REVIEW

Review Topics

- Variables and data types
- Conditionals
- Loops
- Methods (including inputs and outputs)
- Pass by Value
- Writing Classes (including instance data variables, constructor, getters and setters, and toString)
- The equals method
- Inheritance and Overriding Methods
- Polymorphism
- null
- Coding Conventions

VARIABLES AND DATA TYPES

Variable Declaration

- A *variable* is a name for a location in memory
- Variables must be *declared*, meaning you state the:
  - variable type
  - variable name
- Examples:
  - `int total;`
  - `int count, sum;`
  - `String firstName;`

Variable Initialization

- To use a variable, you must initialize it.
  - You can declare and initialize in separate statements or in the same statement.

- Examples:

  -
    ```
    int sum = 0;
    ```

  -
    ```
    int n;
    n = 4;
    ```

  -
    ```
    int base = 32, mid, max = 149;
    ```

  -
    ```
    Student s = new Student(…);
    ```

Variable Type

- All Java variables are either a primitive type or an Object.
  - 8 primitive types
  - Object types defined by classes
- Java is a *strongly typed language*, meaning every variable has a declared type.
  - That declared type cannot change.
- Object variables also have an actual type.
  - This type could change (polymorphism!).

Constants

- A *constant* is an identified that holds the same value throughout its existence.
  - The compiler will not let you change it.
- Use the `final` keyword to declare a constant.
  - By convention, constant names are in all caps and separated with an underscore.

```
final int MIN_HEIGHT = 60;
final double AVG_TEMP = 98.6;
```

Constants… Why?

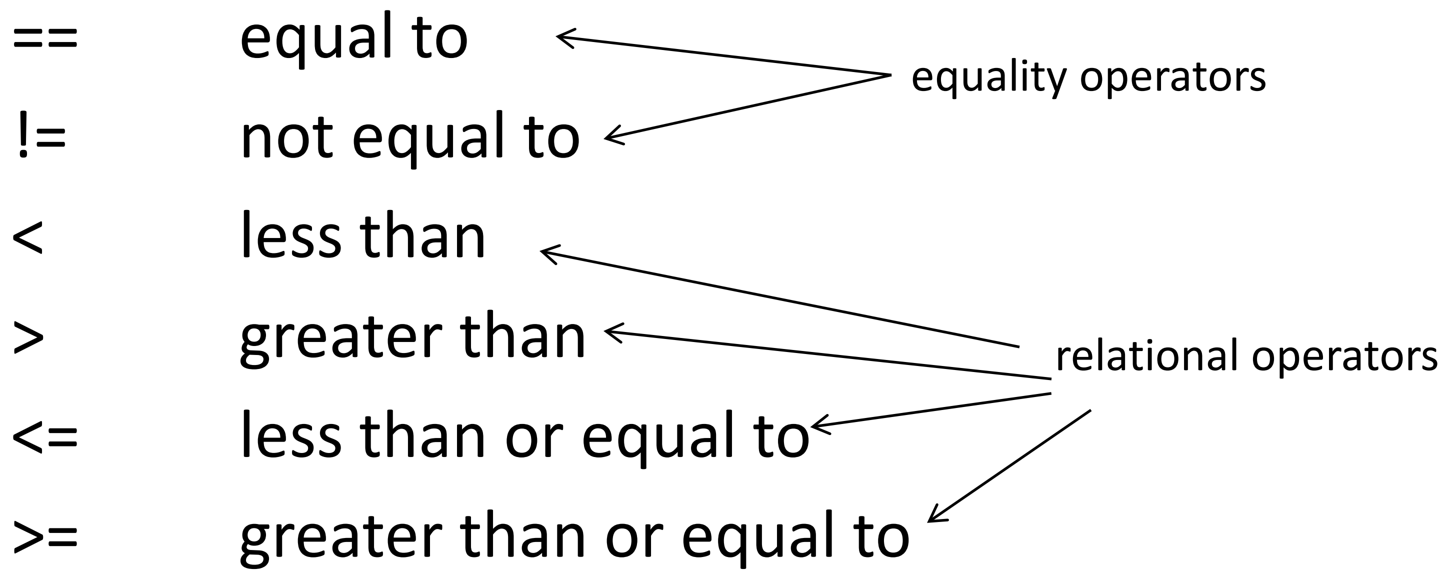
- They give meaning to otherwise unclear literal values.
  - Example: `MAX_STUDENTS` has more meaning than 40.
- They facilitate program maintenance.
  - If a constant is used in multiple places, its value needs to only be updated in one place.
  - Example: if you can now hold 50 students instead of 40, you only have to edit the code that initializes `MAX_STUDENTS` instead of changing the number everywhere it appears.
- They formally establish that a value should not change, avoiding inadvertent errors by programmers.

Before going to bed, a programmer put two glasses on his nightstand: one filled with water and one empty. Her husband asked her "why?" and she said, “The water is there in case I wake up at night and I feel thirsty.” “What about the other one?” “Oh! This is in case I wake up at night and I am not thirsty!”

CONDITIONALS

Boolean Expressions

- A *boolean expression* evaluates to true or false.
- Boolean expressions often use an equality or relational operator to compare two values:



==	equal to
!=	not equal to
<	less than
>	greater than
<=	less than or equal to
>=	greater than or equal to

equality operators

relational operators

Boolean Expressions (cont.)

- Boolean expressions can be combined using logical operators

!	NOT
&&	AND
||	OR

`a`	`!a`
true	false
false	true

`a`	`b`	`a && b`	`a || b`
true	true	true	true
true	false	false	true
false	true	false	true
false	false	false	false

Conditional Statements

- A *conditional statement* allows us to take different actions under different conditions.
- The simplest form is an if-statement.
  - If *`boolean`* is true, the code will `do something`.
  - If *`boolean`* is not true, nothing happens.

```
if (boolean) {
    // do something
}
```

Indentation and Brackets

- Without brackets, one single statement after an if-statement will execute.
- With brackets, all statements inside will execute.
    - This is called a *block statement*.
- With or without brackets, best practice is to indent code within an if-statement.
    - Java doesn’t care about this, but human readers do!

The if-else Statement

- An else clause can be added to an if.
  - If ***boolean*** is true, `statement1` is executed.
  - If ***boolean*** is false, `statement2` is executed.
- One or the other statements is executed, but not both.

```
if (boolean) {
    // statement1
} else {
    // statement2
}
```

The if-else Statement (cont.)

- Just like the if-statement, without brackets, one single line of code is execute.
- With brackets, all code inside the brackets will execute.

Block Statements

- Variables declared inside of a block statement are local to that statement only.
  - They cannot be seen outside the brackets.

```
if (total > MAX)
{
   boolean error = true;
}
if(error)
   System.out.println(“Error”);
// COMPILER ERROR
```

The if-else-if Statement

- You can add multiple conditions with else-if statements.
- Ending with a single else ensures that one of the statements is executed.

```
if (condition1) {
   // do something1
} else if (condition2) {
   // do something2
} else if (condition3) {
   // do something3
} else {
   // do something4
}
```

Conditional Rules- What is Allowed

- a single if with
  - no else
- a single if with
  - a single else
- a single if with
  - any number of else-ifs
  - a single else
- a single if
  - any number of else-ifs
  - no else

- Conditionals are matched based on their *brackets*.
  - But indentation helps humans, too!

The Conditional Operator

- A way to rewrite an if-else in a single statement

condition ? expression1 : expression2 ;

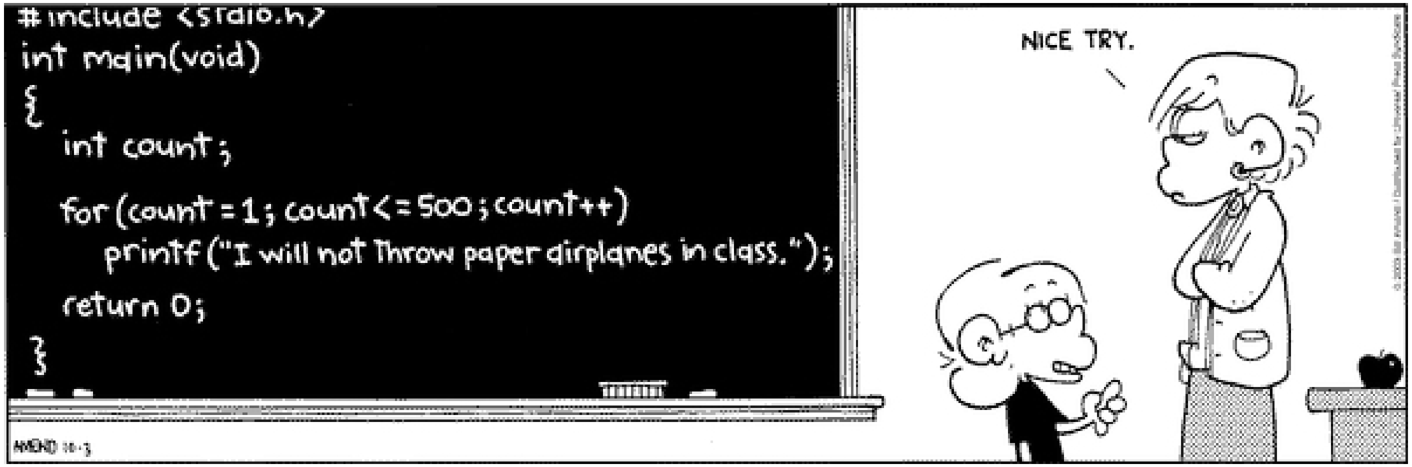
- If condition is true, expression1 is evaluated.
- If condition is false, expression2 is evaluated.

Example

```
int larger =
   num1 > num2  ?  num1  :  num2;
```

this is equivalent to:

```
int larger;
if (num1 > num2)
   larger = num1;
else
   larger = num2;
```



```
#include <stdio.h>
int main(void)
{
   int count;

   for (count = 1; count<=500; count++)
      printf ("I will not Throw paper airplanes in class.");
   return 0;
}
```

LOOPS

The while Loop

```
while (condition) {
  statement;
}
```

1. Check condition.
    1. a) If true:
        - i. Execute Statement.
        - ii. Return to Step 1.
    2. b) If false:
        - i. Move on to the statement after the while loop.

The while Loop (continued)

```
while (condition) {
   statement;
}
```

- As long as *condition* is true, keep executing the code inside (statement).
- Be sure that somewhere inside the loop the *condition* is set to false.
  - Otherwise the loop never ends!

The while Loop (continued)

- The body of a while loop is executed zero or more times.
  - If the condition is false, the statement will never be executed.

The `while` Loop

- The condition can be a complex boolean statement.

```
while (condition1 && condition2) {
    statement;
}

while (condition1 || condition2) {
    statement;
}
```

Local Variables

- Variables declared inside the while loop are local only to that single iteration of the while loop.

```
while(condition) {
     int n=0;
     System.out.println(n);
     …
}
```

Uses of the while Loop

- You don’t know how many times you want to repeat something ahead of time
- You want to repeat until some condition is reached
- You want to continue to obtain input until you get a *sentinel* value (to indicate input is done)
- You want to continue to obtain input until you get a valid value

The do… while Loop

```
do {
   statement;
} while (condition);
```

1. Execute statement.
2. Check condition.
   a) If true:
      i. Return to Step 1.
   b) If false:
      i. Move on to the statement after the do-while loop.

