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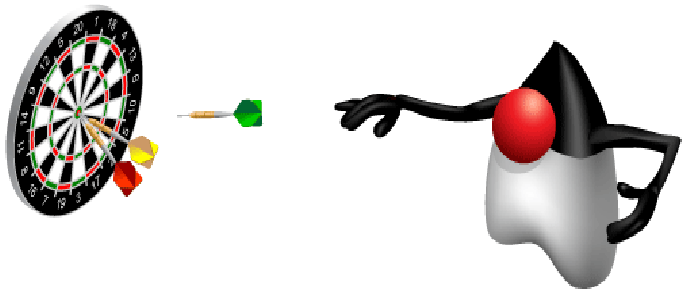
Java Foundations

7-6
Static Variables and Methods

Objectives

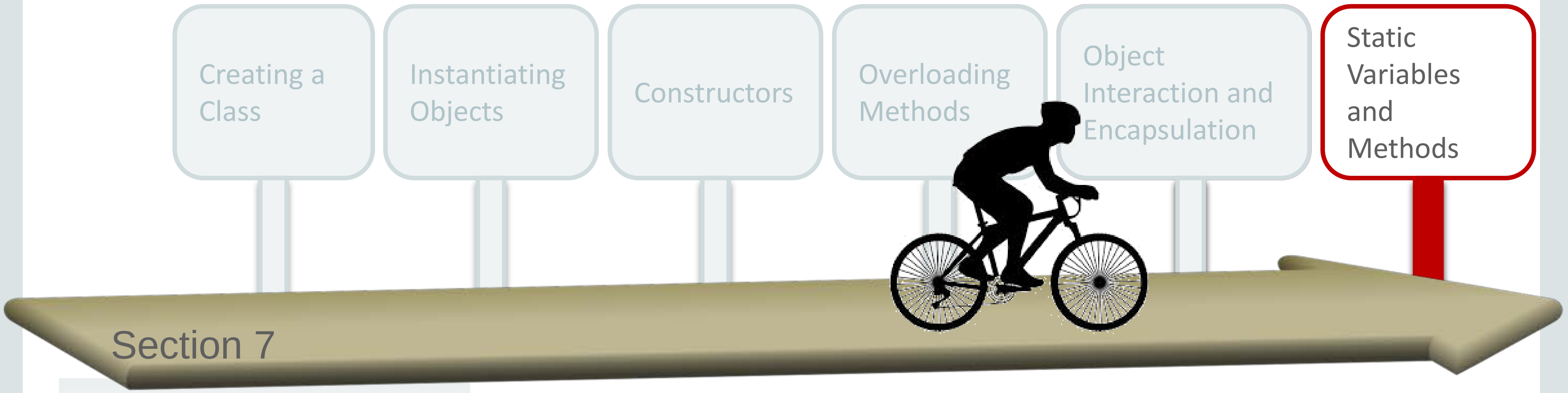
This lesson covers the following objectives:

- 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



Topics

- Understanding Static and Instance Variables
- Programming Static Variables
- Programming Static Methods
- The `final` Keyword



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.**

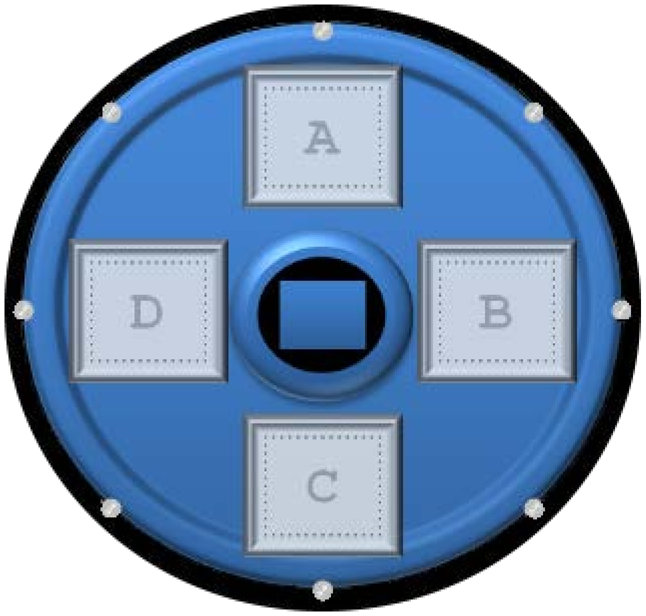
```
                                          //Nothing instantiated
     Math.PI                              //Accessing a static field
     Math.sin(0)                          //Calling a static method
```

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.

