

# Java

ArrayList, HashMap

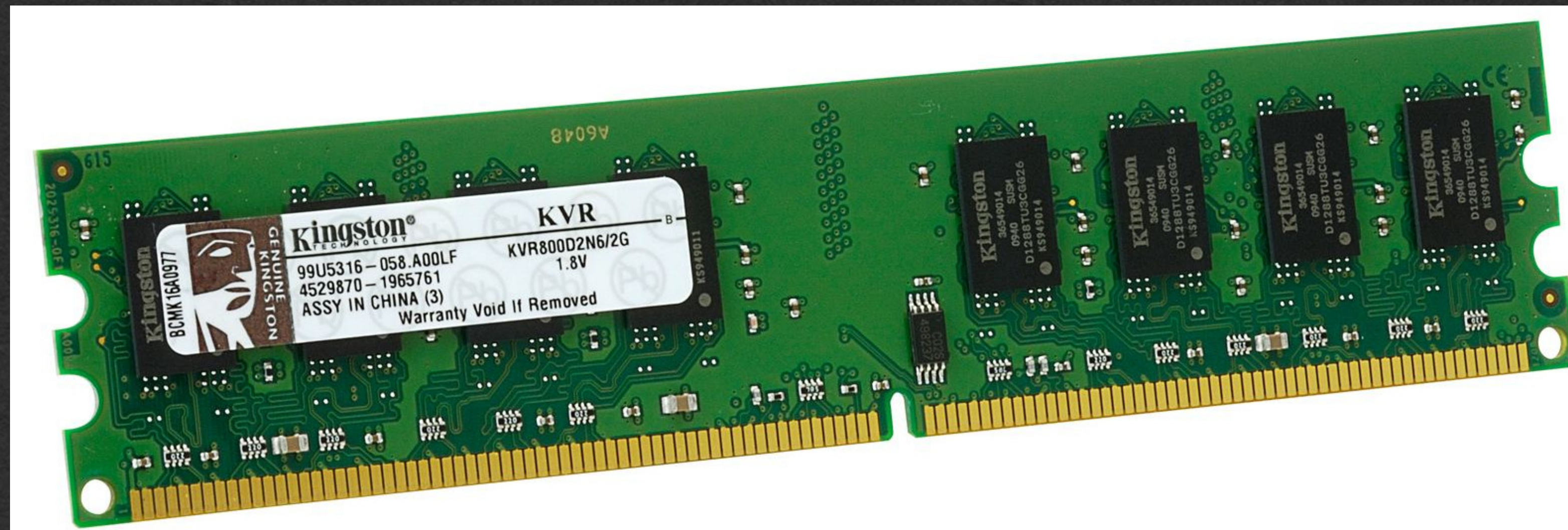


**Memory**



# Let's Talk About Memory

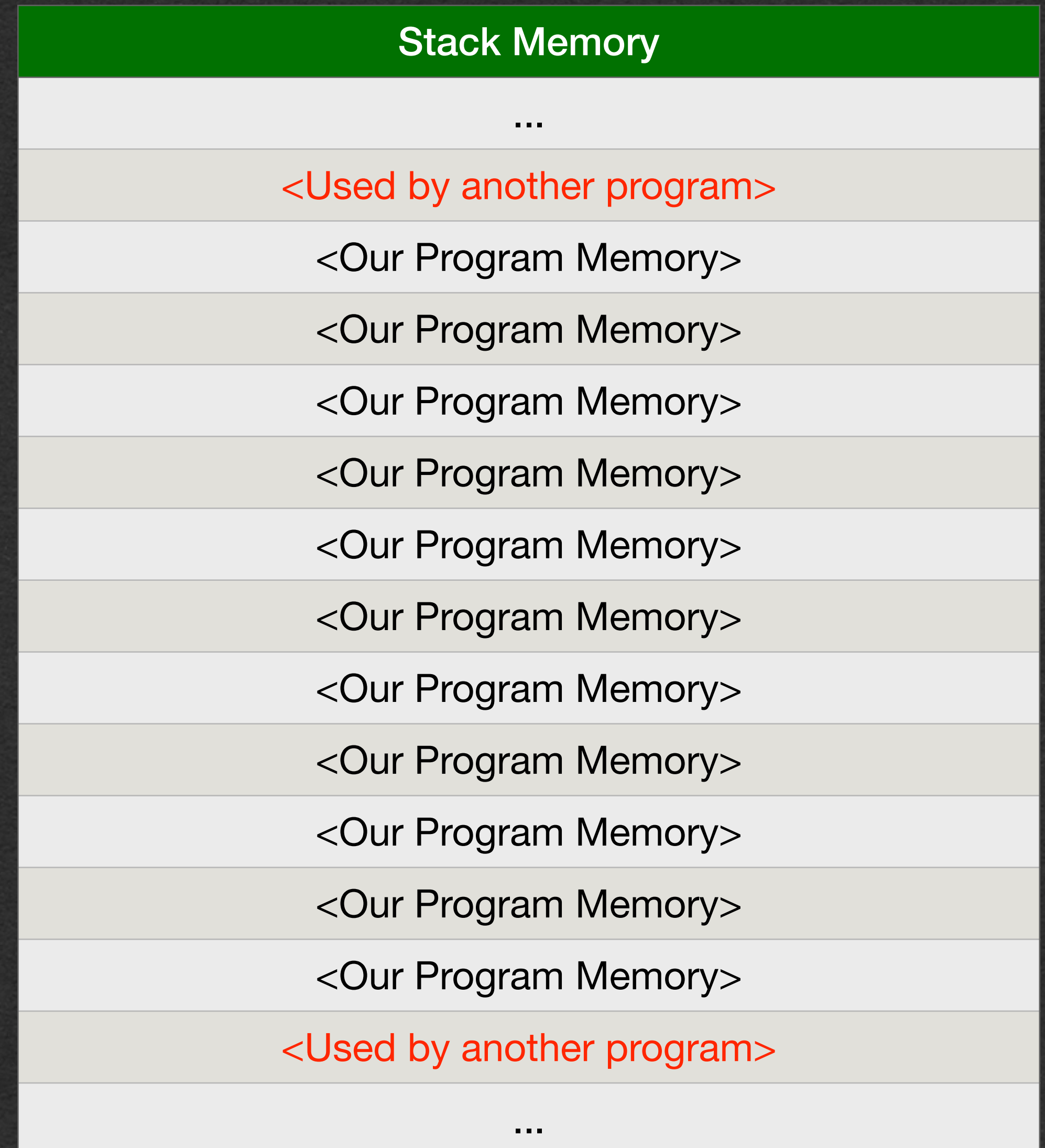
- Random Access Memory (RAM)
- Access any value by index
- Effectively, a giant array
- All values in your program are stored here





# Let's Talk About Memory

- Operating System (OS) controls memory
- On program start, OS allocates a section of memory for our program
- Gives access to a range of memory addresses/indices





# Stack Memory

- Fixed section of memory used to store variables and stack frames
- One continuous section of RAM
- LIFO - Last In First Out
  - New values are added to the end of the stack
  - Only frames at the end of the stack can be removed



# Heap Memory

- ArrayLists and HashMaps will be stored in heap memory
- Heap memory is dynamic
  - We can "ask" the OS/JVM for more heap space as needed
- Heap memory can be anywhere in RAM
  - Location is not important
  - Location can change
- Use **references** to find data
  - **Variables only store references to values in the heap**



# ArrayList



# Java - ArrayList

```
package week2;

import java.util.ArrayList;

public class ArrayList1 {
    public static int sum(ArrayList<Integer> arrIn) {
        int out = 0;
        for (int x=0; x<arrIn.size(); x++) {
            out += arrIn.get(x);
        }
        return out;
    }

    public static void main(String[] args) {
        ArrayList<Integer> arr1 = new ArrayList<>();
        for (int x=0; x<4; x++) {
            arr1.add(10-x);
        }
        System.out.println(arr1);
        ArrayList<Integer> arr2 = arr1;
        System.out.println(arr2);
        int total = sum(arr1);
        System.out.println("total: " + total);
    }
}
```

- Similar to:
  - List in Python
  - Array in JavaScript
- Sequential data structure
- Order matters
- Values indexed starting at 0



# Java - ArrayList

```
package week2;

import java.util.ArrayList;

public class ArrayList1 {
    public static int sum(ArrayList<Integer> arrIn) {
        int out = 0;
        for (int x=0; x<arrIn.size(); x++) {
            out += arrIn.get(x);
        }
        return out;
    }

    public static void main(String[] args) {
        ArrayList<Integer> arr1 = new ArrayList<>();
        for (int x=0; x<4; x++) {
            arr1.add(10-x);
        }
        System.out.println(arr1);
        ArrayList<Integer> arr2 = arr1;
        System.out.println(arr2);
        int total = sum(arr1);
        System.out.println("total: " + total);
    }
}
```

- ArrayList is built-in with Java
- However, it is not automatically available
- Unlike String, int, double, etc.
- Must import ArrayList
- The ArrayList class is in the java.util package
- Importing makes the class available in your code



# Java - ArrayList

```
package week2;

import java.util.ArrayList;

public class ArrayList1 {
    public static int sum(ArrayList<Integer> arrIn) {
        int out = 0;
        for (int x=0; x<arrIn.size(); x++) {
            out += arrIn.get(x);
        }
        return out;
    }

    public static void main(String[] args) {
        ArrayList<Integer> arr1 = new ArrayList<>();
        for (int x=0; x<4; x++) {
            arr1.add(10-x);
        }
        System.out.println(arr1);
        ArrayList<Integer> arr2 = arr1;
        System.out.println(arr2);
        int total = sum(arr1);
        System.out.println("total: " + total);
    }
}
```

- Use the "new" keyword to create a new ArrayList
- Must have <> which is a type parameter list
- Can also have <Integer> in this example
- Must have () which is an empty argument list
- This calls the classes *constructor* method and returns an *object*
- Much more detail to come in week 4



# Java - ArrayList

```
package week2;

import java.util.ArrayList;

public class ArrayList1 {
    public static int sum(ArrayList<Integer> arrIn) {
        int out = 0;
        for (int x=0; x<arrIn.size(); x++) {
            out += arrIn.get(x);
        }
        return out;
    }

    public static void main(String[] args) {
        ArrayList<Integer> arr1 = new ArrayList<>();
        for (int x=0; x<4; x++) {
            arr1.add(10-x);
        }
        System.out.println(arr1);
        ArrayList<Integer> arr2 = arr1;
        System.out.println(arr2);
        int total = sum(arr1);
        System.out.println("total: " + total);
    }
}
```

- An ArrayList variable should have a type parameter in <>
- This ArrayList has a type parameter of Integer
- We say this is an "ArrayList of Integers"
- This ArrayList can **only ever** store Integers



# Java - ArrayList

```
package week2;

import java.util.ArrayList;

public class ArrayList1 {
    public static int sum(ArrayList<Integer> arrIn) {
        int out = 0;
        for (int x=0; x<arrIn.size(); x++) {
            out += arrIn.get(x);
        }
        return out;
    }

    public static void main(String[] args) {
        ArrayList<Integer> arr1 = new ArrayList<>();
        for (int x=0; x<4; x++) {
            arr1.add(10-x);
        }
        System.out.println(arr1);
        ArrayList<Integer> arr2 = arr1;
        System.out.println(arr2);
        int total = sum(arr1);
        System.out.println("total: " + total);
    }
}
```

- The type parameter has to be a class
- Class types start with capital letters
- You cannot create an ArrayList of ints



# Java - ArrayList

```
package week2;

import java.util.ArrayList;

public class ArrayList1 {
    public static int sum(ArrayList<Integer> arrIn) {
        int out = 0;
        for (int x=0; x<arrIn.size(); x++) {
            out += arrIn.get(x);
        }
        return out;
    }

    public static void main(String[] args) {
        ArrayList<Integer> arr1 = new ArrayList<>();
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        }
        System.out.println(arr1);
        ArrayList<Integer> arr2 = arr1;
        System.out.println(arr2);
        int total = sum(arr1);
        System.out.println("total: " + total);
    }
}
```

- `int`  $\approx$  `Integer`
- `double`  $\approx$  `Double`
- `boolean`  $\approx$  `Boolean`
- Use the class equivalents for our primitive (starts with lowercase letter) types
  - [In most cases] Java will automatically convert between the two
  - Conversion is called auto-boxing
  - We'll always use the primitive types unless we must use the class equivalent



# Java - ArrayList

```
package week2;

import java.util.ArrayList;

public class ArrayList1 {
    public static int sum(ArrayList<Integer> arrIn) {
        int out = 0;
        for (int x=0; x<arrIn.size(); x++) {
            out += arrIn.get(x);
        }
        return out;
    }

    public static void main(String[] args) {
        ArrayList<Integer> arr1 = new ArrayList<>();
        for (int x=0; x<4; x++) {
            arr1.add(10-x);
        }
        System.out.println(arr1);
        ArrayList<Integer> arr2 = arr1;
        System.out.println(arr2);
        int total = sum(arr1);
        System.out.println("total: " + total);
    }
}
```

- Call the add method to insert a value at the end of the ArrayList
- Call get with an index to retrieve that value at that index
- **Cannot** use [index] to access a value in an ArrayList



# Memory Diagram



### Stack

Name	Value
<b>Global Variables</b>	
Create Global Variable	
<b>Stack Frames</b>	
<b>main</b>	
arr1	0x002 <span>Cross out</span>
x	<input type="text" value="0"/> <input type="text" value="1"/> <input type="text" value="2"/> <input type="text" value="3"/> <input type="text" value="4"/> <span>Cross out</span>
Uncross out this codeblock	
arr2	0x002 <span>Cross out</span>
total	34 <span>Cross out</span>
<b>sum</b>	
arrIn	0x002 <span>Cross out</span>
out	<input type="text" value="0"/> <input type="text" value="10"/> <input type="text" value="19"/> <input type="text" value="27"/> <input type="text" value="34"/> <span>Cross out</span>
x	<input type="text" value="0"/> <input type="text" value="1"/> <input type="text" value="2"/> <input type="text" value="3"/> <input type="text" value="4"/> <span>Cross out</span>
Uncross out this codeblock	
Create Stack Frame	

### Heap

ArrayList No parent

Name	Value
0	10 <span>Cross out</span>
1	9 <span>Cross out</span>
2	8 <span>Cross out</span>
3	7 <span>Cross out</span>

0x002

Create Heap Object

### IO

[10, 9, 8, 7] ×

[10, 9, 8, 7] ×

total: 34 ×

Create IO Line

```

1 package week2;
2
3 import java.util.ArrayList;
4
5 public class ArrayList1 {
6     public static int sum(ArrayList<Integer> arrIn) {
7         int out = 0;
8         for (int x=0; x<arrIn.size(); x++) {
9             out += arrIn.get(x);
10        }
11        return out;
12    }
13
14    public static void main(String[] args) {
15        ArrayList<Integer> arr1 = new ArrayList<>();
16        for (int x=0; x<4; x++) {
17            arr1.add(10-x);
18        }
19        System.out.println(arr1);
20        ArrayList<Integer> arr2 = arr1;
21        System.out.println(arr2);
22        int total = sum(arr1);
23        System.out.println("total: " + total);
24    }
25 }