The do… while Loop (continued)

- The body of a do-while loop is executed **one** or more times.

- Which to use?
  - Do you want the condition evaluated *before* or *after* the code is executed?
  - Do you want the code executed always once or maybe executed never?

The for Loop

```
for(initialization; condition; update) {
    statement;
}
```

1. Perform initialization.
2. Check condition.
    a) If true:
        i. Execute Statement.
        ii. Perform update.
        iii. Return to Step 2.
    b) If false:
        i. Move on to the statement after the for loop.

The for Loop

- The initialization section can be used to declare a variable.
  - Note that this variable is then *local* to the loop- it cannot be seen outside of the loop.
- The update section can perform any calculation.
- Each section of the loop is optional.

The for Loop (continued)

- A for loop is functionally equivalent to a while loop:

```
initialization;
while (condition) {
    statement;
    update;
}
```

The for Loop (continued)

- The condition of a for loop is tested first.
- The body of a for loop is executed zero or more times.
  - If the condition is false, the statement will never be executed.

Uses of the for Loop

- Executing statements a pre-defined number of times
- Iterating through collections (arrays, ArrayLists, etc.)

Local Variables

- Variables declared inside the for loop are local the for loop.

```
for(int i=0; i<n; i++) {
    System.out.println(i);
}
System.out.println(i); // ERROR!
```

When to use which?

- In general, use a for-loop if you know in advance how many times you want to repeat the code.
- In general use a while-loop if you want to keep repeating code until some condition changes (something becomes true/false), but you don’t know ahead of time when this will happen.

Beware of Infinite Loops!

- The body of a while or do-while loop must eventually make the condition false.
- The update section (or body of) a for loop must eventually make the condition false.

I NEED TO USE THE COMPUTER.
HOLD ON. LET ME SEE IF ANYONE WROTE ON MY FACEBOOK WALL... NOPE.
NOW LET ME SEE IF ANYONE REPLIED TO ME ON TWITTER... NOPE.
NOW LET ME SEE IF ANYONE STARTED FOLLOWING MY TUMBLR... NOPE.
DONE?
LET ME CHECK FACEBOOK AGAIN. SOMEONE COULD HAVE WRITTEN SOMETHING IN THE LAST 30 SECONDS... NOPE.
www.foxtrot.com twitter: @billamend
NOW LET ME CHECK TWITTER AGAIN... NOW TUMBLR...
©2011 Bill Amend / Dist. by Universal Uclick
OUR SISTER HAS GONE INFINITELY LOOPY.
NOW FACEBOOK... NOW TWITTER... NOW TUMBLR... NOW FACEBOOK... NOW TWITTER... NOW TUMBLR... NOW FACEBOOK... NOW TWITTER... NOW TUMBLR...

Nested Loops

- Loops can be nested such that the body of one loop contains another loop.
- For each iteration of the outer loop, the inner loop goes through a full execution.
  - Statements inside an inner loop will execute (outer * inner) times.

Example

- How many times is “Here” printed?

```
for(int i=0; i<20; i++) {
    for(int j=0; j<40; j++) {
        System.out.println ("Here");
    }
}
```

The Enhanced `for` Loop (the “for each” Loop)

```
for(type varName : arrayName)  {
   statement;
}
```

- Use to iterate through arrays
- Use to iterate through any collection *whose class implements Iterable*
  - This includes ArrayList, LinkedList, etc.

The Enhanced `for` Loop (the “for each” Loop)

```
// scores is an int[]
for(int score : scores)  {
   System.out.println(“Score=“ + score);
}
```

- Read as: for each int in scores (called score), print the score

```
// catalog is a Course[]
for(Course c : catalog)  {
   System.out.println(c.getTitle());
}
```

- Read as: for each Course c in the catalog, print the title

`for-each` Loops and `for` Loops

```
int[] nums = new int[10];
for(int i=0; i<nums.length; i++)
  nums[i] = i*5;


  for(int i=0; i<nums.length; i++)
      System.out.println(nums[i]);

  for(int eachNum : nums)
      System.out.println(eachNum);
```

equivalent output

`for-each` Loops and `for` Loops

The for-each is the same as if you had a for-loop but declared a local variable inside the loop: `int eachNum = nums[i]`

```
for(int i=0; i<nums.length; i++) {
   int eachNum = nums[i];
   // do something with eachNum
}
```

equivalent!

```
for(int eachNum : nums) {
   // do something with eachNum
}
```

When to use which?

- Both are acceptable.
  - Although the for-each is gaining in popularity because many people find it easier to read and it eliminates the need for the (often meaningless) index variable.
  - If you don’t care about the index value, use a for-each!
  - Oracle also now recommends its use: https://docs.oracle.com/javase/tutorial/java/nutsandbolts/for.html
- Anything you can do with a for-each can also be done with a regular for.
- But there are things you *can* do with a for-loop that you *cannot* do with a for-each.

What can’t a for-each do?

- Access only *some* elements of the array
  - Example: `for(int i=0; i<array.length; i=i+2)`
    - Allows you to process every-other element in an array
    - Can’t be done directly with a for-each
- Access the *index* of the element
  - Example:
    ```
    for(int i=0; i<array.length; i++)
              System.out.println(“The item at pos. “ +
              (i+1) + ”=“ + array[i]”);
    ```
  - Allows you to fill an array based on the index
  - Since there is no index variable in a for-each, you can’t do this directly
- *Update* the value stored in an array
  - Example:
    ```
    for(int i=0; i<array.length; i++)
              array[i] = newValue;
    ```
  - Allows you to update the contents of an array at a certain position
  - Since there is no index, there is no way to update at that position.

Caution!

- You **cannot** update array contents with a for-each.

```
for(int eachNum : nums) {
    eachNum = newValue;
  }
```

mistake!!

```
for(int i=0; i<nums.length; i++) {
    int eachNum = nums[i];
    eachNum = newValue;
  }
```

that would be the equivalent of this- which does NOT change the array!

Bottom Line

- If you need to do one of the things on the previous slide, use a for loop.
- If you need to do anything else, it’s your choice!
  - But consider the for-each!

METHODS

Methods

- A *method* is a group of statements that perform an action.

- Creating methods allows us to reuse code.
- Methods are used to define the functionality of objects.
  - What can an object do?

Method Header

- Method declaration begins with the method header:
  - visibility
  - return type
  - method name
  - formal parameters
    - type and name of each parameter
  - (static, when appropriate)
- Method body is surrounded by { }

Writing a "Complete Method"

- When you are asked to write a **complete method**, you should write a **full method header** with code surrounded by curly brackets.
- Putting code statements inside of main do **not** count as a complete method.

Method Header Components

- visibility
- (static, when appropriate)
- return type
- method name
- formal parameters
  - type and name of each parameter

Method Visibility

- Methods can be public, private, protected, or the "default" visibility (which is indicated by having no visibility modifier).
  - Most methods are public or private.

Determining Method Visibility

- If a method should be seen and used by someone using your class, make it public.
  - Will someone else invoke this method from outside of this class?
- If the method describes the functionality of an object (what the object does), make it public.
- If a method is an internal helper method, make it private.

Method Name

- Method names:
  - descriptive
  - lowerCamelCase with no underscores
  - often contain a verb or ask a question
- Examples:
  - `calculateScore(…)`
  - `findValue(…)`
  - `isEligible(…)`

Method Return Type

- Methods are void or valued.
- void methods do not return a value.
- Valued methods return a value.
  - The value can be primitive or object.

void Methods

- `void` methods do not return a value.
- `void` methods complete a task and end.

Invoking void Methods

- `void` methods can only be invoked as stand-alone statements.
  - They execute and complete on their own.
- You **cannot** put a void method invocation inside another expression.
  - COMPILER ERROR:
    ```
    System.out.println(myObject.printInfo());
    ```
  - COMPILER ERROR:
    ```
    int val = myObject.printInfo() + 5;
    ```

Valued Methods

- Valued methods return a value.
- The type of the value returned must match the return type of the method.
- The return type can be primitive or Object

Invoking Valued Methods

- When you reach a return statement, control leaves the method and jumps back to the place where the method was invoked.
- No code is executed after a return statement.

Invoking Valued Methods

- All possible branches of execution must contain a return statement.
- Even if you, the human, knows a branch will never execute, there still must be a return statement.

Invoking Valued Methods

```
public int method() {
   if(false) {
       System.out.println("I will never be here!");
   } else {
      return 0;
   }
}
public int method() {
   while(1 < 100) {
      return 0;
   }
}
```

Invoking Valued Methods

- You can use or ignore a returned value.

- Examples:

  -
    ```
    myObject.calculate();
    // returned value is ignored
    ```

  -
    ```
    System.out.println(myObject. calculate());
    // returned value is printed
    ```

  -
    ```
    int val = myObject.calculate();
    // returned value is stored in a local variable
    ```

  -
    ```
    int val = myObject.calculate() * 2;
    // returned value is used in an expression and stored
    ```

Choosing a Return Type

- Think carefully about choosing the return type.
- Is your method completing a task only?
- Is your method figuring something out or creating something?
    - A yes/no type question? Consider boolean
    - A count? Consider int
    - A numeric value? Consider int or double
    - A new object?

Parameters

- Formal parameters are defined in the method header
- Actual parameters are the values sent when the method is invoked
  - These are often called *arguments*

Formal Parameters

- Formal parameters are defined in the method header
- When a method ends, all formal parameters are released for garbage collection.
  - You cannot access formal parameters outside of a method.

- (Local variables are also released for garbage collection.)

Defining Formal Parameters

- Follow variable naming conventions
  - Descriptive (avoid one-letter names)
  - lowerCamelCase with no underscores
- Choose the appropriate data type
  - char, String, int, double, boolean, an object, etc.

