Get to know your class!

- Your classmates are concentrating in…
  - CS, APMA, Econ, Math, IAPA, English, Music, History, and more!
  - And plenty are unsure…that's ok too!
- This course is roughly 43% female and 55% male
- 95% Brown students, 5% RISD students
- Why are you all taking this class?

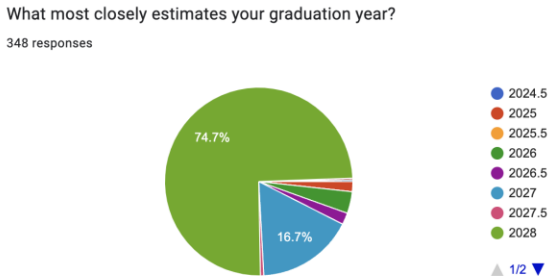
"I want to learn the basics of coding"

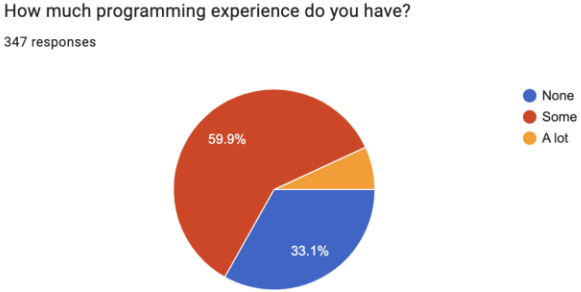
"For fun!"

"It's a requirement for my degree"

"The most exciting intro course"

"The skits :)"





Lecture 4

Working with Objects: Part 1

Review Slides at End of Deck ☺

Outline

- Storing values in variables
- Instances as parameters
- Variable reassignment
- Delegation pattern
- Instance variables

Variables

- Once we create a `Dog` instance, we want to be able to give it commands by calling methods on it!
- To do this, we need to name our `Dog`
- Can name an instance by storing it in a **variable**

```
Dog effie = new Dog();
```

- In this case, `effie` is the variable, and it stores a newly created instance of `Dog`
  - the variable name `effie` is also known as an “identifier”
  - `Dog()` is an invocation of the constructor for the `Dog` class
- Now we can call methods on `effie`, a specific instance of `Dog`
  - i.e., `effie.wagTail();`

Syntax: Variable Declaration and Assignment

- We can both **declare** and **assign** (i.e., initialize) a variable in a single statement, like: `Dog effie = new Dog();`

  `Dog effie` — declaration

  `= new Dog();` — Instantiation, followed by assignment using `=`

```
<type> <name> = <value>;
```

- The "=" operator **assigns** the instance of `Dog` that we created to the variable `effie`. We say "`effie` **gets** a new `Dog`"

- Note: type of `value` must match declared `type` on left

- We can reassign a variable as many times as we like (example soon)

Assignment vs. Equality

In Java:

```
price = price + 1;
```

- Means “add 1 to the current value of price and assign that to price”

In Algebra:

- price = price + 1 is a logical contradiction

Values vs. References

- A variable stores information as either:
  - a **value** of a **primitive** (aka **base**) **type** (like `int` or `float`)
  - a **reference** to an instance (like an instance of `Dog`) of an arbitrary type stored elsewhere in memory
    - we symbolize a reference with an arrow
- Think of the variable like a box; storing a value or reference is like putting something into the box
- Primitives have a predictable memory size, while instances of classes vary in size. Thus, Java simplifies memory management by having a fixed size reference to an instance elsewhere in memory
  - "one level of indirection"

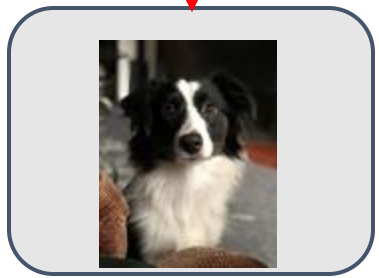
```
int favNumber = 9;
```

favNumber

9

```
Dog effie = new Dog();
```

effie



(somewhere else in memory)

TopHat Question

Join Code: 316062

Given this code, fill in the blanks:

```
int x = 5;
Calculator myCalc = new Calculator();
```

Variable `x` stores a _____, and `myCalc` stores a _____.

A. value, value
B. value, reference
C. reference, value
D. reference, reference

Example: Instantiation (1/2)

- Let's define a new class `PetShop` which has a `testEffie()` method
  - don't worry if the example seems a bit contrived…
- Whenever someone instantiates a `PetShop`, its constructor is called, which calls `testEffie()`
- Then `testEffie()` instantiates a `Dog` and tells it to bark, eat, and wag its tail (see definition of `Dog` for what these methods do)

```
public class PetShop {

   //constructor
   public PetShop() {
     this.testEffie();
   }

   public void testEffie() {
      Dog effie = new Dog();
      effie.bark(5);
      effie.eat();
      effie.wagTail();
   }
}
```

Another Example: Instantiation (2/2)

- *Another example:* can instantiate a `MathStudent` and then call that instance to perform a simple, fixed, calculation, called `performCalculation()`
- First, instantiate a new `Calculator` and store its reference in variable named `myCalc`
- Next, tell `myCalc` to add 2 to 6 and store result in variable named `answer`
- Finally, use `System.out.println` to print value of `answer` to the console!

```
public class MathStudent {

  /* constructor elided */

  public void performCalculation() {
    Calculator myCalc = new Calculator();
    int answer = myCalc.add(2, 6);
    System.out.println(answer);
  }

  /* add() method elided */
        ...
}
```

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- Storing values in variables
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Instances as Parameters (1/3)

- Methods can take in not just numbers but also instances as parameters
- The `PetShop` class has a method `trimFur()`
- `trimFur` method needs to know which `Dog` instance to trim the fur of

```
public class PetShop {

    public PetShop() {
        // this is the constructor!
    }

    public void trimFur(Dog shaggyDog) {
        // code that trims the fur of shaggyDog
    }
}
```

