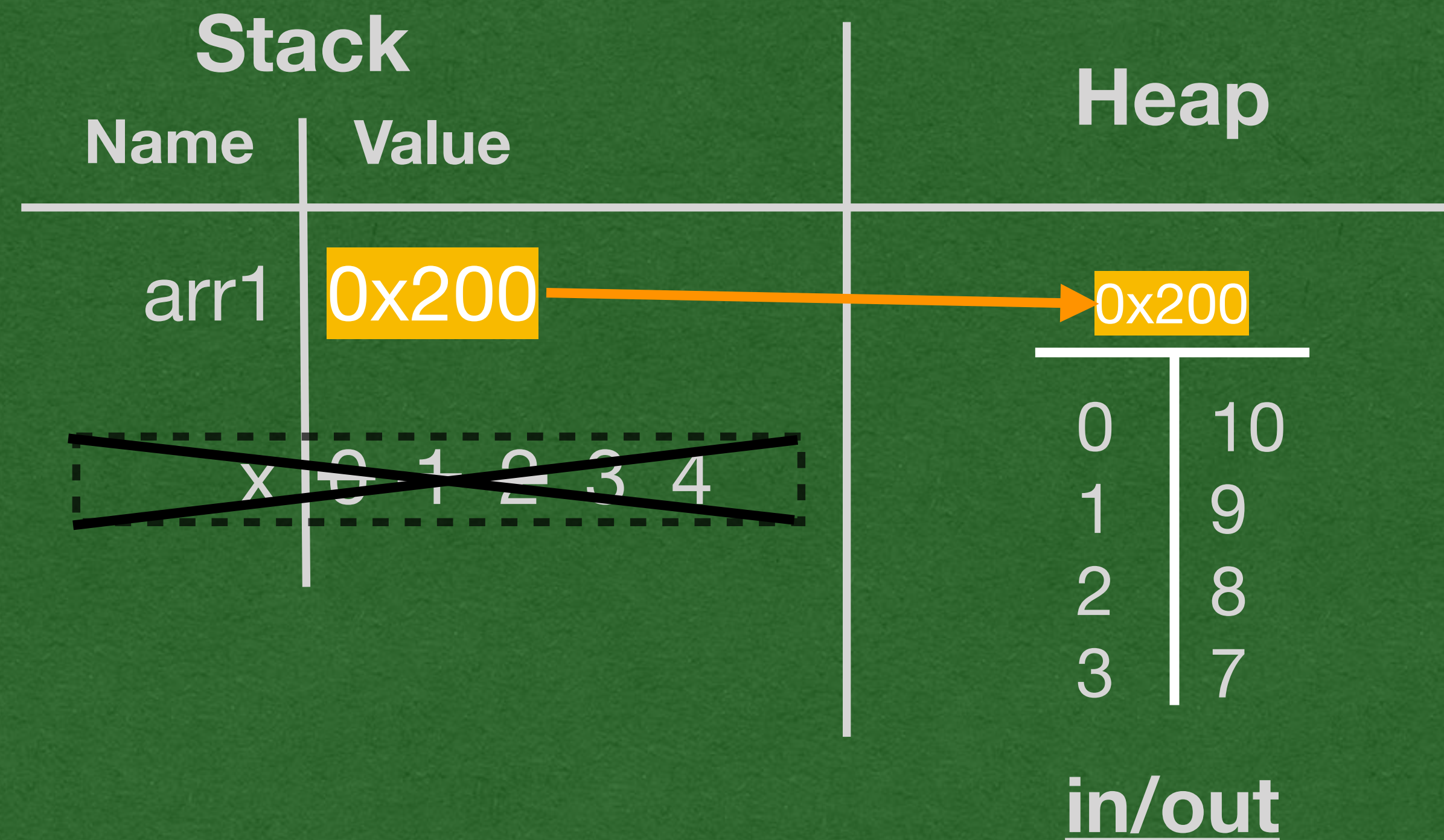


Objects and Classes


```

ArrayList<Integer> arr1 = new ArrayList<>();
for (int x=0; x<4; x++) {
    arr1.add(10-x);
}

```



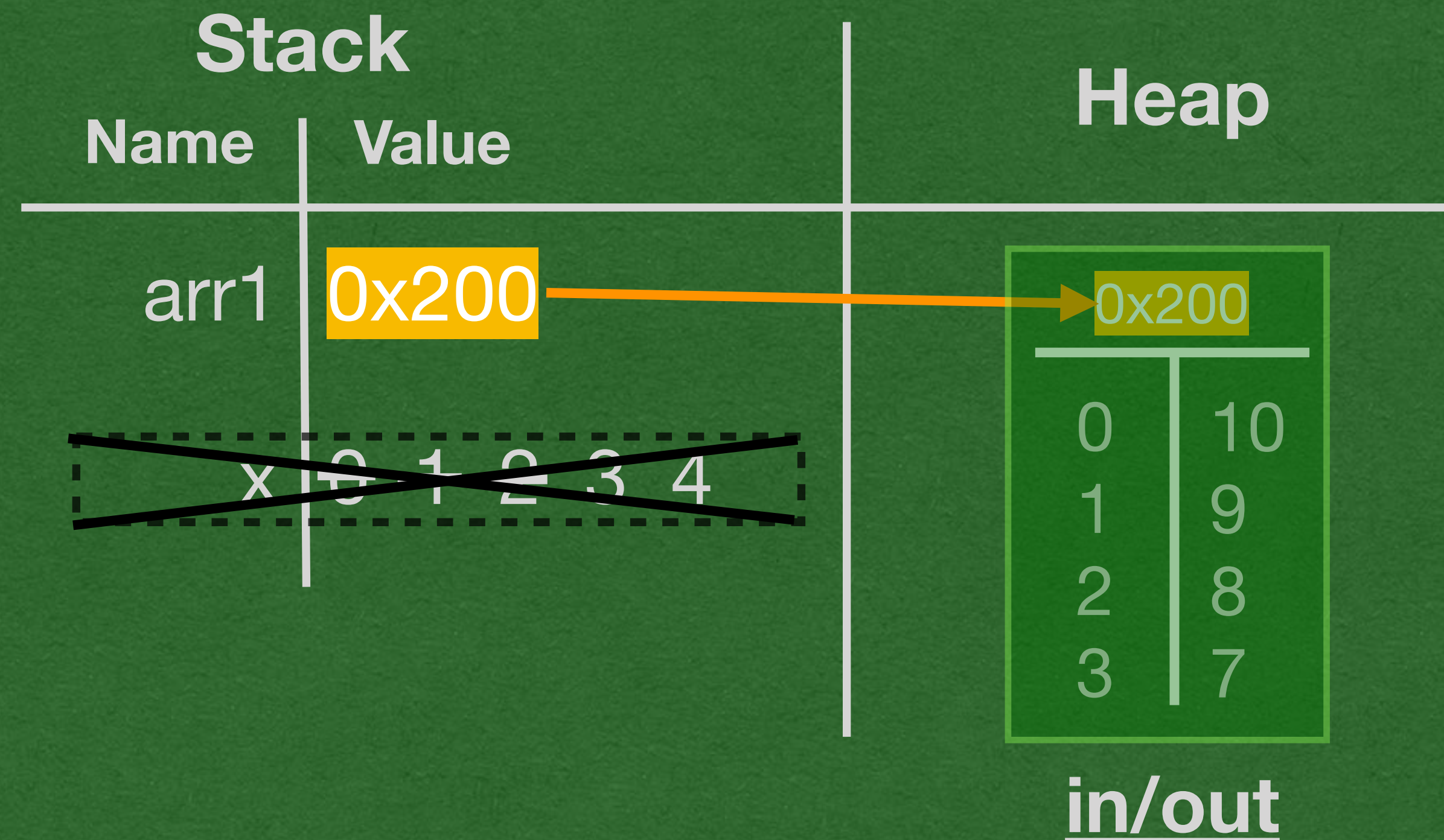
Recall this ArrayList example

- When we use the **new** keyword, we are creating a new **object** of **type** ArrayList
- Using **new** calls a special method called a constructor


```

ArrayList<Integer> arr1 = new ArrayList<>();
for (int x=0; x<4; x++) {
    arr1.add(10-x);
}

```



Recall this ArrayList example

- Objects are stored on the heap
- Only a **reference** to the location of the object is stored in variables
- We use the dot operator to follow the reference and access the objects methods


```
package java.util;
```

```
/** This code is significantly reduced for the slide! */  
/** To see the full code, ctrl+click on ArrayList in IntelliJ */  
public class ArrayList<E> {  
  
}
```

```
package week2;
```

```
import java.util.ArrayList;
```

```
public class ArrayListExample {
```

```
    public static void main(String[] args) {  
        ArrayList<Integer> arr1 = new ArrayList<>();  
        for (int x=0; x<4; x++) {  
            arr1.add(10-x);  
        }  
    }  
}
```

Classes

- Classes are templates used to create objects
- A class tells java how to create our objects
- Defining a class allows us to create many objects of the same type
- We can create many ArrayLists objects from a single ArrayList class


```
package java.util;
```

```
/** This code is significantly reduced for the slide! */
```

```
/** To see the full code, ctrl+click on ArrayList in IntelliJ */
```

```
public class ArrayList<E> {
```

```
    public ArrayList() {
```

```
    }
```

```
}
```

```
package week2;
```

```
import java.util.ArrayList;
```

```
public class ArrayListExample {
```

```
    public static void main(String[] args) {
```

```
        ArrayList<Integer> arr1 = new ArrayList<>();
```

```
        for (int x=0; x<4; x++) {
```

```
            arr1.add(10-x);
```

```
        }
```

```
    }
```

```
}
```

Classes

- Using **new** calls a special method called a constructor
- A constructor is a method that has the same name as the class
- Constructors are not static

Classes

- You can have multiple constructors with **different** parameter lists
- This is called method overloading
- True for all methods, not just constructors
- This ArrayList constructor can be convenient

```
package java.util;

/** This code is significantly reduced for the slide!      */
/** To see the full code, ctrl+click on ArrayList in IntelliJ */
public class ArrayList<E> {

    public ArrayList() {

    }

    public ArrayList(Collection<? extends E> c) {
        /* removed for slides */
    }

}
```

```
package week2;

import java.util.ArrayList;
import java.util.Arrays;

public class ArrayListExample {

    public static void main(String[] args) {
        ArrayList<Integer> arr1 = new ArrayList<>(Arrays.asList(10, 9, 8, 7));
    }

}
```



```
package java.util;
```

```
/** This code is significantly reduced for the slide!      */  
/** To see the full code, ctrl+click on ArrayList in IntelliJ */  
public class ArrayList<E> {
```

```
    private Object[] elementData;  
    private int size;
```

```
    public ArrayList() {  
    }
```

```
    public ArrayList(Collection<? extends E> c) {  
        /* removed for slides */  
    }
```

```
    public int size() {  
        return this.size;  
    }
```

```
}
```

Classes

- Objects have both *state* and *behavior*
- *State*: Any variables declared outside all the classes methods become part of the state of objects
- We call these *instance* variables
- *Behavior*: Any non-static methods define the behavior of an object


```
package java.util;
```

```
/** This code is significantly reduced for the slide!      */  
/** To see the full code, ctrl+click on ArrayList in IntelliJ */  
public class ArrayList<E> {
```

```
    private static final Object[] DEFAULTCAPACITY_EMPTY_ELEMENTDATA = {};
```

```
    private Object[] elementData;  
    private int size;
```

```
    public ArrayList() {  
        this.elementData = DEFAULTCAPACITY_EMPTY_ELEMENTDATA;  
    }
```

```
    public ArrayList(Collection<? extends E> c) {  
        /* removed for slides */  
    }
```

```
    public int size() {  
        return this.size;  
    }
```

```
}
```

Classes

- The constructor is used to initialize the **state** of the new object
- Set the instance variables to their initial values
- If the constructor takes parameters, set the instance variables based on those parameters


```
package java.util;
```

```
/** This code is significantly reduced for the slide!          */  
/** To see the full code, ctrl+click on ArrayList in IntelliJ */  
public class ArrayList<E> {
```

```
    private static final Object[] DEFAULTCAPACITY_EMPTY_ELEMENTDATA = {};
```

```
    private Object[] elementData;  
    private int size;
```

```
    public ArrayList() {  
        this.elementData = ArrayList.DEFAULTCAPACITY_EMPTY_ELEMENTDATA;  
    }
```

```
    public ArrayList(Collection<? extends E> c) {  
        /* removed for slides */  
    }
```

```
    public int size() {  
        return this.size;  
    }
```

```
    public E get(int index) {  
        return (E) this.elementData[index];  
    }
```

```
    private void add(E e, Object[] elementData, int s) {  
        if (s == elementData.length)  
            elementData = grow();  
        elementData[s] = e;  
        this.size = s + 1;  
    }
```

```
    public boolean add(E e) {  
        add(e, this.elementData, this.size);  
        return true;  
    }
```

```
}
```