Invoking a Method: Parameters

- When the method is invoked, it’s as if there is a behind-the-scenes assignment statement:

```
    formalParam = actualParam;
```

Method Example

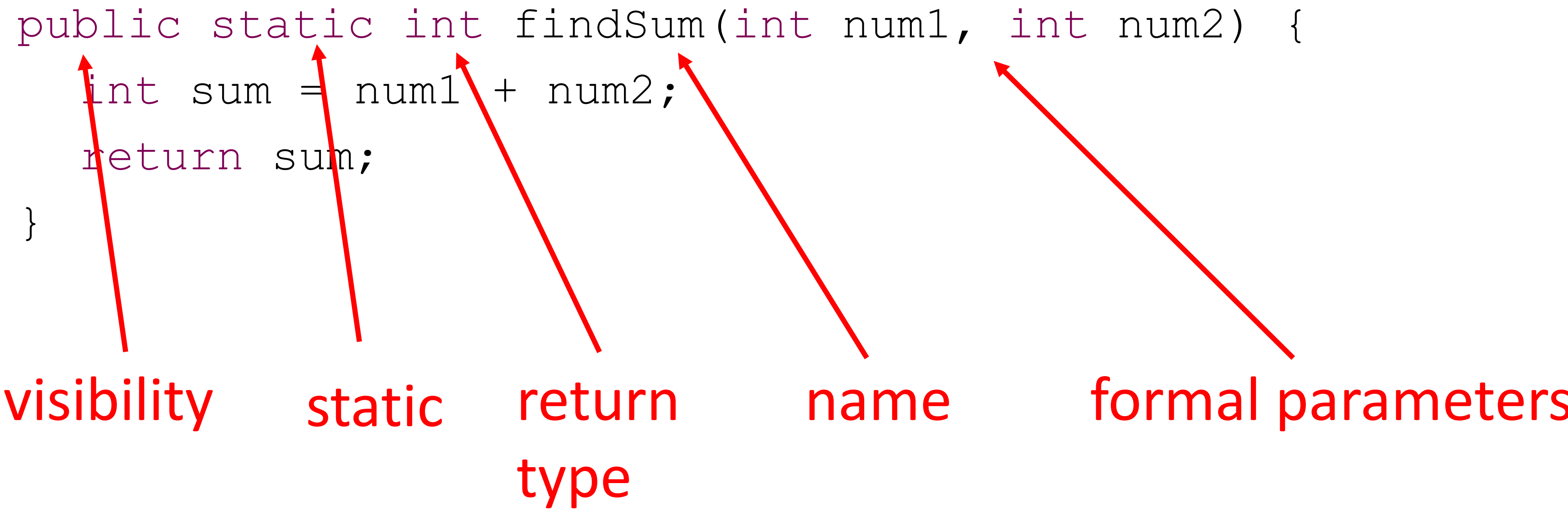
```
public static int findSum(int num1, int num2) {
  int sum = num1 + num2;
  return sum;
}
```

Method Example

```
public static int findSum(int num1, int num2) {
   int sum = num1 + num2;
   return sum;
}
```

method header

Method Example



```
public static int findSum(int num1, int num2) {
   int sum = num1 + num2;
   return sum;
}
```

visibility

static

return type

name

formal parameters

Method Example

```
public static int findSum(int num1, int num2) {
   int sum = num1 + num2;
   return sum;
}
```

formal parameters

only visible/accessible inside the method

garbage collected when the method ends

Method Example

```
public static int findSum(int num1, int num2) {
  int sum = num1 + num2;
  return sum;
}
```

local variable

only visible/accessible inside the method

garbage collected when the method ends

Method Example

```
public static int findSum(int num1, int num2) {
  int sum = num1 + num2;
  return sum;
}
```

return statement

data type of "sum" matches the return type of the method

Declaration vs. Invocation

- Declaring a method specifies what happens when it runs.
  - Specify the full method header (visibility, static?, return type, name, formal parameters).
  - Put the code inside the method body.
- Invoking a method actually makes it run.

Method Invocation

- If the method invoked is in the **same class**, you are only required to use the method name.
  - You can have no invoking object.
- For non-static methods, you can (but are not required to) use `this` as the invoking object.
  - Example:
    `System.out.println(this.toString());`
  - I usually only use `this` if I am in a method that is also invoking a method on another object of the same type. For example, in an equals method, you might say
    `this.getName().equals(other.getName());`

Method Invocation

- If the method invoked is in the **same class**, you are only required to use the method name.
  - You can have no invoking object.
- For static methods, you can (but are not required to) use the name of the class as the invoking class.
  - Example: `MathUtils.multiply(7, 12);`
  - I recommend using class names to invoke static methods in the class. It lets the reader know right away that it's a static method.

Method Invocation

- If the method invoked is in a **different class**, you must have an invoking object (for non-static methods) or class name (for static methods) followed by the dot operator.
  - Examples:

```
student.enroll();
account.deposit(150);
MathUtils.multiply(3, 5);
```

Method Example

```
public static int findSum(int num1, int num2) {
  int sum = num1 + num2;
  return sum;
}

… // in another class
public static void main(String[] args) {
   int num = 1;
   int result = MathUtils.findSum(num, 2);
}
```

Method Example

```
public static int findSum(int num1, int num2) {
   int sum = num1 + num2;
   return sum;
}
```

invoking the method

```
… // in another class
public static void main(String[] args) {
    int num = 1;
    int result = MathUtils.findSum(num, 2);
}
```

invoking class

Method Example

```
public static int findSum(int num1, int num2) {
   int sum = num1 + num2;
   return sum;
}

… // in another class
public static void main(String[] args) {
    int num = 1;
    int result = MathUtils.findSum(num, 2);
}
```

num and 2 are the actual parameters

Method Example

```
public static int findSum(int num1, int num2) {
   int sum = num1 + num2;
   return sum;
}

public static void main(String[] args) {
    int num = 1;
    int result = MathUtils.findSum(num, 2);
}
```

when the method is invoked, behind the scenes we have *formal = actual*, like this:

num1 = num;
num2 = 2;

important: this is direct assignment!

Flow of Control

- Java executes statements in order, starting with the first statement in the main method.

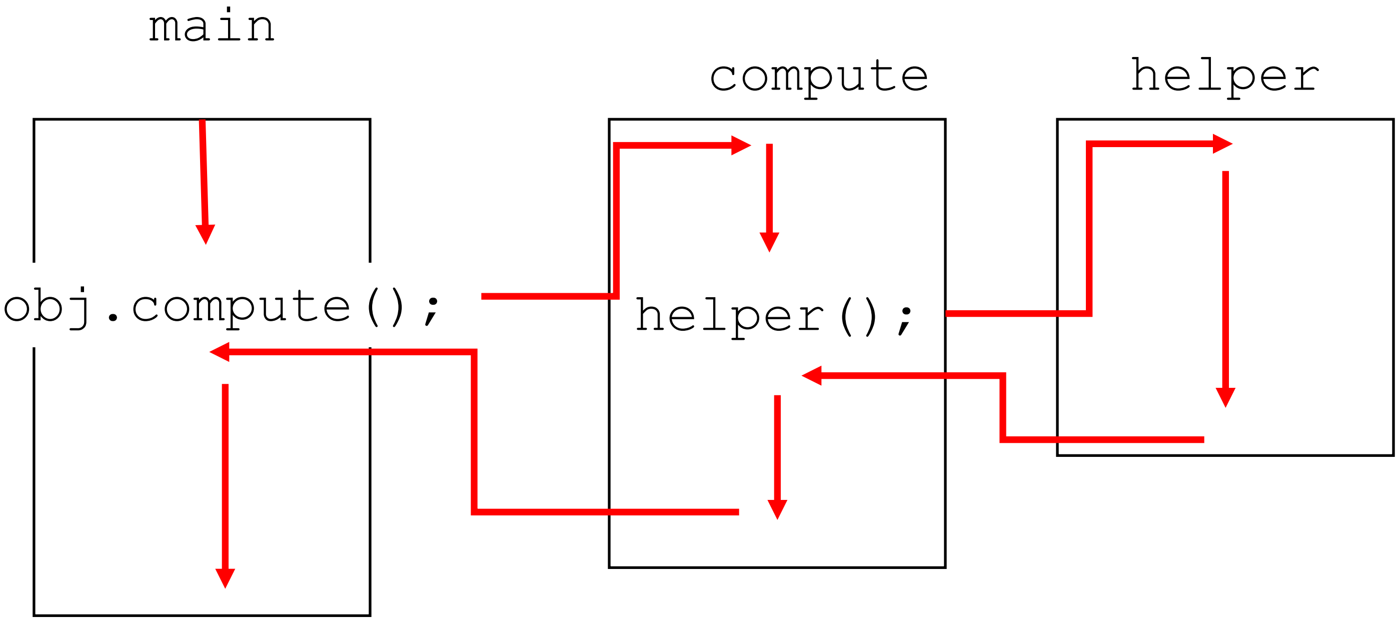
Flow of Control

- When a statement contains a method invocation, the flow of control jumps to that method and begins to execute that method line by line.
  - You can think of the original method as being *put on pause* until the invoked method completes.

Flow of Control

- An invoked method is complete when you reach either:
  1. a `return` statement or
  2. the end of the method
- When the method completes, control returns to where the method was called and continues.

Flow of Control Example



main method invokes the compute() method with the obj as the invoking object

helper() is a private method inside the same class

static Methods

- Static methods (also called class methods) are invoked through the **class** name (**not** through an invoking object)
  - `double answer = Math.sqrt(25)`
  - `double number = Math.random();`
- Static methods are more like *functions* associated with a class
  - They should **not** be used if a method represents an object's functionality.
  - They **cannot** be used if they require access to instance data variables.

Method Overloading

- *Method overloading* allows multiple methods with the same name.
- Overloaded methods differ by:
  - The number of parameters,
  - The type of parameters, or
  - The order of the parameters
- Overloaded methods **cannot** differ only by return type

When to Use Method Overloading

- Use method overloading only when you have multiple methods that take different parameters but do the *same* thing.
  - You often want the client to think it's the same method (e.g., println).
- You should **not** overload methods if two methods perform different tasks.

Overloading Constructors

- It is common to overload constructors
- This provides multiple ways to initialize a new object
  - This is commonly used when you have default values for instance data that can be assigned when the user does not supply values
- More to come on this!

PASS BY VALUE

What is Stored in Memory

- Primitive variables
  - The actual value- the data
- Object variables (also called object *references*)
  - A reference/ pointer/ memory address to the place in memory where all the information about the object resides
- This is a critical distinction in Java!

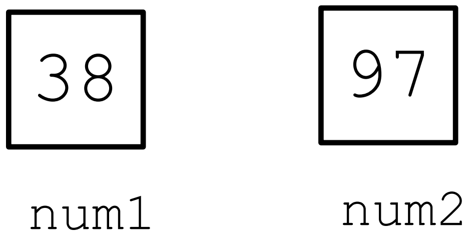
Assignment Statements

- Assignment takes the **value** on the right and stores it in the variable on the left.
- Think about what **the value** is!
  - It’s different for primitives and objects!

Assignment- Primitives

- Assignment takes the value on the right and stores it in the variable on the left.
  - For primitives, the value is just the data!

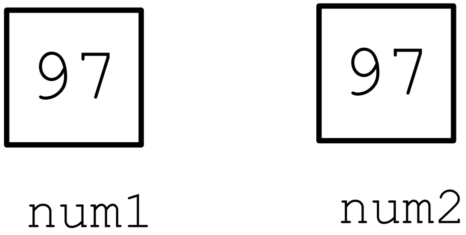
```
int num1 = 38;

int num2 = 97;
```



Assignment- Primitives

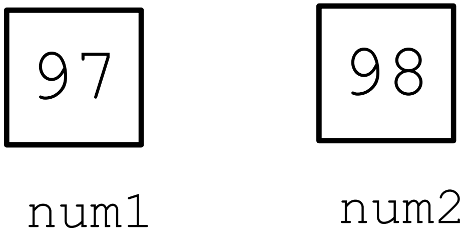
```
num1 = num2;
```

- What is the **value** of num2?
- Because it’s a primitive, the value is just the data! So the data- the actual number- is placed into num1.



