1 What is a String in Java

A **String** in Java is a **sequence of characters**, treated as an object of the String class in the java.lang package.

Java Strings are **immutable**, meaning once created, their values **cannot be changed**.

Real-World Analogy

Think of a **string** as a **word written in ink** on paper — once written (created), you can read, compare, or copy it, but **can't change the ink directly** (immutable). To change it, you create a new paper (new String).

String Declaration and Initialization

```
// Using string literal (stored in string pool)
String s1 = "Hello";

// Using new keyword (stored in heap)
String s2 = new String("World");
```

Common String Methods

METHOD	DESCRIPTION	EXAMPLE
LENGTH()	Returns the number of characters	`s.length()`
CHARAT(INT INDEX)	Returns character at a specific index	`s.charAt(1)`
TOUPPERCASE()	Converts to uppercase	`s.toUpperCase()`
TOLOWERCASE()	Converts to lowercase	`s.toLowerCase()`
EQUALS()	Compares content (case-sensitive)	`s1.equals(s2)`
EQUALSIGNORECASE()	Compares ignoring case	`s1.equalsIgnoreCase(s2)`
CONTAINS()	Checks if string contains substring	`s.contains("text")`
SUBSTRING(START, END)	Extracts substring	`s.substring(1, 4)`
REPLACE(A, B)	Replaces characters	`s.replace("a", "b")`
SPLIT(" ")	Splits string into array	`s.split(" ")`
TRIM()	Removes leading/trailing spaces	`s.trim()`

String Immutability Explained

```
String s = "Hello";
s.concat(" World");  // does NOT change original string
System.out.println(s);  // Output: Hello
```

To reflect the change:

```
s = s.concat(" World");
System.out.println(s);  // Output: Hello World
```

String Comparison

```
String s1 = "Hello";
String s2 = "Hello";
String s3 = new String("Hello");

System.out.println(s1 == s2);      // true (same object in pool)
System.out.println(s1 == s3);      // false (different object)
System.out.println(s1.equals(s3)); // true (same content)
```

Example Program

```
public class StringExample {
    public static void main(String[] args) {
        String name = "Java Programming";

        System.out.println("Length: " + name.length());
        System.out.println("Upper: " + name.toUpperCase());
        System.out.println("First char: " + name.charAt(0));
        System.out.println("Contains 'Java': " + name.contains("Java"));
    }
}
```

Best Practices

- Prefer string **literals** for memory efficiency.
- Use equals() for comparison, **not** ==.
- Use StringBuilder for heavy string modifications (e.g., in loops).
- Avoid unnecessary string concatenations — it's memory-expensive.

Summary

TOPIC	KEY POINT
IMMUTABLE	Once created, cannot be changed
STORAGE	String Pool (literal), Heap (new)
METHODS	Powerful built-in methods for processing
COMPARISON	`equals()` for content, == for reference check
USE CASE	Widely used in file I/O, user input, APIs, etc.

2 String Literal Vs String Object

What is a String Literal?

A **String literal** is any sequence of characters enclosed in double quotes, e.g.:

```
String s1 = "Java";
```

- Stored **in the String Constant Pool (SCP)** inside the **Method Area** of JVM memory.
- If "Java" already exists in the SCP, it **does not create a new object** — it just returns a reference to the existing one.

What is a String Object?

You can also create a String using the `new` keyword:

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

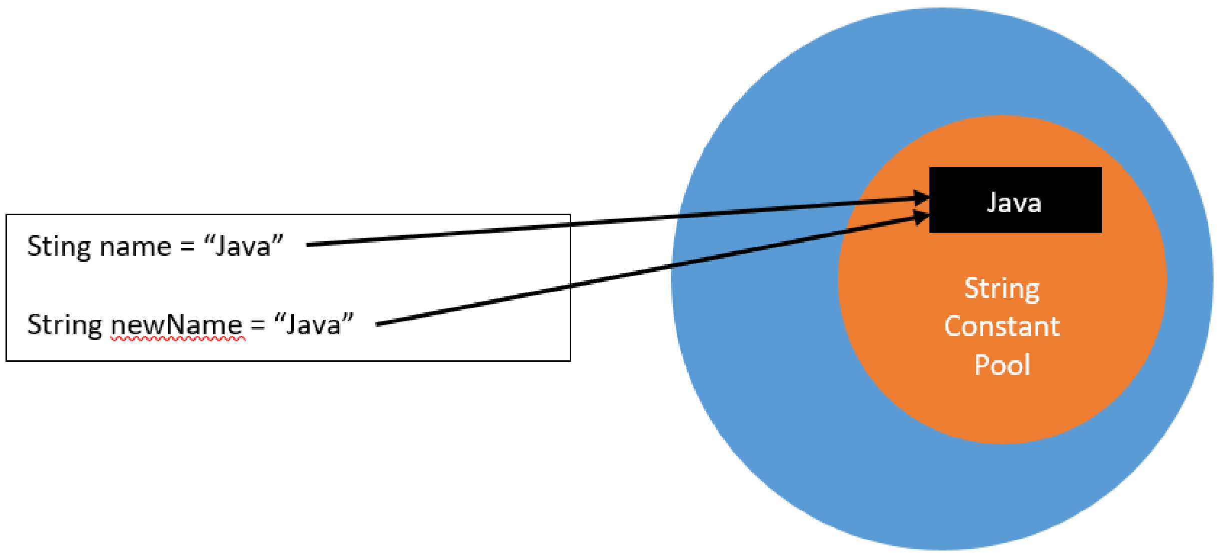
- Creates a **new object in the Heap** memory.
- Also refers to "Java" in the **SCP** (for internal character storage).
- So this creates **two objects**:
  → One in Heap (via `new`)
  → One in SCP (if not already present)

Key Differences: Literal vs Object

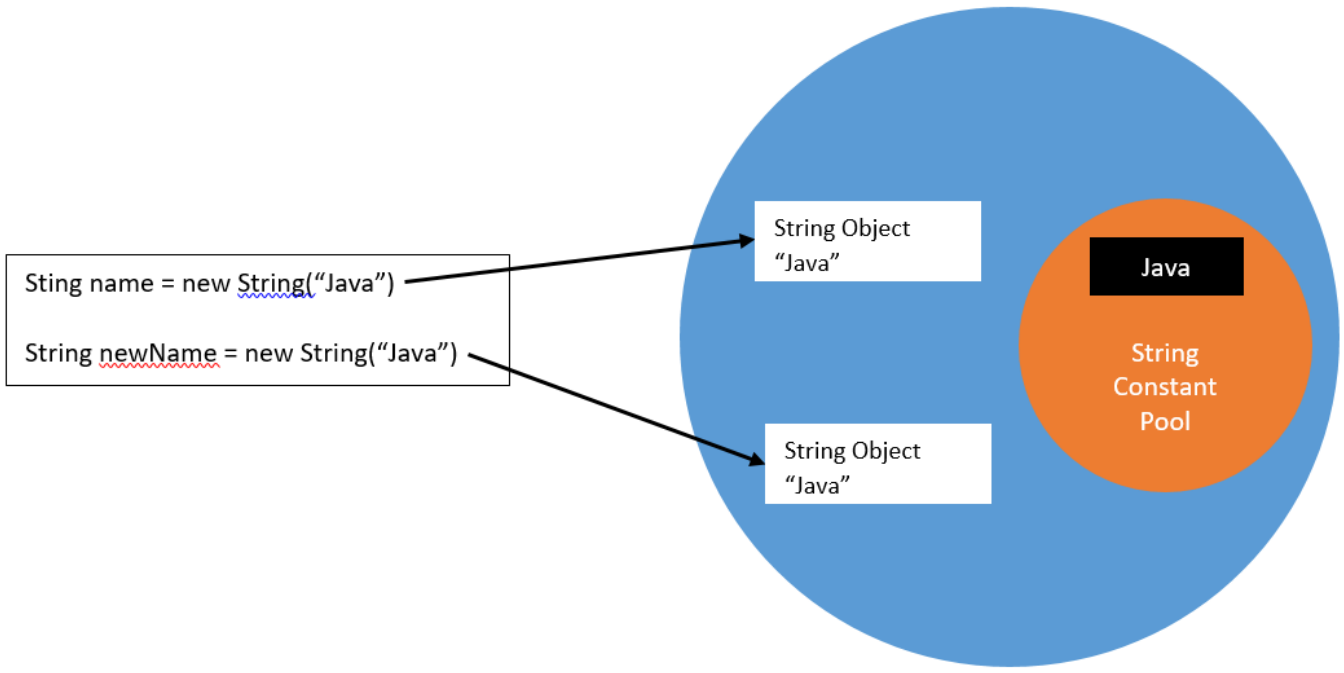
FEATURE	STRING LITERAL ("JAVA")	STRING OBJECT (NEW STRING("JAVA"))
MEMORY LOCATION	String Constant Pool (SCP)	Heap + reference to SCP
REUSE	Reused if already exists	Always a new object
EFFICIENCY	Memory efficient	Less efficient (creates duplicate)
COMPARISON USING ==	Might return `true`	Always returns `false`
EXAMPLE	`String s = "Java";`	`String s = new String("Java");`

