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Java Foundations

7-2
Instantiating Objects

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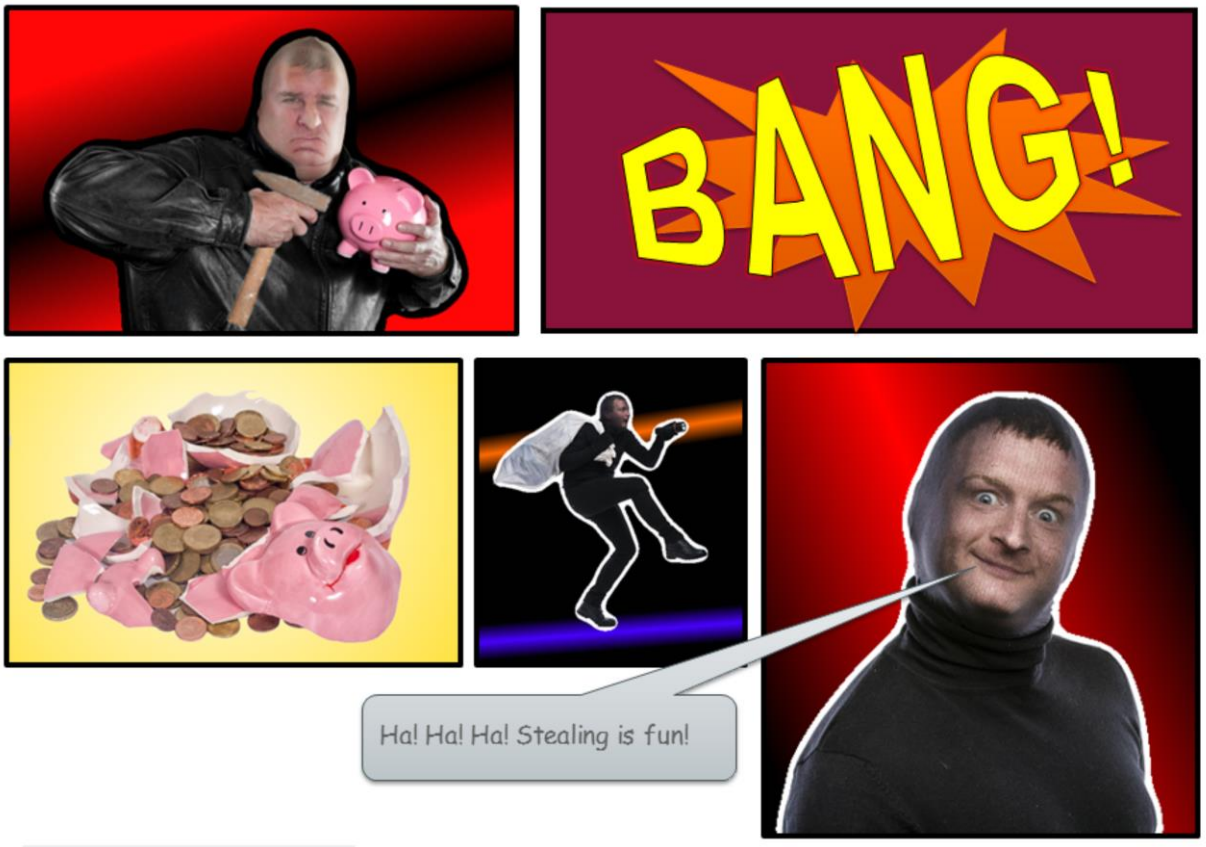
Objectives

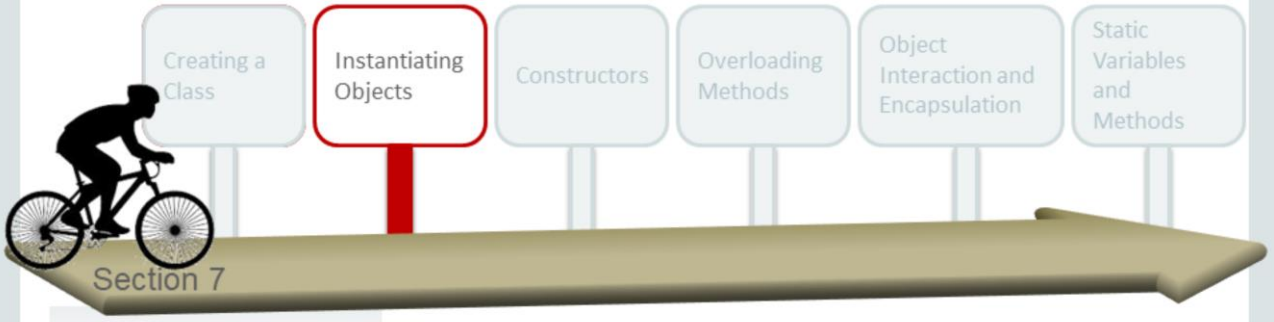
This lesson covers the following objectives:

- Understand the memory consequences of instantiating objects
- Understand object references
- Understand the difference between stack and heap memory
- Understand how `Strings` are special objects



Topics

- Objects in Memory
- Object References and Memory Management
- Instantiating `Strings`



Describing a Prisoner

- Properties:
  - Name
  - Height
  - Years Sentenced
- Behaviors:
  - Think about what they've done

Exercise 1, Part 1

- Create a new Java project.
- Create a `PrisonTest` class with a main method.
- Create a `Prisoner` class based on the description in the previous slide.
- Instantiate two prisoners and assign them the following properties:

```
Variable:  bubba
Name:      Bubba
Height:    6'10"   (2.08m)
Sentence:  4 years
```

```
Variable:  twitch
Name:      Twitch
Height:    5'8"    (1.73m)
Sentence:  3 years
```


It may be easier to program height in meters.

Exercise 1, Part 2

Can prisoners fool security by impersonating each other?

- Write a print statement with a boolean expression that tests if `bubba == twitch`.
- Change the properties of `twitch` so that they match `bubba`.
- Then test the equality of these objects again.

```
Variable:  bubba
Name:      Bubba
Height:    6'10"   (2.08m)
Sentence:  4 years
```

```
Variable:  twitch
Name:      Bubba
Height:    6'10"   (2.08m)
Sentence:  4 years
```

Programming the Prisoner Class

Your class may look something like this:

```
public class Prisoner {
    public String name;
    public double height;
    public int sentence;

    public void think(){
        System.out.println("I'll have my revenge.");
    }
}
```

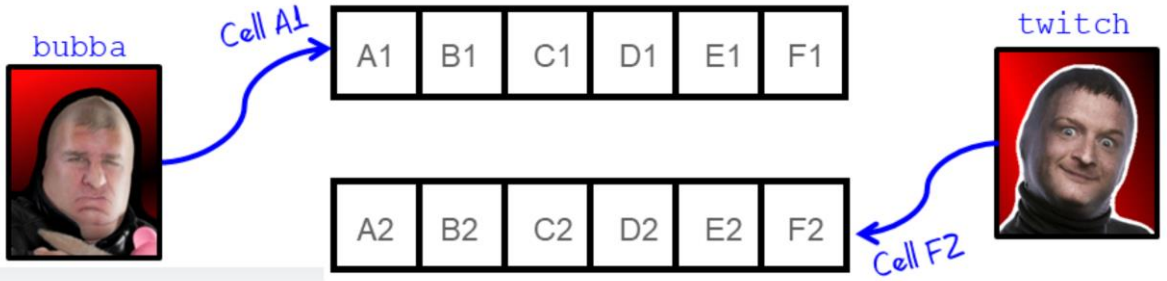
Prisoner Impersonation

- The boolean `bubba == twitch` is `false`.
  - Security wasn't fooled by prisoners who share the same properties.
  - Security understood that each prisoner was a unique object.
- How is this possible?

```
public class PrisonTest {
    public static void main(String[] args){
        Prisoner bubba = new Prisoner();
        Prisoner twitch = new Prisoner();
        …
        System.out.println(bubba == twitch);      //false
    }
}
```

Prisoner Locations

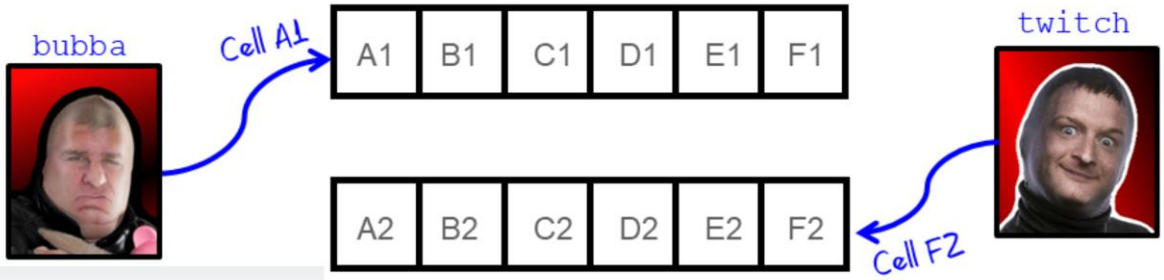
- Prisoners live in cells.
- New prisoners are assigned an available cell for living quarters.
- If a prisoner lives in a unique cell, he's a unique object.