```



```

package week2;

import java.util.ArrayList;

public class ArrayList1 {
    public static int sum(ArrayList<Integer> arrIn) {
        int out = 0;
        for (int x=0; x<arrIn.size(); x++) {
            out += arrIn.get(x);
        }
        return out;
    }
    → public static void main(String[] args) {
        ArrayList<Integer> arr1 = new ArrayList<>();
        for (int x=0; x<4; x++) {
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        }
        System.out.println(arr1);
        ArrayList<Integer> arr2 = arr1;
        System.out.println(arr2);
        int total = sum(arr1);
        System.out.println("total: " + total);
    }
}

```

Stack		Heap
Name	Value	
		<u>in/out</u>

- It all starts the same
- It will quickly become very different



```

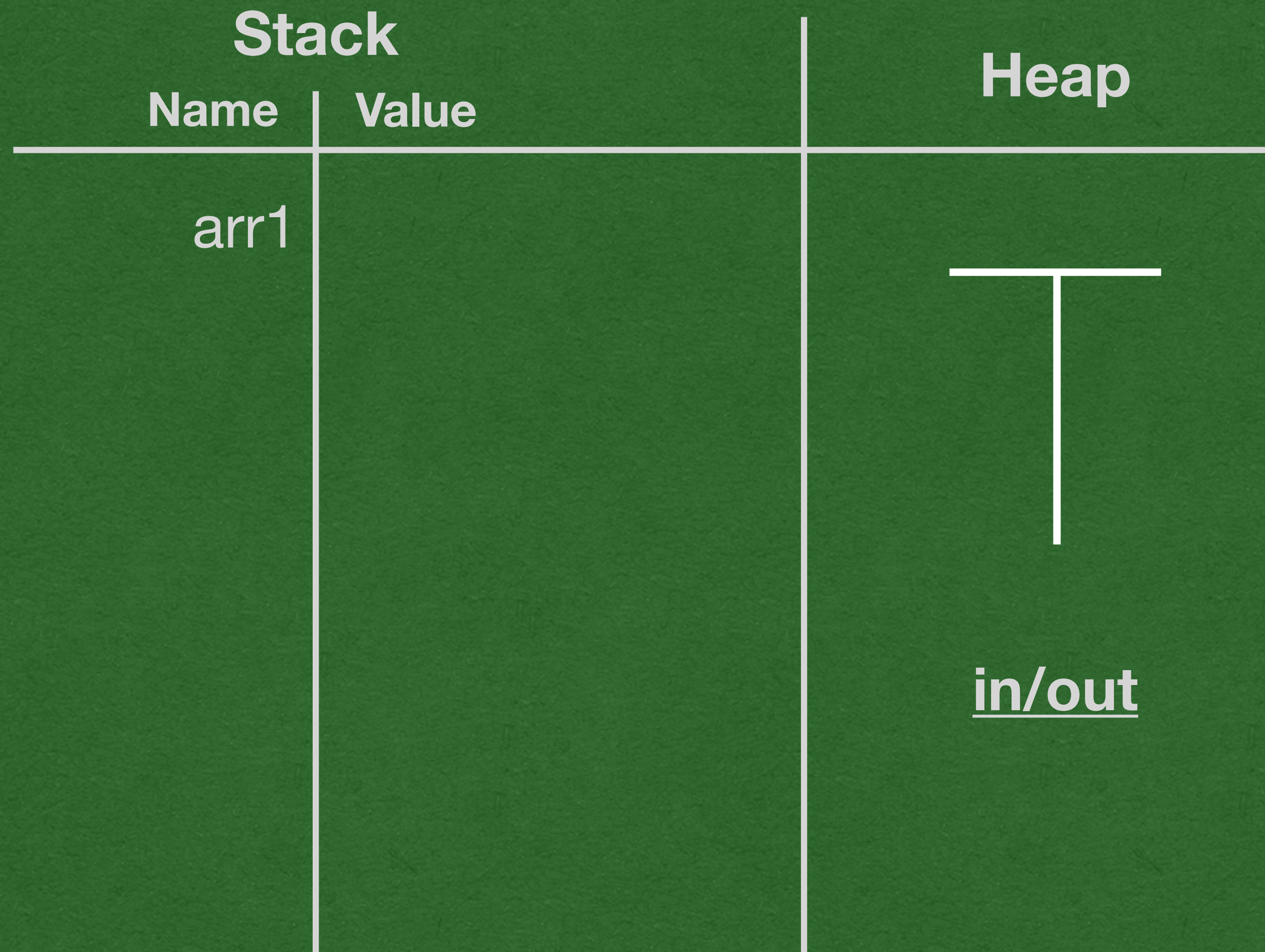
package week2;

import java.util.ArrayList;

public class ArrayList1 {
    public static int sum(ArrayList<Integer> arrIn) {
        int out = 0;
        for (int x=0; x<arrIn.size(); x++) {
            out += arrIn.get(x);
        }
        return out;
    }

    public static void main(String[] args) {
        ➔ ArrayList<Integer> arr1 = new ArrayList<>();
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        }
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        System.out.println(arr2);
        int total = sum(arr1);
        System.out.println("total: " + total);
    }
}

```



- We create an ArrayList
- ArrayLists go in the heap!



```

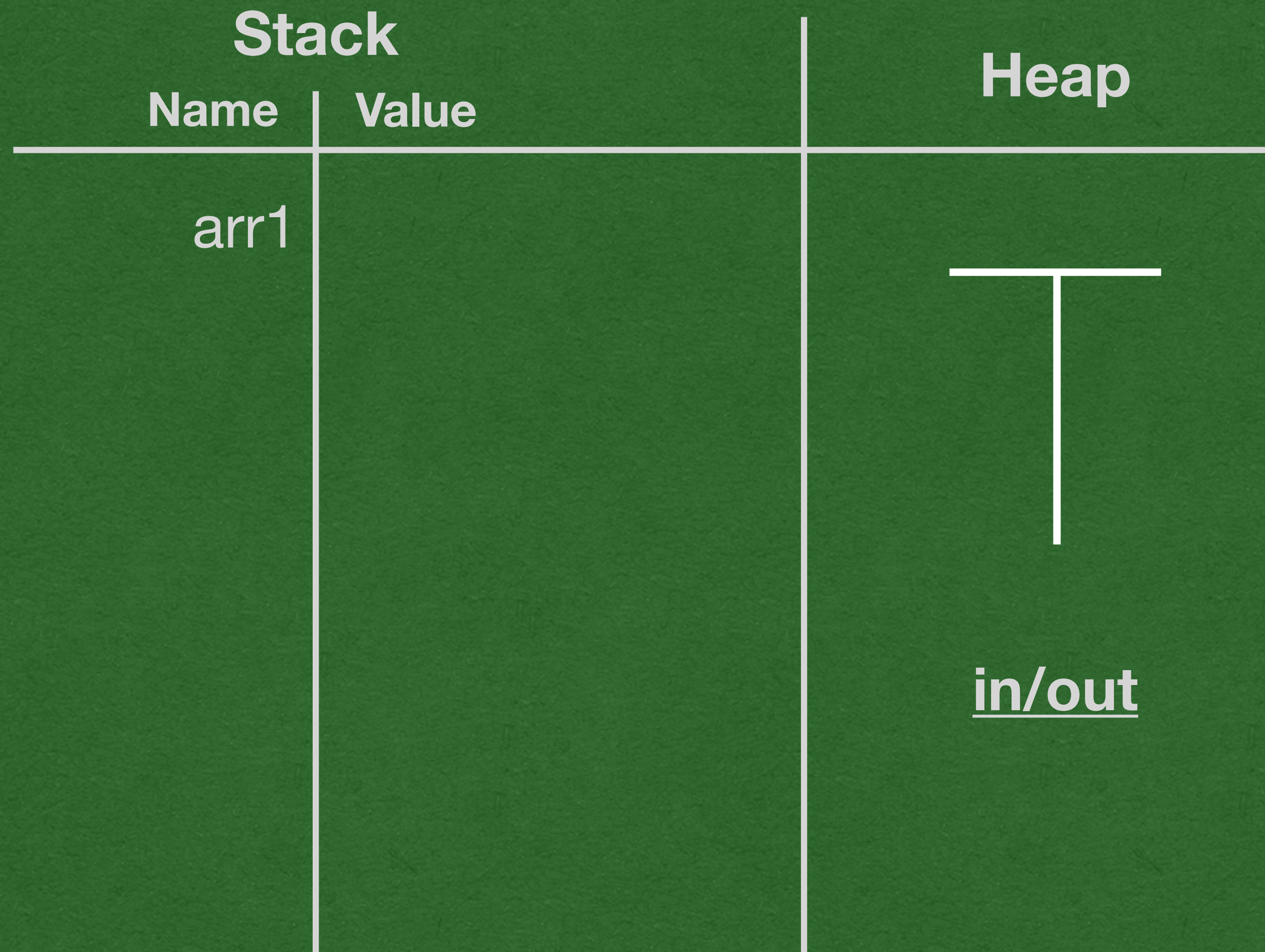
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        }
        return out;
    }

    public static void main(String[] args) {
        ➔ ArrayList<Integer> arr1 = new ArrayList<>();
        for (int x=0; x<4; x++) {
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        ArrayList<Integer> arr2 = arr1;
        System.out.println(arr2);
        int total = sum(arr1);
        System.out.println("total: " + total);
    }
}

```



- When an ArrayList is created on the heap:
- Create 2 columns: One for indices, one for values



```

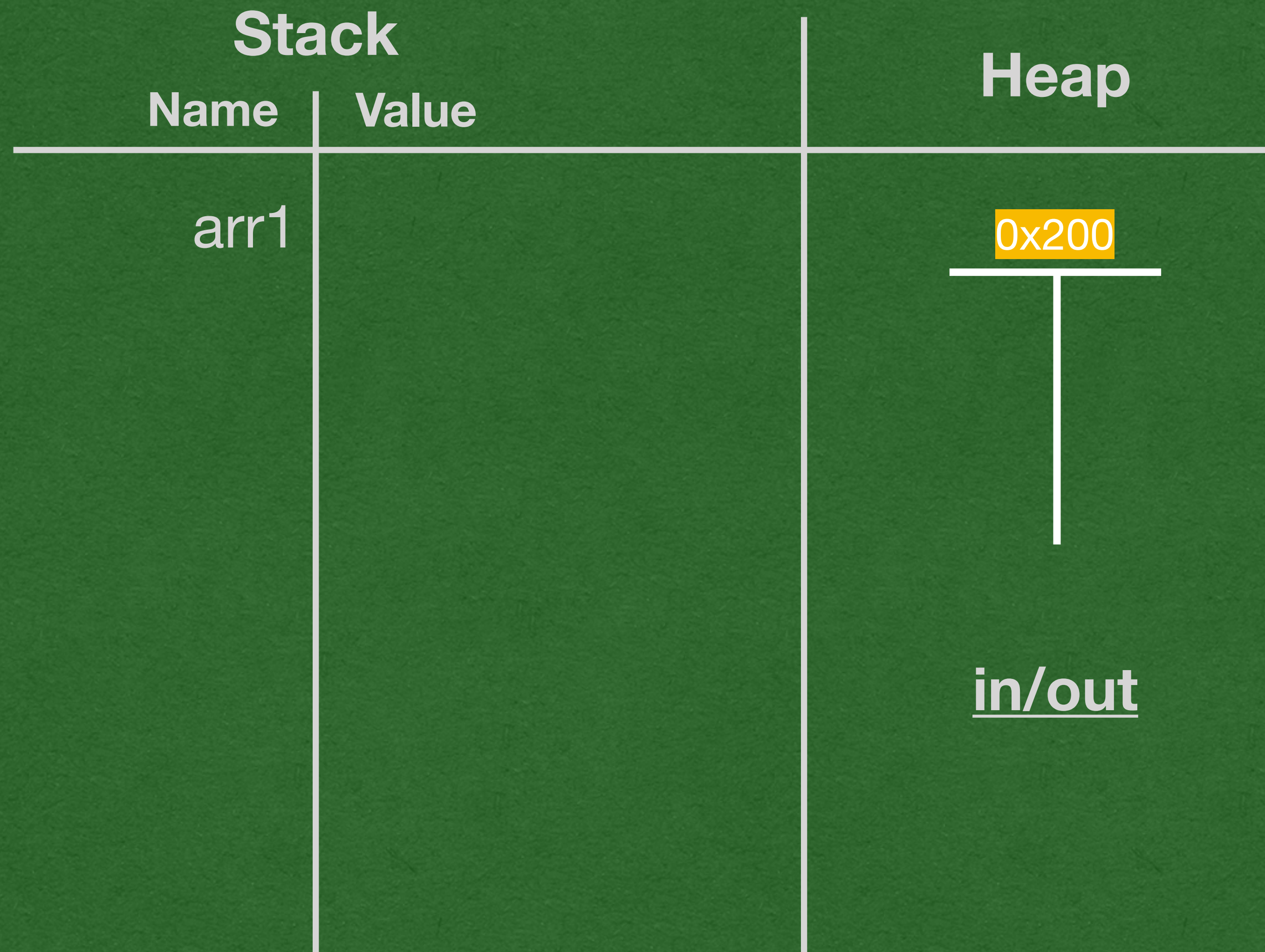
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        }
        return out;
    }

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        }
        System.out.println(arr1);
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        System.out.println(arr2);
        int total = sum(arr1);
        System.out.println("total: " + total);
    }
}