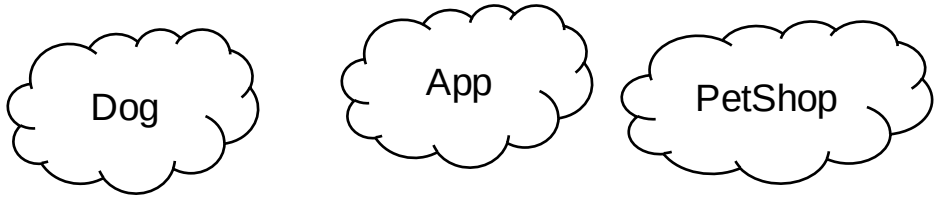
type/class

name of specific instance

- Method calling `trimFur` will have to supply as argument a specific instance of a `Dog`, called `shaggyDog` in `trimFur`
- Analogous to `void moveForward(int numberOfSteps);`

Instances as Parameters (2/3)

- Where to call the `PetShop`'s `trimFur` method?
- Do this in the method `testGrooming()`, a "helper" method
- Call to `testGrooming()` instantiates a `PetShop` and a `Dog`, then calls the `PetShop` to `trimFur` of the `Dog`
- First two lines could be in either order, since they are instantiated adjacently




```
public class App {
   public static void main(String[] args) {
       this.testGrooming();
   }

   public void testGrooming() {
       PetShop sarahsPetShop = new PetShop();
       Dog effie = new Dog();
       sarahsPetShop.trimFur(effie);
   }
}
```

Instances as Parameters (3/3): Flow of Control

1. In `App`'s `main` method, call to `testGrooming()` helper method.

2. A `PetShop` is instantiated (thereby calling `PetShop`'s constructor) and a reference to it is stored in the variable `sarahsPetShop`

3. Next, a `Dog` is instantiated (thereby calling `Dog`'s constructor) and a reference to it is stored in the variable `effie`

4. The `trimFur` method is called on `sarahsPetShop`, passing in `effie` as an argument

5. `sarahsPetShop` trims `effie`'s fur; `trimFur` in `sarahsPetShop` will think of `effie` as `shaggyDog`, a synonym

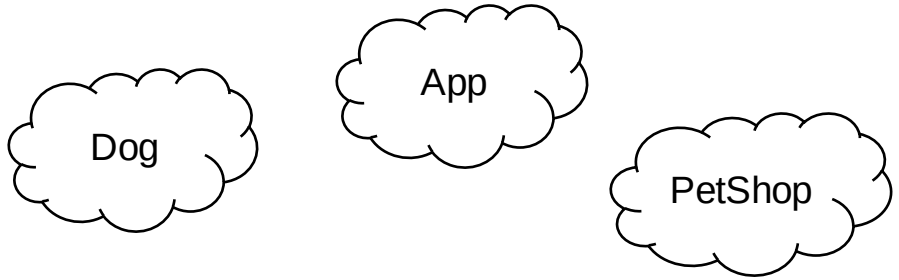
```
public class App {
   public static void main(String[] args) {
1.        this.testGrooming();
   }

   public void testGrooming() {
2.        PetShop sarahsPetShop = new PetShop();
3.        Dog effie = new Dog();
4.        sarahsPetShop.trimFur(effie);
          // exit method, effie and
          // groomer disappear
   }
}

public class PetShop {
   /* constructor elided */

   public void trimFur(Dog shaggyDog) {
5.        // code that trims the
          // fur of shaggyDog argument
   }
}
```

Code from slide 14

Code from slide 13

What is Memory?

- Memory ("system memory" aka RAM, not disk or other peripheral devices) is the hardware in which computers store information during computation
- Think of memory as a list of slots; each slot holds information (e.g., an `int` variable, or a reference to an instance of a class)
- Here, two references are stored in memory: one to a `Dog` instance, and one to a `PetShop` instance



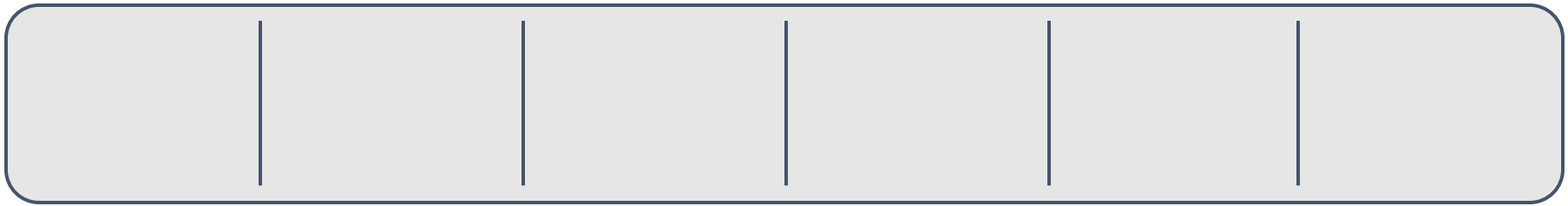

```
public class App
    public static void main(String[] args) {
        this.testGrooming();
    }

    public void testGrooming() {
        PetShop sarahsPetShop = new PetShop();
        Dog effie = new Dog();
        sarahsPetShop.trimFur(effie);
    }
}
```

Instances as Parameters: Under the Hood (1/6)

```
public class App {
   public static void main(String[] args) {
           this.testGrooming();
   }

   public void testGrooming() {
           PetShop sarahsPetShop = new PetShop();
           Dog effie = new Dog();
           sarahsPetShop.trimFur(effie);
   }
}
```

```
public class PetShop {

   public PetShop() {
           // this is the constructor!
   }

   public void trimFur(Dog shaggyDog) {
           // code that trims the fur of shaggyDog
   }
}
```

Somewhere in memory...



Note: Recall that in Java, each class is stored in its own file. Thus, when creating a program with multiple classes, the program will work as long as all classes are written before the program is run. Order doesn't matter.

Instances as Parameters: Under the Hood (2/6)

```
public class App {
   public static void main(String[] args) {
           this.testGrooming();
   }

   public void testGrooming() {
           PetShop sarahsPetShop = new PetShop();
           Dog effie = new Dog();
           sarahsPetShop.trimFur(effie);
   }
}
```

```
public class PetShop {

   public PetShop() {
           // this is the constructor!
   }

   public void trimFur(Dog shaggyDog) {
           // code that trims the fur of shaggyDog
   }
}
```

Somewhere in memory...

When we instantiate a `PetShop`, it's stored somewhere in memory. Our `App` will use the name `sarahsPetShop` to refer to this particular `PetShop`, at this particular location in memory.