Prisoner Object Locations

- Cells are like locations in memory.
- Instantiating a `Prisoner` fills an available location in memory with the new `Prisoner` object.

```
public class PrisonTest {
    public static void main(String[] args){
        Prisoner bubba = new Prisoner();
        Prisoner twitch = new Prisoner();
    }
}
```



The new Keyword

- The new keyword allocates available memory to store a newly created object.
- Java developers don't need to know an object's location in memory.
  - We only need to know the variable for the object.
  - But we can still print memory addresses.

```
public class PrisonTest {
    public static void main(String[] args){
        Prisoner bubba = new Prisoner();
        Prisoner twitch = new Prisoner();
        System.out.println(bubba);      //prisontest.Prisoner@15db9742
        System.out.println(twitch);     //prisontest.Prisoner@6d06d69c
    }
}
```

Memory addresses

Objects with the Same Properties

- Objects may share the same properties.
- But it doesn't mean that these objects are equal.
- As long as you use the `new` keyword during instantiation …
  - You'll have unique objects.
  - Each object will have a different location in memory.

```
Variable:  bubba
Name:      Bubba
Height:    6'10"  (2.08m)
Sentence:  4 years

Memory Address: @15db9742
```

```
Variable:  twitch
Name:      Bubba
Height:    6'10"  (2.08m)
Sentence:  4 years

Memory Address: @6d06d69c
```

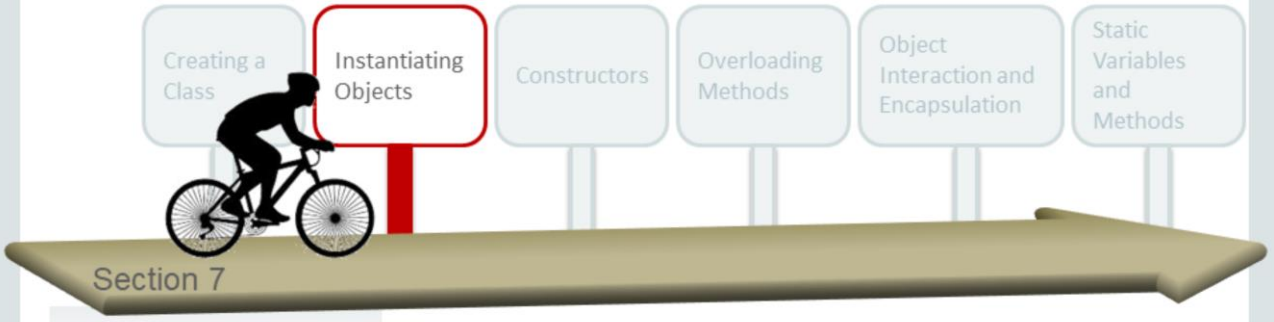
Comparing Objects

- If you compare two objects using the == operator …
  - You're checking if their **memory addresses** are equal.
  - You're **not** checking if their fields are equal.
- The boolean `bubba == twitch` is `false` because …
  - Memory addresses `@15db9742` and `@6d06d69c` are different.
  - It doesn't matter if `bubba` and `twitch` share the same properties.

```
public class PrisonTest {
    public static void main(String[] args){
        Prisoner bubba = new Prisoner();
        Prisoner twitch = new Prisoner();
        …
        System.out.println(bubba == twitch);      //false
    }
}
```

Topics

- Objects in Memory
- Object References and Memory Management
- Instantiating `Strings`



Accessing Objects by Using a Reference

The camera is like the **object** that's accessed by using a reference.

The remote is like the **reference** that's used to access the camera.

Objects are accessed by using reference variables. A good analogy is using a remote control (the reference) to operate a camera (the object). The buttons on the remote control can be used to trigger a particular camera behavior. For example, you can use the remote to call the camera's stop, play, or record functions.

