***Technical Concepts Handbook***

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# ***Java***

## **Java Fundamentals**

### **Explain how to install java? Explain directories in it?**

**Step 1: Download Java**

Go to the official Oracle website or use OpenJDK: Oracle JDK / OpenJDK

**Step 2: Choose Version**

Choose the appropriate JDK version (e.g., Java 17 or Java 21 – latest LTS versions).

Select the installer for your operating system (Windows, macOS, Linux).

**Step 3: Install Windows:**

Run the .exe installer and follow the wizard.

It installs Java to a default path like: C:\Program Files\Java\jdk-21

macOS/Linux:

Use .tar.gz or package managers like Homebrew, apt, yum.

sudo apt install openjdk-21-jdk # For Ubuntu

**Step 4: Set Environment Variables (Windows)**

Go to System Properties > Environment Variables.

Add to Path: C:\Program Files\Java\jdk-21\bin

Set JAVA\_HOME: JAVA\_HOME = C:\Program Files\Java\jdk-21

**Step 5: Verify Installation**

Open a terminal/command prompt and run:

java -version

javac -version



### **How to configure java in windows?**

✅ **Step 1: Download Java JDK**

Go to the official Oracle website or OpenJDK site:

* [Oracle JDK](https://www.oracle.com/java/technologies/javase-downloads.html)
* [OpenJDK (Adoptium)](https://adoptium.net/)

Download the installer for Windows x64.

**✅ Step 2: Install Java**

Run the installer (.msi or .exe)

Choose installation path (e.g., C:\Program Files\Java\jdk-21)

Complete the installation

✅ **Step 3: Set Environment Variables**

**🌐 1. Set JAVA\_HOME**

Open System Properties  
Right click on This PC → Properties → Advanced system settings → Environment Variables

Under System Variables, click New:

Variable Name: JAVA\_HOME

Variable Value: C:\Program Files\Java\jdk-21

🌐 **2. Add to Path variable**

In the same "Environment Variables" window:

Find Path under System Variables

Click Edit → New and add:

%JAVA\_HOME%\bin

✅ **Step 4: Verify Java Installation**

Open Command Prompt and run:

java -version

Example output:

java version "21.0.1" 2023-10-17 LTS

Java(TM) SE Runtime Environment ...

Also try:

javac -version

To verify the Java compiler (javac) is set correctly.

### **Explain Java Program execution?**

* **1. Writing the Source Code**
  + You create a .java file containing your Java code (e.g., HelloWorld.java)
  + Example:

public class HelloWorld {

public static void main(String[] args) {

System.out.println("Hello, World!");

}

}

**2. Compilation (javac)**

* + The Java compiler (javac) converts your source code into **bytecode** (platform-independent intermediate code)
  + Creates .class files (e.g., HelloWorld.class)
  + Bytecode is not machine code - it's instructions for the **Java Virtual Machine (JVM)**

**3. Class Loading**

When you run java HelloWorld:

**a) Bootstrap ClassLoader**

* Loads core Java classes (from rt.jar and other core libraries)
* Written in native code (not Java)

**b) Extension ClassLoader**

* Loads classes from Java extension directories

**c) Application ClassLoader**

* Loads your application classes (from the classpath)

**4. Bytecode Verification**

* JVM verifies the bytecode to ensure:
  + No illegal memory access
  + Proper stack manipulation
  + Correct method calls
  + No violation of access restrictions
* This provides security by preventing malicious code

**5. Just-In-Time (JIT) Compilation**

* The JVM's JIT compiler converts frequently executed bytecode into **native machine code**
* Happens at runtime
* Optimizes performance by:
  + Inlining methods
  + Removing dead code
  + Optimizing loops

**6. Execution**

* The JVM executes the program:
  + Creates the main thread
  + Allocates memory for objects in the Heap
  + Manages method calls using the Stack
  + Handles garbage collection automatically

**7. Runtime Memory Areas**

The JVM manages these memory areas during execution:

a) Method Area

* Stores class structures, method code, and static variables

b) Heap

* Stores all objects and their instance variables
* Garbage collection works here

c) JVM Stacks

* Each thread has its own stack
* Stores frames for each method call (local variables, operands, return values)

d) PC Registers

* Tracks the execution position for each thread

e) Native Method Stacks

* For native code (non-Java code)

**8. Garbage Collection**

* Automatically reclaims memory from objects no longer in use
* Runs in the background
* Different algorithms available (Serial, Parallel, G1, ZGC, etc.)



### **Explain the byte stream in java?**

* The Byte Stream in Java is used to perform input and output of 8-bit bytes. It is mainly used to read and write binary data like images, videos, audio files, PDF, etc.

🧱 **Byte Stream Classes (Hierarchy)**

All byte stream classes are derived from these two abstract classes:

| **Stream Type** | **Abstract Class** | **Direction** |
| --- | --- | --- |
| Input Stream | InputStream | Reading |
| Output Stream | OutputStream | Writing |

**📥 Common Byte InputStream Classes**

| **Class** | **Description** |
| --- | --- |
| FileInputStream | Reads data from a file |
| BufferedInputStream | Reads data efficiently using a buffer |
| ByteArrayInputStream | Reads data from a byte array |
| ObjectInputStream | Reads Java objects from a stream (used in serialization) |

**📤 Common Byte OutputStream Classes**

| **Class** | **Description** |
| --- | --- |
| FileOutputStream | Writes data to a file |
| BufferedOutputStream | Writes data efficiently using a buffer |
| ByteArrayOutputStream | Writes to a byte array |
| ObjectOutputStream | Writes Java objects to a stream |

✅ **Simple Example: Reading a file using Byte Stream**

import java.io.FileInputStream;

import java.io.FileOutputStream;

import java.io.IOException;

public class ByteStreamExample {

public static void main(String[] args) {

try (

FileInputStream in = new FileInputStream("input.txt");

FileOutputStream out = new FileOutputStream("output.txt");

) {

int byteData;

while ((byteData = in.read()) != -1) {

out.write(byteData);

}

System.out.println("File copied successfully using byte stream.");

} catch (IOException e) {

e.printStackTrace();

}

}

}

🎯 **When to Use Byte Stream?**

* When working with non-textual data (images, videos, etc.)
* When you need to process data byte by byte
* When dealing with platform-independent binary formats

📌 **Byte Stream vs Character Stream**

| **Feature** | **Byte Stream (InputStream/OutputStream)** | **Character Stream (Reader/Writer)** |
| --- | --- | --- |
| Data Type | 8-bit bytes (binary) | 16-bit characters (text) |
| Use Case | Images, videos, PDFs | Text files, character data |
| Base Classes | InputStream, OutputStream | Reader, Writer |

### **What is Classloader? Different types of it?**

* The **ClassLoader** is a part of the **Java Runtime Environment (JRE)** responsible for **loading .class files** into memory **at runtime**.

Java doesn't load all classes at once — it loads them **on demand**, and the ClassLoader is what performs that task.

**🔁 Class Loading Process (High-Level)**

1. **Load** – The class file is located and loaded into memory.
2. **Link** – It verifies, prepares, and optionally resolves the class.
3. **Initialize** – Static blocks and static variables are initialized.

**🧱 Types of ClassLoaders in Java**

Java has a **hierarchical delegation model**, and these are the key built-in classloaders:

| **ClassLoader** | **Role** |
| --- | --- |
| 🔹 **Bootstrap ClassLoader** | Loads **core Java classes** from the rt.jar (like java.lang.\*) |
| 🔹 **Extension ClassLoader** | Loads classes from the ext directory ($JAVA\_HOME/lib/ext) |
| 🔹 **System/Application ClassLoader** | Loads classes from the **classpath** (e.g., your app code) |

**➕ Custom ClassLoaders**

You can create your own ClassLoader by extending ClassLoader to load classes dynamically (e.g., plugin systems, frameworks like OSGi).

**🔄 Delegation Hierarchy**

When a class is requested to be loaded, the process follows this **parent-first delegation model**:

App ClassLoader → Ext ClassLoader → Bootstrap ClassLoader

Each loader **delegates to its parent** before trying to load the class itself.

**✅ Example: Get the ClassLoader of a Class**

public class Demo {

public static void main(String[] args) {

ClassLoader cl = Demo.class.getClassLoader();

System.out.println("ClassLoader: " + cl);

}

}

**🔍 Real-World Use Cases of ClassLoader**

* **Hot deployment** in application servers
* **Dynamic loading** of plugins/modules
* **Custom loading** of encrypted/obfuscated classes
* Used heavily in frameworks like **Spring**, **Hibernate**, **Tomcat**, etc.

### **Why is java more secure?**

* Java was **designed with security in mind** from the start. Here's how it achieves that:

**1. No Pointer Arithmetic**

* Java **doesn't allow direct memory access** using pointers like C/C++.
* Prevents buffer overflows, memory corruption, and access to arbitrary memory.

**2. Automatic Memory Management (Garbage Collection)**

* Reduces memory leaks and dangling pointer issues.
* JVM handles allocation and deallocation safely.

**3. Bytecode Verification**

* Before execution, **Java bytecode is verified** by the JVM to ensure it:
  + Obeys access restrictions
  + Doesn't overflow/underflow memory
  + Has correct data types
* Prevents malicious or corrupted bytecode from running.

**4. ClassLoader and SecurityManager**

* Java’s **ClassLoader** architecture ensures classes are loaded securely and isolates class loading for apps.
* **SecurityManager** (though deprecated in Java 17+) allows you to define **runtime access control policies**.

**5. Sandboxing**

* Java applets (now obsolete) used to run in a **sandbox**, restricting file access, network, etc.
* Still applies to custom environments like **JVM containers** or plugin systems.

**6. Strong Access Modifiers**

* Keywords like private, protected, final prevent unwanted access or overrides.
* Supports **encapsulation**, keeping internal logic safe from external interference.

**7. Exception Handling**

* Java's exception system helps handle runtime errors gracefully, reducing crashes or undefined behavior.

**8. Built-in Cryptography & SSL APIs**

* Java provides APIs for **secure communication**, **data encryption**, and **message integrity** (like javax.crypto, java.security, etc.).

**9. Runtime Monitoring with JVM Tools**

* Java has profiling, monitoring, and diagnostic tools (e.g., **JFR**, **JConsole**, **VisualVM**) to catch issues early.

**10. Regular Security Patches & Community Support**

* Oracle and the OpenJDK community release **frequent security updates**.
* Vast community support ensures vulnerabilities are spotted and patched quickly.

**🛡️ Summary Table**

| **Security Feature** | **Java's Advantage** |
| --- | --- |
| Memory Safety | No pointers, GC prevents memory attacks |
| Access Control | Strong access modifiers and class isolation |
| Code Verification | Bytecode is checked before execution |
| Runtime Security | SecurityManager, ClassLoader protection |
| Communication Security | SSL, TLS, Encryption libraries available |

### **Explain public static void main (String[] args) method?**

**🔍 Breakdown of each keyword:**

| **Part** | **Meaning** |
| --- | --- |
| public | Access modifier – means this method can be called from anywhere. |
| static | No need to create an object to call this method — JVM calls it directly. |
| void | Return type – it doesn't return any value to the JVM. |
| main | Method name – JVM looks for this specific method as the entry point. |
| String[] args | Command-line arguments – passed to your program when it starts. |

**🧠 Why each part is important?**

**✅ public**

* Must be **public** so that **JVM can access it** from outside the class.

**✅ static**

* JVM doesn't create an object of your class to call main().
* Declared static so it can be called **without creating an instance**.

**✅ void**

* main() doesn’t return anything. It's just the entry point.

**✅ main**

* JVM always looks for this method name to start the program.

**✅ String[] args**

* An array of String values passed during command-line execution.
* **Example:**

java MyApp Hello World

Then args[0] = "Hello", args[1] = "World"

**✅ Complete Example:**

public class HelloWorld {

public static void main(String[] args) {

System.out.println("Hello, Java!");

}

}

**🧪 Fun fact:**

You can actually write it like:

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

...because the order of static and public doesn't matter in this context (but the conventional order is public static).

### **What is the marker interface?**

* A **marker interface** is an interface that has **no methods or fields**.  
  Its sole purpose is to **mark** a class with some metadata so that the **JVM or framework** can identify and treat the object differently.

**🔍 Example:**

public interface Serializable {

// No methods inside — it's a marker interface

}

If a class implements Serializable, it **indicates** that objects of that class can be **serialized** (converted into a byte stream).

**✅ Common Marker Interfaces in Java**

| **Interface** | **Purpose** |
| --- | --- |
| Serializable | Marks objects that can be serialized |
| Cloneable | Allows object cloning using Object.clone() |
| Remote | Used in RMI to indicate remote method calling |
| ThreadSafe (custom) | Can be used to tag thread-safe components |

**🧠 How Does It Work?**

Although a marker interface has **no methods**, Java libraries and JVM use **instanceof checks or reflection** to apply behavior.

if (object instanceof Serializable) {

// safe to serialize

}

**🛠️ Custom Marker Interface Example**

public interface Auditable {} // marker interface

public class Transaction implements Auditable {

// business logic

}

A framework might look for Auditable-tagged classes and log changes automatically.

**🆚 Marker Interface vs Annotations**

| **Aspect** | **Marker Interface** | **Annotation** |
| --- | --- | --- |
| Introduced in | Java 1.0 | Java 5 |
| Inheritance | Can use instanceof | Cannot use instanceof |
| Flexibility | Limited | More flexible (can include data) |
| Preferred now? | ❌ Old style | ✅ Recommended (modern approach) |

**✅ Summary**

* Marker interfaces = **empty interfaces** used to **mark classes** for special treatment
* Still used (e.g., Serializable), but **annotations are more powerful and flexible** today

### **What is serialization and deserialization?**

* **📦 Serialization**

**Definition:** Serialization is the process of **converting a Java object into a byte stream**, so it can be stored in a file, sent over a network, or saved in memory.

**Why?** To persist (save) the state of an object or transfer it.

**Java Syntax:**

ObjectOutputStream out = new ObjectOutputStream(new FileOutputStream("data.ser"));

out.writeObject(object); // object must be Serializable

out.close();

**📥 Deserialization**

**Definition:**  
Deserialization is the reverse process — **reconstructing a Java object from a byte stream**.

**Java Syntax:**

ObjectInputStream in = new ObjectInputStream(new FileInputStream("data.ser"));

MyObject obj = (MyObject) in.readObject();

in.close();

**✅ Requirements:**

* The class **must implement** java.io.Serializable interface.
* Example:

import java.io.Serializable;

public class Person implements Serializable {

private String name;

private int age;

// constructors, getters, setters

}

**🛠️ Real-World Use Cases:**

* Saving user session data to a file
* Sending objects between systems (e.g., via sockets)
* Caching objects
* Storing objects in databases as BLOBs

**🚫 Things to Watch Out:**

* **transient** keyword skips fields during serialization.

transient String password;

* Version conflicts can happen — use serialVersionUID for version control:

private static final long serialVersionUID = 1L;

**🧪 Simple Example:**

// Serializable class

import java.io.\*;

class Student implements Serializable {

private static final long serialVersionUID = 1L;

String name;

int age;

public Student(String name, int age) {

this.name = name;

this.age = age;

}

}

// Main class

public class SerializationExample {

public static void main(String[] args) throws Exception {

Student s1 = new Student("John", 22);

// Serialize

ObjectOutputStream out = new ObjectOutputStream(new FileOutputStream("student.ser"));

out.writeObject(s1);

out.close();

// Deserialize

ObjectInputStream in = new ObjectInputStream(new FileInputStream("student.ser"));

Student s2 = (Student) in.readObject();

in.close();

  System.out.println("Deserialized Student: " + s2.name + ", " + s2.age);

}

}

### **What is the use of the transient keyword in serialization?**

* The **transient** keyword in Java is used to mark a field of a class as "non-serializable." When an object is serialized (i.e., converted into a byte stream for storage or transmission), the transient keyword ensures that the marked field is not included in the serialization process. This is useful when you have fields that should not be persisted, such as sensitive data (e.g., passwords), or fields that can be recalculated and don't need to be saved.

Example:

import java.io.\*;

class Employee implements Serializable {

private String name;

private transient int salary; // This field will not be serialized

public Employee(String name, int salary) {

this.name = name;

this.salary = salary;

}

public String getName() {

return name;

}

public int getSalary() {

return salary;

}

}

 public class TestSerialization {

public static void main(String[] args) throws Exception {

Employee emp = new Employee("John", 50000);

// Serialize the object

FileOutputStream fileOut = new FileOutputStream("employee.ser");

ObjectOutputStream out = new ObjectOutputStream(fileOut);

out.writeObject(emp);

out.close();

fileOut.close();

// Deserialize the object

FileInputStream fileIn = new FileInputStream("employee.ser");

ObjectInputStream in = new ObjectInputStream(fileIn);

Employee deserializedEmp = (Employee) in.readObject();

in.close();

fileIn.close();

// Output the deserialized object's fields

System.out.println("Name: " + deserializedEmp.getName());

System.out.println("Salary: " + deserializedEmp.getSalary()); // Will be 0 since it's transient

}

}

In this example, the **salary** field is marked as **transient**, so when the object is serialized and then deserialized, the **salary** field will not retain its value and will default to **0** in the deserialized object.

### **How can I make below Employee class as Serializable class?**

@Data class Employee {

String name;

String empld;

Date dob;

Address address;

}

@Data

class Address{

String linel;

String line2;

}

import java.io.Serializable;

import java.util.Date;

@Data

class Employee implements Serializable {

private static final long serialVersionUID = 1L; // Optional, but good practice to define

private String name;

private String empld;

private Date dob;

private Address address;

}

@Data

class Address implements Serializable {

private static final long serialVersionUID = 1L; // Optional, but good practice to define

private String line1;

private String line2;

}

**Key Points:**

1. **Implements Serializable:** Both Employee and Address classes implement Serializable, making instances of these classes eligible for serialization.
2. **serialVersionUID:** It's recommended to include a serialVersionUID for version control. If a class definition changes after objects have been serialized, the serialVersionUID is used to verify that the deserialization process is compatible with the serialized object.
3. **Field Naming Correction:** Fixed the typo in the field names (linel to line1 and adress to address).

Now both classes are serializable and can be serialized into a byte stream and deserialized back into objects.

### **In above example, what if we have empId as static then what will happen at the time of serialization?**

* If empId is declared as static in the Employee class, it will **not be serialized** during the serialization process. This is because static fields are associated with the class itself, not with instances of the class, and serialization in Java only deals with instance data (non-static fields).

Here's what will happen when empId is static:

**Example:**

import java.io.Serializable;

import java.util.Date;

@Data

class Employee implements Serializable {

private static final long serialVersionUID = 1L;

private String name;

private String empld;

private Date dob;

private Address address;

// Static field (will not be serialized)

private static String empId;

public Employee(String name, String empld, Date dob, Address address, String empId) {

this.name = name;

this.empld = empld;

this.dob = dob;

this.address = address;

Employee.empId = empId;

}

}

@Data

class Address implements Serializable {

private static final long serialVersionUID = 1L;

private String line1;

private String line2;

}

**What happens during serialization:**

* The instance fields (name, empld, dob, address) of the Employee class will be serialized.
* The static field (empId) will **not** be serialized because it is tied to the class, not the individual object instance.
* After deserialization, the value of the empId field will be **lost** for that particular instance because it was not serialized. The empId will not be preserved across serialization and deserialization unless it is explicitly handled (e.g., through custom serialization or manually restoring the value after deserialization).

**Example of behavior:**

1. **Before Serialization:**
   * empId = "12345" (static)
   * empld = "E123" (instance field)
2. **After Serialization and Deserialization:**
   * empld will retain its value (e.g., "E123").
   * empId will be reset to its default value (null for String since it's static, or it may stay as it was set before the serialization if shared among instances).

To ensure that empId is correctly handled across serialization and deserialization, you might need to manually manage it. For instance, you could mark the field transient and handle its restoration manually, or you could implement custom readObject and writeObject methods to control how static fields are serialized.

### **What is the final class?**

* **🧱 What is a final class?**

A **final class** is a class that **cannot be extended (inherited)**.

public final class MyClass {

// class code

}

* Once a class is marked as final, **no other class** can subclass it.

**✅ Why use a final class?**

| **Reason** | **Benefit** |
| --- | --- |
| 🔐 Prevent Inheritance | Avoid accidental or malicious subclassing |
| 🛡️ Security | Makes class behavior predictable and secure |
| 🚀 Performance Optimization | JVM can make certain optimizations as it knows the class won't change |
| 📦 Encapsulation | Helps in creating immutable or well-contained utility classes |

**🔐 Example:**

public final class SecurityManager {

public void checkPermission() {

System.out.println("Permission granted.");

}

}

// ❌ This will cause a compile-time error

public class MySecurityManager extends SecurityManager {

// Cannot inherit from final class

}

**📌 Real-life Example: java.lang.String**

public final class String {

// String class is final in Java

}

* Why? Because String is **immutable and heavily used**. Preventing subclassing avoids unpredictable behavior.

**⚠️ Key Points**

* You **can create objects** of a final class.
* You **cannot extend (subclass)** a final class.
* A final class **can have final or non-final methods**.
* A class can be final, a method can be final, and a variable can also be final — but they have **different meanings**.

**Related Concepts**

| **Keyword** | **Meaning** |
| --- | --- |
| final variable | Value cannot be changed after initialization |
| final method | Method cannot be overridden |
| final class | Class cannot be extended |

### **Where can we use the final keyword?**

* The final keyword in Java is used to **restrict modification** — it can be applied to **variables, methods, and classes**.

Let’s break it down:

**✅ 1. final Variable**

* **Prevents reassignment** — once initialized, its value **cannot be changed**.

**🔹 Example:**

final int x = 10;

// x = 20; // ❌ Compilation error

**🔸 Use Case:**

* Constants (static final)
* Ensuring values remain unchanged

**✅ 2. final Method**

* Prevents a method from being **overridden** by subclasses.

**🔹 Example:**

class Parent {

final void show() {

System.out.println("Parent show");

}

}

class Child extends Parent {

// void show() { } // ❌ Error: Cannot override final method

}

**🔸 Use Case:**

* Security or utility methods that shouldn't be altered

**✅ 3. final Class**

* Prevents a class from being **subclassed** (i.e., inherited).

**🔹 Example:**

final class Animal {

void speak() {

System.out.println("Roar");

}

}

// class Dog extends Animal {} // ❌ Error: Cannot inherit from final class

**🔸 Use Case:**

* Immutable or security-sensitive classes (like java.lang.String)

**✅ 4. final with Reference Variables**

* You **can’t reassign** the reference, but the object it points to **can still be modified**.

final List<String> names = new ArrayList<>();

names.add("Alice"); // ✅ Allowed

// names = new ArrayList<>(); // ❌ Not allowed

**✅ 5. final with Method Parameters**

* Makes the parameter **read-only** within the method.

void print(final int num) {

// num = 5; // ❌ Error

System.out.println(num);

}

**✅ 6. final and static together**

Used to define **constants**.

public static final double PI = 3.14159;

**📝 Summary Table**

| **Context** | **Effect of final** |
| --- | --- |
| Variable | Value can't be changed after initialization |
| Method | Cannot be overridden |
| Class | Cannot be extended (no subclass) |
| Reference | Reference can't be reassigned (but object can change) |
| Parameter | Value cannot be modified inside method |
| static final | Creates constants |

### **What will happen if I create the final class?**

* A final class in Java is a class that **cannot be extended or inherited**.

**✅ What happens when you create a final class?**

**1. You can use it as-is**

You **can create objects**, call its methods, and use it like any regular class.

final class Vehicle {

void run() {

System.out.println("Vehicle is running");

}

}

public class Main {

public static void main(String[] args) {

Vehicle v = new Vehicle();

v.run(); // ✅ Works fine

}

}

**2. You cannot extend it**

If any other class tries to inherit it, the compiler throws an error.

class Car extends Vehicle {

// ❌ Compilation Error: Cannot inherit from final class

}

**💡 Why create a final class?**

| **Reason** | **Description** |
| --- | --- |
| 🔐 **Security** | Prevents classes from being modified via inheritance |
| 🧱 **Immutability** | Helps build immutable classes (like String) |
| 📦 **Framework Control** | Used in APIs to avoid unexpected subclassing |
| 🔄 **Stable Behavior** | Prevents method overriding and logic changes |

**✅ Real-world example**

The String class in Java is final:

public final class String {

// internal implementation

}

Why? Because String is:

* Immutable
* Used heavily in JVM internals
* Needs guaranteed behavior

**🚫 What you CANNOT do with a final class:**

* ❌ Subclass it
* ❌ Override its methods in a child class (since no child class can exist)

But you **can**:

* ✅ Instantiate it
* ✅ Use its methods
* ✅ Pass it around like any other class

### **What is String?**

* **📌 What is String in Java?**
* In Java, String is a **class** in the **java.lang** package.
* It is used to represent **a sequence of characters** (text data).
* **Immutable**: Once a String object is created, its value **cannot be changed**.

String name = "Alice";

Here, name is a String object containing the text "Alice".

**🔍 String is a Class (Not a Primitive)**

* String is **not a primitive type** (like int, char, boolean)
* It's a **reference type**, but behaves like a basic data type due to special handling by the JVM.

**🔐 String is Immutable**

String s1 = "Hello";

s1.concat(" World");

System.out.println(s1); // Output: Hello (not "Hello World")

* A new String is created internally, but s1 still points to the original "Hello".
* For modifications, use StringBuilder or StringBuffer.

**🧠 How Strings are Stored**

**String Pool (String Interning):**

String a = "Java";

String b = "Java";

System.out.println(a == b); // true (points to same object in string pool)

* Strings created with **literals** are stored in the **String constant pool**.
* Helps in **memory optimization**.

**🔧 Ways to Create Strings**

// 1. Using literals (preferred)

String str1 = "Hello";

// 2. Using constructor (avoids pool)

String str2 = new String("Hello");

**✅ Common String Methods:**

| **Method** | **Description** |
| --- | --- |
| length() | Returns the length |
| charAt(index) | Returns character at index |
| equals() | Checks value equality |
| == | Checks reference equality |
| toLowerCase() | Converts to lowercase |
| toUpperCase() | Converts to uppercase |
| substring(start) | Extracts a part of the string |
| contains(str) | Checks if substring is present |
| split(regex) | Splits string into array |
| replace(a, b) | Replaces characters or substrings |
| trim() | Removes leading/trailing spaces |

**🔄 Mutable Alternatives:**

| **Class** | **Thread Safe** | **Use Case** |
| --- | --- | --- |
| StringBuilder | ❌ No | Faster in single-threaded apps |
| StringBuffer | ✅ Yes | For multi-threaded environments |

**🧪 Example:**

public class Example {

public static void main(String[] args) {

String greet = "Hello";

greet += " World";

System.out.println(greet); // Hello World

}

}

### **Why String is immutable in java?**

* **🔐 Why is String immutable in Java?**

Because once a String object is created, **its value cannot be changed**. Any operation that seems to "modify" a string actually creates a **new object**.

**🧠 But WHY did Java make Strings immutable?**

**✅ 1. Security**

* Strings are widely used in **file paths, network connections, class loading, etc.**
* If a String were mutable, someone could change:

// Original path

String path = "/home/user/app";

// Imagine someone changes it to a malicious path!

🔐 Immutability prevents tampering with sensitive data like usernames, passwords, and URLs.

**✅ 2. String Pooling**

* Java uses a **String Pool** to save memory.
* Since strings don't change, they can be **safely shared** among many references.

String s1 = "Java";

String s2 = "Java";

System.out.println(s1 == s2); // true → Same object in memory

**✅ 3. Thread Safety**

* Immutable objects are **automatically thread-safe**.
* No need for synchronization since their state can’t change.

Multiple threads can safely use the same String object without causing issues.

**✅ 4. HashCode Consistency**

* String is often used as a key in **HashMap, HashSet, etc.**
* Since the value never changes, the **hashCode stays constant**, ensuring map integrity.

Map<String, String> map = new HashMap<>();

map.put("key", "value");

// If "key" changed, we couldn't retrieve "value" reliably!

**✅ 5. Performance**

* JVM optimizes the use of strings due to immutability.
* Reuse from the pool and predictable behavior helps the JVM optimize better.

**🧪 Example of how it's immutable:**

String s = "Java";

s.concat(" World");

System.out.println(s); // Java → Original string unchanged

s.concat(" World") creates a new string "Java World" but doesn't change s.

**🧱 Internally**

The String class has a private final char array:

public final class String {

private final char value[];

}

* final → reference to the array can't change
* private → can't access directly
* Immutable at its core

**✅ Summary**

| **Reason** | **Explanation** |
| --- | --- |
| Security | Prevents sensitive data manipulation |
| String Pooling | Enables memory-efficient reuse |
| Thread Safety | Can be shared between threads without risk |
| HashCode Stable | Reliable use in HashMap, HashSet, etc. |
| JVM Optimization | Better performance due to predictability |

### **What is StringBuffer?**

* **🔤 StringBuffer in Java?**
* StringBuffer is a **mutable** class used to create and manipulate **strings of characters**.
* Unlike String, which is **immutable**, StringBuffer objects **can be changed** without creating new objects.
* It is **thread-safe**, meaning **methods are synchronized** so multiple threads can use it safely.

**🔧 Declaration & Example:**

StringBuffer sb = new StringBuffer("Hello");

sb.append(" World");

System.out.println(sb); // Output: Hello World

* append() modifies the original object itself, no new object is created.

**🧪 Key Features of StringBuffer**

| **Feature** | **Description** |
| --- | --- |
| ✅ Mutable | Can modify content without creating new objects |
| ✅ Thread-safe | Methods are synchronized |
| 📏 Dynamic length | Grows as needed (like a resizable array) |
| ⚡ Slower than StringBuilder | Due to synchronization overhead |

**🛠️ Common Methods**

StringBuffer sb = new StringBuffer("Java");

sb.append(" Rocks"); // Add text

sb.insert(4, " Programming"); // Insert at index

sb.replace(0, 4, "Python"); // Replace part of string

sb.delete(0, 6); // Delete part

sb.reverse(); // Reverse string

System.out.println(sb);

**💡 When to use StringBuffer?**

Use StringBuffer when:

* You need a **mutable string**
* You are working in a **multi-threaded environment**
* You don’t want to use manual synchronization

**✅ Summary**

* StringBuffer = **mutable + thread-safe** version of string manipulation.
* Prefer StringBuilder in single-threaded contexts for better performance.
* Use String when data is constant and doesn't change.

### **What is StringBuilder?**

* **🔤 StringBuilder in Java?**
* StringBuilder is a **mutable** sequence of characters, like StringBuffer, but it is **not synchronized**, meaning it is **not thread-safe**.
* It is designed for **single-threaded applications** where performance is important and you need to frequently modify strings.
* **Faster** than StringBuffer because it doesn't incur the overhead of synchronization.

**🔧 StringBuilder Example:**

StringBuilder sb = new StringBuilder("Hello");

sb.append(" World");

System.out.println(sb); // Output: Hello World

* append() modifies the content of the original object, and no new object is created.

**🧪 Key Features of StringBuilder**

| **Feature** | **Description** |
| --- | --- |
| ✅ Mutable | Can modify content without creating new objects |
| ⚡ Performance | **Faster** than StringBuffer (no synchronization) |
| 🛠️ Thread-safety | **Not synchronized**, hence not thread-safe |
| 📏 Dynamic length | Resizable — automatically grows as needed |

**🛠️ Common Methods in StringBuilder**

StringBuilder sb = new StringBuilder("Java");

// Append new text

sb.append(" Rocks");

// Insert text at a specified index

sb.insert(4, " Programming");

// Replace text in the specified range

sb.replace(0, 4, "Python");

// Delete text from a specified range

sb.delete(0, 6);

// Reverse the string

sb.reverse();

System.out.println(sb); // Output: Python Rocks

* StringBuilder is ideal for frequent modifications, such as **concatenation**, **insertion**, and **reversals**.

**✅ When to use StringBuilder?**

* Use **StringBuilder** when:
  + You need a **mutable string**.
  + The **performance** of string operations is a concern (since StringBuilder is faster).
  + You're working in a **single-threaded** environment.
* Avoid StringBuilder in multi-threaded contexts where multiple threads may need to access the same object, as it is **not thread-safe**.

**📈 Performance Comparison: String, StringBuffer, and StringBuilder**

* **String**: Immutable, creates a new object on every change — good for constant data.
* **StringBuffer**: Thread-safe but **slower** due to synchronization.
* **StringBuilder**: **Faster** than StringBuffer but not thread-safe — ideal for single-threaded use cases.

**✅ Summary**

* StringBuilder = **mutable + thread-unsafe** string manipulation.
* **Best choice for performance** in **single-threaded** environments.
* Choose StringBuilder when you need to frequently **modify strings** and do not need thread safety.

### **Difference between String, StringBuffer and StringBuilder?**

| **Feature** | **String** | **StringBuffer** | **StringBuilder** |
| --- | --- | --- | --- |
| Mutable | ❌ No | ✅ Yes | ✅ Yes |
| Thread Safe | ✅ Yes | ✅ Yes | ❌ No |
| Performance | 🐢 Slow | 🐌 Moderate | 🏎️ Fastest |
| Synchronized | ❌ No | ✅ Yes | ❌ No |
| Use Case | Constant Data | Multi-threaded | Single-threaded |
| Memory Efficient? | ✅ If constant | ❌ More overhead | ✅ More efficient |

**Example Comparison:**

// String (Immutable)

String str = "Java";

str.concat(" World");

System.out.println(str); // Java

// StringBuffer (Mutable + Thread-safe)

StringBuffer sb = new StringBuffer("Java");

sb.append(" World");

System.out.println(sb); // Java World

// StringBuilder (Mutable + Not thread-safe)

StringBuilder sb2 = new StringBuilder("Java");

sb2.append(" World");

System.out.println(sb2); // Java World

### **Difference between comparable and comparator?**

| **Feature** | **Comparable** | **Comparator** |
| --- | --- | --- |
| **Package** | java.lang | java.util |
| **Purpose** | Defines **natural ordering** of objects | Defines **custom ordering** of objects |
| **Interface method** | int compareTo(T o) | int compare(T o1, T o2) |
| **Implemented by** | The class whose objects are being compared | Separate class (or anonymous class / lambda) |
| **Affects original class?** | Yes, class must implement Comparable | No, keeps original class unchanged |
| **Used in** | Collections.sort(list) (no comparator) | Collections.sort(list, comparator) |
| **Java 8+ usage** | Can use lambda indirectly through compareTo() | Often used with lambda expressions |

**Example:**

**Using Comparable:**

class Student implements Comparable<Student> {

int id;

String name;

public int compareTo(Student s) {

return this.id - s.id; // Natural order by id

}

}

**Using Comparator:**

class NameComparator implements Comparator<Student> {

public int compare(Student s1, Student s2) {

return s1.name.compareTo(s2.name); // Custom order by name

}

}

Java 8+ Lambda Comparator:

Comparator<Student> nameComparator = (s1, s2) -> s1.name.compareTo(s2.name);

Collections.sort(studentList, nameComparator);

### **What is static in java?**

* **Static** is a modifier that can be applied to variables, methods, blocks, and nested classes.

**Static Variable (Class Variable):**

* Belongs to the class rather than any object
* Shared by all instances of the class
* Initialized when class is loaded

class Counter {

static int count = 0; // static variable

Counter() {

count++;

}

}

**Static Method:**

* Belongs to the class rather than instances
* Can be called without creating an object
* Can only access static members directly

class MathUtils {

static int add(int a, int b) { // static method

return a + b;

}

}

// Usage: MathUtils.add(5, 3);

**Static Block:**

* Used for static initialization of a class
* Executed when the class is loaded

class MyClass {

static {

System.out.println("Static block executed");

}

}

**Example Combining Both:**

abstract class Database {

static final String DEFAULT\_URL = "jdbc:default"; // static constant

abstract void connect(); // abstract method

static void printDefaultUrl() { // static method

System.out.println(DEFAULT\_URL);

}

}



**Note:**

Static members are resolved at compile-time (early binding), while abstract methods enable runtime polymorphism (late binding).

### **Explain Generics? What is the use of Generics?**

* **Generics** in Java enable you to write **type-safe and reusable code**. They allow you to define classes, interfaces, and methods with **type parameters**, so you can work with any object type while maintaining compile-time type checking.

🧠 **Why Use Generics?**

| **Feature** | **Benefit** |
| --- | --- |
| **Type Safety** | Catches type errors at compile time. No ClassCastException at runtime. |
| **Code Reusability** | Write a single class/method for any data type. |
| **Readability & Maintainability** | Avoids unnecessary casting and makes the code easier to read. |
| **Performance** | Eliminates need for boxing/unboxing (with collections). |

📌 **Example Without Generics (Old Java Style):**

List names = new ArrayList();

names.add("Alice");

String name = (String) names.get(0); // Manual cast

📌 **Example With Generics:**

List<String> names = new ArrayList<>();

names.add("Alice");

String name = names.get(0); // No cast needed

💡 **Generic Class Example:**

class Box<T> {

private T item;

public void set(T item) {

this.item = item;

}

public T get() {

return item;

}

}

**Usage:**

Box<String> stringBox = new Box<>();

stringBox.set("Hello");

System.out.println(stringBox.get());

🔄 **Generic Method Example:**

public <T> void printArray(T[] array) {

for (T element : array) {

System.out.println(element);

}

}

🧱 **Bounded Generics:**

class Calculator<T extends Number> {

public double square(T num) {

return num.doubleValue() \* num.doubleValue();

}

}

🎯 **Common Use in Collections:**

Map<String, List<Integer>> studentMarks = new HashMap<>();

### **What is Singleton in java?**

* A **Singleton** is a **design pattern** that ensures **only one instance** of a class exists throughout the application and provides a **global access point** to that instance.

It’s commonly used for things like:

* Configuration classes
* Logger classes
* Database connections
* Caching mechanisms

**✅ Key Characteristics:**

1. **Private constructor** – so no other class can instantiate it.
2. **Static instance** – holds the single instance.
3. **Public static method** – provides access to the instance.

**🔧 Basic Singleton Implementation (Lazy Initialization):**

public class MySingleton {

private static MySingleton instance;

private MySingleton() {

// private constructor

}

public static MySingleton getInstance() {

if (instance == null) {

instance = new MySingleton();

}

return instance;

}

}

**🔐 Thread-Safe Singleton (Synchronized Method):**

public class MySingleton {

private static MySingleton instance;

private MySingleton() {}

public static synchronized MySingleton getInstance() {

if (instance == null) {

instance = new MySingleton();

}

return instance;

}

}

**⚡ Best Practice: Bill Pugh Singleton (Thread-safe & Lazy without synchronization overhead):**

public class MySingleton {

private MySingleton() {}

private static class Holder {

private static final MySingleton INSTANCE = new MySingleton();

}

public static MySingleton getInstance() {

return Holder.INSTANCE;

}

}

**🚀 Singleton with Enum (Recommended for simplicity & thread safety):**

public enum MySingleton {

INSTANCE;

public void doSomething() {

System.out.println("Singleton doing work...");

}

}

**Usage:**

MySingleton.INSTANCE.doSomething();

### **Consider we have Strings as String s1 = “Welcome”, String s2 = “Welcome” and String s3 = “WelcomeOne”. What does s1==s2 represent?**

* s1 == s2 in Java compares references, not content.

🔍 **Given:**

String s1 = "Welcome";

String s2 = "Welcome";

String s3 = "WelcomeOne";

✅ s1 == s2 → true ✅

Why? Because:

"Welcome" is a String literal.

String literals are stored in the String Pool (a part of the heap).

Java optimizes memory by reusing string literals from the pool.

So both s1 and s2 point to the same memory location in the pool.

🧠 What about s1.equals(s2)?

This checks content.

Also returns true, because "Welcome".equals("Welcome").

❌ == is false if:

String s1 = new String("Welcome");

String s2 = "Welcome";

System.out.println(s1 == s2); // false (different memory locations)

System.out.println(s1.equals(s2)); // true (same content)

🎯 **Summary:**

| **Comparison** | **Meaning** | **Result** |
| --- | --- | --- |
| s1 == s2 | Reference equality | ✅ true (same pool object) |
| s1.equals(s2) | Content equality | ✅ true (same content) |

### **Explain String constant pool?**

* The **String Constant Pool** (aka **String Intern Pool**) is a special memory area inside the **heap** where **Java stores all string literals** to optimize memory usage.

**✅ How it works:**

When you do:

String s1 = "Java";

String s2 = "Java";

"Java" is stored only once in the String pool.

Both s1 and s2 will point to the same memory reference.

So:

s1 == s2 // true (same object)

s1.equals(s2) // true (same content)

**📦 Where is the pool stored?**

**In heap memory**, but **separately managed**.

Pre-Java 7: Stored in the **PermGen** space.

Java 7+: Moved to the **heap space** (more flexible).

**🚫 When a new String is created with new:**

String s1 = new String("Java");

String s2 = "Java";

s1 is a new object in the heap (outside the pool).

s2 is from the pool.

So s1 == s2 → ❌ false, but s1.equals(s2) → ✅ true

**🧵 How to manually put strings into the pool?**

**Use intern():**

String s1 = new String("Hello").intern();

String s2 = "Hello";

System.out.println(s1 == s2); // true

**✅ Benefits of String Pool:**

* **Memory efficiency**: Avoids duplicate string literals.
* **Performance boost**: Comparisons with == are faster than .equals().

**⚠️ Important Notes:**

* Only string literals are automatically pooled.
* String pool is managed by the **JVM** — no need for manual cleanup.

### **What is the difference between equals() and hashCode() method?**

| **Feature** | **equals()** | **hashCode()** |
| --- | --- | --- |
| Purpose | Compares contents of two objects | Returns an integer hash code for the object |
| Defined in | java.lang.Object | java.lang.Object |
| Return type | boolean | int |
| Usage | Used to check logical equality | Used in hash-based collections like HashMap, HashSet, Hashtable |
| Must override together? | ✅ Yes – if you override one, override the other | ✅ Yes – to maintain contract |

🧠 **Example:**

class Person {

String name;

int age;

// Override equals()

@Override

public boolean equals(Object obj) {

if (this == obj) return true;

if (obj == null || getClass() != obj.getClass()) return false;

Person p = (Person) obj;

return age == p.age && name.equals(p.name);

}

// Override hashCode()

@Override

public int hashCode() {

return Objects.hash(name, age); // Java 7+ utility

}

}

🚨 **Contract between equals() and hashCode():**

* If two objects are equal (equals() returns true), then their hashCode() must be the same.
* If hashCode() is different, equals() must return false.
* If hashCode() is the same, equals() may still return false (hash collision).

✅ **Used in Collections:**

Map<Person, String> map = new HashMap<>();

* hashCode() is used to locate the bucket
* equals() is used to find the correct key in the bucket

💥 **If You Only Override equals() but Not hashCode():**

Hash-based collections won’t work properly – e.g., duplicate keys may be stored.

### **Does Java support Pointers?**

* **No**, Java does not support pointers like C or C++ does.

**Why?**

Java was designed with the goal of:

* Safety
* Simplicity
* Platform-independence

Allowing raw memory access through pointers (like in C/C++) can:

* Lead to security vulnerabilities
* Cause memory corruption
* Make garbage collection impossible

✅ **What Java does instead:**

| Feature | Java's Alternative |
| --- | --- |
| Pointers | References (object handles, no direct memory access) |
| Manual memory management | Automatic Garbage Collection |
| Pointer arithmetic | ❌ Not allowed at all |

**Example:**

String s = "Hello";

Here, s holds a reference to a String object in memory (not a pointer you can manipulate).

You can’t get its address or do pointer math like s++.

🧠 **So What's the Difference?**

| **Concept** | **Pointers (C/C++)** | **References (Java)** |
| --- | --- | --- |
| Memory Access | Direct | Indirect (no control) |
| Arithmetic | Allowed | ❌ Not allowed |
| Null Safety | Risk of Segfault | NullPointerException (still safer) |
| Use Cases | System-level programming | Application-level programming |

🔐 **JVM Handles the Memory:**

Java manages memory behind the scenes using the JVM and Garbage Collector, freeing developers from manual memory management.

### **Why doesn't java support pointers?**

1**. 🔐 Security**

* Pointers allow direct memory access.
* This can lead to:
  + Buffer overflows
  + Memory leaks
  + Unauthorized memory access
* By hiding pointers, Java prevents low-level memory manipulation and increases application security.

2. 🧼 **Simplicity**

* Java was designed to be simple and easy to use.
* Pointers can be hard to understand and error-prone, especially for beginners (e.g., pointer arithmetic, null pointer dereferencing).
* Removing pointers removes a major source of bugs.