```



- Value on the heap always get a memory address
- "0x" followed by a number (You can choose any numbers for your diagrams)
- This tells java where in memory it can find the value



```

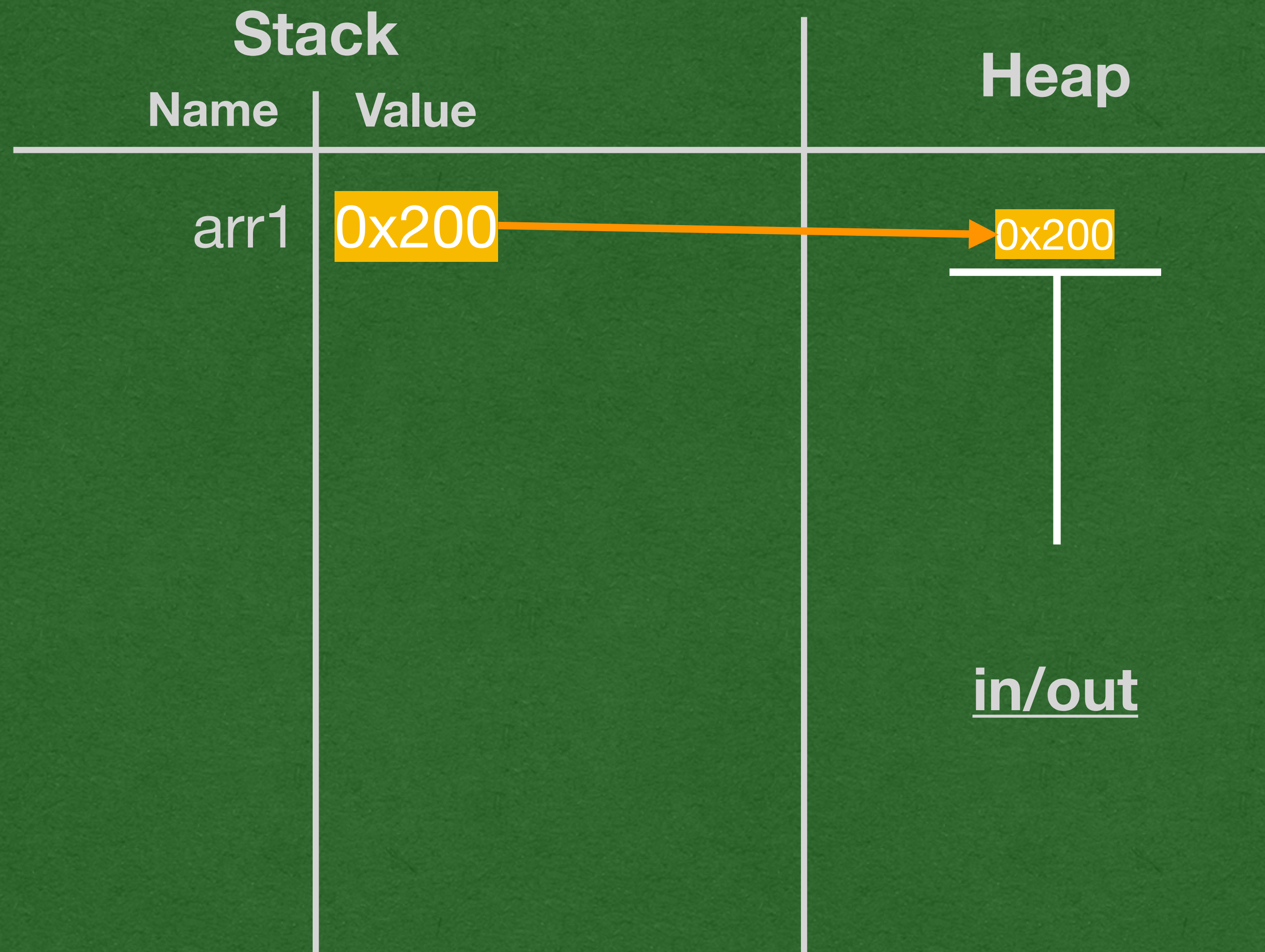
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            out += arrIn.get(x);
        }
        return out;
    }

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        for (int x=0; x<4; x++) {
            arr1.add(10-x);
        }
        System.out.println(arr1);
        ArrayList<Integer> arr2 = arr1;
        System.out.println(arr2);
        int total = sum(arr1);
        System.out.println("total: " + total);
    }
}

```



- When a variable "stores" a value that's on the heap, it only store a **reference** to that value
- arr1 only stores instructions of how to find the ArrayList in the heap



```

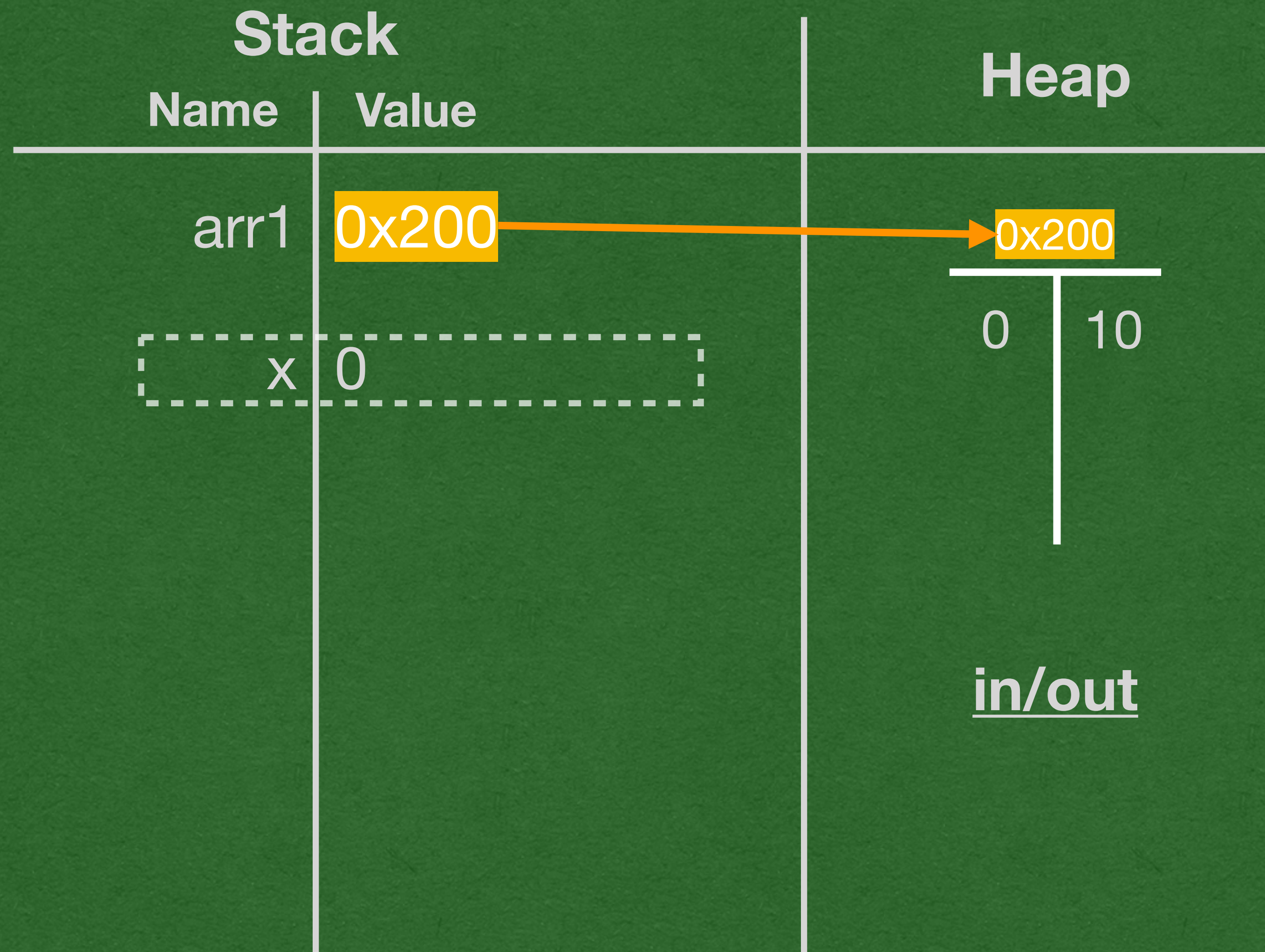
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        int out = 0;
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            out += arrIn.get(x);
        }
        return out;
    }

    public static void main(String[] args) {
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        for (int x=0; x<4; x++) {
            arr1.add(10-x);
        }
        System.out.println(arr1);
        ArrayList<Integer> arr2 = arr1;
        System.out.println(arr2);
        int total = sum(arr1);
        System.out.println("total: " + total);
    }
}

```



- Each time we add a value to an ArrayList, it is added to the next index



```

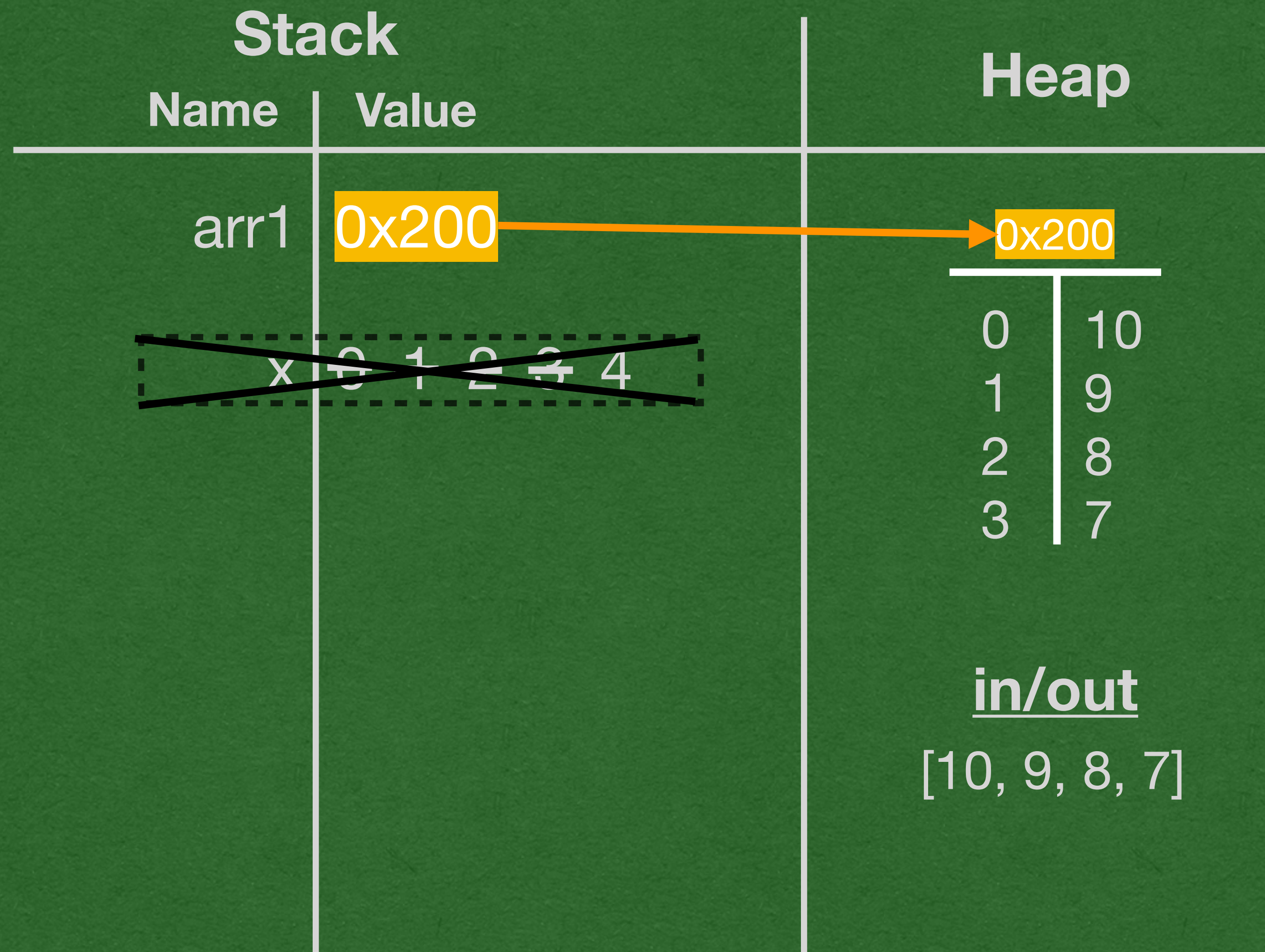
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            out += arrIn.get(x);
        }
        return out;
    }

    public static void main(String[] args) {
        ArrayList<Integer> arr1 = new ArrayList<>();
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        }
        System.out.println(arr1);
        ArrayList<Integer> arr2 = arr1;
        System.out.println(arr2);
        int total = sum(arr1);
        System.out.println("total: " + total);
    }
}

```



- Printing an ArrayList will print all it's values in [ ] separated by commas



```

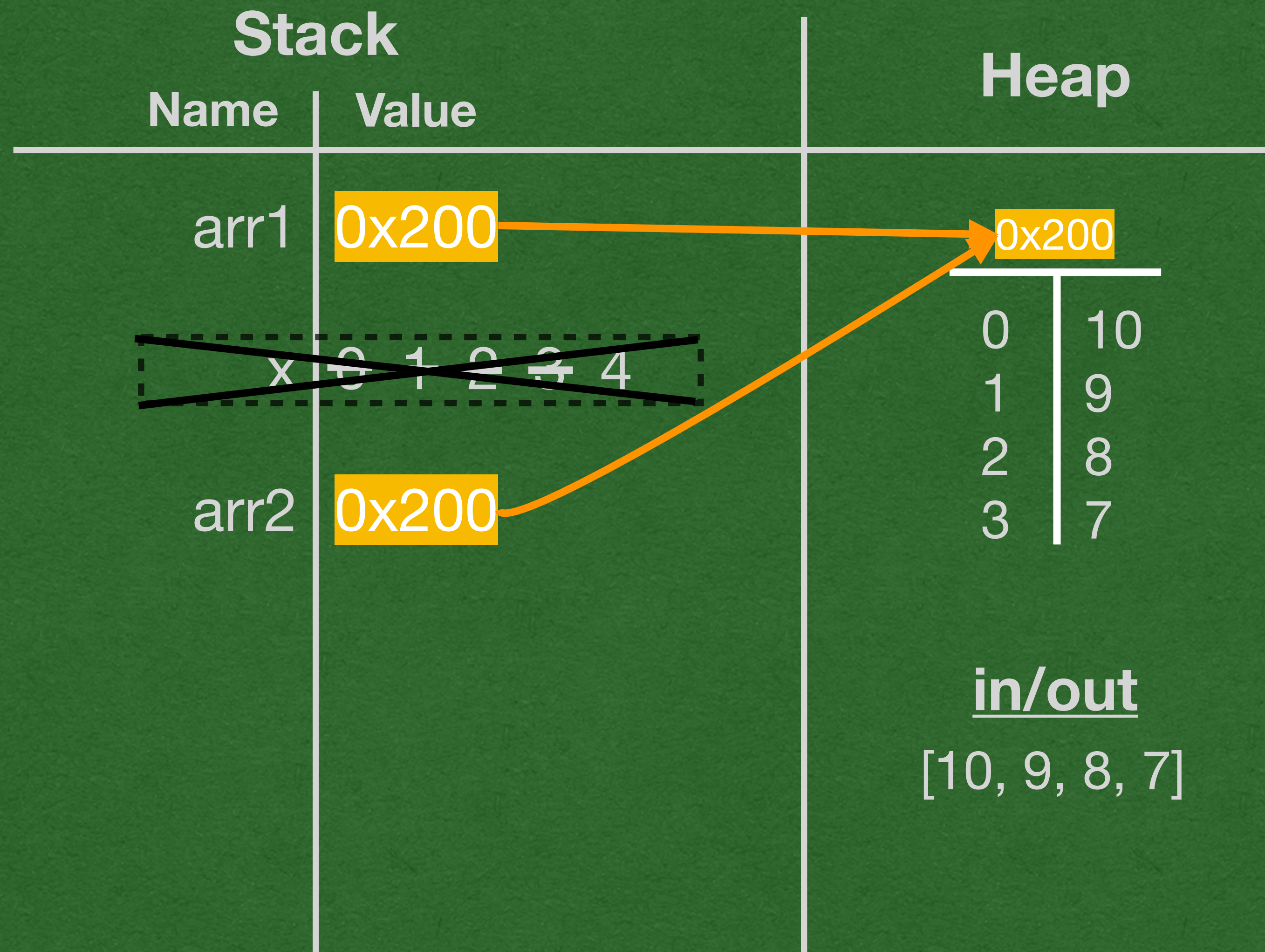
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    }

    public static void main(String[] args) {
        ArrayList<Integer> arr1 = new ArrayList<>();
        for (int x=0; x<4; x++) {
            arr1.add(10-x);
        }
        System.out.println(arr1);
        ➔ ArrayList<Integer> arr2 = arr1;
        System.out.println(arr2);
        int total = sum(arr1);
        System.out.println("total: " + total);
    }
}

