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Java Foundations

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

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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
```


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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

```
                          //Nothing instantiated
Math.PI                   //Accessing a static field
Math.sin(0)               //Calling a static method
```


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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

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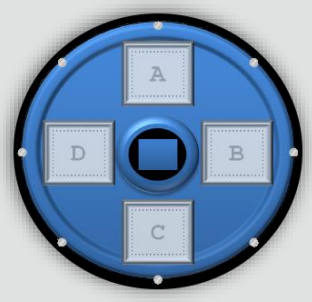
Exercise 1

- 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?



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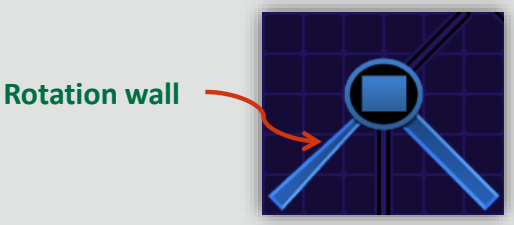
Java Puzzle Ball Debriefing

- 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



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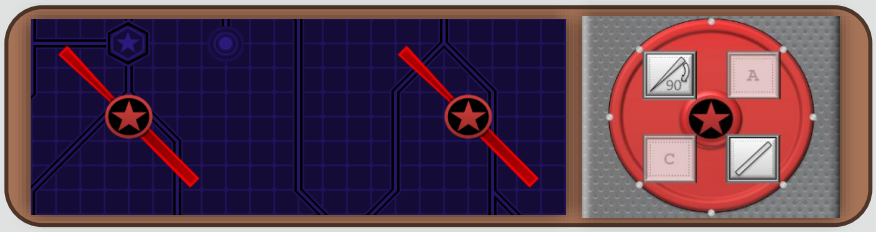
Static Variable: Orientation

- 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



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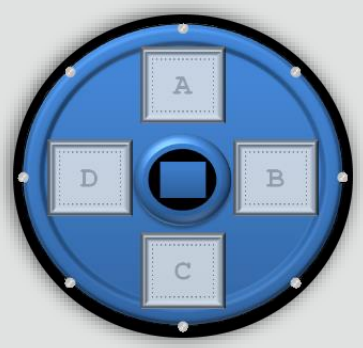
Static Variables with No Instances

- 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



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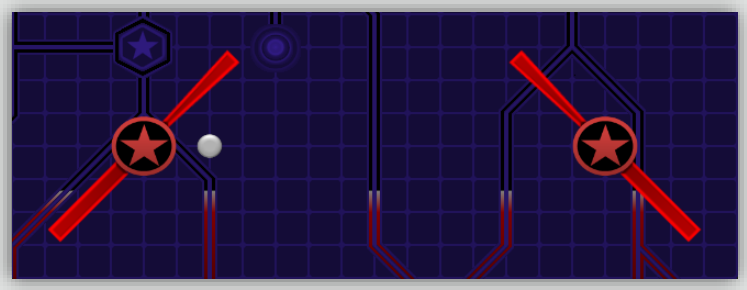
Instance Variables: Rotation

- 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



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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?

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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
```


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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
```


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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
```


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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

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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

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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

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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
```


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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
```


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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
```


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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

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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
```


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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 int prisonerCount = 0;
   public static final int MAX_PRISONER_COUNT = 100;
}//end class Prisoner
```


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`static` variables are variables that are shared by all instances of a class.
Example: A variable that is a counter that will increment each time an instance of the class is created.

`static final` variables are variables that are shared by all instances of the class, but the value cannot change.
Example: Interest Rates or Tax Rates remain constant for all instances of the class. These can also be accessed without creating an instance of the class and should also be public.

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);
```


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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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