Unit 5: Writing Classes
Variables, Scope and Semantics

Adapted from:

1) Building Java Programs: A Back to Basics Approach
by Stuart Reges and Marty Stepp

2) Runestone CSAwesome Curriculum

https://longbaonguyen.github.io

Static Variables

```
private static type name;
```

or,

```
private static type name = value;
```

- Example:

```
private static int theAnswer = 42;
```

static variable: Stored in the class instead of each object.

- A "shared" global field that all objects can access and modify.
- Like a class constant, except that its value can be changed.

Final Static fields

```
public static final type name;
```

or,

```
public static final type name = value;
```

- Example:

```
public static final int NUMOFMONTHS = 12;
```

Final static variable:

- A class constant whose value cannot be changed. Usually public.
- ALL CAPS by convention.

Instance Variables

```
private type name;
```

or,

```
private type name = value;
```

- Example:

```
private int id = 243342;
```

instance variable: Stored in an object instead of the class.

- each object has its own copy of the instance variable.

BankAccount solution

```
public class BankAccount {
    // static count of how many accounts are created
    // (only one count shared for the whole class)
    private static int objectCount = 0;

    // instance variables (replicated for each object)
    private String name;
    private int id;

    public BankAccount(String n) {
        name = n;
        objectCount++;      // advance the id, and
        id = objectCount;   // give number to account
    }
    // clients can call this to find out # accounts created
    public static int getNumAccounts() {
        return objectCount;
    }

    ...
    public int getID() {    // return this account's id
        return id;
    }
}
```

Static vs Instance Call

A static method is called through the name of the class.
An instance method is called through the name of an object.

```
public class Main {
    public static void main(String[] args) {
      BankAccount a = new BankAccount("Jim Smith");

      //getID is instance
      // uses object name + dot notation to call
      System.out.println(a.getID());

      //getNumAccounts is static
      // uses class name + dot notation to call
      System.out.println(BankAccount.getNumAccounts());

    }
}
```

Error: Static Access

```
public class BankAccount {

    private static int objectCount = 0;


    private String name;
    private int id;

    public BankAccount(String n) {
        name = n;
        objectCount++;
        id = objectCount;
    }

    public static int getNumAccounts() {
        System.out.println(name);
        System.out.println(this.id);
        return objectCount;
    }

    ...
    }
```

Error! static method does not have access to any particular object's variables!

(No implicit this parameter)

The `this` keyword

`this` : Within a non-static method or a constructor, the keyword **this** is a reference to the current object—the object whose method or constructor is being called.

- Refer to a field: `this.`**field**
- Call a method: `this.`**method**`(`**parameters**`);`
- One constructor can call another: `this(`**parameters**`);`

Note: "this" can be omitted if it is clear which variable is being referenced. The keyword "this" is helpful to fix the shadowing problem. We discuss this next.

Variable shadowing

- **shadowing**: 2 variables with same name in same scope.
  - Normally illegal, except when one variable is a field.

```
public class Point {
    private int x;
    private int y;

    ...

    // this is legal
    public void setLocation(int x, int y) {
        ...
    }
```

  - In most of the class, `x` and `y` refer to the instance variables.
  - In `setLocation`, `x` and `y` refer to the method's parameters.

Fixing shadowing

```
public class Point {
    private int x;
    private int y;

    ...

    public void setLocation(int x, int y) {
        this.x = x;
        this.y = y;
    }
}
```

- Inside `setLocation`,
  - To refer to the data field `x`, say `this.x`
  - To refer to the parameter `x`, say `x`

Printing objects

By default, Java doesn't know how to print objects:

```
Point p = new Point(10,7);
System.out.println("p is " + p);  // p is Point@9e8c34


// better, but cumbersome; p is (10, 7)
System.out.println("p is (" + p.getX() + ", " +
                               p.getY() + ")");


// desired behavior
System.out.println("p is " + p);  // p is (10, 7)
```

The `toString` method

The `toString` method tells Java how to convert an object into a String.

```
Point p1 = new Point(7, 2);
System.out.println("p1: " + p1);

// the above code is really calling the following:
System.out.println("p1: " + p1.toString());
```

- Every class has a `toString`, even if it isn't in your code.
  - Default: class's name `@` object's memory address (base 16)

```
Point@9e8c34
```