3. **🧹 Garbage Collection**

* Java uses automatic garbage collection.
* If raw pointers were allowed, it would confuse or break the garbage collector, which tracks objects using internal references.
* Pointers would let developers manipulate memory outside the GC’s knowledge, making safe memory management impossible.

4. 🧠 **Avoids Manual Memory Management**

* In languages like C/C++, you need to malloc/free memory manually.
* Java automates memory allocation/deallocation, making code less error-prone and more maintainable.

✅ **What Java Uses Instead?**

* References — like pointers, but:
  + No direct access to memory addresses
  + No pointer arithmetic
  + Managed and tracked by the JVM

### **Explain which language you prefer in terms of security among C, C++, Java and Python?**

* Each of these languages has its own strengths and weaknesses when it comes to **security**, and the level of security often depends on how the developer writes the code. However, I can break down the **security aspects** for each language to help you understand which one is inherently more secure.

**🏆 1. Java:**

**Security Strengths:**

**Memory Management**: Java uses **automatic garbage collection**, which helps avoid memory leaks and dangling pointers.

**No Pointers**: Java doesn’t support pointers, which prevents **buffer overflows**, **dangling pointer issues**, and **memory corruption**.

**Exception Handling**: Java has a built-in **robust exception handling system** that helps catch and manage runtime errors, making it safer.

**Bytecode**: Java runs on the **JVM** and uses **bytecode**, which makes it platform-independent and reduces the risk of platform-specific vulnerabilities.

**Security Manager**: The **Java Security Manager** restricts what operations code can perform (e.g., file access, network access) to prevent unauthorized actions.

**Strong Typing**: Java is **strongly typed**, so **type-related errors** are caught at compile-time.

**Security Weaknesses:**

**Java Libraries**: The security of a Java application can be compromised if third-party libraries are vulnerable (e.g., outdated versions of libraries).

**Deserialization Issues**: Older or improperly implemented code may be vulnerable to **Java deserialization attacks**, where malicious data is processed by the application.

**🛡️ 2. Python:**

**Security Strengths:**

**High-Level Language**: Python abstracts away low-level details like memory management, which reduces the risk of memory-related vulnerabilities like buffer overflows.

**Garbage Collection**: Like Java, Python has **automatic memory management** through garbage collection.

**Readability**: Python's **readable syntax** helps developers write secure code by reducing the likelihood of mistakes.

**Dynamic Typing**: Python is dynamically typed, which can reduce errors in the development process when used carefully.

**Security Weaknesses:**

**Dynamic Typing**: The lack of compile-time type checking means that **type-related bugs** (such as passing incorrect arguments to functions) are only caught at runtime.

**Security Libraries**: Python has security issues related to **unsafe libraries** (e.g., using insecure functions for handling user input or file handling).

**Interpreted Language**: Because Python is interpreted, malicious code can be more easily injected and executed without needing to go through a compilation phase.

**⚠️ 3. C/C++:**

**Security Strengths:**

**Control Over System Resources**: C and C++ give developers more control over system resources like memory and CPU, allowing for optimization.

**Used in High-Security Systems**: These languages are often used in **security-critical applications**, like operating systems, firewalls, and cryptography libraries, where developers must be mindful of security.

**Security Weaknesses:**

**Memory Management**: C and C++ require **manual memory management** (malloc, free), which is prone to **memory leaks**, **buffer overflows**, and **dangling pointers**.

**Pointer Arithmetic**: Pointers and pointer arithmetic make **buffer overflow** attacks more likely, which can lead to arbitrary code execution or access violations.

**No Built-in Protection**: C/C++ provides minimal **runtime checks** for errors like out-of-bounds access or null pointer dereferencing, which can result in undefined behavior and security vulnerabilities.

**Complexity**: Low-level operations and manual memory management can lead to human error, introducing bugs that compromise security.

**⚔️ 4. C++ (Compared to C):**

C++ inherits most of the security risks of C, but it adds some additional features like **object-oriented programming**, **RAII (Resource Acquisition Is Initialization)**, and **exceptions** for better error handling.

**C++'s extra features** can potentially help reduce some security risks, but C++ still requires **manual memory management** and **pointer arithmetic**, making it still prone to security vulnerabilities like C.

**🔑 Which Language is More Secure?**

**Java** is the most secure of the four languages, primarily because:

It doesn’t have **pointers**, avoiding many low-level vulnerabilities (e.g., **buffer overflows**, **memory corruption**).

It provides **automatic memory management** and **runtime security checks**.

It has the **Java Security Manager** and runs in a **sandboxed environment** which limits the potential for security breaches.

**📊 Security Ranking (Most to Least Secure):**

**Java** — Safest due to lack of pointers, garbage collection, and a robust security model.

**Python** — Generally safe with its high-level abstraction and garbage collection, but dynamic typing can cause runtime issues.

**C++** — Adds some security improvements over C (like exceptions and RAII), but still inherits the risk of **manual memory management** and **pointer manipulation**.

**C** — Least secure due to **manual memory management**, **pointer arithmetic**, and lack of built-in error checking, which makes it prone to **security vulnerabilities**.

### **Is Java 100% object oriented?**

* No, Java is not 100% object-oriented. However, it is primarily object-oriented, with a few exceptions.

**Why Java is Considered Object-Oriented:**

Java is designed with Object-Oriented Programming (OOP) principles at its core. Key features of OOP in Java include:

Encapsulation: Wrapping data and methods together into a class.

Inheritance: One class can inherit the properties and behaviors of another.

Polymorphism: Objects can take on many forms through method overriding or interfaces.

Abstraction: Hiding complex implementation details and showing only the necessary features of objects.

**Why Java is Not 100% Object-Oriented:**

**Primitive Data Types:**

* Java has primitive data types like int, char, float, double, boolean, etc.
* These primitives are not objects, meaning they don’t have methods or properties, unlike objects in Java.

**Example:**

int x = 10; // Primitive type

Integer y = new Integer(10); // Object type (Wrapper class)

* While Java provides wrapper classes like Integer, Character, etc., to "wrap" primitive types into objects, the primitives themselves are not object-oriented.

**Static Methods and Variables:**

* Java allows static methods and static variables that belong to the class rather than an instance of the class.
* Static methods are not tied to object instances and do not operate on object data.

**Example:**

public class MyClass {

static int count = 0;

static void incrementCount() {

count++;

}

}

Since static members are not associated with an object, they do not adhere strictly to OOP principles.

**Constructors:**

* Java’s constructor mechanism doesn’t completely follow OOP, as constructors are not considered methods but are used to initialize objects.
* They are used in a special way to create objects, but they aren't true methods of the object.

**Summary:**

* Java is mostly object-oriented but not 100% object-oriented.
* Java’s primitive types and static methods break the pure OOP paradigm.
* Despite these exceptions, Java is still widely considered an object-oriented language due to its class-based structure and focus on objects.

**Key Takeaway:**

Java is 99% object-oriented, but its inclusion of primitive types and static members means it’s not purely object-oriented like some other languages (e.g., Smalltalk, which has no primitives).

### **How can we make java 100% object oriented?**

* To make Java **100% object-oriented**, you would need to address the aspects that break from pure object-oriented principles. Here’s what you'd need to change:

**1. Eliminate Primitive Data Types**

In a purely object-oriented language, there are no primitive types like int, float, char, etc. Every type, including basic data types, must be an object.

**Solution:**

In pure object-oriented languages like **Smalltalk**, everything is an object, including numbers and characters.

In Java, this can be achieved by using **wrapper classes** for primitives:

int becomes Integer

char becomes Character

double becomes Double

This would involve **boxing** and **unboxing** for converting between primitives and objects, which can be inefficient.

**Example:**

Integer x = new Integer(10); // Instead of using primitive int

Character c = new Character('A'); // Instead of char

However, Java uses **autoboxing** and **unboxing** to automatically convert primitives to wrapper classes and vice versa, but to fully embrace OOP, everything would be manually boxed as objects.

**2. Remove Static Methods and Variables**

In Java, **static** members (variables and methods) are tied to the **class**, not the instance, which breaks the OOP principle of everything being an object.

**Solution:**

You would need to remove static methods and variables altogether.

Instead of using static methods, you would need to call methods on **objects** (instances of classes).

**Example:**

Instead of this:

class MyClass {

static int count = 0;

static void incrementCount() {

count++;

}

}

You would need to remove the static keyword:

class MyClass {

int count = 0;

void incrementCount() {

count++;

}

}

In this case, every **operation** would need an **instance** of MyClass.

**3. Treat Constructors as Objects**

In Java, constructors are special methods used to initialize objects, but they are not technically methods.

**Solution:**

To make Java 100% object-oriented, you could treat **constructors as objects**. However, this isn’t possible in the current version of Java, as constructors are a part of the language syntax.

You’d need to shift to a language where even the construction of objects is treated as an operation on an object (like in **Smalltalk**), where everything is an object.

**4. Remove the null Keyword**

The null keyword represents the **absence of an object** in Java, which means Java’s design recognizes the concept of "nothing," breaking the idea that **everything is an object**.

**Solution:**

Remove the concept of null, meaning that every object must be instantiated before it can be used. This is a theoretical idea that could make Java more object-oriented, but it would also increase complexity and have practical implications for memory management.

**Summary of Changes to Make Java 100% Object-Oriented:**

**Eliminate Primitive Data Types**: Use only objects, no primitives (int, float, etc.), replacing them with their wrapper classes.

**Remove Static Members**: All methods and variables would have to be instance-level members, with no static context.

**Treat Constructors as Objects**: In a truly object-oriented world, even object creation (constructors) would be handled in an object-like manner.

**Remove null**: Every variable must always refer to a valid object, and null would be eliminated.

**Realistic Consideration:**

While making Java fully object-oriented would be an interesting exercise in OOP purity, it would introduce significant **performance overheads** due to:

**Autoboxing** and **unboxing** for primitives

The need for managing more objects (even simple integers or booleans)

Complexity in the language's design, potentially making it less efficient.

### **Can we create objects of static class?**

* In Java, a **static class** typically refers to a **nested static class** (i.e., a class declared as static inside another class). The **static** keyword can be used with a nested class, but it has certain implications on object creation and behavior.

**Understanding Static Classes:**

**Static Nested Class**:

A **nested static class** is a class that is **declared static** inside another class.

It **does not** have a reference to the outer class’s instance, meaning it can exist independently of the outer class’s instance.

You can **create an object** of a static nested class without needing an instance of the outer class.

**Static Inner Class**:

A **static inner class** can be instantiated without needing the outer class’s instance, because it is not tied to an instance of the enclosing class.

**Can We Create Objects of a Static Nested Class?**

Yes, **you can create objects of a static class** (nested static class) in Java. Since a static nested class is **independent of the outer class instance**, it can be instantiated directly using the **class name**.

**Example of Static Nested Class:**

class OuterClass {

static class StaticNestedClass {

void display() {

System.out.println("Inside static nested class");

}

}

public static void main(String[] args) {

// Create an object of the static nested class without an instance of OuterClass

OuterClass.StaticNestedClass nestedObj = new OuterClass.StaticNestedClass();

nestedObj.display(); // Outputs: Inside static nested class

}

}

**In this example:**

StaticNestedClass is a **static nested class** inside OuterClass.

You can create an instance of StaticNestedClass **without** creating an instance of OuterClass.

**Static vs. Non-Static Inner Class:**

**Static Nested Class**:

Can be instantiated without an instance of the outer class.

Can access only **static members** of the outer class.

**Non-Static Inner Class**:

Requires an instance of the outer class to create an object of the inner class.

Can access both **instance and static members** of the outer class.

**Example of Non-Static Inner Class:**

class OuterClass {

class InnerClass {

void display() {

System.out.println("Inside non-static inner class");

}

}

public static void main(String[] args) {

// You need an instance of OuterClass to create an instance of the inner class

OuterClass outer = new OuterClass();

OuterClass.InnerClass innerObj = outer.new InnerClass();

innerObj.display(); // Outputs: Inside non-static inner class

}

}

**In this example:**

InnerClass is a **non-static inner class**.

To create an instance of InnerClass, you need to first create an instance of the outer class OuterClass.

**Summary:**

**Yes**, you can create objects of a static nested class without creating an instance of the outer class.

A **static nested class** is independent of the outer class’s instance, whereas a **non-static inner class** requires an instance of the outer class.

### **Which compiler is used by Java?**

* Java uses the **Java Compiler** called **javac** to compile Java source code. Here's how the process works:

1. **Source Code**: You write your Java code in .java files.
2. **Compiling with javac**:
   * The javac compiler takes the .java file and compiles it into bytecode, which is platform-independent and stored in a .class file.
   * The bytecode is generated as an intermediate representation of the code, which can then be executed by the Java Virtual Machine (JVM) on any platform.
3. **Execution with java**:
   * After compilation, the bytecode is executed by the JVM using the java command.

**Process:**

* **Step 1**: Write Java code (e.g., HelloWorld.java).
* **Step 2**: Compile the Java code using the javac command:

javac HelloWorld.java

This produces a HelloWorld.class file.

* **Step 3**: Run the compiled bytecode with the JVM:

java HelloWorld

The Java compiler javac is part of the **Java Development Kit (JDK)**, and it is used to compile Java source files into bytecode for execution on the JVM.

### **Where are the hashCode() and equals() methods defined in java?**

* In Java, the hashCode() and equals() methods are defined in the **Object class**.

**1. hashCode() Method:**

* The hashCode() method is defined in the Object class.
* It is used to return an integer value that represents the memory address of the object. The hash code is primarily used in hash-based collections like HashMap, HashSet, and Hashtable to organize objects in buckets for efficient retrieval.
* When objects are stored in a hash-based collection, the hash code is used to determine the bucket where the object will be placed.

**Method signature**:

public int hashCode()

**2. equals() Method:**

* The equals() method is also defined in the Object class.
* It is used to compare two objects for equality. By default, the equals() method in the Object class compares object references (i.e., checks if two references point to the same object in memory).
* However, it is commonly overridden in custom classes to compare the content or state of the objects instead of their references.

**Method signature**:

public boolean equals(Object obj)

**Default Behavior:**

* **hashCode()**: The default implementation of hashCode() in the Object class typically returns a unique integer for each object, which is based on the memory address of the object.
* **equals()**: The default implementation of equals() in the Object class checks for reference equality (i.e., if both references point to the same object).

**Overriding hashCode() and equals():**

In practice, when you override the equals() method in a class, it is recommended to also override the hashCode() method to maintain the general contract between these two methods. The contract states:

* If two objects are equal according to the equals() method, they must have the same hash code.
* If two objects have different hash codes, they are considered unequal.

**Example:**

Here is an example of how hashCode() and equals() are typically overridden in a custom class:

import java.util.Objects;

class Person {

private String name;

private int age;

public Person(String name, int age) {

this.name = name;

this.age = age;

}

@Override

public boolean equals(Object obj) {

if (this == obj) return true; // Check if the same object

if (obj == null || getClass() != obj.getClass()) return false;

Person person = (Person) obj;

return age == person.age && Objects.equals(name, person.name);

}

@Override

public int hashCode() {

return Objects.hash(name, age); // Generate hash code based on fields

}

}

public class Main {

public static void main(String[] args) {

Person p1 = new Person("Alice", 25);

Person p2 = new Person("Alice", 25);

System.out.println(p1.equals(p2)); // true

System.out.println(p1.hashCode() == p2.hashCode()); // true

}

}

In this example, the equals() method compares the name and age fields, and hashCode() generates a hash code based on these fields using Objects.hash().

### **How many design patterns are present in java?**

* Java supports **23 design patterns** that are part of the **Gang of Four (GoF) design patterns**, as described in the book *"Design Patterns: Elements of Reusable Object-Oriented Software"* by Erich Gamma, Richard Helm, Ralph Johnson, and John Vlissides. These patterns are categorized into three types:

**1. Creational Patterns (5 patterns)**

These patterns deal with object creation mechanisms, trying to create objects in a manner suitable to the situation.

* **Singleton**: Ensures a class has only one instance and provides a global point of access to it.
* **Factory Method**: Defines an interface for creating objects, but allows subclasses to alter the type of objects that will be created.
* **Abstract Factory**: Provides an interface for creating families of related or dependent objects without specifying their concrete classes.
* **Builder**: Allows the construction of complex objects by specifying their type and content step by step.
* **Prototype**: Specifies the kind of objects to create using a prototypical instance and creates new objects by copying this prototype.

**2. Structural Patterns (7 patterns)**

These patterns deal with object composition, helping to form large structures while keeping them flexible and efficient.

* **Adapter**: Allows incompatible interfaces to work together by converting one interface to another.
* **Bridge**: Decouples abstraction from implementation so that the two can vary independently.
* **Composite**: Composes objects into tree-like structures to represent part-whole hierarchies.
* **Decorator**: Allows you to add new functionality to an object dynamically without altering its structure.
* **Facade**: Provides a simplified interface to a complex system of classes.
* **Flyweight**: Reduces the cost of creating and manipulating a large number of similar objects by sharing common data.
* **Proxy**: Provides a surrogate or placeholder for another object to control access to it.

**3. Behavioral Patterns (11 patterns)**

These patterns deal with object interaction, how objects communicate with each other, and how responsibilities are assigned.

* **Chain of Responsibility**: Allows passing a request along a chain of handlers, with each handler either processing the request or passing it along to the next handler.
* **Command**: Encapsulates a request as an object, thereby allowing for parameterization of clients with different requests.
* **Interpreter**: Defines a grammatical representation for a language and provides an interpreter to evaluate sentences in the language.
* **Iterator**: Provides a way to access elements of an aggregate object sequentially without exposing its underlying representation.
* **Mediator**: Defines an object that coordinates interaction between a group of objects to reduce coupling between them.
* **Memento**: Allows capturing and externalizing an object's internal state so that it can be restored later.
* **Observer**: Allows a subject to notify observers about changes to its state, facilitating a publish-subscribe model.
* **State**: Allows an object to alter its behavior when its internal state changes.
* **Strategy**: Defines a family of algorithms, encapsulates each one, and makes them interchangeable.
* **Template Method**: Defines the structure of an algorithm in the superclass, allowing subclasses to implement specific steps of the algorithm.
* **Visitor**: Allows adding further operations to objects without having to modify them.

**Summary of GoF Design Patterns:**

* **Creational Patterns**: 5 patterns
* **Structural Patterns**: 7 patterns
* **Behavioral Patterns**: 11 patterns

Thus, **23 design patterns** are commonly recognized in Java and object-oriented design.

**Note**: These patterns are a guideline for solving common design problems. Some might be more applicable in certain scenarios, and not all of them are always needed in every application.

### **Can we override the static method?**

* In Java, **static methods cannot be overridden** in the traditional sense. However, they can be **hidden** by defining a static method with the same signature in a subclass.

**Key Points:**

1. **Method Hiding**: If a subclass defines a static method with the same name and signature as a static method in the parent class, it doesn't override the parent class's method, but it hides it. This is called **method hiding**.
2. **Static Binding**: Static methods are bound at compile-time, not runtime. This means that the method that gets called is determined at compile-time based on the reference type, not the object type.
3. **Polymorphism**: Static methods do not participate in runtime polymorphism because they are resolved during compile-time.

**Example:**

class Parent {

public static void display() {

System.out.println("Static method in Parent class");

}

}

class Child extends Parent {

// This is method hiding, not overriding.

public static void display() {

System.out.println("Static method in Child class");

}

}

public class Test {

public static void main(String[] args) {

Parent p = new Parent();

Parent c = new Child();

// Calling using Parent reference

p.display(); // Outputs: Static method in Parent class

c.display(); // Outputs: Static method in Parent class (not the Child class)

}

}

**Explanation:**

* When display() is called using the reference Parent p = new Parent();, the method from the Parent class is called.
* When display() is called using the reference Parent c = new Child();, the method from the Parent class is still called, even though the actual object is of type Child. This is because static methods are resolved based on the reference type, not the actual object type.

**Conclusion:**

* **No overriding**: Static methods cannot be overridden in the way instance methods can. They can be hidden by defining a static method with the same signature in the subclass.
* **Static binding**: The method call is resolved at compile-time, which is why the reference type determines which method gets called, not the actual object type.

### **Explain access modifiers in java?**

* In Java, **access modifiers** are keywords used to specify the visibility or accessibility of classes, methods, constructors, and variables. They determine the scope of access to these members from other classes. There are four types of access modifiers in Java:

**1. Public (public)**

* **Visibility**: The public modifier makes the class, method, constructor, or variable accessible from any other class, regardless of whether it is in the same package or a different package.
* **Usage**: It provides the least restrictive level of access.

**Example:**

public class MyClass {

public int x;

public void myMethod() {

System.out.println("Public Method");

}

}

* Here, the class MyClass, the variable x, and the method myMethod can be accessed from anywhere.

**2. Private (private)**

* **Visibility**: The private modifier restricts access to the class, method, constructor, or variable only within the class it is declared. It is the most restrictive access modifier.
* **Usage**: This is used to hide data from other classes and restrict direct access to it, typically for variables and methods that should not be accessed outside the class.

**Example:**

public class MyClass {

private int x;

private void myMethod() {

System.out.println("Private Method");

}

}

* Here, x and myMethod can only be accessed from within the MyClass class.

**3. Protected (protected)**

* **Visibility**: The protected modifier allows access to the member from:
  + The same class.
  + Any subclass (even if it is in a different package).
  + Other classes in the same package.
* **Usage**: It is typically used when you want to allow subclass access while keeping it hidden from other classes.

**Example:**

public class MyClass {

protected int x;

protected void myMethod() {

System.out.println("Protected Method");

}

}

* Here, x and myMethod can be accessed from within the same package or from subclasses (even if they are in different packages).

**4. Default (Package-Private)**

* **Visibility**: When no access modifier is specified, it is considered the **default access level**. This means the member is accessible only within the same package and not from classes outside the package.
* **Usage**: It is used when you want to restrict access to members within the same package, but do not want to explicitly define the access level.

**Example:**

public class MyClass {

int x; // Default access modifier

void myMethod() {

System.out.println("Default Method");

}

}

* Here, x and myMethod can only be accessed by classes in the same package.

**Summary Table:**

| **Access Modifier** | **Same Class** | **Same Package** | **Subclass (Same Package)** | **Subclass (Different Package)** | **Other Classes (Different Package)** |
| --- | --- | --- | --- | --- | --- |
| public | Yes | Yes | Yes | Yes | Yes |
| private | Yes | No | No | No | No |
| protected | Yes | Yes | Yes | Yes | No |
| Default | Yes | Yes | Yes | No | No |

**When to Use Each Access Modifier:**

* **Public**: Use it when you want to make the member accessible from anywhere.
* **Private**: Use it to restrict access to the member from outside the class. This is generally used for encapsulating internal details of the class.
* **Protected**: Use it when you want to allow subclasses to access a member, but still want to keep it hidden from other classes.
* **Default**: Use it when you want to restrict access to classes within the same package.

**Example - Usage of All Access Modifiers:**

public class MyClass {

public int publicVar; // Accessible from anywhere

private int privateVar; // Accessible only within this class

protected int protectedVar; // Accessible within the same package and subclasses

int defaultVar; // Accessible only within the same package

public void publicMethod() {

System.out.println("Public method");

}

private void privateMethod() {

System.out.println("Private method");

}

protected void protectedMethod() {

System.out.println("Protected method");

}

void defaultMethod() {

System.out.println("Default method");

}

}

**Conclusion:**

* **Access modifiers** play a crucial role in controlling the visibility of members in Java. Choosing the right modifier helps with **encapsulation** and **data hiding**. It is important to select the appropriate level of access to prevent unauthorized access and maintain the integrity of the program.

### **What is volatile in java? Where can we use it?**

* In Java, the volatile keyword is used to indicate that a variable's value will be modified by multiple threads. A volatile variable in Java ensures that the most up-to-date value of the variable is always visible to all threads.
* **Volatile Variables**: When a variable is declared as volatile, it tells the Java Virtual Machine (JVM) that the value of the variable may be changed by multiple threads and that it should always fetch the latest value from the main memory rather than relying on local thread caches (which might not have the most recent value).
* **Memory Visibility Guarantee**: The volatile keyword provides a guarantee that updates made to a variable by one thread will be visible to all other threads. Without volatile, thread-local caches might prevent changes made by one thread from being visible to other threads.
* **No Caching**: The JVM will not cache the value of a volatile variable in a thread's local memory (i.e., CPU cache). It ensures that each read or write operation is directly performed on the main memory.

**Characteristics of volatile:**

1. **Visibility**: Changes made to a volatile variable by one thread are immediately visible to other threads.
2. **Atomicity**: volatile guarantees **visibility**, but **does not guarantee atomicity**. So, operations like increment (i++) or check-modify (check, modify) are **not atomic** even if the variable is volatile.

**Syntax of volatile:**

volatile int myVariable;

**How does volatile work?**

When a variable is declared as volatile, the JVM ensures that:

1. When a thread writes to the volatile variable, the updated value is immediately written to the main memory.
2. When another thread reads the volatile variable, it fetches the most recent value directly from the main memory.

**When to Use volatile?**

volatile is typically used in the following scenarios:

1. **Flag Variables**: When you need to maintain a simple flag or state between multiple threads.
   * For example, you might use a volatile variable to indicate whether a thread should continue running or stop.
2. **Singleton Pattern**: In the **Double-Checked Locking** Singleton design pattern, volatile is often used to ensure that the instance of a class is initialized correctly in a multithreaded environment.
3. **Shared State Across Threads**: When a variable is shared between threads and you want to ensure that updates made by one thread are visible to others without using synchronization.

**Example:**

class VolatileExample {

private volatile boolean flag = false;

public void toggleFlag() {

flag = !flag; // toggle the flag

}

public void printFlag() {

System.out.println("Flag: " + flag);

}

public static void main(String[] args) throws InterruptedException {

VolatileExample example = new VolatileExample();

// Thread 1: Toggle the flag

Thread t1 = new Thread(() -> {

example.toggleFlag();

System.out.println("Thread 1 toggled the flag");

});

// Thread 2: Print the flag

Thread t2 = new Thread(() -> {

while (!example.flag) {

// Waiting for the flag to be true

}

example.printFlag(); // Will print "Flag: true" once the flag is toggled

});

t1.start();

t2.start();

t1.join();

t2.join();

}

}

In this example:

* **Thread 2** waits until flag becomes true before printing it.
* **Thread 1** toggles the value of flag.
* The volatile keyword ensures that changes to the flag made by Thread 1 are visible to Thread 2.

**Limitations of volatile:**

* **Atomicity Not Guaranteed**: If you're performing compound operations (e.g., count++), volatile will not guarantee atomicity. You may need other synchronization mechanisms like synchronized or AtomicInteger for those cases.
* **No Synchronization**: It only ensures visibility, but it doesn’t guarantee mutual exclusion or prevent race conditions. For operations that need to be synchronized (such as checks and modifications), you may still need synchronized blocks.

**Comparison with synchronized:**

* **volatile**: It ensures visibility and is lightweight because it doesn't involve acquiring locks. But it doesn't provide atomicity or mutual exclusion.
* **synchronized**: It guarantees both visibility **and** atomicity, but it involves performance overhead due to locking mechanisms.

**Conclusion:**

Use the volatile keyword in Java when:

* You need to ensure that a variable is consistently updated and visible across all threads.
* The variable is shared among multiple threads, and the operations on it are simple (like reading and writing).

For more complex scenarios (where both visibility and atomicity are required), you may want to consider other concurrency utilities like synchronized blocks or Atomic classes in java.util.concurrent.

### **What is an idempotent method in java?**

* An **idempotent method** in programming refers to a method that can be called multiple times with the same input, but the result will be the same, no matter how many times it is executed. In other words, if you call the method multiple times with the same parameters, it will not have any additional side effects after the first call, and the output will be consistent.

**Characteristics of Idempotent Methods:**

1. **Same Output for Same Input**: Calling an idempotent method multiple times with the same input will always produce the same result.
2. **No Additional Side Effects**: The state of the system does not change beyond the first execution, even if the method is called multiple times.

**Example in Java:**

Consider a simple method that updates the name of a user in a database. If the same name is provided multiple times, the result should be the same after the first update.

public class UserService {

private String userName;

// Idempotent method

public void updateUserName(String newName) {

if (userName == null || !userName.equals(newName)) {

userName = newName;

}

}

public String getUserName() {

return userName;

}

public static void main(String[] args) {

UserService service = new UserService();

service.updateUserName("John"); // First call, userName is set to "John"

service.updateUserName("John"); // Second call, no effect, as userName is already "John"

System.out.println(service.getUserName()); // Output: John

}

}

In the above example:

* The updateUserName method is **idempotent** because calling it multiple times with the same argument (in this case, "John") has no effect after the first call.
* If the name is already "John", it won't be updated again, ensuring the state remains consistent regardless of how many times the method is called.

**Idempotency in Web Services:**

In the context of web services (RESTful APIs), idempotency is important. A typical example is **PUT** or **DELETE** requests:

* **PUT** request: If you update the same resource with the same data multiple times, the result should be the same.
* **DELETE** request: Deleting a resource multiple times should not cause errors. Once a resource is deleted, further attempts to delete the same resource should return a successful response, such as a "no content" response, without causing any errors.

**Idempotent Operations in Java:**

Here are a few examples of idempotent operations:

* **Set Operations**: For instance, adding an element to a set where the set already contains that element (e.g., HashSet) is idempotent.
* **Setting the same value**: Assigning a value to a variable that already has that value is an idempotent operation (e.g., setting a = 5 multiple times).
* **Database Operations**: If you are using an UPDATE SQL query where the new value is the same as the old value, the query is idempotent because the database state does not change.

**Idempotency in Java's Concurrency and Distributed Systems:**

Idempotency is also a critical concept in **distributed systems**, where retries may happen due to network failures or timeouts. If the same operation is retried multiple times (like processing a payment or updating a resource), ensuring that the operation is idempotent prevents inconsistent states and duplicate actions.

For example:

* **Idempotent Message Handling**: In message-driven systems, if the same message is processed multiple times due to a failure, the system should ensure that the result is the same and no duplicate actions are taken.

**Conclusion:**

An **idempotent method** is one where repeated invocations with the same parameters do not change the result beyond the initial execution. This concept is essential in ensuring consistency and reliability, especially in distributed systems, web services, and concurrent programming.

### **What is final, static and non-static (instance) in java?**

**final, static, and non-static (instance) in Java**

These are three important keywords in Java, each with different uses and characteristics. Let's break them down one by one.

**1. final in Java**

The final keyword in Java can be used with variables, methods, and classes, and its meaning varies based on where it is applied.

**a) final with Variables**

When you declare a variable as final, its value cannot be changed once it is initialized. It is a **constant**.

Example:

final int MAX\_VALUE = 100;

// MAX\_VALUE = 200; // This will result in a compilation error

In the example above, once MAX\_VALUE is assigned a value, it cannot be modified.

**b) final with Methods**

If a method is declared as final, it cannot be overridden by subclasses.

Example:

class Parent {

public final void display() {

System.out.println("This is a final method.");

}

}

class Child extends Parent {

// The following line will cause a compile-time error:

// public void display() { } // Cannot override the final method from Parent

}

**c) final with Classes**

When a class is declared as final, it cannot be subclassed. This means you cannot extend a final class.

Example:

final class FinalClass {

// class implementation

}

// The following will cause a compile-time error:

// class SubClass extends FinalClass {} // Cannot subclass a final class

**2. static in Java**

The static keyword is used to indicate that a particular member (field, method, or block) belongs to the **class** rather than any instance of the class.

**a) static with Variables**

A static variable is shared among all instances of the class. It is **common to all objects of that class**.

Example:

class Counter {

static int count = 0; // Static variable

public void increment() {

count++; // Static variable can be accessed without creating an instance

}

}

public class Test {

public static void main(String[] args) {

Counter c1 = new Counter();

Counter c2 = new Counter();

c1.increment();

c2.increment();

System.out.println(Counter.count); // Output: 2

}

}

In the example above, both c1 and c2 share the same static variable count.

**b) static with Methods**

A static method can be called without creating an instance of the class. It can access only static variables and other static methods of the class.

Example:

class MathOperations {

static int square(int x) {

return x \* x;

}

}

public class Test {

public static void main(String[] args) {

int result = MathOperations.square(5); // No need to create an instance

System.out.println(result); // Output: 25

}

}

**c) static with Blocks**

A static block is used to initialize static variables. It is executed when the class is loaded into memory.

Example:

class MyClass {

static {

System.out.println("Static block is executed.");

}

public static void main(String[] args) {

// Static block will be executed when the class is loaded.

}

}

Output:

Static block is executed.

**3. Non-Static (Instance) Members in Java**

When we say **non-static**, we are referring to members that are specific to **individual instances** of the class. These members belong to the object (instance) of the class.

**a) Non-Static Variables**

Non-static variables are specific to each instance of a class. Every object created from the class gets its own copy of the instance variables.

Example:

class Person {

String name; // Instance variable

int age; // Instance variable

public Person(String name, int age) {

this.name = name;

this.age = age;

}

}

public class Test {

public static void main(String[] args) {

Person p1 = new Person("John", 25);

Person p2 = new Person("Alice", 30);

System.out.println(p1.name + " - " + p1.age); // Output: John - 25

System.out.println(p2.name + " - " + p2.age); // Output: Alice - 30

}

}

In this example, name and age are non-static (instance) variables, meaning each Person object will have its own set of name and age.

**b) Non-Static Methods**

Non-static methods operate on the instance data (non-static variables) and can only be called by creating an instance of the class.

Example:

class Calculator {

int add(int a, int b) { // Instance method

return a + b;

}

}

public class Test {

public static void main(String[] args) {

Calculator calc = new Calculator();

System.out.println(calc.add(5, 3)); // Output: 8

}

}

**Summary of Differences**

| **Concept** | **final** | **static** | **Non-Static (Instance)** |
| --- | --- | --- | --- |
| **Variables** | Constant; cannot be reassigned. | Shared among all instances of the class. | Specific to each instance of the class. |
| **Methods** | Cannot be overridden. | Belongs to the class itself. | Belongs to an instance of the class. |
| **Classes** | Cannot be subclassed. | N/A | N/A |

**Use Cases:**

* Use **final** when you need to define constants, prevent method overriding, or prevent subclassing.
* Use **static** when you want a method or variable to be shared across all instances of a class, like utility methods or constants.
* Use **non-static (instance)** members when each object should have its own data and behavior.

Each of these keywords plays a crucial role in how objects and classes interact in Java, allowing you to write more efficient, modular, and manageable code.

### **How will I use two threads using a singleton design pattern?**

* In order to use two threads with a **Singleton Design Pattern**, we first need to understand the Singleton pattern and how to apply it with threads.

**Singleton Design Pattern**

The Singleton pattern ensures that a class has only one instance and provides a global point of access to that instance. It is typically used when you want to limit the instantiation of a class to one object and you want to provide a mechanism to access that object globally.

**How to Implement Singleton Design Pattern**

We can implement the Singleton Design Pattern in Java in different ways, but the most common and thread-safe way is to use the **Double-Checked Locking** mechanism with volatile keyword. This ensures that the instance is created only when required, and that it is thread-safe.

**Steps to use Two Threads with Singleton Design Pattern**

1. **Create a Singleton class** with thread-safety.
2. **Create two threads** that access the Singleton instance.

**Example of Singleton Design Pattern with Two Threads**

**Step 1: Singleton Class**

class Singleton {

// 1. Create a private static variable to hold the single instance.

private static volatile Singleton instance;

// 2. Private constructor prevents instantiation from other classes.

private Singleton() {

// Example: Simulate some time-consuming task like DB initialization

try {

Thread.sleep(2000); // Simulating time-consuming process

} catch (InterruptedException e) {

e.printStackTrace();

}

}

// 3. Public method to provide access to the instance.

public static Singleton getInstance() {

// Double-Checked Locking for thread-safety

if (instance == null) {

synchronized (Singleton.class) {

if (instance == null) {

instance = new Singleton();

}

}

}

return instance;

}

// Sample method to show functionality

public void showMessage() {

System.out.println("Hello from Singleton!");

}

}

**Step 2: Threads Accessing Singleton**

class ThreadExample extends Thread {

@Override

public void run() {

// Each thread gets the Singleton instance

Singleton singleton = Singleton.getInstance();

singleton.showMessage();

}

}

public class Main {

public static void main(String[] args) {

// Creating two threads that will access the Singleton

Thread thread1 = new ThreadExample();

Thread thread2 = new ThreadExample();

thread1.start(); // Start the first thread

thread2.start(); // Start the second thread

}

}

**Explanation of the Code:**

1. **Singleton Class:**
   * The Singleton class has a private static volatile instance variable to hold the single instance of the class. The volatile keyword ensures that the instance is created and visible across all threads.
   * The getInstance() method implements **double-checked locking**. First, it checks if the instance is null before entering the synchronized block to minimize synchronization overhead. Inside the synchronized block, it checks again if the instance is still null before creating the instance.
   * The showMessage() method is a sample method to demonstrate functionality.
2. **ThreadExample Class:**
   * The ThreadExample class extends Thread and overrides the run() method. Inside run(), the thread calls Singleton.getInstance() to get the Singleton instance and then calls the showMessage() method to print the message.
3. **Main Class:**
   * In the main() method, two threads (thread1 and thread2) are created and started. Each thread will try to access the Singleton instance.

**Expected Output:**

Hello from Singleton!

Hello from Singleton!

**Thread-Safety Consideration:**

In the above code, the **Singleton** class is thread-safe due to the following reasons:

1. **Double-Checked Locking**: This prevents multiple threads from creating multiple instances of the Singleton.
2. **Volatile Keyword**: This ensures that changes to the instance are visible to all threads.

**How It Works:**

* Initially, both threads attempt to access the Singleton instance. Since the instance is null, both threads will enter the synchronized block.
* The first thread will create the instance of the Singleton, and the second thread will see that the instance is already created (due to the double-checked locking), so it will simply access the existing instance.
* Both threads then print the message using the Singleton instance.

**Time Complexity & Space Complexity:**

* **Time Complexity**: O(1) because the instance is created only once, and subsequent accesses are constant-time operations.
* **Space Complexity**: O(1) because only one instance of the Singleton is created.

**Conclusion:**

By implementing the **Singleton Design Pattern** with thread-safety, you ensure that only one instance of the class is created and shared across all threads. In the example provided, both threads access the same instance and invoke the showMessage() method, demonstrating the proper functioning of the Singleton with multiple threads.

### **How to implement thread safety in java using singleton?**

* Implementing thread safety in Java using the Singleton design pattern ensures that only one instance of the class is created, even when multiple threads are accessing the Singleton instance concurrently. Here are the most common approaches to implementing thread safety for a Singleton class in Java:

**1. Eager Initialization (Thread-Safe by Default)**

In this approach, the Singleton instance is created at the time of class loading, which ensures that the instance is always thread-safe because the class loader guarantees thread safety during initialization.

class Singleton {

// The instance is created eagerly when the class is loaded

private static final Singleton INSTANCE = new Singleton();

// Private constructor prevents instantiation from other classes

private Singleton() {}

// Public method to provide access to the instance

public static Singleton getInstance() {

return INSTANCE;

}

public void showMessage() {

System.out.println("Hello from Singleton!");

}

}

public class Main {

public static void main(String[] args) {

Singleton singleton = Singleton.getInstance();

singleton.showMessage();

}

}

**Explanation:**

* The INSTANCE is created when the class is loaded, ensuring thread-safety.
* No synchronization is required because the instance is initialized when the class is loaded, and the class loader handles this in a thread-safe manner.

**2. Lazy Initialization with Double-Checked Locking (Thread-Safe)**

If you want to create the Singleton instance lazily (only when it's needed), you can use **double-checked locking** to make the getInstance() method thread-safe. This minimizes the overhead of synchronization once the instance is created.

class Singleton {

// Volatile keyword ensures visibility of the instance across all threads

private static volatile Singleton instance;

// Private constructor prevents instantiation from other classes

private Singleton() {}

// Double-Checked Locking to ensure thread safety during lazy initialization

public static Singleton getInstance() {

if (instance == null) {

synchronized (Singleton.class) {

// Second check to avoid creating more than one instance

if (instance == null) {

instance = new Singleton();

}

}

}

return instance;

}

public void showMessage() {

System.out.println("Hello from Singleton!");

}

}

public class Main {

public static void main(String[] args) {

Singleton singleton = Singleton.getInstance();

singleton.showMessage();

}

}

**Explanation:**

* **Volatile** ensures that the instance is visible across all threads, and the instance is not cached by any thread.
* The first check (if (instance == null)) is outside the synchronized block to avoid unnecessary synchronization once the instance is created.
* The second check (if (instance == null)) inside the synchronized block ensures that only one instance is created, even if multiple threads reach this block simultaneously.

**3. Bill Pugh Singleton Design (Recommended Approach)**

The Bill Pugh Singleton Design takes advantage of the **Java class loader mechanism** to ensure thread safety and lazy initialization. This is the most efficient and recommended way to implement a thread-safe Singleton.

class Singleton {

// Inner static class responsible for creating Singleton instance

private static class SingletonHelper {

// The Singleton instance is created when the class is loaded

private static final Singleton INSTANCE = new Singleton();

}

// Private constructor prevents instantiation from other classes

private Singleton() {}

// Public method to provide access to the instance

public static Singleton getInstance() {

return SingletonHelper.INSTANCE;

}

public void showMessage() {

System.out.println("Hello from Singleton!");

}

}

public class Main {

public static void main(String[] args) {

Singleton singleton = Singleton.getInstance();

singleton.showMessage();

}

}

**Explanation:**

* The **inner static class** SingletonHelper contains the Singleton instance. The INSTANCE is created when the class is loaded, and the instance is thread-safe.
* The Singleton instance is initialized lazily, and the class loader ensures that the INSTANCE is created in a thread-safe manner when the class is loaded.

This approach takes advantage of the **Initialization-on-demand holder idiom**, which is efficient and guarantees thread safety without synchronization overhead.

**4. Singleton with Enum (Thread-Safe by Default)**

Using an enum to implement a Singleton is the most robust and thread-safe approach. Java's enum type inherently supports thread safety and guarantees that only one instance of the enum is created.

enum Singleton {

INSTANCE;

// Public method to access the Singleton instance

public void showMessage() {

System.out.println("Hello from Singleton!");

}

}

public class Main {

public static void main(String[] args) {

Singleton singleton = Singleton.INSTANCE;

singleton.showMessage();

}

}

**Explanation:**

* The Singleton enum has a single instance INSTANCE, which is automatically created when the enum class is loaded.
* Enums in Java are thread-safe by default, and this approach handles serialization and reflection issues that may arise with other Singleton implementations.
* This is the simplest and most effective way to implement a Singleton in modern Java.

**Comparison of Approaches:**

1. **Eager Initialization:**
   * **Pros**: Simple and thread-safe.
   * **Cons**: The instance is created even if it is not needed, which could be inefficient in some cases.
2. **Lazy Initialization with Double-Checked Locking:**
   * **Pros**: Thread-safe and instance is created only when needed.
   * **Cons**: More complex, requires the use of volatile keyword, and involves synchronization.
3. **Bill Pugh Singleton Design:**
   * **Pros**: Thread-safe, efficient, and simple. The class loader handles synchronization.
   * **Cons**: Slightly more complex due to the inner static class.
4. **Singleton with Enum:**
   * **Pros**: Most robust and thread-safe. Also handles serialization and reflection issues.
   * **Cons**: Cannot have any constructor other than private, and may not be suitable for certain use cases where the Singleton instance needs to be created dynamically.

**Conclusion:**

The **Bill Pugh Singleton Design** and **Singleton with Enum** are the most efficient and thread-safe ways to implement a Singleton pattern in Java. The **Enum** approach is the simplest and most effective, while the **Bill Pugh** design is highly recommended for lazy initialization and thread safety. The **Double-Checked Locking** approach is suitable for scenarios where you need to control the instance creation manually but comes with some complexity.

### **Write an immutable class in Java?**

import java.io.Serializable;

import java.util.Date;

public final class Employee implements Serializable {

private static final long serialVersionUID = 1L;

private final String name;

private final String empId;

private final double sal;

private final Date dob;

// Constructor to initialize the Employee object

public Employee(String name, String empId, double sal, Date dob) {

this.name = name;

this.empId = empId;

this.sal = sal;

this.dob = new Date(dob.getTime()); // Defensive copy to protect mutable Date

}

// Getter methods for the fields (no setters to ensure immutability)

public String getName() {

return name;

}

public String getEmpId() {

return empId;

}

public double getSal() {

return sal;

}

public Date getDob() {

return new Date(dob.getTime()); // Defensive copy to avoid external modification

}

}

**Key Points:**

**Final Class:** The Employee class is final to prevent subclassing, ensuring that its immutability is not compromised.

**Final Fields:** All instance fields (name, empId, sal, dob) are final, ensuring that they can only be assigned once, during object construction.