Assignment- Primitives

```
num2++;
```



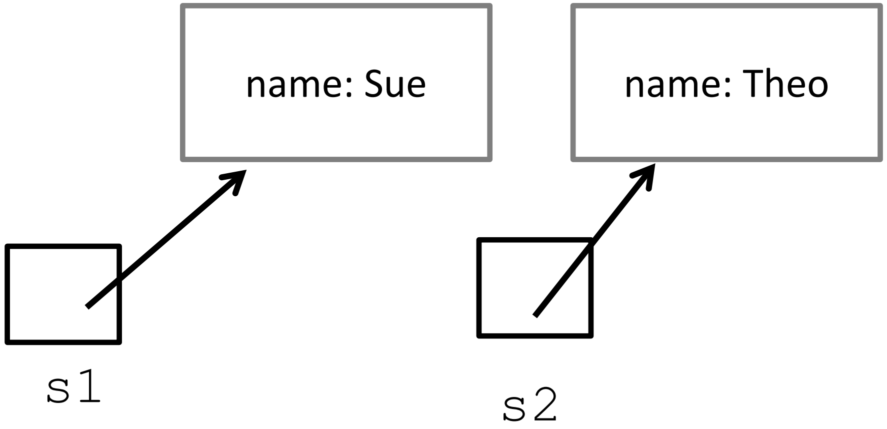
97 98

num1 num2

Assignment- Objects

- Assignment takes the value on the right and stores it in the variable on the left.
  - For objects, the value is a memory address!

```
Student s1 = new Student(“Sue”);
Student s2 = new Student(“Theo”);
```

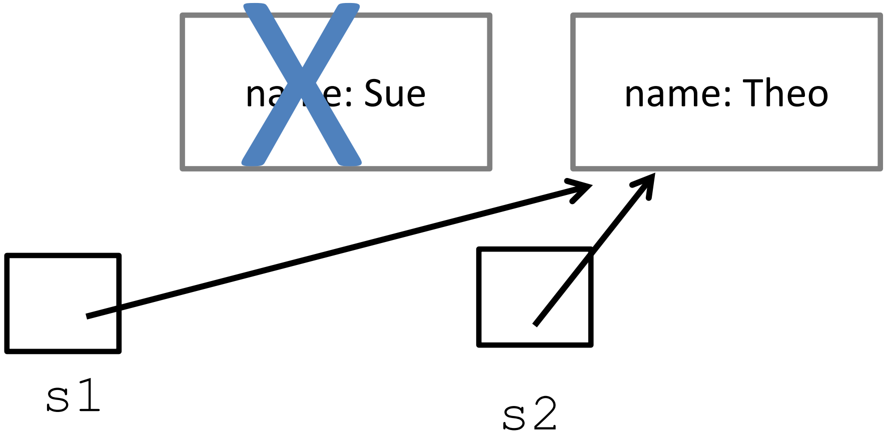


Assignment- Objects

```
s1 = s2;
```

- What is the **value** of s2?
- Because it's an object, the value is the address!
- So now s1 and s2 point to the exact same place in memory- the same address!

- Because no reference points to the other Student object, it gets garbage collected.

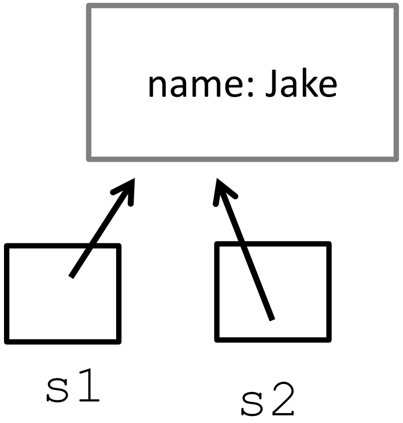


Aliases

- s1 and s2 are now **aliases**.
- Variables that point to the same object (the same place in memory) are *aliases*
- Changing that object through one reference (i.e., one variable name) changes it for *all* references- because there is only **one** object!

Aliases

```
s2.setName(“Jake”);
```



Invoking Methods with Parameters

- Formal parameters are defined in the method header
  - They last as long as the method lasts.
  - When the method is over, these parameters are gone!
- Actual parameters are the values sent when the method is invoked.

Passing Parameters

- When a method is invoked, it’s as if there is assignment statement executed behind the scenes:

```
formalParam = actualParam;
```

- This is an assignment statement!
  - When you use the assignment operator with objects, you create **aliases**.
  - Formal object parameters are **aliases** of actual parameters.

Pass By Value

- Parameters in Java are ***passed by value***
- This means that the ***value*** of the actual parameter is *assigned to* the formal parameter.
  - But remember how assignment works for primitives vs objects!

Objects as Parameters

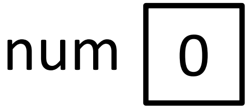
- When an object is passed to a method, the actual parameter and the formal parameter become *aliases* of each other
  - If you change the internal state of the formal parameter by invoking a method, you change it for the actual parameter as well

Review the PassingParameterExample

- In this example, we pass a primitive and an object into a method.

Code Trace- Primitives

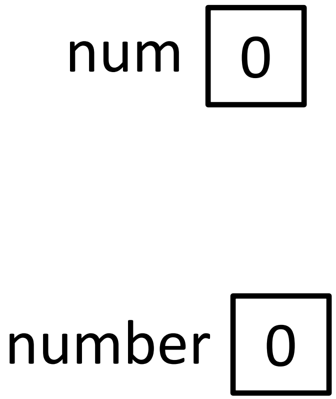
```
int num = 0;
```



num 0

Code Trace- Primitives

```
primitiveParam(num);
// number = num
// value is assigned!
```

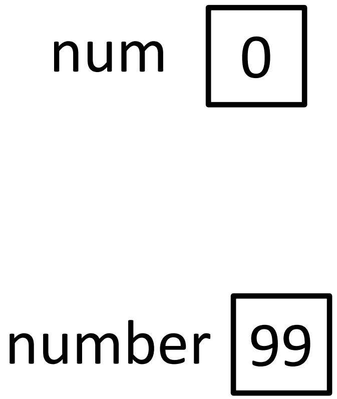


num 0

number 0

Code Trace- Primitives

```
number = 99;
```

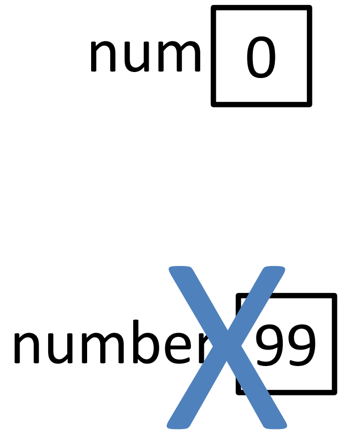


num 0

number 99

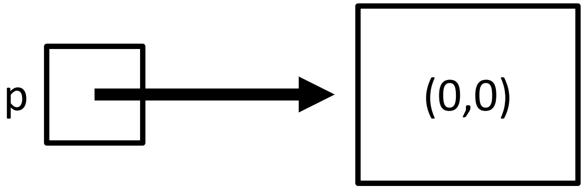
Code Trace- Primitives

```
// method ends
// local variables and
   formal parameters
   are garbage collected
```



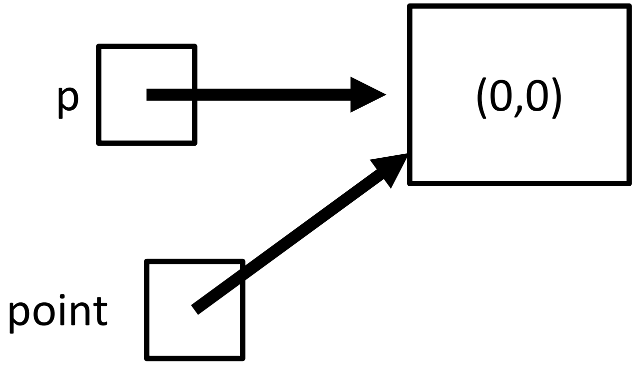
Code Trace- Objects

```
Point p = new Point(0,0);
```



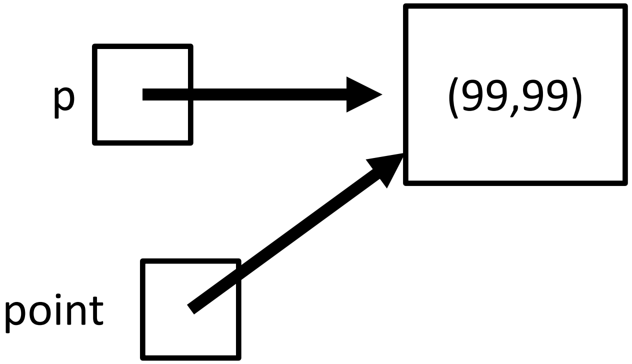
Code Trace- Objects

```
objectParam(p);
// point = p
// value is assigned!
// alias is created!
```



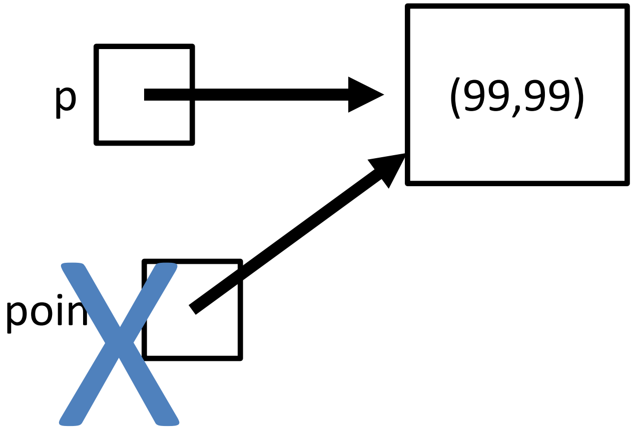
Code Trace- Objects

```
point.setLocation(99,99);
```



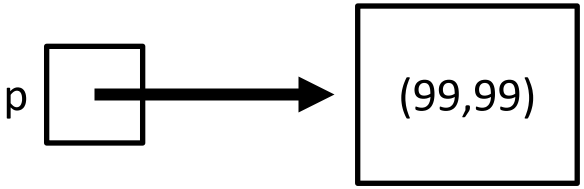
Code Trace- Objects

```
// method ends
// local variables and
   formal parameters
   are garbage collected
```



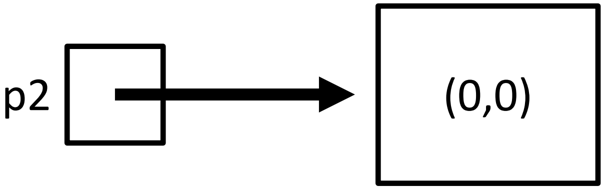
Code Trace- Objects

```
// value is still changed back
in main
```



