STUDENT OUTLINE

Lesson 12 – Object References

INTRODUCTION: This lesson discusses object reference variables. These variables refer to objects (as opposed to holding a primitive data value.)

The key topics for this lesson are:

A. Primitive Data Type Variables
B. Object Reference variables
C. Variable Versus Object Reference Assignment
D. Object References
E. The == operator with Variables and Object References
F. The `equals()` Method.
G. The **`null`** Value.

VOCABULARY:

PRIMITIVE DATA	OBJECT REFERENCE
GARBAGE COLLECTION	ALIAS
`equals()`	**`null`**

DISCUSSION:

A. Primitive Data Type Variables

1. Java has many data types built into it, and you (as a programmer) can define as many more as you need. Other than the primitive data types, all data types are classes. In other words, data is *primitive* data or *object* data. The only type of data a programmer can define is an object data type (a class).

2. Here is a tiny program that uses a primitive data type:

```
class primitiveDataType
{
  public static void main(String[] args)
  {
    long value;

    primitiveValue = 95124;
    System.out.println(primitiveValue);
  }
}
```

3. In this program, the variable value is the name for a 64 bit section of memory that is used to hold long integers. The statement

```
primitiveValue = 95124;
```

puts a particular bit pattern in that 64 bit section of memory.

4. With primitive data types, a variable is a section of memory reserved for a value of a particular style. For example by saying **`long`** `value`, 64 bits of memory are reserved for an integer. By saying **`int`** `sum`, 32 bits of memory are reserved for an integer.

B. Object Reference variables

1. Since objects are big, complicated, and vary in size you **do not** automatically get an object when you declare an *object reference* variable. For example, in the declaration:

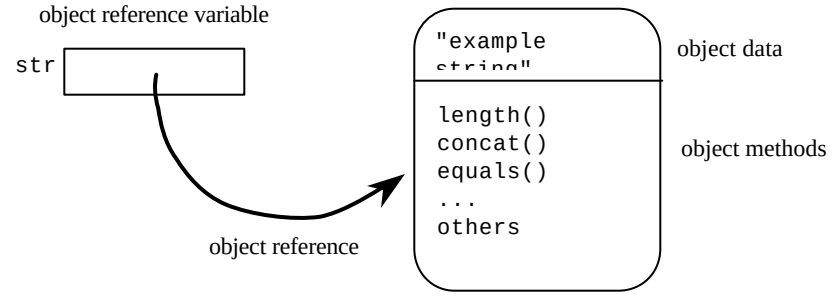
```
String str;
```

the variable `str` does not actually contain the object, but contains information about where the object is. An object reference is information on how to find a particular object. The object is a portion of main memory; a reference to the object serves as a way to get to that portion of memory.

2. Here is a tiny program that declares a reference variable and then creates the object:

```
class StrRefExample
{
  public static void main (String[] args)
  {
    String str;

    str = new String("example string");
    System.out.println(str);
  }
}
```

3. An object contains data and methods (attributes and behaviors). You can visualize the String object in the above program like this:



A String Object

The data section of the object contains the characters. The methods section of the object contains many methods.

4. Objects are created while a program is running. Each object has a unique object reference, which is used to find it. When an object reference is assigned to a variable, then that variable says how to find that object.

C. Variable Versus Object Reference Assignment

1. Notice that there is a difference between the two statements:

```
primitiveValue = 18234;
```

and

```
str = new String("example string");
```

In the first statement, `primitiveValue` is a primitive type, so the assignment statement puts the data directly into it. In the second statement, `str` is an object reference variable (the only other possibility) so a reference to the object is put into that variable.

2. There are only variables containing primitive data and variables containing object references, and each contains a specific kind of information. A variable will *never* contain an object:

Kind of Variable	Information it Contains	When on the left of "="
primitive variable	Contains actual data	Previous data is replaced with new data.
reference variable	Contains information on how to find an object.	Old reference is replaced with a new reference

3. The two types of variable are distinguished by how they are declared. Unless it was declared to be of a primitive type, it is an object reference variable. A variable will not change its declared type.