Memory Diagram

String Literal



String Object


Sting name = new String(“Java”)
String newName = new String(“Java”)
String Object “Java”
String Object “Java”
Java
String Constant Pool

Comparison Example

```
public class StringMemoryDemo {
    public static void main(String[] args) {
        String s1 = "Java";
        String s2 = "Java";
        String s3 = new String("Java");

        System.out.println(s1 == s2);      // true (same SCP object)
        System.out.println(s1 == s3);      // false (heap vs SCP)
        System.out.println(s1.equals(s3)); // true (content comparison)
    }
}
```

Output:

```
true
false
true
```

Real-World Analogy

Imagine the **SCP as a library**:

- When you ask for a book titled "Java":
  - If it already exists on the shelf, you're **given the same copy** (literal).
  - If you say, "I want a brand new one" (using new), then the library **prints a fresh copy** and gives it to you.

Best Practices

- Use string **literals** when possible to save memory.
- ❌ Avoid unnecessary use of new String() unless you need a **separate object**.
- Always use .equals() to compare strings (not ==).

Bonus: `intern()` Method

You can force a string object to refer to SCP:

```
String s4 = new String("Java").intern();
```

Now s4 will point to "Java" in SCP — just like a literal.

Summary

TERM	MEANING
SCP	String Constant Pool — stores unique string literals
HEAP	General object storage area in memory
NEW STRING()	Always creates a new object in Heap
INTERN()	Moves or refers a string to the SCP
==	Compares reference (address)
EQUALS()	Compares content

2.11.3 StringBuffer in Java

1. Overview / Explanation

- StringBuffer is a **mutable** sequence of characters (unlike String, which is immutable).
- Part of java.lang package.
- Used when you need to **modify strings frequently** (e.g., appending, inserting, deleting).
- **Thread-safe** – methods are **synchronized**, so safe to use in multi-threaded environments.

Use Case: When building dynamic strings in a loop or multithreaded app – e.g., processing input, generating reports.

2. Declaration and Instantiation

```
StringBuffer sb1 = new StringBuffer();                // Empty buffer
StringBuffer sb2 = new StringBuffer("Hello");         // Initialized
StringBuffer sb3 = new StringBuffer(50);              // With capacity
```

3. Common Methods with Examples

append()

Adds text at the end.

```
sb1.append("Java");
System.out.println(sb1);  // Java
```

insert()

Inserts text at a specific index.

```
sb1.insert(4, " Programming");
System.out.println(sb1);  // Java Programming
```

replace()

Replaces part of the string between start and end index.

```
sb1.replace(0, 4, "Python");
System.out.println(sb1);  // Python Programming
```

delete()

Deletes characters between start and end index.

```
sb1.delete(0, 7);
System.out.println(sb1);  // Programming
```

`reverse()`

Reverses the entire content.

```
sb1.reverse();
System.out.println(sb1);  // gnimmargorP
```

length() and capacity()

```
System.out.println(sb1.length());   // No. of characters
System.out.println(sb1.capacity()); // Buffer capacity
```

charAt() and setCharAt()

```
char ch = sb1.charAt(0);
sb1.setCharAt(0, 'X');
```