Working with Object References

1 Pick up remote to gain access to the camera.

2 Press remote controls to have the camera do something.

1 Create a Camera object and get a reference to it.

```
Camera remote1 = new Camera();
```

2 Call a method to have the Camera object do something.

```
remote1.play();
```

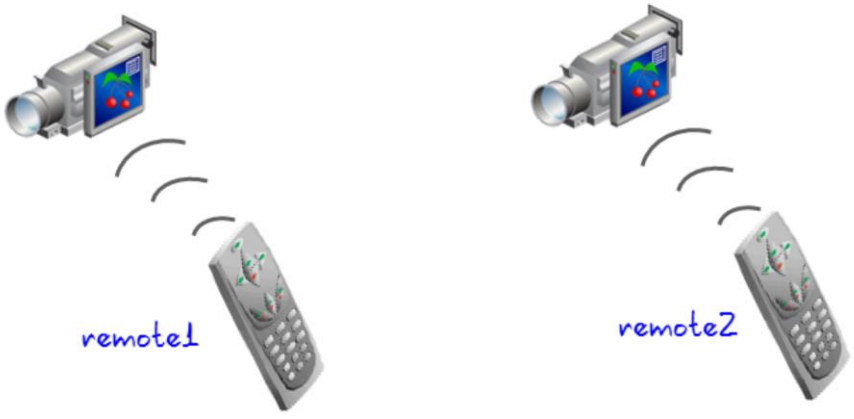

Let's examine the analogy of using a remote control to operate an electronic device. To operate an electronic device with a remote, you need to:

1. Pick up the remote (and possibly turn it on).
2. Press a button on the remote to do something on the camera.

Similarly, to do something with a Java object, you need to:

1. Get its "remote" (called a reference).
2. Press its "buttons" (called methods).

Working with Object References: Example 1



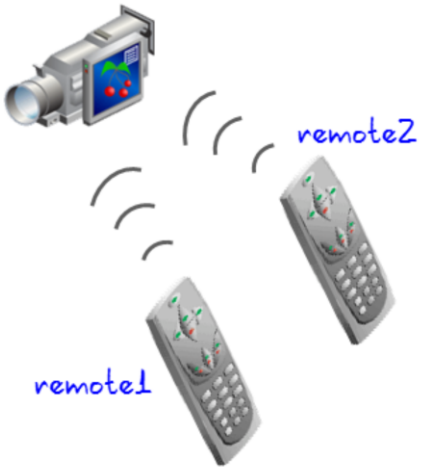

```
Camera remote1 = new Camera();
Camera remote2 = new Camera();

remote1.play();
remote2.play();
```

There are two Camera objects.

There are two camera objects in this example. Each camera has its own unique remote. `remote2` won't work on `remote1`'s camera, and `remote1` won't work on `remote2`'s camera. This reflects how, in Java, two different objects can be instantiated with their own unique references. These references can be used to call methods on their respective objects.

Working with Object References: Example 2



There's only one Camera object.

```
Camera remote1 = new Camera();

Camera remote2 = remote1;

remote1.play();
remote2.stop();
```


The diagram shows another important aspect of how references work.