D. Object References

1. It is possible to reassign an object reference to a new value. For example:

```
class OneStringReference
{
  public static void main (String[] args)
  {
    String str;

    str = new String("first string");
    System.out.println(str);
```

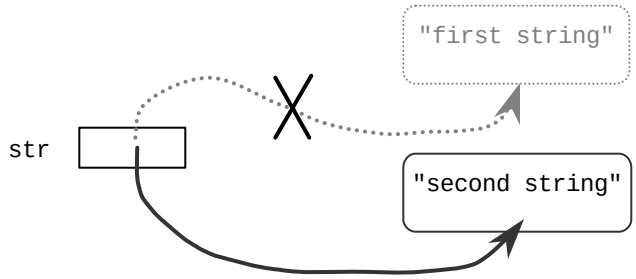
```
    str = new String("second string");
    System.out.println(str);
   }
}
```

Run Output:

```
first string
second string
```

2. Notice that:

   a. Each time the **new** operator is used, a new object is created.
   b. Each time an object is created, there is a reference to it.
   c. This reference is saved in a variable.
   d. Later on, the reference in the variable is used to find the object.
   e. If another reference is saved in the variable, it *replaces* the previous reference (see diagram below).
   f. If no variables hold a reference to an object, there is no way to find it, and it becomes "*garbage*."



3. The word "garbage" is the correct term from computer science to use for objects that have no references. This is a commonly occurring situation, not usually a mistake. As a program executes, a part of the Java system called the "garbage collector" reclaims each lost object (the "garbage") so that memory it used can be available again.

4. Multiple objects of the same class can be maintained by creating unique reference variables for each object.

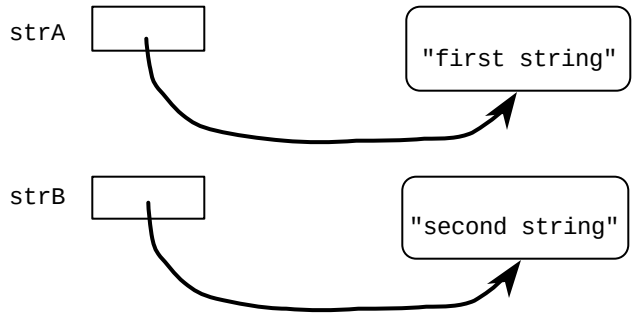
```
class TwoStringReferences
{
  public static void main (String[] args)
  {
    String strA;  // reference to the first object
    String strB;  // reference to the second object

    // create the first object and save its reference
    strA = new String("first string");

    // print data referenced by the first object.
    System.out.println(strA);
```

```
    // create the second object and save its reference
    strB = new String("second string");

    // print data referenced by the first object.
    System.out.println(strB);

    // print data referenced by the second object.
    System.out.println(strA);
  }
}
```

Run Output:

```
first string
second string
first string
```

This program has two reference variables, `strA` and `strB`. It creates two objects and places each reference in one of the variables. Since each object has its own reference variable, no reference is lost, and no object becomes garbage (until the program has finished running.)

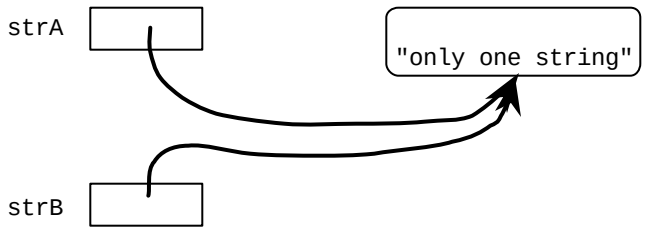


5. Different reference variables that refer to the same object are called *aliases*. In effect, there are two names for the same object. For example:

```
class Alias
{
  public static void main (String[] args)
  {
    String strA;  // reference to the object
    String strB;  // another reference to the object

    // Create the only object and save its
    //   reference in strA
    strA = new String("only one string");
    System.out.println(strA);

    strB = strA;  // copy the reference to strB.
    System.out.println(strB);
  }
}
```

Run Output:

```
only one string
only one string
```



When this program runs, only one object is created (by **`new`**). Information about how to find the object is put into `strA`. The assignment operator in the statement

```
strB = strA; // copy the reference to strB
```

copies the information that is in `strA` to `strB`. It does not make a copy of the object.

E. The == operator with Variables and Object References.

1. The `==` operator is used to look at the contents of two reference variables. If the contents of both reference variables are the same, then the result is **`true`**. Otherwise the result is **`false`**.

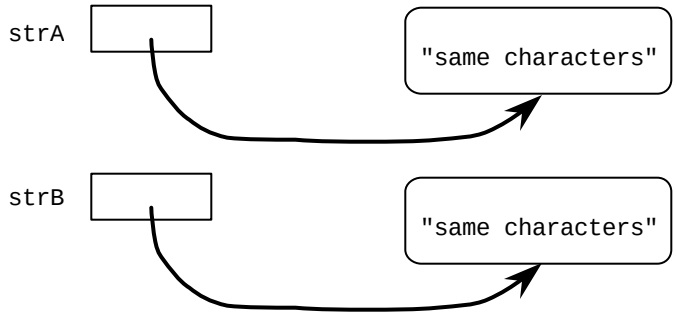
```
class EqualsEquals
{
  public static void main (String[] args)
  {
    String strA;  // reference to the first object
    String strB;  // reference to the second object

    // create the first object and save its reference
    strA = new String("same characters");
    System.out.println(strA);

    // create the second object and save its reference
    strB = new String("same characters");
    System.out.println(strB);

    if (strA == strB)
      System.out.println("This will not print.");
  }
}
```