Classes

- Add more non-static methods to define more behavior for the objects we create
- Behavior often depends on the current state of the object (Values stored in its instance variables)
- In this example, the add method is overloaded with a private add method
- This is called a *helper* method


```
package java.util;
```

```
/** This code is significantly reduced for the slide!          */
/** To see the full code, ctrl+click on ArrayList in IntelliJ */
public class ArrayList<E> {

    private static final Object[] DEFAULTCAPACITY_EMPTY_ELEMENTDATA = {};

    private Object[] elementData;
    private int size;

    public ArrayList() {
        this.elementData = ArrayList.DEFAULTCAPACITY_EMPTY_ELEMENTDATA;
    }

    public ArrayList(Collection<? extends E> c) {
        /* removed for slides */
    }

    public int size() {
        return this.size;
    }

    public E get(int index) {
        return (E) this.elementData[index];
    }

    private void add(E e, Object[] elementData, int s) {
        if (s == elementData.length)
            elementData = grow();
        elementData[s] = e;
        this.size = s + 1;
    }

    public boolean add(E e) {
        add(e, this.elementData, this.size);
        return true;
    }
}
```

Classes

- The "this" keyword is a variable containing a reference to the object that called a method
- For constructors, it's a reference to the object being created
- *More detail when we get to a memory diagram*


```
package java.util;
```

```
/** This code is significantly reduced for the slide!      */  
/** To see the full code, ctrl+click on ArrayList in IntelliJ */  
public class ArrayList<E> {
```

```
    private static final Object[] DEFAULTCAPACITY_EMPTY_ELEMENTDATA = {};
```

```
    private Object[] elementData;  
    private int size;
```

```
    public ArrayList() {  
        this.elementData = ArrayList.DEFAULTCAPACITY_EMPTY_ELEMENTDATA;  
    }
```

```
    public ArrayList(Collection<? extends E> c) {  
        /* removed for slides */  
    }
```

```
    public int size() {  
        return this.size;  
    }
```

```
    public E get(int index) {  
        return (E) this.elementData[index];  
    }
```

```
    private void add(E e, Object[] elementData, int s) {  
        if (s == elementData.length)  
            elementData = grow();  
        elementData[s] = e;  
        this.size = s + 1;  
    }
```

```
    public boolean add(E e) {  
        add(e, this.elementData, this.size);  
        return true;  
    }
```

```
}
```

Encapsulation

- Encapsulation is when we hide data and details not relevant to the outside user
- Any state/behavior we want others to use: Make it **public**
- Any implementation details not relevant to your user: Make it **private**


```
package java.util;
```

```
/** This code is significantly reduced for the slide!      */  
/** To see the full code, ctrl+click on ArrayList in IntelliJ */  
public class ArrayList<E> {
```

```
    private static final Object[] DEFAULTCAPACITY_EMPTY_ELEMENTDATA = {};
```

```
    private Object[] elementData;  
    private int size;
```

```
    public ArrayList() {  
        this.elementData = ArrayList.DEFAULTCAPACITY_EMPTY_ELEMENTDATA;  
    }
```

```
    public ArrayList(Collection<? extends E> c) {  
        /* removed for slides */  
    }
```

```
    public int size() {  
        return this.size;  
    }
```

```
    public E get(int index) {  
        return (E) this.elementData[index];  
    }
```

```
    private void add(E e, Object[] elementData, int s) {  
        if (s == elementData.length)  
            elementData = grow();  
        elementData[s] = e;  
        this.size = s + 1;  
    }
```

```
    public boolean add(E e) {  
        add(e, this.elementData, this.size);  
        return true;  
    }
```

```
}
```

Encapsulation

- As a user of ArrayLists
- You don't care how the underlying state is stored (As a plain array)
- You don't care that the add method is overloaded
- Hide the details we don't need to care about


```
package java.util;
```

```
/** This code is significantly reduced for the slide!      */
/** To see the full code, ctrl+click on ArrayList in IntelliJ */
public class ArrayList<E> {
```

```
    private static final Object[] DEFAULTCAPACITY_EMPTY_ELEMENTDATA = {};
```

```
    private Object[] elementData;
    private int size;
```

```
    public ArrayList() {
        this.elementData = ArrayList.DEFAULTCAPACITY_EMPTY_ELEMENTDATA;
    }
```

```
    public ArrayList(Collection<? extends E> c) {
        /* removed for slides */
    }
```

```
    public int size() {
        return this.size;
    }
```

```
    public E get(int index) {
        return (E) this.elementData[index];
    }
```

```
    private void add(E e, Object[] elementData, int s) {
        if (s == elementData.length)
            elementData = grow();
        elementData[s] = e;
        this.size = s + 1;
    }
```

```
    public boolean add(E e) {
        add(e, this.elementData, this.size);
        return true;
    }
```

```
}
```

Encapsulation

- All of the public state and behavior defines your public interface
- This is how the outside world uses your code
- These are the methods you call when using an ArrayList
- We call this an API (Application Programming Interface)


```
package java.util;
```

```
/** This code is significantly reduced for the slide!          ***/  
/** To see the full code, ctrl+click on ArrayList in IntelliJ ***/  
public class ArrayList<E> {
```

```
    private static final Object[] DEFAULTCAPACITY_EMPTY_ELEMENTDATA = {};
```

```
    private Object[] elementData;  
    private int size;
```

```
    public ArrayList() {  
        this.elementData = ArrayList.DEFAULTCAPACITY_EMPTY_ELEMENTDATA;  
    }
```

```
    public ArrayList(Collection<? extends E> c) {  
        /* removed for slides */  
    }
```

```
    public int size() {  
        return this.size;  
    }
```

```
    public E get(int index) {  
        return (E) this.elementData[index];  
    }
```

```
    private void add(E e, Object[] elementData, int s) {  
        if (s == elementData.length)  
            elementData = grow();  
        elementData[s] = e;  
        this.size = s + 1;  
    }
```

```
    public boolean add(E e) {  
        add(e, this.elementData, this.size);  
        return true;  
    }
```

```
}
```

Static

- Static variables and methods can be accessed through the *class*
- Non-static methods are accessed through *objects* (instances of the class)
- If we just say "method" we mean "non-static method"

Classes

- Some classes are only used for their static state and behavior
- It doesn't make sense to create a new Math object
- Use the static variables and methods from the Math class

```
package java.lang;

/** This code is significantly reduced for the slide!    */
/** To see the full code, ctrl+click on Math in IntelliJ */
public class Math {

    public static final double E = 2.718281828459045;
    public static final double PI = 3.141592653589793;
    public static final double TAU = 2.0 * PI;

    private static final double DEGREES_TO_RADIANS = 0.017453292519943295;
    private static final double RADIANS_TO_DEGREES = 57.29577951308232;

    /**
     * Don't let anyone instantiate this class.
     */
    private Math() {}

    public static int abs(int a) {
        return (a < 0) ? -a : a;
    }
}
```


Creating Our Own Class

Classes

Let's create a Player class with this state and behavior

- State
 - Maximum hit points
 - Current hit points
 - Name
 - Attack power - *Next Lecture*
- Behavior - *Next Lecture*
 - Can take damage - *Next Lecture*
 - Can attack other Players - *Next Lecture*

Player Class

```
public class Player {  
    private int maxHP;  
    private int hp;  
    private String name;  
  
    public Player(String name, int maxHP) {  
        this.maxHP = maxHP;  
        this.hp = maxHP;  
        this.name = name;  
    }  
}
```

- We create the Player class
- Add the instance variables needed for all the state of a Player
- Write a constructor matching the name of the class
- Takes any parameters needed for initialization
- Initializes the instance variables

Player Class

```
public class Player {  
    private int maxHP = 10;  
    private int hp = 10;  
    private String name;  
  
    public Player(String name) {  
        this.name = name;  
    }  
}
```

- You can also initialize instance variables when they are declared
- Use this if you want every object to have the same initial value for a variable

Player Class

```
public class Player {  
    private int maxHP;  
    private int hp;  
    private String name;  
  
    public Player(String name, int maxHP) {  
        this.maxHP = maxHP;  
        this.hp = maxHP;  
        this.name = name;  
    }  
}
```

- Our instance variables are all private
- Very common in Java
- Leverage encapsulation
 - Hide the details of your code
 - Expose public methods for others to interact with your code
- So how does anyone use this state?...

Player Class

```
public class Player {
    private int maxHP;
    private int hp;
    private String name;

    public Player(String name, int maxHP) {
        this.maxHP = maxHP;
        this.hp = maxHP;
        this.name = name;
    }

    public int getMaxHP() {
        return maxHP;
    }
    public void setMaxHP(int maxHP) {
        this.maxHP = maxHP;
    }

    public int getHP() {
        return hp;
    }
    public void setHP(int hp) {
        this.hp = hp;
    }

    public String getName() {
        return name;
    }
    public void setName(String name) {
        this.name = name;
    }
}
```

- Getters and Setters!
- Write public methods that allow access to your state
- Getters - Return the value of the requested variable
- Setters - Takes a value and reassigned the instance variable

Player Class

```
public class Player {
    private int maxHP;
    private int hp;
    private String name;

    public Player(String name, int maxHP) {
        this.maxHP = maxHP;
        this.hp = maxHP;
        this.name = name;
    }

    public int getMaxHP() {
        return maxHP;
    }
    public void setMaxHP(int maxHP) {
        this.maxHP = maxHP;
    }

    public int getHP() {
        return hp;
    }
    public void setHP(int hp) {
        if (hp <= this.maxHP) {
            this.hp = hp;
        } else {
            this.hp = this.maxHP;
        }
    }

    public String getName() {
        return name;
    }
    public void setName(String name) {
        this.name = name;
    }
}
```

- Why???
- It would be easier to just make our variables public!
- Control.
 - If we want to sanitize values, add code to the setter
 - If you want to format output, add code to the getter
- If others write code to access your variables directly, you do not have this option!

Player Class

```
public class Player {  
    private int maxHP;  
    private int hp;  
    private String name;  
  
    public Player(String name, int maxHP) {  
        this.setMaxHP(maxHP);  
        this.setHP(maxHP);  
        this.setName(name);  
    }  
  
    public int getMaxHP() {  
        return maxHP;  
    }  
    public void setMaxHP(int maxHP) {  
        this.maxHP = maxHP;  
    }  
  
    public int getHP() {  
        return hp;  
    }  
    public void setHP(int hp) {  
        if (hp <= this.maxHP) {  
            this.hp = hp;  
        } else {  
            this.hp = this.maxHP;  
        }  
    }  
  
    public String getName() {  
        return name;  
    }  
    public void setName(String name) {  
        this.name = name;  
    }  
}
```

- You should call your setters in your constructor
- Ensures your checks are ran when an object is created

Player Class

```
public class Player {
    private int maxHP;
    private int hp;
    private String name;

    public Player(String name, int maxHP) {
        this.setMaxHP(maxHP);
        this.setHP(maxHP);
        this.setName(name);
    }

    public int getMaxHP() {
        return maxHP;
    }
    public void setMaxHP(int maxHP) {
        this.maxHP = maxHP;
    }


    public int getHP() {
        return hp;
    }
    public void setHP(int hp) {
        if (hp <= this.maxHP) {
            this.hp = hp;
        } else {
            this.hp = this.maxHP;
        }
    }

    public String getName() {
        return name;
    }
    public void setName(String name) {
        this.name = name;
    }
}
```

- Classes define new **types**
 - The ArrayList *class* defines the ArrayList *type*
 - Our Player *class* defines the Player *type*
- We can use Player wherever we could use any other type
 - As variable types
 - As parameter types in methods
 - As the return type of methods
 - As type parameters of data structures

Memory

Diagram



```
public static void main(String[] args) {  
    Player p1 = new Player("Dark Cecil", 10);  
    Player p2 = new Player("Kain", 14);  
    Player p3 = p1;  
    p1.setName("Paladin");  
    System.out.println(p3.getName());  
}
```

Stack		Heap
Name	Value	
		<u>in/out</u>
		<ul style="list-style-type: none">• We'll trace this version of the code• Set up the stack, heap, and in/out


```

➡ public Player(String name, int maxHP) {
    this.setMaxHP(maxHP);
    this.setHP(maxHP);
    this.setName(name);
}

    public void setMaxHP(int maxHP) {
        this.maxHP = maxHP;
    }
    public void setHP(int hp) {
        if (hp <= this.maxHP) {
            this.hp = hp;
        } else {
            this.hp = this.maxHP;
        }
    }

    public String getName() {
        return name;
    }
    public void setName(String name) {
        this.name = name;
    }

➡ public static void main(String[] args) {
    Player p1 = new Player("Dark Cecil", 10);
    Player p2 = new Player("Kain", 14);
    Player p3 = p1;
    p1.setName("Paladin");
    System.out.println(p3.getName());
}
}