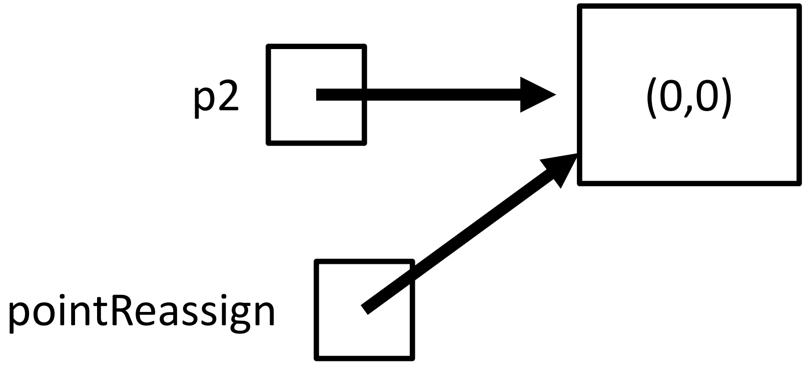
Code Trace- Objects

```
Point p2 = new Point(0,0);
```



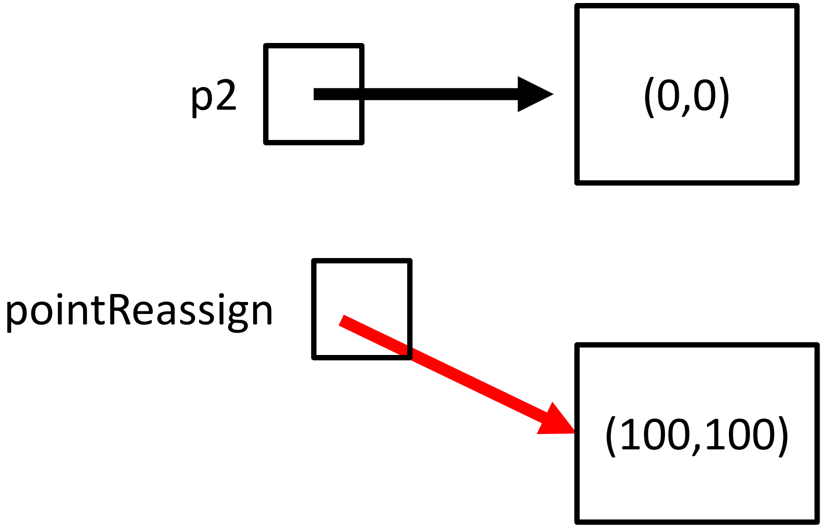
Code Trace- Objects

```
objectParamReassign(p2);
// pointReassign = p2
// value is assigned!
// alias is created!
```



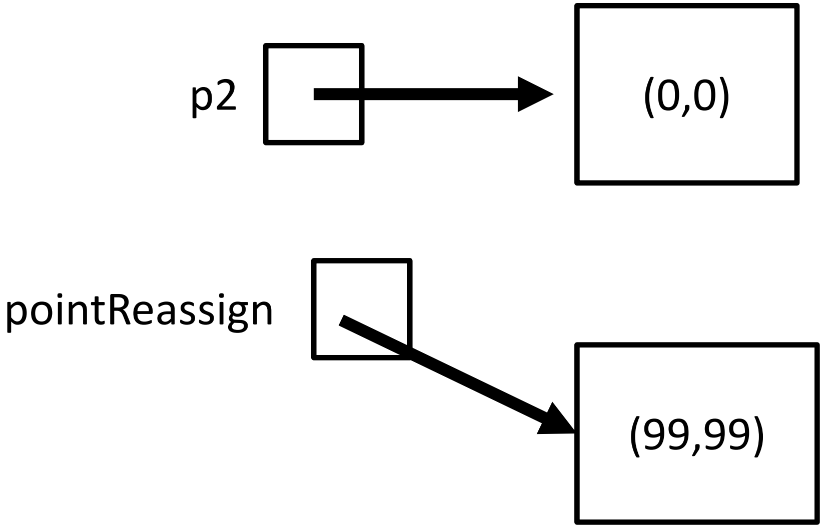
Code Trace- Objects

```
pointReassign = new Point(100,100);
// alias is broken!
```



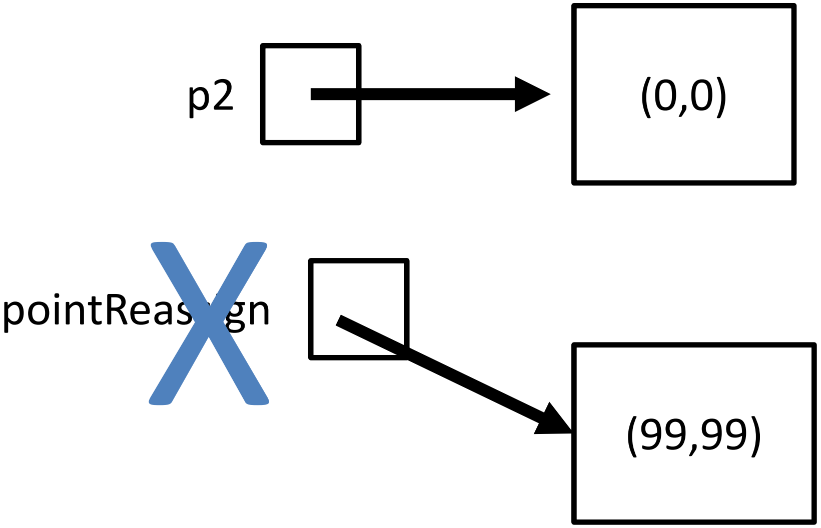
Code Trace- Objects

```
pointReassign.setLocation(99,99);
```



Code Trace- Objects

```
// method ends
// local variables and formal
parameters are garbage collected
```



Key Points about Pass By Value

- Java is pass by value!
- The key is: what is the value?
  - For primitives: the actual data
  - For objects: the memory location/reference
- Using direct assignment with objects creates aliases. (**NOT** copies!)
- Passing objects to parameters creates aliases.
  - Invoking a method (with dot operator) inside the method changes the object inside and outside the method- because it’s the same object!
  - Reassigning a formal parameter (formal parameter on left side of equal sign) breaks the alias link. This is usually a mistake.

WRITING CLASSES

Class Design

- A class is a *concept* of an object
- Once we define a class, we can instantiate as many objects of that class as we need
- Classes define a blueprint of what all objects of that class will look like.
    - The class is the blueprint. The object is the house.
    - The class is the recipe. The object is the cookie.

Class Design

- Classes define:
  - Characteristics (state)
    - What describes the object
    - Represented by instance data
  - Functionality or actions (behaviors)
    - What the object can do or actions that can be done to the object
    - Represented by methods

Object-Oriented Principle: Encapsulation

- Data and functionality is contained within an object
- Data can only be accessed from within the class
- Each object is in charge of its own data and functionality

Class Names

- Descriptive
- Often a singular noun
- Follows naming conventions: UpperCamelCase (with no underscores)

Class Building Blocks

- Instance data variables
- Constructor
- Getters and setters
- toString method
- Other class-specific methods

Instance Data

- Represents the characteristics of the object

Instance Data Variables

- Declared within a class but outside of methods
- Can be accessed by all methods within the class

- Each object has its **own version** of each instance data variable

Declaring Instance Data

- Always make them private
  - This supports encapsulation
- Carefully consider the right type
  - numeric? boolean? String? object?
- Choose a good name
  - Descriptive
  - Follows naming convention: lowerCamelCase without underscores

Constructors

- Create and set up an object
  - An object is an *instance of* the class
- Initialize the instance data variables using values sent in as parameters or default values defined in the class as constants
  - This defines what the object initially looks like

Declaring Constructors

- Has the same name as the class
- Has **no** return type
- Should usually be public

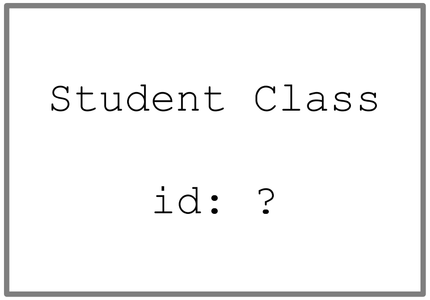
Invoking Constructors

- Called when an object is created with the keyword **`new`**
- This is called *instantiating the object* or *creating an instance of* the class.
- **`new`** does three things:
  1. allocates the necessary memory for the object
  2. executes the constructor
  3. returns the address of (reference to) the object so it can be stored in the variable

Creating Objects

```
Student s1 = new Student(51);

public Student(int id) {
   this.id = id;
}
```

- **new** does three things:
  1. allocates the necessary memory for the object
  2. executes the code inside of the constructor
  3. returns the address of (reference to) the object so it can be stored in the variable



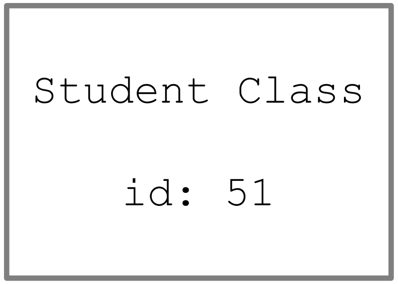
Student Class

id: ?

Creating Objects

```
Student s1 = new Student(51);

public Student(int id) {
   this.id = id;
}
```

- **new** does three things:
  1. allocates the necessary memory for the object
  2. executes the code inside of the constructor
  3. returns the address of (reference to) the object so it can be stored in the variable



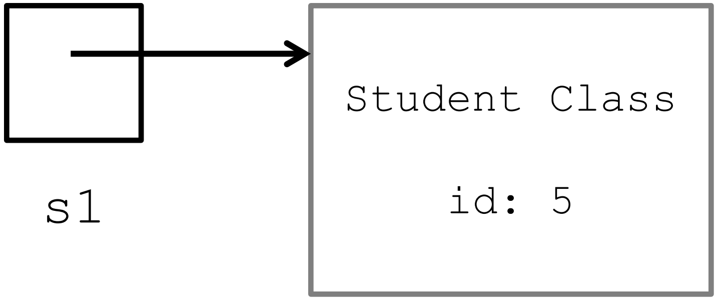
Student Class

id: 51

Creating Objects

```
Student s1 = new Student(51);

public Student(int id) {
   this.id = id;
}
```

- **new** does three things:
  - allocates the necessary memory for the object
  - executes the code inside of the constructor
  - returns the address of (reference to) the object so it can be stored in the variable



Overloading Constructors

- It is common to overload constructors
- This provides multiple ways to initialize a new object
  - This is commonly used when you have default values for instance data that can be assigned when the user does not supply values

Overloading Constructors

- It’s best practice to invoke one constructor from another to avoid duplicated code.
  - Often, you will invoke the “longest” constructor (the one with the most parameters) from the other constructors, using parameters and default values to invoke the constructor.
- Use the `this` keyword is to call an overloaded constructor

- Note: this statement *must* be the first line in the constructor

The `this` Keyword

Example:

```
public static final double DEFAULT_BALANCE = 0;
public static final boolean DEFAULT_OVERDRAFT = false;

public Account(String name, double balance, boolean overdraft) {
   this.name = name;
   this.balance = balance;
   this.overdraft = overdraft;
   // other setup code
}

public Account(String name) {
   this(name, DEFAULT_BALANCE, DEFAULT_OVERDRAFT);
}

public Account(String name, double balance) {
   this(name, balance, DEFAULT_OVERDRAFT);
}
```

Getters and Setters

- Instance data variables are private
  - How do we see them?
  - How do we change their values?