Run Output:

```
same characters
same characters
```

2. In this program, there are two completely separate objects, `strA` and `strB`, each of which happens to contain the same character data. Each object consists of a section of main memory completely separate from the memory that makes up the other object. The variable `strA` contains information on how to find the first object, and the variable `strB` contains information on how to find the second object.

   Since the information in `strA` is different from the information in `strB`, `(strA == strB)` is false. Since there are two objects, made out of two separate sections of main memory, the reference stored in `strA` is different from the reference in `strB`. It doesn't matter that the data inside the objects looks the same.



3. The == operator *does **not** look at objects*. It only looks at references (information about where an object is located.)

4. For primitive types, the == operator looks only at the variables. For example:

```
int x = 32, y = 48;

if (x == y)                              // false, 32 != 48
  System.out.println("They are equal");

x = y;

if (y)                                 // true, 48 == 48
  System.out.println("Now they are equal");
```

   Run Output:

```
Now they are equal
```

   In this code, only the contents of the variables `x` and `y` are examined. But with primitive types, the contents of a variable is the data, so with primitive types == looks at data.

   The following code fragment contains one additional example; note the different way that the strings are instantiated:

```
String strA = "Hello"
String strB = "Hello"
```

When `strA` and `strB` are compared with `==` the result will be **`true`** because `strA` and `strB` point to the same location in memory, where "Hello" is stored. Java saves memory by not creating "Hello" in two locations.

5. With primitive and reference types, == looks at the contents of the variables. However, with reference types, the variables contain object references and with primitive types, the variables contain the actual data values.

F. The `equals()` Method.

1. The result of == is true if and only if the two variables refer to exactly the same object. You rarely care about that: most likely, you want to compare the contents of two objects. To test whether two objects contain matching data, you'll need to use the `equals` method. Every Java class supports the `equals` method, although the definition of "equals" varies from class to class.

2. `String` is one of the classes for which the equals method compares the contents of objects, so we can use `str1.equals(str2)` to test whether `str1` and `str2` contain the same series of characters.

3. The `equals(String)` method *does* look at the contents of objects. It detects "equivalence." The == operator detects "identity". For example,

```
String strA;  // first object
String strB;  // second object

strA = new String("different object, same characters");
strB = new String("different object, same characters");

if (strA == strB)
  System.out.println("This will NOT print");

if (strA.equals(strB))
  System.out.println("This WILL print");
```

Run Output:

```
This WILL print
```

4. In this example, there are two objects. Since each object has its own identity, == reports **`false`**. Each object contains equivalent data so `equals()` reports **`true`**.

G. The **`null`** Value

1. In most programs, objects are created and objects are destroyed, depending on the data and on what is being computed. A reference variable sometimes does and sometimes does not refer to an object. You need a way to say that a variable does not now refer to an object. You do this by assigning **`null`** to the variable.

2. The value **`null`** is a special value that means "no object." A reference variable is set to **`null`** when it is not referring to any object.

```
class nullDemo
{
  public static void main (String[] args)
  {
    String a =                // 1. an object is created;
        new String("stringy") //    variable a refers to it
    String b = null;          // 2. variable b refers to no
                              //    object.
    String c =                // 3. an object is created
        new String("");       //    (containing no chars)
                              //     variable c refers to it
    if (a != null)            // 4. statement true, so
       System.out.println(a); //    the println(a) executes.

    if (b != null)            // 5. statement false, so the
       System.out.println(b); //    println(b) is skipped.

    if (c != null)            // 6. statement true, so the
       System.out.println(c); //    println(c) executes (but
                              //    it has no characters to
                              //    print).
  }
}
```

Run Output:

```
stringy
```

3. Variables `a` and `c` are initialized to object references. Variable `b` is initialized to **`null`**. Note that variable `c` is initialized to a *reference* to a String object containing no characters. Therefore `println(c)` executes, but it has no characters to print. Having no characters is different from the value being **`null`**.

SUMMARY/REVIEW: It is important to understand how an object reference variable differs from a primitive variable. Nearly every program you write will require you to know this. Unfortunately, the topic can get confusing if you rush through it too quickly.

ASSIGNMENT: Worksheet, W.A.12.1, *Objects and Object References*