```

Stack		Heap
Name	Value	
		<div style="border: 1px solid black; width: 60%; height: 80%; margin: auto;"></div>
		<u>in/out</u>
		<ul style="list-style-type: none">• New objects are created on the heap• Only a reference is stored in variables


```
public class Player {
    private int maxHP;
    private int hp;
    private String name;

    ➡ public Player(String name, int maxHP) {
        this.setMaxHP(maxHP);
        this.setHP(maxHP);
        this.setName(name);
    }

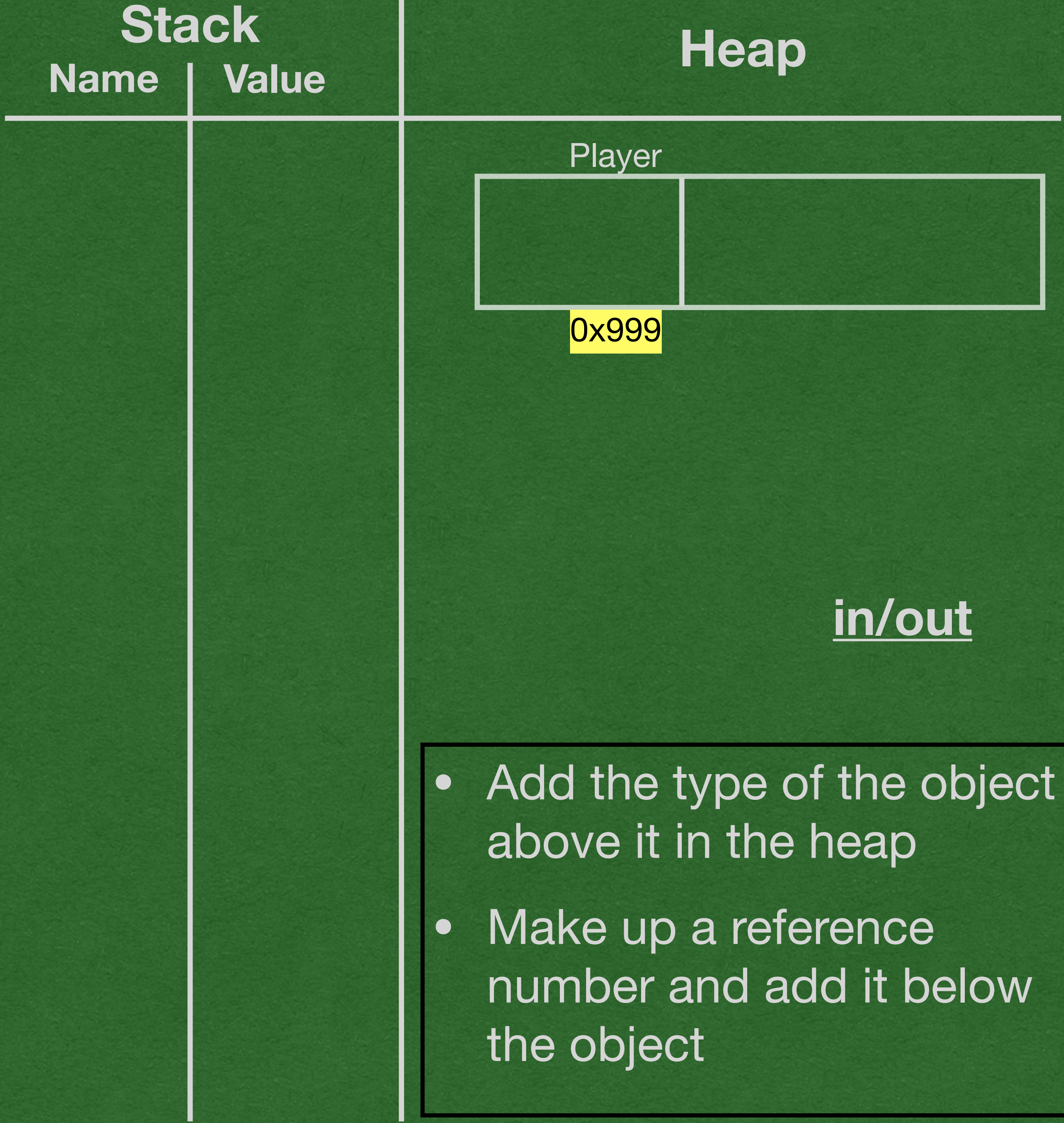
    public void setMaxHP(int maxHP) {
        this.maxHP = maxHP;
    }

    public void setHP(int hp) {
        if (hp <= this.maxHP) {
            this.hp = hp;
        } else {
            this.hp = this.maxHP;
        }
    }

    public String getName() {
        return name;
    }

    public void setName(String name) {
        this.name = name;
    }

    ➡ public static void main(String[] args) {
        Player p1 = new Player("Dark Cecil", 10);
        Player p2 = new Player("Kain", 14);
        Player p3 = p1;
        p1.setName("Paladin");
        System.out.println(p3.getName());
    }
}
```




```
public class Player {
    private int maxHP;
    private int hp;
    private String name;

    ➡ public Player(String name, int maxHP) {
        this.setMaxHP(maxHP);
        this.setHP(maxHP);
        this.setName(name);
    }

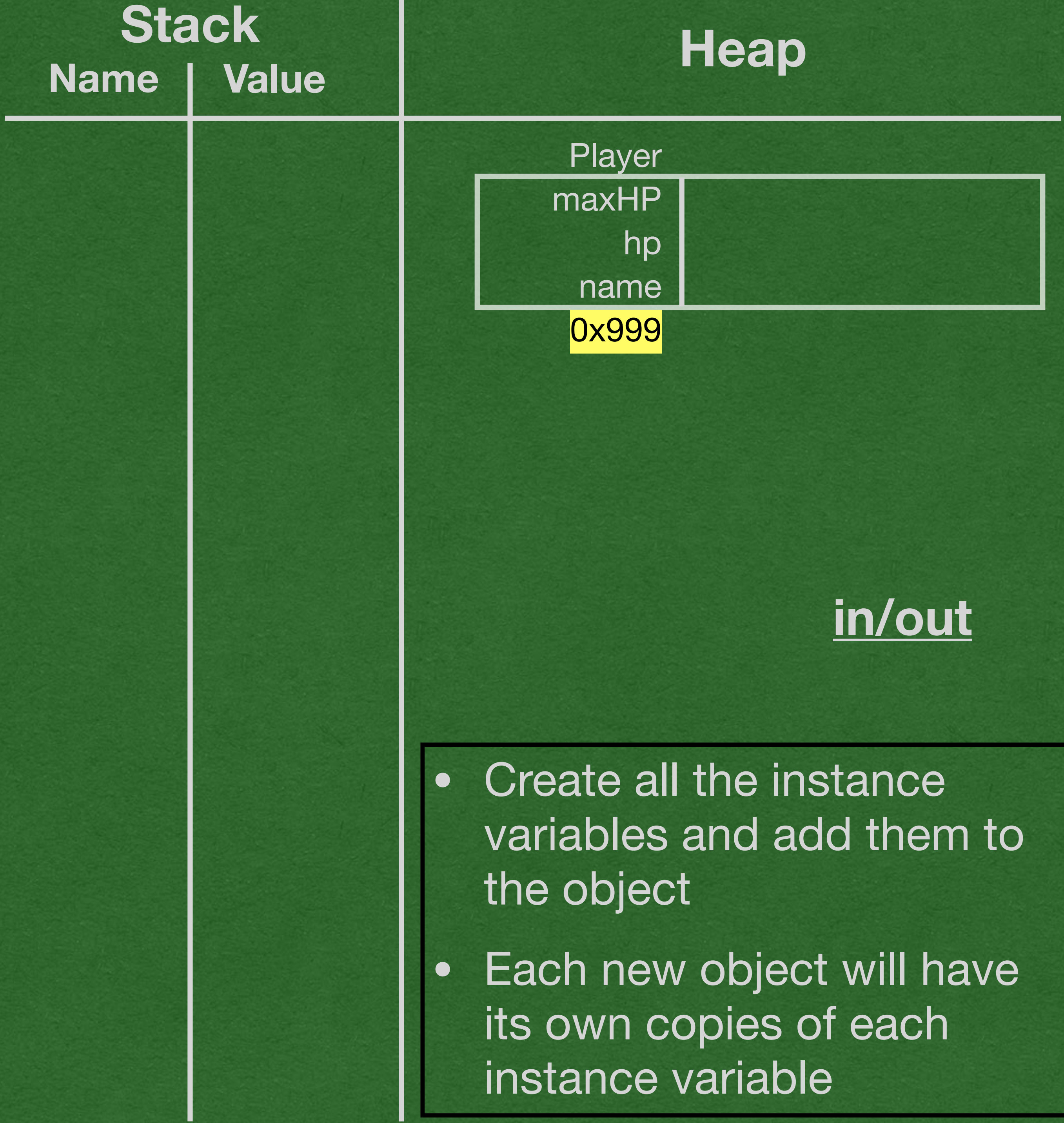
    public void setMaxHP(int maxHP) {
        this.maxHP = maxHP;
    }

    public void setHP(int hp) {
        if (hp <= this.maxHP) {
            this.hp = hp;
        } else {
            this.hp = this.maxHP;
        }
    }

    public String getName() {
        return name;
    }

    public void setName(String name) {
        this.name = name;
    }

    ➡ public static void main(String[] args) {
        Player p1 = new Player("Dark Cecil", 10);
        Player p2 = new Player("Kain", 14);
        Player p3 = p1;
        p1.setName("Paladin");
        System.out.println(p3.getName());
    }
}
```




```
public class Player {
    private int maxHP;
    private int hp;
    private String name;