- Provide access to the instance data
- Also called *accessors* and *mutators*

Getters and Setters

- Should be public
- Setters are void, getters return a value
- Follow naming convention
  - getX and setX
  - for booleans: isX and setX

Getters and Setters

- Getter
  - Returns the current value of a variable

```
public TYPE getVARNAME() {
   return VARNAME;
}
```

- Setter
  - Updates the value of a variable
  - Can define parameters for valid values- validity checks

```
public void setVARNAME(TYPE NEWVALUE) {
   VARNAME = NEWVALUE;
}
```

Validity Checks in Setters

```
public void setVARNAME(TYPE NEWVALUE) {
  if( NEWVALUE meets some test) {
      VARNAME = NEWVALUE;
  } else {
      // maybe do nothing
      // maybe print an error message
      // maybe throw an exception
  }
}
```

toString Method

- Returns a text representation of the object
  - The text representation typically contains all or most of the instance data variables
- Automatically called behind-the-scenes when the object is concatenated with a String or put inside a println method
  - Example: These are equivalent:

```
System.out.println(myObject)
System.out.println(myObject.toString());
```

toString Method

- Has this **exact** header:

```
public String toString() {
    return STRINGVAL;
}
```

`toString` Method

- Be careful- toString doesn't print anything!
- When you invoke toString, it **returns** a String. You then need to take some action with that String.

Class Specific Methods

- The method header is used to declare the method:
  - Visibility
  - Return type
  - Method name
  - Formal parameters
    - List of type and name separated by commas
- Methods represent the functionality for the class.
- Methods often *change the state* of the object (i.e., update the value of the instance data variables).

Practice

- Write a complete class to represent a fraction.
- Include class specific methods to:
  - get the decimal value of the fraction
  - determine if the fraction is reduced (using the greatest common factor)
  - reduce the fraction
  - find the lowest common denominator with another fraction passed in as a parameter
- Write a static method to create a new, reduced fraction.

INHERITANCE

Inheritance

- *Inheritance* allows you to design a new class from an existing class
  - The existing class is called the
    - *parent class*
    - *superclass*
    - *base class*
  - The new class is called the
    - *child class*
    - *Subclass*
    - *derived class*

Inheritance

- Inheritance creates an *is-a* relationship.
  - The child *is a* more specific version of the parent.
- Examples:
  - Parent: BankAccount
  - Child: CheckingAccount, SavingsAccount

  - Parent: Student
  - Child: GraduateStudent, UndergraduateStudent

Inheritance

- The child inherits characteristics of the parent
  - Methods
  - Data
- You can modify the child class by:
  - Adding new methods and variables
  - Modifying inherited methods
- Inheritance is established with the `extends` reserved word
  - Example: `public class GraduateStudent extends Student`

Inheritance and Visibility

- private methods and variables in the parent class **are** inherited into the child class, but they **cannot** be directly accessed.
  - The child class has to use public getters and setters and public methods only, just like all other classes!
- Child classes *can* directly access protected methods and variables.
  - protected visibility does not provide as much encapsulation as private, so you should have a good reason to use it!

Parent Class Constructors

- Constructors are *not* inherited, even though they have public visibility.
    - The child class does not inherit the constructor.
    - The child class needs its own constructor.
    - Often, we still need to set up the “parent’s part” of the object and do additional things for the “child’s part” of the object.
- It’s good practice to call the parent constructor and then add any additional set up needed in the child class.

The `super` Reference

- Use the `super` reference to call the parent's constructor:
  - The child class's constructor calls the parent constructor.
  - The first line of the child constructor should use the `super` reference to call the parent's constructor.
  - Example: `super();` or `super(x, y, z);`
- Without an explicit call, the default constructor of the parent class will be automatically called: `super();`
    - If there is no default constructor in the parent class, you will get a compiler error.

Overriding Methods

- A child class can *override* the definition of an inherited method and provide its own implementation.
- The new method has the same signature (name and parameters) as the parent’s method, but will have a different implementation.

@Override Annotation

- Annotations contain metadata about programs.
- You can use annotations to create new compiler checks.
- @Override will ensure at compile time that the method header is correct.
  - Always best to find an error at compile time rather than try to track it down at runtime!
- It's also a good visual cue to someone reading the code!
- It’s good practice to always use this annotation when overriding a method!

@Override Annotation

- Example:
  - In parent: public void method() { …}
  - In child (mistake): `public void mthod() {…}` // this is a mistake but will compile fine
  - In child (mistake): `public void method(int n) { … }` // this is a mistake but will compile fine

@Override Annotation

- Example:
  - In parent: public void method() { …}
  - In child (mistake): `@Override public void mthod() { … }` // this will no longer compile
  - In child (mistake): `@Override public void method(int n) { … }` // this will no longer compile

Overriding Methods

- When you override a method, you want to either:
  - Do something different
  - Do what the parent method does, but do more
- To *add on* to the parent's method, you can use the `super` reference.
  - Invoke the parent version of the method with `super.method();`

The `super` Reference

- Two uses of `super`:
  - Invoke the parent constructor (using super(…))
    - Must be first line of the constructor!
  - Invoke the parent's version of an overridden method (using super.parentMethod(…))
    - Can be used anywhere!
    - Can be used to invoke *any* parent method.

POLYMORPHISM

Object Type

- All variables in Java have a type.
  - Primitive or object
- Object variables actually have *two* types:
  - Declared Type
  - Actual Type

Declared Type

- The declared type is the type listed when you first declare a variable.
  - Example:

```
Student student;
BankAccount account;
String text;
```

- The declared type is declared only once and cannot be changed.

Declared Type

- The compiler **only** knows about the declared type.
- In order for your code to compile, any method invoked must exist in the **declared** class.
  - Either directly or through inheritance.

Actual Type

- Object variables also have an **actual type**.
- The actual type is based on how the object is created (usually by a call to the constructor).
- The actual type might change throughout the program or across different runnings of the program.

Actual Type

- The actual type is not considered at compile time.
- The actual type is used at runtime.

Actual Type and Declared Type

- The actual type must be **compatible with** the declared type.
- Actual class must be the same class, a child class, or any other class lower on the inheritance tree.
- If declared type is an interface, the actual class must be some class that implements that interface.

Actual Type

- If the code compiles, we know that a method exists in the declared class.
- At run time, the actual type is used to determine **which version** of a method is invoked.
  - The most specific version will be invoked- the one closest to the actual type.

Example

```
public class Student {
    …
    public void printInfo() {}
}

public class UndergradStudent extends
Student {
    …
    @Override
    public void printInfo() {}
}
```

Example

```
public class Student {
   …
   public void printInfo() {}
}

public class UndergradStudent extends Student {
   …
   @Override
   public void printInfo() {}
}


Student student1;  // declared type: Student
                   // actual type not yet known- could be
                   //   Student or UndergradStudent
```

Example

```
public class Student {
   …
   public void printInfo() {}
}

public class UndergradStudent extends Student {
   …
   @Override
   public void printInfo() {}
}


Student student1 = new Student();
               // declared type: Student
               // actual type: Student
```

Example

```
public class Student {
   …
   public void printInfo() {}
}

public class UndergradStudent extends Student {
   …
   @Override
   public void printInfo() {}
}


Student student1 = new UndergradStudent();
                  // declared type: Student
                  // actual type: UndergradStudent
                  // allowed because UndergradStudent is child of Student
```

Example

```
public class Student {
   …
   public void printInfo() {}
}

public class UndergradStudent extends Student {
   …
   @Override
   public void printInfo() {}
}


UndergradStudent student1 = new UndergradStudent();
              // declared type: UndergradStudent
              // actual type: UndergradStudent
```

Example

```
public class Student {
   …
   public void printInfo() {}
}

public class UndergradStudent extends Student {
   …
   @Override
   public void printInfo() {}
}


UndergradStudent student1 = new Student();
             // COMPILER ERROR!
```

Example

```
public class Student {
   …
   public void printInfo() {}
}

public class UndergradStudent extends Student {
   …
   @Override
   public void printInfo() {}

}

Student student1 = new UndergradStudent();
         // declared: Student; actual: UndergradStudent

student1 = new Student();
         // declared: Student; actual: Student
         // declared cannot change! actual might!
```

Example

```
public class Student {
   …
   public void printInfo() {}
}

public class UndergradStudent extends Student {
   …
   @Override
   public void printInfo() {}

   public void earnBachelorsDegree() { }
}


Student student1 = new UndergradStudent();
       // declared: Student; actual: UndergradStudent
```

Example

```
public class Student {
   …
   public void printInfo() {}
}

public class UndergradStudent extends Student {
   …
   @Override
   public void printInfo() {}

   public void earnBachelorsDegree() { }
}


Student student1 = new UndergradStudent();
// declared: Student; actual: UndergradStudent

student1.printInfo();
// allowed: printInfo exists in Student, the declared type
// at runtime, the version from UndergradStudent is invoked, because that is the actual
type
```

Example

```
public class Student {
   …
   public void printInfo() {}
}

public class UndergradStudent extends Student {
   …
   @Override
   public void printInfo() {}

   public void earnBachelorsDegree() { }
}


Student student1 = new UndergradStudent();
// declared: Student; actual: UndergradStudent

student1.earnBachelorsDegree();
// COMPILER ERROR!
// earnBachelorsDegree() is not in the declared class
```

Polymorphism

- *Polymorphism* means “having many forms”
- A *polymorphic reference* is a variable that can refer to different types of objects at different points in time
- The method invoked through a polymorphic reference can change from one invocation to the next
- In Java, all object references are potentially polymorphic

Object References

- You can declare an object (left hand side) to be of a type high up on the inheritance hierarchy.
- You can then instantiate that object (right hand side) to be that same type or any type lower on the hierarchy.

Example

```
public class Employee
public class UnpaidEmployee extends Employee
public class PaidEmployee extends Employee
public class SalariedPaidEmployee extends PaidEmployee
public class HourlyPaidEmployee extends PaidEmployee
```

Example

```
public class Employee
public class UnpaidEmployee extends Employee
public class PaidEmployee extends Employee
public class SalariedPaidEmployee extends PaidEmployee
public class HourlyPaidEmployee extends PaidEmployee


Employee e;
      // declared type: Employee
      // actual type could be any of these 5 classes!
```

Example

```
public class Employee
public class UnpaidEmployee extends Employee
public class PaidEmployee extends Employee
public class SalariedPaidEmployee extends PaidEmployee
public class HourlyPaidEmployee extends PaidEmployee
```

```
Employee e = new Employee();
Employee e = new HourlyPaidEmployee();
PaidEmployee e = new SalariedPaidEmployee();
PaidEmployee e = new UnpaidEmployee(); // COMPILER ERROR
```

declared type

actual type

Using Polymoprhism

- Why would we want to use a different declared and actual type?
- We often don't with a single variable.
- Polymoprhism allows us to group together objects into one collection!