**No Setters:** There are no setter methods, ensuring that the fields cannot be modified after the object is created.

Defensive Copying for Date: Since Date is mutable, a defensive copy is made in the constructor (new Date(dob.getTime())) and when accessing it via the getter (new Date(dob.getTime())), to prevent the internal dob field from being changed externally.

This makes the Employee class immutable, and its state cannot be changed once the object is created.

### **Can we override the protected method?**

* Yes, we can override a protected method in Java, but there are some important points to consider.

**Understanding protected Method**

A protected method in Java is one that can be accessed within the same package or by subclasses, even if the subclass is in a different package.

**Overriding a Protected Method**

You can override a protected method in a subclass. However, there are some restrictions related to the access level of the overridden method.

**Key Points:**

1. **In the same package**: If the subclass is in the same package as the parent class, it can override the protected method without any issues.
2. **In a different package**: If the subclass is in a different package, the protected method can still be overridden, but the access level of the overridden method must be at least protected. It cannot be made more restrictive (e.g., turning it into private), but it can be made more permissive (e.g., turning it into public).

**Example 1: Overriding protected method within the same package**

// Parent class

class Parent {

protected void display() {

System.out.println("Protected method in Parent");

}

}

// Subclass in the same package

class Child extends Parent {

@Override

protected void display() {

System.out.println("Overridden protected method in Child");

}

}

public class Main {

public static void main(String[] args) {

Child child = new Child();

child.display(); // Output: Overridden protected method in Child

}

}

**Example 2: Overriding protected method in a different package**

// Parent class (In package p1)

package p1;

public class Parent {

protected void display() {

System.out.println("Protected method in Parent");

}

}

// Subclass (In package p2)

package p2;

import p1.Parent;

public class Child extends Parent {

@Override

public void display() { // Can increase the visibility to public

System.out.println("Overridden public method in Child");

}

}

public class Main {

public static void main(String[] args) {

Child child = new Child();

child.display(); // Output: Overridden public method in Child

}

}

**Key Takeaways:**

* **Overriding is allowed**: You can override a protected method in a subclass.
* **Access Modifier Rule**: You can make the overridden method public, protected, or package-private (default). You cannot make it private or more restrictive than the original method.
* **Inheritance Rules**: You must maintain the visibility of the method as per the original access level (i.e., protected, public), but you can make it less restrictive (e.g., public).

In summary, **you can override a protected method**, but you need to ensure that the overridden method's access level is at least as permissive as the original method.

### **What is marker interface in java? What is the purpose of the marker interface?**

* Answer

**What is a Marker Interface in Java?**

A **marker interface** is an interface in Java that doesn't contain any methods. Its sole purpose is to signal or "mark" a class with a specific property, behavior, or ability. In essence, a marker interface is an empty interface used to convey some metadata to the JVM or other parts of the program.

**Example of a Marker Interface:**

// Marker interface

public interface Serializable {

// No methods or fields

}

// Class that implements the marker interface

public class MyClass implements Serializable {

private int id;

private String name;

// Getters and Setters

}

In the above example, Serializable is a marker interface. It does not contain any methods, but a class that implements it (like MyClass) is considered to have a special behavior related to serialization.

**Purpose of Marker Interface**

1. **Indicating a special behavior or property**: Marker interfaces are used to provide metadata that the class has a specific capability. This is particularly useful in cases where you want the class to be handled differently based on its "marked" behavior.
2. **Enabling custom handling**: A marker interface allows certain objects to be handled in a special way by other parts of the application, such as enabling serialization or cloning behavior. For example, the Serializable interface is a marker interface used by the Java serialization mechanism to mark classes that can be serialized.
3. **Type-safe operation**: Since the marker interface doesn't define any methods, it doesn't enforce any specific behavior. However, its presence allows you to safely check if an object has a certain capability. For example, you can use instanceof to check if a class implements a marker interface, and then decide how to handle it.

**Example of Using Marker Interface:**

// Marker interface

public interface Validatable {

// No methods here

}

// Class implementing the marker interface

public class User implements Validatable {

private String name;

private String email;

// Constructor, Getters, Setters

}

// Validator class that checks if an object is validatable

public class Validator {

public void validate(Object obj) {

if (obj instanceof Validatable) {

System.out.println("This object is validatable.");

} else {

System.out.println("This object is NOT validatable.");

}

}

}

public class Main {

public static void main(String[] args) {

User user = new User();

Validator validator = new Validator();

validator.validate(user); // Output: This object is validatable.

}

}

In the above example:

* The Validatable interface is a marker interface.
* The Validator class checks if the object implements the Validatable interface using instanceof.
* The program can handle the User object differently based on whether it implements the marker interface.

**Examples of Marker Interfaces in Java**

1. **Serializable**: Marks a class as being serializable (i.e., its state can be saved to a stream).
2. **Cloneable**: Marks a class as being cloneable (i.e., it allows for creating a copy of an object via Object.clone()).
3. **Remote**: Marks a class as a remote object in the RMI (Remote Method Invocation) system.

**Benefits of Using Marker Interfaces**

1. **Separation of concerns**: Marker interfaces allow you to separate concerns in the program. For instance, classes that require serialization can implement the Serializable interface without having to be concerned about serialization logic themselves.
2. **Increased flexibility**: The marker interface pattern allows for flexibility and extension without changing existing code. New marker interfaces can be introduced to give classes special abilities or properties.
3. **Type-safety**: Using instanceof with a marker interface provides a safe way to check for specific capabilities, avoiding potential errors or casting issues.

**Conclusion**

A **marker interface** in Java is an empty interface used to convey metadata or information about a class. The class that implements this interface can be treated in a special way, usually by using reflection or checking with instanceof. Its primary use is to indicate that an object has a certain property or behavior without actually enforcing any methods or logic.

### **How can we ignore the finally block?**

* Answer

In Java, the finally block is always executed after the try block, regardless of whether an exception is thrown or not. However, there are a few scenarios where the finally block might seem "ignored" or not executed:

**1. If System.exit() is called in the try or catch block**

The System.exit() method terminates the JVM immediately, and any code after that (including the finally block) will not be executed.

**Example:**

public class FinallyExample {

public static void main(String[] args) {

try {

System.out.println("Inside try block");

System.exit(0); // Terminate the JVM

} catch (Exception e) {

System.out.println("Inside catch block");

} finally {

// This will not be executed

System.out.println("Inside finally block");

}

}

}

**Output:**

Inside try block

In this case, the System.exit(0) call causes the program to terminate before the finally block is reached, so it is ignored.

**2. If the thread executing the finally block is interrupted**

If a finally block contains code that is being executed by a thread, and that thread is interrupted (for example, by calling Thread.interrupt()), the finally block might not complete its execution. This can happen especially when the finally block contains long-running operations, like I/O or network operations.

**Example:**

public class FinallyExample {

public static void main(String[] args) throws InterruptedException {

Thread thread = new Thread(() -> {

try {

System.out.println("Inside try block");

} finally {

try {

System.out.println("Inside finally block");

Thread.sleep(10000); // Simulating long-running task

} catch (InterruptedException e) {

System.out.println("Finally block was interrupted");

}

}

});

thread.start();

Thread.sleep(100); // Wait for the thread to start execution

thread.interrupt(); // Interrupt the thread during the execution of finally

}

}

**Output:**

Inside try block

Finally block was interrupted

Here, the finally block is interrupted during execution, and the exception InterruptedException is caught, causing the block to exit prematurely.

**3. If the JVM crashes (Fatal Errors)**

In cases of a JVM crash or severe errors (such as OutOfMemoryError or StackOverflowError), the finally block may not be executed because the JVM itself is terminating abnormally.

**Example:**

public class FinallyExample {

public static void main(String[] args) {

try {

System.out.println("Inside try block");

// Simulating an error that causes the JVM to crash

throw new OutOfMemoryError();

} finally {

// This will not be executed if JVM crashes

System.out.println("Inside finally block");

}

}

}

**Note**: While these scenarios are rare, they do demonstrate situations where the finally block might not be executed.

**Conclusion**

* **System.exit()**: Exits the JVM, preventing the finally block from running.
* **Thread interruption**: If the thread is interrupted during the finally block's execution, it may not complete.
* **JVM crashes or fatal errors**: The finally block may not be executed if the JVM crashes.

In general, the finally block is designed to always execute, but the above exceptions are cases where it might be skipped or ignored.

### **What is synchronous and asynchronous call?**

* Answer

**Synchronous Call**

In a **synchronous call**, the execution of the program is blocked until the operation being called completes. In other words, when a function is invoked, the calling thread waits for the function to finish its task before it proceeds to the next operation. The caller is blocked while waiting for the response, making it a **blocking** operation.

**Characteristics of Synchronous Call:**

1. **Blocking:** The program execution halts until the current operation is completed.
2. **Order:** The tasks are executed in sequence, and the next task is dependent on the completion of the previous one.
3. **Linear Execution:** Each task waits for the previous one to finish before it starts.

**Example:**

public class SynchronousExample {

public static void main(String[] args) {

System.out.println("Task 1 Started");

task1();

System.out.println("Task 1 Finished");

System.out.println("Task 2 Started");

task2();

System.out.println("Task 2 Finished");

}

public static void task1() {

try {

Thread.sleep(3000); // Simulate a 3-second task

} catch (InterruptedException e) {

e.printStackTrace();

}

}

public static void task2() {

try {

Thread.sleep(2000); // Simulate a 2-second task

} catch (InterruptedException e) {

e.printStackTrace();

}

}

}

**Output:**

Task 1 Started

Task 1 Finished

Task 2 Started

Task 2 Finished

In this example, **Task 1** has to finish before **Task 2** can start, as the program execution is **blocked** during task1() and task2().

**Asynchronous Call**

In an **asynchronous call**, the program does **not wait** for the operation to complete. The operation is executed in the background, and the program continues executing other tasks without waiting for the current one to finish. The calling thread **does not block** but instead proceeds to the next task. The result of the operation is usually provided via a callback or a future result.

**Characteristics of Asynchronous Call:**

1. **Non-blocking:** The caller is free to continue execution while waiting for the task to finish in the background.
2. **Parallel Execution:** Multiple tasks can run concurrently.
3. **Callback/Promise:** Often involves some mechanism to handle the result once the operation is complete (like a callback function, promise, or future).

**Example:**

import java.util.concurrent.\*;

public class AsynchronousExample {

public static void main(String[] args) {

System.out.println("Task 1 Started");

// Asynchronous task execution using ExecutorService

ExecutorService executor = Executors.newSingleThreadExecutor();

Future<?> future1 = executor.submit(() -> {

try {

Thread.sleep(3000); // Simulate a 3-second task

} catch (InterruptedException e) {

e.printStackTrace();

}

});

System.out.println("Task 1 is running asynchronously");

// Continue with other tasks while the asynchronous task is running

System.out.println("Task 2 Started");

task2();

try {

future1.get(); // Wait for Task 1 to complete before shutting down executor

} catch (InterruptedException | ExecutionException e) {

e.printStackTrace();

}

System.out.println("Task 2 Finished");

executor.shutdown();

}

public static void task2() {

try {

Thread.sleep(2000); // Simulate a 2-second task

} catch (InterruptedException e) {

e.printStackTrace();

}

}

}

**Output:**

Task 1 Started

Task 1 is running asynchronously

Task 2 Started

Task 2 Finished

Task 1 Finished

In this example:

* **Task 1** is executed asynchronously, allowing **Task 2** to run concurrently.
* The program does not block on **Task 1**, allowing it to proceed to **Task 2**.
* **Task 1** finishes in the background, and we use future1.get() to wait for it to complete at the end.

**Key Differences Between Synchronous and Asynchronous Calls:**

| **Aspect** | **Synchronous** | **Asynchronous** |
| --- | --- | --- |
| **Blocking** | Caller is blocked, waits for the task to complete. | Caller continues execution without waiting for the task. |
| **Execution Order** | Executes in a sequential/blocking manner. | Executes in a non-blocking/parallel manner. |
| **Use Case** | When the result of the task is immediately required. | When the task can run in the background while other tasks continue. |
| **Performance** | May cause delays, especially if tasks take time. | Improves performance and responsiveness by allowing other tasks to run concurrently. |
| **Examples** | File I/O operations, database queries (without async support). | Web requests, long-running background tasks, parallel processing. |

**When to Use Which?**

* **Synchronous** calls are suitable when the result is immediately required and when the tasks depend on each other.
* **Asynchronous** calls are ideal for tasks that can run in parallel or do not require an immediate result, like network requests, background tasks, or long-running computations.

### **Can we write the main method as private?**

* Answer

No, the main method cannot be written as private if you want to run the Java program as a standalone application.

The main method serves as the entry point for any Java application when run from the command line or IDE. It has a specific signature that is required for the Java Virtual Machine (JVM) to locate and execute the program. The standard signature is:

public static void main(String[] args)

**Here's why private would not work:**

1. **Access Modifier**: The JVM needs to access the main method from outside the class to start the execution of the program. If the main method is private, it cannot be accessed by the JVM (which tries to call it when you run the program), and the program will fail to start.
2. **Static Modifier**: The main method needs to be static because it is called by the JVM without creating an instance of the class.

**Example:**

public class MyClass {

private static void main(String[] args) {

System.out.println("Hello, World!");

}

}

This will not work because the JVM cannot access the private main method, and the program will not run.

**Correct Usage:**

public class MyClass {

public static void main(String[] args) {

System.out.println("Hello, World!");

}

}

In this example, the main method is **public**, allowing the JVM to access and execute it.

### **What is the use of static keywords in java?**

* Answer

The static keyword in Java is used to define class-level members that belong to the class itself rather than to instances of the class (objects). It can be applied to variables, methods, blocks, and nested classes. Here's a detailed explanation of how and where the static keyword is used:

**1. Static Variables (Class Variables)**

* A static variable is shared among all instances of a class. It is not tied to a specific object but belongs to the class itself. This means all objects of that class will access the same instance of the variable.

**Example:**

class Counter {

static int count = 0; // Static variable

Counter() {

count++; // Increment shared static variable

}

static void displayCount() {

System.out.println("Count: " + count);

}

}

public class Test {

public static void main(String[] args) {

new Counter();

new Counter();

Counter.displayCount(); // Outputs: Count: 2

}

}

* **Key Point**: Static variables are initialized when the class is loaded into memory and shared by all instances of the class.

**2. Static Methods**

* A static method belongs to the class rather than to any particular object of the class. It can be called using the class name and does not require an instance of the class to be created.
* Static methods can only directly access static variables and other static methods. They cannot access instance variables or instance methods.

**Example:**

class MathOperations {

static int add(int a, int b) {

return a + b;

}

}

public class Test {

public static void main(String[] args) {

int result = MathOperations.add(5, 10); // Static method call

System.out.println(result); // Outputs: 15

}

}

**3. Static Blocks**

* A static block is used for static initialization of a class. It is executed only once when the class is loaded into memory (before any constructor or method is called).
* This is commonly used for initialization tasks like setting up static variables or performing one-time setup actions.

**Example:**

class InitializationExample {

static {

System.out.println("Static block executed");

}

public static void main(String[] args) {

System.out.println("Main method executed");

}

}

**Output:**

Static block executed

Main method executed

* **Key Point**: Static blocks are executed in the order they appear in the class, and only once per class load.

**4. Static Classes (Nested Static Classes)**

* A static class is a nested class that is associated with the outer class, but it does not have access to instance variables and methods of the outer class. It can only access the static members of the outer class.

**Example:**

class Outer {

static int staticVar = 10;

static class Nested {

void display() {

System.out.println("Static variable from outer class: " + staticVar);

}

}

}

public class Test {

public static void main(String[] args) {

Outer.Nested nested = new Outer.Nested();

nested.display(); // Outputs: Static variable from outer class: 10

}

}

**5. Static Import**

* In Java, you can use static import to access static members (variables and methods) of a class directly without qualifying them with the class name.

**Example:**

import static java.lang.Math.\*;

public class Test {

public static void main(String[] args) {

System.out.println(sqrt(25)); // Instead of Math.sqrt(25), just sqrt(25)

}

}

**Key Points:**

1. **Class-level**: Static members are shared by all instances of the class.
2. **Memory Efficiency**: Static members are allocated memory once when the class is loaded, and they are not duplicated for each instance.
3. **Accessing Static Members**: Static members can be accessed directly using the class name, without creating an instance of the class.

**When to Use static:**

* Use static when a variable or method should be shared across all instances of the class.
* Use static for utility methods (like Math.sqrt(), Collections.sort()).
* Use static to define constants (e.g., public static final double PI = 3.14159;).

By using static, you reduce memory consumption (as the same member is shared across all instances) and allow methods and variables to be accessed without creating an object of the class.

### **What is inner class? Have you used inner class in your project?**

* Answer

**What is an Inner Class?**

In Java, an **inner class** is a class that is defined within another class. Inner classes are used when you want to logically group classes that are used in only one place or need to access the outer class's members.

There are several types of inner classes in Java:

1. **Member Inner Class**: A class defined within another class at the member level.
2. **Local Inner Class**: A class defined within a method or a block.
3. **Anonymous Inner Class**: A class without a name, often used to instantiate classes that implement interfaces or extend other classes.
4. **Static Nested Class**: A class defined within another class but with the static modifier, meaning it does not need an instance of the outer class.

**Example of Inner Class**

Here’s an example of different types of inner classes:

**1. Member Inner Class**

A **member inner class** is a regular inner class that is declared at the member level inside an outer class. It can access all members (including private members) of the outer class.

class OuterClass {

private String outerVariable = "Outer Class Variable";

class InnerClass {

public void display() {

System.out.println("Accessing outer class variable: " + outerVariable);

}

}

public void createInnerClass() {

InnerClass inner = new InnerClass(); // Inner class can be created inside an outer method

inner.display();

}

}

public class Test {

public static void main(String[] args) {

OuterClass outer = new OuterClass();

outer.createInnerClass();

}

}

**2. Local Inner Class**

A **local inner class** is defined within a method or a constructor. It has access to local variables and parameters within that method or constructor.

class OuterClass {

public void display() {

class LocalInnerClass {

void show() {

System.out.println("Inside Local Inner Class");

}

}

LocalInnerClass localInner = new LocalInnerClass();

localInner.show();

}

}

public class Test {

public static void main(String[] args) {

OuterClass outer = new OuterClass();

outer.display();

}

}

**3. Anonymous Inner Class**

An **anonymous inner class** is a type of inner class that doesn’t have a name. It is used to instantiate classes that extend other classes or implement interfaces directly.

interface Greeting {

void greet();

}

public class Test {

public static void main(String[] args) {

Greeting greeting = new Greeting() { // Anonymous inner class

@Override

public void greet() {

System.out.println("Hello from the anonymous class!");

}

};

greeting.greet();

}

}

**4. Static Nested Class**

A **static nested class** is a static inner class that doesn’t require an instance of the outer class to be instantiated.

class OuterClass {

private static String staticVariable = "Static Variable";

static class StaticNestedClass {

public void display() {

System.out.println("Accessing static variable: " + staticVariable);

}

}

}

public class Test {

public static void main(String[] args) {

OuterClass.StaticNestedClass nested = new OuterClass.StaticNestedClass();

nested.display();

}

}

**Use of Inner Classes in Projects**

Yes, inner classes are widely used in real-world projects. Here are a few use cases where I’ve utilized inner classes in projects:

1. **Event Handling in GUI**: Inner classes are commonly used for event handling, particularly with GUIs (like Swing). Anonymous inner classes are used to implement event listener interfaces directly within methods.
2. button.addActionListener(new ActionListener() {
3. public void actionPerformed(ActionEvent e) {
4. System.out.println("Button clicked!");
5. }
6. });
7. **Encapsulating Helper Classes**: When a helper class is only used within the outer class, defining it as an inner class improves encapsulation. This allows it to access private members of the outer class.
8. **Iterator Pattern**: Inner classes can implement iterators within the class they are iterating over. It provides a clean way to manage the iteration over data in the class.
9. **Accessing Outer Class Members**: Inner classes have direct access to the outer class's members, which is useful when inner classes need to manipulate or access data from the outer class, especially in multi-threaded environments or event-driven systems.
10. **Thread Handling**: Sometimes, inner classes are used to define and run threads that need to interact with the outer class’s state.
11. class OuterClass {
12. private String message = "Hello, Thread!";
13. class InnerThread extends Thread {
14. public void run() {
15. System.out.println(message); // Accessing outer class variable
16. }
17. }
18. public void startThread() {
19. InnerThread thread = new InnerThread();
20. thread.start();
21. }
22. }

**Advantages of Using Inner Classes:**

* **Encapsulation**: Inner classes help to logically group classes together, making the code more organized and reducing potential conflicts with other classes.
* **Access to Outer Class Members**: Inner classes have direct access to all members (including private members) of the outer class, which simplifies implementation when the inner class needs to interact closely with the outer class.
* **Event Handling and Callbacks**: Inner classes are often used in event-driven programming, especially with GUI frameworks (Swing, JavaFX) where you can define event listeners or callbacks directly within the outer class.

**Disadvantages of Inner Classes:**

* **Increased Complexity**: Too many inner classes in a class can make the code harder to understand and maintain.
* **Tight Coupling**: Inner classes are tightly coupled with their outer class, meaning they cannot be reused in other contexts without also involving the outer class.

**Conclusion:**

Inner classes are a powerful tool in Java, allowing you to group logically related classes together and access the outer class's members. However, they should be used judiciously to avoid unnecessary complexity in the code.

### **What is the purpose of inner class?**

* Answer

**Purpose of an Inner Class in Java**

An **inner class** in Java is a class defined within another class. The primary purpose of an inner class is to logically group classes that are used in only one place, and to allow them to access the members (including private members) of the outer class. Here are some specific purposes and benefits of using inner classes:

**1. Encapsulation and Logical Grouping**

* Inner classes allow for better **encapsulation** by grouping classes together that are closely related. This makes the code easier to maintain, understand, and modify.
* It helps in keeping the inner class hidden from other parts of the program where it is not needed, thereby improving the structure of the code.

Example:

class OuterClass {

private String name = "Outer";

class InnerClass {

public void printName() {

System.out.println(name); // Accessing private member of outer class

}

}

}

**2. Access to Outer Class Members**

* **Inner classes** have direct access to the outer class’s **private fields and methods**, which is useful when the inner class needs to manipulate or interact with the outer class's state.
* This is beneficial when there is a tight coupling between the inner and outer class.

Example:

class OuterClass {

private String message = "Hello from outer class!";

class InnerClass {

public void printMessage() {

System.out.println(message); // Accessing outer class's private member

}

}

}

**3. Event Handling and Callback Mechanism**

* Inner classes are commonly used in **event-driven programming** (like **Swing** or **JavaFX** for GUI applications) to define event listeners or callbacks.
* **Anonymous inner classes** are often used to implement interfaces or extend classes for event handling, which helps in keeping event handling logic within the context of the outer class.

Example:

button.addActionListener(new ActionListener() {

public void actionPerformed(ActionEvent e) {

System.out.println("Button clicked!");

}

});

**4. Iteration and Traversing Data**

* Inner classes can be used to implement **iterators** in collection classes. For example, a collection class may have an inner class that implements the Iterator interface, and this class can traverse or manipulate the data in the collection.

Example:

class MyCollection {

private int[] data = {1, 2, 3, 4, 5};

class MyIterator implements Iterator {

private int index = 0;

public boolean hasNext() {

return index < data.length;

}

public Integer next() {

return data[index++];

}

}

public Iterator getIterator() {

return new MyIterator();

}

}

**5. Improving Readability and Maintainability**

* Using inner classes helps improve the **readability** and **maintainability** of the code by logically grouping related classes together.
* This also reduces clutter by not exposing the inner class to the external world if it is not needed.

**6. Implementing Adapter and Strategy Patterns**

* Inner classes are useful for implementing certain **design patterns**, such as **Adapter** and **Strategy patterns**, where a behavior or strategy can be defined within a class that is used only by the outer class.

Example (Strategy Pattern):

class Context {

private Strategy strategy;

public void setStrategy(Strategy strategy) {

this.strategy = strategy;

}

public void executeStrategy() {

strategy.execute();

}

interface Strategy {

void execute();

}

class ConcreteStrategyA implements Strategy {

public void execute() {

System.out.println("Executing strategy A");

}

}

}

**7. Helper and Utility Classes**

* Inner classes are often used as **helper** or **utility** classes within a larger class. These classes are used to perform specific tasks that are needed only within the outer class, and they do not need to be exposed to other classes.

**8. Threading and Runnable Classes**

* Inner classes are useful for implementing **threads** or **runnable tasks** when the task is tightly coupled with the outer class and needs to access the outer class’s data.

Example:

class OuterClass {

private int count = 0;

class InnerThread extends Thread {

public void run() {

for (int i = 0; i < 5; i++) {

count++;

System.out.println(count);

}

}

}

public void startThread() {

InnerThread thread = new InnerThread();

thread.start();

}

}

**9. Anonymous Inner Classes**

* **Anonymous inner classes** are used when you need to create an instance of a class that implements an interface or extends a class and you don’t want to create a separate named class for it.
* This is commonly seen in frameworks or libraries where you can pass behavior (such as event listeners) directly as parameters.

**Conclusion**

The **purpose of inner classes** is to provide a means of grouping classes that are logically related to each other and encapsulate them within a parent class. They enhance encapsulation, help access outer class members, and improve code readability and maintainability. Inner classes are especially useful in cases like event handling, callbacks, iteration, and implementing certain design patterns.

### **What is Enum? Write a syntax for enum?**

* Answer

**What is an Enum in Java?**

An **enum** (short for "enumeration") is a special Java type used to define collections of constants. It is a way of defining a type that can hold a predefined set of constant values. Enums are typically used when you need a fixed set of constants, such as days of the week, months of the year, or a set of commands.

**Key Features of Enums:**

* **Type-safe**: Enums provide type safety by ensuring that only valid constants are used.
* **Fixed set of constants**: Once an enum is defined, it cannot have additional values added to it.
* **Methods**: Enums can have fields, methods, and constructors.
* **Implements java.lang.Enum**: All enums implicitly extend java.lang.Enum, and thus they inherit methods like ordinal(), name(), and values().

**Syntax for Enum in Java**

Here's the basic syntax for defining an enum in Java:

enum EnumName {

CONSTANT1, CONSTANT2, CONSTANT3; // List of enum constants

}

**Example of an Enum in Java:**

// Enum to represent Days of the Week

enum Day {

SUNDAY, MONDAY, TUESDAY, WEDNESDAY, THURSDAY, FRIDAY, SATURDAY;

}

public class EnumExample {

public static void main(String[] args) {

// Accessing an enum constant

Day today = Day.MONDAY;

// Printing enum constant

System.out.println("Today is: " + today);

// Using enum with switch statement

switch (today) {

case MONDAY:

System.out.println("Start of the week!");

break;

case FRIDAY:

System.out.println("Weekend is near!");

break;

default:

System.out.println("Another day!");

break;

}

}

}

**Output:**

Today is: MONDAY

Start of the week!

**Enum with Fields and Methods**

Enums can also have fields, constructors, and methods to store additional information or perform specific operations.

enum Day {

SUNDAY("Weekend"), MONDAY("Weekday"), TUESDAY("Weekday"), WEDNESDAY("Weekday"),

THURSDAY("Weekday"), FRIDAY("Weekday"), SATURDAY("Weekend");

private final String type; // Field to store the type of day (Weekend/Weekday)

// Constructor to initialize the type

Day(String type) {

this.type = type;

}

// Method to get the type of day

public String getType() {

return this.type;

}

}

public class EnumExample {

public static void main(String[] args) {

// Accessing an enum constant and its method

Day today = Day.MONDAY;

System.out.println("Today is " + today + " and it is a " + today.getType());

}

}

**Output:**

Today is MONDAY and it is a Weekday

**Key Points:**

* **Enums are implicitly public, static, and final**: You cannot subclass enums.
* **Enums are a great way to ensure type safety** and they provide built-in methods like values(), ordinal(), and valueOf().

### **Difference between static and non-static in java?**

* Answer

**Difference Between Static and Non-Static in Java**

In Java, **static** and **non-static** refer to whether a member (field or method) belongs to a specific instance of a class or to the class itself. Below is a detailed comparison between static and non-static:

| **Aspect** | **Static** | **Non-Static (Instance)** |
| --- | --- | --- |
| **Keyword** | Uses the static keyword | No keyword used |
| **Memory Allocation** | Shared among all instances of the class. Only one copy of the static member exists. | Each instance of the class gets its own copy of non-static members. |
| **Accessing Mechanism** | Can be accessed using the class name (ClassName.member) or through an object. | Can only be accessed through an object of the class. |
| **Instance Requirement** | Does not require an object instance to be accessed. | Requires an object instance to be accessed. |
| **Default Value** | Static variables are initialized only once and are shared among all instances. | Non-static variables are initialized for each instance individually. |
| **Memory Location** | Stored in the **method area** (part of the class's memory). | Stored in the **heap memory** (each object has its own copy). |
| **Method Invocation** | Static methods can be called directly using the class name. | Non-static methods must be called through an object instance. |
| **Polymorphism** | Cannot be overridden (in terms of dynamic method dispatch) but can be hidden (by re-declaring in a subclass). | Non-static methods can be overridden in subclasses. |
| **Lifecycle** | Exists as long as the class is loaded in memory, even if no object is created. | Exists only as long as the object exists. |
| **Use Case** | Best used for functionality that is independent of instance-specific data (e.g., utility methods, constants). | Best used for instance-specific functionality (e.g., instance data manipulation). |

**Example:**

**Static Example:**

class Example {

static int staticCount = 0; // Static field

// Static method

static void increment() {

staticCount++;

}

public static void main(String[] args) {

// Accessing static member directly using class name

Example.increment();

System.out.println("Static count: " + Example.staticCount); // Output: Static count: 1

}

}

**Non-Static Example:**

class Example {

int instanceCount = 0; // Non-static field

// Non-static method

void increment() {

instanceCount++;

}

public static void main(String[] args) {

Example obj1 = new Example();

Example obj2 = new Example();

obj1.increment();

obj2.increment();

System.out.println("Instance count for obj1: " + obj1.instanceCount); // Output: Instance count for obj1: 1

System.out.println("Instance count for obj2: " + obj2.instanceCount); // Output: Instance count for obj2: 1

}

}

**Key Differences:**

1. **Static variables**: Shared by all instances of a class, whereas **non-static variables** are specific to each instance.
2. **Static methods**: Can be called without creating an object of the class, whereas **non-static methods** require an object to be called.
3. **Static methods** cannot access **instance variables** directly, while **non-static methods** can access both static and non-static variables.

**Summary:**

* **Static members** belong to the class itself, and there is only one copy of a static member shared across all instances.
* **Non-static members** belong to each instance of the class, and each object has its own copy of these members.

### **How can we break the singleton pattern?**

* Answer

Breaking the Singleton Pattern in Java can occur in several ways, either intentionally (for testing purposes or design flaws) or unintentionally due to poor implementation. Below are some common ways in which the Singleton pattern can be broken:

**1. Reflection**

Using reflection, you can instantiate a class even if its constructor is private, which violates the Singleton pattern. By accessing the private constructor, you can create multiple instances of the Singleton class.

**Example:**

import java.lang.reflect.Constructor;

public class Singleton {

private static Singleton instance;

private Singleton() {

// private constructor

}

public static Singleton getInstance() {

if (instance == null) {

instance = new Singleton();

}

return instance;

}

public static void main(String[] args) throws Exception {

Singleton s1 = Singleton.getInstance();

System.out.println(s1);

// Break Singleton using reflection

Constructor<Singleton> constructor = Singleton.class.getDeclaredConstructor();

constructor.setAccessible(true); // Allow access to private constructor

Singleton s2 = constructor.newInstance();

System.out.println(s2); // New instance created

}

}

In the above example, even though the constructor of Singleton is private, we are able to create a new instance using reflection and break the Singleton pattern.

**2. Serialization and Deserialization**

In the case of serialization (which converts an object into a stream of bytes), the Singleton pattern can be broken by creating a new instance during deserialization.

**Example:**

import java.io.\*;

public class Singleton implements Serializable {

private static Singleton instance;

private Singleton() {

// private constructor

}

public static Singleton getInstance() {

if (instance == null) {

instance = new Singleton();

}

return instance;

}

private Object readResolve() {

// Prevent breaking the Singleton during deserialization

return instance;

}

public static void main(String[] args) throws Exception {

Singleton s1 = Singleton.getInstance();

System.out.println(s1);

// Serialize the Singleton object

ObjectOutputStream out = new ObjectOutputStream(new FileOutputStream("singleton.ser"));

out.writeObject(s1);

out.close();

// Deserialize and break the Singleton pattern

ObjectInputStream in = new ObjectInputStream(new FileInputStream("singleton.ser"));

Singleton s2 = (Singleton) in.readObject();

in.close();

System.out.println(s2); // A new instance is created

}

}

In the above code, the deserialization of the object creates a new instance, which breaks the Singleton pattern. The readResolve() method can prevent this by returning the existing instance instead of creating a new one.

**3. Multiple Class Loaders**

In Java, different class loaders can load the same class multiple times, creating different instances of the Singleton class. This can break the Singleton pattern.

**Example:**

public class Singleton {

private static Singleton instance;

private Singleton() {

// private constructor

}

public static Singleton getInstance() {

if (instance == null) {

instance = new Singleton();

}

return instance;

}

public static void main(String[] args) throws Exception {

ClassLoader classLoader1 = new MyClassLoader();

ClassLoader classLoader2 = new MyClassLoader();

// Load Singleton using two different class loaders

Class<?> singletonClass1 = classLoader1.loadClass("Singleton");

Class<?> singletonClass2 = classLoader2.loadClass("Singleton");

Singleton s1 = (Singleton) singletonClass1.newInstance();

Singleton s2 = (Singleton) singletonClass2.newInstance();

System.out.println(s1);

System.out.println(s2); // Different instance

}

}

In this case, by using multiple class loaders, you could potentially load different instances of the Singleton class, breaking the Singleton pattern.

**4. Cloning**

If the Singleton class implements Cloneable, the clone() method can be used to create a new instance, which breaks the Singleton pattern.

**Example:**

public class Singleton implements Cloneable {

private static Singleton instance;

private Singleton() {

// private constructor

}

public static Singleton getInstance() {

if (instance == null) {

instance = new Singleton();

}

return instance;

}

@Override

public Object clone() throws CloneNotSupportedException {

return super.clone(); // Allows cloning, which breaks Singleton

}

public static void main(String[] args) throws CloneNotSupportedException {

Singleton s1 = Singleton.getInstance();

System.out.println(s1);

Singleton s2 = (Singleton) s1.clone();

System.out.println(s2); // New instance created

}

}

By overriding the clone() method and allowing cloning, you can create a new instance of the Singleton class.

**5. Thread-Safety Issues**

If the Singleton implementation is not thread-safe, it is possible for multiple threads to create multiple instances of the Singleton class.

**Example:**

public class Singleton {

private static Singleton instance;

private Singleton() {

// private constructor

}

public static Singleton getInstance() {

if (instance == null) {

instance = new Singleton();

}

return instance;

}

public static void main(String[] args) {

Thread t1 = new Thread(() -> {

Singleton s1 = Singleton.getInstance();

System.out.println(s1);

});

Thread t2 = new Thread(() -> {

Singleton s2 = Singleton.getInstance();

System.out.println(s2);

});

t1.start();

t2.start();

}

}

In this case, if getInstance() is not synchronized or does not use other thread-safety mechanisms (e.g., double-checked locking, volatile keyword), multiple threads may create separate instances, breaking the Singleton pattern.

**Conclusion:**

* **Reflection, Serialization, and Multiple Class Loaders** can all break the Singleton pattern by creating multiple instances of the Singleton class.
* **Cloning** and **Thread-Safety issues** can also break the Singleton pattern if not handled properly.

To prevent breaking the Singleton pattern, you can implement the following safeguards:

* Use the readResolve() method to handle serialization.
* Prevent cloning by overriding the clone() method and throwing CloneNotSupportedException.
* Ensure thread-safety using synchronization or volatile.
* Prevent reflection access to the constructor by throwing an exception in the constructor if an instance already exists.

### **Difference between default and protected access modifier?**

* Answer

In Java, access modifiers determine the visibility or accessibility of classes, methods, variables, and constructors. Both **default** and **protected** access modifiers provide different levels of access within different scopes. Here’s a comparison between them:

**1. Default Access Modifier (Package-Private)**

* **Visibility:** The **default** access modifier, also known as **package-private**, is the access level when no modifier is specified.
* **Access Scope:** The member is accessible only within the **same package**. It cannot be accessed from classes outside the package.
* **Inheritance:** If a class has a default access modifier, subclasses in the same package can access it. However, subclasses in different packages cannot access it.
* **Example:**
* class MyClass {
* int num; // default access modifier (package-private)
* void show() {
* System.out.println("Inside MyClass");
* }
* }

**Explanation:**

* + num and show() are only accessible within the same package.
  + If you try to access num or show() from another package, a compilation error will occur.

**2. Protected Access Modifier**

* **Visibility:** The **protected** access modifier allows access to the member from the same package and **subclasses** (including subclasses in different packages).
* **Access Scope:** A member marked as protected is accessible:
  + Within the **same package**.
  + By subclasses (even if they are in **different packages**).
  + By other classes in the **same package**.
* **Inheritance:** Subclasses can inherit and access protected members from the parent class, even if they are in a different package.
* **Example:**
* class Parent {
* protected int num; // protected access modifier
* protected void show() {
* System.out.println("Inside Parent class");
* }
* }
* class Child extends Parent {
* void display() {
* System.out.println(num); // Accessible because it's inherited
* show(); // Accessible because it's inherited
* }
* }

**Explanation:**

* + num and show() are accessible from the Child class because Child is a subclass of Parent.
  + Even if Child were in a different package from Parent, num and show() would still be accessible.

**Key Differences:**

| **Feature** | **Default (Package-Private)** | **Protected** |
| --- | --- | --- |
| **Visibility** | Accessible only within the **same package** | Accessible within the **same package** and by **subclasses** (even if in different packages) |
| **Access by subclasses** | Not accessible outside the package, even in subclasses | Accessible by subclasses (same package or different package) |
| **Inheritance** | Members are not inherited by subclasses in other packages | Members can be inherited by subclasses (same package or different package) |
| **Use Case** | Typically used when you want to limit access to the package scope only | Used when you want to allow access to subclasses (even in other packages) |

**Conclusion:**

* **Default (Package-Private)** is used when you want a class or member to be accessible only within the same package.
* **Protected** is used when you want the class or member to be accessible within the same package and by subclasses, even if they are in different packages.

### **Why is string immutable?**

* Answer

In Java, **String** is immutable, which means that once a String object is created, its value cannot be changed. This immutability provides several important benefits in terms of performance, security, and thread safety.

**Reasons why String is immutable in Java:**

**1. Security**

* **String objects are often used in security-sensitive operations**, such as in file paths, network connections, database queries, or even user authentication (passwords). If Strings were mutable, an attacker could alter their value while it is in use, leading to potential security vulnerabilities. By making Strings immutable, we ensure that their value cannot be modified once they are created, which helps maintain the integrity of sensitive data.

**2. Caching and Performance Optimization**

* **String pooling** is a technique in Java that helps save memory by reusing existing string objects rather than creating new ones every time a string is encountered. The **String Pool** (also called the "String Literal Pool") stores string literals in a special pool to avoid redundancy.
* Because Strings are immutable, they can safely be shared across multiple parts of a program without any risk of one part altering the string, which would affect other parts of the program using the same string. This enhances performance and saves memory.
* Since Strings are immutable, they can be used as **keys in hash-based collections** like HashMap, HashSet, etc., because their hash codes remain constant throughout their existence.

**3. Thread Safety**

* **Immutable objects are inherently thread-safe.** This means that multiple threads can safely access a String object without any synchronization needed because the value of the String cannot be modified after it is created.
* For example, in multi-threaded applications, the immutability of Strings guarantees that no thread can change the value of a String object, thus avoiding concurrency issues.

**4. Simplicity and Reliability**

* Immutability simplifies debugging and reasoning about the program because once a String is created, its value is fixed. This reduces the chance of accidental changes to its value, which could lead to subtle bugs.
* It makes the code **reliable** because any operations that involve strings will always yield the same result for the same input values, reducing errors in string manipulation.

**5. Hashing Consistency**

* **Strings are widely used in hash-based collections** like HashMap or HashSet. In such collections, the hash value of an object is used to quickly locate the object. If a string were mutable, its hash value could change, leading to incorrect behavior in these collections. By making String immutable, the hash value remains constant throughout the life of the object, ensuring the consistency and reliability of hash-based collections.

**6. Immutability and Optimized Memory Usage**

* Since Strings are immutable, Java can optimize memory usage by sharing String objects across multiple references. For example, if the same string value is used multiple times in a program, Java can point all references to the same memory location for that string, rather than creating multiple copies.
* This is particularly important when dealing with large amounts of text data, where memory efficiency is crucial.

**Example:**

public class StringImmutability {

public static void main(String[] args) {

String str1 = "Hello";

String str2 = "Hello";

// Both str1 and str2 point to the same object in the String pool

System.out.println(str1 == str2); // true, both refer to the same object

// Attempt to modify str1 (since Strings are immutable, this creates a new object)

str1 = str1.concat(" World");

// Now str1 points to a new String object, while str2 still points to the original "Hello"

System.out.println(str1); // Hello World

System.out.println(str2); // Hello

System.out.println(str1 == str2); // false, as str1 and str2 refer to different objects

}

}

In this example:

* Initially, both str1 and str2 point to the same object in the String pool because of the String literal "Hello".
* When we call concat() on str1, it creates a new String object because Strings are immutable. The original str2 remains unchanged.

**Conclusion:**

The immutability of Strings in Java is a design decision that helps in optimizing memory usage, improving performance, enhancing security, and ensuring thread safety. It simplifies code maintenance and debugging and allows for efficient use of String objects across different parts of a program.

### **What is an immutable class?**

* Answer

An **immutable class** in Java is a class whose objects cannot be modified once they are created. The state (fields or properties) of an immutable object is set only during object creation, and after that, it cannot be changed. The immutability of a class provides several benefits, such as thread safety, easier debugging, and improved security.

**Characteristics of an Immutable Class:**

1. **Final class:**
   * The class is typically declared as final to prevent subclassing. This ensures that the behavior of the immutable class cannot be altered by subclassing.
2. public final class ImmutableClass {
3. // Class body
4. }
5. **Final fields:**
   * All the fields of the class are declared as final, meaning that once they are assigned a value, they cannot be modified.
6. private final String name;
7. private final int age;
8. **No setter methods:**
   * The class does not provide any "setter" methods that could modify the values of the fields after the object is created. This ensures the immutability of the object.
9. public void setName(String name) {
10. this.name = name; // This method does not exist in an immutable class
11. }
12. **Initialization via constructor:**
    * The fields of an immutable class are typically initialized via the constructor when the object is created. Once set, they cannot be changed.
13. public ImmutableClass(String name, int age) {
14. this.name = name;
15. this.age = age;
16. }
17. **Defensive copying:**
    * If the immutable class contains fields that refer to mutable objects (like arrays, lists, or other objects), defensive copying is performed. This means that the mutable objects are copied before being stored, and copies are returned when accessed. This ensures that the internal state of the class cannot be modified from the outside.
18. private final List<String> hobbies;
19. public ImmutableClass(List<String> hobbies) {
20. // Create a new list to ensure the original list is not modified outside
21. this.hobbies = new ArrayList<>(hobbies);
22. }
23. public List<String> getHobbies() {
24. // Return a copy of the list to prevent external modification
25. return new ArrayList<>(hobbies);
26. }

**Example of an Immutable Class:**

import java.util.List;

import java.util.ArrayList;

public final class ImmutablePerson {

private final String name;

private final int age;

private final List<String> hobbies;

// Constructor to initialize fields

public ImmutablePerson(String name, int age, List<String> hobbies) {

this.name = name;

this.age = age;

// Defensive copy of the mutable object

this.hobbies = new ArrayList<>(hobbies);

}

// Getter methods (no setters to modify fields)

public String getName() {

return name;

}

public int getAge() {

return age;

}

// Defensive copy when returning a mutable object

public List<String> getHobbies() {

return new ArrayList<>(hobbies);

}

// Main method to test

public static void main(String[] args) {

List<String> hobbies = new ArrayList<>();

hobbies.add("Reading");

hobbies.add("Traveling");

ImmutablePerson person = new ImmutablePerson("John", 25, hobbies);

// Accessing fields through getter methods

System.out.println("Name: " + person.getName());

System.out.println("Age: " + person.getAge());

System.out.println("Hobbies: " + person.getHobbies());

// Trying to modify the list (will not affect the original object)

hobbies.add("Photography");

System.out.println("Person's Hobbies after modification: " + person.getHobbies());

}

}

**Explanation:**

1. The class ImmutablePerson is marked as final to prevent subclassing.
2. The fields name, age, and hobbies are final and initialized via the constructor. After initialization, these fields cannot be changed.
3. The hobbies field is a mutable object (List<String>), so a defensive copy of the list is made in the constructor, and when accessing the list, a copy is returned, not the original list. This ensures that the list cannot be modified from outside the class.

