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Java for AP Computer Science A

7-6

Static Variables and Methods

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Objectives

- This lesson covers the following objectives:
 - Describe a static variable and demonstrate its use within a program
 - Describe a static method and demonstrate its use within a program
 - Understand how to use the final keyword with static variables



Review of Object References

- An object must be instantiated before its fields and methods can be accessed
- Instantiation provides us with an object reference
- An object reference is used to access an object's fields and methods

```
Prisoner p01 = new Prisoner()  
p01.name           //Accessing a field  
p01.display()      //Calling a method
```

The Math Class Is Different

- It would be tedious to create a new Math object every time we wanted to do a little math
- Thankfully, we never need to instantiate a Math object
- Math fields and methods are accessed by directly referencing the Math class
- These are known as static variables and static methods

```
Math.PI  
Math.sin(0)
```

```
//Nothing instantiated  
//Accessing a static field  
//Calling a static method
```

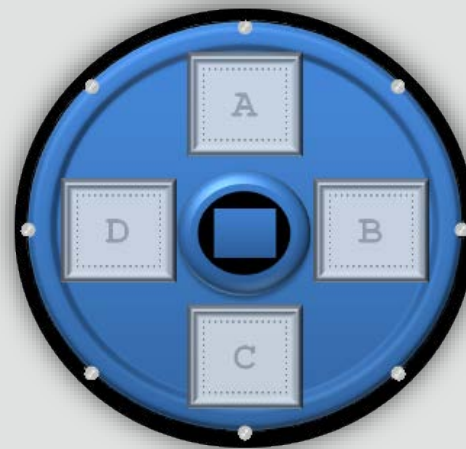
What Does This Mean?

- Why are these two facts important?
 - An object reference is used to access an object's fields and methods
 - Static fields and methods are accessed by directly referencing the class
- There's more to it than just the convenience of not having to instantiate an object
- The next exercise lets you explore a use-case for static data
 - Then we'll debrief you on what you may have noticed



Exercise 1

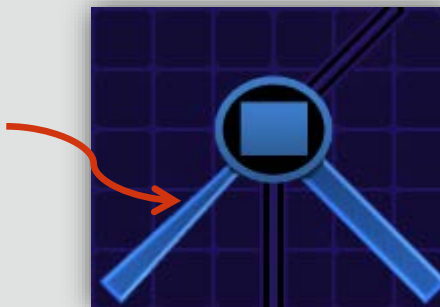
- Play Basic Puzzles 8 through 11
 - <https://objectstorage.ca-toronto-1.oraclecloud.com/n/yzr73ksbiwdp/b/Games/o/JavaPuzzleBall/index.html>
- Consider the following:
 - What happens when you rotate the BlueWheel?
 - How else can you affect the rotation of bumpers?



Java Puzzle Ball Debriefing

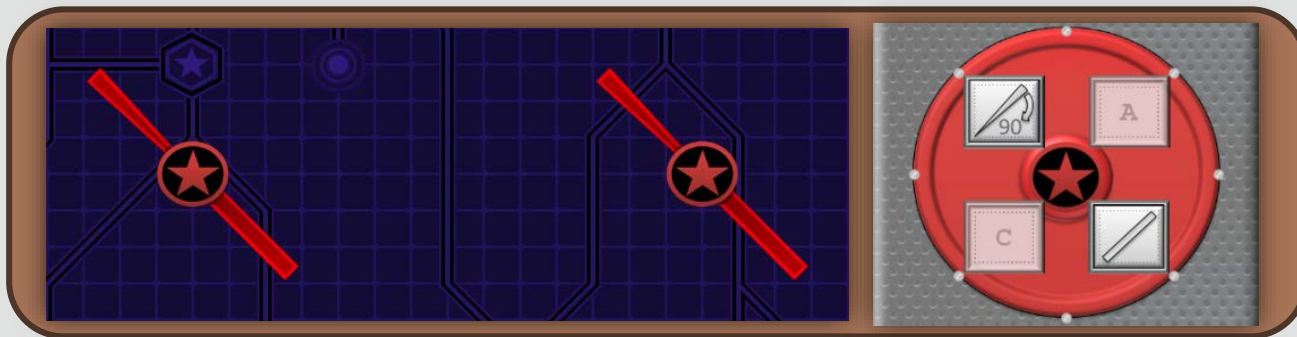
- What happens when you rotate the BlueWheel?
 - The orientation of all BlueBumpers change
 - All BlueBumpers share the orientation property
 - Orientation can be represented by a static variable
- How else can you affect the rotation of bumpers?
 - After the ball strikes a rotation wall, the rotation of an individual bumper changes
 - Rotation can be represented by an instance variable