```



- When a variable is assigned a value that is a reference, **only the reference** is assigned!
- There is no copy of the ArrayList created. Only 1 ArrayList exists in memory
  - That ArrayList is *referred to* by the 2 variables that store its reference



```

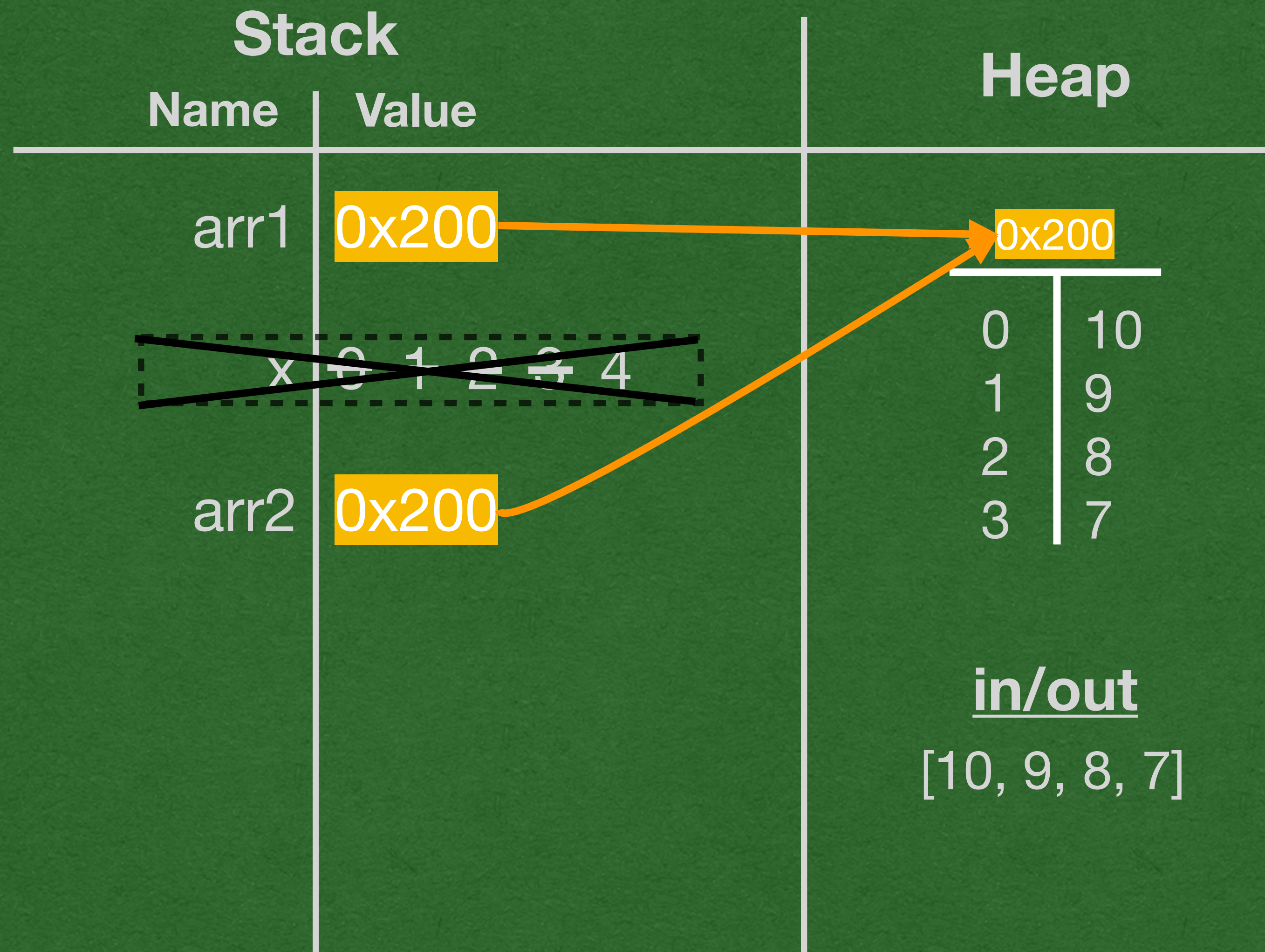
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        int out = 0;
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        }
        return out;
    }

    public static void main(String[] args) {
        ArrayList<Integer> arr1 = new ArrayList<>();
        for (int x=0; x<4; x++) {
            arr1.add(10-x);
        }
        System.out.println(arr1);
        ➔ ArrayList<Integer> arr2 = arr1;
        System.out.println(arr2);
        int total = sum(arr1);
        System.out.println("total: " + total);
    }
}

```



- This is **\*\*assign-by-reference\*\***
- Only the reference is assigned

Technically it's assign-by-value, but the value is a reference



```

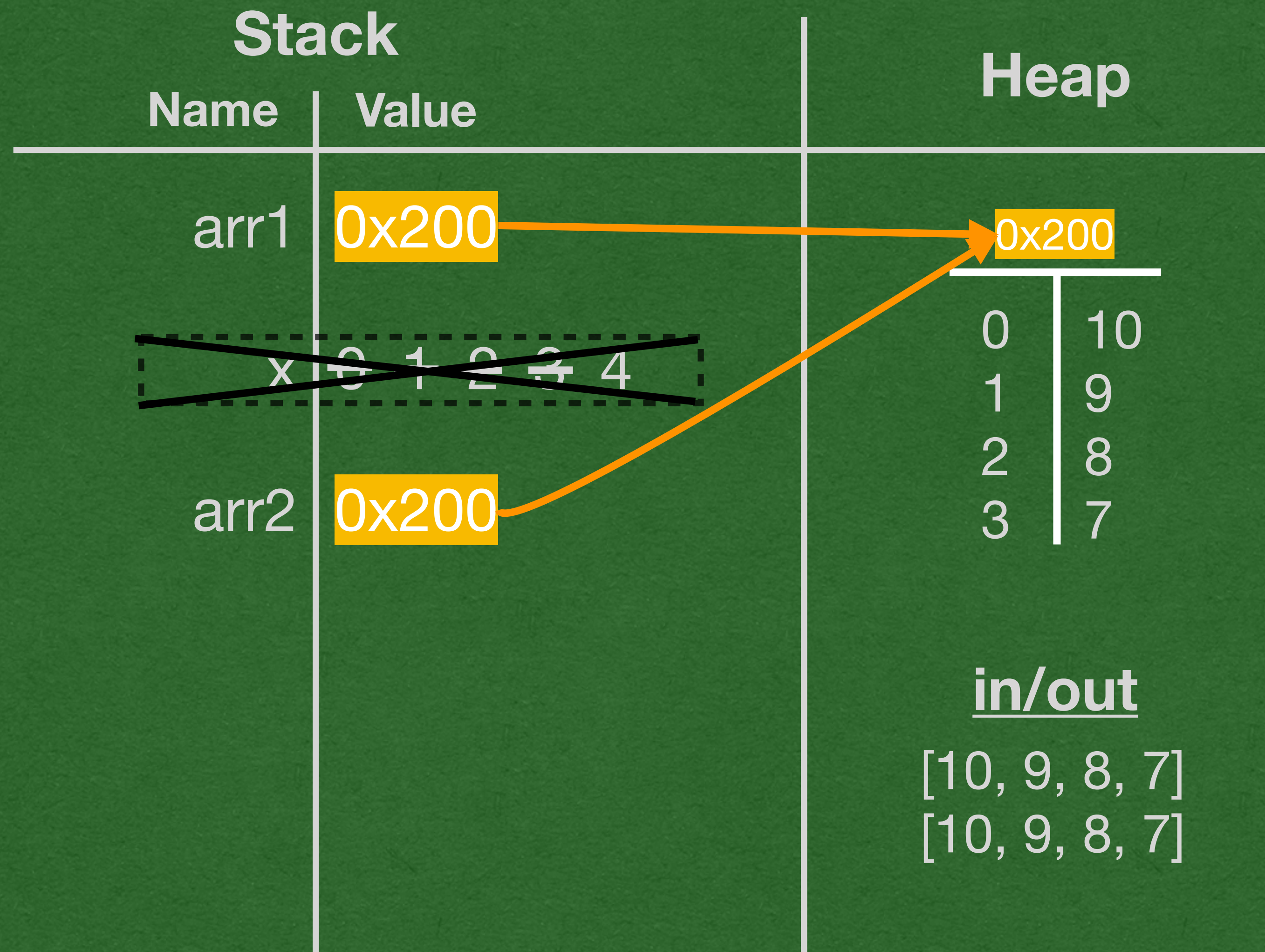
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        }
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    }

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        }
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        ArrayList<Integer> arr2 = arr1;
        System.out.println(arr2);
        int total = sum(arr1);
        System.out.println("total: " + total);
    }
}

```



- arr2 refers to the same ArrayList as arr1 -- the only ArrayList in this example
- Printing arr2 is the same as printing arr1



```

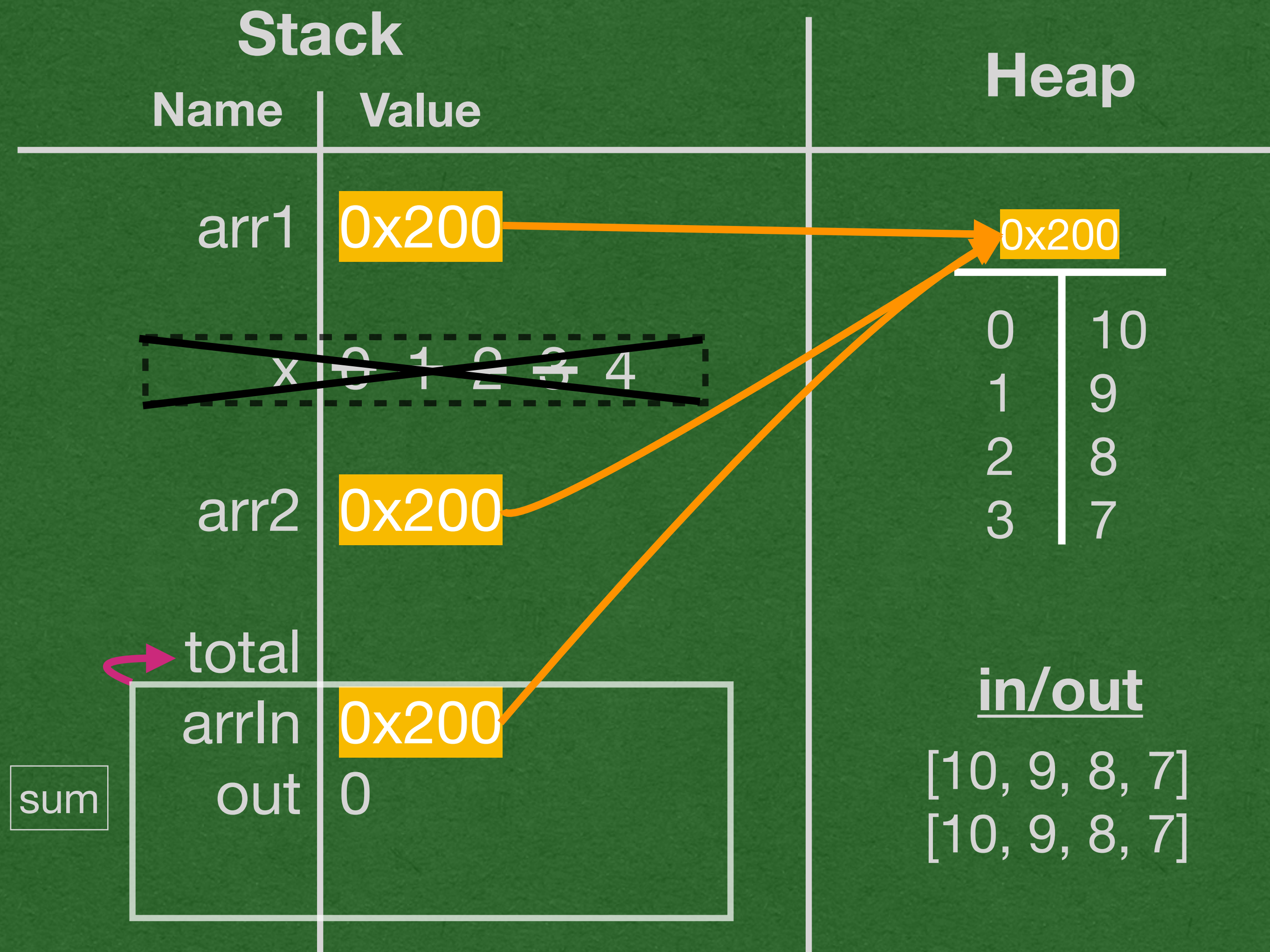
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            out += arrIn.get(x);
        }
        return out;
    }

    public static void main(String[] args) {
        ArrayList<Integer> arr1 = new ArrayList<>();
        for (int x=0; x<4; x++) {
            arr1.add(10-x);
        }
        System.out.println(arr1);
        ArrayList<Integer> arr2 = arr1;
        System.out.println(arr2);
        int total = sum(arr1);
        System.out.println("total: " + total);
    }
}

```



- When a method is called that take an object on the heap as a parameter, only the reference is passed into the stack frame
- This is **\*\*pass-by-reference\*\***

