and play. However, the below code demonstrates an example of bad program design. Right now, only LilTroy instances can ball.

```java
public class BallCourt {
    public void play(LilTroy lilTroy) {
        lilTroy.ball();
    }
}
```

Fix the play method so that all the BigBallers can ball.

```java
public class BallCourt {
    public void play(BigBaller baller) {
        baller.ball();
    }
}
```

c) We discover that Rappers have some common behaviors, leading to the following class.

```java
class Rapper {
    public abstract String getLine();
    public final void rap() {
        System.out.println("Say: " + getLine());
    }
}
```

Will the above class compile? If not, why not? How can we fix it? This class will NOT compile. Rapper class has a method names getLine, which is declared abstract. It does not have any method implementation. Would it be possible to create an object from a class where a method
lacks the implementation? Definitely not! By adding the `abstract` keyword before the `class` keyword, the class will compile normally. The first line should look like `abstract class Rapper`.

d) Rewrite LilTroy so that LilTroy extends Rapper and displays exactly the same behavior as in part a) without overriding the `rap` method (in fact, you cannot override final methods).

```java
class LilTroy extends Rapper implements BigBaller, ShotCaller {
    @Override
    public void ball() {
        System.out.println("Wanna be a, baller");
    }

    @Override
    public void callShots() {
        System.out.println("Shot caller");
    }

    @Override
    public String getLine() {
        return "Twenty inch blades on the Impala";
    }
}
```

Note that most of the `Rapper`'s implementation can be reused in all its subclasses, as long as they correctly implement `getLine`. `Rapper` captures a reusable and common behavior (`rap`), while delegating some parts of implementations to its subclasses.

3 Raining Cats & Dogs

We now have the `Dog` class! (Assume that the `Cat` and `Dog` classes are both in the same file as the `Animal` class.)

```java
class Dog extends Animal {
    public Dog(String name, int age) {
        super(name, age);
        noise = "Woof!";
    }

    public void playFetch() {
        System.out.println("Fetch, " + name + "!");
    }
}
```

Consider the following `main` function in the `Animal` class. Decide whether each line causes a compile time error, a runtime error, or no error. If a line works correctly, draw a box-and-pointer diagram and/or note what the line prints.

```java
public static void main(String[] args) {
    Cat nyan = new Animal("Nyan Cat", 5); // (A) compile time error
}
```

The static type of `nyan` must be the same class or a superclass of the dynamic type. It doesn’t make sense for the dynamic type to be the superclass of the static type.
Animal a = new Cat("Olivia Benson", 3);  (B) no error
a = new Dog("Fido", 7);  (C) no error
System.out.println(a.greet());  (D) "Fido: Woof!"
a.playFetch();  (E) compile time error

The compiler attempts to find the method playFetch in the Animal class (a’s static type). Because it does not find it there, there is an error because the compiler does not check the Dog class (dynamic type) at compile time.

Dog d1 = a;  (F) compile time error

The compiler views the type of variable a to be Animal because that is its static type. It doesn’t make sense to assign an Animal to a Dog variable.

Dog d2 = (Dog) a;  (G) no error

The (Dog) a part is a cast. Casting tells the compiler to treat a as if it were a Dog. Casting changes the compiler’s perception of a variable’s dynamic type for the one line of the cast. After that line, a’s static type goes back to being Animal.

d2.playFetch();  (H) "Fetch, Fido!"
(Dog) a.playFetch();  (I) compile time error

Parentheses are important when casting. Here, the cast happens after a.playFetch() is evaluated. The return type of playFetch() is void, and it makes no sense to cast something void to a Dog. This is simply invalid. Something that would work is: ((Dog) a).playFetch();

Animal imposter = new Cat("Pedro", 12);  (J) no error
Dog fakeDog = (Dog) imposter;  (K) runtime error

The compiler sees that we’d like to treat imposter like a Dog. imposter’s static type is Animal, so it’s possible that its dynamic type is actually Dog. However, at runtime, when the cast actually happens, we see a ClassCastException because the dynamic type of imposter (Cat) is not compatible with Dog.

Cat failImposter = new Cat("Jimmy", 21);  (L) no error
Dog failDog = (Dog) failImposter;  (M) compile time error

The compiler sees that we’d like to treat failImposter like a Dog. However, unlike the example above, failImposter’s static type is Cat, so it’s impossible that its dynamic type is actually Dog. Thus, the compiler states that these are inconvertible (incompatible) types.

}
4 Bonus: An Exercise in Inheritance Misery

Cross out any lines that cause compile or runtime errors. What does the main program output after removing those lines?

class A {
    int x = 5;
    public void m1() {System.out.println("Am1-> " + x);}  
    public void m2() {System.out.println("Am2-> " + this.x);}  
    public void update() {x = 99; }
}
class B extends A {
    int x = 10;
    public void m2() {System.out.println("Bm2-> " + x);}  
    public void m3() {System.out.println("Bm3-> " + super.x);}  
    public void m4() {System.out.print("Bm4-> "); super.m2();}
}
class C extends B {
    int y = x + 1;
    public void m2() {System.out.println("Cm2-> " + super.x);)
    /* public void m3() {System.out.println("Cm3-> " + super.super.x);} */
    super.super is invalid syntax.
    public void m4() {System.out.println("Cm4-> " + y);)
    /* public void m5() {System.out.println("Cm5-> " + super.y);} */

C’s superclass B, and B’s superclass A both don’t have the variable y.
}
class D {
    public static void main (String[] args) {
        A b0 = new B();
        System.out.println(b0.x); (A) 5
        b0.m1(); (B) Am1->5
        b0.m2(); (C) Bm2->10
        /* b0.m3(); */ (D) compile time error because A does not have method m3
        B b1 = new B();
        b1.m3(); (E) Bm3->5
        b1.m4(); (F) Bm4->Am2->5
        A c0 = new C();
        c0.m1(); (G) Am1->5
        A a1 = (A) c0;
        C c2 = (C) a1;
        c2.m4(); (H) Cm4->11
        ((C) c0).m3(); (I) Bm3->5
        b0.update();
        b0.m1(); (J) Am1->99
    }
}