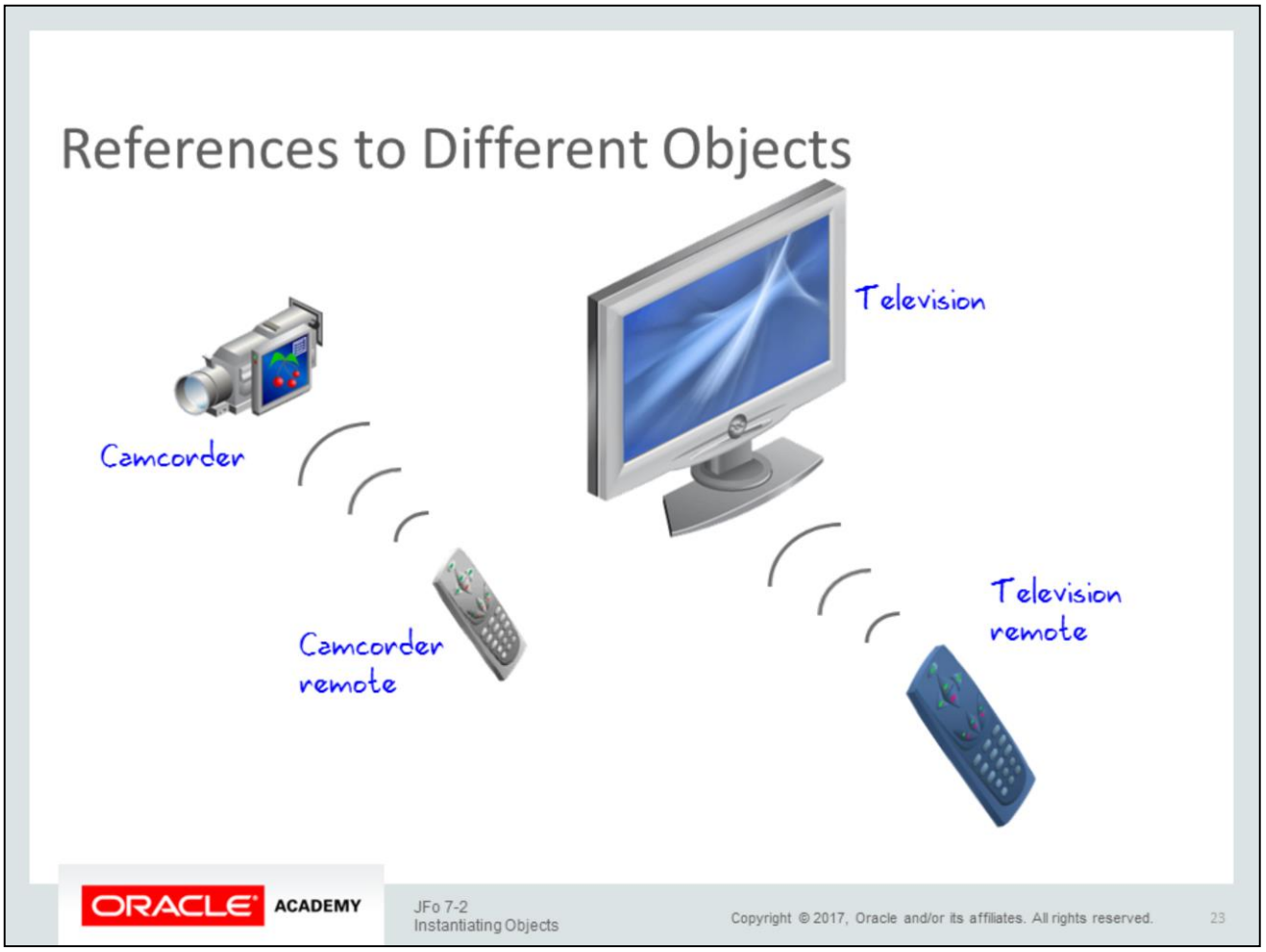
In this example, a `Camera` object is created with the reference `remote1`.

This reference is then assigned to another `Camera` reference, `remote2`.

Both `remote1` and `remote2` references are associated with the same `Camera` object.

Calling methods using either reference affect the same `Camera` object.

Calling `remote1.play()` is no different than calling `remote2.play()`.



Working with different types of objects (for example, a camera and a television) requires a remote specific to that object type. In Java, you need a reference variable of the correct type for the object you are referencing.

References to Different Objects: Example


```
Camera remote1 = new Camera();
remote1.menu();

TV remote2 = new TV();
remote2.menu();

Prisoner bubba = new Prisoner();
bubba.think();
```

References to Different Objects: Example

- The following example isn't allowed because …
  - The **Reference Type** doesn't match the **Object Type.**
  - A prisoner and a TV are completely different things.

```
Prisoner twitch = new TV();
```


A prisoner can't impersonate a TV to fool security.

Exercise 2

- Continue experimenting with the `PrisonTest` class.
- Is security fooled when reference variables change?
  - Instantiate two prisoners and assign them the properties below.
  - Test the equality of these objects.
  - Then set the reference variable for `bubba` equal to `twitch`.
  - Test the equality of these objects again.