Technically it's pass-by-value, but the value passed is a reference



```

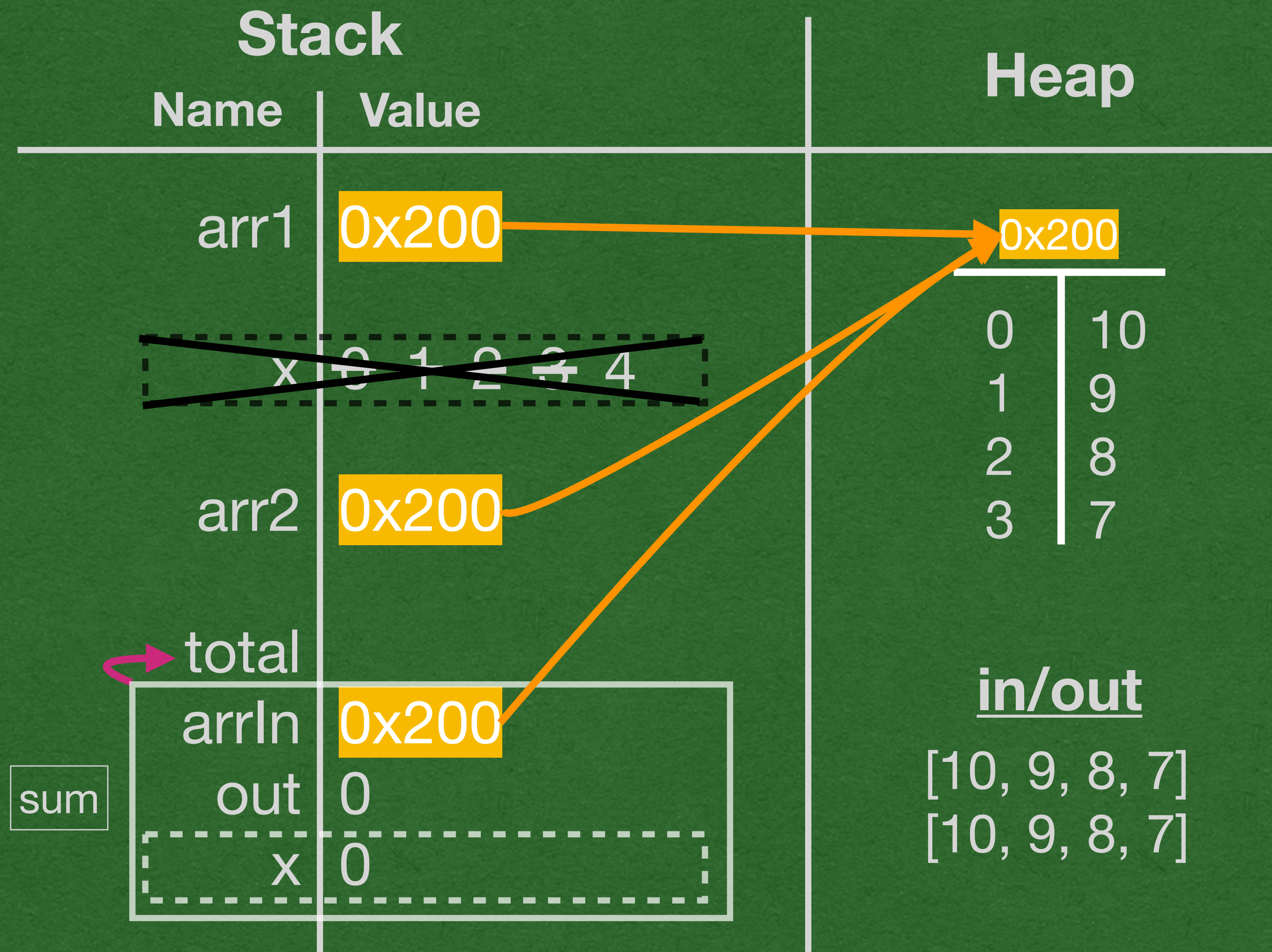
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import java.util.ArrayList;

public class ArrayList1 {
    public static int sum(ArrayList<Integer> arrIn) {
        int out = 0;
        → for (int x=0; x<arrIn.size(); x++) {
            out += arrIn.get(x);
        }
        return out;
    }

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        }
        System.out.println(arr1);
        ArrayList<Integer> arr2 = arr1;
        System.out.println(arr2);
        → int total = sum(arr1);
        System.out.println("total: " + total);
    }
}

```



- When using the reference, the dot operator . means we follow the reference to the object to which it refers
- arrIn.size() means - go to the ArrayList referred to by this reference and call it's size method



```

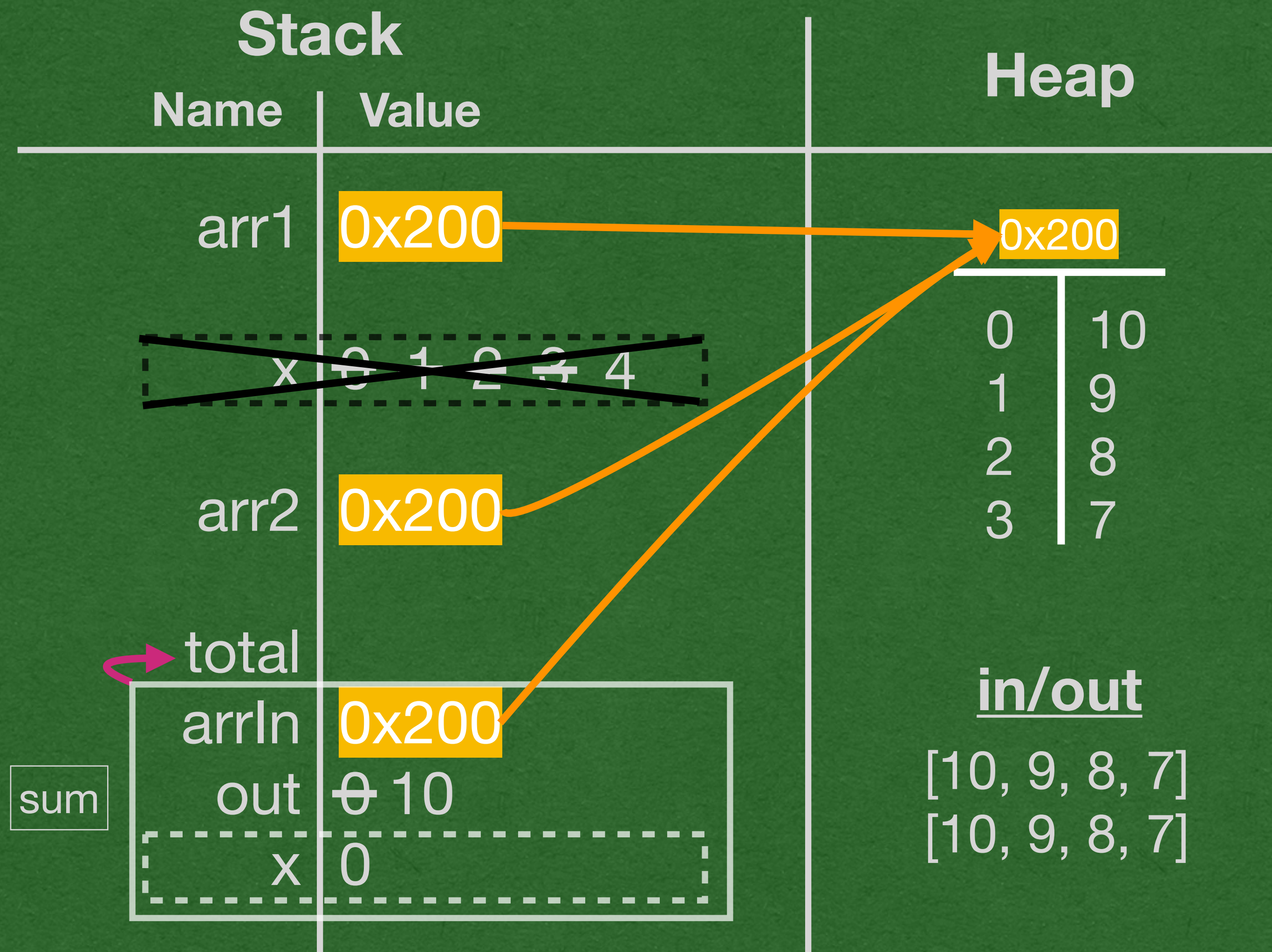
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        int out = 0;
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        }
        return out;
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        }
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        ArrayList<Integer> arr2 = arr1;
        System.out.println(arr2);
        int total = sum(arr1);
        System.out.println("total: " + total);
    }
}

```



- arrIn.get(x)
- Follow the reference
- Return the value stored at index x and add 10 to the out variable



```

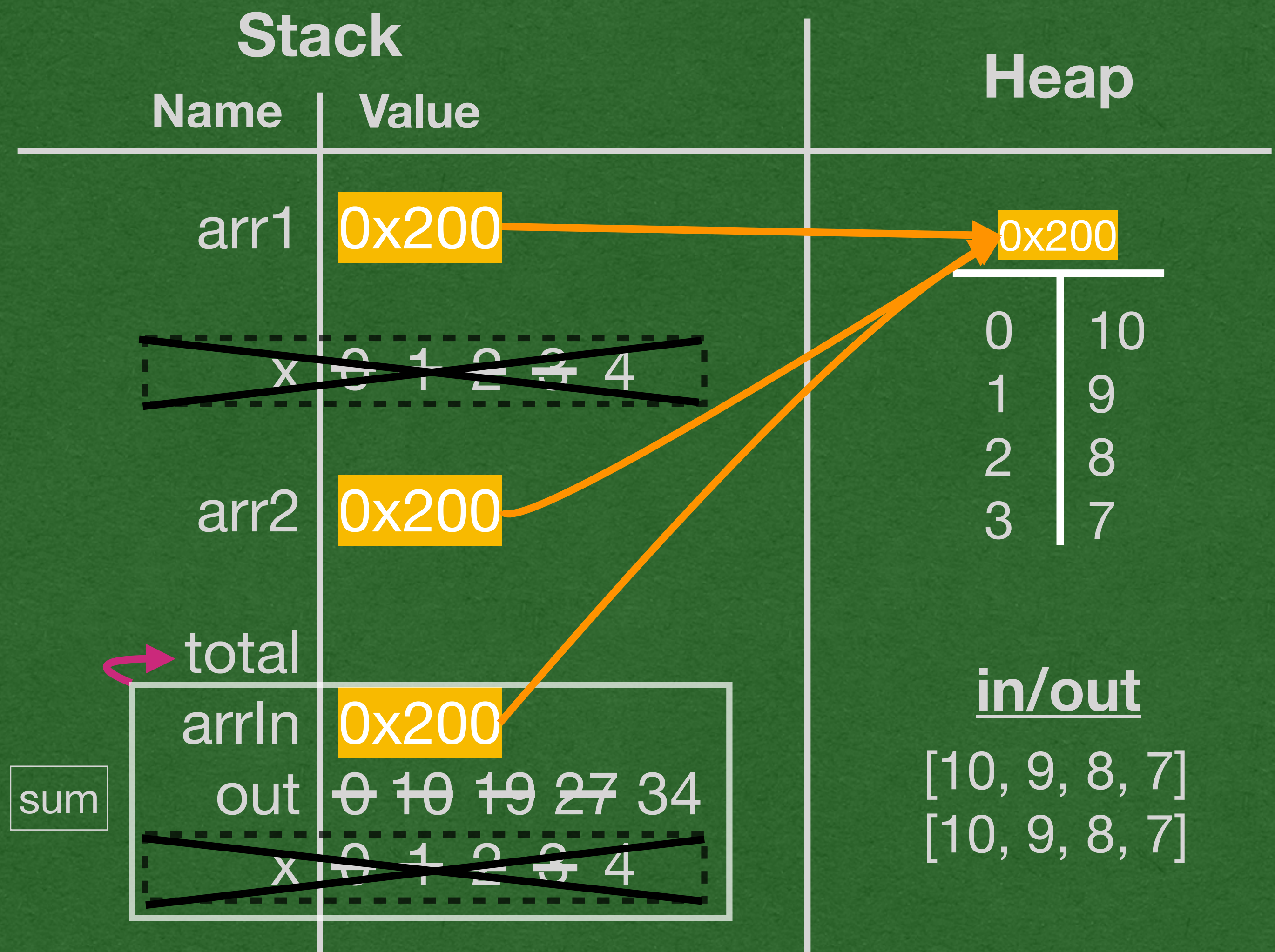
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        ArrayList<Integer> arr2 = arr1;
        System.out.println(arr2);
        int total = sum(arr1);
        System.out.println("total: " + total);
    }
}

```



- When x is 4, x<arrIn.size() is false
- The loop ends and x is removed from memory



```

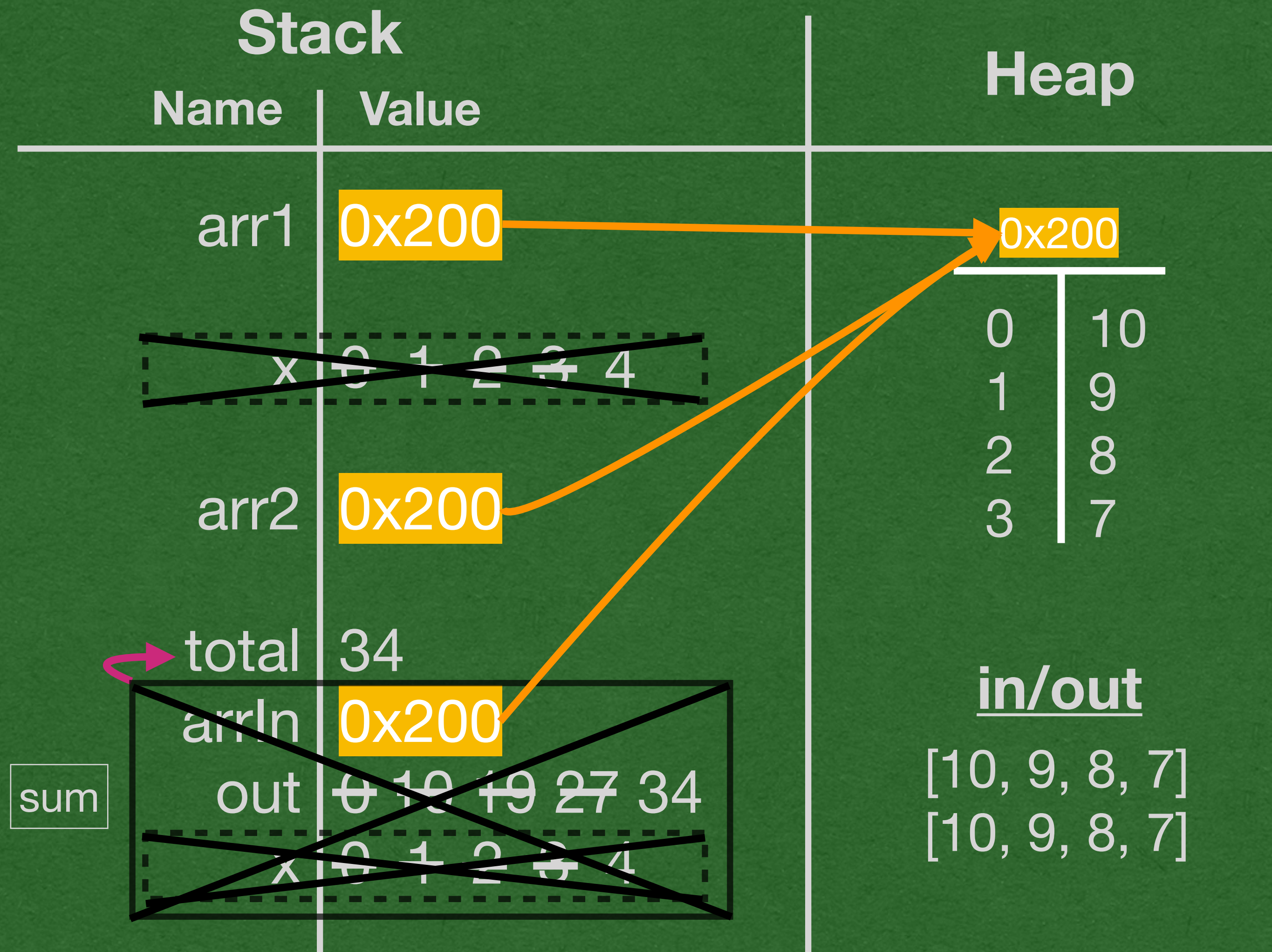
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import java.util.ArrayList;

public class ArrayList1 {
    public static int sum(ArrayList<Integer> arrIn) {
        int out = 0;
        for (int x=0; x<arrIn.size(); x++) {
            out += arrIn.get(x);
        }
        return out;
    }

    public static void main(String[] args) {
        ArrayList<Integer> arr1 = new ArrayList<>();
        for (int x=0; x<4; x++) {
            arr1.add(10-x);
        }
        System.out.println(arr1);
        ArrayList<Integer> arr2 = arr1;
        System.out.println(arr2);
        int total = sum(arr1);
        System.out.println("total: " + total);
    }
}