Instances as Parameters: Under the Hood (3/6)

```
public class App {
   public static void main(String[] args) {
           this.testGrooming();
   }

   public void testGrooming() {
           PetShop sarahsPetShop = new PetShop();
           Dog effie = new Dog();
           sarahsPetShop.trimFur(effie);
   }
}
```

```
public class PetShop {

   public PetShop() {
           // this is the constructor!
   }

   public void trimFur(Dog shaggyDog) {
           // code that trims the fur of shaggyDog
   }
}
```

Somewhere in memory...

. . .

Usually not adjacent in memory!

Same goes for the `Dog`—we store a particular `Dog` somewhere in memory. Our `App` knows this `Dog` by the name `effie`.

Instances as Parameters: Under the Hood (4/6)

```
public class App {
   public static void main(String[] args) {
           this.testGrooming();
   }

   public void testGrooming() {
           PetShop sarahsPetShop = new PetShop();
           Dog effie = new Dog();
           sarahsPetShop.trimFur(effie);
   }
}
```

```
public class PetShop {

   public PetShop() {
           // this is the constructor!
   }

   public void trimFur(Dog shaggyDog) {
           // code that trims the fur of shaggyDog
   }
}
```

Somewhere in memory...

. . .

Usually not adjacent in memory!

We call the `trimFur` method on our `PetShop`, `sarahsPetShop`. We need to tell it which `Dog` to `trimFur` (since the `trimFur` method takes in a parameter of type `Dog`). We tell it to trim `effie`.

Instances as Parameters: Under the Hood (5/6)

```
public class App {
   public static void main(String[] args) {
           this.testGrooming();
   }

   public void testGrooming() {
           PetShop sarahsPetShop = new PetShop();
           Dog effie = new Dog();
           sarahsPetShop.trimFur(effie);
   }
}
```

```
public class PetShop {

   public PetShop() {
           // this is the constructor!
   }

   public void trimFur(Dog shaggyDog) {
           // code that trims the fur of shaggyDog
   }
}
```

Somewhere in memory...

. . .

Usually not adjacent in memory!

When we pass in `effie` as an argument to the `trimFur` method, we're telling the `trimFur` method about her. When `trimFur` executes, it sees that it has been passed that particular `Dog`.

Instances as Parameters: Under the Hood (6/6)

```
public class App {
   public static void main(String[] args) {
           this.testGrooming();
   }

   public void testGrooming() {
           PetShop sarahsPetShop = new PetShop();
           Dog effie = new Dog();
           sarahsPetShop.trimFur(effie);
   }
}
```

```
public class PetShop {

   public PetShop() {
           // this is the constructor!
   }

   public void trimFur(Dog shaggyDog) {
           // code that trims the fur of shaggyDog
   }
}
```

Somewhere in memory...

. . .

Usually not adjacent in memory!

The `trimFur` method doesn't really care which `Dog` it's told to `trimFur`—no matter what another instance's name for the `Dog` is, `trimFur` is going to know it by the name `shaggyDog`.

Outline

- Storing values in variables
- Instances as parameters
- Variable reassignment
- Delegation pattern
- Instance variables

Variable Reassignment (1/3)

- After giving a variable an initial value or reference, we can **reassign** it (make it refer to a different instance)
- What if we wanted our `PetShop` to `trimFur` two different `Dog`s?
- Could create another variable, or re-use the variable `effie` to first point to one `Dog`, then another!

```
public class App {
   public static void main(String[] args) {
          this.testGrooming();
   }

   public void testGrooming() {
          PetShop sarahsPetShop = new PetShop();
          Dog effie = new Dog();
          sarahsPetShop.trimFur(effie);
   }
}
```

Variable Reassignment (2/3)

- First, instantiate another `Dog`, and **reassign** variable `effie` to point to it
- Now `effie` no longer refers to the first `Dog` instance we created, which was already groomed
- Then tell `PetShop` to `trimFur` the new `Dog`. It will also be known as `shaggyDog` inside the `trimFur` method

```
public class App {
   public static void main(String[] args) {
          this.testGrooming();
   }

   public void testGrooming() {
          PetShop sarahsPetShop = new PetShop();
          Dog effie = new Dog();
          sarahsPetShop.trimFur(effie);
          effie = new Dog(); // reassign effie
          sarahsPetShop.trimFur(effie);
   }
}
```

Variable Reassignment (3/3)

- When we **reassign** a variable, we do not declare its type again, Java remembers from first time
- Can **reassign** to a brand new instance (like in `PetShop`) or to an already existing instance by using its identifier

```
Dog effie = new Dog();
Dog appa = new Dog();
effie = appa; // reassigns effie to refer to the same Dog as appa
```

- Now `effie` and `appa` refer to the same `Dog`, specifically the one that was originally referenced by `appa`

Variable Reassignment: Under the Hood (1/5)

```
public class App {
   public static void main(String[] args) {
           this.testGrooming();
   }

   public void testGrooming() {
           PetShop sarahsPetShop = new PetShop();
           Dog effie = new Dog();
           sarahsPetShop.trimFur(effie);
           effie = new Dog();
           sarahsPetShop.trimFur(effie);
   }
}
```

Variable Reassignment: Under the Hood (2/5)

```
public class App {
   public static void main(String[] args) {
           this.testGrooming();
   }

   public void testGrooming() {
           PetShop sarahsPetShop = new PetShop();
           Dog effie = new Dog();
           sarahsPetShop.trimFur(effie);
           effie = new Dog();
           sarahsPetShop.trimFur(effie);
   }
}
```

Variable Reassignment: Under the Hood (3/5)