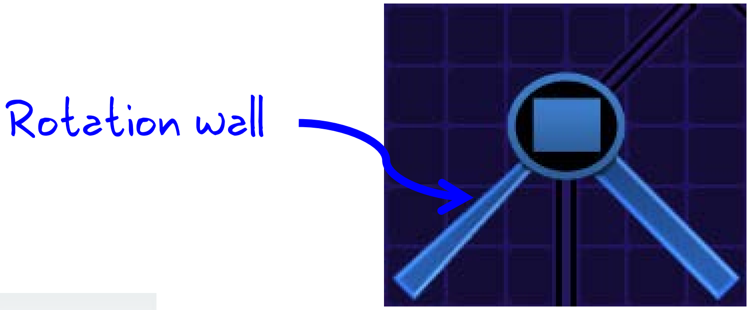
Exercise 1

- Play **Basic Puzzles 8 through 11.**
- Consider the following:
  - What happens when you rotate the BlueWheel?
  - How else can you affect the rotation of bumpers?



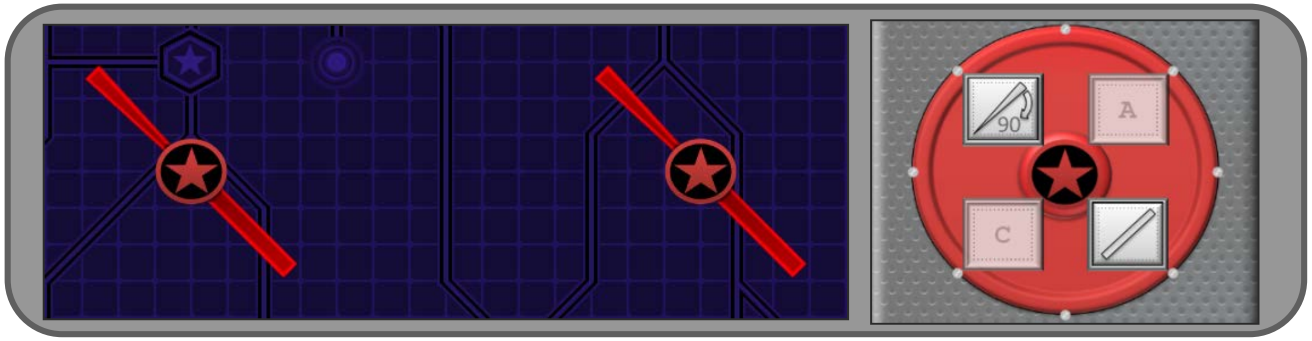
Java Puzzle Ball Debriefing

- 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**.



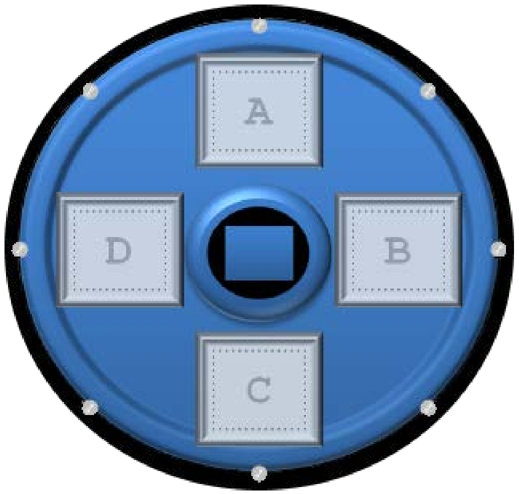
Static Variable: Orientation

- 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.