    ➡ public Player(String name, int maxHP) {
        this.setMaxHP(maxHP);
        this.setHP(maxHP);
        this.setName(name);
    }

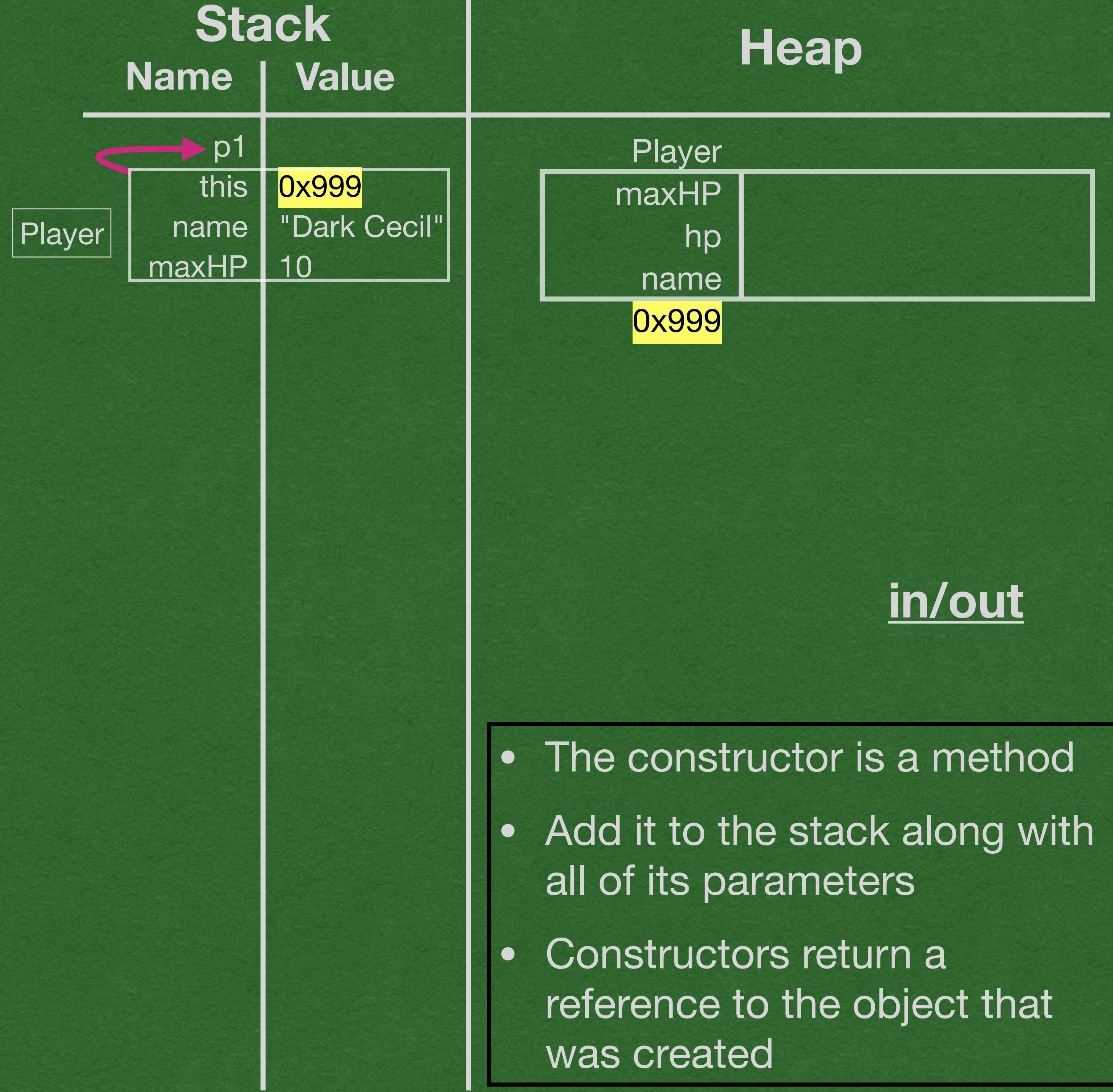
    public void setMaxHP(int maxHP) {
        this.maxHP = maxHP;
    }

    public void setHP(int hp) {
        if (hp <= this.maxHP) {
            this.hp = hp;
        } else {
            this.hp = this.maxHP;
        }
    }

    public String getName() {
        return name;
    }

    public void setName(String name) {
        this.name = name;
    }

    ➡ public static void main(String[] args) {
        Player p1 = new Player("Dark Cecil", 10);
        Player p2 = new Player("Kain", 14);
        Player p3 = p1;
        p1.setName("Paladin");
        System.out.println(p3.getName());
    }
}
```




```
public class Player {
    private int maxHP;
    private int hp;
    private String name;

    ➡ public Player(String name, int maxHP) {
        this.setMaxHP(maxHP);
        this.setHP(maxHP);
        this.setName(name);
    }

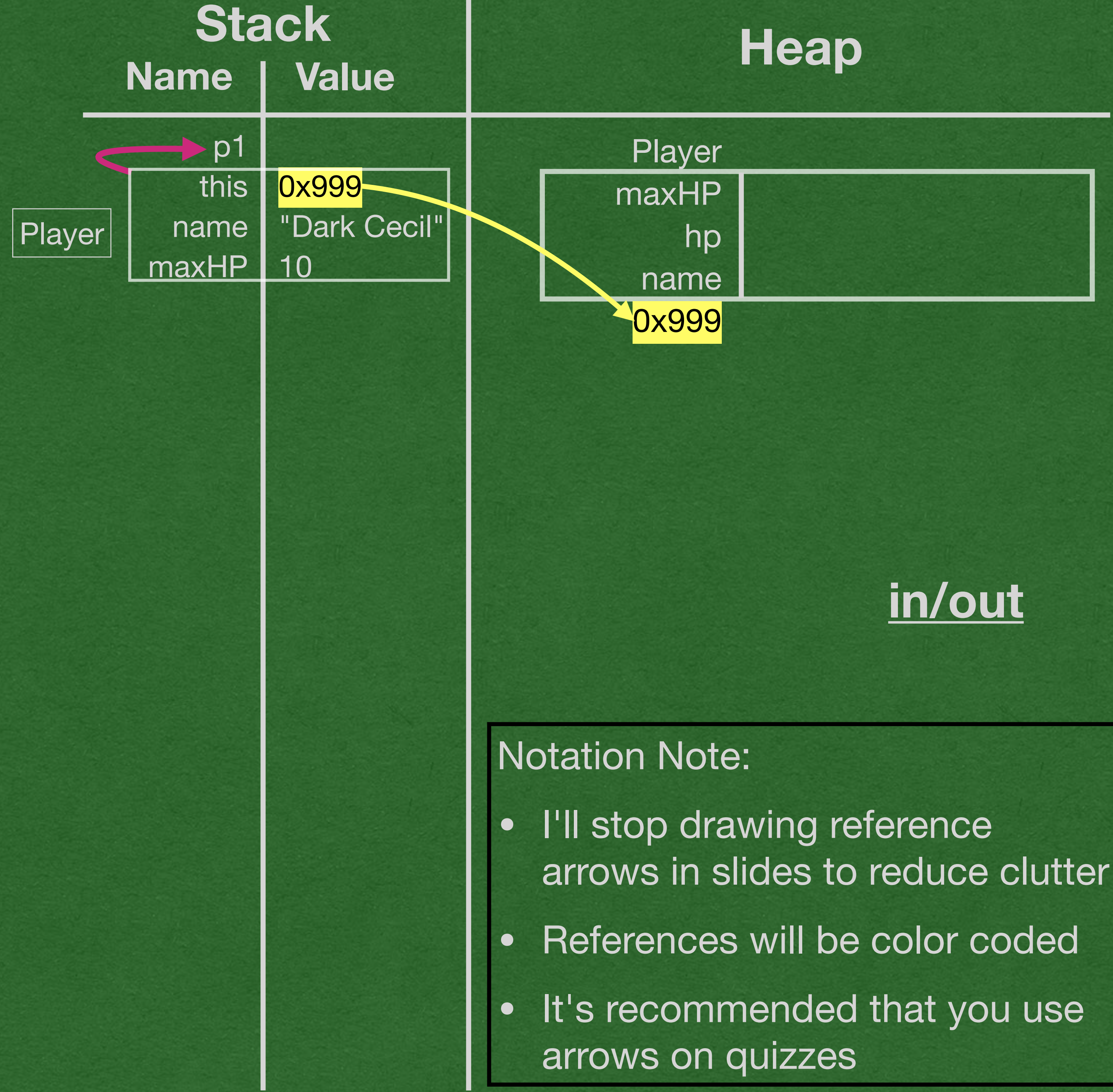
    public void setMaxHP(int maxHP) {
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    public String getName() {
        return name;
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    ➡ public static void main(String[] args) {
        Player p1 = new Player("Dark Cecil", 10);
        Player p2 = new Player("Kain", 14);
        Player p3 = p1;
        p1.setName("Paladin");
        System.out.println(p3.getName());
    }
}
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public class Player {
    private int maxHP;
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    }

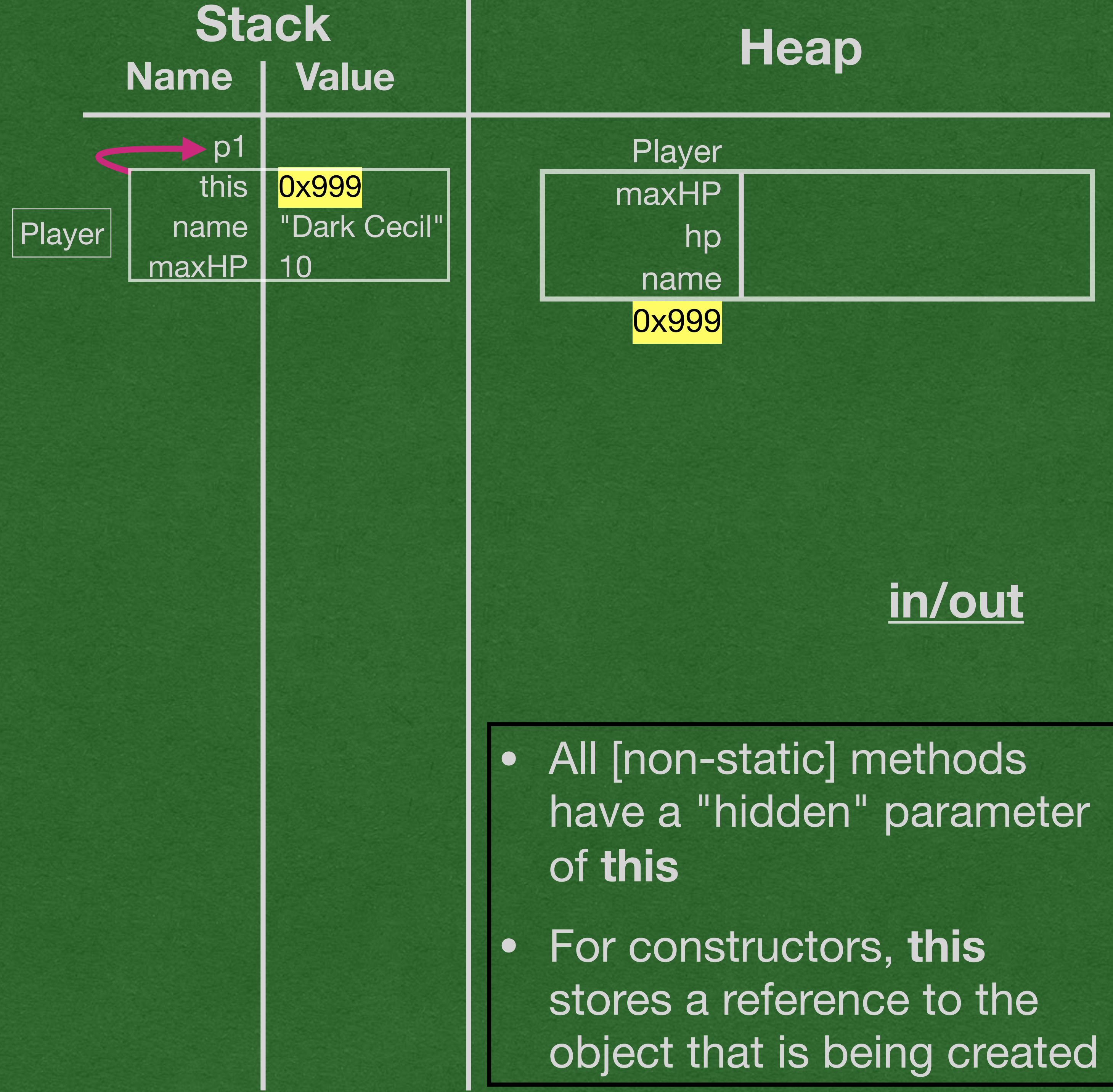
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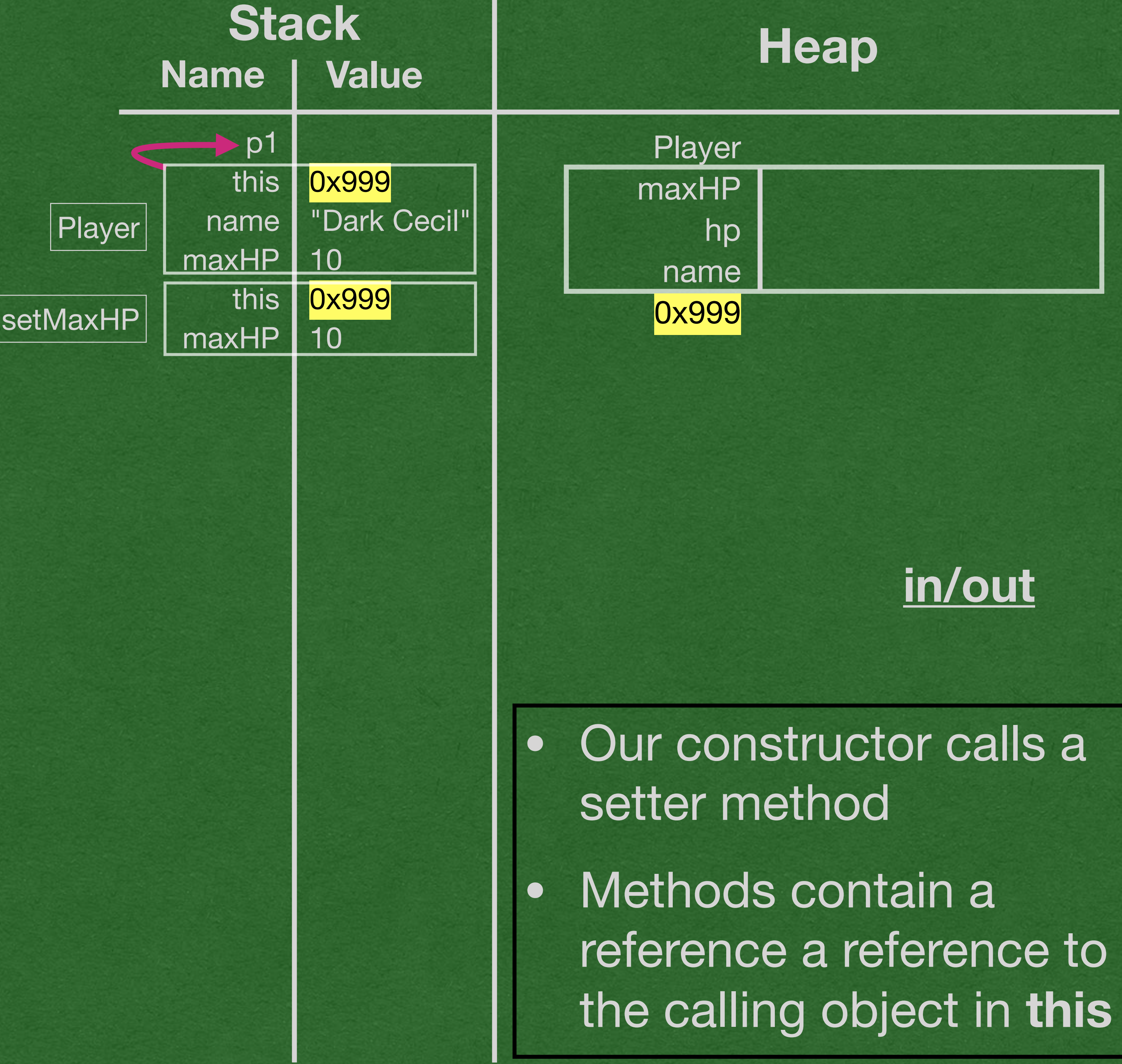
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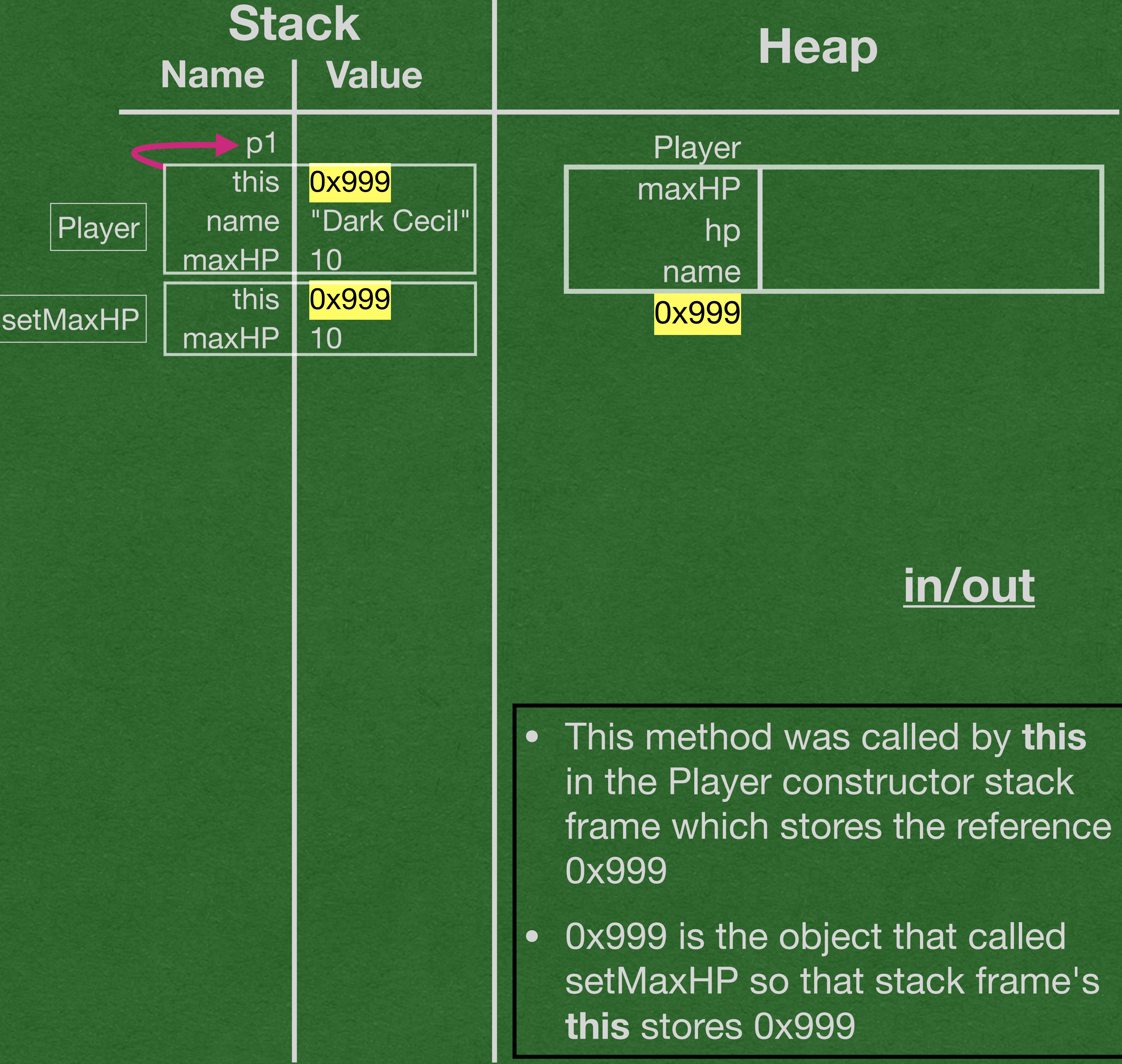
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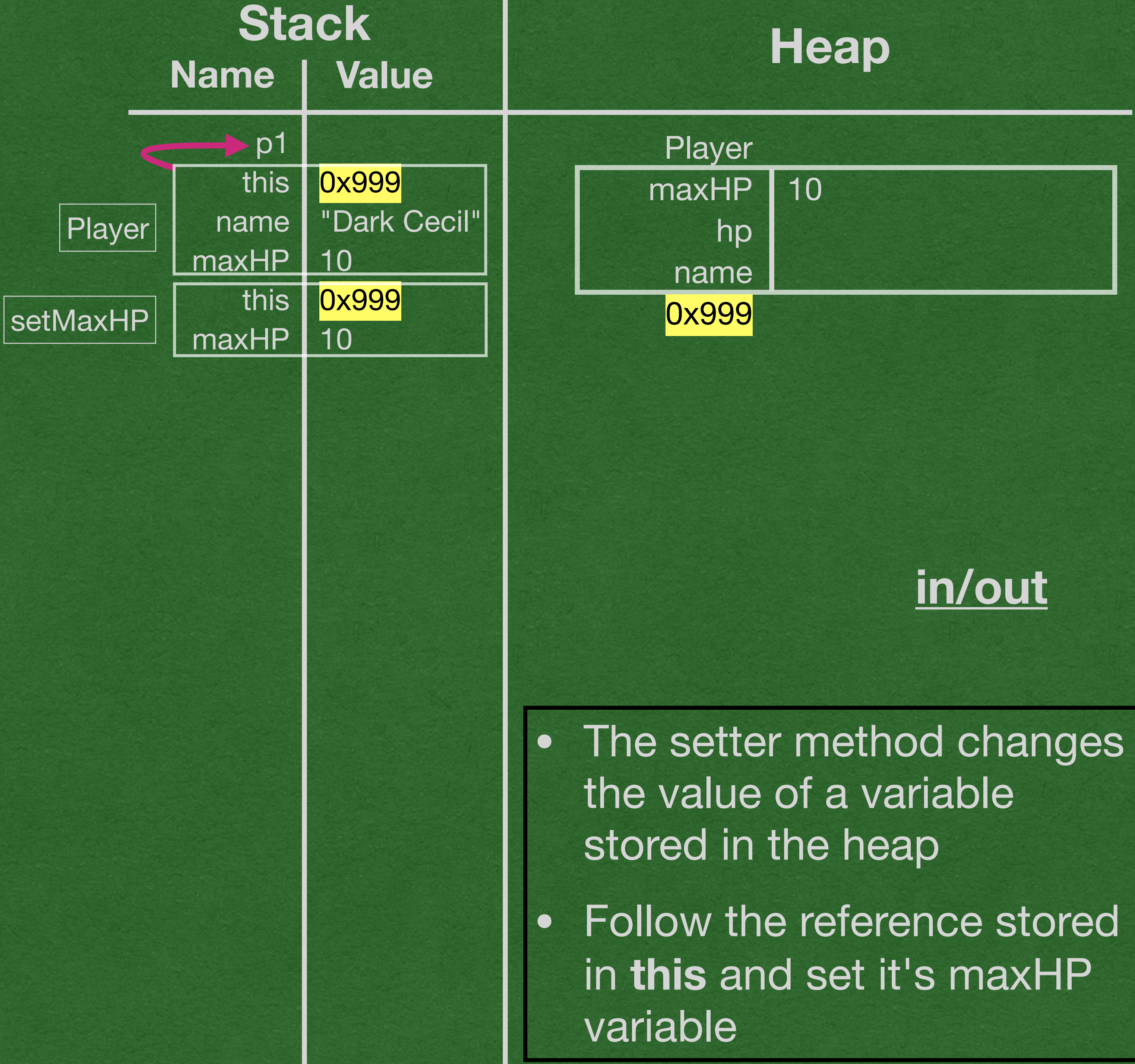
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        System.out.println(p3.getName());
    }
}
```