Rotation wall



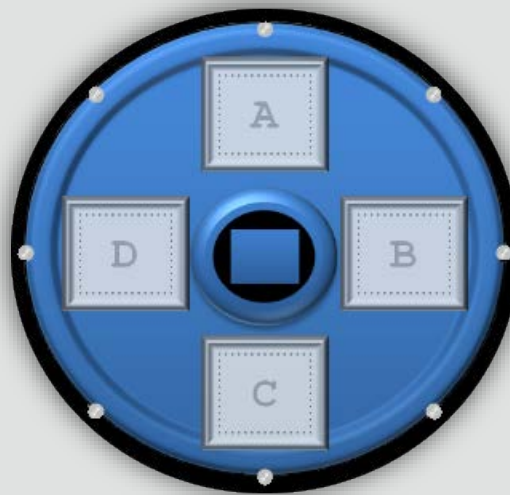
Static Variable: Orientation

- This static variable is shared by all instances
- Static variables belong to the class, not to any individual instance
- Therefore, a static variable needs to be changed only once for every instance to be affected
- In Basic Puzzle 11, rotating the RedWheel changes the orientation of all RedBumper objects



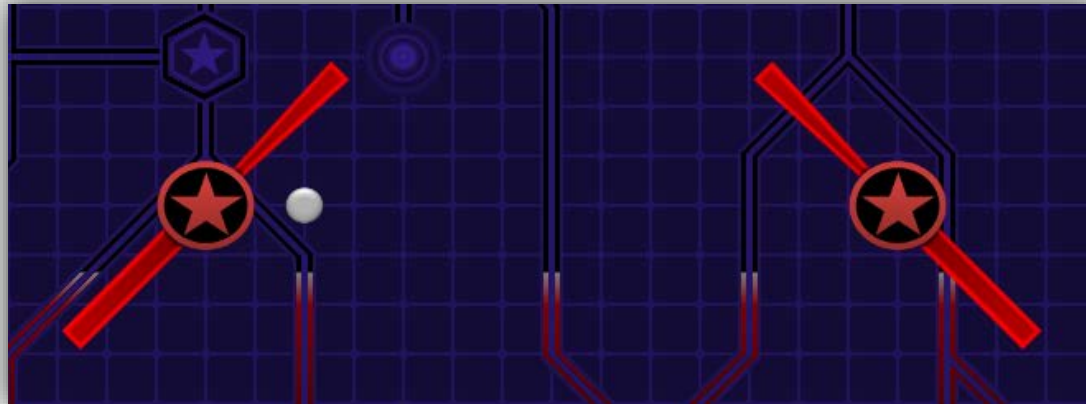
Static Variables with No Instances

- Static variables can be accessed, even if no objects have been instantiated
- In Basic Puzzle 11, the BlueWheel can be rotated to change the orientation property of all BlueBumpers
 - There just aren't any BlueBumpers to show the effects of this change



Instance Variables: Rotation

- Unique instance variables exist for every instance of an object
- Therefore, instance variables need to be changed for each individual object
- In Basic Puzzle 11, an individual RedBumper's rotation changes after being struck by the ball



When Should a Field Be Static?

- Here are a few points to consider:
 - Will the value of this field be different for each individual object? Or will it be the same for all objects?
 - Does the field describe the class more than it describes any individual object?
 - Do you find yourself repeating the same value throughout the class?
 - Is this value a constant that will be used in calculations?
 - Will this value need to be accessed before any objects are instantiated?

Creating Static Variables

- A variable becomes static when its declaration includes the static keyword
- Initialize static variables as they're declared
 - Otherwise, repeated constructor calls could “initialize” the same static variable many times

```
public class RedBumper{
    //Fields
    public static int orientation = 45;    //Static variable
    public int rotation;                  //Instance variable

    //Constructor
    public RedBumper(int rotation){
        this.rotation = rotation;
    }//end constructor
}//end class RedBumper
```

Accessing Static Variables in Their Class

- Even if static variables aren't initialized in the constructor, they can still be accessed
- Like any other variable, static variables are accessible within their class

```
public class RedBumper{  
    //Fields  
    public static int orientation = 45; //Static variable  
    public int rotation;                //Instance variable  
    ...  
    //Methods  
    public void display(){  
        System.out.println(orientation); //Access static var  
        System.out.println(rotation);    //Access instance var  
    } //end method display  
} //end class RedBumper
```

Accessing Static Variables Elsewhere

- Static variables can appear in constructors, methods, or outside their class
- Calling static variables outside their class relies on referencing the class's name rather than a specific reference variable

```
public class TestClass {  
    public static void main(String[] args){  
        int x;  
        x = RedBumper.orientation;    //Access static variable  
  
        RedBumper rb01 = new RedBumper(90); //Instance  
        int y;  
        y = rb01.rotation;             //Access instance variable  
    }//end method main  
}//end class TestClass
```


