Openjdk source code repository

- Welcome to the JDK!

Java Visualizer

Java Visualizer

(beta: report a bug)

Write your Java code here:

```
1 public class ClassNameHere {
2    public static void main(String[] args) {
3
4    }
5 }
```

Superclass `Object`

- Superclass of all Java™ classes.
- Common methods to be redefined by derived classes.

String literals

Stack

Heap

String s1 = "Kate";

String s2 = "Kate";

String literals

Stack

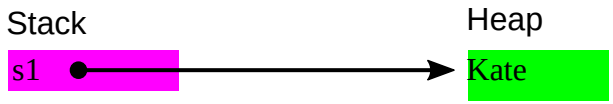
Heap

```
String s1 = "Kate";

String s2 = "Kate";
```

Kate

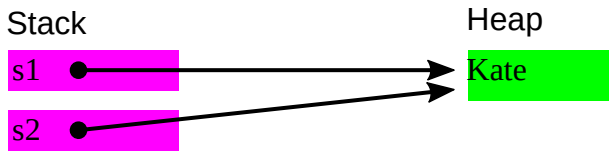
String literals

```
String s1 = "Kate";

String s2 = "Kate";
```



String literals

```
String s1 = "Kate";

String s2 = "Kate";
```



OpenJDK String implementation

Implementation of `java.lang.String`:

```
public final class String ... {
  private final char value[];
  private int hash;
  private static final long serialVersionUID = -6849794470754667710L;
...
}
```

String copy constructor

Code	Output

`final String s = "Eve"; ❶`
`final String sCopy = new String(s); ❷`
`System.out.println("sCopy == s: " + (sCopy == s)); ❸`
`System.out.println("sCopy.equals(s): " + sCopy.equals(s)); ❹`
	`sCopy == s: false ❸`
	`sCopy.equals(s): true ❹`

Copy constructor and heap

Stack

Heap

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

String s2 =
 new String("Kate");
```

Copy constructor and heap

Stack

Heap

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

String s2 =
 new String("Kate");
```

Kate

Copy constructor and heap

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Stack

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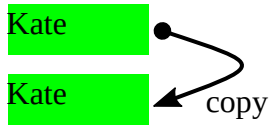
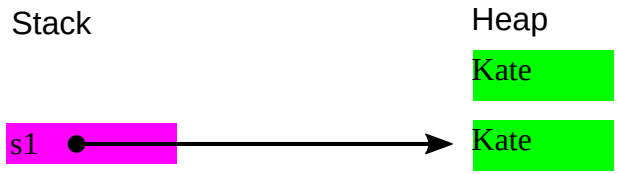


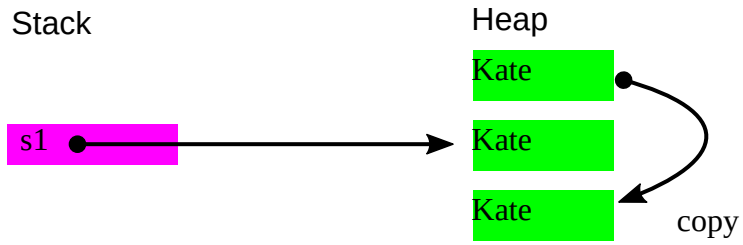
Copy constructor and heap

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

String s2 =
 new String("Kate");
```



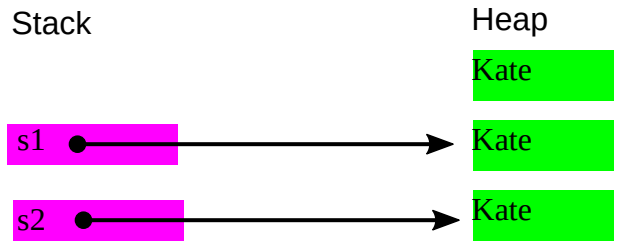
Copy constructor and heap

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

String s2 =
 new String("Kate");
```



Copy constructor and heap

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

String s2 =
 new String("Kate");
```



Operator == and `equals()`

Primitive type

```
// equal values
int a = 12, b = 12;

System.out.println(
    "==: " + (a == b));
// No equals(...) method
// for primitive types
```

```
==: true
```

Object

```
String
 s1 = new String("Kate"),
 s2 = new String("Kate");

System.out.println(
  "    ==: " + (s1 == s2));
System.out.println(
  "equals: " + s1.equals(s2));
```

```
    ==: false
equals: true
```

Remarks == vs. `equals()`

- The == operator acting on primitive types compares expression values.
- The == operator acting on objects compares for equality of reference values and thus for object identity.
- The == operator acting on objects does **not** check whether two objects carry semantically equal values.
- The `equals()` method defines the equality two objects.

Operator == and `equals()` implications

- Each object is equal by value to itself:

`object1 == object2` $\Rightarrow$ `object1.equals(object2)`

- The converse is not true. Two different objects may be of common value:

Code

```
String s = "Hello", copy = new String(s);

System.out.println("equals: " + s.equals(copy));
System.out.println("    ==: " + (s == copy));
```

Result

```
equals: true
    ==: false
```

`equals()` is being defined within respective class!

Implementation at https://github.com/openjdk/ .../String.java :

```
public final class String ... {
public boolean equals(Object anObject) {
  if (this == anObject) {
    return true;
  }
  return (anObject instanceof String aString)
    && (!COMPACT_STRINGS || this.coder == aString.coder)
    && StringLatin1.equals(value, aString.value);
}
```

Hashing principle

“I want the 12p one”

Quickly identify by “simple” value

- Where is the blond haired guy?
- I take the pink flower.
- The 334.50$ cellular phone.

Hashing in Java and `equals()`

Method `hashCode()`: Instance 0 # o.`hashCode()`, of type `int`.

- Same value on repeated invocation
- Objects with identical value with respect to `equals()` must have identical hash values:

  `true == a.equals(b)` # `a.hashCode() == b.hashCode()`.

- Conversely: Two instances differing with respect to `equals()` may have identical hash values.

Consequence: `equals()` and `hashCode()` must be **redefined simultaneously**!

Rectangle equals(...) and hashCode()

```
public class Rectangle {
    int width, height;
    @Override public boolean equals(Object o) {
        if (o instanceof  Rectangle r) {
            return width == r.width
                    && height == r.height;
        } else {
            return false;
        }
    }
    @Override public int hashCode() {
        return width + height;
    }
}
```

Rectangle hash values

```
public class Rectangle {
    int width, height;
...
    @Override public int hashCode() {
        return width + height;
    }
}
```

width	height	hash value
1	**3**	**4**
2	**2**	**4**
5	5	10
2	7	9
4	9	13

Better hashCode() method

```
public class Rectangle {
    int width, height;
...
    @Override public int hashCode() {
        return width + 13 * height;
    }
}
```

width	height	hash value
1	3	40
2	2	28
5	5	70
2	7	93
4	9	121

Related exercises

Exercise 128: Choosing a “good” `hashCode()` method
Exercise 129: `String` and good hashCode() implementations.

Math.sin(double x)

Code	Result	Math notation

`final double x = 90;`
`final double y = Math.sin(x);`
`System.out.println(y + " == sin(" + x + ")");`
	`0.8939966636005579 == sin(90.0)`	

Related exercises

Exercise 130: Common pitfall using trigonometric functions
Exercise 131: Using constants from `java.lang.Math`.
Exercise 132: Strings on CodingBat
Exercise 133: Masking strings
Exercise 134: Analyzing strings
Exercise 135: Pitfalls using “==”: Equality of `String` instances
Exercise 136: Weird, weirder, weirdest!
Exercise 137: Analyzing file pathnames