**Advantages of Immutable Classes:**

1. **Thread Safety:**
   * Since immutable objects cannot be modified after they are created, they are inherently thread-safe. Multiple threads can access the same immutable object without synchronization.
2. **Security:**
   * Immutable objects are often used for security-sensitive data. Since they cannot be altered, sensitive information (e.g., passwords, encryption keys) is less likely to be tampered with.
3. **Predictability and Debugging:**
   * Immutable objects simplify debugging and reasoning about your code, as their state never changes. This makes the program more predictable.
4. **Caching:**
   * Immutable objects can be safely shared and reused across multiple parts of an application. They can be used as keys in hash-based collections (like HashMap or HashSet) without worrying about their state changing.

**Conclusion:**

An **immutable class** is a class that ensures the integrity of its state by making sure that once an object is created, its fields cannot be modified. This is achieved by using final fields, a constructor for initialization, and avoiding setter methods. Immutable classes offer benefits such as thread safety, easier debugging, and reliability.

### **What is atomic integer in java?**

* Answer

In Java, an **AtomicInteger** is a class that provides an integer value that may be updated atomically. It is part of the java.util.concurrent.atomic package and is used when multiple threads need to modify an integer value concurrently without causing issues like race conditions or synchronization problems.

**Key Features of AtomicInteger:**

* **Atomic Operations:** The operations provided by AtomicInteger, such as incrementAndGet(), decrementAndGet(), getAndAdd(), and compareAndSet(), are atomic, meaning they are performed in a single, uninterrupted operation. These operations are designed to work without locks and are thread-safe.
* **No Synchronization Needed:** Unlike using synchronized blocks or ReentrantLock to ensure thread safety while modifying a shared integer, AtomicInteger uses low-level hardware instructions to provide atomicity, making it more efficient in some cases.
* **Non-blocking:** Since it does not rely on locking, it is more efficient for applications with frequent read and write operations on shared variables.

**Methods in AtomicInteger:**

1. **get():**
   * Returns the current value of the atomic integer.
2. int currentValue = atomicInteger.get();
3. **set(int newValue):**
   * Sets the value of the atomic integer to a new value.
4. atomicInteger.set(10);
5. **incrementAndGet():**
   * Atomically increments the value by 1 and returns the new value.
6. int newValue = atomicInteger.incrementAndGet();
7. **decrementAndGet():**
   * Atomically decrements the value by 1 and returns the new value.
8. int newValue = atomicInteger.decrementAndGet();
9. **getAndAdd(int delta):**
   * Atomically adds the given value (delta) to the current value and returns the old value.
10. int oldValue = atomicInteger.getAndAdd(5);
11. **compareAndSet(int expectedValue, int newValue):**
    * Atomically sets the value to the new value if the current value is equal to the expected value.
12. boolean success = atomicInteger.compareAndSet(10, 20);
13. **addAndGet(int delta):**
    * Atomically adds the given value (delta) to the current value and returns the new value.
14. int newValue = atomicInteger.addAndGet(5);

**Example of Using AtomicInteger:**

import java.util.concurrent.atomic.AtomicInteger;

public class AtomicIntegerExample {

public static void main(String[] args) {

// Create an AtomicInteger with an initial value of 0

AtomicInteger atomicInt = new AtomicInteger(0);

// Print the initial value

System.out.println("Initial Value: " + atomicInt.get());

// Increment the value by 1 atomically and print the result

System.out.println("After Increment: " + atomicInt.incrementAndGet());

// Decrement the value by 1 atomically and print the result

System.out.println("After Decrement: " + atomicInt.decrementAndGet());

// Add 5 atomically and print the result

System.out.println("After Adding 5: " + atomicInt.addAndGet(5));

// Atomically compare and set the value if the current value is 5

boolean isSet = atomicInt.compareAndSet(5, 10);

System.out.println("Compare and Set (5 -> 10): " + isSet);

System.out.println("Current Value: " + atomicInt.get());

}

}

**Output:**

Initial Value: 0

After Increment: 1

After Decrement: 0

After Adding 5: 5

Compare and Set (5 -> 10): true

Current Value: 10

**Why Use AtomicInteger?**

1. **Thread Safety without Locks:**
   * AtomicInteger allows atomic updates on the integer value without using synchronization, which improves performance by avoiding the overhead of acquiring and releasing locks.
2. **Efficient for Counters:**
   * It is particularly useful in scenarios where multiple threads need to modify a shared counter or value concurrently (e.g., in parallel processing or multi-threaded applications).
3. **Non-blocking:**
   * Since atomic operations are performed without blocking, they help in reducing contention between threads and increase performance in high-concurrency environments.

**When to Use AtomicInteger:**

* **Counters:** It is commonly used for counters where atomic updates are needed (e.g., request counts, number of active threads, etc.).
* **Thread-safe increment/decrement:** When the task requires incrementing or decrementing values by multiple threads concurrently.
* **Without synchronization:** When you want to avoid the overhead of locking and synchronization but still need thread-safe operations.

**Drawbacks:**

* **Limited functionality:** While AtomicInteger provides atomic operations for integer values, it only works with simple integer data types. For more complex types (like objects), you would need to use AtomicReference or other synchronization mechanisms.
* **Not suitable for all use cases:** It is useful only for specific scenarios where atomic operations on integers are required. For more complex data manipulations, AtomicInteger may not be the right solution.

### **How can you make a singleton class as thread safe?**

* Answer

To make a **Singleton** class thread-safe in Java, you need to ensure that the class's instance is created only once, even when multiple threads access it concurrently. There are different approaches to achieve thread safety, each with its own trade-offs in terms of performance and complexity. Below are the common ways to implement a thread-safe Singleton class:

**1. Lazy Initialization with synchronized block (Double-Checked Locking)**

This approach uses synchronization to ensure that the instance is created only once, while minimizing the performance overhead. The synchronized block is only used when the instance is null, and the double-checking avoids locking after the instance is created.

public class Singleton {

private static volatile Singleton instance;

private Singleton() {

// private constructor to prevent instantiation

}

public static Singleton getInstance() {

if (instance == null) { // First check (no synchronization)

synchronized (Singleton.class) { // Locking only once

if (instance == null) { // Second check (within synchronized block)

instance = new Singleton();

}

}

}

return instance;

}

}

* **Explanation:**
  + The volatile keyword ensures that the instance is properly visible to all threads and prevents the instance from being cached.
  + The double-checked locking pattern ensures that synchronization is only done the first time the instance is created, reducing overhead in subsequent calls.

**2. Eager Initialization (Thread-Safe by Default)**

In this approach, the Singleton instance is created when the class is loaded, ensuring that the instance is created only once. Since the instance is created at the class loading time, this is thread-safe without any synchronization required.

public class Singleton {

private static final Singleton instance = new Singleton();

private Singleton() {

// private constructor to prevent instantiation

}

public static Singleton getInstance() {

return instance;

}

}

* **Explanation:**
  + The instance is created when the class is loaded, and Java guarantees that class loading is thread-safe.
  + No synchronization is needed here, making this method efficient.
  + The downside is that the instance is created regardless of whether it is used or not, which could be inefficient if the instance is never used.

**3. Bill Pugh Singleton Design (Using Static Inner Class)**

This is a highly efficient and thread-safe approach. The Singleton instance is created when the static inner class is accessed for the first time, and the Java ClassLoader mechanism ensures that the instance is created lazily and thread-safe.

public class Singleton {

private Singleton() {

// private constructor to prevent instantiation

}

private static class SingletonHelper {

// The instance is created when the class is accessed for the first time

private static final Singleton INSTANCE = new Singleton();

}

public static Singleton getInstance() {

return SingletonHelper.INSTANCE;

}

}

* **Explanation:**
  + The inner static class (SingletonHelper) contains the Singleton instance.
  + The instance is created only when getInstance() is called for the first time, ensuring lazy initialization.
  + This approach takes advantage of the **ClassLoader mechanism** to handle the synchronization automatically, ensuring thread safety.

**4. Singleton with Enum (Best Practice)**

Using an enum to implement a Singleton is the simplest and most efficient approach. This approach guarantees thread-safety and serialization while avoiding the complexities of synchronization.

public enum Singleton {

INSTANCE;

public void doSomething() {

// method implementation

}

}

* **Explanation:**
  + Java ensures that enums are instantiated only once, which guarantees thread-safety.
  + This approach is also immune to serialization issues, making it the best and most recommended approach for Singleton in modern Java.

**Comparison of Approaches**

| **Approach** | **Thread-Safety** | **Performance** | **Complexity** | **Notes** |
| --- | --- | --- | --- | --- |
| Lazy Initialization with synchronized | Yes | Moderate | High | May cause performance overhead with synchronization. |
| Eager Initialization | Yes | High | Low | Instance is created regardless of use. |
| Bill Pugh Singleton Design | Yes | High | Low | Best for lazy initialization with thread-safety. |
| Singleton with Enum | Yes | High | Low | Best practice, simple, and thread-safe. |

**Conclusion:**

* **Best Approach:** The **Bill Pugh Singleton** (using a static inner class) and **Singleton with Enum** are generally the most efficient and thread-safe ways to implement a Singleton in Java.
* **When to Use:** Choose **Bill Pugh Singleton** if you need lazy initialization and don't want to create the instance until it's needed. Use **Singleton with Enum** for simplicity and when you need the most robust and concise solution.

### **Difference between compareTo and compare method?**

* Answer

In Java, both the compareTo() and compare() methods are used for comparing objects, but they are used in different contexts and serve slightly different purposes. Here's a breakdown of the differences:

**1. compareTo() Method**

* **Purpose**: It is a method defined in the Comparable interface. It is used to compare the current object (the object that compareTo() is called on) with another object of the same type.
* **Usage**: Typically used to implement natural ordering for a class.
* **Signature**: public int compareTo(T o)
* **Return Value**:
  + Returns 0 if the objects are equal.
  + Returns a negative integer if the current object is "less than" the specified object.
  + Returns a positive integer if the current object is "greater than" the specified object.
* **Example**:
* public class Student implements Comparable<Student> {
* private String name;
* private int age;
* public Student(String name, int age) {
* this.name = name;
* this.age = age;
* }
* @Override
* public int compareTo(Student other) {
* return this.age - other.age; // Compare by age
* }
* }
* Student s1 = new Student("Alice", 20);
* Student s2 = new Student("Bob", 25);
* System.out.println(s1.compareTo(s2)); // Will return a negative value (20 - 25)

**2. compare() Method**

* **Purpose**: It is a method defined in the Comparator interface. It is used for comparing two objects of any class (not necessarily the current class), and it allows for custom ordering of objects.
* **Usage**: Typically used when you need a different or custom sorting logic than the natural ordering defined by compareTo().
* **Signature**: public int compare(T o1, T o2)
* **Return Value**:
  + Returns 0 if the two objects are equal.
  + Returns a negative integer if o1 is less than o2.
  + Returns a positive integer if o1 is greater than o2.
* **Example**:
* import java.util.\*;
* public class Student {
* private String name;
* private int age;
* public Student(String name, int age) {
* this.name = name;
* this.age = age;
* }
* public String getName() {
* return name;
* }
* public int getAge() {
* return age;
* }
* }
* public class AgeComparator implements Comparator<Student> {
* @Override
* public int compare(Student s1, Student s2) {
* return s1.getAge() - s2.getAge(); // Compare by age
* }
* }
* public static void main(String[] args) {
* List<Student> students = Arrays.asList(
* new Student("Alice", 20),
* new Student("Bob", 25),
* new Student("Charlie", 18)
* );
* Collections.sort(students, new AgeComparator());
* // After sorting, students will be ordered by age.
* }

**Key Differences Between compareTo() and compare():**

| **Feature** | **compareTo()** | **compare()** |
| --- | --- | --- |
| **Defined in** | Comparable interface | Comparator interface |
| **Used for** | Natural ordering of objects | Custom ordering of objects |
| **Method Signature** | int compareTo(T o) | int compare(T o1, T o2) |
| **Context** | Used when objects are compared within their own class (implements Comparable) | Used when a custom comparison logic is required (typically in sorting or collections) |
| **Object Being Compared** | Compares the current object (this) with the given object (o) | Compares two separate objects (o1, o2) |
| **Usage** | Often used when the class implements Comparable | Often used when we want a custom sorting order without changing the class itself |

**Summary:**

* **compareTo()**: A method from the Comparable interface used to define the natural ordering of objects within a class.
* **compare()**: A method from the Comparator interface used to define custom comparison logic, allowing comparisons between objects of any class.

Both methods are crucial in sorting and comparing objects, but compareTo() is typically used for natural ordering, while compare() is used for custom ordering in scenarios like sorting a list with a specific criterion.

### **What is the return type of compare method?**

* Answer

The return type of the compare() method in the Comparator interface is **int**.

**Explanation:**

* **int compare(T o1, T o2)**: This method compares two objects, o1 and o2, and returns an integer value that indicates the order of the two objects.

The possible return values are:

* **Negative integer**: If o1 is less than o2.
* **Zero**: If o1 is equal to o2.
* **Positive integer**: If o1 is greater than o2.

**Example:**

import java.util.\*;

class Student {

String name;

int age;

public Student(String name, int age) {

this.name = name;

this.age = age;

}

public int getAge() {

return age;

}

}

class AgeComparator implements Comparator<Student> {

@Override

public int compare(Student s1, Student s2) {

return Integer.compare(s1.getAge(), s2.getAge()); // Returns the difference of ages

}

}

public class Main {

public static void main(String[] args) {

Student s1 = new Student("Alice", 20);

Student s2 = new Student("Bob", 25);

AgeComparator ageComparator = new AgeComparator();

System.out.println(ageComparator.compare(s1, s2)); // Output will be a negative integer (-5)

}

}

In this example:

* compare(s1, s2) returns a negative integer because s1 (Alice) is younger than s2 (Bob).

### **What is contract in equals and hashcode method?**

* Answer

The **contract** between the equals() and hashCode() methods in Java is defined by the Object class, and it's critical for ensuring the correct behavior of objects in hash-based collections like HashMap, HashSet, and Hashtable.

**The equals() and hashCode() Contract:**

1. **Consistency between equals() and hashCode():**
   * **If two objects are considered equal according to the equals() method, they must have the same hash code.**
     + This means that if a.equals(b) returns true, then a.hashCode() must be equal to b.hashCode().
   * **However, two objects having the same hash code does not necessarily mean they are equal according to equals().**
     + Different objects can have the same hash code (hash collisions), but they may not be considered equal by the equals() method.
2. **equals() Contract:**
   * **Reflexive**: An object must be equal to itself.
     + a.equals(a) must return true.
   * **Symmetric**: If a.equals(b) returns true, then b.equals(a) must also return true.
   * **Transitive**: If a.equals(b) returns true and b.equals(c) returns true, then a.equals(c) must also return true.
   * **Consistent**: Repeated calls to a.equals(b) should consistently return the same result, as long as the objects are not modified.
   * **Null comparison**: a.equals(null) should always return false.
3. **hashCode() Contract:**
   * **Consistent**: For any object, the hashCode() method must return the same integer value during the lifetime of the object, provided no fields used in equals() are modified.
   * **If two objects are equal (i.e., a.equals(b) is true), they must have the same hash code**.
   * **If two objects are not equal (i.e., a.equals(b) is false), it is not required for their hash codes to be different**, but it's highly recommended to minimize hash collisions to improve the performance of hash-based collections.

**Example:**

import java.util.Objects;

class Person {

private String name;

private int age;

public Person(String name, int age) {

this.name = name;

this.age = age;

}

// Implementing equals

@Override

public boolean equals(Object obj) {

if (this == obj) return true;

if (obj == null || getClass() != obj.getClass()) return false;

Person person = (Person) obj;

return age == person.age && Objects.equals(name, person.name);

}

// Implementing hashCode

@Override

public int hashCode() {

return Objects.hash(name, age);

}

}

public class Main {

public static void main(String[] args) {

Person p1 = new Person("John", 25);

Person p2 = new Person("John", 25);

System.out.println(p1.equals(p2)); // true

System.out.println(p1.hashCode() == p2.hashCode()); // true

}

}

**Breakdown of the Contract:**

* **Equality (equals())**:
  + In this example, p1.equals(p2) returns true because both p1 and p2 have the same name and age.
* **Hash Code Consistency**:
  + Since p1.equals(p2) is true, p1.hashCode() must be the same as p2.hashCode(), which is checked by the expression p1.hashCode() == p2.hashCode().

**Why is this contract important?**

* **Hash-based collections (like HashMap, HashSet)** rely on both equals() and hashCode() to efficiently locate objects.
  + If you don't follow the contract, it can cause unexpected behavior, such as objects being misplaced in a HashSet or HashMap, leading to bugs that are difficult to track down. For example, two objects that are considered equal according to equals() but have different hash codes could end up in separate buckets, violating the contract and potentially leading to inconsistent results when searching for or removing them.

Thus, ensuring a correct implementation of both equals() and hashCode() is critical for using objects in hash-based collections.

### **Difference between Marker interface and Functional interface?**

* Answer

**Difference between Marker Interface and Functional Interface**

**1. Marker Interface:** A **marker interface** is an interface that does not contain any methods. It is used to mark or signal that a class possesses some special property or behavior.

* **Purpose:** The primary purpose of a marker interface is to provide metadata or a "marker" that can be checked at runtime using reflection or other techniques. A class implementing a marker interface indicates that it should be treated in a certain way by the system.
* **Example:**
  + **Serializable** interface is a typical marker interface. It marks the class as serializable, and the JVM knows that such a class can be converted to a byte stream.
* interface Serializable {} // Marker Interface
* class Person implements Serializable {
* String name;
* int age;
* }

In this example, the Serializable interface does not contain any methods. The Person class implements it to indicate that instances of Person can be serialized.

* **Key Characteristics:**
  + Contains no methods.
  + Used to mark or tag classes for specific behaviors.
  + The behavior is typically handled by other components in the system.

**2. Functional Interface:** A **functional interface** is an interface that contains exactly one abstract method. It can have multiple default or static methods, but only one abstract method. It is used to represent a single function or action and is typically used with lambda expressions in Java.

* **Purpose:** The primary purpose of a functional interface is to represent a single operation or action that can be passed around as a lambda expression or method reference.
* **Example:**
  + The Runnable interface is an example of a functional interface, which has a single abstract method run().
* @FunctionalInterface
* interface Runnable {
* void run();
* }
* class Task implements Runnable {
* public void run() {
* System.out.println("Task is running");
* }
* }

In this example, Runnable is a functional interface with a single abstract method run(). It can be implemented using a lambda expression like this:

Runnable task = () -> System.out.println("Task is running");

task.run();

* **Key Characteristics:**
  + Contains exactly one abstract method.
  + Can contain multiple default or static methods.
  + Can be used with lambda expressions or method references.
  + Represented using @FunctionalInterface annotation (optional, but recommended).

**Comparison of Marker Interface vs Functional Interface:**

| **Aspect** | **Marker Interface** | **Functional Interface** |
| --- | --- | --- |
| **Definition** | An interface with no methods (empty interface). | An interface with exactly one abstract method. |
| **Purpose** | Used to mark or tag a class with a special property or behavior. | Used to represent a single operation that can be passed around and executed. |
| **Methods** | No methods. | One abstract method, can have multiple default/static methods. |
| **Example** | Serializable, Cloneable. | Runnable, Callable, Comparator. |
| **Usage** | Classes implementing the interface are recognized by the system for specific behavior. | Used primarily in lambda expressions or method references. |
| **Annotation** | No annotation required. | Typically annotated with @FunctionalInterface (optional). |

**In Summary:**

* A **Marker Interface** does not define any methods and is used to mark a class for specific behavior.
* A **Functional Interface** contains exactly one abstract method and is used to represent a single operation, commonly used with lambda expressions.

### **Difference between Abstract class and Interface? Explain with scenarios which one you will it be used with conditions?**

* Answer

**Difference between Abstract Class and Interface in Java**

In Java, both **abstract classes** and **interfaces** are used to define common behavior and structure for classes. However, there are some significant differences between the two, and each has its own use cases. Let's explore the differences:

**1. Definition:**

* **Abstract Class:**
  + An abstract class is a class that cannot be instantiated on its own and may contain both abstract (unimplemented) and concrete (implemented) methods.
  + It can have state (instance variables) and behaviors (methods) that can be inherited by subclasses.
* **Interface:**
  + An interface is a reference type, similar to a class, but it can only contain abstract methods (until Java 8, when default and static methods were introduced).
  + An interface cannot contain state (instance variables) except for constants (static final variables).

**2. Key Characteristics:**

| **Feature** | **Abstract Class** | **Interface** |
| --- | --- | --- |
| **Methods** | Can have both abstract and concrete (implemented) methods. | Can only have abstract methods (prior to Java 8). From Java 8 onwards, it can have default and static methods. |
| **Variables** | Can have instance variables. | Can only have constants (static final variables). |
| **Access Modifiers** | Can have any access modifier (public, private, protected, default). | Methods are implicitly public. Variables are public static final. |
| **Constructor** | Can have constructors to initialize the state of an object. | Cannot have constructors. |
| **Multiple Inheritance** | A class can extend only one abstract class due to single inheritance. | A class can implement multiple interfaces, allowing multiple inheritance of behavior. |
| **Use Case** | Used when classes share common implementation but also have some specific behavior. | Used when different classes need to share common behavior but don't share a common implementation. |
| **Inheritance Type** | Inherited by subclasses using extends. | Inherited by classes using implements. |

**3. Key Differences:**

| **Aspect** | **Abstract Class** | **Interface** |
| --- | --- | --- |
| **Instantiation** | Cannot be instantiated directly. | Cannot be instantiated directly. |
| **Default Method Implementation** | Can have method implementations. | Can have default and static method implementations (Java 8+). |
| **Abstract Methods** | Can have both abstract and concrete methods. | Can have only abstract methods (before Java 8). |
| **Multiple Inheritance** | A class can only extend one abstract class. | A class can implement multiple interfaces. |
| **Use of extends/implements** | A class can extend only one abstract class. | A class can implement multiple interfaces. |
| **State (Instance Variables)** | Can have instance variables. | Cannot have instance variables (only constants). |

**4. When to Use Abstract Class vs Interface?**

**1. Use Abstract Class When:**

* **Common functionality**: When you have a common base class that provides common functionality for all subclasses, but you also want to allow subclasses to override some of the behavior.
* **Shared state**: When you want to provide shared state (instance variables) for subclasses.
* **Default implementation**: If you need to provide default method implementation (which is common to all subclasses), you can use an abstract class.

**Example Scenario:**

Imagine you are creating a framework for vehicles. All vehicles have common properties like speed, fuelLevel, and location. You can have an abstract class Vehicle that provides common methods like startEngine(), stopEngine(), and some abstract methods that must be implemented by subclasses like accelerate(), brake().

abstract class Vehicle {

int speed;

int fuelLevel;

public abstract void accelerate();

public void startEngine() {

System.out.println("Engine started");

}

}

class Car extends Vehicle {

@Override

public void accelerate() {

System.out.println("Car accelerating");

}

}

class Bike extends Vehicle {

@Override

public void accelerate() {

System.out.println("Bike accelerating");

}

}

**2. Use Interface When:**

* **Multiple inheritance**: When you want to provide a common set of methods but allow different types of classes to implement those methods, without enforcing a common base class. Multiple interfaces can be implemented by a class.
* **Decoupling**: If you want to decouple behavior from implementation and allow multiple unrelated classes to share the same behavior.

**Example Scenario:**

Imagine you are creating a system where different objects can be "Sortable" and "Clonable". By using interfaces, you can ensure that multiple unrelated classes can have these behaviors, even if they don't share a common parent class.

interface Sortable {

void sort();

}

interface Clonable {

Object clone();

}

class Person implements Sortable, Clonable {

String name;

@Override

public void sort() {

System.out.println("Sorting person objects");

}

@Override

public Object clone() {

return new Person(name);

}

}

**5. Performance Considerations:**

* **Abstract Class**: Since it can have state (instance variables), it may involve additional memory usage due to the instance variables.
* **Interface**: Typically has no state, so it can be lighter. However, calling interface methods might involve slight overhead because of dynamic dispatch (virtual method calls).

**Summary:**

| **Criteria** | **Abstract Class** | **Interface** |
| --- | --- | --- |
| **Purpose** | Share common behavior and state with subclasses. | Share common behavior across classes with different hierarchies. |
| **Method Implementation** | Can have both abstract and concrete methods. | Can only have abstract methods (except default and static methods from Java 8). |
| **Instance Variables** | Can have instance variables. | Cannot have instance variables (only constants). |
| **Inheritance** | Single inheritance. | Multiple inheritance (can implement multiple interfaces). |
| **Default Implementation** | Can have concrete methods with default behavior. | Can have default methods from Java 8. |
| **Usage Scenario** | Common base class for shared implementation and state. | Used when classes need to share common behavior, but not necessarily a common implementation. |

In conclusion, choose **abstract classes** when you need to provide a base class with common functionality and shared state, and choose **interfaces** when you need to define common behavior for multiple unrelated classes, especially when the classes need to implement multiple behaviors.

### **What is the use of static and instance variables in java?**

* Answer

**Static vs Instance Variables in Java**

In Java, variables can be categorized into **static variables** and **instance variables**, and each serves a different purpose. Understanding their differences and usage is essential for writing efficient and maintainable code.

**1. Static Variables**

**Definition:**

* A **static variable** is a variable that belongs to the class, rather than to any specific instance of the class.
* It is shared among all instances of the class and can be accessed directly using the class name without creating an object of the class.

**Key Characteristics:**

* **Memory Allocation:** Static variables are stored in a special memory area called the **Method Area** and are initialized only once when the class is loaded.
* **Class-level Variable:** A static variable is associated with the class and is common to all instances of the class.
* **Default Value:** If not explicitly initialized, static variables are assigned default values (e.g., null for objects, 0 for numeric types, false for boolean).
* **Access:** You can access static variables using the class name or via an instance of the class, but it is recommended to use the class name for clarity.

**Usage Example:**

class MyClass {

// Static variable

static int count = 0;

MyClass() {

count++; // Static variable shared among all instances

}

void display() {

System.out.println("Count: " + count);

}

}

public class Main {

public static void main(String[] args) {

MyClass obj1 = new MyClass(); // count becomes 1

obj1.display();

MyClass obj2 = new MyClass(); // count becomes 2

obj2.display();

}

}

* **Output:**
* Count: 1
* Count: 2

**When to Use Static Variables:**

* **Shared Data:** When you want to maintain a value that is shared by all instances of a class, such as a counter that tracks the number of instances created.
* **Class-level Information:** When the data should be tied to the class rather than any specific instance, such as configuration constants, global flags, etc.

**2. Instance Variables**

**Definition:**

* An **instance variable** is a variable that belongs to an individual instance of a class.
* Every object (instance) of the class has its own copy of instance variables.

**Key Characteristics:**

* **Memory Allocation:** Instance variables are stored in the **Heap memory**, and each object gets its own copy of the instance variables.
* **Object-level Variable:** Instance variables are specific to each object created from the class. They can have different values for different instances of the class.
* **Default Value:** If not explicitly initialized, instance variables are assigned default values (e.g., null for objects, 0 for numeric types, false for boolean).
* **Access:** Instance variables are accessed via object references (i.e., through an instance of the class).

**Usage Example:**

class Person {

// Instance variables

String name;

int age;

Person(String name, int age) {

this.name = name; // Instance variable 'name' is unique to each object

this.age = age; // Instance variable 'age' is unique to each object

}

void display() {

System.out.println("Name: " + name + ", Age: " + age);

}

}

public class Main {

public static void main(String[] args) {

Person person1 = new Person("Alice", 30);

person1.display();

Person person2 = new Person("Bob", 25);

person2.display();

}

}

* **Output:**
* Name: Alice, Age: 30
* Name: Bob, Age: 25

**When to Use Instance Variables:**

* **Object-specific Data:** When each object needs to have its own copy of data, such as name, age, salary, etc.
* **Different Values for Different Objects:** When different instances of a class require different values for the same property.

**Key Differences Between Static and Instance Variables:**

| **Aspect** | **Static Variable** | **Instance Variable** |
| --- | --- | --- |
| **Belongs To** | Class (shared among all instances) | Instance (unique to each object) |
| **Memory Location** | Stored in **Method Area** | Stored in **Heap memory** |
| **Access** | Can be accessed by class name or object | Can only be accessed by object reference |
| **Default Value** | Default values (e.g., 0, null) | Default values (e.g., 0, null) |
| **Usage** | Shared data for all objects of the class | Data specific to individual objects |
| **Initialization** | Initialized once when the class is loaded | Initialized when an object is created |
| **Example** | static int count; | int age; |

**Summary:**

* **Static Variables** are used for values that need to be shared by all instances of a class. They belong to the class itself and are often used for tracking things like counters or common settings.
* **Instance Variables** are used for values that are specific to each object. They belong to individual instances of the class and each object can have different values for them.

### **How will you access JNDI in java code?**

* Answer

**Accessing JNDI in Java**

JNDI (Java Naming and Directory Interface) is an API provided by Java to access different types of naming and directory services, such as DNS, LDAP, RMI registry, and file systems. JNDI is typically used in Java EE applications for accessing resources like databases, JMS connections, and EJBs.

Here’s how to access JNDI resources in Java:

**1. Setup JNDI in Java**

Before accessing JNDI resources, you need to ensure the JNDI provider is correctly configured. This is typically done by creating a Context object and looking up resources using a name.

Here’s a basic outline of how to access JNDI in Java:

**Steps to Access JNDI Resource:**

1. **Create an InitialContext Object:**
   * To access a JNDI provider, you first need to create an instance of the InitialContext class. It is the entry point for the JNDI lookup.
2. **Perform a Lookup:**
   * You use the lookup() method of the Context object to fetch the resource by its JNDI name.
3. **Use the Resource:**
   * Once the lookup is successful, you can cast the object to the correct type and use it as needed.

**Example Code to Access JNDI in Java**

**Example 1: Accessing a DataSource (Database Connection)**

import javax.naming.\*;

import javax.sql.DataSource;

import java.sql.Connection;

import java.sql.SQLException;

public class JNDIExample {

public static void main(String[] args) {

try {

// Set up environment properties for JNDI

Hashtable<String, String> env = new Hashtable<String, String>();

env.put(Context.INITIAL\_CONTEXT\_FACTORY, "com.sun.jndi.fscontext.RefFSContextFactory");

env.put(Context.PROVIDER\_URL, "file:///C:/JNDI"); // Sample provider URL (file system-based JNDI)

// Create the InitialContext

Context ctx = new InitialContext(env);

// Lookup the DataSource object using JNDI name

DataSource ds = (DataSource) ctx.lookup("jdbc/myDataSource");

// Get a connection from the DataSource

Connection connection = ds.getConnection();

System.out.println("Connected to the database successfully!");

// Use the connection as needed

} catch (NamingException | SQLException e) {

e.printStackTrace();

}

}

}

**Explanation:**

1. **Setting up the Environment:**
   * The environment Hashtable is configured with two properties:
     + **INITIAL\_CONTEXT\_FACTORY**: This specifies the JNDI context factory to be used.
     + **PROVIDER\_URL**: Specifies the JNDI provider URL. In this case, a file-based provider is being used (file:///C:/JNDI).
2. **Creating the InitialContext:**
   * Context ctx = new InitialContext(env) creates an InitialContext object using the environment properties.
3. **Lookup the DataSource:**
   * DataSource ds = (DataSource) ctx.lookup("jdbc/myDataSource") performs the JNDI lookup using the JNDI name ("jdbc/myDataSource"). This name should match the JNDI configuration in your container (such as Tomcat, Glassfish, etc.).
4. **Get Connection:**
   * Once the DataSource is fetched, you can call ds.getConnection() to obtain a database connection from the connection pool managed by the container.

**Example 2: Accessing an EJB (Enterprise Java Bean)**

import javax.naming.\*;

import javax.ejb.\*;

public class EJBJNDIExample {

public static void main(String[] args) {

try {

// Set up the environment properties for JNDI

Hashtable<String, String> env = new Hashtable<>();

env.put(Context.INITIAL\_CONTEXT\_FACTORY, "org.jboss.naming.client.InitialContextFactory");

env.put(Context.PROVIDER\_URL, "http-remoting://localhost:8080");

// Create the InitialContext

Context ctx = new InitialContext(env);

// Lookup the EJB using its JNDI name

MyEJBRemote myEJB = (MyEJBRemote) ctx.lookup("java:global/MyApp/MyEJB!com.example.MyEJBRemote");

// Use the EJB

myEJB.someMethod();

System.out.println("EJB method invoked successfully!");

} catch (NamingException e) {

e.printStackTrace();

}

}

}

**Explanation:**

1. **Setting up JNDI Environment for EJB:**
   * The JNDI environment is configured for a remote EJB lookup (using http-remoting://localhost:8080 as the provider URL).
2. **Creating the InitialContext:**
   * The InitialContext object is created using the environment properties.
3. **Lookup the EJB:**
   * You use ctx.lookup("java:global/MyApp/MyEJB!com.example.MyEJBRemote") to look up the remote EJB. The JNDI name follows the pattern "java:global/<application\_name>/<module\_name>/<bean\_name>!".
4. **Use the EJB:**
   * After looking up the EJB, you can invoke methods on it as you would with any regular Java object.

**Example 3: Accessing a JMS Queue**

import javax.jms.\*;

import javax.naming.\*;

public class JMSJNDIExample {

public static void main(String[] args) {

try {

// Set up environment properties for JNDI

Hashtable<String, String> env = new Hashtable<>();

env.put(Context.INITIAL\_CONTEXT\_FACTORY, "org.apache.activemq.jndi.ActiveMQInitialContextFactory");

env.put(Context.PROVIDER\_URL, "tcp://localhost:61616"); // ActiveMQ broker URL

// Create the InitialContext

Context ctx = new InitialContext(env);

// Lookup the JMS Queue

Queue queue = (Queue) ctx.lookup("dynamicQueues/myQueue");

// Set up JMS connection, session, and message producer/consumer

// (JMS connection and session setup omitted for brevity)

System.out.println("JMS Queue lookup successful!");

} catch (NamingException e) {

e.printStackTrace();

}

}

}

**Explanation:**

* The environment is set for ActiveMQ JMS. The queue is looked up using the JNDI name "dynamicQueues/myQueue".
* After the lookup, you can use JMS APIs (e.g., QueueSession, QueueConnection) to send/receive messages.

**Summary of Steps to Access JNDI:**

1. **Create an environment (Hashtable) with relevant properties** (context factory, provider URL).
2. **Initialize a Context object** using InitialContext.
3. **Perform a lookup** on the desired JNDI resource using the lookup() method.
4. **Cast the looked-up object** to the appropriate type.
5. **Use the resource** (e.g., sending/receiving messages, interacting with a database).

**Conclusion:**

JNDI is a powerful Java API that allows you to access a variety of resources like databases, message queues, EJBs, etc., in a flexible and standardized way. The process involves setting up a context, performing a lookup, and using the resource.

### **Why is the main method in java static?**

* Answer

The main method in Java is defined as static for several important reasons, all related to the way Java programs are executed. Here's why it's static:

**1. Entry Point for Program Execution**

The main method serves as the entry point for the Java program when it is executed. When a Java application starts, the Java Virtual Machine (JVM) calls the main method to begin execution. Since the main method is static, it can be called without creating an instance of the class. The JVM doesn't need to create an object of the class to start running the program.

**Example:**

public class Main {

public static void main(String[] args) {

System.out.println("Hello, World!");

}

}

Here, the JVM can directly invoke Main.main() without needing to instantiate the Main class.

**2. No Object Instantiation Required**

The static keyword means that the method belongs to the class rather than to an instance of the class. Since the main method is the starting point of the program, it is called by the JVM before any objects are created, so it cannot rely on instance-level variables or methods that require an object to be instantiated.

If the main method were not static, the JVM would have to instantiate the class (i.e., create an object) first before calling the method. This would introduce unnecessary complexity and prevent the program from starting without object instantiation.

**3. Consistency Across the Program**

Having a static main method ensures that there is a consistent way for the JVM to start any Java application. The main method signature is always public static void main(String[] args), and it's universally recognized as the entry point, which makes Java programs predictable and standard.

**4. Allows Access to Command-Line Arguments**

The main method allows passing command-line arguments through its parameter String[] args. Since it's static, the JVM can directly pass the command-line arguments to the method without needing an instance of the class to be created first.

**Summary:**

* **Static** allows the JVM to call the method without creating an instance of the class.
* The main method is the entry point for program execution, and static ensures it is available for execution before any objects are created.
* It ensures **consistency** in how Java programs are started and allows for the **passing of command-line arguments**.

In essence, making the main method static enables the JVM to invoke it directly without the need for an object instantiation, which simplifies the process of program startup.

### **What is the use of the static keyword?**

* Answer

The static keyword in Java is used to declare members (variables, methods, blocks, or inner classes) that belong to the class rather than to instances of the class. This means that static members are shared among all instances of the class. Here are the main uses and benefits of the static keyword:

**1. Static Variables (Class Variables)**

A static variable is shared among all instances of the class. It is not tied to a specific object, but rather to the class itself. Every object of the class shares the same static variable. Static variables are used when you want to have a common property for all instances of the class.

**Example:**

class Counter {

static int count = 0; // Static variable

public Counter() {

count++; // Increment count whenever a new object is created

}

}

public class Main {

public static void main(String[] args) {

new Counter();

new Counter();

System.out.println(Counter.count); // Output: 2

}

}

In this example, count is a static variable, and it keeps track of how many instances of the Counter class are created. The value is shared across all instances of the class.

**2. Static Methods**

A static method can be called on the class itself, rather than on instances of the class. Static methods can only access static variables and other static methods. They cannot access instance variables or methods because they don't have an object context.

**Example:**

class Calculator {

static int add(int a, int b) {

return a + b; // Static method

}

}

public class Main {

public static void main(String[] args) {

int result = Calculator.add(5, 3); // Calling static method

System.out.println(result); // Output: 8

}

}

In this example, the add method is static, so it can be called using the class name, without creating an instance of the Calculator class.

**3. Static Blocks**

Static blocks are used for initialization of static variables or performing setup tasks when the class is loaded into memory. A static block is executed only once when the class is first loaded.

**Example:**

class Demo {

static {

System.out.println("Static block executed.");

}

}

public class Main {

public static void main(String[] args) {

new Demo(); // Static block will be executed the first time the class is loaded

}

}

In this example, the static block is executed once when the class Demo is loaded into memory, before any objects are created.

**4. Static Classes (Nested Classes)**

A static inner class is a nested class that is associated with its outer class, but it does not require an instance of the outer class to be instantiated. It can only access static members of the outer class.

**Example:**

class OuterClass {

static int num = 10;

static class InnerClass {

void display() {

System.out.println("Value of num: " + num);

}

}

}

public class Main {

public static void main(String[] args) {

OuterClass.InnerClass inner = new OuterClass.InnerClass();

inner.display(); // Output: Value of num: 10

}

}

Here, InnerClass is a static nested class, and it can be instantiated without an instance of the OuterClass.

**5. Static Import**

The static keyword can also be used to import static members (variables or methods) of a class directly into your code, allowing you to use them without qualifying with the class name.

**Example:**

import static java.lang.Math.\*;

public class Main {

public static void main(String[] args) {

double result = sqrt(16); // No need to use Math.sqrt()

System.out.println(result); // Output: 4.0

}

}

In this example, sqrt is imported statically, so it can be used without referencing the Math class.

**6. Static vs Instance**

* **Static members** belong to the class itself and are shared among all instances.
* **Instance members** belong to individual objects and are specific to each object.

**Summary of Uses of static Keyword:**

1. **Static Variables**: Shared by all instances of the class.
2. **Static Methods**: Can be called without creating an instance of the class.
3. **Static Blocks**: Used for class initialization.
4. **Static Nested Classes**: Do not require an instance of the outer class.
5. **Static Import**: Allows importing static members for direct access.

**Benefits of static Keyword:**

* **Memory efficiency**: Static variables and methods reduce memory consumption because they are shared by all instances.
* **Global access**: Static members can be accessed directly via the class name, making them globally accessible.
* **Initialization**: Static blocks allow for initialization of static variables when the class is loaded.

The static keyword is an essential feature in Java that helps manage shared resources, class-level operations, and object-independent behavior.

### **How many ways can we create beans in java?**

* Answer

In Java, beans (also known as **JavaBeans**) are classes that adhere to certain conventions. These classes are typically used in frameworks like Spring to define objects that can be easily manipulated and injected into other parts of an application.

There are several ways to create beans in Java, especially in the context of **Spring Framework**. Here are the main ways you can create and manage beans in Java:

**1. Using XML Configuration (Spring)**

This is one of the traditional ways to create beans in Spring. Beans are declared in an XML configuration file and can be instantiated, configured, and injected by the Spring container.

**Example:**

<bean id="myBean" class="com.example.MyClass">

<property name="property1" value="value1"/>

</bean>

In this method, the Spring framework uses the XML configuration to define the beans, their dependencies, and other properties.

**2. Using Annotation-Based Configuration (Spring)**

Since Spring 2.5, **annotations** can be used to configure beans. This is a more modern approach and is widely used in Spring applications.

**Common annotations:**

* @Component: Marks a class as a Spring-managed bean.
* @Autowired: Injects dependencies into the bean.
* @Configuration: Indicates that the class contains bean definitions.
* @Bean: Defines beans within a @Configuration class.
* @Value: Injects property values into fields.

**Example:**

@Component

public class MyClass {

@Autowired

private AnotherBean anotherBean;

// Constructor, setters, and other methods

}

@Configuration

public class AppConfig {

@Bean

public MyClass myClass() {

return new MyClass();

}

}

Here, the @Component annotation is used to mark MyClass as a bean, and Spring will manage its lifecycle. The @Bean annotation inside @Configuration is used to define a bean manually.

**3. Using Java-based Configuration (Spring)**

Spring also provides a **Java-based configuration** (also known as **JavaConfig**) to define beans and their dependencies in Java classes rather than in XML.

**Example:**

@Configuration

public class AppConfig {

@Bean

public MyClass myClass() {

return new MyClass();

}

}

This allows a more programmatic approach to creating beans, without the need for XML files.

**4. Using @ComponentScan (Spring)**

In Spring, you can use @ComponentScan to automatically scan the specified package (and its sub-packages) for classes annotated with @Component, @Service, @Repository, or @Controller. These beans are automatically registered with the Spring context.

**Example:**

@Configuration

@ComponentScan("com.example")

public class AppConfig {

// Beans will be scanned from the "com.example" package

}

**5. Factory Method (Spring or Plain Java)**

A **Factory method** pattern can be used to create beans in a more customized way. A factory method can instantiate and configure objects according to specific conditions.

**Example:**

@Component

public class MyClassFactory {

public static MyClass createMyClass() {

return new MyClass("Some property value");

}

}

@Configuration

public class AppConfig {

@Bean

public MyClass myClass() {

return MyClassFactory.createMyClass();

}

}

In this case, MyClass is created using a factory method, which can perform additional logic before returning the object.

**6. Using @PostConstruct and @PreDestroy (Spring)**

These annotations are used to specify initialization and destruction methods for beans. The methods annotated with @PostConstruct will be called after the bean is instantiated, and those with @PreDestroy will be called before the bean is destroyed.

**Example:**

@Component

public class MyClass {

@PostConstruct

public void init() {

// Initialization logic

}

@PreDestroy

public void cleanup() {

// Cleanup logic

}

}

This ensures that proper resource management (initialization and destruction) is handled for beans.

**7. Singleton and Prototype Beans (Spring)**

By default, Spring beans are **singleton**-scoped, meaning only one instance of the bean is created and shared within the Spring context. However, you can also define **prototype**-scoped beans, where a new instance is created every time the bean is requested.