Stack	
Name	Value
Player	p1
	this 0x999
	name "Dark Cecil"
setMaxHP	maxHP 10
	this 0x999
	maxHP 10

Heap

Player	
maxHP	10
hp	
name	

0x999

in/out

Notation Note:

- I'll gray out a stack frame that is removed from the stack
- This will have the same meaning as crossing it out
- Makes the variables readable


```
public class Player {
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    private int hp;
    private String name;

    public Player(String name, int maxHP) {
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        System.out.println(p3.getName());
    }
}
```

Stack	
Name	Value
Player	p1
	this 0x999
	name "Dark Cecil"
setMaxHP	this 0x999
	maxHP 10
setHP	this 0x999
	hp 10

Heap

Player	
maxHP	10
hp	10
name	

0x999

in/out

- Calling setHP will set the hp variable on the stack for this object

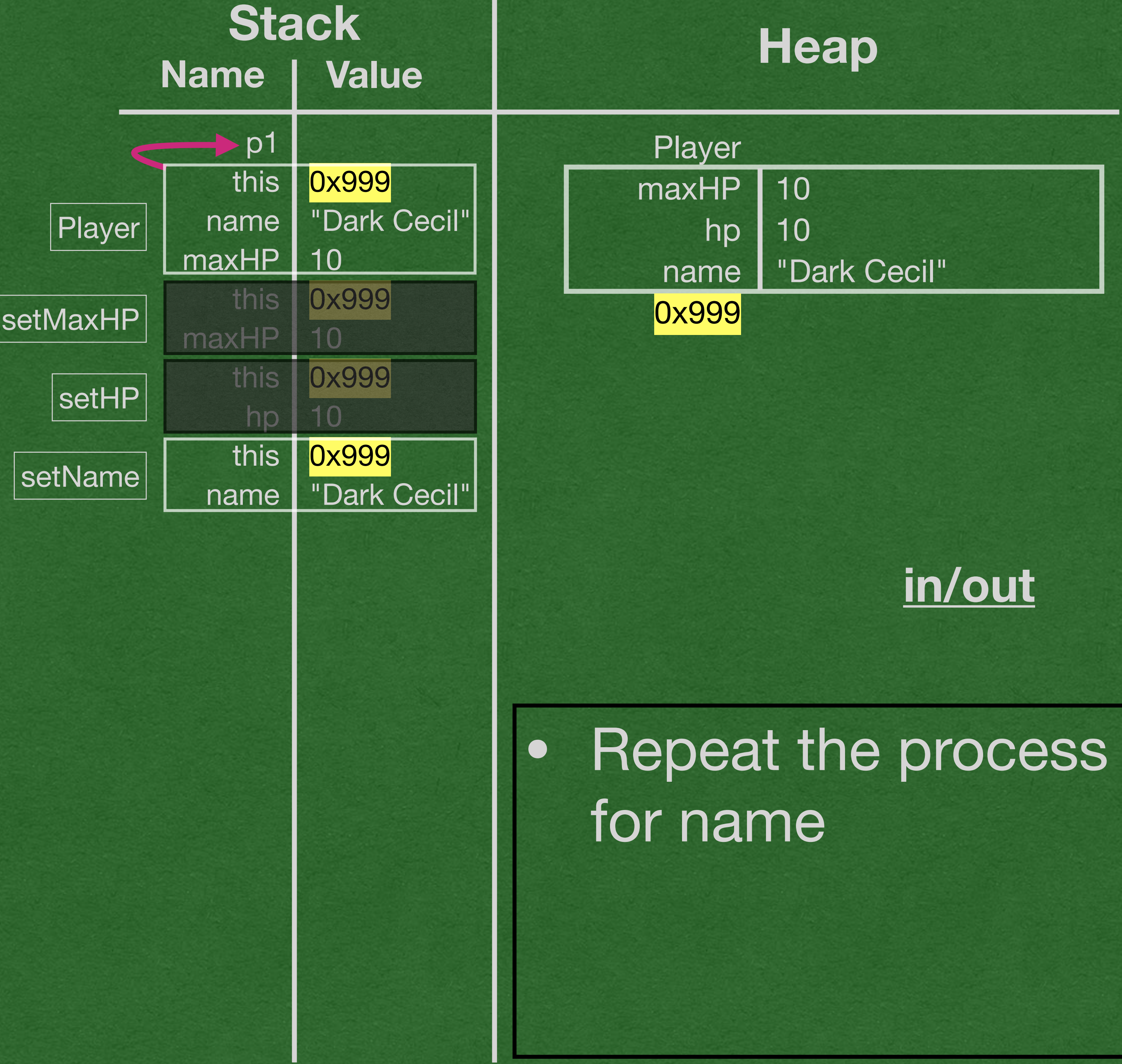
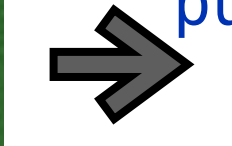
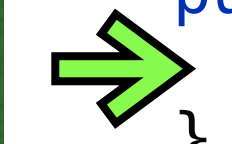
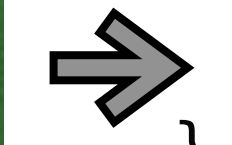