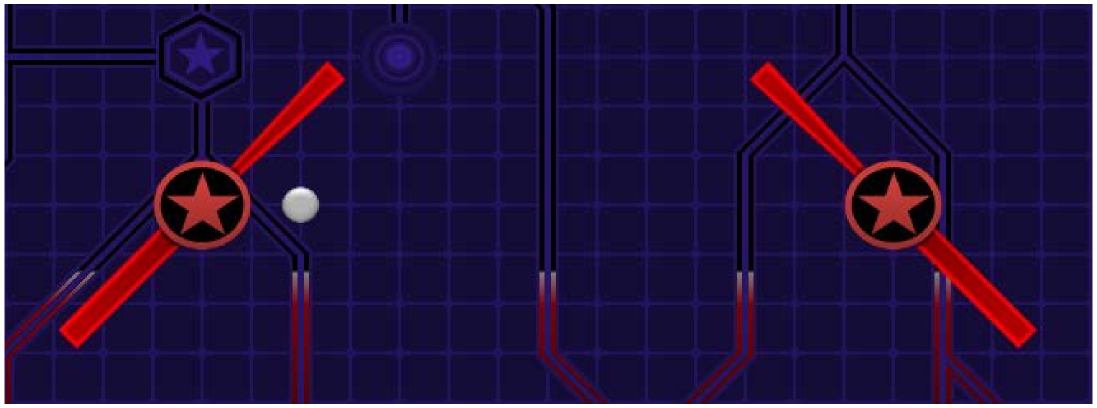
Static Variables with No Instances

- 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.



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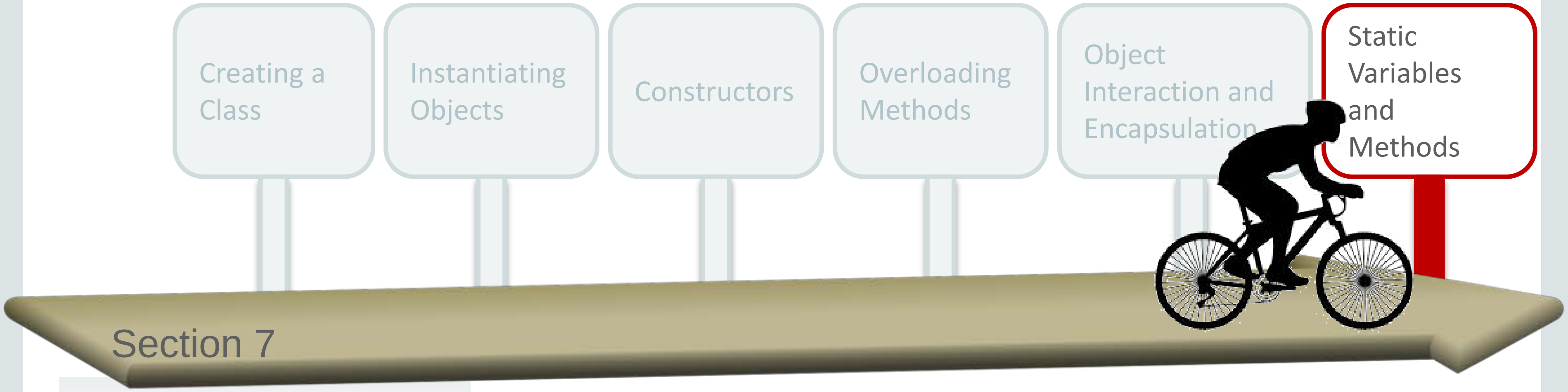

When Should a Field Be Static?

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?

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;
    }
}
```

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
    }
}
```

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.

```java
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
    }
}
```

Exercise 2

- Continue editing the `PrisonTest` project.
  - A version of this program is provided for you.
- 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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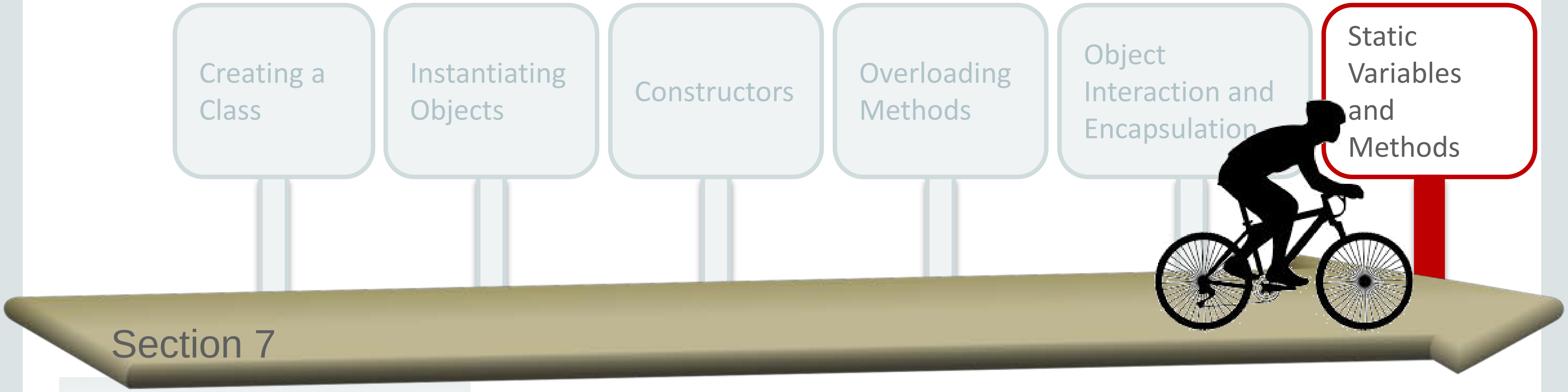