**Example:**

@Scope("singleton")

@Component

public class MySingletonBean {

// Singleton bean

}

@Scope("prototype")

@Component

public class MyPrototypeBean {

// Prototype bean

}

You can define the scope of the bean either using the @Scope annotation or in XML configuration.

**8. Using @Value and External Configuration (Spring)**

Beans can be configured with external property values using the @Value annotation. These values can come from property files, system properties, or environment variables.

**Example:**

@Component

public class MyClass {

@Value("${my.property}")

private String propertyValue;

// Constructor and methods

}

In this case, Spring will inject the value of my.property from an external configuration file into the propertyValue field.

**9. Using Dependency Injection via Constructor or Setter Injection**

In Spring, beans can be injected either through **constructor injection** or **setter injection**. Constructor injection is preferred for mandatory dependencies, while setter injection is used for optional dependencies.

**Constructor Injection:**

@Component

public class MyClass {

private AnotherBean anotherBean;

@Autowired

public MyClass(AnotherBean anotherBean) {

this.anotherBean = anotherBean;

}

}

**Setter Injection:**

@Component

public class MyClass {

private AnotherBean anotherBean;

@Autowired

public void setAnotherBean(AnotherBean anotherBean) {

this.anotherBean = anotherBean;

}

}

**Summary of Ways to Create Beans in Java:**

1. **XML Configuration** (Traditional approach in Spring)
2. **Annotation-based Configuration** (Modern Spring approach)
3. **Java-based Configuration** (Programmatic bean definition)
4. **Component Scanning** (@ComponentScan)
5. **Factory Method Pattern**
6. **@PostConstruct and @PreDestroy for lifecycle management**
7. **Singleton and Prototype Beans**
8. **External Configuration using @Value**
9. **Dependency Injection** (Constructor or Setter injection)

The method you choose to define and manage beans will depend on your use case, application size, and preferences (e.g., using XML or JavaConfig in Spring).

### **Explain different types of calling beans?**

* Answer

In Java, specifically in the context of the **Spring Framework**, there are different types of beans that can be called, injected, or created based on various configurations and lifecycles. The **Spring IoC (Inversion of Control) container** handles the management of beans, their creation, initialization, and destruction. Beans in Spring can be accessed and invoked in different ways depending on the configuration style, scope, and injection strategy.

**1. Types of Bean Injection in Spring**

Here are the different ways beans can be called and injected in Spring:

**a. Constructor Injection**

Constructor injection is a way to provide dependencies to a bean through its constructor. Spring automatically calls the constructor with the required dependencies when the bean is instantiated.

**Example:**

@Component

public class Car {

private Engine engine;

@Autowired

public Car(Engine engine) {

this.engine = engine;

}

}

In this example, Car has a constructor that takes an Engine object. Spring will automatically inject an instance of Engine when it creates the Car bean.

**b. Setter Injection**

In setter injection, dependencies are provided through setter methods. Spring will call the setter method after the bean has been instantiated, allowing for the injection of dependencies.

**Example:**

@Component

public class Car {

private Engine engine;

@Autowired

public void setEngine(Engine engine) {

this.engine = engine;

}

}

In this case, Spring calls the setEngine() method after the Car bean is instantiated to inject the Engine dependency.

**c. Field Injection (Direct Injection)**

Field injection is the simplest form of injection, where Spring directly injects dependencies into fields, bypassing the need for constructor or setter methods. This method is easy to use but can make the class harder to test, as dependencies are tightly coupled.

**Example:**

@Component

public class Car {

@Autowired

private Engine engine;

}

Here, Spring directly injects an instance of Engine into the engine field of the Car bean. Note that this type of injection relies on reflection and annotations, making it less explicit than constructor or setter injection.

**2. Types of Bean Scopes in Spring**

In Spring, beans can have different **scopes**, which define their lifecycle and how they are instantiated and managed by the Spring container. The scope of a bean defines how long it lives and how it is shared across the application.

**a. Singleton Scope (Default Scope)**

* **Definition**: A singleton-scoped bean is instantiated once for the entire Spring container. This is the default scope if no scope is defined.
* **Usage**: Singleton beans are shared across the entire application, and any reference to the bean points to the same instance.
* **Example:**
* @Component
* @Scope("singleton")
* public class Car {
* // Car bean is created once and shared across the application
* }

**b. Prototype Scope**

* **Definition**: A prototype-scoped bean is instantiated each time it is requested from the Spring container.
* **Usage**: Every time a prototype bean is requested, a new instance of the bean is created.
* **Example:**
* @Component
* @Scope("prototype")
* public class Car {
* // A new Car bean is created every time it is requested
* }

**c. Request Scope**

* **Definition**: The bean is created once per HTTP request. This is typically used for web applications where a new bean instance is needed for each HTTP request.
* **Usage**: When the HTTP request ends, the bean is destroyed.
* **Example:**
* @Component
* @Scope("request")
* public class Car {
* // A new Car bean is created for each HTTP request
* }

**d. Session Scope**

* **Definition**: A session-scoped bean is created once per HTTP session. The bean is maintained for the entire duration of the user's session.
* **Usage**: The bean is stored in the session and remains available as long as the session is active.
* **Example:**
* @Component
* @Scope("session")
* public class Car {
* // A new Car bean is created for each HTTP session
* }

**e. Application Scope**

* **Definition**: The bean is created once per Spring ServletContext. This scope is typically used for beans that are shared across all sessions and requests.
* **Usage**: The bean is created once during the application context initialization and is available throughout the entire application.
* **Example:**
* @Component
* @Scope("application")
* public class Car {
* // A new Car bean is created for the entire application context
* }

**f. WebSocket Scope**

* **Definition**: This scope is used for WebSocket communication. A WebSocket-scoped bean is created once per WebSocket connection.
* **Usage**: The bean is maintained for the duration of the WebSocket session.
* **Example:**
* @Component
* @Scope("websocket")
* public class Car {
* // A new Car bean is created for each WebSocket session
* }

**3. Types of Bean Initialization and Destruction**

Spring provides ways to manage the initialization and destruction of beans. These are commonly used for resource management, such as opening or closing connections.

**a. Using @PostConstruct and @PreDestroy Annotations**

* **@PostConstruct**: This annotation is used to specify a method that should be called immediately after the bean's properties have been set.
* **@PreDestroy**: This annotation specifies a method that should be called just before the bean is destroyed.

**Example:**

@Component

public class Car {

@PostConstruct

public void init() {

System.out.println("Car initialized");

}

@PreDestroy

public void cleanup() {

System.out.println("Car destroyed");

}

}

**b. Using init-method and destroy-method in XML Configuration**

* These methods can be defined in XML configuration to specify the initialization and destruction methods.

**Example:**

<bean id="car" class="com.example.Car" init-method="init" destroy-method="cleanup"/>

**4. Calling Beans Using Spring Context**

* In Spring, beans can be accessed or called through the **ApplicationContext** or **BeanFactory**.
* **ApplicationContext** is the central interface for the Spring IoC container, and it is used to retrieve beans that are defined in the Spring container.

**Example:**

ApplicationContext context = new ClassPathXmlApplicationContext("beans.xml");

Car car = context.getBean(Car.class); // Access the Car bean from the context

**5. Lazy Initialization of Beans**

* By default, Spring initializes beans eagerly (i.e., at the start of the application). However, you can use lazy initialization to delay the creation of the bean until it is actually required.

**Example:**

@Component

@Scope("singleton")

@Lazy

public class Car {

// Bean will be created only when requested

}

**Conclusion**

In Spring, beans can be injected and called in a variety of ways, depending on the requirements of your application:

1. **Constructor Injection**: Inject dependencies via the constructor.
2. **Setter Injection**: Inject dependencies via setter methods.
3. **Field Injection**: Inject dependencies directly into fields.
4. **Bean Scopes**: Define the lifecycle of a bean using singleton, prototype, request, session, application, or WebSocket scopes.
5. **Initialization and Destruction**: Use @PostConstruct/@PreDestroy or XML configuration methods for bean initialization and destruction.
6. **Lazy Initialization**: Delay bean creation until it is needed.

These options allow you to fine-tune the behavior of beans and their dependencies based on the specific needs of your application.

### **What are the default methods?**

* Answer

In Java, **default methods** were introduced in **Java 8** as part of **interfaces** to allow developers to add new functionality to interfaces without breaking the existing implementations of those interfaces.

**What are Default Methods?**

A **default method** is a method defined in an interface with a body (implementation) provided. Unlike abstract methods in interfaces, default methods can contain concrete (implemented) code. The key point about default methods is that they allow an interface to evolve by adding new methods while still maintaining backward compatibility with classes that implement the interface.

**Syntax of Default Method**

A default method is declared using the default keyword before the method signature in the interface.

public interface MyInterface {

// Regular abstract method

void regularMethod();

// Default method with implementation

default void defaultMethod() {

System.out.println("This is a default method.");

}

}

**Key Points about Default Methods**

1. **Default Implementation**: The method has a body and provides a default implementation in the interface itself. This is different from abstract methods, which don't provide a body.
2. **Backward Compatibility**: Default methods allow you to add new methods to an existing interface without breaking the classes that already implement that interface. These classes do not need to implement the new method, as it already has a default implementation.
3. **Overriding Default Methods**: If a class implementing an interface provides a new implementation for a default method, the default implementation is overridden.
4. **Multiple Interface Inheritance**: If a class implements multiple interfaces that contain default methods with the same signature, the class must explicitly override the method to resolve the ambiguity.
5. **Not Allowed in Abstract Classes**: Default methods are only allowed in interfaces, not in abstract classes.

**Example**

Here is an example that demonstrates the use of a default method:

interface Vehicle {

// Abstract method

void drive();

// Default method

default void honk() {

System.out.println("Vehicle honking");

}

}

class Car implements Vehicle {

@Override

public void drive() {

System.out.println("Car is driving");

}

// Optional: Override the default method

@Override

public void honk() {

System.out.println("Car honking");

}

}

public class Main {

public static void main(String[] args) {

Vehicle myCar = new Car();

myCar.drive(); // Output: Car is driving

myCar.honk(); // Output: Car honking

}

}

In this example:

* The Vehicle interface has a default method honk() with a default implementation.
* The Car class implements Vehicle and provides its own implementation of honk(). This overrides the default implementation.
* If the Car class hadn't overridden honk(), the default implementation from the Vehicle interface would be used.

**Why Use Default Methods?**

1. **Backward Compatibility**: Default methods enable you to add new methods to an interface without breaking existing classes that implement the interface.
2. **Code Reusability**: You can provide a common behavior (implementation) in the interface itself, avoiding duplication in all implementing classes.
3. **Multiple Inheritance**: Default methods enable you to avoid issues when multiple interfaces provide the same default method (although this may need explicit resolution in case of conflicts).

**Example with Conflict Resolution**

If two interfaces have default methods with the same signature, and a class implements both interfaces, the class must override the method to resolve the conflict:

interface A {

default void show() {

System.out.println("A's show");

}

}

interface B {

default void show() {

System.out.println("B's show");

}

}

class C implements A, B {

// Resolving conflict by overriding the default method

@Override

public void show() {

System.out.println("C's show");

}

}

public class Main {

public static void main(String[] args) {

C c = new C();

c.show(); // Output: C's show

}

}

**Conclusion**

Default methods in Java allow you to provide method implementations within interfaces, facilitating backward compatibility, code reuse, and resolving issues with multiple inheritance. They make interfaces more flexible and adaptable without breaking the existing code.

### **Can I add one more new default method in my child class? Does it give any problems with my existing classes?**

* Answer

Yes, you can add a new **default method** in a **child class**, but whether it creates problems depends on the **context** in which it is done and how the class hierarchy is structured.

Here are a few key points to consider:

**1. Adding a Default Method in the Child Class:**

If you add a new default method in the **child class**, it will be treated as a regular method within the child class and won't directly impact the parent class or its existing implementations.

**Example**:

interface Vehicle {

void drive();

// Default method in the interface

default void honk() {

System.out.println("Vehicle honking");

}

}

class Car implements Vehicle {

@Override

public void drive() {

System.out.println("Car is driving");

}

// You can add a new default method in the child class

public void openSunroof() {

System.out.println("Opening sunroof");

}

}

public class Main {

public static void main(String[] args) {

Vehicle myCar = new Car();

myCar.honk(); // Output: Vehicle honking (default implementation in Vehicle)

}

}

In this example:

* The Car class does not affect the existing default method honk() from the Vehicle interface.
* You can add new methods (like openSunroof()) in the Car class, and they won't interfere with any existing classes.

**2. Adding or Overriding Default Methods in the Child Class:**

* If the **parent class** or **interface** already has a **default method**, you can **override** it in the **child class** to provide your own implementation.
* If the **child class** introduces a new **default method** (not already in the parent class or interface), there is no direct issue with existing classes. Existing classes that inherit from the parent class/interface will not be affected, as they will not automatically inherit the new method unless they explicitly implement it.

**3. What Happens If You Add a New Default Method to the Parent Interface?**

If you add a **new default method** to an existing **interface** (which is already implemented by some classes), it **will not break the existing classes** because those classes will automatically inherit the default method unless they override it.

**Example**:

interface Vehicle {

void drive();

// Existing default method in Vehicle

default void honk() {

System.out.println("Vehicle honking");

}

// New default method added later

default void startEngine() {

System.out.println("Vehicle engine started");

}

}

class Car implements Vehicle {

@Override

public void drive() {

System.out.println("Car is driving");

}

}

public class Main {

public static void main(String[] args) {

Vehicle myCar = new Car();

myCar.honk(); // Output: Vehicle honking

myCar.startEngine(); // Output: Vehicle engine started

}

}

In this example:

* When the new method startEngine() is added to the Vehicle interface, it doesn't break the Car class implementation, as it automatically inherits the new default method.
* However, if the Car class already had a custom implementation for startEngine(), it would override the default method.

**4. Potential Issues:**

The potential issue arises when you add a **default method in multiple interfaces** and a class implements those interfaces, leading to a **conflict**.

For example:

interface A {

default void show() {

System.out.println("A's show");

}

}

interface B {

default void show() {

System.out.println("B's show");

}

}

class C implements A, B {

// You must override the conflicting default method

@Override

public void show() {

System.out.println("C's show");

}

}

public class Main {

public static void main(String[] args) {

C c = new C();

c.show(); // Output: C's show

}

}

Here, both interfaces A and B have a default method show(), and C has to **resolve the conflict** by overriding the method.

**5. Conclusion:**

* You **can add a new default method in the child class**, and it will not cause any issues for the existing classes, provided that they don't try to access this new method.
* Adding a **new default method to the parent interface** does **not** break existing implementations of the interface; those classes will inherit the new method automatically.
* **Conflicts** arise if multiple interfaces have default methods with the same signature, and the child class will need to explicitly **resolve the conflict** by overriding the method.

### **In Java, which class is the base class of all the classes?**

* In Java, the **Object** class is the base class of all classes. Every class in Java, whether explicitly or implicitly, inherits from the Object class. It provides fundamental methods such as equals(), hashCode(), toString(), and others, which can be overridden by subclasses for specific behavior.

### **Why is the equals method required?**

* Answer

The **equals()** method in Java is required to determine if two objects are considered equal. By default, the equals() method in the Object class checks if the two object references point to the same memory location, i.e., if they are the exact same object. However, for many types of objects, especially in collections like HashMap, HashSet, and List, it's necessary to define what it means for two objects to be logically equal, not just refer to the same memory location.

Here are some reasons why the equals() method is needed:

1. **Logical Equality**:
   * For example, in a Person class, two Person objects with the same name and age may be considered logically equal, even if they are different instances (i.e., stored in different memory locations).
2. **Correctness in Collections**:
   * Java collections like HashSet and HashMap rely on the equals() method to check if an element or key already exists in the collection. Without a properly overridden equals() method, these collections would not function as expected.
3. **Consistent with hashCode()**:
   * If two objects are considered equal by the equals() method, their hashCode() values must also be the same. This is critical for the correct functioning of hash-based collections like HashMap and HashSet.
4. **Custom Equality**:
   * You can customize the logic for object equality based on specific fields, such as checking if two Employee objects are equal based on their id and name rather than their memory address.

**Example:**

class Person {

private String name;

private int age;

// Constructor

public Person(String name, int age) {

this.name = name;

this.age = age;

}

// Overriding equals method to compare based on name and age

@Override

public boolean equals(Object obj) {

if (this == obj) {

return true; // Same object

}

if (obj == null || getClass() != obj.getClass()) {

return false; // Null or different class

}

Person person = (Person) obj;

return age == person.age && name.equals(person.name);

}

@Override

public int hashCode() {

return Objects.hash(name, age); // Consistent with equals

}

}

public class Test {

public static void main(String[] args) {

Person p1 = new Person("John", 30);

Person p2 = new Person("John", 30);

// Using the overridden equals method

System.out.println(p1.equals(p2)); // Output: true

}

}

In this example, p1 and p2 are logically equal because they have the same name and age, even though they are two different objects in memory. This behavior is controlled by the overridden equals() method.

### **Is it possible to have the same hashcode for multiple objects?**

* Answer

Yes, it is possible for multiple objects to have the same **hashCode()**. This situation is known as a **hash collision**.

**Explanation:**

The **hashCode()** method in Java returns an integer value (hash code) that represents the object. The hash code is used by collections like HashMap, HashSet, and others to quickly compare objects and store them in hash-based data structures. Ideally, each object should have a unique hash code, but this is not always guaranteed due to the limited range of integer values that the hashCode() method can return (it returns a 32-bit signed integer).

Thus, it's possible that two or more objects can have the same hash code even though they are logically distinct objects. When this happens, it's called a **hash collision**.

**Hash Collision in Hash-Based Collections:**

* When two different objects have the same hash code, the collection (e.g., HashMap, HashSet) needs to compare the objects more thoroughly using the **equals()** method to ensure they are truly equal. This is why it's important to correctly override both the **hashCode()** and **equals()** methods in your class.
* If two objects have the same hash code, they are stored in the same bucket in a hash-based collection. The collection will then rely on the **equals()** method to distinguish between the objects in the same bucket.

**Example of Hash Collision:**

import java.util.HashMap;

class Person {

private String name;

private int age;

public Person(String name, int age) {

this.name = name;

this.age = age;

}

@Override

public int hashCode() {

return 42; // All instances of Person will have the same hash code (42)

}

@Override

public boolean equals(Object obj) {

if (this == obj) return true;

if (obj == null || getClass() != obj.getClass()) return false;

Person person = (Person) obj;

return age == person.age && name.equals(person.name);

}

}

public class Main {

public static void main(String[] args) {

Person p1 = new Person("Alice", 30);

Person p2 = new Person("Bob", 25);

HashMap<Person, String> map = new HashMap<>();

map.put(p1, "Person 1");

map.put(p2, "Person 2");

// Check if the map works correctly despite the hash collision

System.out.println(map.get(p1)); // Output: Person 1

System.out.println(map.get(p2)); // Output: Person 2

}

}

**Why Do Hash Collisions Occur?**

* **Limited Range of hashCode()**: The **hashCode()** method returns a 32-bit integer, which means there are only 2^32 possible values for the hash code. Since there are infinite possible objects, it's inevitable that different objects might end up with the same hash code.
* **Object Fields Affect Hash Code**: If your hashCode() method is based on a small subset of object fields, two objects with different field values could still end up with the same hash code.

**How to Handle Hash Collisions:**

* **Override equals() and hashCode()**: Always override both methods to ensure that objects with the same values for their fields are considered equal. This will prevent collisions from causing incorrect behavior in hash-based collections.
* **Distribute Hash Codes Evenly**: When overriding hashCode(), try to ensure that the hash codes are distributed evenly to minimize collisions.

**Conclusion:**

While it is possible for multiple objects to have the same **hashCode()**, proper implementation of the **equals()** method ensures that these collisions do not affect the correctness of hash-based collections. You should design your hashCode() method to minimize collisions but be aware that they are inevitable in some cases.

### **Enlist a few predefined interfaces from Java 8?**

* Answer

Java 8 introduced several predefined interfaces that are part of the **java.util.function** package, which are extensively used for functional programming, especially with lambdas and streams. Some key predefined interfaces in Java 8 are:

**1. Predicate**

* Represents a boolean-valued function of one argument.
* Commonly used for filtering or matching conditions.
* Example:
* Predicate<Integer> isEven = n -> n % 2 == 0;
* System.out.println(isEven.test(4)); // true

**2. Function<T, R>**

* Represents a function that takes an argument of type T and produces a result of type R.
* Commonly used for transformation operations.
* Example:
* Function<String, Integer> stringLength = s -> s.length();
* System.out.println(stringLength.apply("Hello")); // 5

**3. Consumer**

* Represents an operation that accepts a single input argument and returns no result (void).
* Commonly used for operations that only consume a value, like printing or modifying an object.
* Example:
* Consumer<String> printUpperCase = s -> System.out.println(s.toUpperCase());
* printUpperCase.accept("hello"); // HELLO

**4. Supplier**

* Represents a supplier of results, i.e., it produces a result of type T but doesn't take any input.
* Commonly used when you need to generate values or create new objects.
* Example:
* Supplier<Double> randomValue = () -> Math.random();
* System.out.println(randomValue.get()); // prints a random number

**5. UnaryOperator**

* A special case of Function<T, T>, which represents a function that takes an argument of type T and returns a result of the same type T.
* Often used for operations that modify or process the same type.
* Example:
* UnaryOperator<Integer> doubleValue = n -> n \* 2;
* System.out.println(doubleValue.apply(4)); // 8

**6. BinaryOperator**

* A special case of BiFunction<T, T, T>, which represents a function that takes two arguments of the same type T and returns a result of the same type T.
* Commonly used for combining two values of the same type.
* Example:
* BinaryOperator<Integer> add = (a, b) -> a + b;
* System.out.println(add.apply(2, 3)); // 5

**7. BiFunction<T, U, R>**

* Represents a function that takes two arguments, one of type T and the other of type U, and returns a result of type R.
* Useful for operations that require two arguments and return a result.
* Example:
* BiFunction<Integer, Integer, Integer> multiply = (a, b) -> a \* b;
* System.out.println(multiply.apply(2, 3)); // 6

**8. BiPredicate<T, U>**

* Represents a predicate (boolean-valued function) that takes two arguments, one of type T and the other of type U.
* Example:
* BiPredicate<Integer, Integer> isSumEven = (a, b) -> (a + b) % 2 == 0;
* System.out.println(isSumEven.test(1, 3)); // true

**9. Comparator**

* Represents a comparison function, which is used to compare two objects of type T for sorting.
* Commonly used with collections like List.sort() or Collections.sort().
* Example:
* Comparator<Integer> compareAsc = (a, b) -> a - b;
* System.out.println(compareAsc.compare(3, 5)); // -2 (3 is less than 5)

**10. Optional**

* Although not part of java.util.function, Optional is a predefined class that was introduced in Java 8.
* It represents a container for possibly null values, providing methods to handle null more gracefully.
* Example:
* Optional<String> optionalName = Optional.ofNullable("John");
* optionalName.ifPresent(name -> System.out.println(name)); // John

These interfaces help facilitate the functional programming paradigm introduced in Java 8, enabling you to write cleaner, more expressive, and reusable code with lambdas and streams.

### **If I have a 200 MB excel file so can java read that file?**

* Yes, Java can read a 200 MB Excel file, but how efficiently it can do so depends on the approach used and the libraries employed. Large files, such as a 200 MB Excel file, may need to be handled carefully to avoid excessive memory usage or performance bottlenecks.

Here are a few things to consider:

**Libraries for Reading Excel Files:**

Java provides several libraries for reading Excel files. Some popular ones include:

1. **Apache POI**
   * Apache POI is a widely used library for reading and writing Excel files in Java. It can handle both .xls (HSSF) and .xlsx (XSSF) file formats.
   * Apache POI's XSSF (for .xlsx files) and HSSF (for .xls files) are typically used to read Excel files.
2. **Apache POI Streaming API (SXSSF)**
   * If you're dealing with very large files (like a 200 MB Excel file), consider using **SXSSF** (Streaming Usermodel API) from Apache POI. SXSSF is designed for writing large Excel files, but it also helps to read large files efficiently by processing them in a streaming fashion, minimizing memory usage.
   * SXSSF writes data to disk and keeps a small in-memory buffer for the current sheet, which can be helpful when reading large Excel files.
3. **OpenCSV**
   * For reading CSV data in a memory-efficient way, OpenCSV is a good option, though it only works with CSV files. If your Excel file can be saved as CSV, this could be a good choice.

**Considerations for Reading Large Excel Files:**

1. **Memory Management**:
   * Reading large files directly into memory can consume a lot of resources, leading to OutOfMemoryError.
   * **SXSSF** (for writing large files) and **Streaming API** (for reading) are more memory-efficient because they process the file in chunks rather than loading it entirely into memory.
2. **Streaming**:
   * Use streaming approaches, such as the **Apache POI Streaming API**, which reads and processes the file in chunks, reducing the memory footprint.
3. **Processing in Chunks**:
   * Instead of processing the entire file at once, read and process it row-by-row or in small batches. This helps keep memory usage low.
   * For example, reading rows from the Excel file as streams and performing necessary operations incrementally.
4. **Multithreading**:
   * If you're reading very large files and need to perform intensive processing, consider using multithreading to break the task into smaller chunks (e.g., by sheets or rows).

**Example using Apache POI's Streaming API:**

Here’s a simple example of how you might use Apache POI to read a large .xlsx Excel file with minimal memory usage:

import org.apache.poi.xssf.streaming.SXSSFWorkbook;

import org.apache.poi.ss.usermodel.\*;

import java.io.FileInputStream;

import java.io.IOException;

public class ReadLargeExcelFile {

public static void main(String[] args) throws IOException {

FileInputStream fis = new FileInputStream("large\_file.xlsx");

try (SXSSFWorkbook wb = new SXSSFWorkbook(fis)) {

Sheet sheet = wb.getSheetAt(0); // Read the first sheet

for (Row row : sheet) {

for (Cell cell : row) {

switch (cell.getCellType()) {

case STRING:

System.out.print(cell.getStringCellValue() + "\t");

break;

case NUMERIC:

System.out.print(cell.getNumericCellValue() + "\t");

break;

case BOOLEAN:

System.out.print(cell.getBooleanCellValue() + "\t");

break;

default:

System.out.print("Unknown\t");

}

}

System.out.println();

}

}

}

}

**Summary of Techniques for Efficient File Handling:**

1. **Use Apache POI SXSSF for Large Files**: This approach allows you to handle large files with minimal memory usage by streaming the data.
2. **Read Files Row-by-Row**: Avoid loading the entire file into memory. Process the file in chunks (one row at a time).
3. **Optimize Memory Usage**: Make sure you're not holding large objects in memory for longer than necessary, and be mindful of large intermediate objects.

In conclusion, Java can read a 200 MB Excel file, but efficient memory management and choosing the right approach (such as using streaming or chunk-based processing) will ensure the task is done efficiently without running into performance or memory issues.

### **What is immutability and mutability in java?**

* Answer

**Immutability and Mutability in Java:**

**Immutability** and **mutability** are concepts that refer to whether or not an object's state can be changed after it is created. These concepts are crucial for understanding how Java objects behave with respect to their state.

**1. Immutability:**

An **immutable** object is one whose state (data) cannot be changed once it is created. In other words, an immutable object is a read-only object, and all its fields are final. After the object is constructed, you cannot modify any of its fields.

**Key Characteristics of Immutable Objects:**

* **Fields are final**: Once assigned, they cannot be changed.
* **No setters or mutators**: The object does not provide methods to modify its internal state.
* **Deep copies**: If the object contains fields that are mutable (like arrays or collections), a deep copy of those fields is made during construction or when they are accessed, to prevent external changes to the state of the object.
* **Thread safety**: Immutable objects are inherently thread-safe because their state cannot change once they are created.

**Why Use Immutable Objects?**

* They are **thread-safe**: Because their state cannot be changed, they can be safely shared between multiple threads.
* They are **easier to reason about**: Since they cannot change, there is no risk of side effects or unexpected behavior in the program.
* They are **suitable for caching**: Once created, they remain the same, so they can be used as cache keys or in other scenarios where you want predictable behavior.

**Example of an Immutable Class in Java:**

public final class Person {

private final String name;

private final int age;

public Person(String name, int age) {

this.name = name;

this.age = age;

}

public String getName() {

return name;

}

public int getAge() {

return age;

}

}

In this example:

* The class is final to prevent subclassing, ensuring immutability.
* The fields are final, so their values cannot be changed after initialization.
* There are no setter methods to modify the fields.

**2. Mutability:**

A **mutable** object is one whose state can be changed after it is created. You can modify the object's fields during its lifetime. Mutable objects provide methods (typically setters) that allow you to change their state.

**Key Characteristics of Mutable Objects:**

* **Fields can be changed**: You can change the values of fields after the object is constructed.
* **Setters or mutators**: Mutable objects usually provide setter methods that allow external code to modify their internal state.
* **Not inherently thread-safe**: Since the state can change at any time, mutable objects may not be thread-safe unless you synchronize access to them or otherwise manage concurrency.

**Why Use Mutable Objects?**

* They are more **flexible**: You can modify the object as needed, which is useful for many scenarios (like updating user data, changing attributes of a product, etc.).
* They can **save memory**: Mutable objects can be reused or modified instead of creating new instances each time.

**Example of a Mutable Class in Java:**

public class Employee {

private String name;

private int age;

public Employee(String name, int age) {

this.name = name;

this.age = age;

}

// Getter methods

public String getName() {

return name;

}

public int getAge() {

return age;

}

// Setter methods for mutability

public void setName(String name) {

this.name = name;

}

public void setAge(int age) {

this.age = age;

}

}

In this example:

* The class Employee has mutable fields.
* There are setter methods (setName and setAge) that allow changes to the state of the object after it is created.

**Comparing Immutability and Mutability:**

| **Aspect** | **Immutability** | **Mutability** |
| --- | --- | --- |
| **State** | Cannot be changed after object creation. | State can be changed after object creation. |
| **Thread Safety** | Naturally thread-safe because state cannot change. | Not inherently thread-safe; requires synchronization. |
| **Usage** | Used for values that should not change, like String, Integer. | Used for objects whose state needs to change, like Employee, Product. |
| **Memory Efficiency** | May require creating new objects for changes. | More memory efficient when modifying existing objects. |
| **Example** | String, Integer, LocalDate | ArrayList, StringBuilder |

**When to Use Immutability or Mutability?**

* **Immutability** should be used when:
  + The object represents a constant value.
  + The object needs to be thread-safe.
  + You need predictability and security in your objects.
* **Mutability** should be used when:
  + The object's state needs to change after creation.
  + Performance is a consideration, and you want to reuse the same object.
  + You don't need to worry about thread safety (or you handle it with synchronization).

**Example of Immutability vs. Mutability in Real-world Scenario:**

* **Immutable Example**: A Person class where you store someone's name, and once the person is created, you don't want the name or other attributes to change.
* **Mutable Example**: A BankAccount class where you need to change the balance after every transaction.

In summary, **immutable objects** are objects whose state cannot be changed once they are created, while **mutable objects** allow changes to their state. Immutability is favored in concurrent or multi-threaded environments for simplicity and thread safety, whereas mutability is used when the object's state needs to be flexible.

### **Custom implementation of Singleton beans?**

* Answer

**Custom Implementation of Singleton Beans in Java**

In Java, the **Singleton pattern** ensures that a class has only one instance and provides a global point of access to that instance. This is useful for resources like database connections or configurations where having more than one instance would be wasteful or inefficient.

When implementing Singleton beans in Java (e.g., for dependency injection in Spring or for general Java classes), we typically follow certain design patterns and principles to ensure proper thread safety, lazy initialization, and proper handling of the instance.

**Custom Implementation of Singleton Pattern in Java**

Here’s a custom implementation of a **Singleton pattern**:

**1. Eager Initialization Singleton:**

In this approach, the singleton instance is created at the time of class loading, which ensures that the instance is created even before it is accessed.

public class Singleton {

// Eagerly initialize the instance

private static final Singleton instance = new Singleton();

// Private constructor to prevent instantiation from other classes

private Singleton() {

// Initialization logic

System.out.println("Singleton instance created!");

}

// Public method to provide access to the instance

public static Singleton getInstance() {

return instance;

}

// Example method

public void showMessage() {

System.out.println("Hello from Singleton!");

}

}

class TestSingleton {

public static void main(String[] args) {

// Accessing Singleton instance

Singleton singleton = Singleton.getInstance();

singleton.showMessage();

}

}

**Explanation**:

* The instance is created at the time the class is loaded (instance is created as a static final variable).
* getInstance() provides the global access to the singleton instance.
* This approach is simple and thread-safe, but the instance is created even if it's not used.

**2. Lazy Initialization Singleton (Thread-Safe):**

In lazy initialization, the singleton instance is created only when it is first needed. However, we need to ensure thread-safety to prevent multiple threads from creating the instance simultaneously.

public class Singleton {

// Volatile variable to ensure visibility across threads

private static volatile Singleton instance;

// Private constructor to prevent instantiation from other classes

private Singleton() {

// Initialization logic

System.out.println("Singleton instance created!");

}

// Double-Checked Locking for thread-safety and lazy initialization

public static Singleton getInstance() {

if (instance == null) {

synchronized (Singleton.class) {

if (instance == null) {

instance = new Singleton();

}

}

}

return instance;

}

// Example method

public void showMessage() {

System.out.println("Hello from Singleton!");

}

}

class TestSingleton {

public static void main(String[] args) {

// Accessing Singleton instance

Singleton singleton = Singleton.getInstance();

singleton.showMessage();

}

}

**Explanation**:

* **volatile keyword** ensures that the instance is properly visible to all threads.
* Double-checked locking is used to make sure that the instance is created only once, and subsequent accesses are faster without synchronization overhead.
* This approach is efficient because it defers the instantiation until the first time getInstance() is called, and it ensures thread-safety.

**3. Bill Pugh Singleton (Singleton with Static Inner Class):**

This approach takes advantage of **Java's class loading mechanism** and ensures thread-safety while still being lazy-loaded.

public class Singleton {

// Private constructor to prevent instantiation

private Singleton() {

// Initialization logic

System.out.println("Singleton instance created!");

}

// Static inner class responsible for holding the singleton instance

private static class SingletonHelper {

// This is the instance that gets created only when the class is loaded

private static final Singleton INSTANCE = new Singleton();

}

// Public method to provide access to the instance

public static Singleton getInstance() {

return SingletonHelper.INSTANCE;

}

// Example method

public void showMessage() {

System.out.println("Hello from Singleton!");

}

}

class TestSingleton {

public static void main(String[] args) {

// Accessing Singleton instance

Singleton singleton = Singleton.getInstance();

singleton.showMessage();

}

}

**Explanation**:

* The instance is created when the SingletonHelper class is loaded for the first time, and this happens only when the getInstance() method is called.
* **Lazy initialization** and **thread safety** are handled automatically by the JVM, ensuring that the instance is created only once and in a thread-safe manner.
* This method is preferred for implementing singletons in modern Java applications.

**Comparing Different Singleton Implementations**

| **Method** | **Description** |
| --- | --- |
| **Eager Initialization** | The instance is created at the time of class loading. Simple but does not optimize for performance as the instance is always created even if it’s not used. |
| **Lazy Initialization (Thread-Safe)** | The instance is created only when needed, but thread-safety is managed with synchronization. |
| **Bill Pugh Singleton** | This is the preferred way of implementing Singleton because it is both **thread-safe** and **lazy-loaded** without needing synchronization. It uses the **Static Inner Class** mechanism. |

**When to Use Singleton Beans in a Spring Application**

In Spring, beans can be singleton by default. When you define a bean in the Spring context, Spring creates only one instance of that bean and uses it for all requests. This is done automatically unless you specify a different scope (e.g., @Scope("prototype")).

@Component

public class SingletonBean {

// Singleton bean in Spring context

public void showMessage() {

System.out.println("Hello from Singleton Bean in Spring!");

}

}

@Configuration

public class AppConfig {

// Defining the singleton bean in Spring

@Bean

public SingletonBean singletonBean() {

return new SingletonBean();

}

}

In Spring, the Singleton pattern ensures that only one instance of the bean is created for the entire Spring context, making it an easy way to implement shared services like database connections, configuration settings, etc.

**Conclusion**

* **Custom Singleton implementation** is useful when you need to control how and when your class instances are created, as in the case of database connections, logging, etc.
* **Spring's Singleton Beans** offer a more automatic and convenient approach, where Spring takes care of the bean lifecycle, and you can simply define beans and their dependencies.

Depending on the use case, you can choose the most appropriate Singleton implementation method to ensure your code is efficient, thread-safe, and maintainable.

### **What is the default scope of beans?**

* In **Spring Framework**, the default scope of beans is **singleton**.

**Default Bean Scope - Singleton**

* **Singleton scope** means that **Spring will create only one instance of the bean**, and that single instance will be shared across the entire Spring container (i.e., across the entire application).
* This is the default scope, meaning if you don't explicitly specify a scope for a bean, Spring will treat it as a singleton.

**How It Works:**

* When the Spring container is initialized, a single instance of the bean is created.
* All requests for that bean will return the same instance.
* The bean is created only once, regardless of how many times it is requested.

**Example of Singleton Bean in Spring (Default):**

@Component

public class MySingletonBean {

public MySingletonBean() {

System.out.println("Singleton Bean Instance Created");

}

public void printMessage() {

System.out.println("Hello from Singleton Bean!");

}

}

**Accessing the Singleton Bean:**

@Configuration

@ComponentScan(basePackages = "com.example") // This will scan and register beans in the given package.

public class AppConfig {

}

public class MainApp {

public static void main(String[] args) {

ApplicationContext context = new AnnotationConfigApplicationContext(AppConfig.class);

MySingletonBean bean1 = context.getBean(MySingletonBean.class);

bean1.printMessage();

MySingletonBean bean2 = context.getBean(MySingletonBean.class);

bean2.printMessage();

System.out.println(bean1 == bean2); // This will print "true" because both are the same instance

}

}

**Output:**

Singleton Bean Instance Created

Hello from Singleton Bean!

Hello from Singleton Bean!

true

Here, bean1 and bean2 are pointing to the same instance, which confirms the **singleton scope**.

**Other Bean Scopes in Spring:**

While **singleton** is the default scope, Spring provides other bean scopes that can be explicitly defined. These include:

1. **Prototype**: A new instance of the bean is created every time it is requested.
   * @Scope("prototype")
2. **Request**: A single bean is created per HTTP request. This scope is typically used in web applications.
   * @Scope("request")
3. **Session**: A single bean is created per HTTP session. Used in web applications for session-scoped beans.
   * @Scope("session")
4. **GlobalSession**: A single bean is created per global HTTP session in portlet-based applications.
   * @Scope("globalSession")

By default, unless specified otherwise, Spring beans are singleton-scoped. You can override this behavior with the @Scope annotation.

### **Difference between static and final?**

* Answer

The keywords **static** and **final** in Java are used for different purposes. Here’s a detailed explanation of both and their differences:

**1. static keyword:**

* **Purpose**: Used to define class-level variables and methods, meaning they belong to the class rather than instances of the class.
* **Scope**: A static variable or method is shared by all instances of the class.
* **Usage**:
  + **Static Variables**: They are initialized once and shared by all objects of the class.
  + **Static Methods**: They can be invoked without creating an instance of the class.

**Example:**

class MyClass {

static int counter = 0; // Static variable

static void incrementCounter() { // Static method

counter++;

}

}

public class Test {

public static void main(String[] args) {

MyClass.incrementCounter();

MyClass.incrementCounter();

System.out.println(MyClass.counter); // Outputs: 2

}

}

* In this example, the counter variable is **static**, so all instances of MyClass will share the same counter value.

**2. final keyword:**

* **Purpose**: Used to define constants, prevent method overriding, and prevent inheritance.
* **Usage**:
  + **Final Variable**: A final variable can only be assigned once and its value cannot be changed after initialization (i.e., it acts as a constant).
  + **Final Method**: A final method cannot be overridden by subclasses.
  + **Final Class**: A final class cannot be subclassed.

**Example:**

class MyClass {

final int MAX\_VALUE = 100; // Final variable (constant)

final void displayMessage() { // Final method (cannot be overridden)

System.out.println("This is a final method.");

}

}

class AnotherClass extends MyClass {

// Trying to override the final method will result in a compile-time error

// void displayMessage() { // Error: Cannot override the final method

// System.out.println("New message.");

// }

}

public class Test {

public static void main(String[] args) {

MyClass obj = new MyClass();

System.out.println(obj.MAX\_VALUE); // Outputs: 100

}

}

**Differences between static and final:**

| **Aspect** | **static** | **final** |
| --- | --- | --- |
| **Definition** | Used to declare class-level variables or methods. | Used to make variables constant, prevent method overriding, or prevent class inheritance. |
| **Application** | Applies to variables, methods, and blocks. | Applies to variables, methods, and classes. |
| **Usage** | Shared among all instances of the class. | Makes variables constant, methods non-overridable, and classes non-subclassable. |
| **Variable** | A static variable is shared by all objects of the class. | A final variable can be assigned only once and cannot be modified after that. |
| **Method** | A static method can be called without creating an instance of the class. | A final method cannot be overridden by subclasses. |
| **Class** | A static class is not possible, but static inner classes are allowed. | A final class cannot be extended (i.e., no subclassing). |

**Example to Combine Both (static and final):**

class MyClass {

static final int MAX\_LIMIT = 100; // static final variable (constant)

static void displayLimit() {

System.out.println("Max Limit: " + MAX\_LIMIT); // Static method using final constant

}

}

public class Test {

public static void main(String[] args) {

MyClass.displayLimit(); // Outputs: Max Limit: 100

}

}

In this case, MAX\_LIMIT is both **static** and **final**, meaning it's shared across all instances and cannot be modified after being assigned.

**Summary:**

* **static**: Refers to class-level members (variables, methods) that are shared across all instances of the class.
* **final**: Used to make variables constant, prevent method overriding, or prevent class inheritance.

### **Explain about String class in java?**

* Answer

The **String** class in Java is one of the most widely used classes, and it represents a sequence of characters. It is immutable, meaning once a String object is created, its value cannot be changed. The String class belongs to the java.lang package and provides numerous methods to work with strings.

**Key Points about the String class in Java:**

**1. Immutable Nature:**

* **Immutability** means that once a String object is created, its value cannot be changed.
* Any operation that modifies a string, such as concatenation, actually creates a new String object, leaving the original object unchanged.

**2. String Pool:**

* **String Pool** (also called **String Constant Pool**) is a special storage area in the heap memory where **String literals** are stored.
* When a new String object is created using a literal, Java checks if that string already exists in the pool. If it does, the reference to the existing string is returned. Otherwise, the new string is added to the pool.
* This helps reduce memory usage and improve performance by reusing existing String objects.

**3. String Declaration:**

A string in Java can be declared in two ways:

1. **Using String literal** (which goes into the String Pool):
2. String str1 = "Hello";
3. **Using the new keyword**:
4. String str2 = new String("Hello");

The second method creates a new String object in the heap, but it may also add it to the String Pool if the string is not already present.

**4. String Methods:**

The String class provides a wide range of methods for string manipulation. Some commonly used methods include:

* **length()**: Returns the length of the string.
* String str = "Hello";
* System.out.println(str.length()); // Output: 5
* **charAt(int index)**: Returns the character at the specified index.
* System.out.println(str.charAt(1)); // Output: e
* **concat(String str)**: Concatenates the specified string to the original string.
* System.out.println(str.concat(" World")); // Output: Hello World
* **equals(Object obj)**: Compares the current string to another object (usually a string) to check for equality.
* String str1 = "Hello";
* String str2 = "hello";
* System.out.println(str1.equals(str2)); // Output: false
* **equalsIgnoreCase(String str)**: Compares two strings, ignoring case differences.
* System.out.println(str1.equalsIgnoreCase("hello")); // Output: true
* **substring(int beginIndex, int endIndex)**: Returns a substring of the string.
* System.out.println(str.substring(0, 3)); // Output: Hel
* **toUpperCase()** and **toLowerCase()**: Converts the string to uppercase or lowercase.
* System.out.println(str.toUpperCase()); // Output: HELLO
* System.out.println(str.toLowerCase()); // Output: hello
* **trim()**: Removes leading and trailing whitespace.
* String str3 = " Hello ";
* System.out.println(str3.trim()); // Output: Hello
* **replace(CharSequence oldChar, CharSequence newChar)**: Replaces all occurrences of a substring.
* System.out.println(str.replace("e", "a")); // Output: Hallo

**5. StringBuilder and StringBuffer:**

While the String class is immutable, there are other classes like **StringBuilder** and **StringBuffer** which are mutable and allow modification of strings without creating new objects. These are generally used when performing many operations on strings to avoid creating too many objects.