```



- Return the value of the out variable to the total variable
- The entire stack frame is removed from memory



```

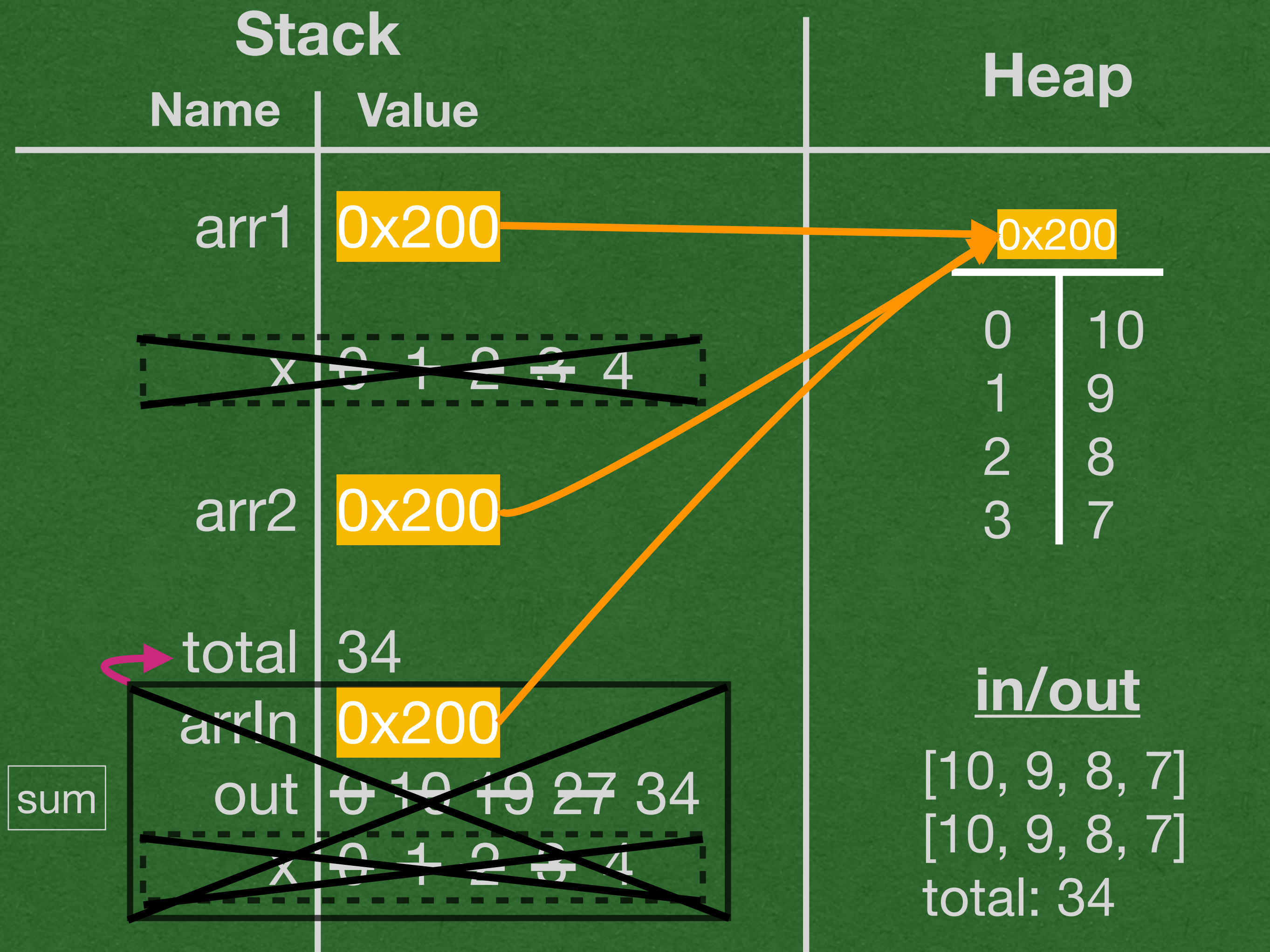
package week2;

import java.util.ArrayList;

public class ArrayList1 {
    public static int sum(ArrayList<Integer> arrIn) {
        int out = 0;
        for (int x=0; x<arrIn.size(); x++) {
            out += arrIn.get(x);
        }
        return out;
    }

    public static void main(String[] args) {
        ArrayList<Integer> arr1 = new ArrayList<>();
        for (int x=0; x<4; x++) {
            arr1.add(10-x);
        }
        System.out.println(arr1);
        ArrayList<Integer> arr2 = arr1;
        System.out.println(arr2);
        int total = sum(arr1);
        System.out.println("total: " + total);
    }
}

```



- Print total
- End of program



### Stack

Name	Value
<b>Global Variables</b>	
Create Global Variable	
<b>Stack Frames</b>	
<b>main</b>	
arr1	0x002 <span>☒ Cross out</span>
x	<div style="display: flex; justify-content: space-around;"> <span>0</span> <span>1</span> <span>2</span> <span>3</span> </div> 4 <span>☒ Cross out</span>
Uncross out this codeblock	
arr2	0x002 <span>☒ Cross out</span>
total	34 <span>☒ Cross out</span>
<b>sum</b>	
arrIn	0x002 <span>☒ Cross out</span>
out	<div style="display: flex; justify-content: space-around;"> <span>0</span> <span>10</span> <span>19</span> <span>27</span> </div> 34 <span>☒ Cross out</span>
x	<div style="display: flex; justify-content: space-around;"> <span>0</span> <span>1</span> <span>2</span> <span>3</span> </div> 4 <span>☒ Cross out</span>
Uncross out this codeblock	
Create Stack Frame	

### Heap

ArrayList No parent

☰	Name	Value
...	0	10 <span>☒ Cross out</span>
...	1	9 <span>☒ Cross out</span>
...	2	8 <span>☒ Cross out</span>
...	3	7 <span>☒ Cross out</span>

0x002

Create Heap Object

### IO

[10, 9, 8, 7] ☒

[10, 9, 8, 7] ☒

total: 34 ☒

Create IO Line

```

1 package week2;
2
3 import java.util.ArrayList;
4
5 public class ArrayList1 {
6     public static int sum(ArrayList<Integer> arrIn) {
7         int out = 0;
8         for (int x=0; x<arrIn.size(); x++) {
9             out += arrIn.get(x);
10        }
11        return out;
12    }
13
14    public static void main(String[] args) {
15        ArrayList<Integer> arr1 = new ArrayList<>();
16        for (int x=0; x<4; x++) {
17            arr1.add(10-x);
18        }
19        System.out.println(arr1);
20        ArrayList<Integer> arr2 = arr1;
21        System.out.println(arr2);
22        int total = sum(arr1);
23        System.out.println("total: " + total);
24    }
25 }
  
```



# HashMap



# Java - HashMap

```
package week2;

import java.util.HashMap;

public class HashMap1 {
    public static void main(String[] args) {
        HashMap<String, Integer> bills = new HashMap<>();

        bills.put("Allen", 17);
        bills.put("Diggs", 14);
        System.out.print("What is Allen's number? ");
        System.out.println(bills.get("Allen"));
        System.out.println(bills);
        for (String key : bills.keySet()) {
            System.out.println(key);
        }
        for (Integer value : bills.values()) {
            System.out.println(value);
        }
        for (String key : bills.keySet()) {
            int value = bills.get(key);
            System.out.print(key + "'s number is: ");
            System.out.println(value);
        }
    }
}
```

- Similar to:
  - Dictionary in Python
  - Object in JavaScript
- Key-Value Store
  - Order does not matter
  - Cannot have duplicate keys
- Used to associate keys with values



# Java - HashMap

```
package week2;

import java.util.HashMap;

public class HashMap1 {
    public static void main(String[] args) {
        HashMap<String, Integer> bills = new HashMap<>();

        bills.put("Allen", 17);
        bills.put("Diggs", 14);
        System.out.print("What is Allen's number? ");
        System.out.println(bills.get("Allen"));
        System.out.println(bills);
        for (String key : bills.keySet()) {
            System.out.println(key);
        }
        for (Integer value : bills.values()) {
            System.out.println(value);
        }
        for (String key : bills.keySet()) {
            int value = bills.get(key);
            System.out.print(key + "'s number is: ");
            System.out.println(value);
        }
    }
}
```

- Must import before use
- Most types we use from here onward need to be imported
- Only primitives and classes in the java.lang package do not need to be imported



# Java - HashMap

```
package week2;

import java.util.HashMap;

public class HashMap1 {
    public static void main(String[] args) {
        HashMap<String, Integer> bills = new HashMap<>();

        bills.put("Allen", 17);
        bills.put("Diggs", 14);
        System.out.print("What is Allen's number? ");
        System.out.println(bills.get("Allen"));
        System.out.println(bills);
        for (String key : bills.keySet()) {
            System.out.println(key);
        }
        for (Integer value : bills.values()) {
            System.out.println(value);
        }
        for (String key : bills.keySet()) {
            int value = bills.get(key);
            System.out.print(key + "'s number is: ");
            System.out.println(value);
        }
    }
}
```

- HashMaps have 2 type parameters
- First is the type of the keys
- Second is the type of the values
- We say this is a:
  - HashMap from String to Integer
  - Maps Strings to Integers



# Java - HashMap

```
package week2;

import java.util.HashMap;

public class HashMap1 {
    public static void main(String[] args) {
        HashMap<String, Integer> bills = new HashMap<>();

        bills.put("Allen", 17);
        bills.put("Diggs", 14);
        System.out.print("What is Allen's number? ");
        System.out.println(bills.get("Allen"));
        System.out.println(bills);
        for (String key : bills.keySet()) {
            System.out.println(key);
        }
        for (Integer value : bills.values()) {
            System.out.println(value);
        }
        for (String key : bills.keySet()) {
            int value = bills.get(key);
            System.out.print(key + "'s number is: ");
            System.out.println(value);
        }
    }
}
```

- Add key-value pairs using "put"
- Retrieve a value at a particular key using "get"



# Java - HashMap

```
package week2;

import java.util.HashMap;

public class HashMap1 {
    public static void main(String[] args) {
        HashMap<String, Integer> bills = new HashMap<>();

        bills.put("Allen", 17);
        bills.put("Diggs", 14);
        System.out.print("What is Allen's number? ");
        System.out.println(bills.get("Allen"));
        System.out.println(bills);
        for (String key : bills.keySet()) {
            System.out.println(key);
        }
        for (Integer value : bills.values()) {
            System.out.println(value);
        }
        for (String key : bills.keySet()) {
            int value = bills.get(key);
            System.out.print(key + "'s number is: ");
            System.out.println(value);
        }
    }
}
```

- for-each loop
- Or "enhanced" loop in the world of Java
- Very similar to Python loops  
for (type variableName : dataStructure)
- Read: for variableName in dataStructure

Doesn't have to be a data structure.  
Anything that can be iterated over will work



# Java - HashMap

```
package week2;

import java.util.HashMap;

public class HashMap1 {
    public static void main(String[] args) {
        HashMap<String, Integer> bills = new HashMap<>();

        bills.put("Allen", 17);
        bills.put("Diggs", 14);
        System.out.print("What is Allen's number? ");
        System.out.println(bills.get("Allen"));
        System.out.println(bills);
        for (String key : bills.keySet()) {
            System.out.println(key);
        }
        for (Integer value : bills.values()) {
            System.out.println(value);
        }
        for (String key : bills.keySet()) {
            int value = bills.get(key);
            System.out.print(key + "'s number is: ");
            System.out.println(value);
        }
    }
}
```

- keySet
  - Allows us iterate (loop) over the keys
- values
  - Allows us to iterate over the values
- Common to iterate over the keys and access the values if you need both



# Memory Diagram



### Stack

Name	Value
<b>Stack Frames</b>	
<div style="background-color: #333; color: white; padding: 2px;"> <span>☰ main</span> </div>	
...	<b>bills</b> 0x002 <input type="button" value="Cross out"/>
...	<div style="border: 1px solid gray; padding: 2px;">"Allen"</div>
...	<b>key</b> "Diggs" <input type="button" value="Cross out"/>
Uncross out this codeblock	
...	<b>value</b> 17    14 <input type="button" value="Cross out"/>
Uncross out this codeblock	
...	<div style="border: 1px solid gray; padding: 2px;">"Allen"</div>
...	<b>key</b> "Diggs" <input type="button" value="Cross out"/>
...	<b>value</b> 17    14 <input type="button" value="Cross out"/>
Uncross out this codeblock	
<input type="button" value="Create Stack Frame"/>	

### Heap

HashMap    No parent

Name	Value
...	<b>"Allen"</b> 17 <input type="button" value="Cross out"/>
...	<b>"Diggs"</b> 14 <input type="button" value="Cross out"/>

0x002

### IO

What is Allen's number? 17    ✕

{Allen=17, Diggs=14}    ✕

Allen    ✕

Diggs    ✕

17    ✕

14    ✕

Allen's number is: 17    ✕

Diggs's number is: 14    ✕

```

1 package week2;
2
3 import java.util.HashMap;
4
5 public class HashMap1 {
6     public static void main(String[] args) {
7         HashMap<String, Integer> bills = new HashMap<>();
8
9         bills.put("Allen", 17);
10        bills.put("Diggs", 14);
11        System.out.print("What is Allen's number? ");
12        System.out.println(bills.get("Allen"));
13        System.out.println(bills);
14        for (String key : bills.keySet()) {
15            System.out.println(key);
16        }
17        for (Integer value : bills.values()) {
18            System.out.println(value);
19        }
20        for (String key : bills.keySet()) {
21            int value = bills.get(key);
22            System.out.print(key + "'s number is: ");
23            System.out.println(value);
24        }
25    }
26 }