`toString` syntax

`toString` can be overwritten to return a desired String representation of the object.

```
public String toString() {
        code that returns a String representing this object;
}
```

- Method name, return, and parameters must match exactly.
- Example:

```
// Returns a String representing this Point.
public String toString() {
    return "(" + x + ", " + y + ")";
}
```

Point class

```
// A Point object represents an (x, y) location.
public class Point {
    private int x;
    private int y;

    public Point(int initialX, int initialY) {
        x = initialX;
        y = initialY;
    }
    // accessor methods
    public int getX() {
        return x;
    }

    public int getY() {
        return y;
    }

   public String toString() {
      return "(" + x + ", " + y + ")";
    }

    public void setLocation(int newX, int newY) {
        x = newX;
        y = newY;
    }

    public void translate(int dx, int dy) {
        setLocation(x + dx, y + dy);
    }
}
```

Client code

```
public class PointMain {
    public static void main(String[] args) {

        Point p1 = new Point(5, 2);
        Point p2 = new Point(4, 3);

        System.out.println("p1: ” + p1);
         //same as above
        System.out.println(”p2: ” + p2.toString());



}
}
```

OUTPUT:

```
p1:(5,2)
p2:(4,3)
```

Limitations of variables

- Idea: Make a variable to represent the size.
  - Use the variable's value in the methods.

- Problem: A variable in one method can't be seen in others.

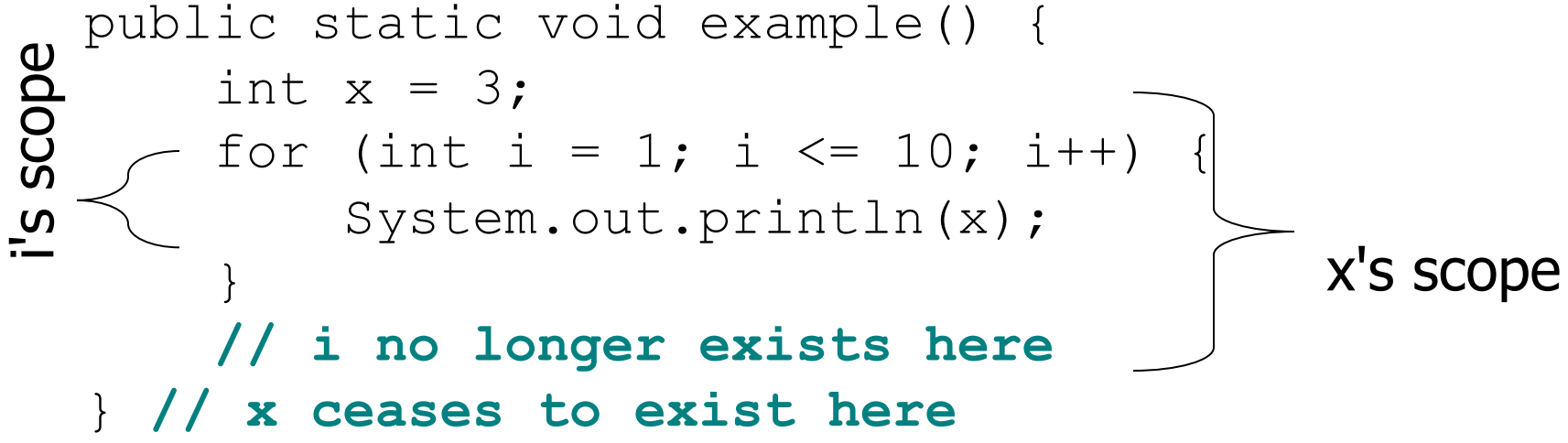
```
public static void main(String[] args) {
    int size = 4;
    topHalf();
    printBottom();
}

public static void topHalf() {
    for (int i = 1; i <= size; i++) {    // ERROR: size not found
        ...
    }
}

public static void bottomHalf() {
    for (int i = size; i >= 1; i--) {    // ERROR: size not found
        ...
    }
}
```

Scope

- **scope**: The part of a program where a variable exists.
  - From its declaration to the end of the `{ }` braces
    - A variable declared in a `for` loop exists only in that loop.
    - A variable declared in a method exists only in that method.