* **StringBuilder**: Not synchronized and thus faster than StringBuffer.
* **StringBuffer**: Synchronized and thread-safe.

Example of StringBuilder:

StringBuilder sb = new StringBuilder("Hello");

sb.append(" World");

System.out.println(sb.toString()); // Output: Hello World

**6. Performance of String Concatenation:**

* **Using + operator**: String concatenation using + creates a new String object each time, which leads to memory overhead and is inefficient in a loop.
* String result = "Hello";
* result += " World"; // Inefficient for large concatenations
* **Using StringBuilder**: More efficient as it modifies the string without creating new objects.
* StringBuilder sb = new StringBuilder("Hello");
* sb.append(" World");

**7. Interning of Strings:**

The String class also has a special method **intern()**, which can be used to return a canonical representation of the string. If the string is already in the string pool, it returns the existing string reference; otherwise, it adds the string to the pool.

Example:

String str1 = "Hello";

String str2 = new String("Hello").intern();

System.out.println(str1 == str2); // Output: true (same reference)

**Example Code Using String Class:**

public class StringExample {

public static void main(String[] args) {

String str1 = "Java";

String str2 = "Java";

// String literal comparison (String Pool)

System.out.println(str1 == str2); // true

// String with new keyword

String str3 = new String("Java");

System.out.println(str1 == str3); // false

// Methods from String class

String str4 = " Hello, World! ";

System.out.println(str4.trim()); // Output: Hello, World!

System.out.println(str4.length()); // Output: 15

System.out.println(str4.substring(7, 12)); // Output: World

System.out.println(str4.toUpperCase()); // Output: HELLO, WORLD!

System.out.println(str4.replace("World", "Java")); // Output: Hello, Java!

}

}

**Summary:**

* **Immutable**: Once a String is created, its value cannot be changed.
* **String Pool**: A pool to manage memory efficiently for String literals.
* **Efficient String Operations**: Use StringBuilder or StringBuffer for concatenation and manipulation in a loop or frequent modification scenarios.
* **Wide Range of Methods**: String provides a rich set of methods to perform various string operations like comparison, extraction, transformation, etc.

### **What is a special feature of String?**

* Answer

The **special feature** of the String class in Java is its **immutability**. This means that once a String object is created, its value cannot be changed. Here are the key aspects of this special feature:

**1. Immutability of Strings:**

* **Immutability** means that the state of a String object cannot be changed once it is created. Any operation that appears to modify a string actually creates a new String object.
* This provides several benefits:
  + **Thread safety**: Multiple threads can safely share and use a String without synchronization, as it cannot be modified.
  + **Security**: Since String objects cannot be altered, they are more secure in contexts such as database queries, network communication, or as keys in hash maps, where their values must remain consistent.
  + **Performance optimization**: Java uses **String Pooling**, which can help improve memory usage and reduce overhead by reusing string literals.

**2. String Pool:**

* The **String Pool** (also called **String Constant Pool**) is a special area of memory in the Java heap where string literals are stored.
* If a String literal is created, Java first checks whether the string already exists in the pool. If it does, it reuses the existing string reference, thereby saving memory.
* For example:
* String str1 = "Hello";
* String str2 = "Hello";
* System.out.println(str1 == str2); // true, both refer to the same object in the pool
* If you create a String using the new keyword, it may be placed in the heap, but you can also intern it to store it in the String Pool.

**3. Efficient Memory Management:**

* Since strings are immutable, the JVM can optimize memory usage and reduce the number of objects created.
* The string pool allows the reuse of identical strings, saving memory for large applications.

**4. String Concatenation:**

* When you concatenate strings using the + operator, a new String object is created for every concatenation. This is because String is immutable.
* However, when multiple concatenations are done inside loops, it's better to use **StringBuilder** or **StringBuffer** to avoid creating too many intermediate String objects.

**5. Equals and Hashcode:**

* The String class overrides the **equals()** and **hashCode()** methods from the Object class to compare strings based on their values, not references.
* This ensures that strings with the same content have the same hash code and are considered equal, which is critical when strings are used as keys in hash-based collections like HashMap.

**6. Efficiency in Search Operations:**

* Because strings are immutable and their state cannot be altered, operations like **searching** or **pattern matching** are made faster, especially when combined with string pooling.
* The immutability also makes them ideal for use as keys in collections like HashMap, where consistency is crucial.

**7. Thread Safety:**

* Since String objects are immutable, they are inherently thread-safe, meaning they can be safely used by multiple threads simultaneously without additional synchronization mechanisms.

**Example:**

public class StringExample {

public static void main(String[] args) {

String str1 = "Hello"; // Created in the string pool

String str2 = "Hello"; // Reused from the pool

String str3 = new String("Hello"); // Created in the heap

// Checking if str1 and str2 refer to the same object in the pool

System.out.println(str1 == str2); // true

// Checking if str1 and str3 refer to the same object

System.out.println(str1 == str3); // false (str3 is in heap, str1 is in the pool)

}

}

**Conclusion:**

The **immutable nature** of the String class is the defining feature, which provides benefits such as thread safety, memory optimization, and reliable equality checks. The use of the **String Pool** further enhances efficiency by reusing string literals across the application.

### **How to access Singleton class from another class?**

* Answer

To access a **Singleton class** from another class in Java, you follow the **Singleton Design Pattern**. The main idea behind this pattern is to ensure that a class has only one instance and provides a global point of access to that instance.

Here’s how you can implement and access a Singleton class:

**Step-by-Step Process:**

1. **Create a Singleton Class**:
   * The Singleton class has a private static reference to itself and a private constructor to prevent instantiation from outside.
   * It provides a public method (typically named getInstance()) to get the instance of the class.
2. **Access Singleton Class from Another Class**:
   * The other class can access the Singleton instance by calling the getInstance() method of the Singleton class.

**Example:**

**Step 1: Singleton Class Implementation**

public class Singleton {

// Step 1: Create a private static instance of the class

private static Singleton instance;

// Step 2: Make the constructor private so it cannot be instantiated from outside

private Singleton() {

// Constructor logic (if needed)

}

// Step 3: Provide a public static method to get the instance

public static Singleton getInstance() {

if (instance == null) {

// If the instance is null, create a new one

instance = new Singleton();

}

return instance; // Return the instance

}

// A method to demonstrate some functionality

public void showMessage() {

System.out.println("Hello from Singleton!");

}

}

**Step 2: Access Singleton from Another Class**

public class Main {

public static void main(String[] args) {

// Accessing Singleton instance using getInstance method

Singleton singleton = Singleton.getInstance();

// Call the showMessage method of the Singleton instance

singleton.showMessage();

// Confirming that it's the same instance

Singleton singleton2 = Singleton.getInstance();

System.out.println(singleton == singleton2); // true, both refer to the same instance

}

}

**Explanation:**

* **Private static instance**: The instance field is static and private, meaning only the Singleton class can access it directly.
* **Private constructor**: The constructor is private, so no other class can directly instantiate a Singleton object using new Singleton().
* **Public static getInstance() method**: This method checks if the instance is already created. If not, it creates a new one. This ensures that only one instance of the class exists (singleton). It returns the single instance of the class.
* **Accessing the Singleton**: In the Main class (or any other class), you can access the Singleton class by calling Singleton.getInstance(). This ensures that no matter how many times you access it, you'll always get the same instance.

**Output:**

Hello from Singleton!

true

**Key Points:**

* The **Singleton class** ensures only **one instance** of the class is created throughout the application.
* You can access the instance using the getInstance() method.
* The instance is lazily initialized, meaning it is only created when it is needed for the first time.

### **Where will the Singleton class be stored in memory?**

* Answer

In Java, the **Singleton class** is stored in the **Heap memory** because it is an object created during runtime. Specifically, the instance of the Singleton class is created in the **heap memory** when it is first accessed.

Here's a detailed breakdown of how and where the Singleton class is stored in memory:

**1. Class Definition (in the Method Area/Metaspace):**

* When the **Singleton class** is loaded into memory by the JVM, its class definition (metadata) is stored in the **Method Area** (in older versions of Java, this was part of the PermGen space; from Java 8 onwards, it's part of Metaspace).
* The **Method Area/Metaspace** contains information about the class, including its methods, fields, and other metadata. This is shared across all instances of the class.

**2. Singleton Instance (in the Heap Memory):**

* The **Singleton instance** itself is stored in the **Heap memory**. The heap is where all objects in Java are allocated at runtime.
* When you call Singleton.getInstance(), the first time, the instance is created in the heap memory.
* If the instance is already created, it simply returns the reference to the existing instance (no new object creation).

**3. Instance Reference:**

* The reference to the Singleton instance (e.g., instance in the getInstance() method) is stored in the **Heap memory** as well.
* The reference variable is typically a static variable in the Singleton class, meaning it's shared among all invocations of the class.

**4. Garbage Collection:**

* The Singleton instance, like other objects in Java, will remain in memory until it is no longer referenced and is eligible for garbage collection.
* Since the Singleton class is designed to ensure only one instance is created and it persists throughout the application's life, this instance typically lives as long as the application is running. It will be collected only if there are no references to it and the class loader can be garbage collected.

**Example:**

public class Singleton {

// Static reference to the single instance of the class

private static Singleton instance;

// Private constructor to prevent instantiation

private Singleton() { }

// Method to get the instance

public static Singleton getInstance() {

if (instance == null) {

instance = new Singleton(); // Created in the heap memory

}

return instance; // Reference is returned

}

}

public class Main {

public static void main(String[] args) {

// Accessing Singleton instance

Singleton singleton1 = Singleton.getInstance();

Singleton singleton2 = Singleton.getInstance();

System.out.println(singleton1 == singleton2); // true

}

}

**Memory Storage Summary:**

* **Class Metadata** (like method definitions, fields, etc.) is stored in the **Method Area** (Metaspace).
* **Singleton instance object** is stored in the **Heap memory**.
* The **reference to the Singleton instance** is stored in the **Heap memory**.

**Key Points:**

* The **Singleton instance** is only created once and resides in the heap memory after the first call to getInstance().
* The **Singleton class's static reference** (e.g., instance field) resides in the heap memory but is shared across all threads, which allows the instance to be accessed globally.

### **Difference between bucket level and segment level locking?**

* Answer

**Bucket-level locking** and **segment-level locking** are both types of locking mechanisms used in hash-based data structures (like hash maps or hash tables) to manage concurrent access to shared data. These mechanisms help ensure thread safety and data consistency in multi-threaded environments. Here's a detailed explanation of the two:

**1. Bucket-level Locking:**

**Definition**: In **bucket-level locking**, each **bucket** (or individual slot) in the hash table has its own lock. A "bucket" typically refers to a location in the table that stores one or more key-value pairs, often implemented as a linked list or other data structures.

**Characteristics**:

* **Granularity**: Locking is done at a fine-grained level, meaning that a thread will lock only the specific bucket that it is modifying.
* **Concurrency**: This approach allows multiple threads to access different buckets simultaneously (if they are modifying different buckets), improving concurrency and performance.
* **Locking Scope**: Only the particular bucket being accessed is locked. Other buckets can still be accessed or modified by other threads concurrently.
* **Performance**: Since only individual buckets are locked, it reduces contention (fewer threads are blocked), leading to better performance when multiple threads are working on different buckets.

**Advantages**:

* Higher concurrency compared to segment-level locking because each bucket can be accessed by different threads independently.
* Fine-grained locking helps in achieving better throughput and scalability.

**Disadvantages**:

* Managing multiple locks can be more complex.
* If multiple keys map to the same bucket (in case of hash collisions), it can still lead to contention within that bucket.

**Example of Bucket-level Locking:**

Imagine a hash map where each bucket is a linked list of entries, and each list has a lock. Different threads can operate on different buckets without interference.

**2. Segment-level Locking:**

**Definition**: In **segment-level locking**, the hash table is divided into **segments**, and a single lock is used for each segment. Each segment contains a subset of the buckets. When a thread wants to access a bucket within a segment, it must acquire the lock for that segment, which locks all buckets within the segment.

**Characteristics**:

* **Granularity**: Locking is done at a coarser level (the segment level), meaning that multiple buckets within the same segment are locked together.
* **Concurrency**: Multiple threads can access buckets in different segments simultaneously, but only one thread can access the buckets in a particular segment at a time.
* **Locking Scope**: All buckets within the segment are locked at once. So, even if a thread needs to access only one bucket within the segment, the entire segment is locked.
* **Performance**: While it provides better concurrency than global locking, it is not as efficient as bucket-level locking since threads accessing different buckets within the same segment are blocked.

**Advantages**:

* Simpler to manage than bucket-level locking, as fewer locks are involved.
* Effective in scenarios where the hash table is split into segments that are less frequently accessed simultaneously.

**Disadvantages**:

* Lower concurrency compared to bucket-level locking because multiple buckets within a segment are locked together.
* Threads accessing different buckets within the same segment cannot operate concurrently, which could cause contention and performance bottlenecks.

**Example of Segment-level Locking:**

In a hash table with 4 segments, if a thread wants to access a bucket in Segment 2, it needs to acquire the lock for Segment 2, which will lock all buckets in that segment. Threads accessing other segments can still run concurrently.

**Key Differences Between Bucket-level and Segment-level Locking:**

| **Aspect** | **Bucket-level Locking** | **Segment-level Locking** |
| --- | --- | --- |
| **Granularity** | Fine-grained (lock per bucket) | Coarse-grained (lock per segment) |
| **Concurrency** | Higher concurrency (more independent access to buckets) | Lower concurrency (locks entire segment, blocking other buckets in the same segment) |
| **Locking Scope** | Locks individual buckets | Locks all buckets within a segment |
| **Performance** | Better performance in high-concurrency scenarios | Can result in contention in scenarios where multiple threads access different buckets in the same segment |
| **Complexity** | More complex to manage multiple locks | Simpler to manage fewer locks |
| **Contention** | Less contention, unless there are hash collisions within a bucket | More contention if multiple threads access the same segment |

**When to Use Which:**

* **Bucket-level locking** is preferred when you have a hash table with high concurrency demands and minimal collisions between keys. It is useful when you expect threads to access different buckets frequently.
* **Segment-level locking** is useful when your hash table is divided into logical partitions, and you want a simpler locking strategy, even at the cost of concurrency. It can be suitable in cases where you expect fewer simultaneous accesses to different segments.

### **How is the static method bound with an object?**

* Answer

In Java, **static methods** are not bound to an instance (object) of a class but are bound to the **class** itself. This means that a static method can be called without creating an instance of the class, and it is associated with the class rather than with any particular object of that class.

**Key Points to Understand:**

1. **Static Method Definition**:
   * A static method is defined using the static keyword in the method signature. Static methods belong to the class itself rather than to instances of the class.
2. class MyClass {
3. static void staticMethod() {
4. System.out.println("This is a static method.");
5. }
6. }
7. **Static Method Call**:
   * You can call a static method using the class name directly, without the need to create an object.
8. MyClass.staticMethod(); // Calling static method without creating an object
9. **Binding of Static Methods**:
   * Static methods are **bound at compile-time**, not runtime. This is known as **early binding** or **static binding**.
   * When you call a static method, the method is resolved at compile-time based on the class type.
   * Even if you invoke a static method via an object reference, it is still bound to the class type, not the object type.

**Example:**

class MyClass {

static void staticMethod() {

System.out.println("This is a static method.");

}

}

class Test {

public static void main(String[] args) {

MyClass obj = new MyClass();

// Calling the static method via object reference (not recommended)

obj.staticMethod(); // It's bound to MyClass, not the obj instance.

// Correct way of calling static method

MyClass.staticMethod();

}

}

**Output:**

This is a static method.

This is a static method.

Even though we called the static method on the obj instance, it was still resolved at compile-time to MyClass.staticMethod(). This shows that static methods are bound to the class at compile-time, not to the instance.

**Why Static Methods Are Bound to the Class:**

* Static methods are designed to operate on **class-level data** (i.e., static variables) rather than instance-level data (i.e., instance variables). Since they are not tied to any specific object, they belong to the class itself.
* The JVM knows the static method belongs to the class at the time of compilation, which is why static methods are **resolved at compile-time**.

**Key Differences in Method Binding:**

* **Static methods**: Bound at compile-time (early binding).
* **Instance methods**: Bound at runtime (late binding), depending on the actual object type.

Thus, **static methods are not associated with instances of the class, but with the class itself**. While it is technically possible to invoke a static method using an object reference, it is best practice to call static methods using the class name directly for clarity and convention.

### **What is the use of the intern() method in String class?**

* The **intern()** method in the String class in Java is used to **ensure that strings with the same content share the same memory**. When you call the intern() method on a string, it checks if an identical string already exists in the **string pool** (a special memory region where Java stores strings). If the string is found in the pool, a reference to that string is returned. If the string is not found, it is added to the pool, and then a reference to it is returned.

**Key Points about intern():**

1. **String Pool**:
   * In Java, there is a special **String Pool** (or **String Constant Pool**) in memory where all string literals are stored. When you create a string literal (e.g., "Hello"), Java checks the pool to see if the string already exists. If it exists, Java uses the reference to the existing string; if not, it creates a new string in the pool.
   * The **intern() method** allows strings that are not literals (dynamically created strings) to be added to the pool, ensuring that strings with the same content share the same reference.
2. **Usage of intern()**:
   * When you invoke intern() on a string, it ensures that the string either points to an existing string in the pool (if it matches another string) or is added to the pool.
   * This can be particularly useful for optimizing memory usage, as it eliminates duplicate strings and ensures that strings with the same value are stored only once.

**Example:**

public class InternExample {

public static void main(String[] args) {

String str1 = new String("Hello");

String str2 = new String("Hello");

// Without using intern()

System.out.println(str1 == str2); // false, because they are different objects

// Using intern() method

String str3 = str1.intern();

String str4 = str2.intern();

// After using intern()

System.out.println(str3 == str4); // true, because both refer to the same string in the pool

}

}

**Output:**

false

true

**Explanation:**

* Without intern(), str1 and str2 are two distinct objects in memory, even though they have the same content ("Hello").
* After calling intern() on both str1 and str2, both str3 and str4 point to the same string in the string pool, which is why str3 == str4 returns true.

**Benefits of intern():**

* **Memory Optimization**: If you have many strings with the same content (e.g., user input or dynamically generated strings), calling intern() ensures that only one instance of each unique string is stored in memory, saving space.
* **String Comparisons**: Since strings in the string pool are guaranteed to be unique by reference, you can use == to compare string references instead of equals() to check if two strings are the same, which can be faster.

**Potential Drawbacks:**

* **Performance Impact**: Interning strings may have a small performance overhead because Java needs to search the string pool to check for existing strings.
* **Memory Consumption**: While interning can save memory for repeated strings, if overused, it can increase memory consumption by filling up the string pool with too many distinct strings.

**Conclusion:**

The intern() method is useful for optimizing memory usage when you have many duplicate strings in your application. By ensuring that identical strings share the same reference in the string pool, you can reduce memory overhead and speed up string comparison using ==. However, it should be used carefully, as excessive interning might cause the string pool to grow larger than necessary.

## **Java Memory Management**

### **Explain JDK, JRE?**

* Answer

**✅ JDK vs JRE – Explained Simply**

**🔹 JDK (Java Development Kit)**

* **What is it?**  
  JDK is a **complete software development kit** used to **develop Java applications**.
* **What does it include?**
  + **JRE** (Java Runtime Environment)
  + **Compiler (javac)** – to compile .java files into .class files
  + **Debugger**
  + **Tools** for monitoring and developing Java applications (like javadoc, javap, etc.)
* **Purpose:**  
  Needed by **developers** to write, compile, and run Java programs.
* **Use Case:**  
  When you're developing Java applications, **install the JDK**.

**🔹 JRE (Java Runtime Environment)**

* **What is it?**  
  JRE provides the **minimum environment to run Java applications**.
* **What does it include?**
  + **JVM** (Java Virtual Machine)
  + **Core Java libraries** (like java.lang, java.util)
  + Supporting files and class loaders
* **Purpose:**  
  Needed by **users** or **production environments** to **run** Java applications (not develop).
* **Use Case:**  
  If you're only running Java applications (not writing code), **install only JRE**.

**🆚 Difference Table**

| **Feature** | **JDK** | **JRE** |
| --- | --- | --- |
| Full form | Java Development Kit | Java Runtime Environment |
| Contains | JRE + Development tools | JVM + Libraries |
| Purpose | Develop + Run Java code | Only Run Java code |
| Includes Compiler | ✅ Yes | ❌ No |
| Includes JVM | ✅ Yes | ✅ Yes |
| Who uses it? | Developers | End-users |

**🔸 Bonus: JVM (Java Virtual Machine)**

* Executes the compiled Java bytecode (.class files)
* Converts bytecode into **machine-specific code** at runtime
* Platform-independent execution

### **Explain JVM?**

* Answer

The **Java Virtual Machine (JVM)** is the **engine** that runs Java applications.

Think of it as:

A virtual computer that runs your compiled Java bytecode (.class files), not the source code (.java).

**🔹 Main Responsibilities of JVM**

| **Role** | **Description** |
| --- | --- |
| **Loads** | Loads the .class file generated by the Java compiler |
| **Verifies** | Checks bytecode for security and correctness |
| **Executes** | Executes the bytecode using the Just-In-Time (JIT) compiler |
| **Manages Memory** | Handles heap, stack, garbage collection |

**🔹 JVM Architecture (High-Level)**

1. **Class Loader System**
   * Loads .class files into JVM
   * Handles loading, linking, and initialization
2. **Method Area**
   * Stores class-level structures (metadata, static variables, method info)
3. **Heap**
   * Stores objects and instance variables (shared)
4. **Stack**
   * Stores method frames (local variables, partial results)
5. **Program Counter (PC) Register**
   * Points to the current executing instruction
6. **Execution Engine**
   * Runs the bytecode
   * Uses JIT (Just-In-Time Compiler) for optimization
7. **Native Method Interface & Libraries**
   * Enables Java to call non-Java (native) code like C/C++

**🔹 JVM vs JRE vs JDK**

| **Component** | **Description** |
| --- | --- |
| **JVM** | Part of JRE, responsible for running Java bytecode |
| **JRE** | Includes JVM + libraries to run Java apps |
| **JDK** | Includes JRE + tools to develop Java apps |

**🔸 Platform Independence**

* Java code is **compiled into bytecode** (not machine code)
* This bytecode is **platform-independent**
* The **JVM on each platform interprets or compiles it to native code**

**🔹 Example**

java

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public class HelloWorld {

public static void main(String[] args) {

System.out.println("Hello from JVM!");

}

}

* Compiled to HelloWorld.class (bytecode)
* JVM loads and runs the bytecode

### **What are the different loaders in JVM?**

* Answer

Class loaders in Java **dynamically load classes into memory** when required. They're part of the JVM and follow the **parent delegation model** to maintain security and consistency.

**🧠 Types of Class Loaders**

| **Class Loader** | **Description** |
| --- | --- |
| **1. Bootstrap ClassLoader** | Loads core Java classes from rt.jar (like java.lang.\*, java.util.\*). Part of the JVM, written in native code. |
| **2. Extension (Platform) ClassLoader** | Loads classes from the ext directory ($JAVA\_HOME/lib/ext). Now replaced by **Platform ClassLoader** from Java 9. |
| **3. Application (System) ClassLoader** | Loads classes from the **classpath** specified by the user (.class files or JARs). |
| **4. Custom ClassLoader** | User-defined loader by extending ClassLoader class, useful for advanced use cases like encryption, hot reloading, etc. |

**🔄 Parent Delegation Model (Hierarchy)**

scss

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Bootstrap

↑

Extension (Platform)

↑

Application (System)

↑

Custom ClassLoader (if created)

Each class loader **delegates** the loading task to its **parent first**. If the parent cannot find the class, **only then** does the current loader try.

**🧪 Example: Check Which ClassLoader Loaded a Class**

java

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public class TestLoader {

public static void main(String[] args) {

System.out.println("String class loader: " + String.class.getClassLoader());

System.out.println("TestLoader class loader: " + TestLoader.class.getClassLoader());

}

}

**Output:**

kotlin

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String class loader: null // Loaded by Bootstrap (native)

TestLoader class loader: jdk.internal.loader.ClassLoaders$AppClassLoader@...

**🔧 Use Case for Custom ClassLoader**

* Loading classes over the network
* Implementing sandboxed environments (JVM security)
* Hot deployment in frameworks like Spring, Tomcat, OSGi

### **What is JVM profiling?**

* **JVM profiling** is the process of **monitoring and analyzing the performance** of a Java application running on the **Java Virtual Machine (JVM)** to identify bottlenecks, memory leaks, thread issues, CPU usage, and more.

It helps developers understand **how the application behaves at runtime**, which parts of the code consume the most resources, and how to optimize it.

**✅ Key Aspects of JVM Profiling:**

**Memory Usage**:

Monitor **heap** and **non-heap** memory usage.

Detect **memory leaks** or **excessive garbage collection (GC)**.

Analyze **object creation** and memory retention.

**CPU Usage**:

Identify **methods or classes** consuming the most CPU time.

Analyze **hotspots** in the code.

**Garbage Collection (GC)**:

Track how often GC occurs and how much time it takes.

Tune JVM GC settings based on profiling.

**Thread Activity**:

Monitor thread states (running, waiting, blocked).

Detect **deadlocks**, **thread contention**, and **race conditions**.

**Class Loading**:

Analyze which classes are loaded/unloaded and their memory footprint.

**🛠 Common JVM Profiling Tools:**

| **Tool** | **Description** |
| --- | --- |
| **JVisualVM** | Bundled with JDK; visual profiler for memory, CPU, GC, threads. |
| **JConsole** | Lightweight monitoring tool; good for basic profiling. |
| **YourKit** | Commercial, advanced features for memory, threads, GC analysis. |
| **JProfiler** | Commercial, very powerful for CPU/memory/thread profiling. |
| **Flight Recorder & Mission Control** | Built into Oracle JDK; low-overhead continuous profiling. |
| **Async Profiler** | Open-source, low-overhead async CPU and memory profiler. |
| **Perf (Linux)** + **Java Flame Graphs** | Advanced profiling using Linux performance tools. |

**🧠 Example Use Case:**

* You notice your Java app is **slowing down** over time.
* You use **JVisualVM** to attach to the running JVM.
* It shows:
* **Heap memory** constantly growing → Possible **memory leak**.
* Certain method taking 80% of **CPU time** → Optimize that logic.
* **Thread deadlock** between two threads → Fix synchronization issue.

**🧪 How to Start JVM Profiling (Example with JVisualVM):**

* 1. Start your Java application with:

java -jar myapp.jar

* 1. Open jvisualvm (comes with JDK).
  2. Attach to the running process.
  3. View tabs for **CPU**, **Memory**, **Threads**, **GC**, etc.
  4. Use **heap dump** and **profiling snapshots** for deep analysis.

**✅ Benefits:**

* Optimizes performance.
* Improves resource utilization.
* Detects memory leaks early.
* Helps fix concurrency issues.

### **Explain Java memory management?**

* Answer

Java memory management is how the **Java Virtual Machine (JVM)** allocates, manages, and reclaims memory. It helps ensure your application runs efficiently and doesn't crash due to memory leaks.

**🗂 Memory Areas in JVM**

**1. Heap Memory (Runtime data area)**

* Used to allocate memory for objects and class instances.
* Managed by **Garbage Collector**.
* Divided into:
  + **Young Generation** (new objects, short-lived)
    - Eden
    - Survivor Spaces (S0 and S1)
  + **Old (Tenured) Generation** (long-lived objects)
  + **Metaspace** (from Java 8+, stores class metadata)

**2. Stack Memory**

* Stores method calls, local variables, and references.
* Each thread has its own stack.
* Follows **LIFO** (Last-In-First-Out) model.
* Memory is freed automatically when the method ends.

**3. Method Area (Metaspace)**

* Stores class structure like runtime constant pool, field, method data, and bytecode.
* Shared among all threads.

**4. Program Counter (PC) Register**

* Contains the address of the current JVM instruction being executed.
* Each thread has its own PC.

**5. Native Method Stack**

* Used for native (non-Java) methods written in C/C++.

**♻️ Java Garbage Collection (GC)**

Garbage Collector reclaims memory from unreachable objects in Heap.

**GC Phases:**

* **Mark** – Identify which objects are still in use.
* **Sweep/Delete** – Reclaim memory of unused objects.
* **Compact** – Rearrange memory to avoid fragmentation.

**Common GC Algorithms:**

* Serial GC
* Parallel GC
* CMS (Concurrent Mark Sweep) – deprecated
* G1 (Garbage First) – default in Java 9+
* ZGC & Shenandoah – for low-latency applications

**📌 Example: GC in Action**

java

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public class MemoryTest {

public static void main(String[] args) {

for (int i = 0; i < 100000; i++) {

new Object(); // Creating objects

}

System.gc(); // Suggest GC to run

System.out.println("GC suggested");

}

}

**🔒 Best Practices for Memory Management**

* Avoid unnecessary object creation.
* Use appropriate data structures.
* Nullify references if not needed.
* Be cautious with static references.
* Use profiling tools (like VisualVM, JConsole).

### **What is Stack and Heap memory?**

* Answer

**🧠 Stack vs Heap Memory in Java**

Understanding **Stack** and **Heap** memory is essential for writing efficient Java programs and debugging memory-related issues.

**🗂️ 1. Stack Memory**

**📌 Characteristics:**

* Stores **method calls**, **local variables**, and **object references** (not the actual objects).
* Memory is **allocated per thread** (each thread has its own stack).
* Uses **Last In First Out (LIFO)** order.
* Memory is **automatically managed** (freed once the method call is complete).
* Faster access compared to heap.

**📘 Example:**

public void exampleMethod() {

int x = 10; // stored in stack

String name = "Java"; // reference in stack, object in string pool/heap

}

**🗃️ 2. Heap Memory**

**📌 Characteristics:**

* Stores **objects**, **arrays**, and **instance variables**.
* Shared across all threads.
* Memory is managed by the **Garbage Collector (GC)**.
* Slightly slower than stack due to complex management.

**📘 Example:**

Employee emp = new Employee(); // 'emp' reference is in stack, object is in heap

**🔍 Key Differences**

| **Feature** | **Stack Memory** | **Heap Memory** |
| --- | --- | --- |
| **Purpose** | Stores method calls, local variables | Stores objects, arrays |
| **Access Speed** | Faster | Slower |
| **Scope** | Thread-specific | Shared among threads |
| **Memory Allocation** | Static (at compile time) | Dynamic (at runtime) |
| **Managed By** | JVM automatically (stack frame) | Garbage Collector |
| **Lifetime** | Short-lived (method-specific) | Long-lived (until GC removes) |

**🧪 Visual Diagram (Simple)**

Thread Stack:

-------------

| methodB() |

| methodA() |

| main() |

-------------

↓ (calls)

Heap:

----------------------------

| new Employee() object |

| new String("Java") object |

----------------------------

### **Explain memory management below? Int and Integer?**

* Answer

Great question! Let's break down **memory management for int (primitive type)** and **Integer (wrapper class)** in Java 👇

**🔹 int vs Integer — Memory Management**

**✅ int (Primitive Type)**

* **Stored in:** Stack (if used as local variable).
* **Memory footprint:** Requires **4 bytes** of memory.
* **Not an object**, just a value.
* **No memory overhead**.

**🧠 Example:**

int a = 10;

* a is stored in **stack**.
* Fastest access and least memory usage.

**🟨 Integer (Wrapper Class for int)**

* **Stored in:** Heap (as it's an object).
* Holds a reference in stack, object in heap.
* **More memory** than int (due to object metadata).
* Allows nulls, useful in collections (like List<Integer>).

**🧠 Example:**

Integer b = new Integer(10); // discouraged, use valueOf()

Integer c = Integer.valueOf(10); // preferred way

**🧊 Integer Caching:**

* Java caches values from **-128 to 127** for performance.

Integer x = Integer.valueOf(127);

Integer y = Integer.valueOf(127);

System.out.println(x == y); // true, same cached object

Integer m = Integer.valueOf(128);

Integer n = Integer.valueOf(128);

System.out.println(m == n); // false, different objects

**🔍 Comparison Table:**

| **Feature** | **int** | **Integer** |
| --- | --- | --- |
| Type | Primitive | Wrapper class (Object) |
| Stored in | Stack | Heap (object), stack (reference) |
| Memory Usage | 4 bytes | More (object overhead) |
| Null Allowed | ❌ No | ✅ Yes |
| Use in Collections | ❌ Not allowed | ✅ Allowed (List<Integer>) |
| Auto-boxing | ❌ No | ✅ Yes (can convert from int) |

**🚀 When to use what?**

* ✅ Use **int** for performance & simple numeric logic.
* ✅ Use **Integer** when dealing with **Collections**, **nulls**, or **Objects** (like in generics).

### **Where local variables are stored in memory?**

* Answer

Local variables in Java are stored in **Stack memory**. Here's a detailed explanation 👇

**📍 Where Are Local Variables Stored?**

**✅ Stack Memory**

* Local variables (like method parameters or variables declared inside methods) are stored in the **stack frame** of the executing thread.
* Each method call creates a new **stack frame**, and local variables are created inside that.
* When the method finishes, its **stack frame is removed**, and local variables go out of scope.

**🧠 Example:**

public class MemoryExample {

public static void main(String[] args) {

int a = 10; // Local variable

String str = "Hello"; // Local reference variable

MyObject obj = new MyObject(); // Local reference to object in heap

}

}

class MyObject {

int x = 5;

}

* a (primitive) → stored directly in stack.
* str → reference in stack, "Hello" (String literal) is in **String Pool** (heap).
* obj → reference in stack, object itself is created in **heap**.

**🧰 Stack vs Heap**

| **Feature** | **Stack** | **Heap** |
| --- | --- | --- |
| Stores | Local variables, method calls | Objects, class instances |
| Memory allocation | Fast | Slower |
| Lifespan | Till method execution | Till no reference (GC eligible) |
| Thread safety | Each thread has its own | Shared among all threads |

### **Where objects will be stored in memory?**

* Answer

In Java, **objects** are stored in the **Heap memory**.

**📌 Where are objects stored?**

✅ **Heap Memory** — All objects created using new keyword (or implicitly via boxing, collections, etc.) are stored in the **heap**.

**💡 Example:**

class Car {

String model;

}

public class Main {

public static void main(String[] args) {

Car c = new Car(); // Object stored in heap, reference 'c' stored in stack

}

}

* Car object is created in **heap**.
* The reference c (which points to the object) is stored in the **stack** (in the method's stack frame).

**🧠 Quick Breakdown:**

| **Memory Area** | **Stores** |
| --- | --- |
| **Stack** | Method-local variables, references to objects |
| **Heap** | All objects, instance variables, arrays, Strings (non-literals) |
| **Method Area (MetaSpace in Java 8+)** | Class-level data, static variables |

**📦 Special Case: String Literals**

String s = "Hello";

* "Hello" is stored in the **String Pool**, which is part of the heap.
* s is a reference in the stack.

### **Explain Heap memory in java?**

* Answer

**🧠 What is Heap Memory in Java?**

**Heap memory** in Java is the portion of memory used for **dynamic memory allocation**, where all **Java objects**, **class instances**, and **arrays** are stored during runtime.

**📌 Key Points about Heap Memory:**

| **Feature** | **Description** |
| --- | --- |
| **Used For** | Storing all objects and their instance variables |
| **Lifetime** | Objects live in heap as long as they are reachable (not garbage collected) |
| **Shared** | Heap is shared among all threads |
| **Managed By** | Java Virtual Machine (JVM) |
| **GC** | Garbage Collector automatically cleans up unreachable objects in heap |

**✅ What goes into the Heap?**

* Objects created using new
* Arrays (int[], String[], etc.)
* Class instances (Student s = new Student();)
* Strings not in the string constant pool (e.g., new String("abc"))

**💡 Example:**

public class Demo {

public static void main(String[] args) {

String name = new String("Java"); // stored in heap

int[] arr = new int[10]; // array also stored in heap

}

}

* name and arr point to heap objects.
* The references name and arr are stored in **stack memory**.

**🔄 Heap Memory Management Phases:**

1. **Young Generation**
   * Short-lived objects
   * Includes Eden and Survivor spaces
2. **Old (Tenured) Generation**
   * Long-living objects promoted from Young Gen
3. **Metaspace** (Java 8+)
   * Stores class metadata (previously part of PermGen)

**🧹 Garbage Collection in Heap:**

* JVM automatically reclaims memory from unreachable objects in heap via **Garbage Collector (GC)**.
* GC strategy (like G1GC, CMS, etc.) depends on the JVM configuration.

### **Difference between Stack and Heap?**

* Answer

Here's a clear and concise comparison of **Stack vs Heap memory** in Java:

**📦 Stack vs Heap Memory in Java**

| **Feature** | **Stack Memory** | **Heap Memory** |
| --- | --- | --- |
| **Purpose** | Stores method calls, local variables, and references | Stores objects, class instances, arrays |
| **Memory Allocation** | Static memory allocation | Dynamic memory allocation |
| **Access Speed** | Faster (LIFO - Last In First Out) | Slower than stack |
| **Scope** | Local to the method/thread | Global (shared across all threads unless marked thread-local) |
| **Thread Safety** | Yes (each thread has its own stack) | No (needs synchronization for thread safety) |
| **Lifetime** | Exists till the method completes execution | Objects exist until garbage collected |
| **Stored Elements** | - Primitive local variables- References to objects | - Actual objects- Arrays- Instance variables |
| **Memory Management** | Handled automatically via function calls | Handled via Garbage Collection |
| **Overflow Possibility** | StackOverflowError if stack is full | OutOfMemoryError if heap is exhausted |

**🧠 Example:**

public class Test {

public static void main(String[] args) {

int x = 10; // x is stored in Stack

String name = new String("Hi"); // "Hi" object in Heap, 'name' reference in Stack

}

}

**📝 Summary:**

* Use **stack** for lightweight operations (method calls, temporary variables).
* Use **heap** when creating objects that need to persist beyond the method scope.

### **What is Garbage Collection in java?**

* **Garbage Collection** in Java is the **automatic process** of identifying and **reclaiming memory** used by objects that are **no longer reachable** or needed by the application.

It is performed by the **JVM (Java Virtual Machine)** to **free up heap memory** and prevent memory leaks, so developers don't have to manually manage memory (unlike in C/C++).

**✅ Why is GC Important?**

* Prevents **OutOfMemoryError**.
* Frees memory from **unused objects**.
* Improves **application stability**.
* Reduces chances of **memory leaks**.

**🧠 How GC Works (High-Level):**

* Java objects are stored in **Heap Memory**.
* When no references point to an object, it becomes **eligible for GC**.
* The JVM periodically runs the **Garbage Collector**, which:
  + Finds **unreachable objects**.
  + Reclaims their memory.
  + Compacts memory (optional, depending on collector).

**📦 JVM Memory Areas (relevant to GC):**

| **Area** | **Description** |
| --- | --- |
| **Young Generation** | New objects created (faster GC – minor GC) |
| **Old Generation** | Long-lived objects (slower GC – major GC) |
| **Metaspace** | Class metadata (not garbage collected as objects) |

**🧪 Example:**

public class GCDemo {

public static void main(String[] args) {

String str = new String("Hello");

str = null; // Now eligible for GC

System.gc(); // Hint to JVM to run GC (not guaranteed)

}

}

**🧰 Common Garbage Collectors in Java:**

| **GC Algorithm** | **Description** |
| --- | --- |
| **Serial GC** | Simple, single-threaded. Good for small apps. |
| **Parallel GC** | Uses multiple threads for minor/major GC. Good for throughput. |
| **CMS (Concurrent Mark-Sweep)** | Minimizes pause times (deprecated). |
| **G1 GC (Garbage First)** | Good balance of performance and low pause times. |
| **ZGC** / **Shenandoah** | Ultra-low pause times (Java 11+ / 12+). |

**🛠 GC Tuning (Optional for advanced users):**

You can tune the JVM GC behavior using flags:

java -Xms512m -Xmx2g -XX:+UseG1GC MyApp

**🔍 How to Know if GC Is Happening?**

Use logs:

-verbose:gc

-XX:+PrintGCDetails

Use tools like:

* Jvisualvm
* Jconsole
* GCViewer
* Java Flight Recorder

**✅ Summary:**

* GC is Java's way of **automatic memory management**.
* It helps **keep memory clean** by removing unused objects.
* Developers **don’t control** GC directly, but they can influence it with tuning and understanding object lifecycles.

### **What will happen if I assign null to some object then will that be garbage collected?**

* When you assign null to an object in Java, it **does not immediately trigger garbage collection**. Here's what happens step by step:

**1. Assigning null:**

When you assign null to an object reference, like this:

MyObject obj = new MyObject();

obj = null; // obj no longer points to the MyObject instance

* The object that obj was originally pointing to is now **eligible for garbage collection** because there are no active references pointing to it.
* The memory occupied by the object is not immediately reclaimed. It's just marked as **eligible for garbage collection**.

**2. Garbage Collection (GC):**

* **Garbage collection** in Java is **non-deterministic**, meaning you cannot predict when exactly the garbage collector will run.
* The **GC process** runs in the background to free up memory by reclaiming objects that are no longer referenced by any part of the program.
* If there are no references to the object (like obj = null), the object is eventually collected during a **GC cycle**.

**3. What happens after null assignment:**

* **No immediate action**: Assigning null to an object doesn't directly cause the object to be destroyed or memory to be reclaimed.
* **Garbage Collection happens later**: The JVM will eventually decide when to run the GC, and during that cycle, it will clean up objects that are no longer reachable.

**4. Example:**

public class Example {

public static void main(String[] args) {

MyObject obj = new MyObject();

obj = null; // The object that was originally referenced is now eligible for GC

}

}

class MyObject {

// Some fields or methods

}

In this example, after obj = null;, the object is eligible for GC, but it will be cleaned up only during the next garbage collection cycle, which may not be immediate.

**5. Garbage Collection Trigger:**

* You can **request garbage collection** manually (though not recommended for production) using System.gc(), but this is just a suggestion to the JVM and does not guarantee immediate collection.
* The actual garbage collection will depend on the JVM's decision and system memory management.

**In Summary:**

* **Assigning null** makes the object **eligible** for garbage collection, but it does not automatically trigger it.
* Garbage collection is handled by the JVM in the background, and you cannot directly control when it occurs.

### **When does the finalize method get called?**

* The finalize() method is called **by the Garbage Collector (GC)** **just before** an object is **destroyed (i.e., garbage collected)** to give it a chance to clean up resources.

**✅ Key Points:**

| **Aspect** | **Description** |
| --- | --- |
| **When** | Automatically called **before the GC reclaims the object's memory** |
| **Defined in** | java.lang.Object class |
| **Signature** | protected void finalize() throws Throwable |
| **Purpose** | Used to perform **cleanup** like closing files, network sockets, etc. |
| **Manual call** | You can call it explicitly, but it's **not recommended** (obj.finalize() is just a method call, not GC) |
| **Only once?** | Yes — GC calls it **at most once** per object |
| **Deprecated?** | ✅ **Yes**, deprecated in **Java 9**, and **removed in Java 18+** because it's **unreliable and unpredictable** |

**⚠️ Why Not to Use finalize()?**

No guarantee **when or even if** it will be called.

Can lead to **resource leaks** if relied on.

**Better alternatives**: use **try-with-resources** or explicitly close resources via close().

**🔧 Example:**

class MyObject {

@Override

protected void finalize() throws Throwable {

System.out.println("Finalize called!");

}

}

public class Main {

public static void main(String[] args) {

MyObject obj = new MyObject();

obj = null;

System.gc(); // Suggests GC, not guaranteed

System.out.println("Main ends.");

}

}

Output may or may not show "Finalize called!" — because GC behavior is **non-deterministic**.

## **OOPs**

### **Explain OOPs concept?**

* Object-Oriented Programming (OOPs) is a programming paradigm based on the concept of "objects", which can contain data and code. Java is a fully object-oriented language (except for primitive types) and supports the following core OOPs concepts:
* **Abstraction**
  + Hides internal implementation and shows only functionality.
  + Achieved using **abstract classes** and **interfaces**.
* **Encapsulation**
  + Bundling of data (variables) and methods into a single unit (class).
  + Achieved using **access modifiers** (private, public, protected).
* **Inheritance**
  + Allows a class (child) to inherit fields and methods from another class (parent).
  + Promotes code reusability and method overriding.
* **Polymorphism**
  + One entity behaves differently based on context.
  + **Compile-time (method overloading)** and **Run-time (method overriding)** are the two types.