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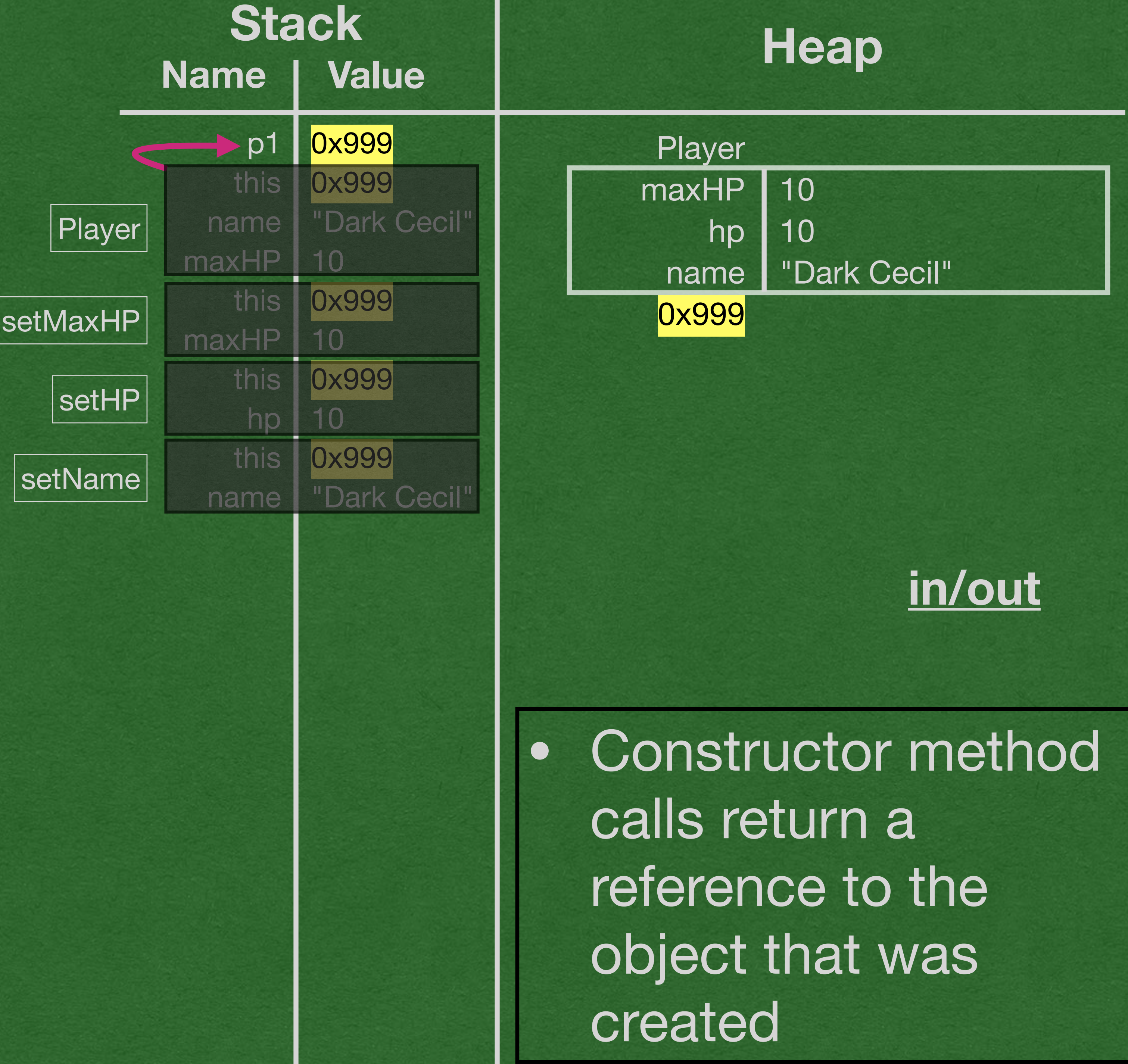
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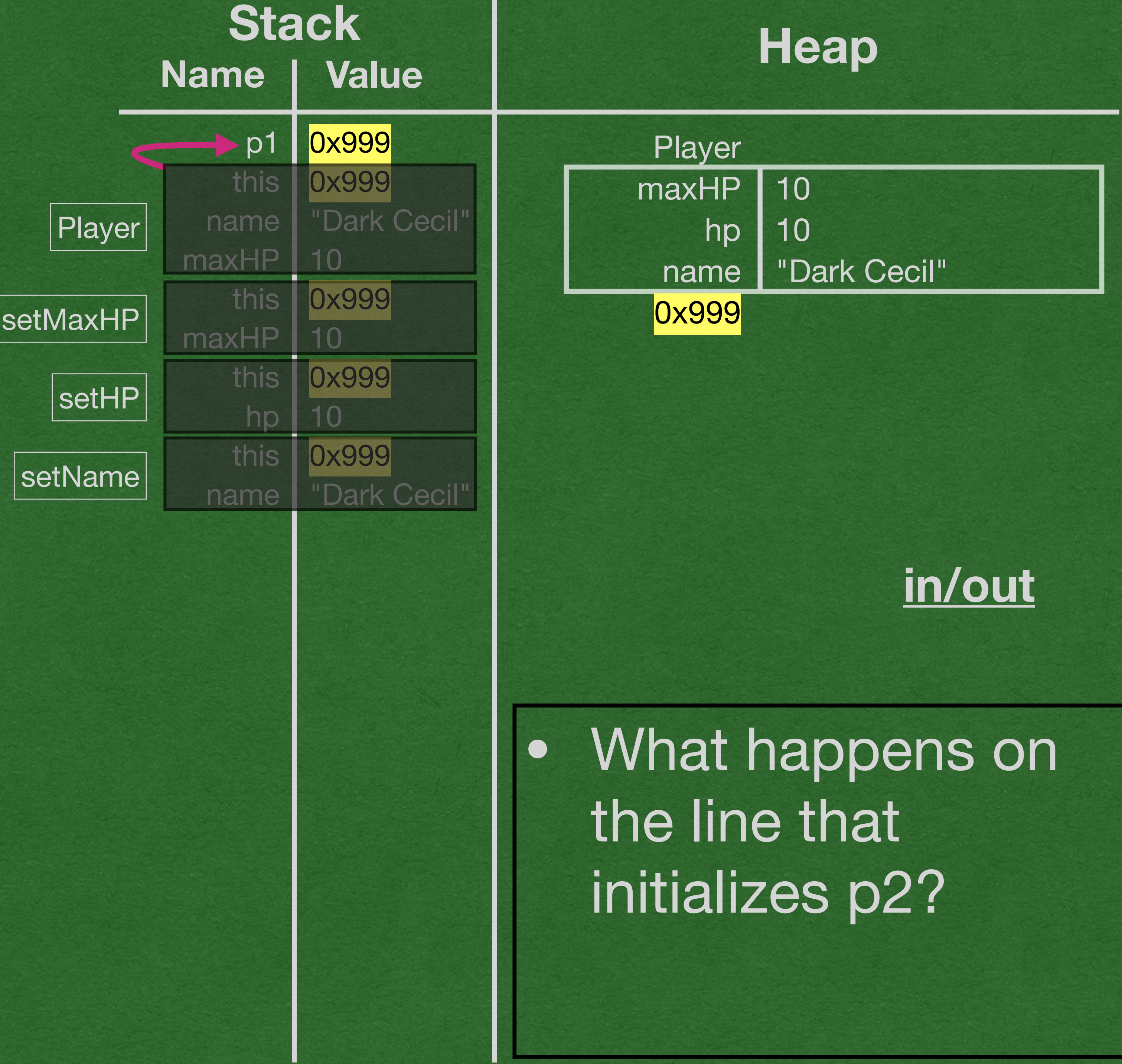
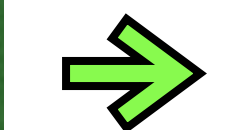
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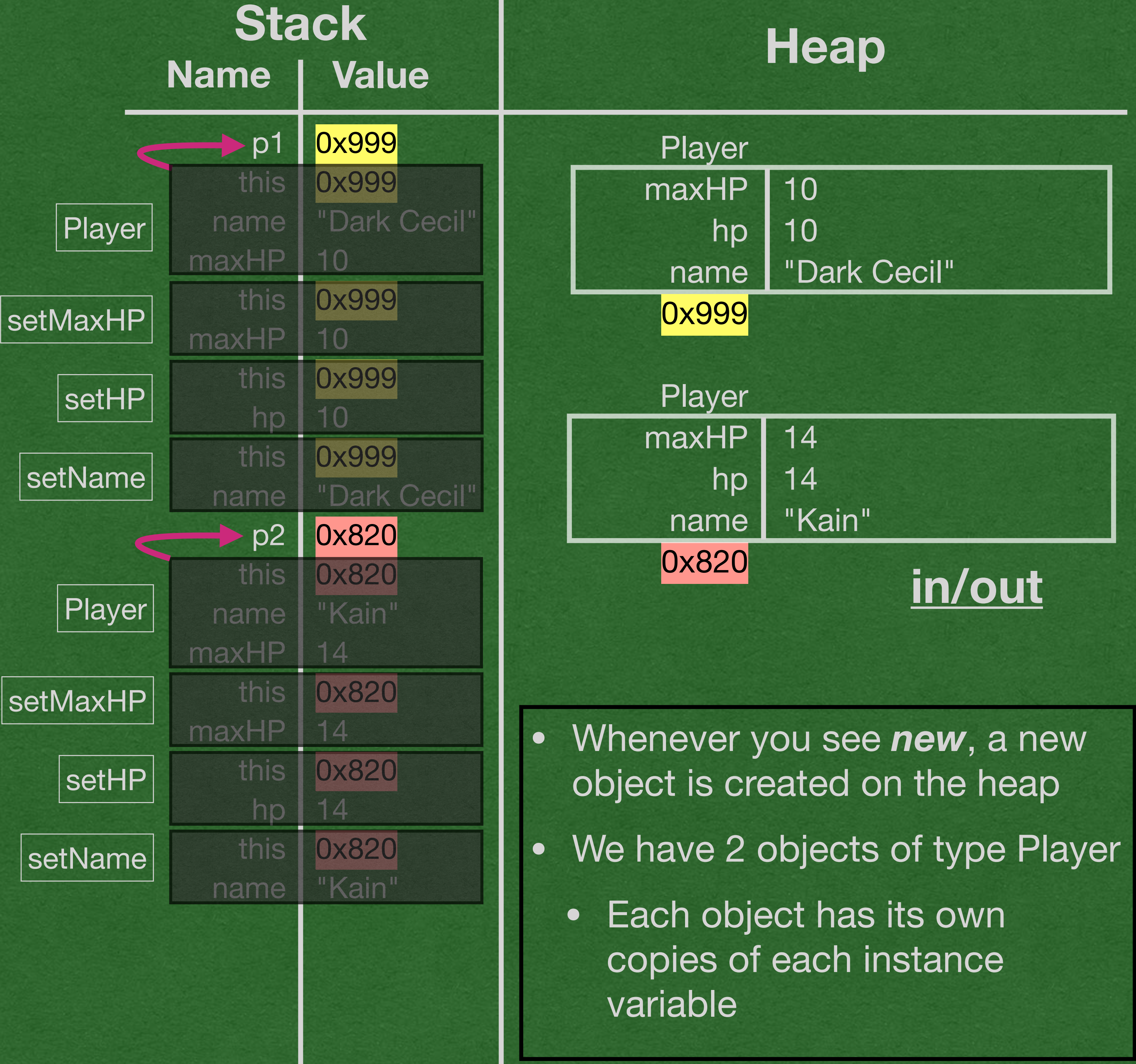
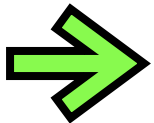
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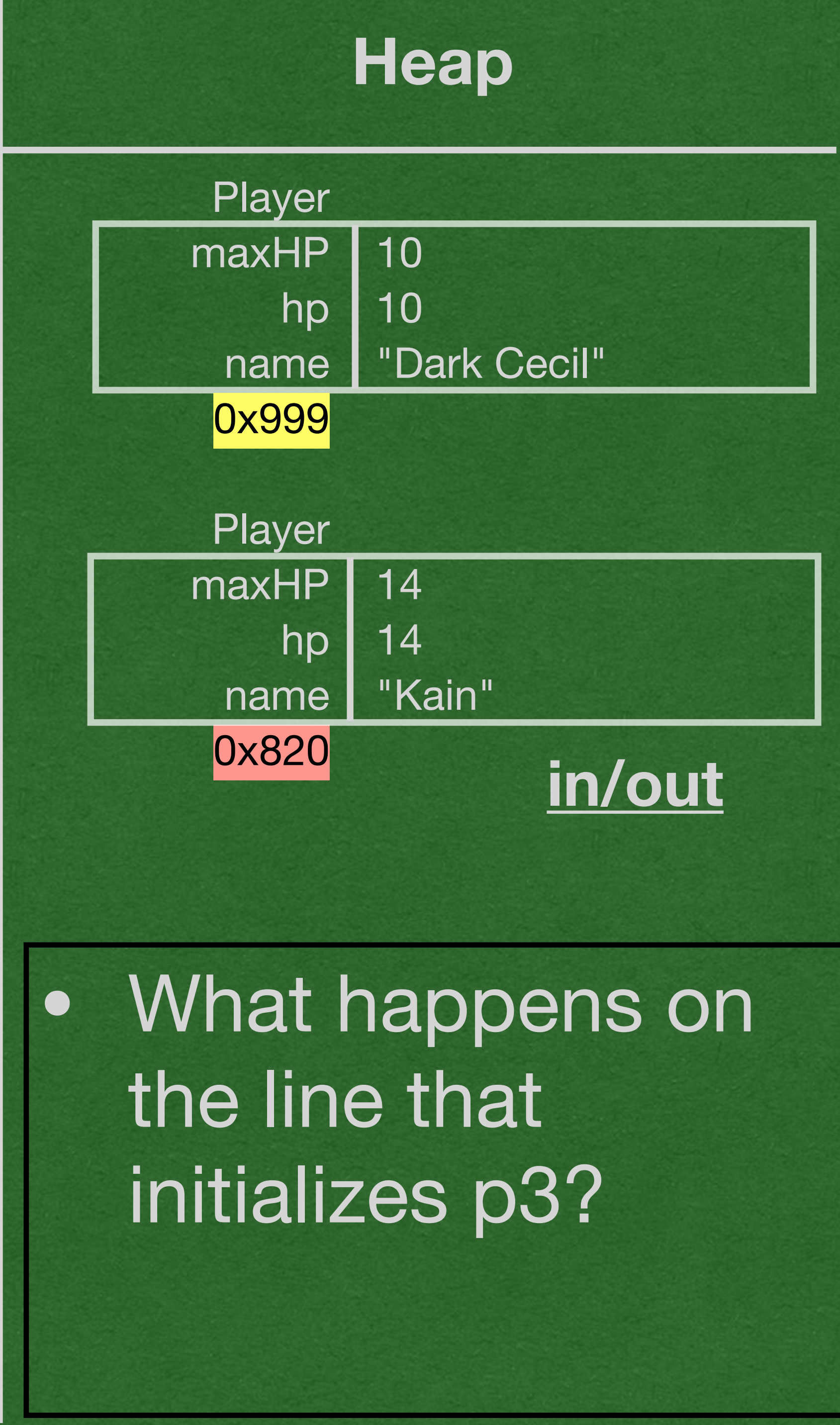