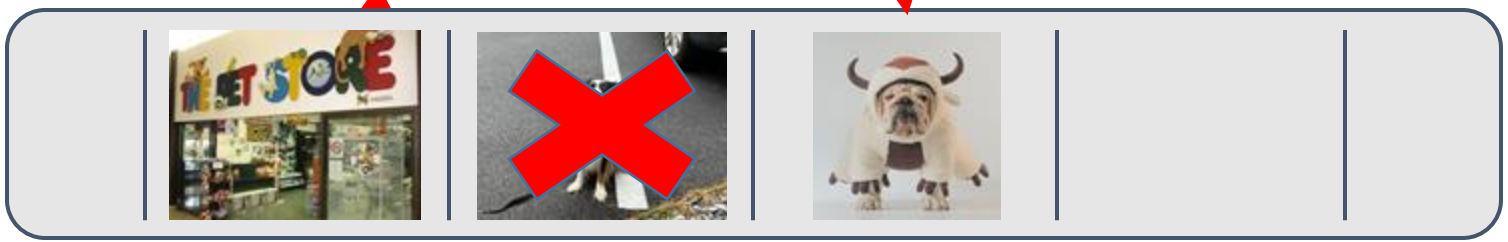
```
public class App {
   public static void main(String[] args) {
           this.testGrooming();
   }

   public void testGrooming() {
           PetShop sarahsPetShop = new PetShop();
           Dog effie = new Dog();
           sarahsPetShop.trimFur(effie);
           effie = new Dog();
           sarahsPetShop.trimFur(effie);
   }
}
```

Variable Reassignment: Under the Hood (4/5)

```
public class App {
   public static void main(String[] args) {
           this.testGrooming();
   }

   public void testGrooming() {
           PetShop sarahsPetShop = new PetShop();
           Dog effie = new Dog();
           sarahsPetShop.trimFur(effie);
           effie = new Dog();   //old ref garbage collected – stay tuned!
           sarahsPetShop.trimFur(effie);
   }
}
```

Variable Reassignment: Under the Hood (5/5)

```
public class App {
   public static void main(String[] args) {
           this.testGrooming();
   }

   public void testGrooming() {
           PetShop sarahsPetShop = new PetShop();
           Dog effie = new Dog();
           sarahsPetShop.trimFur(effie);
           effie = new Dog();   //old ref garbage collected – stay tuned!
           sarahsPetShop.trimFur(effie);
   }
}
```



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Adding `PetShop` Capabilities

- The `PetShop` only has the capability (method) to `trimFur`
- What if we want the `PetShop` to expand with more functionality?
- `PetShop` class would be long!

- `trimFur`
- `shampooFur`
- `dryFur`
- `teachSit`
- `teachBark`
- `teachFetch`
- `sellDogToy`
- and more…

Delegation Pattern (1/4)

- Just like a real-life pet shop would hire employees to **delegate** work, we should create new classes to **delegate** code

- Pass responsibility to something / someone else to manage parts of a task

- `PetShop` doesn't need to care *how* the dog gets trimmed, if it gets done properly

Delegation Pattern (2/4)

- Delegation results in a **chain of abstraction**, where each level deals with more specifics to complete an action

Delegation Pattern (3/4)

- We delegate responsibilities to `DogGroomer`!
- `trimFur`, `shampooFur`, `dryFur` become a capability of `DogGroomer` instead of `PetShop`
- `teachSit` and `teachBark` can be delegated to `DogTrainer`

```
public class DogGroomer {
  /* constructor elided */

  public void trimFur(Dog shaggyDog) {
      //code that trims the fur of shaggyDog
  }

  public void shampooFur(Dog dirtyDog) {
      //code that shampoos the fur of dirtyDog
  }

  public void dryFur(Dog wetDog) {
      //code that dries the fur of wetDog
  }
}
```

Delegation Pattern (4/4)

- Now that we've delegated responsibilities to the `DogGroomer`, the `PetShop` can instantiate a `DogGroomer`
- In the `testGrooming` method, `PetShop` can call `DogGroomer`'s methods on `groomer`
- It may seem unnatural to instantiate a `DogGroomer` in a method of the `PetShop` class, but it works in the kind of modeling that OOP makes possible

```
public class PetShop {

    public PetShop() {
        this.testGrooming();
    }

    public void testGrooming() {
        DogGroomer groomer = new DogGroomer();
        Dog effie = new Dog();
        groomer.shampooFur(effie);
        groomer.trimFur(effie);
        groomer.dryFur(effie);
    }
}
```

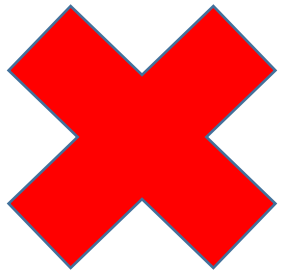
(Notice the methods being called on `groomer` are defined in `DogGroomer`)

Delegating to Top-Level Class (1/2)

- `App` class should never have more than a few lines of code
- Can we delegate `testGrooming` to a different class?

```
public class App {
   public static void main(String[] args) {
       this.testGrooming();
   }

   public void testGrooming() {
       DogGroomer groomer = new DogGroomer();
       Dog effie = new Dog();
       groomer.shampooFur(effie);
       groomer.trimFur(effie);
       groomer.dryFur(effie);
   }
}
```



Delegating to Top-Level Class (2/2)

- **Top-level class** is class that contains high-level logic of program
- `App` **delegates** to **top-level class** (here, `PetShop`) to simplify `App` as much as possible
- Same **functionality** of the program, with a different **code design**
  - easier to visually follow program's high-level control flow
- As CS15 programs increase in complexity, purpose of separating top-level class from `App` will become clearer

```
public class App {
   public static void main(String[] args) {
       new PetShop();
   }
}

public class PetShop {
   public PetShop() {
      this.testGrooming();
   }

   public void testGrooming() {
       DogGroomer groomer = new DogGroomer();
       Dog effie = new Dog();
       groomer.shampooFur(effie);
       groomer.trimFur(effie);
       groomer.dryFur(effie);
   }
}
```

TopHat Question

Join Code: 316062

Which of the following is NOT true?