Example

```
public class Employee
public class UnpaidEmployee extends Employee
public class PaidEmployee extends Employee
public class SalariedPaidEmployee extends PaidEmployee
public class HourlyPaidEmployee extends PaidEmployee

ArrayList<Employee> list = new ArrayList<Employee>();
list.add(new Employee());
list.add(new HourlyPaidEmployee());
list.add(new SalariedPaidEmployee());
list.add(new UnpaidEmployee());
```

Example

```
public class Employee
public class UnpaidEmployee extends Employee
public class PaidEmployee extends Employee
public class SalariedPaidEmployee extends PaidEmployee
public class HourlyPaidEmployee extends PaidEmployee

ArrayList<Employee> list = new ArrayList<Employee>();
   // all objects in the list have declared type Employee
list.add(new Employee()); // actual type: Employee
list.add(new HourlyPaidEmployee()); // actual: Hourly
list.add(new SalariedPaidEmployee()); // actual: Salaried
list.add(new UnpaidEmployee()); // actual: Unpaid
```

Example

```
public class Employee {
          public void hire() {}
}
public class UnpaidEmployee extends Employee {
          @Override
          public void hire() { }
public class PaidEmployee extends Employee {
          public void pay() {}
}
public class SalariedPaidEmployee extends PaidEmployee {
          @Override
          public void pay() {}
}
public class HourlyPaidEmployee extends PaidEmployee

ArrayList<Employee> list = new ArrayList<Employee>();
list.add(new Employee()); // invoke version in Employee
list.add(new HourlyPaidEmployee()); // invoke version in Employee
list.add(new SalariedPaidEmployee()); // invoke version in Employee
list.add(new UnpaidEmployee()); // invoke version in UnpaidEmployee
for(Employee e : list) {
   e.hire();
   // compiles because there is a hire() method in the Employee class
   // will invoke the proper version based on runtime, actual type
}
```

Example

```
public class Employee {
          public void hire() {}
}
public class UnpaidEmployee extends Employee {
          @Override
          public void hire() { }
public class PaidEmployee extends Employee {
          public void pay() {}
}
public class SalariedPaidEmployee extends PaidEmployee {
          @Override
          public void pay() {}
}
public class HourlyPaidEmployee extends PaidEmployee

ArrayList<Employee> list = new ArrayList<Employee>();
list.add(new Employee());
list.add(new HourlyPaidEmployee());
list.add(new SalariedPaidEmployee());
list.add(new UnpaidEmployee());
for(Employee e : list) {
   e.pay();
   // COMPILER ERROR- pay does not exist in declared class Employee
}
```

Example

```
public class Employee {
          public void hire() {}
}
public class UnpaidEmployee extends Employee {
          @Override
          public void hire() { }
public class PaidEmployee extends Employee {
          public void pay() {}
}
public class SalariedPaidEmployee extends PaidEmployee {
          @Override
          public void pay() {}
}
public class HourlyPaidEmployee extends PaidEmployee

ArrayList< PaidEmployee > list = new ArrayList< PaidEmployee >();
list.add(new Employee()); // COMPILER ERROR
list.add(new HourlyPaidEmployee());
list.add(new SalariedPaidEmployee());
list.add(new UnpaidEmployee()); // COMPILER ERROR
for(PaidEmployee e : list) {
   e.pay();

}
```

Example

```
public class Employee {
          public void hire() {}
}
public class UnpaidEmployee extends Employee {
          @Override
          public void hire() { }
public class PaidEmployee extends Employee {
          public void pay() {}
}
public class SalariedPaidEmployee extends PaidEmployee {
          @Override
          public void pay() {}
}
public class HourlyPaidEmployee extends PaidEmployee

ArrayList< PaidEmployee > list = new ArrayList< PaidEmployee >();
~~list.add(new Employee());~~
list.add(new HourlyPaidEmployee()); // invokes version in PaidEmployee
list.add(new SalariedPaidEmployee()); // invokes version in SalariedPaidEmployee
~~list.add(new UnpaidEmployee());~~
for(PaidEmployee e : list) {
   e.pay();
   // compiles because there is a hire() method in the PaidEmployee class
   // will invoke the proper version based on runtime, actual type
}
```

Polymorphism

- This is polymorphism!
- An employee object invoking the pay method could invoke different versions of the method depending on the *actual type* of the object.

Summary

- You can declare an object (left hand side of assignment statement) to be of a type high up on the inheritance hierarchy. You can then instantiate that object (right hand side of assignment statement) to be of any type lower on the hierarchy.

Summary

- When you declare an object variable, you specify the declared type (left hand side of the assignment).
  - The declared type cannot change.
  - The compiler only knows about this type.
  - The compiler only allows you to invoke methods in this declared class.
- At runtime, the JVM knows the *actual* type of the object (right hand side of the assignment).
  - It is based on how the object was created (e.g., a constructor).
  - It could be the declared type or any subclass of the declared type.
  - The actual type might not always be the same at different times in the same program or at different runnings of the program.
  - The actual type is used to invoke the correct version of a method.

Downcasting

- You *can* invoke a method that exists in the child class actual class but not the parent class declared class.
- To do this, you have to *downcast*.
- You should always use the `instanceof` operator with a downcast.

Example

```
public class Employee {
       public void hire() {}
}
public class PaidEmployee extends Employee {
       public void pay() {}
}

ArrayList<Employee> list = new ArrayList<Employee>();
list.add(new Employee());
list.add(new HourlyPaidEmployee());
list.add(new SalariedPaidEmployee());
list.add(new UnpaidEmployee());
for(Employee e : list) {
   e.pay(); // COMPILER ERROR- pay does not exist in Employee
}
```

Example

```
public class Employee {
       public void hire() {}
}
public class PaidEmployee extends Employee {
       public void pay() {}
}

ArrayList<Employee> list = new ArrayList<Employee>();
list.add(new Employee());
list.add(new HourlyPaidEmployee());
list.add(new SalariedPaidEmployee());
list.add(new UnpaidEmployee());
for(Employee e : list) {
   if(e instanceof PaidEmployee) {
      PaidEmployee p = (PaidEmployee) e;
      p.pay();
   }
}
```

Example

```
public class Employee {
       public void hire() {}
}
public class PaidEmployee extends Employee {
       public void pay() {}
}

ArrayList<Employee> list = new ArrayList<Employee>();
list.add(new Employee());
list.add(new HourlyPaidEmployee());
list.add(new SalariedPaidEmployee());
list.add(new UnpaidEmployee());
for(Employee e : list) {
   if(e instanceof PaidEmployee) {
      ((PaidEmployee) e).pay();
}
}
```

tells the compiler to temporarily treat e like a PaidEmployee; does **not** change the type of e!

Downcasting

- instanceof is a safety check that you have the right type.
  - Best practice!!!
- The cast is the command to the compiler.
- You need to do both!

Example

```
public class Employee {
       public void hire() {}
}
public class PaidEmployee extends Employee {
       public void pay() {}
}

ArrayList<Employee> list = new ArrayList<Employee>();
list.add(new Employee());
list.add(new HourlyPaidEmployee());
list.add(new SalariedPaidEmployee());
list.add(new UnpaidEmployee());
for(Employee e : list) {
   if(e instanceof PaidEmployee) {
      e.pay(); // COMPILER ERROR- declared type is still
               // Employee because the compiler evaluates this
               // line on its own- it doesn't look at the if
   }
}
```

Example

```
public class Employee {
       public void hire() {}
}
public class PaidEmployee extends Employee {
       public void pay() {}
}

ArrayList<Employee> list = new ArrayList<Employee>();
list.add(new Employee());
list.add(new HourlyPaidEmployee());
list.add(new SalariedPaidEmployee());
list.add(new UnpaidEmployee());
for(Employee e : list) {
   ((PaidEmployee) e).pay(); // will compile, but this is
              // dangerous because if the object isn't (actual)
              // type PaidEmployee, the code will throw a
              // runtime exception and crash
}
```

THE EQUALS METHOD

Comparing Objects for Equality

- It's a common thing to compare two objects to see if they are *the same*.
- Sometimes we do this directly, sometimes it happens indirectly.
    - Example: asking a list if it contains a certain object.

Comparing Objects for Equality

- What does *the same* mean?
- Usually, we want *the same* to mean *logically equivalent*.
- This means *the same* based on the data that describes them (their instance data variables).
  - Example: students with the same ID
  - Example: employees with the same name and ID
  - Example: books with the same title, author, publisher, and year

Comparing Objects for Equality

- All objects inherit an equals method that can be invoked to determine equality.

```
objectA.equals(objectB);
```

- But the default version of this method does **not** compare objects based on any data that describes the object.
- The default version only compares whether the objects are **aliases**.

The Inherited Version of equals

- `public boolean equals(Object obj)`

- The inherited version returns true if the parameter is an **alias** with the invoking object.
  - Reference that point to the exact same object (the same place in memory) are *aliases.*

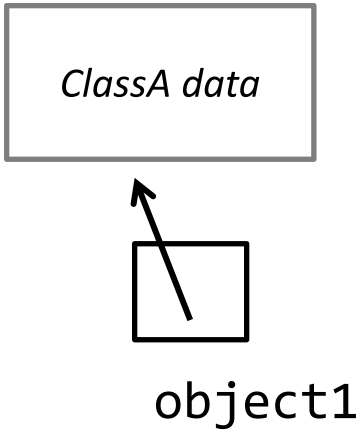
Alias

- Aliases: References that point to the exact same object (the same place in memory)

```
ClassA object1 = new ClassA(…);
ClassA object2 = object1;
boolean result = object1.equals(object2);
```

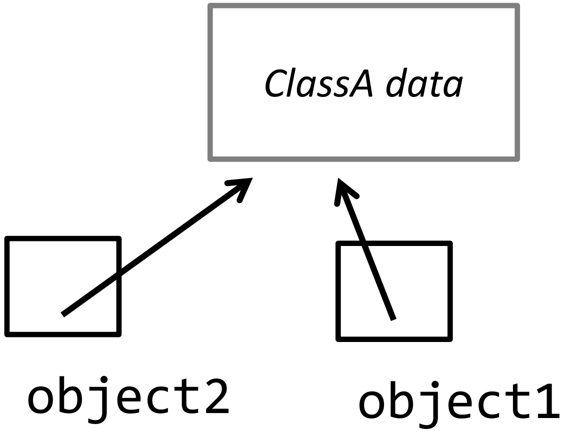
Alias

```
ClassA object1 = new ClassA(…);
ClassA object2 = object1;
boolean result = object1.equals(object2);
```



Alias

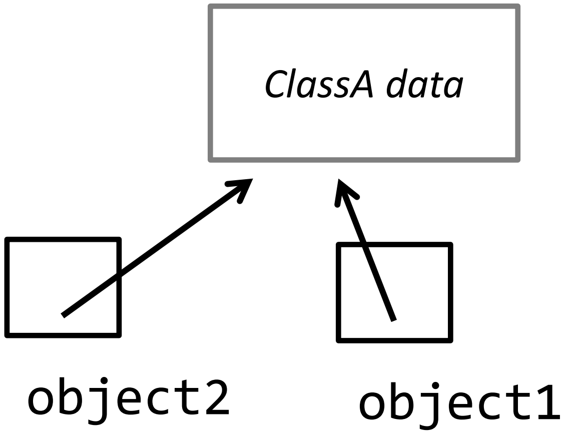
```
ClassA object1 = new ClassA(…);
ClassA object2 = object1;
boolean result = object1.equals(object2);
```



the value on the right (a memory address) gets put in the variable on the left

Alias

```
ClassA object1 = new ClassA(…);
ClassA object2 = object1;
boolean result = object1.equals(object2);
   // true!
```



The Inherited Version of equals

- The inherited version returns true if two references are **aliases**
- *Sometimes* this might be what we want… but it's usually not.