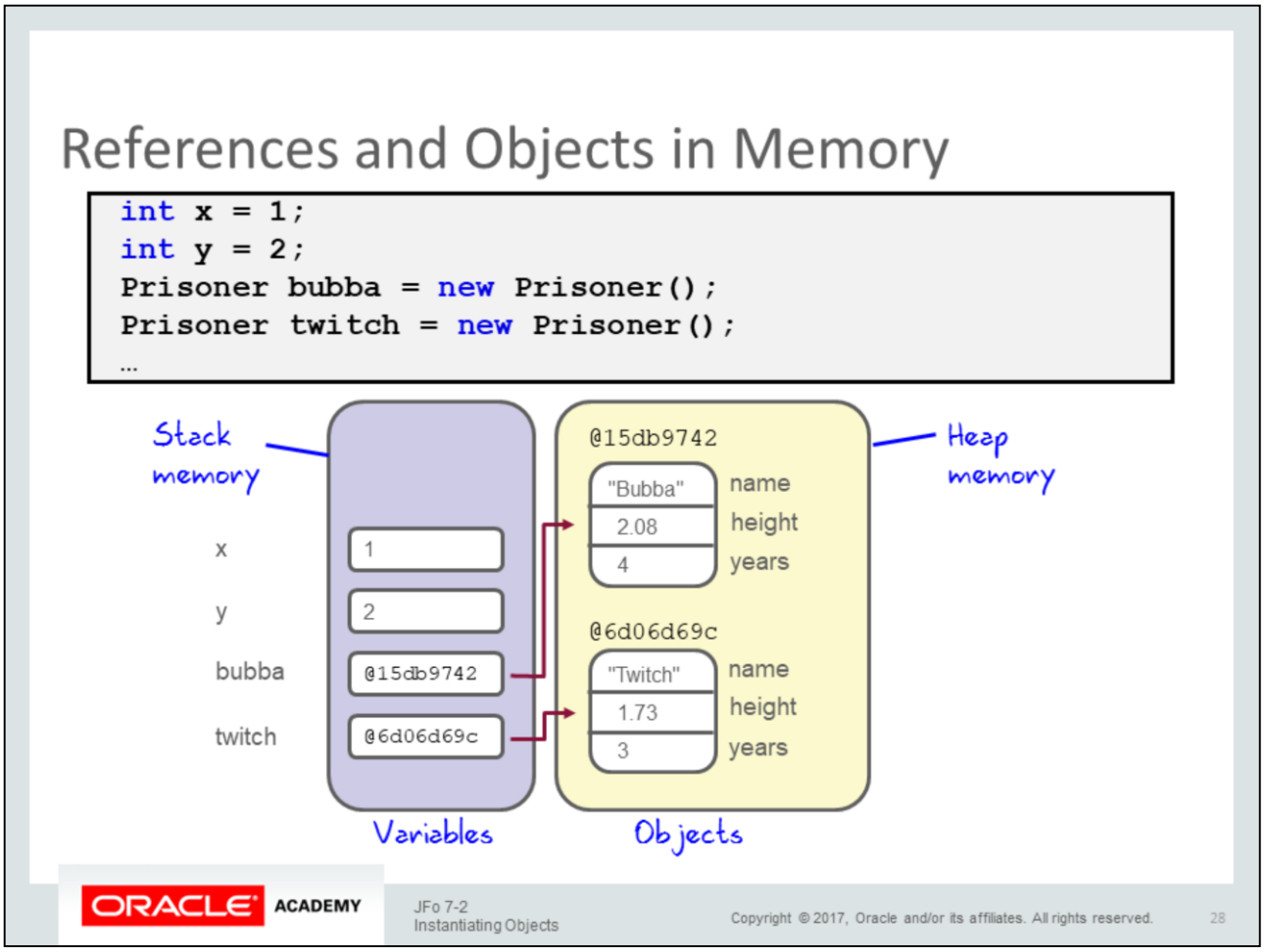
```
Variable:  bubba
Name:      Bubba
Height:    6'10"   (2.08m)
Sentence:  4 years
```

```
Variable:  twitch
Name:      Twitch
Height:    5'8"    (1.73m)
Sentence:  3 years
```

Stack Memory and Heap Memory

Understanding the results of Exercise 2 requires an understanding of the types of memory that Java uses.

- **Stack memory** is used to store …
  - Local variables
  - Primitives
  - References to locations in the heap memory
- **Heap memory** is used to store …
  - Objects

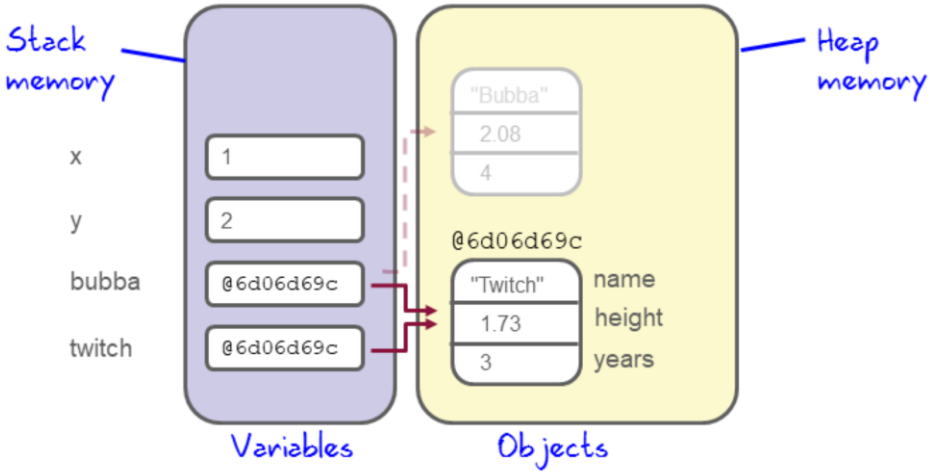


This diagram shows how reference variables point to a particular object in memory. There are two `Prisoner` object references pointing to two `Prisoner` objects.