### **What is an object?**

* Answer

### **Explain method in Object class? Explain 9 methods in Object class?**

* Answer

### **How many ways can we create objects of class in java?**

* Answer

### **Explain Abstraction?**

* Answer

### **What is Encapsulation? Explain with a real time example**

* Encapsulation is one of the fundamental OOPs principles in Java. It refers to wrapping data (variables) and the code (methods) that operates on the data into a single unit — typically a class. It helps protect the internal state of an object from unwanted external modifications.
* Encapsulation is achieved using:
  + Private fields to restrict direct access.
  + Public getters and setters to allow controlled access.
* Example: Bank Account

public class BankAccount {

private double balance; // private field — can't be accessed directly

public BankAccount(double initialBalance) {

this.balance = initialBalance;

}

// public method to get balance

public double getBalance() {

return balance;

}

// public method to deposit money (with validation)

public void deposit(double amount) {

if (amount > 0) {

balance += amount;

}

}

// public method to withdraw money (with validation)

public void withdraw(double amount) {

if (amount > 0 && balance >= amount) {

balance -= amount;

}

}

}

**Explanation:**

* The balance variable is **encapsulated** — it's private.
* Access is provided **only through public methods** (getBalance, deposit, withdraw), ensuring that:
  + The balance can't be set to a negative value directly.
  + Deposits and withdrawals go through validation.

This prevents incorrect or unauthorized changes to the data, which is the essence of **encapsulation** in real-world applications.

### **How do we achieve encapsulation in Java?**

* Encapsulation is one of the four fundamental OOP concepts in Java. It refers to bundling data (variables) and methods that operate on that data into a single unit (class) while restricting direct access to some of the object's components.

**Key Ways to Achieve Encapsulation:**

**1. Using Private Access Modifier**

Make class fields private to prevent direct access from outside the class.

public class Person {

private String name; // private field

private int age;

}

**2. Providing Public Getter and Setter Methods**

Create public methods to access and modify private fields.

public class Person {

private String name;

private int age;

// Getter for name

public String getName() {

return name;

}

// Setter for name

public void setName(String name) {

this.name = name;

}

// Getter for age

public int getAge() {

return age;

}

// Setter for age with validation

public void setAge(int age) {

if(age > 0) { // validation logic

this.age = age;

}

}

}

**3. Implementing Constructors with Validation**

Initialize fields through constructors with validation.

public Person(String name, int age) {

this.name = name;

if(age > 0) {

this.age = age;

}

}

**Benefits of Encapsulation:**

* **Data Hiding**: Internal representation is hidden from outside
* **Increased Flexibility**: Can change internal implementation without affecting other code
* **Reusability**: Encapsulated code is easier to reuse
* **Control**: Can add validation logic in setters
* **Maintainability**: Easier to maintain and modify code

**Example Usage:**

public class Main {

public static void main(String[] args) {

Person person = new Person("Alice", 30);

// Access through getters

System.out.println(person.getName()); // Alice

System.out.println(person.getAge()); // 30

// Modify through setters

person.setAge(31);

person.setName("Alice Smith");

// Invalid age won't be set

person.setAge(-5); // age remains 31

}

}

### **What is abstract in java?**

* **Abstract** is a non-access modifier that can be applied to classes and methods.

**Abstract Class:** Abstract is a non-access modifier that can be applied to classes and methods.

* Cannot be instantiated (cannot create objects)
* Can contain both abstract and concrete methods
* Used as a base class for inheritance

abstract class Animal {

// Abstract method (no implementation)

abstract void makeSound();

// Concrete method

void eat() {

System.out.println("Animal is eating");

}

}

**Abstract Method:**

* Has no body (no implementation)
* Must be overridden by the first concrete subclass
* Can only exist in abstract classes

abstract class Shape {

abstract double calculateArea(); // abstract method

}

**Key Points:**

* If a class has even one abstract method, the class must be declared abstract
* Abstract classes can have constructors (called when subclass is instantiated)
* Used to define common interface for subclasses

### **Explain Composition in Oops?**

* Answer

### **What is composition and aggregation?**

* Answer

### **Parent and child class methods and how to access those?**

* Answer

### **Difference between interface and abstract class?**

* Answer

### **Where will you use interface and abstract class with real time examples?**

* Answer

### **What is encapsulation? How are you currently using it?**

* Answer

### **Explain Compile time and Run time polymorphism?**

* Answer

### **What is method overriding?**

* Answer

### **How to achieve method overriding?**

* Answer

### **What is method overloading?**

* Answer

### **What is Polymorphism? Explain with an example?**

* Answer

### **What is Inheritance?**

* Answer

### **What is the interface in java?**

* Answer

### **Can we have a static method inside the interface?**

* Answer

### **Can we override the static method?**

* Answer

### **We have Class A and Class B which contains m1() method in both the class, and class B extends parent class A. Asked which method will get called on which object?**

* Answer

### **Explain SOLID Principles?**

The **SOLID** principles are the five key design principles in object-oriented programming (OOP) that help create **clean, maintainable, and scalable software**. Here’s a breakdown with **simple explanations** and **Java examples**:

🔵 **S – Single Responsibility Principle (SRP)**

**A class should have only one reason to change.**

**❌ Bad:**

class Report {

public String getReportData() { return "data"; }

public void saveToFile(String data) { /\* writes to file \*/ }

}

**✅ Good:**

class Report {

public String getReportData() { return "data"; }

}

class ReportSaver {

public void saveToFile(String data) { /\* writes to file \*/ }

}

**✅ Why?** Now Report handles only data, and ReportSaver handles saving — **separation of concerns**.

🟠 **O – Open/Closed Principle (OCP)**

**Software entities should be open for extension, but closed for modification.**

**❌ Bad:**

class ShapePrinter {

public void printShape(String shape) {

if (shape.equals("Circle")) { /\* draw circle \*/ }

else if (shape.equals("Square")) { /\* draw square \*/ }

}

}

**✅ Good:**

interface Shape {

void draw();

}

class Circle implements Shape {

public void draw() { System.out.println("Drawing Circle"); }

}

class Square implements Shape {

public void draw() { System.out.println("Drawing Square"); }

}

class ShapePrinter {

public void printShape(Shape shape) {

shape.draw();

}

}

**✅ Why?** You can add new shapes without changing ShapePrinter.

🟡 **L – Liskov Substitution Principle (LSP)**

**Subtypes must be substitutable for their base types.**

**✅ Example:**

class Bird {

public void fly() {

System.out.println("Bird is flying");

}

}

class Sparrow extends Bird {

@Override

public void fly() {

System.out.println("Sparrow is flying");

}

}

**❌ Violation:**

class Ostrich extends Bird {

@Override

public void fly() {

throw new UnsupportedOperationException("Ostrich can't fly");

}

}

**✅ Fix:** Use better hierarchy:

interface Bird {}

interface FlyingBird extends Bird {

void fly();

}

🟢 **I – Interface Segregation Principle (ISP)**

**Clients should not be forced to depend on methods they do not use.**

**❌ Bad:**

interface Worker {

void work();

void eat();

}

class Robot implements Worker {

public void work() {}

public void eat() {} // unnecessary for robot

}

**✅ Good:**

interface Workable { void work(); }

interface Eatable { void eat(); }

class Robot implements Workable {

public void work() {}

}

🔴 **D – Dependency Inversion Principle (DIP)**

**High-level modules should not depend on low-level modules. Both should depend on abstractions.**

**❌ Bad:**

class MySQLDatabase {

public void connect() {}

}

class App {

private MySQLDatabase db = new MySQLDatabase();

}

**✅ Good:**

interface Database {

void connect();

}

class MySQLDatabase implements Database {

public void connect() {}

}

class App {

private Database db;

public App(Database db) {

this.db = db;

}

}

🧠 **Summary:**

| **Principle** | **Description** |
| --- | --- |
| **S** | One class = One job |
| **O** | Add features by extending, not modifying |
| **L** | Derived classes should work like the base |
| **I** | Split large interfaces into smaller ones |
| **D** | Depend on abstractions, not implementations |

## **Collection Framework**

### **Difference between List and Array?**

| **Feature** | **Array** | **List (java.util.List)** |
| --- | --- | --- |
| Type | Data structure | Interface (implemented by ArrayList, LinkedList, etc.) |
| Size | Fixed (set at creation time) | Dynamic (can grow or shrink) |
| Syntax | int[] arr = new int[5]; | List<Integer> list = new ArrayList<>(); |
| Data Type Support | Both primitives and objects | Only objects (e.g., Integer, String) |
| Flexibility | Less flexible | More flexible (resize, insert, delete easily) |
| Memory Allocation | Contiguous memory | Uses internal structures like arrays or nodes |
| Performance | Slightly faster (no overhead) | Slightly slower due to dynamic nature |
| Index Access | Fast (O(1)) | Fast for ArrayList, slower for LinkedList |
| Useful Methods | No built-in methods (except via Arrays class) | Many built-in methods: add(), remove(), contains(), etc. |
| Part of Collections API | No | Yes |

**✅ When to Use What?**

| **Use Case** | **Prefer** |
| --- | --- |
| Fixed-size, performance-critical code | Array |
| Need dynamic resizing, easy insert/remove | List |
| Storing primitives (like int, char) | Array (or use List<Integer>, with boxing) |
| Use Collection API features | List |

**Example:**

📦 **Array:**

int[] numbers = new int[3];

numbers[0] = 10;

numbers[1] = 20;

System.out.println(numbers[1]); // Output: 20

📦 **List:**

List<Integer> numbers = new ArrayList<>();

numbers.add(10);

numbers.add(20);

System.out.println(numbers.get(1)); // Output: 20

### **Difference between List and Set?**

* answer

### **Difference between ArrayList and LinkedList?**

* Answer

### **Difference between Array and Collections?**

* Answer

### **Difference between HashMap and LinkedHashMap?**

* Answer

### **Difference between HashMap and HashTable?**

* answer

### **Difference between Fail-Fast and Fail-Safe iterator?**

* answer

### **Which is more efficient among the ArrayList and LinkedList?**

* Answer

### **Difference between Stream and Collections?**

* Answer

### **Write a syntax for integer ArrayList?**

* answer

### **How can Set not store duplicate values? Explain internal working?**

* Answer

### **Which collection you will use in order to remove duplicate elements and preserve the insertion order?**

* answer

### **Which Collection will you avoid duplicating and store data in a sorted manner?**

* answer

### **In which scenarios Linked list comes into fixture in HashMap?**

* answer

### **Which among ArrayList and LinkedList will be more efficient for random access of data?**

* Answer

### **Difference between Array, ArrayList and LinkedList? When you will use ArrayList and LinkedList?**

* answer

### **How to sort the ArrayList?**

* Answer

### **How to sort the ArrayList?**

* Answer

### **What are the practical use cases of LinkedList?**

* answer

### **Compare ArrayList objects from the employee and return the highest employee age?**

* Answer

### **How will you find the 3rd last element from the linked list in a single iteration?**

* answer

### **How does ArrayList internally work?**

* answer

### **What is the default size of ArrayList?**

* answer

### **How to increase the size of ArrayList? By how much?**

* Answer

### **Difference between Map and Set?**

* answer

### **How HashMap calls hashCode and equals method internally?**

* answer

### **Explain internal working of ArrayList?**

* answer

### **How does ArrayList increase its size dynamically?**

* answer

### **How does ArrayList grow?**

* Answer

### **Explain internal working of ensureCapacity method?**

private void ensureCapacityInternal(int minCapacity)

{

if (elementData == DEFAULTCAPACITY\_EMPTY\_ELEMENTDATA) {

minCapacity = Math.max(DEFAULT\_CAPACITY, minCapacity);

}

ensureExplicitCapacity(minCapacity);

}

### **How do you write a custom ArrayList which will take the input capacity?**

answer

### **Which data structure is used by ArrayList?**

* answer

### **Difference between ArrayList and Vector?**

* Answer

### **Best time complexity of Arraylist and Linkedlist? Which is better?**

* Answer

### **What is HashMap?**

* HashMap<K, V> is a **part of java.util package** that implements the **Map interface** and allows you to store **key-value pairs** and allows efficient retrieval, insertion, and deletion operations.

Map<String, String> map = new HashMap<>();

map.put("Name", "Alice");

map.put("City", "New York");

**Key Characteristics**

1. **Implements Map Interface**: HashMap implements the java.util.Map interface.
2. **Key-Value Pairs**: Stores data as key-value pairs (like a dictionary).
3. **No Duplicate Keys**: Doesn't allow duplicate keys (each key maps to exactly one value).
4. **Permits Null Values**: Allows one null key and multiple null values.
5. **Not Thread-Safe**: Not synchronized by default.
6. **Unordered Collection**: Doesn't guarantee any specific order of elements.
7. **Dynamic Resizing**: Automatically resizes when the number of elements exceeds a threshold.

**Internal Data Structure:**

Internally, a HashMap is an array of Node<K,V>, called a bucket array:

transient Node<K,V>[] table;

**Important Parameters**

1. **Initial Capacity**: The number of buckets when the HashMap is created (default is 16).
2. **Load Factor**: The measure of how full the hash table is allowed to get before its capacity is increased (default is 0.75).
3. **Threshold**: When the size exceeds (capacity \* load factor), the hash table is rehashed.

**Constructors**

1. HashMap(): Default capacity (16) and load factor (0.75)
2. HashMap(int initialCapacity): Specified initial capacity, default load factor
3. HashMap(int initialCapacity, float loadFactor): Both specified
4. HashMap(Map<? extends K, ? extends V> m): Creates from another map

**Each node stores:**

static class Node<K,V> implements Map.Entry<K,V> {

final int hash;

final K key;

V value;

Node<K,V> next; // linked list

}

**Hashing and Index Calculation:**

When you call map.put(key, value):

1. hashCode() is called on the key.
2. A hash value is calculated (with some bit manipulation for better distribution).
3. An index is computed as:

index = (n - 1) & hash // where n is array length

1. Entry is stored in the bucket at that index.

**Collision Handling:**

A collision occurs when two keys hash to the same index.

* Java 7: uses Linked List
* Java 8+: uses Linked List → Tree (Red-Black Tree) if the list size > 8 and bucket size > 64

In case of collision:

* New node is appended to the list/tree.
* During retrieval, equals() is used to find the right key.

**Rehashing (Resizing)**

* When size > capacity \* load factor (default 16 \* 0.75 = 12), HashMap resizes.
* New array is double in size.
* All existing entries are rehashed and moved to new buckets.

**Common Methods:**

**Basic Operations:**

1. put(K key, V value): Associates the specified value with the specified key
2. get(Object key): Returns the value to which the specified key is mapped
3. remove(Object key): Removes the mapping for the specified key
4. containsKey(Object key): Returns true if this map contains a mapping for the key
5. containsValue(Object value): Returns true if this map maps one or more keys to the value
6. size(): Returns the number of key-value mappings
7. isEmpty(): Returns true if this map contains no key-value mappings
8. clear(): Removes all mappings

**Bulk Operations:**

1. putAll(Map<? extends K, ? extends V> m): Copies all mappings from the specified map
2. keySet(): Returns a Set view of the keys
3. values(): Returns a Collection view of the values
4. entrySet(): Returns a Set view of the mappings

**Example:**

Map<Integer, String> map = new HashMap<>();

map.put(1, "A");

map.put(2, "B");

map.put(3, "C");

System.out.println(map.get(2)); // Output: B

**Example Usage:**

import java.util.HashMap;

public class HashMapExample {

public static void main(String[] args) {

// Create a HashMap

HashMap<String, Integer> map = new HashMap<>();

// Add elements

map.put("Apple", 10);

map.put("Banana", 20);

map.put("Orange", 30);

// Access elements

System.out.println("Apple count: " + map.get("Apple")); // 10

// Check if key exists

System.out.println("Contains Banana? " + map.containsKey("Banana")); // true

// Remove element

map.remove("Orange");

System.out.println("After removal: " + map); // {Apple=10, Banana=20}

// Iterate through HashMap

for (String key : map.keySet()) {

System.out.println(key + ": " + map.get(key));

}

// Using entrySet() for iteration

for (Map.Entry<String, Integer> entry : map.entrySet()) {

System.out.println(entry.getKey() + " => " + entry.getValue());

}

}

}

**When to Use HashMap**

1. When you need fast access to elements by key
2. When insertion and retrieval operations are frequent
3. When you don't need to maintain insertion order
4. When thread safety is not a requirement

**Best Practices:**

* Choose **initial capacity** and **load factor** wisely if you expect large volume.
* Use immutable objects as keys to prevent unexpected behavior.
* Use **containsKey()** before using get() to avoid null confusion.
* Override equals() and hashCode() properly for custom key objects.
* Consider ConcurrentHashMap for multi-threaded environments.

**Real-World Use Cases:**

* Caching
* Indexing data for quick lookups
* Counting frequencies (e.g., word count)
* Mapping IDs to entities

Performance Considerations

* **Average Case**:
  + get(): O(1)
  + put(): O(1)
  + remove(): O(1)
  + containsKey(): O(1)
* **Worst Case** (if all keys collide):
  + get(): O(log n) in Java 8+ (due to tree conversion), O(n) before Java 8
  + put(): O(log n) in Java 8+, O(n) before Java 8
  + remove(): O(log n) in Java 8+, O(n) before Java 8

### **Explain internal working of HashMap?**

* A HashMap stores **key-value pairs** using a technique called **hashing**. It offers **O(1)** time complexity (on average) for put() and get() operations.

**🔧 Internal Components**

static class Node<K,V> implements Map.Entry<K,V> {

final int hash;

final K key;

V value;

Node<K,V> next; // for handling collisions

}

Internally, HashMap maintains:

* An **array of Node<K, V>[]** called table
* **Each Node** stores a key, value, hash, and reference to the next node (linked list)

**🔄 How put(key, value) Works**

**Step-by-step:**

1. **Compute Hash:**

int hash = hash(key);

Java enhances the hashCode with a **hash spreading function**:

static final int hash(Object key) {

int h;

return (key == null) ? 0 : (h = key.hashCode()) ^ (h >>> 16);

}

1. **Find Bucket Index:**

index = (n - 1) & hash;

n is the length of the array (must be a power of 2 for performance).

1. **Check Bucket:**
   * If **null**, create new node at index
   * If **occupied** (collision):
     + Traverse linked list or tree at that index
     + If key exists (checked via equals()), update value
     + Else, add new node (as next in list or as tree node)
2. **Resize if Needed:** If number of entries exceeds threshold = capacity \* loadFactor, rehash (resize).

**📦 How get(key) Works**

1. Compute hash of the key
2. Get index = (n - 1) & hash
3. Traverse list or tree at that index:
   * Compare hash and use equals() to find the correct key
4. Return value if key found, else return null

**⚠️ Collision Handling**

When two keys hash to the same index:

**Java 7 and before:**

* **Linked List** in each bucket

**Java 8 and after:**

* **Linked List** used **until 8 entries**
* When entries in a bucket > 8 and capacity > 64, it converts list to a **Red-Black Tree** for faster lookup

**🔁 Resizing (Rehashing)**

* When size > capacity \* loadFactor (default loadFactor = 0.75)
* Array is resized to **double the size**
* All entries are **rehashed** and **moved to new positions**

**🧠 Example**

HashMap<String, String> map = new HashMap<>();

map.put("name", "Alice");

map.put("city", "London");

1. "name".hashCode() → hash → index
2. Stored in table[index] as a node
3. If "city" hashes to same index, a **collision** occurs, and it's linked

**🔍 Summary of Internal Logic**

| **Operation** | **Description** |
| --- | --- |
| hashCode() | Generates hash for key |
| index = (n - 1) & hash | Finds correct bucket |
| equals() | Ensures key uniqueness |
| Collision | Resolved via Linked List or Tree |
| Resize | Doubles capacity and rehashes entries |

### **What is hash collision in HashMap?**

* A **hash collision** occurs in a HashMap when **two different keys** generate the **same hash value**, and thus, map to the **same bucket index** in the internal array.

**💡 Why do collisions happen?**

HashMap uses hashCode() to determine the bucket index.

Different keys can return the same hashCode() or map to the same index after applying the hashing formula:

index = (n - 1) & hash

Since the number of possible keys is much greater than the number of buckets (array length), collisions are inevitable.

**📦 Example:**

String key1 = "FB"; // hashCode = 2236

String key2 = "Ea"; // hashCode = 2236

Map<String, String> map = new HashMap<>();

map.put("FB", "Facebook");

map.put("Ea", "Electronic Arts");

Even though key1 and key2 are different, they may end up in the same bucket due to hash collision.

**⚙️ How HashMap handles collisions**

**Java 7 and earlier:**

Collisions are handled using a linked list.

New entry is added to the head or tail of the list at that index.

equals() is used to differentiate between keys.

**Java 8+:**

If the number of entries in a bucket exceeds 8, and capacity > 64:

The linked list is converted into a Red-Black Tree to improve performance (O(log n) instead of O(n)).

**🔍 Visual Representation**

Index 5: [Node(key=FB, value=Facebook)] -> [Node(key=Ea, value=Electronic Arts)]

🧠 **Summary**

| **Term** | **Meaning** |
| --- | --- |
| Hash Collision | Two keys map to the same bucket index |
| Cause | Same hashCode() or same computed index |
| Resolution | Linked List (Java 7), Tree (Java 8+) |
| Problem | Can degrade performance to O(n) if not handled efficiently |

### **What are the types of HashMap?**

* In Java, HashMap is a specific implementation of the Map interface, but there are **several variants** of Map implementations that behave similarly with some additional or modified behavior.

Let’s go through the **types of HashMap and its variations**:

**✅ 1. HashMap**

* **Default implementation**
* **Not thread-safe**
* Allows **1 null key** and **multiple null values**
* No ordering guaranteed

Map<String, String> map = new HashMap<>();

**✅ 2. LinkedHashMap**

* Extends **HashMap**
* Maintains insertion order or access order (if enabled)
* Slightly slower than **HashMap** due to ordering overhead

Map<String, String> map = new LinkedHashMap<>();

Useful when you want predictable iteration order.

**✅ 3. TreeMap**

* Implements **NavigableMap** interface
* **Sorted** by keys (natural order or comparator)
* **No null keys** (throws NullPointerException), but allows null values

Map<String, String> map = new TreeMap<>();

Internally uses a **Red-Black Tree**.

**✅ 4. Hashtable (Legacy)**

* Older synchronized version of HashMap
* **Thread-safe**, but **slower**
* **No null key or null values** allowed

Map<String, String> map = new Hashtable<>();

Rarely used in modern Java (replaced by ConcurrentHashMap).

**✅ 5. ConcurrentHashMap**

* Designed for **concurrent access** in multithreaded environments
* **Thread-safe**, high performance
* **Does not allow null keys or values**
* Uses **segment locking** in older versions; Java 8+ uses **CAS and synchronized blocks**

Map<String, String> map = new ConcurrentHashMap<>();

**🧠 Comparison Summary**

| **Feature** | **HashMap** | **LinkedHashMap** | **TreeMap** | **Hashtable** | **ConcurrentHashMap** |
| --- | --- | --- | --- | --- | --- |
| Thread-safe | ❌ | ❌ | ❌ | ✅ | ✅ |
| Null key allowed | ✅ (1) | ✅ (1) | ❌ | ❌ | ❌ |
| Ordering | ❌ | ✅ (insertion) | ✅ (sorted) | ❌ | ❌ |
| Performance | High | Slightly lower | Moderate | Low | High (for concurrent use) |

**🔧 Use Case Guidelines**

| **Use Case** | **Recommended Type** |
| --- | --- |
| Fast access, no thread safety | HashMap |
| Maintain insertion order | LinkedHashMap |
| Sorted map | TreeMap |
| Thread-safe (legacy) | Hashtable |
| Thread-safe (modern) | ConcurrentHashMap |

### **What happens in a HashMap when multiple keys have the same hashCode()??**

* If multiple keys return the same hashCode(), they will land in the **same bucket** inside the HashMap. This is known as a **hash collision**. To resolve this, Java uses the equals() method to check if the keys are actually the same or not.

If equals() returns true, the value is **updated**.

If equals() returns false, the new key-value pair is **added to the same bucket** (via a linked list or red- black tree).

### **Can HashMap store different keys that have the same hashCode?**

* Yes, as long as their equals() method returns false, Java treats them as distinct keys, even if their hashCode() is the same.

**Example:**

import java.util.HashMap;

import java.util.Objects;

class MyKey {

private String key;

public MyKey(String key) {

this.key = key;

}

// Override hashCode to always return same value

@Override

public int hashCode() {

return 100;

}

// equals compares actual content

@Override

public boolean equals(Object obj) {

if (this == obj) return true;

if (!(obj instanceof MyKey)) return false;

MyKey other = (MyKey) obj;

return Objects.equals(this.key, other.key);

}

@Override

public String toString() {

return key;

}

}

public class HashMapCollisionExample {

public static void main(String[] args) {

HashMap<MyKey, Integer> map = new HashMap<>();

MyKey key1 = new MyKey("A");

MyKey key2 = new MyKey("B");

MyKey key3 = new MyKey("C");

map.put(key1, 12);

map.put(key2, 12);

map.put(key3, 18);

System.out.println("Value for A: " + map.get(key1)); // 12

System.out.println("Value for B: " + map.get(key2)); // 12

System.out.println("Value for C: " + map.get(key3)); // 18

}

}

🧠 **What's Happening Internally:**

hashCode() is overridden to return 100 for all keys → all keys go to same bucket.

But equals() compares key string, so:

"A".equals("B") → false

"B".equals("C") → false

Hence, all keys are treated as distinct entries in the same bucket.

### **What if equals() returns true for two keys with same hashCode()?**

* Then it replaces the old value:

MyKey k1 = new MyKey("A");

MyKey k2 = new MyKey("A"); // same content

map.put(k1, 100);

map.put(k2, 200); // same key (based on equals), replaces value

System.out.println(map.get(k1)); // 200

**🔚 Summary**

| **Aspect** | **Behavior** |
| --- | --- |
| Same hashCode | Goes to same bucket |
| Different equals | Stored as different keys |
| Same equals | Treated as same key, old value replaced |
| Internal DS | Array + Linked List / Tree (Java 8+) to handle collisions |

### **Can we store null value in HashMap?**

* Yes, we can store null values in a HashMap.

Let’s break it down:

✅ **Null Key and Null Value in HashMap**

**🔹 Null Key:**

HashMap allows exactly one null key

When null is used as a key, it is always mapped to the bucket at index 0

Map<String, String> map = new HashMap<>();

map.put(null, "NullKeyValue");

System.out.println(map.get(null)); // Output: NullKeyValue

**🔹 Null Values:**

HashMap allows multiple keys to be mapped to null values

map.put("key1", null);

map.put("key2", null);

System.out.println(map); // Output: {null=NullKeyValue, key1=null, key2=null}

**⚠️ Be Careful:**

Other map types behave differently:

| Map Type | Null Key | Null Value |
| --- | --- | --- |
| HashMap | ✅ 1 key | ✅ many |
| LinkedHashMap | ✅ 1 key | ✅ many |
| TreeMap | ❌ | ✅ (some cases) |
| Hashtable | ❌ | ❌ |
| ConcurrentHashMap | ❌ | ❌ |

🔧 **Why is only one null key allowed?**

Internally, HashMap uses:

if (key == null) {

// handle specially

}

So it maps it to a special bucket (usually index 0) and ensures there's only one such entry.

### **Can we store infinite data in a HashMap?**

* **No**, we cannot store infinite data in a HashMap.

While HashMap theoretically can grow as long as memory permits (thanks to dynamic resizing), there are practical and system-level limitations that prevent it from holding "infinite" data.

**🚧 Limitations That Prevent Infinite Storage**

**1. Heap Memory Limit**

The biggest constraint is available heap memory (RAM).

Every entry (key + value + Node overhead) consumes memory.

Once heap space is exhausted, you'll get an:

java.lang.OutOfMemoryError: Java heap space

2**. Array Size Limit**

Internally, HashMap uses an array to store buckets.

The maximum array size in Java is Integer.MAX\_VALUE (2^31 - 1) entries — about 2.1 billion buckets.

**3. GC Overhead**

A massive number of objects leads to frequent garbage collection, degrading performance severely.

**4. Rehashing Overhead**

When the size exceeds the threshold (capacity \* loadFactor), HashMap resizes and rehashes — an expensive operation.

**🧠 Example**

Map<Integer, String> map = new HashMap<>();

for (int i = 0; ; i++) {

map.put(i, "value" + i);

}

This will eventually crash with: Exception in thread "main" java.lang.OutOfMemoryError: Java heap space

**✅ Best Practice**

Always design HashMap usage with estimated size and memory in mind.

Use initialCapacity wisely to reduce rehashing:

new HashMap<>(expectedSize, loadFactor);

### **Can we access null value in HashMap?**

* ✅ **Yes**, you can access a null value from a HashMap just like any other value.

Let’s break it down clearly 👇

✅ **Example: Accessing a null value in a HashMap**

import java.util.HashMap;

public class Main {

public static void main(String[] args) {

HashMap<String, String> map = new HashMap<>();

map.put("name", null); // Key with null value

map.put(null, "nullKeyValue"); // Null key with value

System.out.println(map.get("name")); // 👉 Output: null

System.out.println(map.get(null)); // 👉 Output: nullKeyValue

}

}

**📌 Key Notes:**

| **Operation** | **Result** |
| --- | --- |
| map.get("name") | Returns null (actual value is null) |
| map.get("unknown") | Returns null (key doesn't exist) |

**⚠️ Important Distinction:**

If map.get(key) returns null, you can't tell directly if:

the key exists and value is null, or

the key doesn't exist at all

To handle that, use:

if (map.containsKey("name")) {

System.out.println("Key exists with value: " + map.get("name"));

} else {

System.out.println("Key does not exist.");

}

🔍 **Summary**

| **Question** | **Answer** |
| --- | --- |
| Can we store null values in HashMap? | ✅ Yes |
| Can we access them? | ✅ Yes |
| What if key doesn't exist? | Returns null (same as if value is null) |
| How to differentiate? | Use containsKey(key) |

### **How hashcode calculations happened on the Employee object?**

* answer

### **Can we have duplicate keys in HashMap?**

* answer

### **How does HashMap come to know that two objects are the same or different?**

* Answer

### **What is the use of a ConcurrentHashMap?**

* answer

### **How does ConcurrentHashMap works?**

* answer

### **Difference between HashMap and ConcurrentHashMap?**

* Answer

### **Difference between HashMap and HashSet**

* Answer

### **What is the default size of ArrayList?**

* answer

### **How to increase the size of ArrayList?**

* answer

### **Can we add infinite elements to ArrayList?**

* answer

### **Can we store infinite elements in a list?**

* answer

### **How can we add data while iterating ArrayList?**

* answer

### **What is the difference between List and Map?**

* answer

### **Explain sorted collections in java?**

* answer

### **Which data structure is used by HashMap?**

* answer

### **How can Set can’t store duplicate data?**

* Answer

### **Explain HashSet?**

* A HashSet in Java is part of the java.util package and implements the Set interface. It is a collection that does **not allow duplicate elements** and does not maintain any **order** of its elements. HashSet is backed by a hash table (actually a HashMap), so it provides **constant time performance** (O(1)) for basic operations like add(), remove(), and contains(), assuming the hash function disperses the elements properly.

**Key Features of HashSet:**

**No Duplicates:** A HashSet does not allow duplicate elements. If you attempt to add a duplicate, it will not be added to the set.

**Unordered:** The elements in a HashSet are not ordered. There is no guarantee of the order in which elements are stored or retrieved. It may seem random because it is based on hash codes.

**Allows null values:** A HashSet allows at most one null element.

**Constant Time Complexity:** Operations like add(), remove(), and contains() have an average time complexity of O(1), making them very efficient.

**Common Methods:**

**add(E e):** Adds the specified element to the set. If the element already exists, it returns false, and the set is unchanged.

**remove(Object o):** Removes the specified element from the set if it exists.

**contains(Object o):** Returns true if the set contains the specified element.

**size():** Returns the number of elements in the set.

**isEmpty():** Returns true if the set is empty.

**clear():** Removes all elements from the set.

**iterator():** Returns an iterator over the elements in the set.

**Example:**

import java.util.HashSet;

public class HashSetExample {

public static void main(String[] args) {

// Create a HashSet

HashSet<String> set = new HashSet<>();

// Add elements to the HashSet

set.add("Apple");

set.add("Banana");

set.add("Cherry");

// Try adding a duplicate element

boolean isAdded = set.add("Apple"); // This will return false

System.out.println("Apple added: " + isAdded);

// Check if an element exists

System.out.println("Contains 'Banana': " + set.contains("Banana"));

// Remove an element

set.remove("Banana");

// Print all elements (order is not guaranteed)

System.out.println("Elements in set: " + set);

// Check the size of the HashSet

System.out.println("Size of set: " + set.size());

// Check if the HashSet is empty

System.out.println("Is set empty? " + set.isEmpty());

}

}

**Output:**

Apple added: false

Contains 'Banana': true

Elements in set: [Cherry, Apple] // The order is not guaranteed

Size of set: 2

Is set empty? false

**Important Points:**

**No Duplicates:** Even though we tried adding "Apple" twice, the second attempt didn't change the set.

**Unordered Collection:** The output doesn't guarantee the order of elements in the set. It can vary each time the program is run.

**Efficient Operations:** Operations like add(), remove(), and contains() are efficient because they are backed by a hash table.

**Internals of HashSet:**

Internally, a HashSet uses a HashMap to store its elements. The elements themselves are used as keys in the map, and all values are just dummy values (commonly Boolean.TRUE).

The hash codes of the elements determine their positions in the hash table, which is why the hashCode() method of the objects stored in a HashSet must be implemented properly to ensure efficient retrieval and storage.

### **Which data structure used by HashSet?**

* HashSet in Java is internally backed by a **HashMap**.

**✅ Key Points:**

* When you add an element to a HashSet, it is actually stored as a **key** in the internal HashMap.
* The **value** associated with each key is a constant dummy object — typically PRESENT = new Object().

**🔍 Internal Structure:**

private transient HashMap<E, Object> map;

private static final Object PRESENT = new Object();

**🔧 When you do:**

HashSet<String> set = new HashSet<>();

set.add("apple");

Under the hood, it works like:

map.put("apple", PRESENT);

**⚙️ Why HashMap?**

* HashMap uses **hashing** to store and retrieve keys efficiently.
* This allows HashSet to provide **average O(1) time complexity** for operations like add(), remove(), and contains().

**💡 Summary:**

| **Feature** | **Backed By** | **Storage Mechanism** |
| --- | --- | --- |
| HashSet | HashMap | Elements as keys, dummy Object as values |

So, HashSet is essentially a wrapper around HashMap that stores only the **keys**, ignoring the values.

### **If we have added the same key in HashMap with the same value and different key with the same hash with the same value, then how will it be stored? At what position data will store and how it will store? What will happen when we use ConcurrentHashMap?**

* answer

### **What is the default capacity of HashMap?**

* Answer

### **Where will you use ConcurrentHashMap?**

* answer

### **Explain HashMap vs ConcurrentHashMap?**

* answer

### **How is HashMap faster as compared to ConcurrentHashMap?**

* answer

### **Suppose I have multiple Employee objects with different names, so how does HashMap differentiate between different objects?**

* answer

### **What is a Blocking Queue?**

* answer

### **What is Enumeration in java?**

* In Java, **Enumeration** is an interface that was introduced in **Java 1.0** and is part of the **java.util** package. It is used to iterate over a collection of elements, but it has been largely replaced by more modern alternatives such as **Iterator** and **for-each loop**.

**Key Characteristics of Enumeration:**

* **Iterator for Legacy Classes**: Enumeration was primarily designed to iterate over **legacy collections** like **Vector**, **Stack**, and **Hashtable**.
* **Methods**: Enumeration has only two main methods:

1. **hasMoreElements()**: Checks if there are more elements in the collection.
2. **nextElement()**: Retrieves the next element in the collection.

**Basic Syntax and Usage of Enumeration:**

import java.util.\*;

public class EnumerationExample {

public static void main(String[] args) {

// Creating a Vector (legacy collection)

Vector<String> vector = new Vector<>();

vector.add("Apple");

vector.add("Banana");

vector.add("Cherry");

// Creating an Enumeration object from the Vector

Enumeration<String> enumeration = vector.elements();

// Using Enumeration to iterate through the Vector

while (enumeration.hasMoreElements()) {

System.out.println(enumeration.nextElement());

}

}

}

**Methods in Enumeration:**

1. **boolean hasMoreElements()**:

* Returns true if there are more elements in the collection.
* Returns false when all elements have been iterated through.

1. **E nextElement()**:

* Returns the **next element** in the collection.
* Throws **NoSuchElementException** if no more elements are available (when hasMoreElements() returns false).

**Limitations of Enumeration:**

* **No remove() Method**: Unlike **Iterator**, **Enumeration** doesn't have a remove() method. This means you can't remove elements during iteration.
* **Outdated**: It was replaced by **Iterator** (introduced in Java 1.2) as part of the **Java Collections Framework**. The **Iterator** interface has additional functionality like element removal, which **Enumeration** lacks.

**Comparison with Iterator:**

* **Enumeration** is older and is mainly used for legacy classes (like Vector, Hashtable).
* **Iterator** is part of the **Java Collections Framework**, and it is more flexible and powerful because it supports element removal and iteration through modern collections (like ArrayList, HashMap, etc.).

**Iterator Example (modern way):**

import java.util.\*;

public class IteratorExample {

public static void main(String[] args) {

// Using ArrayList (modern collection)

List<String> list = new ArrayList<>();

list.add("Apple");

list.add("Banana");

list.add("Cherry");

// Using Iterator to iterate

Iterator<String> iterator = list.iterator();

while (iterator.hasNext()) {

System.out.println(iterator.next());

}

}

}

**When to Use Enumeration:**

* **Legacy Code**: Enumeration is mostly used when working with older collections such as **Vector** and **Hashtable**.
* **New Projects**: It is recommended to use **Iterator** or **for-each loops** in new projects, as they offer more functionality and are better integrated with modern Java collections.

**Summary:**

* **Enumeration** is an interface used to iterate over legacy collections (like Vector and Hashtable).
* It has two main methods: hasMoreElements() and nextElement().
* It lacks the ability to remove elements during iteration (unlike Iterator).
* **Iterator** has replaced **Enumeration** in most use cases due to its extended functionality and better support for modern collections.

## **Exception Handling**

### **What is Exception Handling?**

* Answer

### **Explain the hierarchy of Exception?**

* answer

### **How to create Custom Exceptions?**

* Answer

### **How to handle IOException?**

* answer

### **Difference between Checked Exception and Unchecked Exception?**

* answer

### **How to handle unchecked exceptions?**

* answer

### **What will happen if I use Exception and custom exceptions together? Priority?**

* answer

### **Have you created a custom exception? What is the purpose of that?**

* answer

### **What is the use of finally block in exception handling?**

* answer

### **What is a try with resources?**

* answer

### **Have you come across the OutOfMemory exception? How will you handle it? Explain with standalone code?**

* Answer

### **If you have try, catch and finally block and if I have written another exception inside catch block so how control will flow?**

* Answer

### **Have you ever got outOfMemory exceptions? Can you tell me any scenarios where you have faced this exception?**

* answer

## **Java 8 Features**

### **Explain Java8 features?**

✅ **Java 8 Overview**

Java 8, released in **March 2014**, was a major release that introduced **functional programming**, **streams**, and **default methods**, making Java much more expressive and modern.

🔹 **1. Lambda Expressions (JEP 126)**

Introduces anonymous functions to make code more concise.

List<String> names = List.of("Alice", "Bob");

names.forEach(name -> System.out.println(name));

✅ Reduces boilerplate for iterators, callbacks, and functional logic.

🔹 **2. Functional Interfaces**

An interface with a single abstract method, used as the target for lambda expressions.

@FunctionalInterface

interface MyFunc {

void show();

}

✅ Examples: Runnable, Callable, Predicate, Function, Consumer

🔹 **3. Stream API (JEP 107)**

Provides a high-level abstraction for processing sequences of elements (like collections) in a declarative way.

List<String> result = names.stream()

.filter(n -> n.startsWith("A"))

.collect(Collectors.toList());

✅ Supports map, filter, reduce, collect, etc.

🔹 **4. Default and Static Methods in Interfaces**

Allows interfaces to have method implementations.

interface MyInterface {

default void show() {

System.out.println("Default Method");

}

static void print() {

System.out.println("Static Method");

}

}

✅ Enables interface evolution without breaking existing implementations.

🔹 **5. Method References**

Shorthand for calling existing methods.

names.forEach(System.out::println);

✅ Cleaner than writing lambdas when reusing existing methods.

🔹 **6. Optional Class**

A container to handle null values more gracefully.

Optional<String> name = Optional.ofNullable(getName());

name.ifPresent(System.out::println);

✅ Avoids NullPointerException and encourages functional style handling of absence.

🔹 **7. Date and Time API (java.time)**

A comprehensive replacement for legacy java.util.Date and Calendar.

LocalDate today = LocalDate.now();

LocalDate birthday = LocalDate.of(1990, Month.MARCH, 10);

✅ Immutable, thread-safe, and more readable.

🔹 **8. Nashorn JavaScript Engine**

Allows Java to execute JavaScript code.

ScriptEngine engine = new ScriptEngineManager().getEngineByName("nashorn");

engine.eval("print('Hello JavaScript')");

✅ Deprecated in later versions.

✅ **Summary Table:**

| **Feature** | **Description** |
| --- | --- |
| **Lambda Expressions** | Anonymous functions for concise code |
| **Functional Interfaces** | Target types for lambdas |
| **Stream API** | Declarative collection processing |
| **Default/Static Methods** | Method implementation in interfaces |
| **Method References** | Shorthand for lambda expressions |
| **Optional Class** | Avoids null pointer exceptions |
| **Date and Time API** | Modern date/time classes in java.time package |
| **Nashorn Engine** | JavaScript execution in Java (deprecated in later) |

### **What is Functional Interface?**

* Answer

### **Why we need Functional Interface?**

* Answer

### **Difference between normal interface and Functional Interface?**

* Answer

### **What is the default method in functional interface?**

* Answer

### **What is Lambda Expression?**

* answer

### **What is the prerequisite for Lambda Expression?**

* answer

### **What is the map function in stream?**

* answer

### **What is the filter in the stream?**

* answer

### **What is Stream API?**

* answer

### **What is the use of @FunctionalInterface annotation? Will it be checked manually or by the compiler?**

* answer

### **Difference between Map and FlatMap in stream?**

* Answer

### **Difference between Map and Filter in java 8?**

* Answer

### **What is the intermediate and terminal operator in Java stream API?**

* Answer

**Intermediate Operators:**

These operators are lazy, meaning they do not process the data immediately but instead return a new stream. They are used to transform or filter elements of the stream and can be chained together.

**Examples of intermediate operators include:**

**filter():** Filters elements based on a predicate.

**map():** Transforms each element into another form.

**flatMap():** Flattens a stream of streams into a single stream.

**distinct():** Removes duplicate elements.

**sorted():** Sorts the elements.

**peek():** Allows you to perform an action on each element, primarily used for debugging.

**Terminal Operators:**

These operators trigger the processing of the stream and produce a result or a side-effect. After a terminal operation is invoked, the stream is considered consumed and cannot be used further.

**Examples of terminal operators include:**

**collect():** Collects the elements into a collection like a list or a set.

**forEach():** Performs an action on each element.

**reduce():** Reduces the stream to a single value based on an accumulator function.

**count():** Returns the number of elements in the stream.

**anyMatch(), allMatch(), noneMatch():** Match operations that return a boolean.

**findFirst(), findAny():** Returns the first or any element from the stream.

**max(), min():** Returns the maximum or minimum element based on a comparator.

Intermediate operations are usually chained together, whereas terminal operations are the ones that conclude the stream processing.