4. Why Use StringBuffer Over String?

OPERATION	STRING	STRINGBUFFER
MUTABILITY	Immutable	Mutable
THREAD-SAFE	Not thread-safe	Yes
PERFORMANCE	Slower in loops	Faster in loops

5. StringBuffer vs StringBuilder

FEATURE	STRINGBUFFER	STRINGBUILDER
THREAD-SAFETY	Yes (synchronized)	No
PERFORMANCE	Slower	Faster (in single-thread)
USE CASE	Multithreaded apps	Single-thread apps

2.11.4 StringBuilder in Java

1. Overview / Explanation

- StringBuilder is a **mutable** sequence of characters, just like StringBuffer.
- **Not thread-safe**, but **faster** than StringBuffer in single-threaded applications.
- Part of java.lang package.
- Ideal when you're performing **lots of modifications to strings** in a **single-threaded** context.

Use Case: Building or modifying strings inside loops, parsing files, generating HTML reports, etc.

2. Declaration and Instantiation

```
StringBuilder sb1 = new StringBuilder();              // Empty buffer
StringBuilder sb2 = new StringBuilder("Hello");       // With initial value
StringBuilder sb3 = new StringBuilder(50);            // With specific capacity
```

3. Common Methods with Examples

append()

```
sb1.append("Java");
System.out.println(sb1);  // Java
```

insert()

```
sb1.insert(4, " World");
System.out.println(sb1);  // Java World
```

replace()

```
sb1.replace(0, 4, "Hello");
System.out.println(sb1);  // Hello World
```

delete()

```
sb1.delete(5, 11);
System.out.println(sb1);  // Hello
```

reverse()

```
sb1.reverse();
System.out.println(sb1);  // olleH
```

length() and capacity()

```
System.out.println(sb1.length());     // Number of characters
System.out.println(sb1.capacity());  // Total buffer size (default is 16 + initial content
length)
```

charAt() and setCharAt()

```
char ch = sb1.charAt(0);
sb1.setCharAt(0, 'M');
System.out.println(sb1);  // Ml...
```

4. StringBuilder vs String vs StringBuffer

FEATURE	STRING	STRINGBUILDER	STRINGBUFFER
MUTABILITY	✗ Immutable	Mutable	Mutable
THREAD-SAFE	✗ No	✗ No	Yes
PERFORMANCE	✗ Slower	Fastest	⚠ Slower (sync)
BEST FOR	Constant text	Fast updates (1 thread)	Multithreading

2.11.5 String vs StringBuffer vs StringBuilder

FEATURE	STRING	STRINGBUFFER	STRINGBUILDER
MUTABILITY	✗ Immutable	Mutable	Mutable
THREAD-SAFE	✗ No	Yes (all methods are synchronized)	✗ No
PERFORMANCE	✗ Slowest (new object per change)	⚠ Slower (due to thread-safety overhead)	Fastest (no sync overhead)
SYNCHRONIZATION	✗ Not applicable	Synchronized	✗ Not synchronized
USE CASE	Constant/fixed string content	Multi-threaded environment	Single-threaded environment
PACKAGE	java.lang	java.lang	java.lang
INTRODUCED IN	JDK 1.0	JDK 1.0	JDK 1.5
METHODS FOR CHANGE	N/A (strings can't be modified)	append(), insert(), delete(), replace()	append(), insert(), delete(), replace()
MEMORY EFFICIENT?	✗ No (creates many objects)	Yes	Yes

Example Comparison

```
// String (immutable)
String s = "Hello";
s = s + " World";  // Creates a new String object

// StringBuffer (mutable, thread-safe)
StringBuffer sb = new StringBuffer("Hello");
sb.append(" World");  // Modifies original object

// StringBuilder (mutable, not thread-safe)
StringBuilder sb2 = new StringBuilder("Hello");
sb2.append(" World");  // Modifies original object
```

When to Use What?

SITUATION	RECOMMENDED TYPE
SIMPLE, UNCHANGING TEXT	String
MANY STRING CHANGES IN MULTITHREADED CODE	StringBuffer
MANY STRING CHANGES IN SINGLE-THREADED CODE	StringBuilder