Stack memory holds local variables, either primitives or reference variables, and the heap holds objects.

Assigning a Reference to Another Reference

```
bubba = twitch;
```



Both `bubba` and `twitch` reference variables now point to the same object.

Two References, One Object

- As of line 14, `bubba` and `twitch` reference the same object.
- Either reference variable could be used to access the same data.

```
11 Prisoner bubba = new Prisoner();
12 Prisoner twitch = new Prisoner();
13
14 bubba = twitch;
15
16 bubba.name = "Bubba";
17 twitch.name = "Twitch";
19
20 System.out.println(bubba.name);       //Twitch
21 System.out.println(bubba == twitch); //true
```


Printing `bubba.name` results in `"Twitch"` being printed because both `bubba.name` and `twitch.name` reference the same field in the same object.

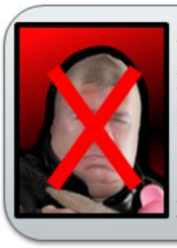
Two References, Two Primitives

- Primitives are always separate variables.
- Primitive values always occupy different locations in the stack memory.
- Line 14 briefly makes primitive values `x` and `y` equal.

```
11 int x;
12 int y;
13
14 x = y;
15
16 x = 1;
17 y = 2;
19
20 System.out.println(x);              //1
21 System.out.println(x == y);         //false
```

What Happened to Bubba?

- If no more reference variables point to an object …
- Java **automatically** clears the memory once occupied by that object.
  - This is called **Garbage Collection.**
  - The data associated with this object is lost forever.



```
Variable:
Name:       Bubba
Height:     6'10"   (2.08m)
Sentence:   4 years

Memory Address:
```

```
Variables: twitch, bubba
Name:       Twitch
Height:     5'8"    (1.73m)
Sentence:   3 years

Memory Address: @6d06d69c
```


Languages like C++ make you clear memory manually.

Topics

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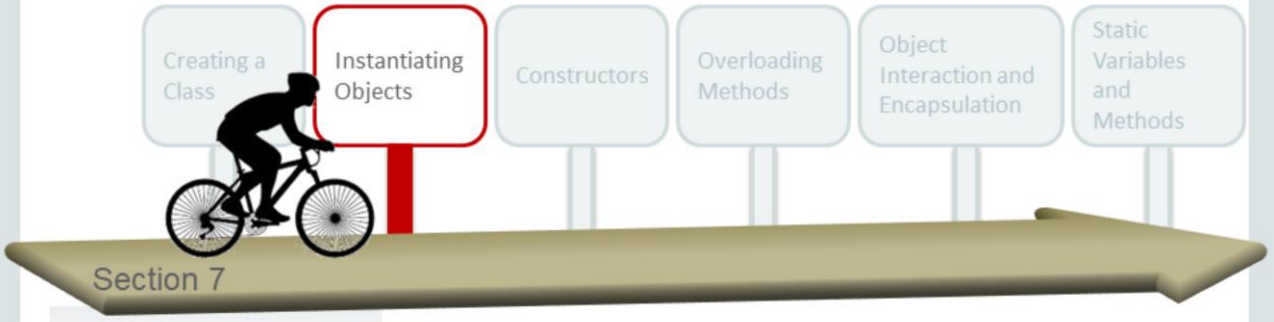
- Instantiating `Strings`



Strings Are Special Objects

- Printing a String reference prints the actual String instead of the object's memory address.
- Strings can be instantiated with the new keyword.
  - But you shouldn't do this.

```
String s1 = new String("Test");
```

- Strings should be instantiated without new.
  - This is more memory-efficient.
  - We'll explore why in the next few slides.

```
String s2 = "Test";
```

Exercise 3

- Continue experimenting with the `PrisonTest` class.
- See the memory consequences of `String`s for yourself.
  - Instantiate two prisoners with the names shown below.
  - Set their names by using the `new` keyword and test the equality of these `String`s by using ==.
  - Set their names without using the `new` keyword and test the equality of these `String`s by using ==.