```



```

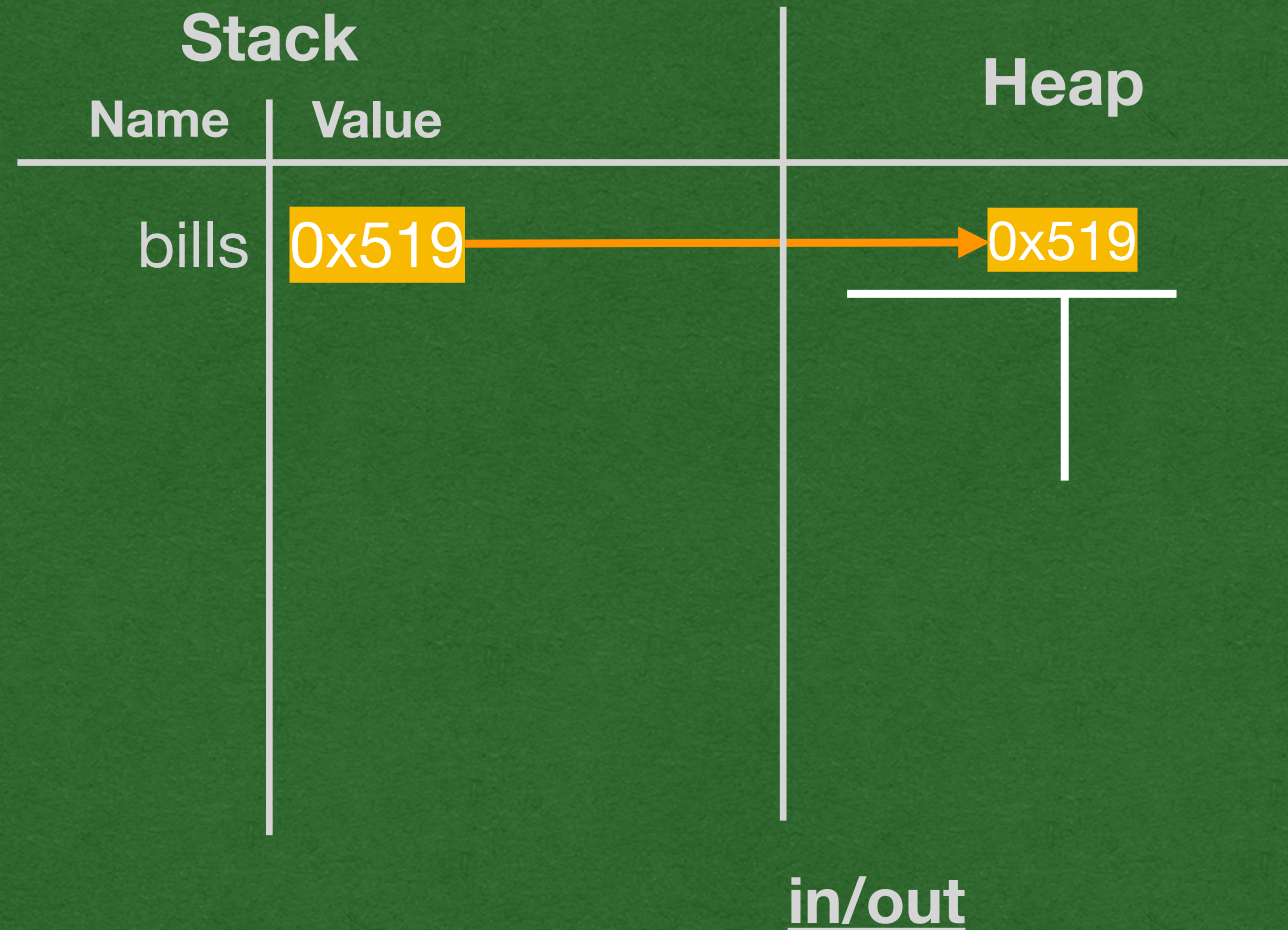
package week2;

import java.util.HashMap;

public class HashMap1 {
    → public static void main(String[] args) {
        HashMap<String, Integer> bills = new HashMap<>();

        bills.put("Allen", 17);
        bills.put("Diggs", 14);
        System.out.print("What is Allen's number? ");
        System.out.println(bills.get("Allen"));
        System.out.println(bills);
        for (String key : bills.keySet()) {
            System.out.println(key);
        }
        for (Integer value : bills.values()) {
            System.out.println(value);
        }
        for (String key : bills.keySet()) {
            int value = bills.get(key);
            System.out.print(key + "'s number is: ");
            System.out.println(value);
        }
    }
}

```



- HashMaps go in the heap
- Only a reference to the HashMap is stored on the stack



```

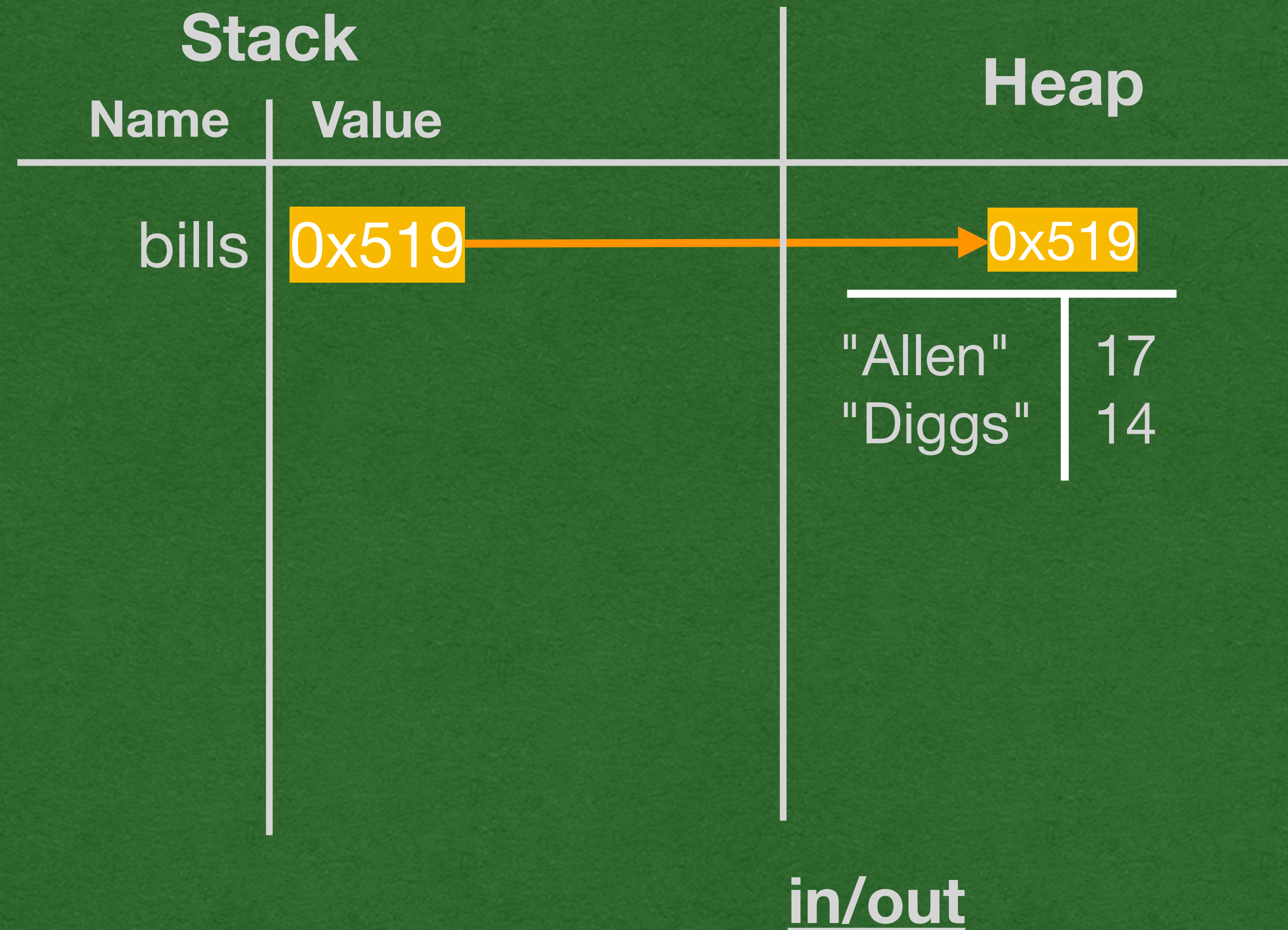
package week2;

import java.util.HashMap;

public class HashMap1 {
    public static void main(String[] args) {
        HashMap<String, Integer> bills = new HashMap<>();

        bills.put("Allen", 17);
        bills.put("Diggs", 14);
        System.out.print("What is Allen's number? ");
        System.out.println(bills.get("Allen"));
        System.out.println(bills);
        for (String key : bills.keySet()) {
            System.out.println(key);
        }
        for (Integer value : bills.values()) {
            System.out.println(value);
        }
        for (String key : bills.keySet()) {
            int value = bills.get(key);
            System.out.print(key + "'s number is: ");
            System.out.println(value);
        }
    }
}

```



- HashMaps have columns for keys and values



```

package week2;

import java.util.HashMap;

public class HashMap1 {
    public static void main(String[] args) {
        HashMap<String, Integer> bills = new HashMap<>();

        bills.put("Allen", 17);
        bills.put("Diggs", 14);
        System.out.print("What is Allen's number? ");
        System.out.println(bills.get("Allen"));
        System.out.println(bills);
        → for (String key : bills.keySet()) {
            System.out.println(key);
        }
        for (Integer value : bills.values()) {
            System.out.println(value);
        }
        for (String key : bills.keySet()) {
            int value = bills.get(key);
            System.out.print(key + "'s number is: ");
            System.out.println(value);
        }
    }
}

```



### in/out

What is Allen's number? 17  
 {Diggs=14, Allen=17}

- HashMap prints as a list of key-value pairs in { } separated by commas
- Equal sign = separates each key from it's value



```

package week2;

import java.util.HashMap;

public class HashMap1 {
    public static void main(String[] args) {
        HashMap<String, Integer> bills = new HashMap<>();

        bills.put("Allen", 17);
        bills.put("Diggs", 14);
        System.out.print("What is Allen's number? ");
        System.out.println(bills.get("Allen"));
        System.out.println(bills);
        → for (String key : bills.keySet()) {
            System.out.println(key);
        }
        for (Integer value : bills.values()) {
            System.out.println(value);
        }
        for (String key : bills.keySet()) {
            int value = bills.get(key);
            System.out.print(key + "'s number is: ");
            System.out.println(value);
        }
    }
}

```



### in/out

What is Allen's number? 17  
 {Diggs=14, Allen=17}

- Order does not matter in a HashMap!
- Notice how "Diggs" was printed before "Allen"
- No simple way to predict the order



```

package week2;

import java.util.HashMap;

public class HashMap1 {
    public static void main(String[] args) {
        HashMap<String, Integer> bills = new HashMap<>();

        bills.put("Allen", 17);
        bills.put("Diggs", 14);
        System.out.print("What is Allen's number? ");
        System.out.println(bills.get("Allen"));
        System.out.println(bills);
        → for (String key : bills.keySet()) {
            System.out.println(key);
        }
        for (Integer value : bills.values()) {
            System.out.println(value);
        }
        for (String key : bills.keySet()) {
            int value = bills.get(key);
            System.out.print(key + "'s number is: ");
            System.out.println(value);
        }
    }
}

```



### in/out

What is Allen's number? 17  
 {Diggs=14, Allen=17}

- In your memory diagrams, any order is acceptable for credit



```

package week2;

import java.util.HashMap;

public class HashMap1 {
    public static void main(String[] args) {
        HashMap<String, Integer> bills = new HashMap<>();

        bills.put("Allen", 17);
        bills.put("Diggs", 14);
        System.out.print("What is Allen's number? ");
        System.out.println(bills.get("Allen"));
        System.out.println(bills);
        for (String key : bills.keySet()) {
            System.out.println(key);
        }
        for (Integer value : bills.values()) {
            System.out.println(value);
        }
        for (String key : bills.keySet()) {
            int value = bills.get(key);
            System.out.print(key + "'s number is: ");
            System.out.println(value);
        }
    }
}

```



### in/out

What is Allen's number? 17  
 {Diggs=14, Allen=17}  
 Allen

- Iterating over the keySet stores each key in the "key" variable and runs the body of the loop for each key



```

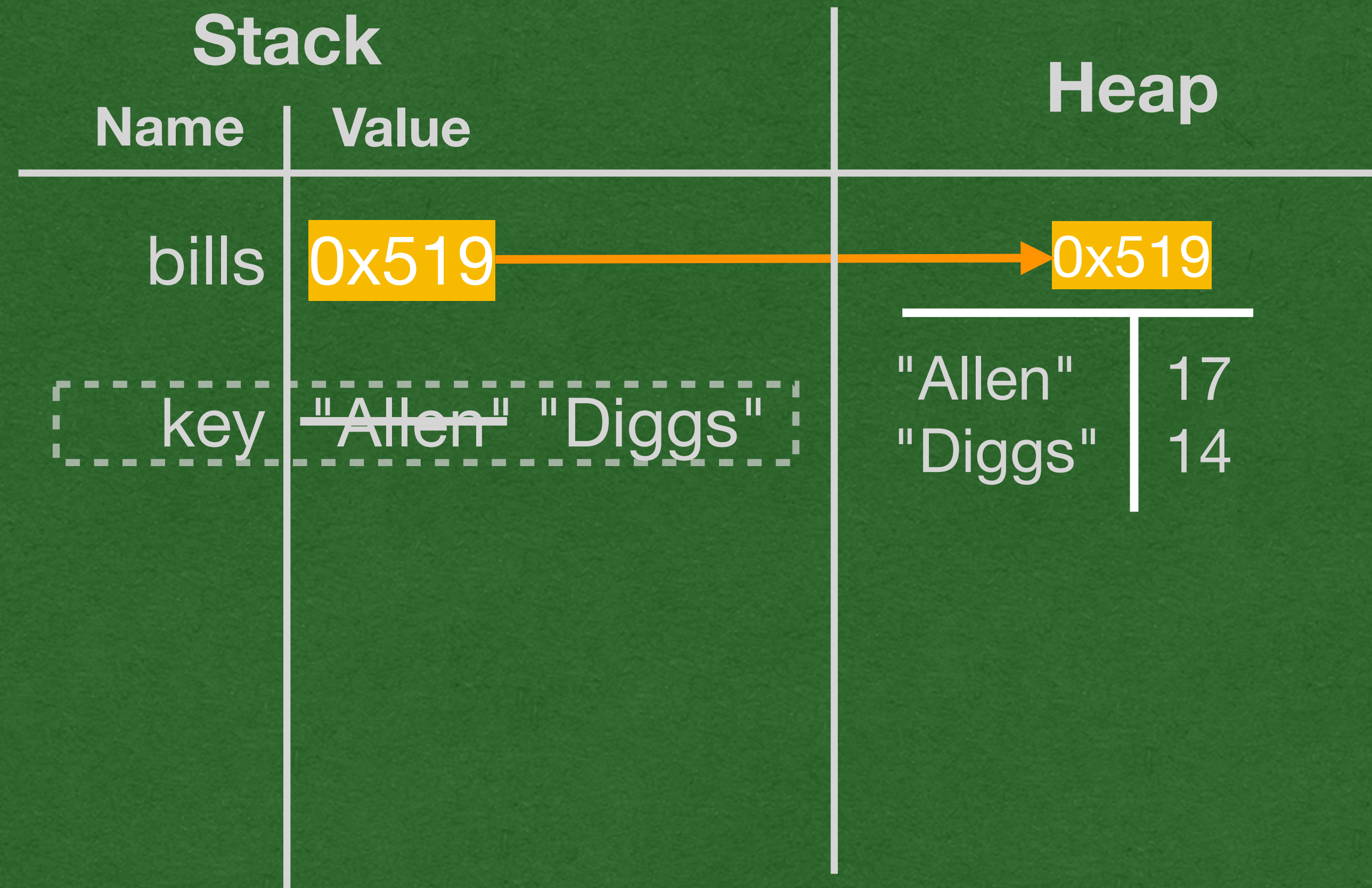
package week2;

import java.util.HashMap;

public class HashMap1 {
    public static void main(String[] args) {
        HashMap<String, Integer> bills = new HashMap<>();

        bills.put("Allen", 17);
        bills.put("Diggs", 14);
        System.out.print("What is Allen's number? ");
        System.out.println(bills.get("Allen"));
        System.out.println(bills);
        for (String key : bills.keySet()) {
            System.out.println(key);
        }
        for (Integer value : bills.values()) {
            System.out.println(value);
        }
        for (String key : bills.keySet()) {
            int value = bills.get(key);
            System.out.print(key + "'s number is: ");
            System.out.println(value);
        }
    }
}