A. `App` should delegate to the top-level class
B. The `App` class should never have more than a few lines of code
C. The top-level class should instantiate `App`
D. The top-level class contains high-level logic of program

Design Patterns and Principles

- **Delegation** is the first **design pattern** we're learning
- We'll learn many throughout the course – these are crucial to OOP
- OOP is about much more than **functionality** of programs
  - `PetShop` could operate fine without `DogGroomer` or `DogTrainer`; delegating is our design choice to make code easier to read, more modular and extensible
- Later, assignment grades will be based as much on your design choices as functionality
- In future projects, YOU will have to decide how to delegate your program to different classes!
  - (not quite yet though)

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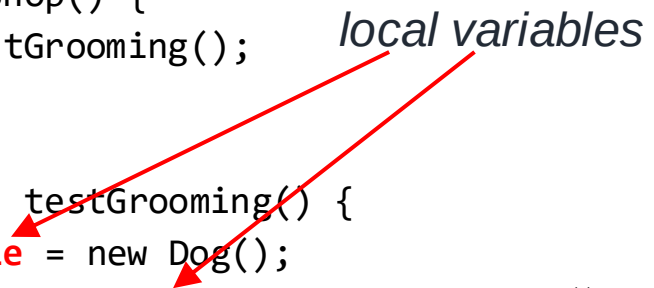
Local Variables (1/2)

- All variables we've seen so far have been **local variables**: variables declared **inside a method**
- Problem: the **scope** of a local variable (where it is known and can be accessed) is limited to its own method—it cannot be accessed from anywhere else
  - same is true of method's parameters

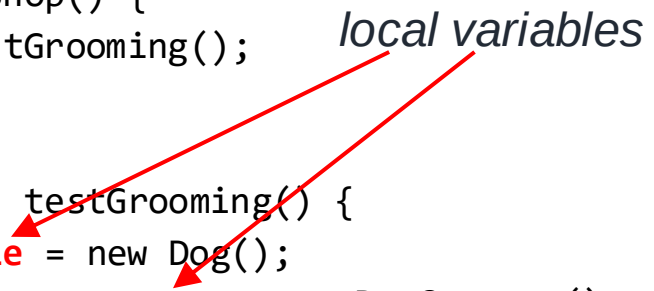
```
public class PetShop {

   public PetShop() {
      this.testGrooming();
   }

   public void testGrooming() {
      Dog effie = new Dog();
      DogGroomer groomer = new DogGroomer();
      groomer.shampooFur(effie);
      groomer.trimFur(effie);
      groomer.dryFur(effie);
   }

}
```



Local Variables (2/2)

- We created `groomer` and `effie` in our `PetShop`'s `testGrooming` method, but as far as the rest of the class is concerned, they don't exist and cannot be used
- Once the method is completely executed, they're gone :(
  - this is known as "Garbage Collection"

```
public class PetShop {

   public PetShop() {
      this.testGrooming();
   }

   public void testGrooming() {
      Dog effie = new Dog();
      DogGroomer groomer = new DogGroomer();
      groomer.shampooFur(effie);
      groomer.trimFur(effie);
      groomer.dryFur(effie);
   }

}
```



Garbage Collection

- If an instance referred to by a variable goes out of scope, we can no longer access it. Because we can't access the instance, it gets garbage collected
  - in garbage collection, the space that the instance took up in memory is freed and the instance no longer exists
- Lose access to an instance when:
  - at the end of method execution, local variables created within that method go out of scope
  - variables lose their reference to an instance during variable reassignment (`effie`, slide 35)

Accessing Local Variables

- If you try to access a local variable outside of its method, you'll receive a "cannot find symbol" compilation error:

In Terminal after `javac *.java`:

```
PetShop.java:13: error: cannot find symbol
  groomer.sweep();
    ^
  symbol: variable groomer
  location: class PetShop
```

scope of ***groomer***

```
public class PetShop {

    public PetShop() {
        DogGroomer groomer = new DogGroomer();
        this.cleanShop();
    }

    public void cleanShop() {
        //assume we've added a sweep method
        //to DogGroomer
        groomer.sweep();
    }
}
```

Introducing… Instance Variables!

- Local variables aren't always what we want. We'd like every `PetShop` to come with a `DogGroomer` who exists for as long as the `PetShop` exists
- That way, as long as the `PetShop` is in business, we'll have our `DogGroomer` on hand
- We accomplish this by storing the `DogGroomer` in an **instance variable**

What's an Instance Variable?

- An **instance variable** models a **property** that all instances of a class have
  - its ***value*** can differ from instance to instance
- Instance variables are declared within a class, not within a single method, and therefore are accessible from anywhere within the class, unlike local variables – their **scope** is the entire class
- Instance variables and local variables are identical in terms of what they can store—either can store a base type (like an `int`) or a reference to an instance of some other class

Instance Variables (1/4)

- We've modified `PetShop` example to make our `DogGroomer` an **instance variable** for the benefit of multiple methods
- Split up declaration and assignment of instance variable:
  - **declare** instance variable at the top of the class above the constructor, to notify Java compiler
  - **initialize** the instance variable by assigning a value to it in the constructor
  - **primary purpose of constructor is to initialize all instance variables so each instance has a valid initial "state" at its "birth"; typically does no other work**
  - **state** is the set of all values for all properties—local variables don't hold properties; they are "temporaries". State typically varies over time

```
public class PetShop {

   private DogGroomer groomer;

   public PetShop() {
      this.groomer = new DogGroomer();
      this.testGrooming();
   }

   public void testGrooming() {
      Dog effie = new Dog();
      this.groomer.trimFur(effie);
   }

   public void payGroomer () {
      this.groomer.getPaidDollars(5);
   }
}
```

declaration

instance variable

initialization

local variable

Instance Variables (2/4)

- Like we use `this` when an instance calls a method on itself, we also use `this` when an instance references one of its instance variables after declaration
  - Java compiler will work without it, **but required in CS15** to easily distinguish instance variables from local variables
- Thus, we use `this` to refer to capabilities (methods) and properties (instance variables) of an instance

```
public class PetShop {

   private DogGroomer groomer;

   public PetShop() {
      this.groomer = new DogGroomer();
      this.testGrooming();
   }

   public void testGrooming() {
      Dog effie = new Dog();//local var
      this.groomer.trimFur(effie);
   }
   //payGroomer() method elided
}
```

Instance Variables (3/4)