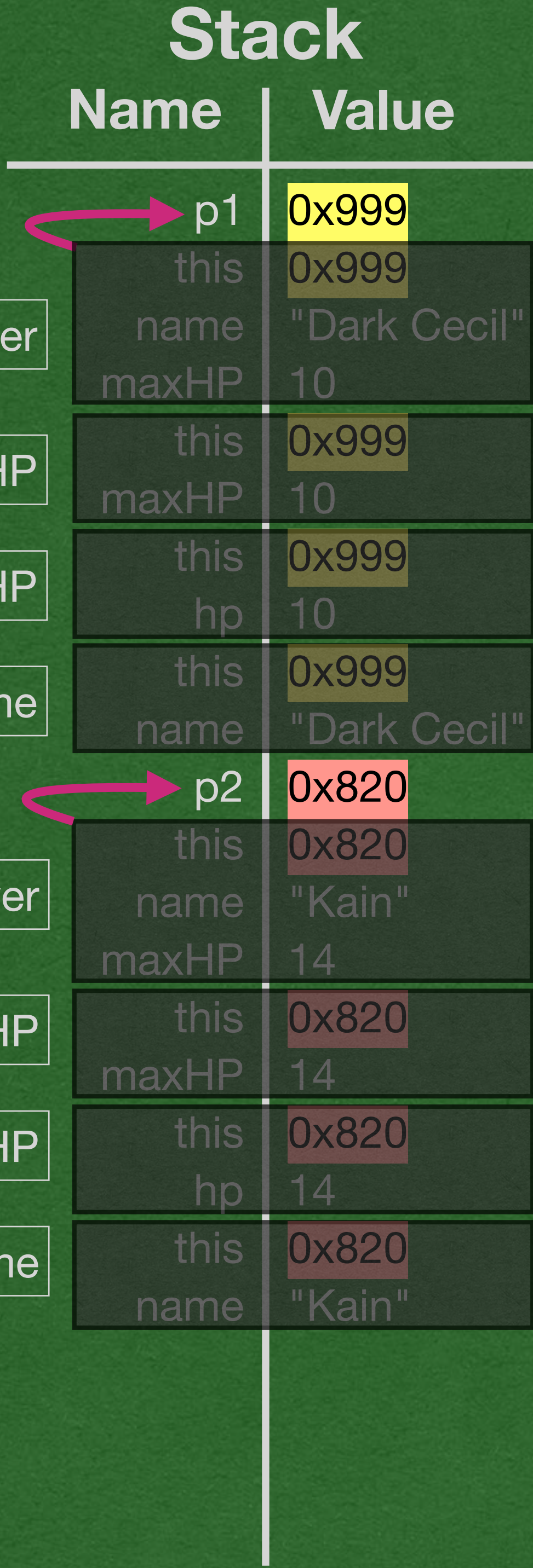
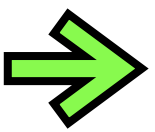
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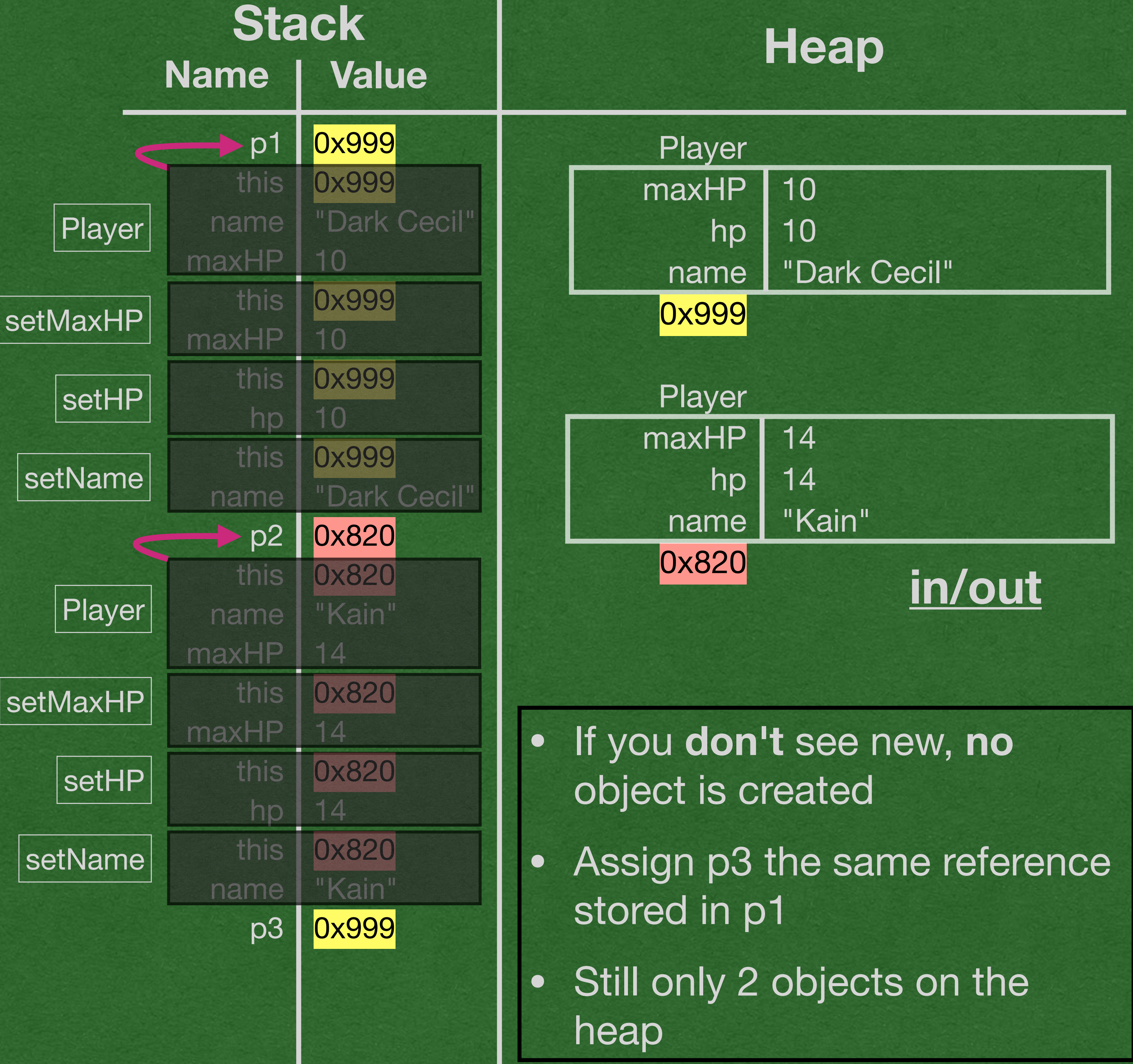
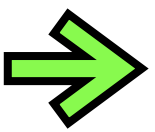
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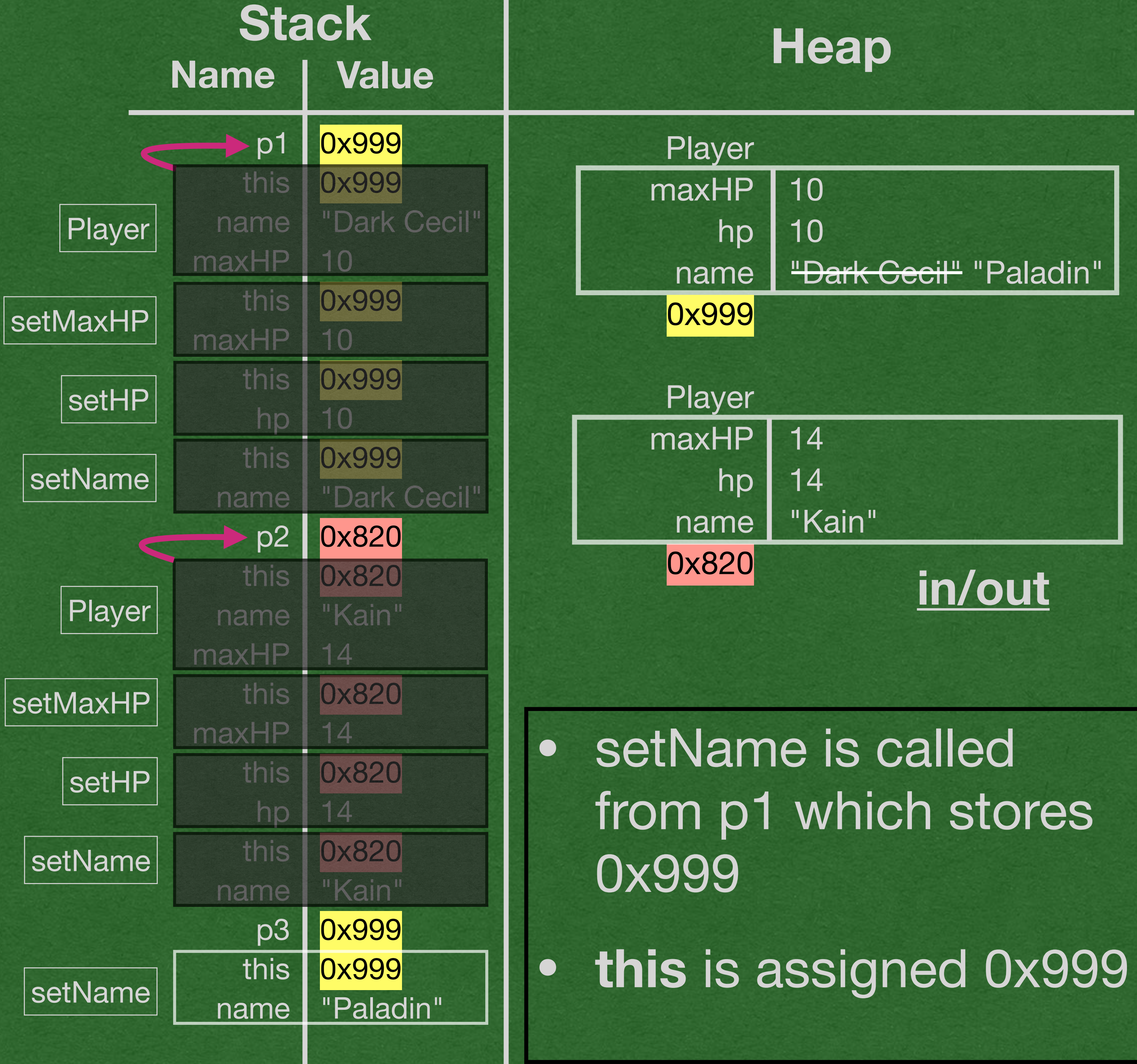
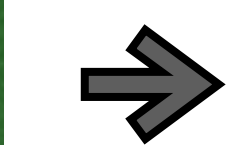
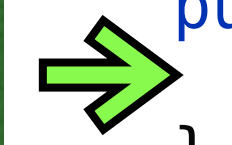