Introducing Static Methods

- 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.

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);
    }
}
```

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{
    //Fields
    private static int prisonerCount = 0;  //Static variable
    private int bookingNumber;             //Instance variable

    //Methods
    public static void displayPrisonerCount(){ //Static method
        System.out.println(prisonerCount);
    }
    public void callAnotherMethod(){         //Instance method
        displayPrisonerCount();
    }
}
```

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
    }
}
```

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 NetBeans' complaints?
- From the main method:
  - Call the getter method that you just created and print the returned value.

Why Did NetBeans 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);
    }
```

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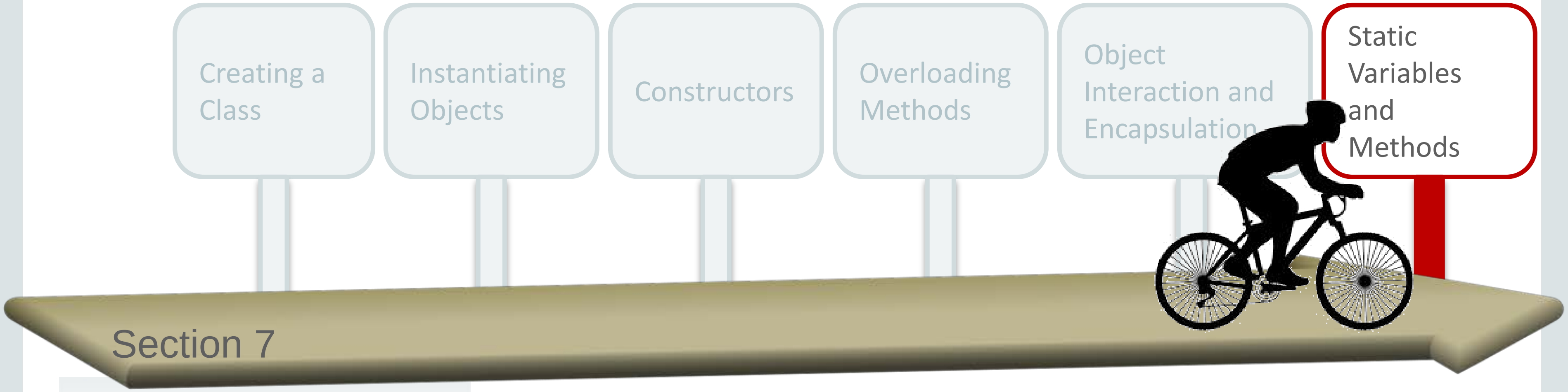


Writing static final Fields

- 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 prisonerCount = 0;
     public static final MAX_PRISONER_COUNT = 100;
}
```

Making `static final` Primitive Fields `public`

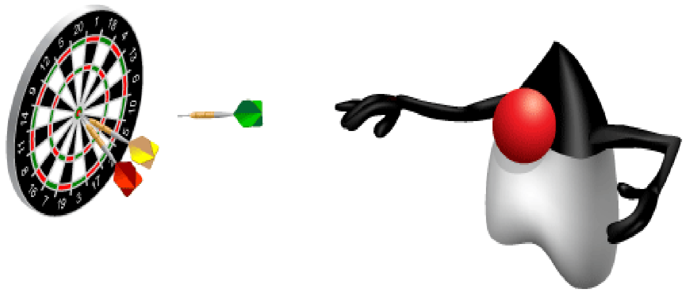
- Encapsulation prevents variables from being manipulated in an undesirable way.
- But there's no risk of `public static final` primitives being tampered with because it's impossible for their values to change.
- This is useful for constants such as π, e, or other values constantly used in calculations.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