```



### in/out

What is Allen's number? 17  
 {Diggs=14, Allen=17}  
 Allen  
 Diggs

- Once we iterate over all the keys, the loops ends
- Note: If there are no key-value pairs in the HashMap, the loop body will never execute



```

package week2;

import java.util.HashMap;

public class HashMap1 {
    public static void main(String[] args) {
        HashMap<String, Integer> bills = new HashMap<>();

        bills.put("Allen", 17);
        bills.put("Diggs", 14);
        System.out.print("What is Allen's number? ");
        System.out.println(bills.get("Allen"));
        System.out.println(bills);
        for (String key : bills.keySet()) {
            System.out.println(key);
        }
        for (Integer value : bills.values()) {
            System.out.println(value);
        }
        for (String key : bills.keySet()) {
            int value = bills.get(key);
            System.out.print(key + "'s number is: ");
            System.out.println(value);
        }
    }
}

```



### in/out

What is Allen's number? 17  
 {Diggs=14, Allen=17}  
 Allen  
 Diggs  
 17

- Iterating over the values only stores the values in the iteration variable



```

package week2;

import java.util.HashMap;

public class HashMap1 {
    public static void main(String[] args) {
        HashMap<String, Integer> bills = new HashMap<>();

        bills.put("Allen", 17);
        bills.put("Diggs", 14);
        System.out.print("What is Allen's number? ");
        System.out.println(bills.get("Allen"));
        System.out.println(bills);
        for (String key : bills.keySet()) {
            System.out.println(key);
        }
        for (Integer value : bills.values()) {
            System.out.println(value);
        }
        for (String key : bills.keySet()) {
            int value = bills.get(key);
            System.out.print(key + "'s number is: ");
            System.out.println(value);
        }
    }
}

```



### in/out

```

What is Allen's number? 17
{Diggs=14, Allen=17}
Allen
Diggs
17
14

```

- Iterate until we run out of values



```

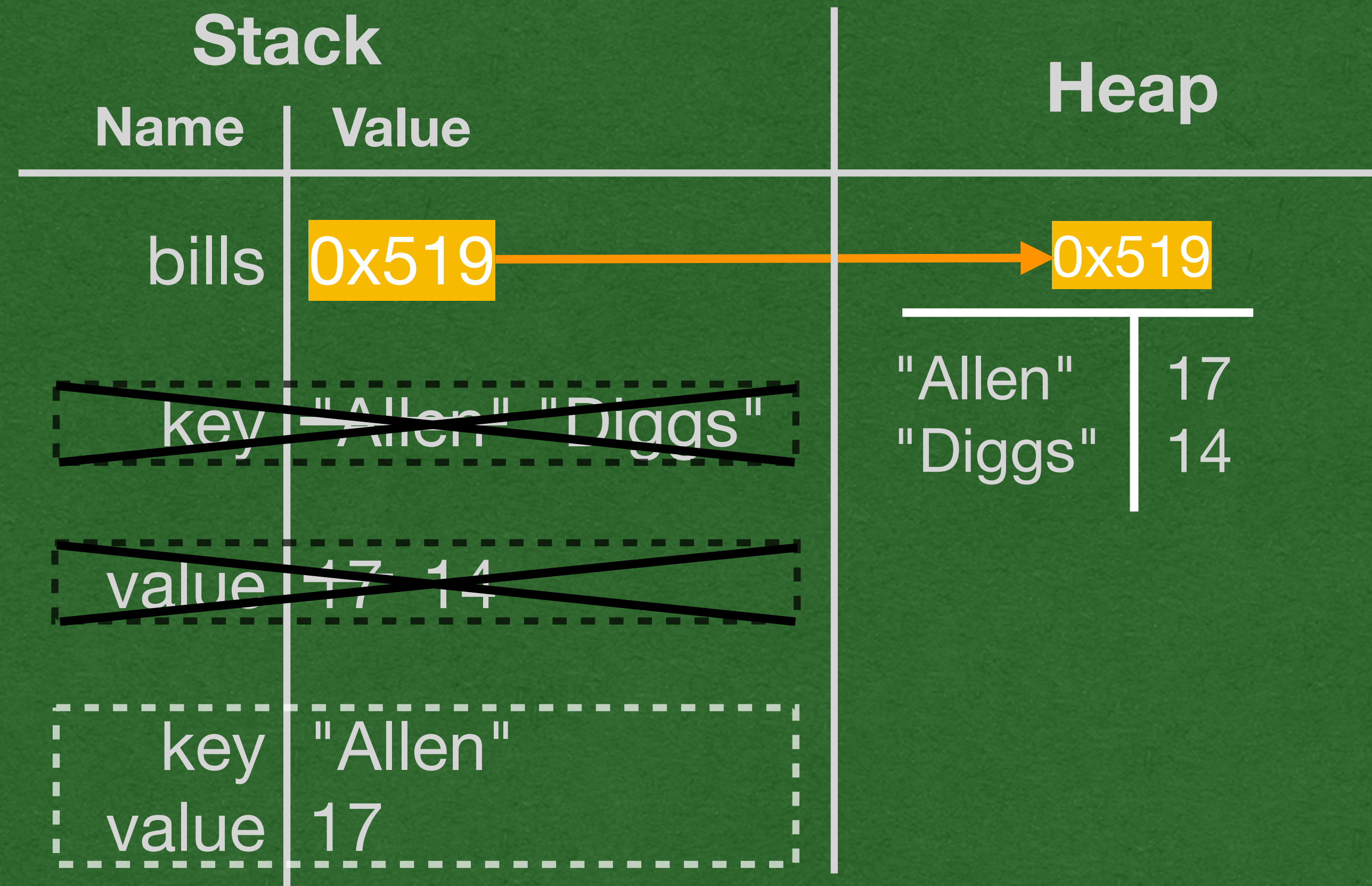
package week2;

import java.util.HashMap;

public class HashMap1 {
    public static void main(String[] args) {
        HashMap<String, Integer> bills = new HashMap<>();

        bills.put("Allen", 17);
        bills.put("Diggs", 14);
        System.out.print("What is Allen's number? ");
        System.out.println(bills.get("Allen"));
        System.out.println(bills);
        for (String key : bills.keySet()) {
            System.out.println(key);
        }
        for (Integer value : bills.values()) {
            System.out.println(value);
        }
        for (String key : bills.keySet()) {
            int value = bills.get(key);
            System.out.print(key + "'s number is: ");
            System.out.println(value);
        }
    }
}

```



### in/out

```

What is Allen's number? 17
{Diggs=14, Allen=17}
Allen
Diggs
17
14
Allen's number is: 17

```

- If we iterate over the keys and get the values, we can access the key-value pairs



```

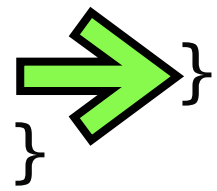
package week2;

import java.util.HashMap;

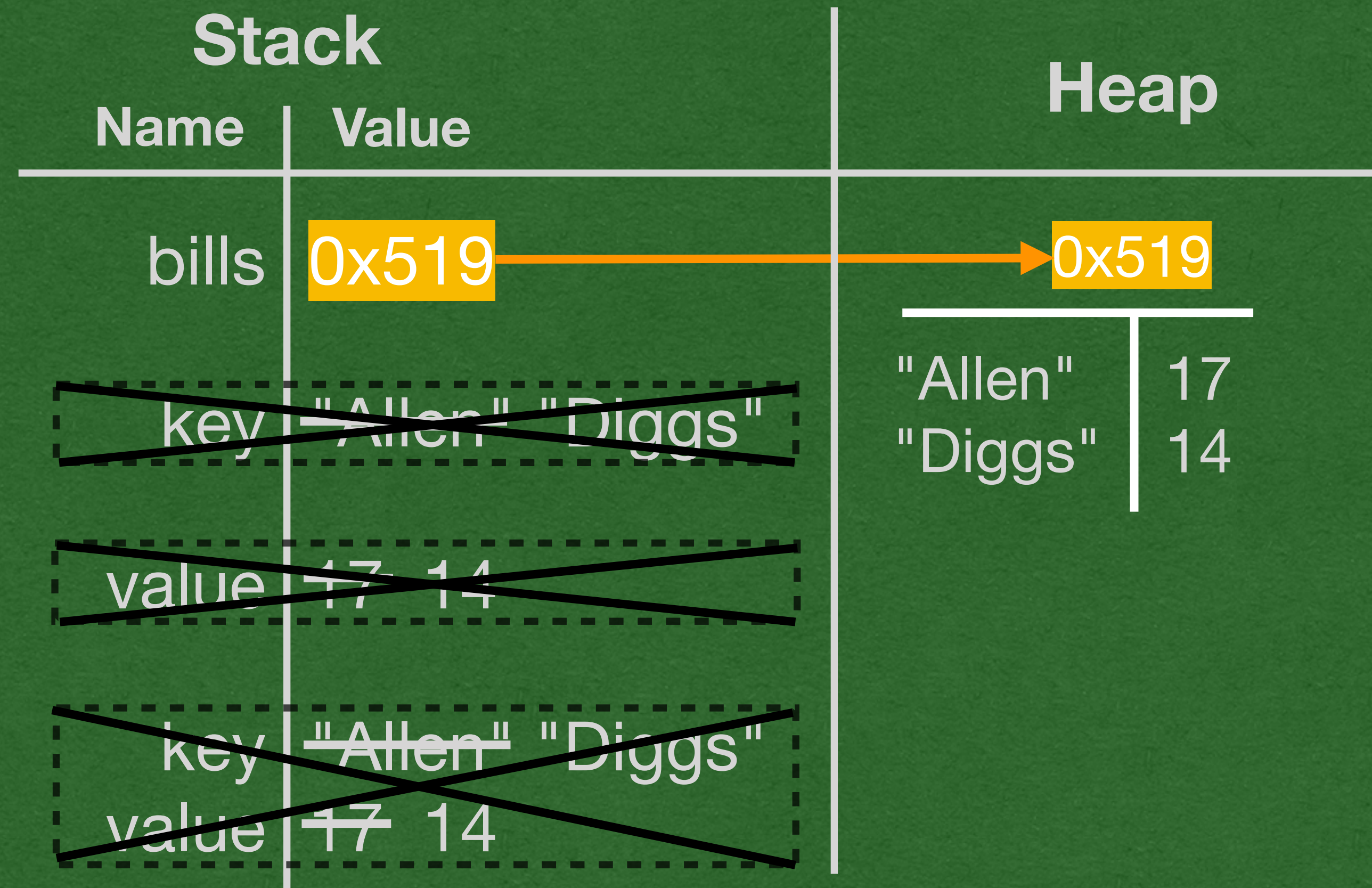
public class HashMap1 {
    public static void main(String[] args) {
        HashMap<String, Integer> bills = new HashMap<>();

        bills.put("Allen", 17);
        bills.put("Diggs", 14);
        System.out.print("What is Allen's number? ");
        System.out.println(bills.get("Allen"));
        System.out.println(bills);
        for (String key : bills.keySet()) {
            System.out.println(key);
        }
        for (Integer value : bills.values()) {
            System.out.println(value);
        }
        for (String key : bills.keySet()) {
            int value = bills.get(key);
            System.out.print(key + "'s number is: ");
            System.out.println(value);
        }
    }
}

```



- Reach the end of main
- That's the end of the program



### in/out

```

What is Allen's number? 17
{Diggs=14, Allen=17}
Allen
Diggs
17
14
Allen's number is: 17
Diggs's number is: 14

```



### Stack

Name	Value
<b>Stack Frames</b>	
<div style="background-color: #333; color: white; padding: 2px;"> <span>☰ main</span> </div>	
...	<b>bills</b> 0x002 <input type="button" value="Cross out"/>
...	<div style="border: 1px solid gray; padding: 2px;">"Allen"</div>
...	<b>key</b> "Diggs" <input type="button" value="Cross out"/>
Uncross out this codeblock	
...	<b>value</b> 17    14 <input type="button" value="Cross out"/>
Uncross out this codeblock	
...	<div style="border: 1px solid gray; padding: 2px;">"Allen"</div>
...	<b>key</b> "Diggs" <input type="button" value="Cross out"/>
...	<b>value</b> 17    14 <input type="button" value="Cross out"/>
Uncross out this codeblock	
<input type="button" value="Create Stack Frame"/>	

### Heap

HashMap    No parent

Name	Value
...	<b>"Allen"</b> 17 <input type="button" value="Cross out"/>
...	<b>"Diggs"</b> 14 <input type="button" value="Cross out"/>

0x002

### IO

What is Allen's number? 17    ✕

{Allen=17, Diggs=14}    ✕

Allen    ✕

Diggs    ✕

17    ✕

14    ✕

Allen's number is: 17    ✕

Diggs's number is: 14    ✕

```

1 package week2;
2
3 import java.util.HashMap;
4
5 public class HashMap1 {
6     public static void main(String[] args) {
7         HashMap<String, Integer> bills = new HashMap<>();
8
9         bills.put("Allen", 17);
10        bills.put("Diggs", 14);
11        System.out.print("What is Allen's number? ");
12        System.out.println(bills.get("Allen"));
13        System.out.println(bills);
14        for (String key : bills.keySet()) {
15            System.out.println(key);
16        }
17        for (Integer value : bills.values()) {
18            System.out.println(value);
19        }
20        for (String key : bills.keySet()) {
21            int value = bills.get(key);
22            System.out.print(key + "'s number is: ");
23            System.out.println(value);
24        }
25    }
26 }

```