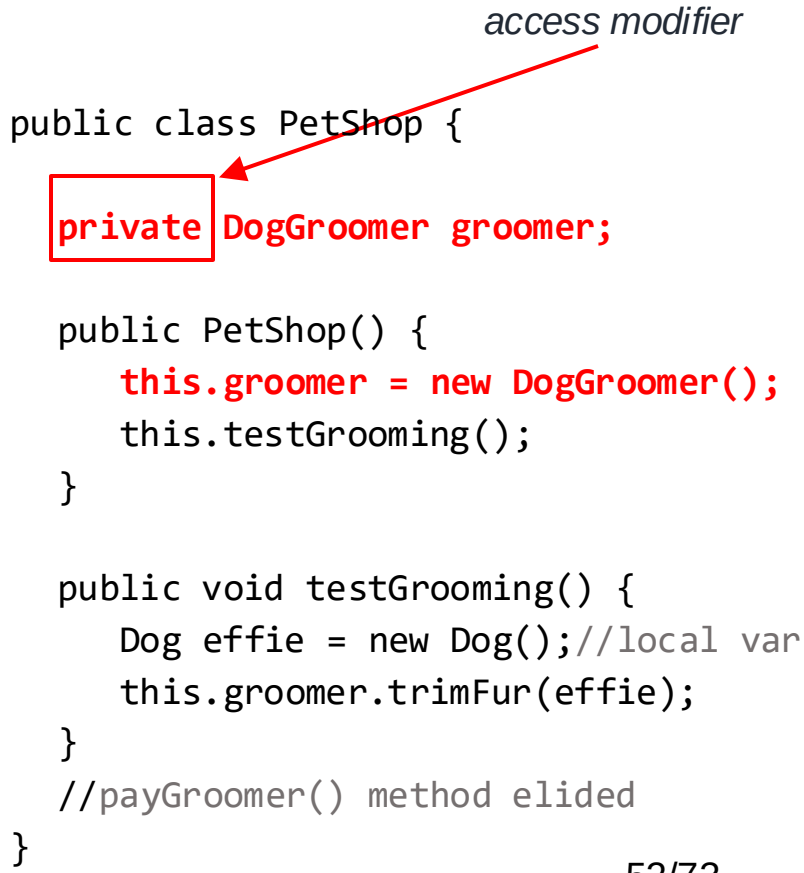
- Note we include the keyword `private` in declaration of our instance variable
- `private` is an **access modifier**, just like `public`, which we've been using in our method declarations

access modifier

```
public class PetShop {

   private DogGroomer groomer;

   public PetShop() {
      this.groomer = new DogGroomer();
      this.testGrooming();
   }

   public void testGrooming() {
      Dog effie = new Dog();//local var
      this.groomer.trimFur(effie);
   }
   //payGroomer() method elided
}
```

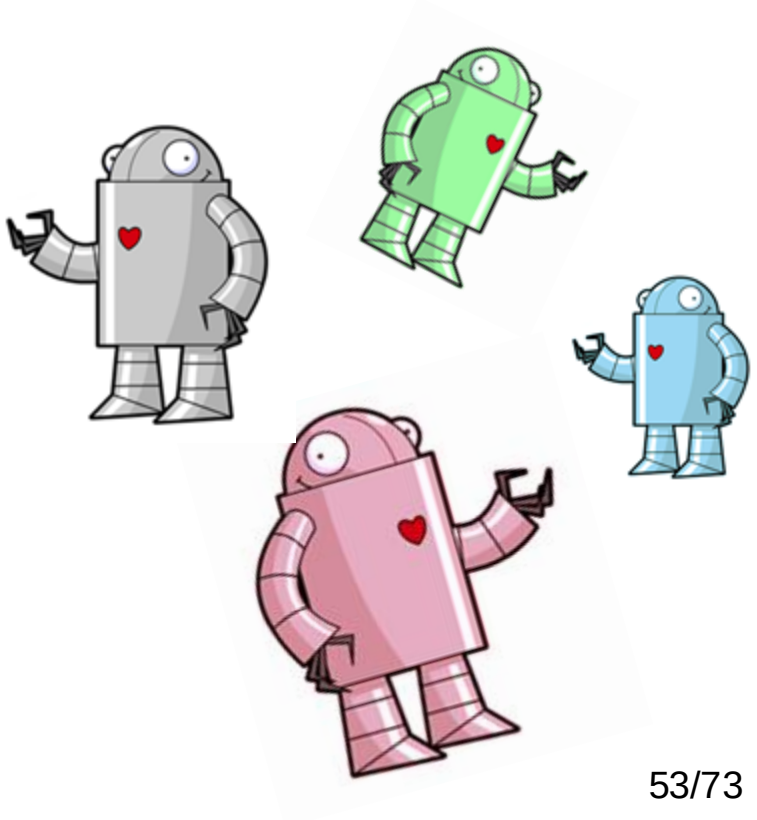
Instance Variables (4/4)

- If declared as `private`, the method or instance variable can only be accessed inside the class – their **scope** is entire class
- If declared as `public`, can be accessed from anywhere – their **scope** can include multiple classes – very unsafe!
- **In CS15, you'll declare instance variables as `private`, with rare exception!**
- Note that local variables don't have access modifiers – their scope is always the method they are declared in.
- Note: instance variables are `private`, to protect them, methods are `public` for the use by any instance



Modeling Properties with Instance Variables (1/4)

- Methods model **capabilities** of a class (e.g., move, dance)
- All instances of same class have exact same methods (capabilities) **and the same properties**
- BUT: the **values** of those **properties** can be different and can differentiate one instance from other instances of the same class
- We use instance variables to model these properties and their values (e.g., the robot's size, position, orientation, color, …)



Modeling Properties with Instance Variables (2/4)

- All instances of a class have same set of properties, but ***values*** of these properties will differ
- E.g., `CS15Students` all have a height
- `CS15Student` class would have an **instance variable** to represent their height
  - all `CS15Student`s have a `height`, but the value stored in instance variable would differ from instance to instance
  - for one student, the value of `height` is 5'2". For another, it's 6'4"
- Properties can further be broken down into **attributes**, **components**, and references to **peer objects**

Modeling Properties with Instance Variables (3/4)

- **Attributes** are descriptors of objects
  - models “described by” relationship
    - `Human`s are described by `age`, `height`, `weight`, etc.
  - attributes typically described by primitives (i.e., `int`)
- **Components** are structural parts of composite objects
  - models “composed of” relationship
    - `Human`s are composed of a `Head`, `Torso`, `Leg`s, etc.
    - can have hierarchal relationships - `Head` is further composed of `Eye`s, `Ear`s, etc.
  - composite objects are exceedingly common
  - our classes are typically composed of other classes in our program
- **Peer Objects** are classes that a class can send messages to
  - models “knows about” relationship
    - `Human`s know about `Computer`s, `Pet`s, `Bed`s, etc.