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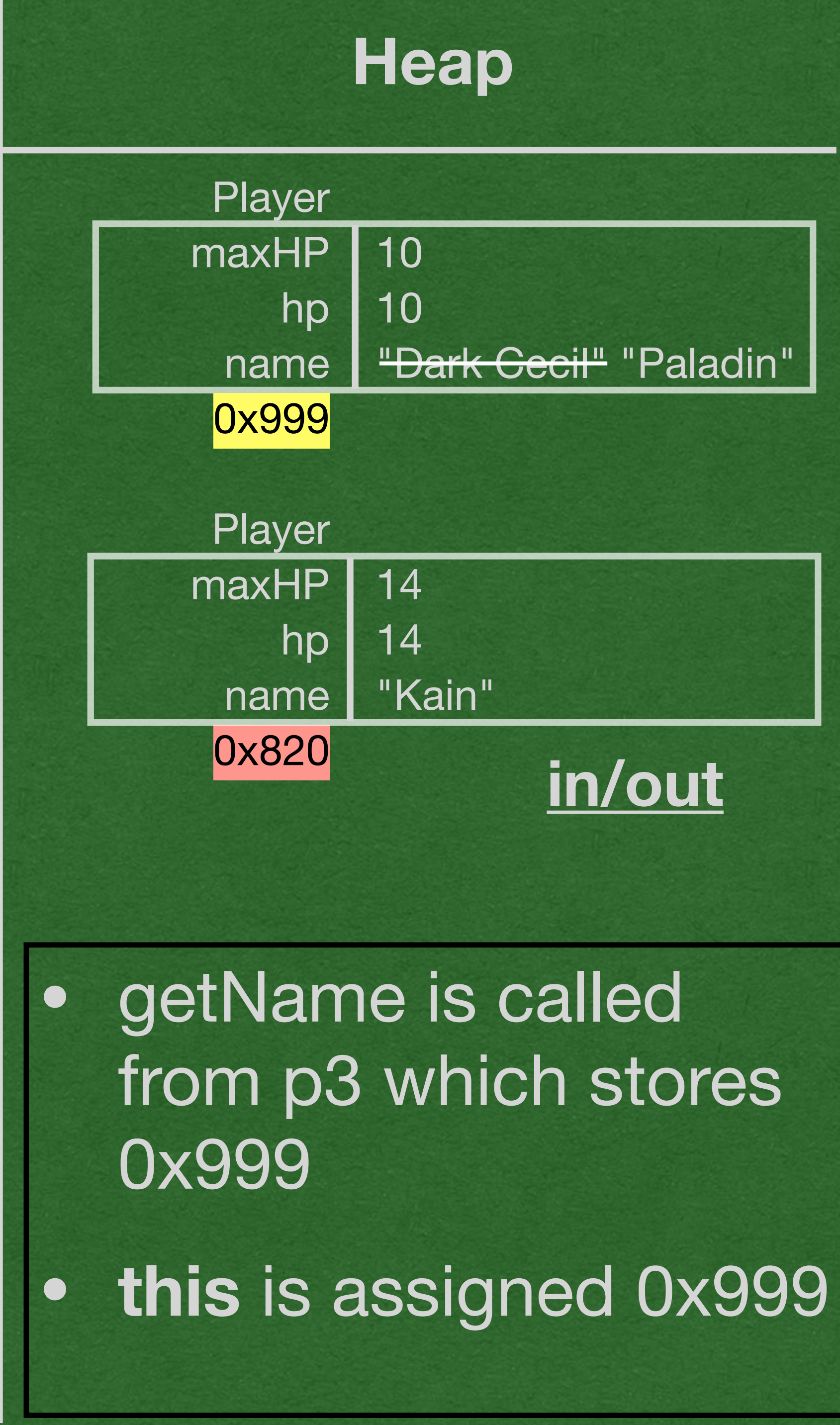
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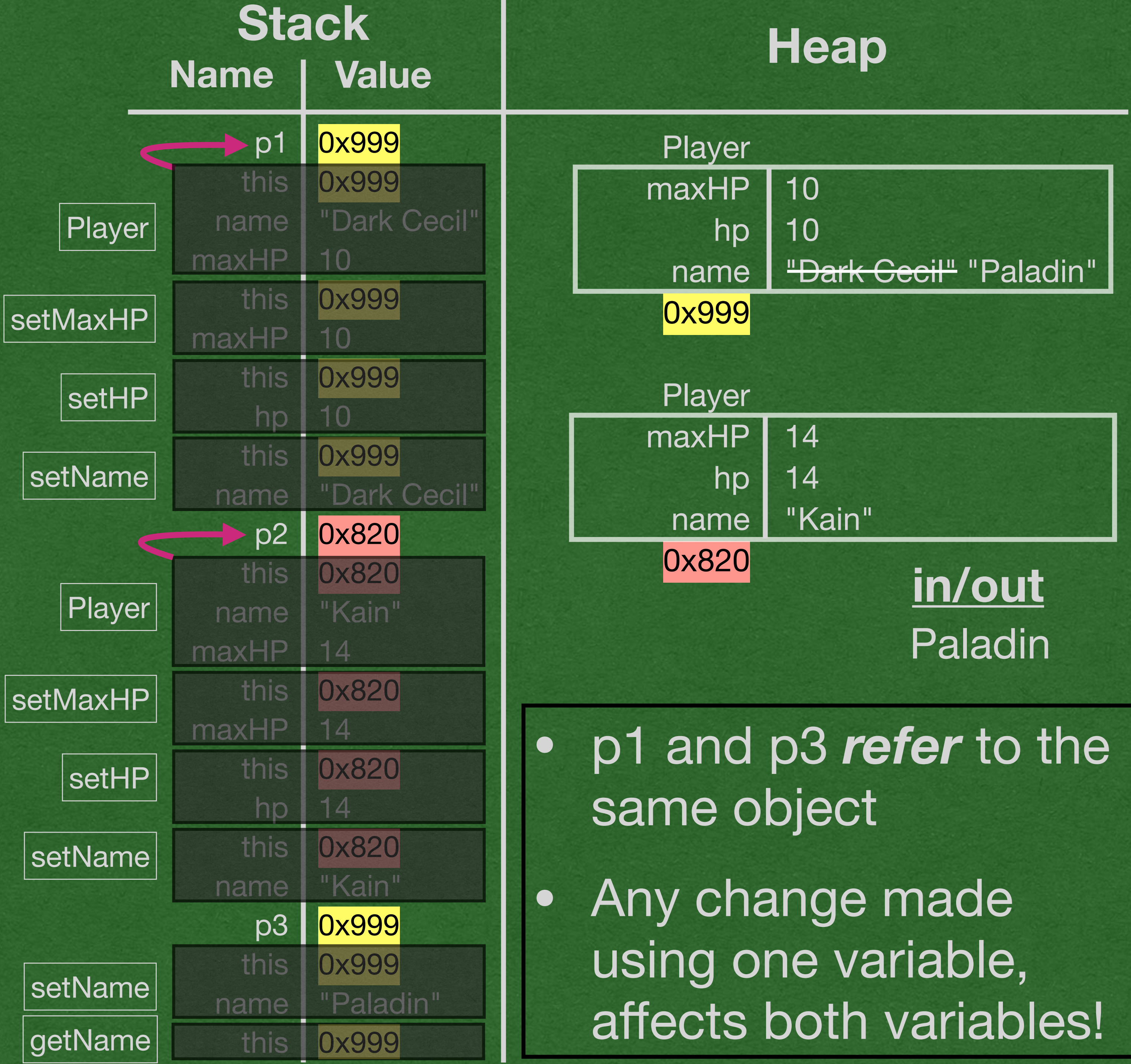
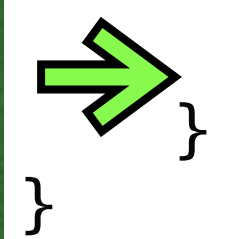
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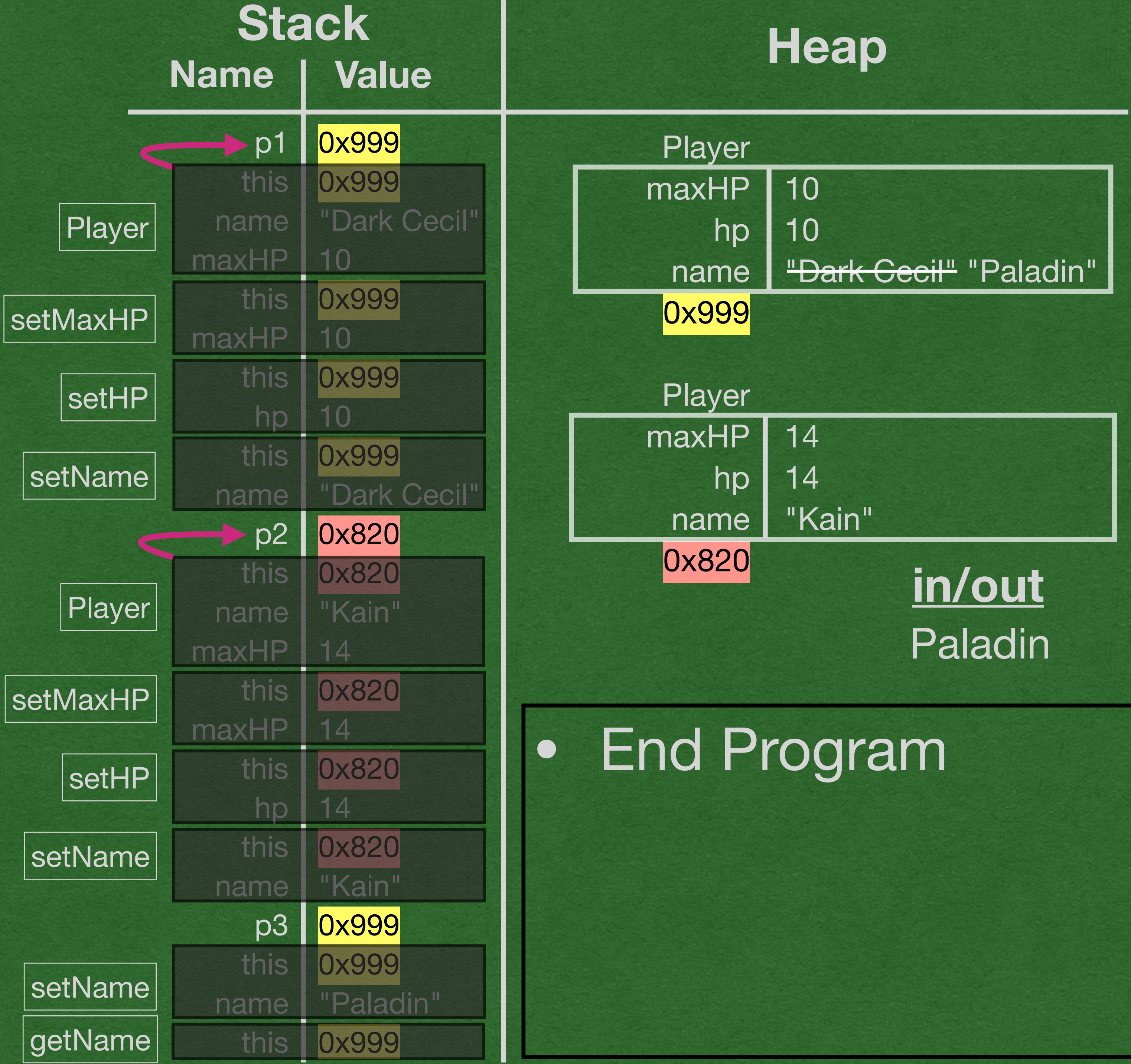
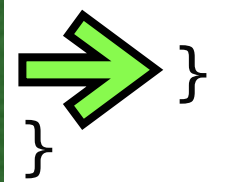
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in/out

Paladin

• End Program