Exercise 2

- Continue editing the `PrisonTest` project
 - A version of this program is provided for you in the files `PrisonTest_Student_7_6.java`, `Prisoner_Student_7_6.java`, and `Cell_Student_7_6.java`
- Modify the `Prisoner` class:
 - Include a static integer `prisonerCount` field
 - This field counts the total number of prisoners instantiated
 - Initialize this field to 0
 - Increase this field every time a prisoner is instantiated
 - Include an integer `bookingNumber` field
 - This field is initialized with the current value of `prisonerCount`
 - Print the `bookingNumber` and `prisonerCount` as part of the `display()` method
- Instantiate a few prisoners and display their info.

You don't need to write getters for this exercise

Introducing Static Methods

- You may have noticed from the previous exercise:
 - The `display()` method can access a static variable
 - Static variables are accessible from nonstatic methods
- Most methods you've written in this course (excluding the `main` method) are considered instance methods
 - Instance methods are nonstatic methods
- Methods can also be made static

When Should a Method Be Static?

- Here are a few points to consider:
 - Will the method read or modify static fields?
 - Will the method not read or modify the fields of any particular object?
 - Will the method need to be called before any objects are instantiated?
- Static methods are for dealing with static data
 - Static variables are accessible from static methods

Creating Static Methods

- A method becomes static when its declaration includes the static keyword

```
public class Prisoner{  
    //Fields  
    private static int prisonerCount = 0;    //Static variable  
    private int bookingNumber;                //Instance variable  
  
    //Methods  
    public static void displayPrisonerCount(){ //Static method  
        System.out.println(prisonerCount);  
    }//end method displayPrisonerCount  
}//end class Prisoner
```

Calling Static Methods in Their Class

- Like any other method, static methods are callable within their class
- Static or instance methods may call a static method

```
public class Prisoner{  
    private static int prisonerCount = 0;    //Static variable  
    private int bookingNumber;              //Instance variable  
  
    public static void displayPrisonerCount(){ //Static method  
        System.out.println(prisonerCount);  
    }//end method displayPrisonerCount  
    public void callAnotherMethod(){          //Instance method  
        displayPrisonerCount();  
    }//end method callAnotherMethod  
}//end class Prisoner
```

Calling Static Methods Elsewhere

- Static methods can be called from constructors, other methods, or outside their class
- Calling static methods outside their class relies on referencing the class's name rather than a specific reference variable

```
public class TestClass {  
    public static void main(String[] args){  
        Prisoner.displayPrisonerCount; //Call static method  
  
        Cell cA1 = new Cell("A1", false, 1234);  
        Prisoner bubba = new Prisoner("Bubba", 2.08, 4, cA1);  
        bubba.display(); //Call instance method  
    } //end method main  
} //end class TestClass
```

Exercise 3

- Continue editing the `PrisonTest` project
- Modify the `Prisoner` class:
 - Encapsulate the `prisonerCount` field. Make this field private and create a static getter method
 - Try making the `display` method static
 - What are your IDE's complaints?
- From the main method:
 - Call the getter method that you just created and print the returned value

Why Did Your IDE Complain?

- Static fields and static methods can be called without instantiating an object
- But instance variables must be associated with a specific instance
- A paradox is created if a static method tries to access information about an instance before it's created
- Therefore, Java doesn't allow static methods to contain instance variables or instance methods

```
public static void display(){  
    System.out.println(prisonerCount);  
    System.out.println(bookingNumber);  
} //end method display
```



Writing static final Fields

- You're encouraged to make static variables final
 - But the reasons are beyond the scope of this course
- Remember, the names of final variables ...
 - Are capitalized by convention
 - Use an underscore (_) to separate words

```
public class Prisoner{  
    //Fields  
  
    ...  
    private int bookingNumber;  
    private static prisonerCount = 0;  
    public static final MAX_PRISONER_COUNT = 100;  
} //end class Prisoner
```

Making static final Primitive Fields public

- Encapsulation prevents variables from being manipulated in an undesirable way
- But there's no risk of public static final primitives being tampered with because it's impossible for their values to change
- This is useful for constants such as π , e , or other values constantly used in calculations
- These variables are called directly instead of through getters

```
System.out.println(Math.PI);  
System.out.println(Math.E);
```

Summary

- In this lesson, you should have learned how to:
 - Describe a static variable and demonstrate its use within a program
 - Describe a static method and demonstrate its use within a program
 - Understand how to use the final keyword with static variables





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