Scope implications

- Variables without overlapping scope can have same name.

```
for (int i = 1; i <= 100; i++) {
    System.out.print("A");
}
for (int i = 1; i <= 100; i++) {    // OK
    System.out.print("BB");
}
int i = 5;                          // OK: outside of loop's scope
```

- A variable can't be declared twice or used out of its scope.

```
for (int i = 1; i <= 100 * line; i++) {
    int i = 2;                      // ERROR: overlapping scope
    System.out.print("/");
}
i = 4;                              // ERROR: outside scope
```

Example

```
if( x <= 3)
{
  int y = 2;
  …
}

y = 5; // error since y does not exist outside
       // the if block
```

Swapping values

```
public static void main(String[] args) {
    int a = 7;
    int b = 35;

    // swap a with b?
    a = b;
    b = a;

    System.out.println(a + " " + b);
}
```

– What is wrong with this code? What is its output?

- The red code should be replaced with:

```
int temp = a;
a = b;
b = temp;
```

A `swap` method?

- Does the following `swap` method work? Why or why not?

```
public static void main(String[] args) {
    int a = 7;
    int b = 35;

    // swap a with b?
    swap(a, b);

    System.out.println(a + " " + b);
    // 7 35 (unchanged)
}
public static void swap(int a, int b) {
    int temp = a;
    a = b;
    b = temp;
}
```

Value semantics

- **value semantics**: Behavior where values are copied when assigned, passed as parameters, or returned.
  - All primitive types in Java use value semantics.
  - When one variable is assigned to another, its value is copied.
  - Modifying the value of one variable does not affect others.

```
int x = 5;
int y = x;      // x = 5, y = 5
y = 17;         // x = 5, y = 17
x = 8;          // x = 8, y = 17
```

Reference semantics (objects)

- **reference semantics**: Behavior where variables actually store the address of an object in memory.
  - When one variable is assigned to another, the object is *not* copied; both variables refer to the *same object*(aliases).
  - Modifying the value of one variable *will* affect others.

```
Sprite a = new Sprite(10.0, 20.0);
Sprite b = a;// refers to the same Sprite object as a
b.center_x = 50.0;
System.out.println(a.center_x); // 50.0
```

Objects as parameters

Custom objects(except String) use reference semantics. Why?

- *efficiency.* Copying large objects slows down a program.
- *sharing.* It's useful to share an object's data among methods.

When an object is passed as a parameter, the object is *not* copied. The parameter refers to the same object.

- If the parameter is modified, it *will* affect the original object.

Value Semantics

The primitive types int, double, boolean all use value semantics.

Example:

```
   public static void triple(int number) {
       number = number * 3;
  }
   public static void main(String[] args) {

           int x = 2;
           triple(x);
           System.out.println(x); // x is unchanged!

}
```

Value Semantics

String uses value semantics like primitive types.

Example:

```
   public static void repeat(String str) {
       str = str + str;
  }
   public static void main(String[] args) {

           String str = “hi”;
           repeat(str);
           System.out.println(str); // "hi"
}
```

Reference Semantics

In the example below, a and b both reference the same object. They are aliases. Modifying one will modify the other.

Example:

```
   public static void moveRight(Sprite b) {
             b.center_x += 5.0;
       }
  }
   public static void main(String[] args) {

            Sprite a = new Sprite(100.0, 200.0);
            moveRight(a);
            System.out.println(a.center_x);
            // 105.0
}
```

Summary of Java classes

- A class is used for any of the following in a large program:
  - a *program* : Has a main and perhaps other static methods.
    - example: `GuessingGame`, `Birthday`, `MadLibs`,
    - does not usually declare any static fields (except `final`)
  - an *object class* : Defines a new type of objects.
    - example: `Point`, `BankAccount`, `Date`, `Car`, `TetrisPiece`
    - declares object fields, constructor(s), and methods
    - might declare static fields or methods, but these are less of a focus
    - should be encapsulated (all fields and static fields `private`)
  - a *module* : Utility code implemented as static methods.
    - example: `Math`

References

1) Building Java Programs: A Back to Basics Approach by Stuart Reges and Marty Stepp

2) Runestone CSAwesome Curriculum: https://runestone.academy/runestone/books/published/csawesome/index.html

For more tutorials/lecture notes in Java, Python, game programming, artificial intelligence with neural networks:

https://longbaonguyen.github.io