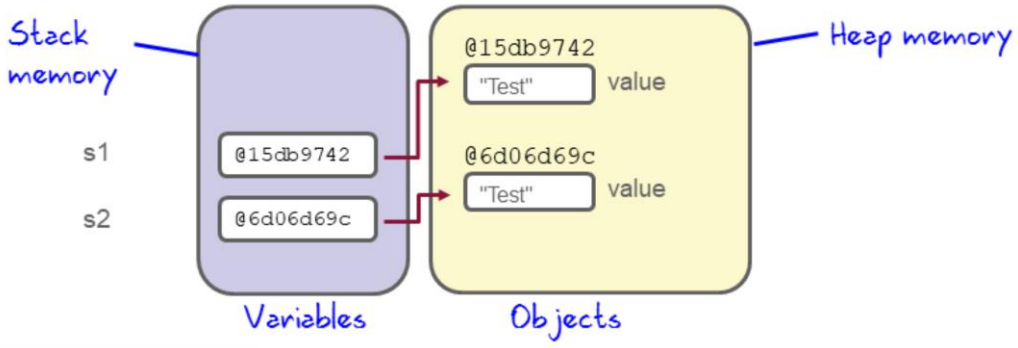
```
Variable:  bubba
Name:      Bubba
Height:    6'10"  (2.08m)
Sentence:  4 years
```

```
Variable:  twitch
Name:      Bubba
Height:    6'10"  (2.08m)
Sentence:  4 years
```

Instantiating `Strings` with the `new` Keyword

Using the `new` keyword creates two different references to two different objects.

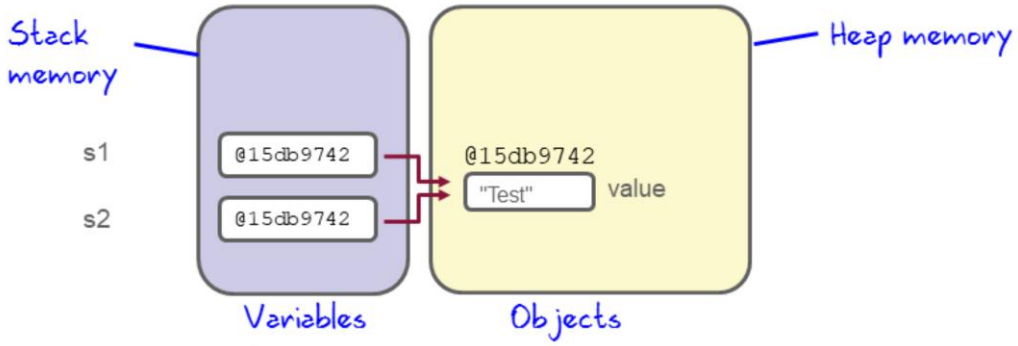
```
String s1 = new String("Test");
String s2 = new String("Test");
```



Instantiating `Strings` Without the `new` Keyword

- Java automatically recognizes identical `Strings` and saves memory by storing the object only once.
- This creates two different references to one object.

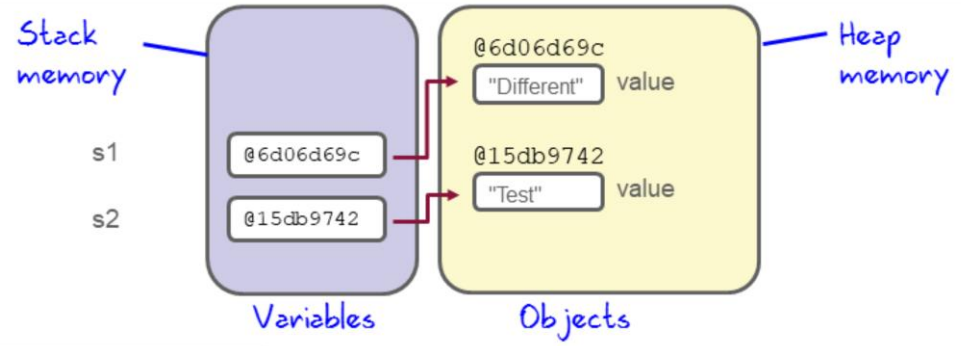
```
String s1 = "Test";
String s2 = "Test";
```



`String` References

- Altering a `String` using one reference won't affect other references.
- Java allocates new memory for a different `String`.

```
String s1 = "Test";
String s2 = "Test";
s1 = "Different";
```



Summary

In this lesson, you should have learned how to:

- Understand the memory consequences of instantiating objects
- Understand object references
- Understand the difference between stack and heap memory
- Understand how `Strings` are special objects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