Modeling Properties with Instance Variables (4/4)

- The distinction between components, attributes, and peer objects isn't syntactic – they are all stored in instance variables
  - requires thinking about the purpose of these properties for modeling each class
  - requires thinking through what relationship you are trying to model

- We will cover attributes and components today - peer objects next lecture!

Modeling Attributes with Instance Variables (1/2)

- Add instance variable to a class to add a property
- How would we categorize the relationship between `age` and the `DogGroomer` class?
  - the `DogGroomer` is "described by" `age` – an attribute
- Assigned an initial value to `groomer` by assigning a `new DogGroomer`
  - whoever creates a `DogGroomer` initializes its `age` to `myAge`, by supplying an `int` argument in the call on the `DogGroomer` constructor

```
public class DogGroomer {

   private int age;

   public DogGroomer(int myAge){
      this.age = myAge;
   }

   // other methods elided
}
```

```
public class PetShop {

   private DogGroomer groomer;

   public PetShop() {
      this.groomer = new DogGroomer(<age arg>);
      this.testGrooming();
   }
    // methods elided
}
```

Modeling Attributes with Instance Variables (2/2)

- Can use properties in any methods inside class
  - instance variables have entire class as their scope
  - `printAge` prints the `age` attribute into the terminal using `System.out.println`
- `DogGroomer` has other attributes elided
  - `name`, `address`, `height`, etc.

```
public class DogGroomer {

   private int age;
   // other instance variable properties elided

   public DogGroomer(int myAge){
      this.age = myAge;
   }

   public void printAge(){
      System.out.println(this.age);
   }

   // other methods elided
}
```

TopHat Question

Join Code: 316062

Which of the following is **NOT** true about attributes?

A. Typically primitive types
B. Models “described by” relationship
C. Have hierarchal relationship – attributes are composed further of their own attributes
D. Can be parameter passed through constructor to initialize

Modeling Components with Instance Variables

- The `PetShop` class declares an instance variable `groomer`
  - `Groomer`'s age attribute is set to 24
- Initialize `groomer` by instantiating `new DogGroomer`
- How would we categorize the relationship between `groomer` and the `PetShop` class?
  - the `PetShop` is "composed of" `groomer` – a component
- `PetShop` has other components elided
  - `Manager`, `Animal`s, `PetFood`, etc.

```
public class PetShop {

   private DogGroomer groomer;
   // other instance variable properties, like
   //name, address, phone number,… elided

   public PetShop() {
      this.groomer = new DogGroomer(24);
      this.testGrooming();
   }

   public void testGrooming() {
      Dog effie = new Dog(); //local var
      this.groomer.trimFur(effie);
      this.groomer.printAge(); //prints 24
   }
   //payGroomer() method elided
}
```

TopHat Question

Join Code: 316062

Which of the following properties is **NOT** a component of the `Farm` class?

A. farmHouse
B. wilbur
C. bessy
D. betty
E. address

```
public class Farm {
    private House farmHouse;
    private Pig wilbur;
    private Cow bessy;
    private Cow betty;
    private int address;

    public Farm(House myFarmHouse) {
        this.farmHouse = myFarmHouse;
        this.wilbur = new Pig();
        this.bessy = new Cow();
        this.betty = new Cow();
        this.address = 3;
    }
}
```

Encapsulation Design Pattern

- Why `private` instance variables?
- **Encapsulation** for safety… your properties are your private business
- Allows for **chain of abstraction** so classes don't need to worry about the inner workings of classes they instantiate
    - we will also show you safe ways of allowing other classes to have selective access to designated properties… stay tuned

`DogOwner`

`PetShop`

`DogGroomer`

`Shampoo`

`HairDryer`

`Clippers`

Always Remember to Initialize!

- What if you declare an instance variable, but forget to initialize it?
  - Happens if you don't supply a constructor
- The instance variable will assume a "default value"
  - if it's an `int`, it will be 0, `float` 0.0, etc.
  - if it's an instance, it will be `null`— a special value that means your variable is not referencing any instance at the moment

```
public class PetShop {

   private DogGroomer groomer;

   public PetShop() {
       // oops! Forgot to initialize groomer
       this.testGrooming();
   }

   public void testGrooming() {
       Dog effie = new Dog();//local var
       this.groomer.trimFur(effie);
   }

}
```

NullPointerExceptions

- If a variable's value is null and you try to give it a command, you'll be rewarded with a ***runtime error***—you can't call a method on "nothing"!
- `groomer`'s default value is `null`, so this particular error yields a `NullPointerException`
- When you run into one of these (we promise, you will), make sure all instance variables have been explicitly initialized, preferably in the constructor, and no variables are initialized as null

```
public class PetShop {

   private DogGroomer groomer;

   public PetShop() {
       //oops! Forgot to initialize groomer
       this.testGrooming();
   }

   public void testGrooming() {
       Dog effie = new Dog(); //local var
       this.groomer.trimFur(effie);
   }

}
```

Our Program

```
public class PetShop {

   private DogGroomer groomer;

   public PetShop() {
       this.groomer = new DogGroomer(24);
       this.testGrooming();
   }

   public void testGrooming() {
       Dog effie = new Dog(); //local var
       this.groomer.shampooFur(effie);
       this.groomer.trimFur(effie);
       this.groomer.printAge(); //prints 24
       effie = new Dog(); //var reassignment
       this.groomer.shampooFur(effie);
       this.groomer.trimFur(effie);
   }
}
```

```
public class App {
   public static void main(String[] args)
   {
       new PetShop();
   }
}
```

```
public class DogGroomer {

   private int age;

   public DogGroomer(int myAge){
      this.age = myAge;
   }

   public void printAge(){
      System.out.println(this.age);
   }

   public void trimFur(Dog shaggyDog) {
       //code that trims the fur of shaggyDog
   }
      ...
}
```

Summary

- **delegation pattern**: passing responsibility of task details to another class to maintain clean code design
    - results in a **chain of abstraction**
- **local variables**: scope is limited to a method
- **instance variables**: store the properties of instances of a class for use by multiple methods—use them only for that purpose
    - attributes are descriptors of objects
    - components are structural parts of composite objects
    - peer objects are classes that a class can send messages to
- A variable that “goes out of scope” is **garbage collected**
    - for a local variable, when the method ends
    - for an instance variable, when the last reference to it is deleted