- Note: The == operator has this same functionality.
  - So if we want to check for aliases, we can always use ==

Overriding equals

- You can override this method to define *meaningful* or *logical* equality in a more appropriate way
    - Examples: same ID, same name, etc.
    - Example: `String` overrides equals to return true if two `String` objects contain the same characters

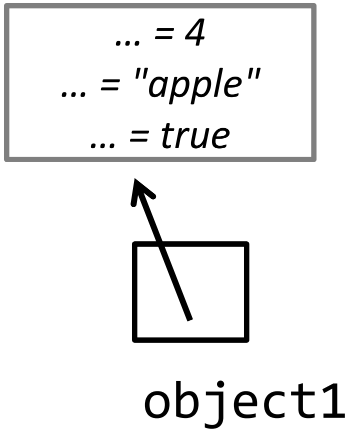
Logically Equivalent

- Aliases: References that point to the exact same object (the same place in memory)
- Logically Equivalent references are "the same" in some meaningful way.

```
ClassA object1 = new ClassA(4, "apple", true);
ClassA object2 = new ClassA(4, "apple", true);
boolean result = object1.equals(object2);
```

Logically Equivalent

```
ClassA object1 = new ClassA(4, "apple", true);
ClassA object2 = new ClassA(4, "apple", true);
boolean result = object1.equals(object2);
```



… = 4

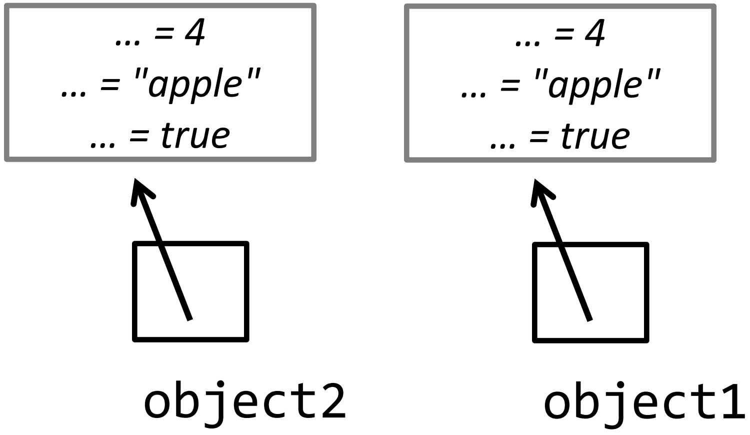
… = "apple"

… = true

object1

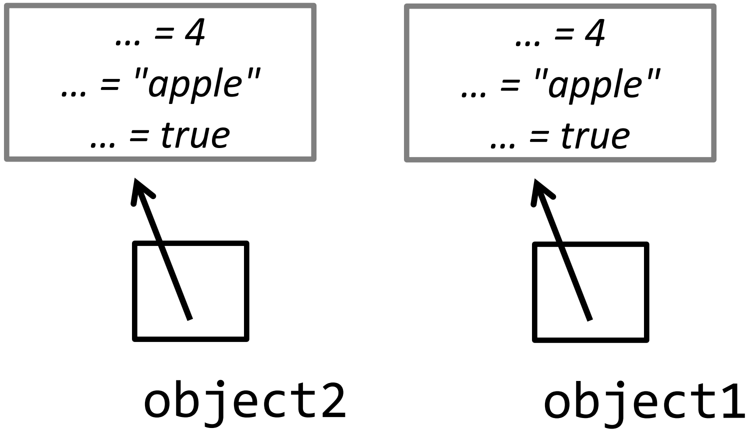
Logically Equivalent

```
ClassA object1 = new ClassA(4, "apple", true);
ClassA object2 = new ClassA(4, "apple", true);
boolean result = object1.equals(object2);
```



Logically Equivalent

```
ClassA object1 = new ClassA(4, "apple", true);
ClassA object2 = new ClassA(4, "apple", true);
boolean result = object1.equals(object2);
      // false!
```



Overriding equals

- Override the inherited method to specify what makes an object *logically equivalent* or "the same as" another object.
- Inside the equals method, compare instance data variables.

Overriding equals

- The parameter is type Object (not ClassA, etc.) so we first need to check that we've been given an object with the right type.
- We do this with the `instanceof` operator
  - `instanceof` returns a boolean that represents whether an object is an *instance of* a class
- Example:

```
    if(obj instanceof ClassA) {
```

Overriding equals

- If the parameter is the right type, we use a *cast* to tell the compiler that we want to treat the parameter as that type.
- Example:

```
if(obj instanceof ClassA) {
    ClassA other = (ClassA) obj;
```

Overriding equals

- It's critical to use `instanceof` **and** the cast.
  - `instanceof` ensures there are no runtime `ClassCastException` crashes.
  - the cast tells the compiler to treat the object as that type, which allows you to access the object's instance data variables.

Overriding equals

- Finally, we compare whatever information we are using to determine equality.
- We do this by comparing instance data variables of the current object ("`this`") to the parameter.
- Comparing variables:
  - If the variables are objects, use the `equals` method
  - For Strings, you can use `equals` or `equalsIgnoreCase`
  - For `int`, `boolean`, `chars`, use ==
  - For `double` and `float`, use:

```
Math.abs(dub1-dub2) < threshold
```

Overriding Equals

```
@Override
public boolean equals(Object obj) {
    if(obj instanceof MyClass) {
        MyClass other = (MyClass) obj;

        // compare whether the variables are the same, e.g., :
        // this.objectVar.equals(other.objectVar)
        // this.intVar==other.intVar

    } else {
        return false;
    }
}
```

The `equals` Method header

- A common error is to accept a parameter of your class, instead of object.
- This is incorrect because this method no longer overrides the inherited method!
- Be very careful not to do this!

✗

```
public boolean equals(Employee e)
```

NULL

null

- null is a keyword/reserved word in Java
- null represents **no value**

null as a Default Value

- Instance data variables are given a default value when they are declared.
  - Local variables are not.
- Each data type has a value that is used for the default value.
- null is the default value for objects when they have been declared but not initialized.
  - private int age; // default value for int is 0
  - private String name; // default value of name is null
  - private Student s; // default value of s is null

null as a Value

- null is a value that can be assigned to any *object* reference (variable).
- null cannot be assigned to primitives.
- Examples:
  - Student s = null; // allowed
  - int n = null; // not allowed
  - Integer m = null; // allowed

What can you do with null?

- Compare it with ==
- Examples:
  - if(student!=null) { … }
  - if(student!=null && student.meetsCriteria()) { … }

What **can't** you do with null?

- Pretty much anything else!
- Most importantly: you cannot invoke any methods or try to access any variables on null.
- Invoking a method on a null object will throw a NullPointerException, which will crash your program.
  - This is a bad exception because it is almost always a result of programmer error.
  - This is almost always entirely preventable.

What **can’t** you do with null?

- Example:
  - String s = null
  - s.equals(“hello”); // crash!
  - s==“hello”; // allowed- will not crash, returns false
- Example:
  - Student student = null;
  - System.out.println(student.name); // crash!

null and Linked Nodes

- null will matter a lot when we cover nodes and linked lists!!

null and Strings

- A string whose value is the empty String is **not** null.
- An empty String is a String that does not contain any characters. (But it is not null!)
  – String s1 = “”; // empty string! length = 0
  – String s2 = null; // no length- no value!
  – s1==s2; // false

null and Strings

```
String s1 = "";
String s2 = null;
String s3; // value is also null

System.out.println(s1.toUpperCase());
// allowed- but nothing will be printed!

System.out.println(s1.length());
// allowed and will print 0

System.out.println(s2.toUpperCase());
// not allowed- will crash with NullPointerException

System.out.println(s3.length());
// not allowed- will crash with NullPointerException
```

CODING CONVENTIONS

Conventions- Why do they matter?

- Makes code more readable
- Makes code easier to maintain (by you or, more likely, by others)
- Provides a quick signifier to the reader of the type of information (e.g., variable, constant, class)
- Offers an indicator of the quality of your code
  - Oracle: If you ship your source code as a product, you need to make sure it is as well packaged and clean as any other product you create.
- More in-depth discussion: http://hilton.org.uk/presentations/naming-guidelines

Java Conventions

- Oracle: https://www.oracle.com/technetwork/java/javase/overview/codeconvtoc-136057.html
- Google: https://google.github.io/styleguide/javaguide.html
- GitHub: https://github.com/twitter/commons/blob/master/src/java/com/twitter/common/styleguide.md

Variables

- lowerCamelCase
  - first letter lowercase, first letter of each internal word capitalized
- descriptive and meaningful
  - avoid one-character names except for temporary variables (like looping variables)

- This applies to parameters, too!

Constants

- ALL_CAPS_WITH_UNDERSCORES
- From Oracle: Numerical constants (literals) should not be coded directly, except for -1, 0, and 1, which can appear in a for loop as counter values.

Methods

- lowerCamelCase
- descriptive
- often contains a verb

Classes and Interfaces

- UpperCamelCase
  - first letter and each internal word capitalized
- Simple and Descriptive
- Often a singular noun
- Use whole words
- Avoid acronyms and abbreviations (unless abbreviation is much more widely used, such as URL or HTML)

Others

- Oracle: It is generally a good idea to use parentheses liberally in expressions involving mixed operators to avoid operator precedence problems. Even if the operator precedence seems clear to you, it might not be to others-you shouldn't assume that other programmers know precedence as well as you do.
- Use indentation and whitespace to improve readability

A Final Thought

“Coding conventions should be used as a guide, not as a sacred, immutable law of nature.

Those with less experience will initially benefit from following conventions, but as you gain experience, you should rely more on your own sense of taste, as opposed to blindly following the rules. The problem with rules is that there are many cases in which they should be broken.

In general, the question in your mind should always be one of **compassion for the reader**: *"Will this help or hinder a maintainer who is unfamiliar with my code?"*. That is the guiding principle.”

Source: http://www.javapractices.com/topic/TopicAction.do?Id=115