Announcements

- Lab 1 (Intro to Java) begins today
  - Some section rooms assignments have changed, so be sure to read email from section TAs
- AndyBot due tomorrow 9/18
  - No late deadline = no credit for code submitted past the deadline
  - Double check your code in gradescope and github
- Java syntax code along recording on the website, stay tuned for more code alongs on new material
  - More on the next code-along Thursday!
- Mentors will be reaching out soon regarding first meeting

Review: Methods

- **Call methods**: used on an instance of a class

```
samBot.turnRight();
```

- **Define methods**: give a class specific capabilities

```
public void turnLeft() {
        // code to turn Robot left goes here
}
```

Review: Parameters and Arguments

- **Define** methods that take in generic **parameters** (input) and have **return** values (output); e.g., this `Calculator`'s method:

```
public int add(int x, int y) {
    return x + y; // x, y are dummy (symbolic) variables
}
```

- **Call** such methods on instances of a class by providing specific **arguments** (actual values for symbolic parameters)

```
myCalculator.add(5, 8);
```

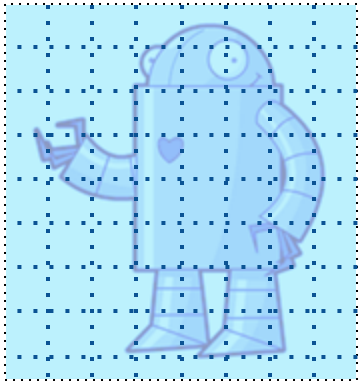
- Remember the one-to-one correspondence rule: list of arguments must match list of parameters in number, order, and types
  - thus, Java can substitute each argument for its corresponding parameters

Review: Classes

- Recall that classes are just blueprints
- A class gives a basic definition of an **object** we want to model (one or more instances of that class)
- It tells the **properties** and **capabilities** of that **object**
- You can create any class you want and invent any methods and properties you choose for it!

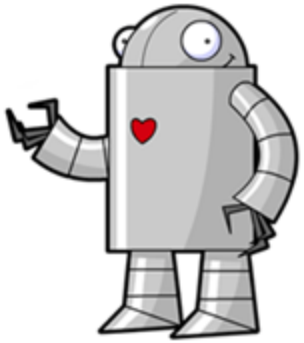
Review: Instantiation

- **Instantiation** means building an instance from its class
  - the capabilities of the instance are defined through the class's methods
- Ex: `new Robot();` creates an instance of Robot by calling the `Robot` class' **constructor** (see next slide)



← The `Robot` class

`new Robot();`



← instance

Review: Constructors (1/2)

- A **constructor** is a method that is called to create a new instance
- Let's define one for the Dog class
- Let's also add methods for actions all Dogs know how to do like bark, eat, and wag their tails

```
public class Dog {
  public Dog() {
        // this is the constructor!
  }

  public void bark(int numTimes) {
        // code for barking goes here
  }

  public void eat() {
        // code for eating goes here
  }

  public void wagTail() {
        // code for wagging tail goes here
  }
}
```

Review: Constructors (2/2)

- Note constructors do not specify a return type
- Name of constructor must exactly match name of class
- Now we can instantiate a Dog in some method using the `new` keyword:

```
new Dog();
```

```
public class Dog {
  public Dog() {
        // this is the constructor!
  }

  public void bark(int numTimes) {
        // code for barking goes here
  }

  public void eat() {
        // code for eating goes here
  }

  public void wagTail() {
        // code for wagging tail goes here
  }
}
```

Topics in Socially Responsible Computing

Antitrust & Big Tech

Image: Shutterstock

Antitrust = against monopolies

vs.

Images: Getty

Antitrust = against monopolies

VS.

Sherman Antitrust Act (1890): Banned any business practice that set out to restrict competition and create a monopoly

Source: FTC

Antitrust = against monopolies

VS.

Federal Trade Commission Act (1914):
Banned deceptive business practices and created the FTC

Clayton Antitrust Act (1914):
Banned mergers and other actions not covered by Sherman

Source: FTC

Big Tech's Power: Modern Monopolies?

➔Google, Amazon, Meta, and Apple took in about **60%** of digital ad earnings in 2022

➔Amazon takes in about **40%** of online spending in the US

➔Google's search engine conducts >**90%** of web searches

➔Microsoft is a top-three vendor to **84%** of businesses

Source: Statista (2024), Forbes (2024),

NY Times (2024), Harvard Business Review (2022)

Then…

1984

2001

Source: Reuters (2019), NYT (2001)

Now!

US judge sets October 2026 trial for FTC antitrust suit against Amazon

By **David Shepardson**

February 13, 2024 7:01 PM EST · Updated 5 months ago

Strongest U.S. Challenge to Big Tech's Power Nears Climax in Google Trial

Source: Reuters (2024), NYT (2024)

How to identify a monopoly: two red flags!

 Negative effects on consumers

 Barriers to entry for potential competitors

Amazon's Antitrust Paradox

Lina M. Khan

ANTITRUST LAW • CONSUMER LAW

Yale Law Journal (2017)

FTC Chair Lina Khan

Amazon's Monopolizing Playbook, according to Lina Khan:

- ❑ Merchants cannot list products on any other site for less than they sell on Amazon
- ❑ Hikes fees for merchants to sell on Amazon
- ❑ Merchants cannot raise prices on other sites to account for fees
- ❑ End up selling on Amazon exclusively so they can raise prices
- ❑ Results in higher prices across the economy- not just on Amazon

Source: NPR (2023)

How to identify a monopoly: two red flags!


Negative effects on consumers


Barriers to entry for potential competitors

In the event of a complete TikTok ban, Meta stands to gain up to **60%** of TikTok's American ad revenue.

Source: Fortune (2022), NYT (2024)

U.S. et al. vs. Google

August 5th, 2024: Federal Judge finds Google guilty of violating antitrust laws

Justice Department:

- Go…s deal…with Apple and other …e the default search …petition …ion in 2021 alone to …le Web”

…us…oogle because Google is …he…t optio…

- It is q…ite simply the best experience, which is why companies like Apple continue to renew contracts

Source: NYT (May 2024)