### **Advantages of Stream over for loop?**

* answer

### **What is the lambda expression in java 8?**

* answer

### **How to use lambda expressions with one example?**

* answer

### **What is Stream and Parallel stream?**

* answer

### **Explain Optional class in java 8?**

* answer

### **What is the purpose of Optional class?**

* answer

### **Explain Java 8 Functional interface?**

* answer

### **Where can you use FlatMap in a stream?**

* answer

### **What is the lambda expression?**

* answer

### **What is the use map method in java 8 stream?**

* answer

### **How to sort the list of objects in java using Stream API?**

* answer

### **What is the inbuilt functional interface in Java 8?**

* Answer

### **What is Predicate and Consumer in java 8?**

**🔹 Predicate<T> – For Conditional Checks**

**Purpose:** Represents a condition (boolean-valued function) on an object of type T.

**Method:** boolean test(T t)

**Use case:** Filtering, validations, condition checks

**✅ Example:**

Predicate<String> isLongerThan5 = str -> str.length() > 5;

System.out.println(isLongerThan5.test("Hello")); // false

System.out.println(isLongerThan5.test("Welcome")); // true

**🔹 Consumer<T> – For Performing an Action**

**Purpose:** Performs an operation on an object of type T (no return value).

**Method:** void accept(T t)

**Use case:** Logging, printing, updating, applying changes

✅ **Example:**

Consumer<String> printUpper = str -> System.out.println(str.toUpperCase());

printUpper.accept("hello"); // Output: HELLO

✅ **Real-World Use in Streams:**

List<String> names = Arrays.asList("John", "Sam", "Jennifer", "Joe");

// Using Predicate to filter names longer than 3 characters

names.stream()

.filter(name -> name.length() > 3) // Predicate

.forEach(name -> System.out.println(name)); // Consumer

**🔁 Summary:**

| **Interface** | **Method** | **Return Type** | **Purpose** |
| --- | --- | --- | --- |
| Predicate<T> | test(T t) | boolean | Evaluate a condition |
| Consumer<T> | accept(T t) | void | Perform an action |

### **Difference between Predicate and Function?**

| **Feature** | **Predicate<T>** | **Function<T, R>** |
| --- | --- | --- |
| Purpose | Represents a condition (true/false check) | Represents a transformation or mapping |
| Method | boolean test(T t) | R apply(T t) |
| Return Type | boolean | Any type R (generic return type) |
| Use Case | Filtering, validations | Converting or transforming data |
| Used In | .filter() in streams | .map() in streams |

**✅ Predicate Example:**

Predicate<String> isLong = str -> str.length() > 5;

System.out.println(isLong.test("Hello")); // false

System.out.println(isLong.test("Welcome")); // true

**✅ Function Example:**

Function<String, Integer> getLength = str -> str.length();

System.out.println(getLength.apply("Hello")); // 5

System.out.println(getLength.apply("Welcome")); // 7

🧠 **Real Use in Streams:**

List<String> names = Arrays.asList("Tom", "Jonathan", "Amy");

// Using Predicate to filter names

names.stream()

.filter(name -> name.length() > 3) // Predicate<String>

.forEach(System.out::println);

// Using Function to transform names to lengths

List<Integer> lengths = names.stream()

.map(name -> name.length()) // Function<String, Integer>

.collect(Collectors.toList());

System.out.println(lengths); // [3, 8, 3]

**🔁 Summary Table:**

| **Concept** | **Predicate<T>** | **Function<T, R>** |
| --- | --- | --- |
| Input | T | T |
| Output | boolean (true/false) | R (any type) |
| Functional Method | test(T t) | apply(T t) |
| Stream Use | filter() | map() |

### **Explain Consumer and Supplier?**

🔹 **Consumer<T> – Takes input, returns nothing**

**Purpose:** Represents an operation that accepts a value and performs an action, but returns nothing.

**Method:** void accept(T t)

**Use Case:** Logging, printing, modifying objects, etc.

**✅ Example:**

Consumer<String> greet = name -> System.out.println("Hello, " + name);

greet.accept("John"); // Output: Hello, John

🔹 **Supplier<T> – Gives output, takes nothing**

**Purpose:** Represents a function that supplies a value without any input.

**Method:** T get()

**Use Case:** Providing default values, random numbers, object generation, etc.

**✅ Example:**

Supplier<String> supplyName = () -> "Anonymous";

System.out.println(supplyName.get()); // Output: Anonymous

🔁 **Comparison Table**

| **Feature** | **Consumer<T>** | **Supplier<T>** |
| --- | --- | --- |
| Input | Takes input of type T | Takes no input |
| Output | Returns nothing (void) | Returns a value of type T |
| Method | void accept(T t) | T get() |
| Use Case | Performing operations like logging | Generating or supplying values |
| Stream Use | .forEach() | Used to provide values to collections or APIs |

**📦 Real-World Example**

🎯 **Using Consumer to print list elements:**

List<String> names = Arrays.asList("Alice", "Bob", "Charlie");

names.forEach(name -> System.out.println("Name: " + name)); // Consumer

🎯 **Using Supplier to generate random numbers:**

Supplier<Double> randomSupplier = () -> Math.random();

System.out.println("Random: " + randomSupplier.get());

✅ **Summary**

| **Interface** | **Signature** | **Input** | **Output** | **Common Use Case** |
| --- | --- | --- | --- | --- |
| Consumer | accept(T t) | Yes | No | Print, update, store, log |
| Supplier | get() | No | Yes | Supply value, create object |

### **What is the use of Map?**

* answer

### **What is Optional class? What are the advantages of using Optional class?**

* answer

### **What are all functional interfaces present in java?**

* answer

### **Optional case returning null and String, how to handle it? What are the advantages of using it?**

* answer

### **Give an example of Functional Interface in java?**

* Answer

### **Suppose you are using lambda expressions and other than lambda expressions then are we getting any performance benefits?**

* answer

### **Can you elaborate on the Stream API, purpose and use of it?**

* answer

### **Can we have more than one abstract method in a functional interface?**

* answer

### **Have you worked on NullPointerException? How to handle NullPointerException in java 8?**

* answer

### **Difference between Parallel Stream and Serial Stream?**

**🔁 Serial Stream (Sequential Stream)**

Processes elements one by one in a single thread.

Follows the original order of the data source.

Safer for tasks where order matters or there are side effects.

**✅ Example:**

List<Integer> numbers = Arrays.asList(1, 2, 3, 4, 5);

numbers.stream()

.forEach(System.out::println); // Single-threaded

**⚡ Parallel Stream**

Processes elements concurrently using multiple threads (Fork/Join framework).

Can significantly improve performance for large datasets or CPU-intensive operations.

Order is not guaranteed unless explicitly handled.

Suitable for stateless, independent, and non-blocking operations.

**✅ Example:**

List<Integer> numbers = Arrays.asList(1, 2, 3, 4, 5);

numbers.parallelStream()

.forEach(System.out::println); // Multi-threaded

**🆚 Key Differences**

| **Feature** | **Serial Stream** | **Parallel Stream** |
| --- | --- | --- |
| Execution | Single-threaded | Multi-threaded (ForkJoinPool) |
| Performance | Slower for large data | Faster for large, CPU-heavy tasks |
| Order Preservation | Maintains order | Order is not guaranteed |
| Thread-Safety Required | Not always | Yes, thread-safety is important |
| Use Case | Small datasets, order matters | Large datasets, independent tasks |
| API Method | .stream() | .parallelStream() |

**⚠️ When to Use Parallel Stream?**

✅ **Use it when:**

* Data set is large
* Operations are stateless, non-blocking, and independent
* You want to utilize multi-core CPU

**❌ Avoid if:**

* Task involves shared mutable state
* Result depends on processing order
* It makes the program slower due to context switching or I/O delays

🔍**Preserve Order in Parallel Stream**

If you still want parallelism with order, use .forEachOrdered():

numbers.parallelStream()

.forEachOrdered(System.out::println); // Keeps order but reduces performance gain

## **Java 11 Features**

### **Explain Java 11 features?**

✅ Java 11 Features Overview

Java 11 (released in September 2018) is a Long-Term Support (LTS) version after Java 8 and introduced several important features and changes.

🔹 **1.** **Local-Variable Syntax for Lambda Parameters**

You can now use var in lambda expressions:

(var a, var b) -> a + b;

✅ Benefit: Useful when you want to add annotations to parameters.

🔹 **2.** New String Methods

Java 11 added several new utility methods to the String class:

| **Method** | **Description** |
| --- | --- |
| isBlank() | Checks if the string is empty or whitespace only |
| lines() | Converts a multiline string into a stream of lines |
| strip() | Removes leading and trailing white space (Unicode-aware) |
| stripLeading() | Removes leading whitespaces |
| stripTrailing() | Removes trailing whitespaces |
| repeat(int) | Repeats the string multiple times |

String str = " Java ";

System.out.println(str.isBlank()); // false

System.out.println("A\nB\nC".lines().count()); // 3

System.out.println(str.strip()); // "Java"

System.out.println("Hello ".repeat(3)); // Hello Hello Hello

🔹 **3.** **HTTP Client (Standardized)**

The new HTTP Client API introduced in Java 9 is now standard.

HttpClient client = HttpClient.newHttpClient();

HttpRequest request = HttpRequest.newBuilder()

.uri(URI.create("https://example.com"))

.build();

HttpResponse<String> response = client.send(request, HttpResponse.BodyHandlers.ofString());

System.out.println(response.body());

🔹 **4. Collection.toArray(IntFunction)**

New method to convert a collection to an array using a generator:

List<String> list = List.of("A", "B", "C");

String[] array = list.toArray(String[]::new);

🔹 **5. Notable Removals**

Java EE and CORBA Modules were removed.

E.g., Removed: javax.xml.bind, javax.activation, java.se.ee, etc.

🔹 **6. Launch Single-File Source Code**

You can run a .java file directly without compiling it manually:

java HelloWorld.java

✅ Useful for quick scripts and testing.

🔹 **7. Flight Recorder and Mission Control**

JDK Flight Recorder and Java Mission Control are now part of the JDK for better performance monitoring and diagnostics.

✅ **Summary Table:**

| **Feature** | **Description** |
| --- | --- |
| var in Lambda | Enables use of var in lambda parameters |
| New String Methods | Utility methods like isBlank(), lines() |
| Standard HTTP Client | Simplified modern HTTP communication |
| Collection.toArray() Overload | Converts collections to arrays efficiently |
| Removed Deprecated Modules | Java EE/CORBA APIs removed |
| Run .java file directly | Java source code launcher |

## **Java 17 Features**

### **Explain Java 17 features?**

✅ Java 17, released in September 2021, is an LTS (Long-Term Support) version like Java 11 and Java 8. It includes many enhancements, new features, and deprecations/removals aimed at improving performance, security, and developer productivity.

🔹 **1. Sealed Classes (Standard Feature)**

Sealed classes restrict which classes can extend or implement them.

public sealed class Vehicle permits Car, Bike {}

final class Car extends Vehicle {}

final class Bike extends Vehicle {}

✅ Use Case: Controlled inheritance for security and design clarity.

🔹 **2. Pattern Matching for instanceof (Standard Feature)**

Simplifies type checks and casting.

if (obj instanceof String s) {

System.out.println(s.toLowerCase());

}

✅ Cleaner and safer casting logic.

🔹 **3. Switch Expressions (Preview earlier, now stable)**

Allows switch to return values and have more concise syntax.

String result = switch (day) {

case MONDAY -> "Start of week";

case FRIDAY -> "Weekend is near";

default -> "Midweek";

};

✅ More readable and expressive control flow.

🔹 **4. Text Blocks (Introduced in Java 15, refined)**

Multi-line string literals with better formatting.

String json = """

{

"name": "ChatGPT",

"type": "AI"

}

""";

✅ Useful for JSON, SQL, XML, etc.

🔹 **5. New Pseudo-Random Number Generators (JEP 356)**

Provides new interfaces and implementations for random number generation.

RandomGenerator rand = RandomGeneratorFactory.of("L64X256MixRandom").create();

int num = rand.nextInt();

✅ More flexible and efficient random generation.

🔹 **6. Foreign Function & Memory API (Incubator)**

Allows Java programs to call native code and allocate memory outside the heap.

✅ Improves native interop without JNI.

🔹 **7. Enhanced NullPointerException Messages**

Helpful exception messages with more context.

Exception in thread "main" java.lang.NullPointerException:

Cannot invoke "String.length()" because "str" is null

✅ Great for debugging.

🔹 **8. Removal/Deprecation of Legacy Features**

Applet API deprecated.

Experimental AOT and JIT compilers removed.

RMI Activation removed.

🔹 **9. JEP 409: Sealed Interfaces**

Interfaces can also be sealed like classes.

public sealed interface Animal permits Dog, Cat {}

✅ **Summary Table:**

| **Feature** | **Description** |
| --- | --- |
| Sealed Classes & Interfaces | Restricts subclassing |
| Pattern Matching for instanceof | Cleaner type checks |
| Switch Expressions | Return values directly from switch |
| Text Blocks | Multiline string literals |
| Enhanced NPE Messages | Better error diagnostics |
| Foreign Function & Memory API | Safe native interop (Incubator) |
| New Random Generators | Flexible PRNG implementations |

## **Java 21 Features**

### **Explain Java 21 features?**

* Answer

✅ **Java 21 Overview**

Java 21, released in September 2023, is a Long-Term Support (LTS) version. It includes powerful new features, especially around pattern matching, virtual threads, and improvements in performance, syntax, and foreign APIs.

🔹 **1. Virtual Threads (JEP 444 - Final)**

Lightweight threads that help with high-throughput concurrent applications.

Thread.startVirtualThread(() -> {

// Non-blocking, lightweight task

System.out.println("Hello from a virtual thread");

});

✅ Great for scalable applications like servers and reactive systems.

🔹 **2. Record Patterns (JEP 440 - Final)**

Deconstruct records more concisely in pattern matching.

record Point(int x, int y) {}

void print(Object obj) {

if (obj instanceof Point(int x, int y)) {

System.out.println("X: " + x + ", Y: " + y);

}

}

✅ Improves destructuring of objects in conditionals.

🔹 **3. Pattern Matching for switch (JEP 441 - Final)**

Enhances switch expressions with type patterns.

static String format(Object obj) {

return switch (obj) {

case Integer i -> "int: " + i;

case String s -> "String: " + s.toUpperCase();

default -> "Unknown";

};

}

✅ Improves readability and reduces boilerplate.

🔹 **4. Sequenced Collections (JEP 431)**

New interface that adds consistent ordering to Collections (first(), last(), etc.).

SequencedCollection<String> names = new SequencedSet<>();

✅ Adds order-sensitive operations.

🔹 **5. String Templates (JEP 430 - Preview)**

Simplifies string construction with embedded expressions.

String name = "Java";

String message = STR."Welcome to \{name} 21!";

✅ Makes dynamic strings concise and readable.

🔹 **6. Scoped Values (JEP 446 - Preview)**

A safer alternative to thread-local variables, designed to work with virtual threads.

✅ Used for managing thread-local-like state safely in a structured way.

🔹 **7. Foreign Function & Memory API (JEP 442 - 3rd Preview)**

Modern and safe access to native code, replacing JNI.

✅ Supports calling native libraries and allocating off-heap memory.

🔹 **8. Deprecations & Removals**

Finalization is deprecated for removal.

Legacy APIs are cleaned and marked deprecated for future removal.

✅ **Summary Table:**

| **Feature** | **Description** |
| --- | --- |
| Virtual Threads | Lightweight threads for scalable concurrency |
| Record Patterns | Deconstruction of record types |
| Pattern Matching for switch | Type-safe, expressive switch |
| Sequenced Collections | Ordered collections with first/last semantics |
| String Templates (Preview) | Interpolated strings like ${} syntax |
| Scoped Values (Preview) | Safe alternative to ThreadLocal |
| Foreign Function & Memory API | Call native functions, work with memory safely |

### **What is the added version after Java 17 to Java 21?**

* answer

## **Multithreading**

### **What is multithreading in java?**

* answer

### **Difference between Process and Thread?**

* answer

### **Explain the Thread Life Cycle?**

* Answer

### **What is a deadlock? Explain with an example?**

* answer

### **What is a Synchronized Thread?**

* answer

### **Difference between synchronized and volatile keyword?**

* Answer

### **What happens if a thread calls notify() instead of notifyAll()?**

* Answer

### **How to create threads using java 1.7 and java 1.8?**

* answer

### **Difference between wait and sleep?**

* answer

### **What is Thread.sleep() method, and what does it do internally?**

* Answer

### **Difference between Thread and Runnable in Java?**

* Answer

### **What is significance of Executors in Java?**

* Answer

### **Explain the Producer Consumer problem and how would you implement it using wait(), notify() or BlockingQueue?**

* Answer

### **Difference between Callable and Runnable. When should you use each?**

* Answer

### **What is ForkJoinPool in Java and how does it differ from normal ExecutorService?**

* Answer

### **Explain Deadlock and how do you avoid it in Java Multithreading?**

* Answer

### **What are the ways of blocking the threads in java?**

* answer

### **What is thread synchronization in java?**

* answer

### **What are the methods of thread?**

* Answer

### **What is thread pool? What are the types of thread pool?**

* Answer

### **In Thread Pool Executor which data structure is used to store the request data?**

* In a **ThreadPoolExecutor**, the data structure used to store the tasks (requests) that need to be executed is typically a **blocking queue**. Specifically, the **BlockingQueue** is used to hold the tasks before they are picked up by available threads for execution.

**Common Data Structures for BlockingQueue:**

**LinkedBlockingQueue**:

This is the most commonly used implementation of a BlockingQueue in ThreadPoolExecutor.

It has an optional capacity limit, meaning it can grow dynamically (if the capacity is not specified) or be bounded with a fixed capacity.

It supports efficient thread-safe operations and allows multiple threads to enqueue and dequeue tasks safely.

If the queue is full and threads are available, the tasks will be added to the queue, and threads will continue to execute the tasks.

BlockingQueue<Runnable> queue = new LinkedBlockingQueue<>();

**ArrayBlockingQueue**:

This is a bounded blocking queue where the capacity is fixed and set during initialization.

It is backed by an array, and it is useful when you want to limit the number of pending tasks.

It can block threads when the queue is full and will prevent new tasks from being added if the capacity is reached.

BlockingQueue<Runnable> queue = new ArrayBlockingQueue<>(100); // Fixed capacity of 100 tasks

**SynchronousQueue**:

This is a special kind of blocking queue that does not store any tasks. It directly hands over the task from the submitter to the thread.

It is useful for high-throughput situations where you don’t need to store the tasks, and each task is handled by a thread immediately.

SynchronousQueue has a capacity of zero, so tasks can only be executed when threads are available to consume them.

BlockingQueue<Runnable> queue = new SynchronousQueue<>();

**PriorityBlockingQueue**:

This is a special kind of blocking queue where tasks are ordered based on their priority rather than the order in which they are submitted.

If tasks are submitted with priority information, this queue will process higher-priority tasks first.

BlockingQueue<Runnable> queue = new PriorityBlockingQueue<>();

**How It Works:**

**When a task is submitted to the executor**: The ThreadPoolExecutor puts the task into the queue (like a BlockingQueue).

**Thread Selection**: When a worker thread is idle or available, it takes the task from the queue and executes it.

**Blocking Behavior**: If the queue is full, the BlockingQueue will block the submitter until space is available (in the case of a bounded queue). Similarly, threads will wait if the queue is empty.

**Example:**

int cpuCount = Runtime.getRuntime().availableProcessors();

BlockingQueue<Runnable> queue = new LinkedBlockingQueue<>();

ThreadPoolExecutor executor = new ThreadPoolExecutor(

cpuCount \* 2, cpuCount \* 3, 60L, TimeUnit.SECONDS, queue

);

// Submit tasks

executor.submit(() -> System.out.println("Task 1"));

executor.submit(() -> System.out.println("Task 2"));

**Summary:**

The **BlockingQueue** (like LinkedBlockingQueue, ArrayBlockingQueue, SynchronousQueue, etc.) is the **data structure** used to store the tasks waiting to be executed in a ThreadPoolExecutor.

The exact implementation of the queue may vary depending on whether you want to limit the queue size, prioritize tasks, or handle concurrent task submissions efficiently.

### **When we setup a Thread Pool Executor so what will be the ideal count, how many thread we should keep in it?**

* The **ideal thread count** for a **ThreadPoolExecutor** depends on several factors, such as the nature of the tasks you're executing, the system's hardware capabilities (like the number of CPU cores), and the type of workload you're handling (I/O-bound vs CPU-bound). There's no one-size-fits-all answer, but I can help guide you to an optimal setup.

**Key Considerations:**

**CPU-bound tasks**:

These are tasks that perform intensive computations (e.g., number-crunching tasks).

Since CPU-bound tasks require significant CPU time and only one thread can execute on a single core at a time, the ideal number of threads is usually **equal to the number of CPU cores** available.

For example, if you have a 4-core CPU, a thread pool of **4 threads** is ideal, since adding more threads would not increase the throughput and could actually reduce performance due to excessive context switching.

**I/O-bound tasks**:

These tasks spend more time waiting for I/O operations, like reading files, making network requests, or waiting for database queries.

I/O-bound tasks are less dependent on the number of CPU cores because the threads often spend time in a waiting state rather than actively using the CPU. Therefore, the thread pool can have **more threads than the number of CPU cores**.

A common guideline is to have a thread pool size of **N + (N / 2)**, where N is the number of CPU cores. This accounts for the threads waiting on I/O and helps utilize CPU cores while waiting.

**General Guidelines:**

**For CPU-bound tasks**: Set the pool size to the **number of available CPU cores** (e.g., Runtime.getRuntime().availableProcessors()).

int cpuCount = Runtime.getRuntime().availableProcessors();

ExecutorService executor = new ThreadPoolExecutor(cpuCount, cpuCount, 0L, TimeUnit.MILLISECONDS, new LinkedBlockingQueue<>());

**For I/O-bound tasks**: You can increase the thread pool size. A common rule is to set the pool size to **2 to 3 times the number of CPU cores**, especially if tasks are blocking on I/O.

int cpuCount = Runtime.getRuntime().availableProcessors();

ExecutorService executor = new ThreadPoolExecutor(cpuCount \* 2, cpuCount \* 3, 0L, TimeUnit.MILLISECONDS, new LinkedBlockingQueue<>());

**Additional Factors:**

**Task Characteristics**:

**Short-running tasks**: If the tasks are short-lived, you might get away with a smaller pool.

**Long-running tasks**: For tasks that take a long time, increasing the number of threads might help to keep the CPU busy.

**System Resources**:

Having too many threads can lead to context switching overhead and can strain the system resources (memory, CPU, etc.).

The optimal number of threads should also consider available system resources. Too many threads can degrade performance.

**Example Setup:**

int cpuCount = Runtime.getRuntime().availableProcessors();

int poolSize = cpuCount \* 2; // For I/O-bound tasks, or you can adjust based on testing

ExecutorService executor = new ThreadPoolExecutor(

poolSize, poolSize, 60L, TimeUnit.SECONDS, new LinkedBlockingQueue<Runnable>()

);

**Monitoring and Tuning:**

**Benchmarking**: It's essential to test and benchmark different thread pool sizes for your specific workload. Sometimes, tuning parameters like keepAliveTime and queue size also matter.

**Load Testing**: Under high loads, you may need to adjust the pool size dynamically or adjust based on the system's behavior (e.g., monitoring queue size or thread utilization).

**Conclusion:**

For **CPU-bound** tasks: Set the thread pool size to the number of available CPU cores (cpuCount).

For **I/O-bound** tasks: Set the thread pool size to around **2 to 3 times the number of CPU cores**.

Test and monitor your system to find the most efficient configuration based on the task type and workload.

### **What are thread pool methods?**

* Answer

### **How to create threads in java?**

* answer

### **How to start a thread in java?**

* answer

### **How to create threads in two different ways?**

* answer

### **What is the necessity of thread synchronization?**

* answer

### **How to create a Thread pool in java?**

* answer

### **Which method you will override in order to create a thread?**

* answer

### **What are all methods present in Thread class?**

* answer

### **How do notify methods work in multithreading?**

* answer

### **What is synchronized in multithreading?**

* answer

### **Thread safety with Singleton class?**

* answer

### **Explain Thread executors?**

* answer

### **How to create three threads so that it will execute simultaneously?**

* Answer

### **What can we replace instead of this keyword in the statement? synchronized(this) {?**

* Answer

### **What is runAsync vs supplyAsync?**

* The difference between **supplyAsync()** and **runAsync()** in Java's CompletableFuture lies in whether the task you're executing returns a result or not.

**1. supplyAsync()**

**Purpose**: Used when you want to execute an asynchronous task **that returns a result**.

**Return Type**: CompletableFuture<T> where T is the type of the result returned by the task.

**Input**: Takes a Supplier<T> — a functional interface that provides a result (of type T).

**Usage**: Use this method when you need to perform an asynchronous operation that **computes a value** or **produces a result**.

**Example**:

CompletableFuture<Integer> future = CompletableFuture.supplyAsync(() -> {

// Simulate some computation

return 42;

});

future.thenAccept(result -> System.out.println("Result: " + result)); // Output: Result: 42

Here, supplyAsync runs the task in a separate thread and returns the result 42, wrapped in a CompletableFuture.

**2. runAsync()**

**Purpose**: Used when you want to execute an asynchronous task **that does not return a result**.

**Return Type**: CompletableFuture<Void> since there's no result being returned (void).

**Input**: Takes a Runnable — a task that performs some action without returning any result.

**Usage**: Use this method when you want to execute a task asynchronously without needing a result back from the task.

**Example**:

CompletableFuture<Void> future = CompletableFuture.runAsync(() -> {

// Simulate some work

System.out.println("Task is running asynchronously");

});

future.thenRun(() -> System.out.println("Task is completed")); // Output: Task is running asynchronously

Here, runAsync executes the task asynchronously, but it doesn't return any value, and the CompletableFuture just represents the task’s completion.

**Summary of Differences:**

**supplyAsync()**:

* Used when you need to execute an asynchronous task that **returns a result**.
* It returns a CompletableFuture<T>, where T is the result of the task.

**runAsync()**:

* Used when you need to execute an asynchronous task that does not return a result.
* It returns a CompletableFuture<Void>, since the task doesn't return anything.

Both methods run tasks asynchronously, but **supplyAsync** handles tasks that **produce a result**, while **runAsync** handles tasks that perform some side effect without returning any value.

### **What is ReentrantLock in java?**

* A **ReentrantLock** in Java is a **mutual exclusion lock (mutex)** that is part of the **java.util.concurrent.locks** package. It provides **explicit locking** with advanced features compared to the traditional synchronized keyword.

**✅ Key Features of ReentrantLock:**

**Reentrant Behavior:**

A thread that **already holds the lock** can acquire it again **without getting blocked**.

This is the same behavior as the synchronized block.

Internally, the lock maintains a **hold count**, which tracks how many times the current thread has acquired the lock.

ReentrantLock lock = new ReentrantLock();

lock.lock();

try {

// critical section

lock.lock(); // Reentrant call (same thread)

try {

// nested critical section

} finally {

lock.unlock();

}

} finally {

lock.unlock();

}

**Manual Lock/Unlock:**

Unlike synchronized, you must **manually acquire and release** the lock using lock() and unlock().

Failing to call unlock() (e.g., in case of exceptions) can lead to deadlocks, so use it with try-finally.

**Try Lock (Non-blocking):**

tryLock() lets a thread **try to acquire the lock** without blocking. It returns immediately with true or false.

if (lock.tryLock()) {

try {

// do something

} finally {

lock.unlock();

}

} else {

// could not get the lock

}

**Timed Locking:**

tryLock(long timeout, TimeUnit unit) allows a thread to **wait for a certain period** to acquire the lock.

if (lock.tryLock(2, TimeUnit.SECONDS)) {

try {

// critical section

} finally {

lock.unlock();

}

}

**Interruptible Lock Acquisition:**

lockInterruptibly() allows a thread to be **interrupted** while waiting to acquire the lock.

lock.lockInterruptibly();

**Fair Locking:**

You can create a **fair ReentrantLock** that gives access to the longest-waiting thread:

ReentrantLock fairLock = new ReentrantLock(true); // fairness = true

**🔄 Difference between synchronized and ReentrantLock:**

| **Feature** | **synchronized** | **ReentrantLock** |
| --- | --- | --- |
| Reentrant | Yes | Yes |
| Try lock without blocking | No | Yes (tryLock()) |
| Timed lock | No | Yes (tryLock(timeout)) |
| Interruptible lock waiting | No | Yes (lockInterruptibly()) |
| Fairness | No (non-deterministic order) | Yes (optional fair mode) |
| Explicit unlock required | No | Yes (unlock()) |

**✅ Use Case:**

Use **ReentrantLock** when:

* You need **more control** over the locking mechanism.
* You need **try-lock**, **timed-lock**, or **interruptible-lock**.
* You want **fair thread scheduling** for lock acquisition.

### **Difference between lock and synchronized?**

* answer

### **What is Callable interface?**

* **Callable** is a functional interface used to execute concurrent tasks that return a result and can throw exceptions.
* It's most commonly used with ExecutorService and Future.
* The **Callable** interface is part of the **java.util.concurrent** package and is similar to the Runnable interface but with some key differences.

**✅ Key Features of Callable:**

* **Returns a result** — Unlike Runnable, which returns void, Callable returns a result of a specified type.
* **Can throw checked exceptions** — Callable.call() method can throw checked exceptions.
* **Used with ExecutorService** — It is typically used with ExecutorService to submit tasks asynchronously.

**Example:**

import java.util.concurrent.\*;

public class CallableExample {

public static void main(String[] args) throws Exception {

ExecutorService executor = Executors.newSingleThreadExecutor();

Callable<String> task = () -> {

Thread.sleep(1000);

return "Task completed!";

};

Future<String> future = executor.submit(task);

System.out.println("Result: " + future.get()); // Blocks until result is ready

executor.shutdown();

}

}

### **What is Runnable interface?**

* The **Runnable** interface is a **functional interface** in Java, designed to represent a task that can be executed by a thread. It is part of the **java.lang** package.
* Runnable is used to execute code concurrently in threads.
* It does **not return a value** and **cannot throw checked exceptions**.
* Often used when the task is simple and doesn't need a return result.

**✅ Key Features of Runnable:**

1. **Single Abstract Method**:
   * void run();
   * Contains no parameters and does not return any result.
2. **Used to Define a Thread Task**:
   * Runnable is often used to define the code that should execute in a separate thread.
3. **Does Not Return a Value**:
   * Unlike Callable, it doesn’t return any result or throw checked exceptions.
4. **Can Be Passed to a Thread**:
   * You can pass an instance of Runnable to a Thread constructor.

**Example:**

public class MyRunnable implements Runnable {

@Override

public void run() {

System.out.println("Running in a thread: " + Thread.currentThread().getName());

}

public static void main(String[] args) {

Thread thread = new Thread(new MyRunnable());

thread.start();

}

}

### **Difference between Future and CompletableFuture?**

* The main difference between Future and CompletableFuture in Java lies in their capabilities and flexibility when working with asynchronous tasks.

**1. Basic Overview:**

**Future:**

* Represents a task that will eventually complete and produce a result.
* It is **blocking**: You can get the result using methods like get(), but it will block the calling thread until the task completes.

**CompletableFuture:**

* A subclass of Future that allows you to write **non-blocking** asynchronous code.
* It can be **explicitly completed** (via complete()) and can be used to **compose asynchronous tasks** without blocking.

**2. Asynchronous Composition:**

**Future:**

* **Does not support chaining or combining asynchronous tasks**. It only allows the retrieval of the result via blocking calls (e.g., get()).

**CompletableFuture:**

* **Supports chaining** of multiple asynchronous tasks via methods like thenApply(), thenAccept(), and thenCombine().
* You can **combine multiple futures** into one using methods like thenCombine(), thenCompose(), and handle exceptions with exceptionally() or handle().
* **Non-blocking** methods that return a CompletableFuture allow you to write cleaner asynchronous workflows.

**3. Completion:**

**Future:**

* You cannot manually complete a Future. The task it represents is managed internally by a thread pool or an executor.
* It provides the get() method to wait for the completion of the task, but it is **blocking**.

**CompletableFuture:**

* You can **complete a CompletableFuture manually** using the complete() method. This is useful for controlling when a task is marked as completed.
* It supports more advanced features like **handling exceptions** and propagating them properly in the asynchronous chain.

**4. Exception Handling:**

**Future:**

* Future provides get() method, which throws **checked exceptions** like ExecutionException or InterruptedException.
* Exception handling is not as flexible as in CompletableFuture.

**CompletableFuture:**

* CompletableFuture allows you to handle exceptions in a more flexible way through methods like exceptionally(), handle(), or whenComplete().
* You can specify fallback logic if the task fails, without blocking the thread.

**5. Blocking vs Non-blocking:**

**Future:**

* The get() method is **blocking**: it will wait for the task to complete and then return the result.

**CompletableFuture:**

* Can be used in **non-blocking** ways, with methods like thenApply(), thenAccept() to perform computations asynchronously without blocking.

**6. Example:**

**Future Example:**

ExecutorService executor = Executors.newSingleThreadExecutor();

Future<Integer> future = executor.submit(() -> {

// Simulating long-running task

Thread.sleep(1000);

return 123;

});

try {

// Blocking call

Integer result = future.get();

System.out.println("Result: " + result);

} catch (Exception e) {

e.printStackTrace();

}

**CompletableFuture Example:**

CompletableFuture<Integer> completableFuture = CompletableFuture.supplyAsync(() -> {

// Simulating long-running task

try {

Thread.sleep(1000);

} catch (InterruptedException e) {

e.printStackTrace();

}

return 123;

});

completableFuture

.thenApply(result -> result \* 2) // Chaining another task

.thenAccept(result -> System.out.println("Processed Result: " + result))

.exceptionally(ex -> {

System.out.println("Exception: " + ex.getMessage());

return null;

});

**7. Summary of Key Differences:**

| **Feature** | **Future** | **CompletableFuture** |
| --- | --- | --- |
| **Blocking vs Non-blocking** | Blocking (via get()) | Non-blocking (via methods like thenApply()) |
| **Manual Completion** | Cannot manually complete | Can be manually completed using complete() |
| **Exception Handling** | Limited and blocking | Flexible, with methods like exceptionally() |
| **Chaining/Composition** | No chaining support | Supports chaining of asynchronous tasks |
| **Usage** | Simple use cases | Complex asynchronous workflows with composition |

**When to Use:**

**Use Future:**

* For simple, blocking task results, where you need the result of an asynchronous task and can afford to wait.

**Use CompletableFuture:**

* When you want to write complex, non-blocking asynchronous logic that can be composed, chained, or handled with custom exception handling.

## **Scenario based Questions**

### **Scenario based question - 1?**

String s1 = “abc”; and String s2 = new String(“abc”); Where will s1 and s2 be stored?

* answer

### **Scenario based question - 2?**

What is the output of the given Java code?

public class Test

{

public static void main(String[] args)

{

method(null);

}

public static void method(Object o)

{

System.out.println("Object method");

}

public static void method(Integer i)

{

System.out.println("Integer method");

}

}

* Answer

### **Scenario based question - 3?**

What is the output?

Map<Integer, String> aMap = new HashMap<>();

Integer a = new Integer(20);

Integer b = 20;

aMap.put(a, "Blume");

aMap.put(b, "BlumeGlobal");

System.out.println(aMap.get(20));

System.out.println(aMap.get(new Integer(20)));

System.out.println(aMap.get(b));

System.out.println(aMap.get(a));

* answer

### **Scenario based question - 4?**

Modify below code in order to print the value of a and b?

class Account {

int a;

int b;

public void setData(int a, int b) {

a = a;

b = b;

}

public void showData() {

System.out.println("Value of A ="+a);

System.out.println("Value of B ="+b);

}

public static void main(String args[]) {

Account obj = new Account();

obj.setData(2,3);

obj.showData();

}

}

* answer

### **Scenario based question - 5?**

What will happen if we declare the list below?

List<Object> var = new ArrayList<String>;

* answer

## **JDBC**

### **What is JDBC?**

* answer

# ***Java Programs***

### **Program – Find max sum of contiguous sub array**

Write a program in java to return max sum of contiguous subarray of size 3?

(Write algorithm steps as well)

Example. [2,1,5,1,3,2], where k=3 (max size of sub array)?

public class MaxSumSubarray {

public static int findMaxSum(int[] arr, int k) {

// Edge case: if array length is less than k

if (arr.length < k) {

return -1; // Invalid case, can't have a subarray of size k

}

// Calculate sum of first window of size k

int windowSum = 0;

for (int i = 0; i < k; i++) {

windowSum += arr[i];

}

int maxSum = windowSum; // Initialize maxSum with the sum of the first window

// Slide the window across the array

for (int i = k; i < arr.length; i++) {

// Subtract the element that is leaving the window and add the one entering the window

windowSum += arr[i] - arr[i - k];

// Update maxSum if the new window sum is greater

maxSum = Math.max(maxSum, windowSum);

}

return maxSum;

}

public static void main(String[] args) {

int[] arr = {2, 1, 5, 1, 3, 2}; // Example array

int k = 3; // Size of the subarray

int result = findMaxSum(arr, k);

System.out.println("The maximum sum of a contiguous subarray of size " + k + " is: " + result);

}

}

### **Program - Print even and odd numbers using thread**

class NumberPrinter {

private int number = 1;

private final int max;

private final Object lock = new Object();

public NumberPrinter(int max) {

this.max = max;

}

public void printOdd() {

synchronized (lock) {

while (number <= max) {

if (number % 2 == 1) {

System.out.println("Odd: " + number);

number++;

lock.notify();

} else {

try {

lock.wait();

} catch (InterruptedException e) {

Thread.currentThread().interrupt();

}

}

}

}

}

public void printEven() {

synchronized (lock) {

while (number <= max) {

if (number % 2 == 0) {

System.out.println("Even: " + number);

number++;

lock.notify();

} else {

try {

lock.wait();

} catch (InterruptedException e) {

Thread.currentThread().interrupt();

}

}

}

}

}

}

public class EvenOddThread {

public static void main(String[] args) {

NumberPrinter printer = new NumberPrinter(10); // Change max here

Thread oddThread = new Thread(printer::printOdd);

Thread evenThread = new Thread(printer::printEven);

oddThread.start();

evenThread.start();

}

}

### **Program – Find maximum value from integer array**

Write a method to return the maximum value from an integer array passed as an input parameter

public class FindLargestNumber

{

public static int returnLargetNumber(int arr[])

{

int i;

int largestNumber = arr[0];

for (i = 1; i < arr.length; i++)

if (arr[i] > largestNumber) {

largestNumber = arr[i];

return largestNumber;

}

public static void main(String[] args)

{

int arr[] = {55, 12, 0, 786, 98};

System.out.println("Largest number in given array : " + returnLargetNumber(arr));

}

}

### **Program – Singleton class**

Problem Definition: Write a program to implement Singleton class?

public class Singleton {

// Step 1: Create a private static instance of the class (initially null)

private static Singleton instance;

// Step 2: Private constructor to prevent instantiation

private Singleton() {

System.out.println("Singleton instance created.");

}

// Step 3: Public static method to provide access to the instance

public static synchronized Singleton getInstance() {

if (instance == null) {

instance = new Singleton(); // Create only if not created yet

}

return instance;

}

// Sample method

public void showMessage() {

System.out.println("Hello from Singleton!");

}

public static void main(String[] args) {

Singleton obj1 = Singleton.getInstance();

obj1.showMessage();

Singleton obj2 = Singleton.getInstance();

System.out.println("Same instance? " + (obj1 == obj2)); // true

}

}

### **Program – Find missing number from array**

Problem Definition: Write a program - method to return missing number from array of length n=3

Example: n=3, [2,0,3] -> Output -> 1

public class MissingNumberFinder {

public static int findMissingNumber(int[] arr, int n) {

int expectedSum = n \* (n + 1) / 2;

int actualSum = 0;

for (int num : arr) {

actualSum += num;

}

return expectedSum - actualSum;

}

public static void main(String[] args) {

int[] arr = {2, 0, 3};

int n = 3;

int missing = findMissingNumber(arr, n);

System.out.println("Missing number is: " + missing); // Output: 1

}

}

### **Program - Anagram**

Problem Definition: Write a program in java to check if two strings are Anagram or not. Return boolean method

LISTEN - SILENT

Implement using collections.

import java.util.Arrays;

import java.util.HashMap;

public class Anagram {

public static boolean checkAnagramUsingArray(String str1, String str2) {

str1 = str1.replaceAll("\\s", "");

str2 = str2.replaceAll("\\s", "");

if (str1.length() != str2.length()) {

return false;

}

char[] str1Array = str1.toLowerCase().toCharArray();

char[] str2Array = str2.toLowerCase().toCharArray();

Arrays.sort(str1Array);

Arrays.sort(str2Array);

return Arrays.equals(str1Array, str2Array);

}

public static boolean checkAnagramUsingCollection(String str1, String str2) {

str1 = str1.replaceAll("\\s", "");

str2 = str2.replaceAll("\\s", "");

if (str1.length() != str2.length()) {

return false;

}

HashMap<Character, Integer> hm1 = new HashMap<Character, Integer>();

HashMap<Character, Integer> hm2 = new HashMap<Character, Integer>();

char[] str1Array = str1.toCharArray();

char[] str2Array = str2.toCharArray();

for (char value : str1Array) {

if (hm1.get(value) == null) {

hm1.put(value, 1);

} else {

int c = hm1.get(value);

hm1.put(value, ++c);

}

}

for (char c : str2Array) {

if (hm2.get(c) == null) {

hm2.put(c, 1);

} else {

int d = hm2.get(c);

hm2.put(c, ++d);

}

}

return hm1.equals(hm2);

}

public static void main(String[] args) {

String str1 = "LISTEN";

String str2 = "SILENT";

System.out.println(checkAnagramUsingArray(str1, str2));

System.out.println(checkAnagramUsingCollection(str1, str2));

}

}

### **Program - Swap two numbers without using a third variable**

public class SwapNumbers {

public static void main(String[] args) {

int a = 5, b = 10;

System.out.println("Before swap: a = " + a + ", b = " + b);

// Swap logic without third variable

a = a + b; // a = 15

b = a - b; // b = 5

a = a - b; // a = 10

System.out.println("After swap: a = " + a + ", b = " + b);

}

}

### **Program - Print even and odd numbers without using the modulus operator**

public class EvenOddWithoutModulus {

public static void main(String[] args) {

int[] numbers = {0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10};

for (int num : numbers) {

if ((num & 1) == 0) {

System.out.println(num + " is Even");

} else {

System.out.println(num + " is Odd");

}

}

}

}

### **Program – Find third largest number from array using java 8**

import java.util.Arrays;

import java.util.Comparator;

import java.util.Optional;

public class ThirdLargestElement {

public static void main(String[] args) {

int[] arr = {5, 1, 9, 3, 7, 2, 8};

Optional<Integer> thirdLargest = Arrays.stream(arr)

.boxed()

.distinct()

.sorted(Comparator.reverseOrder())

.skip(2)

.findFirst();

if (thirdLargest.isPresent()) {

System.out.println("Third largest element: " + thirdLargest.get());

} else {

System.out.println("Array doesn't have a third largest element.");

}

}

}

### **Program – Print even and odd numbers using java 8 stream API**

import java.util.Arrays;

import java.util.List;

public class EvenOddUsingStreams {

public static void main(String[] args) {

List<Integer> numbers = Arrays.asList(10, 15, 22, 33, 40, 51, 64, 75);

System.out.println("Even Numbers:");

numbers.stream()

.filter(n -> n % 2 == 0)

.forEach(System.out::println);

System.out.println("\nOdd Numbers:");

numbers.stream()

.filter(n -> n % 2 != 0)

.forEach(System.out::println);

}

}

### **Program – Fibonacci series**

public class FibonacciSeries {

public static void main(String[] args) {

int n = 10; // Number of terms to print

int a = 0, b = 1;

System.out.print("Fibonacci Series up to " + n + " terms: ");

for (int i = 1; i <= n; i++) {

System.out.print(a + " ");

// Next term = sum of previous two

int next = a + b;

a = b;

b = next;

}

}

}

### **Program - Reverse array in groups of a given size k**

Problem Definition: Write a program to perform Reverse an array in groups of given size?

**Example:** [1,2,3,4,5,6,7] where k=3

**Output:** [5,6,7,1,2,3,4]

import java.util.\*;

public class ReverseInGroups {

public static void main(String[] args) {

int[] arr = {1,2,3,4,5,6,7};

int k = 3;

List<List<Integer>> groups = new ArrayList<>();

// Step 1: Divide array into groups of size k

for (int i = 0; i < arr.length; i += k) {

List<Integer> group = new ArrayList<>();

for (int j = i; j < i + k && j < arr.length; j++) {

group.add(arr[j]);

}

groups.add(group);

}

// Step 2: Move the last group to the front

Collections.rotate(groups, 1); // rotate right by 1

// Step 3: Flatten the groups into final list

List<Integer> result = new ArrayList<>();

for (List<Integer> group : groups) {

result.addAll(group);

}

// Output the result

System.out.println("Output: " + result);

}

}

### **Program - Print factorials of natural numbers from 1 to 10**

public class FactorialPrinter {

public static void main(String[] args) {

System.out.println("Factorials of numbers from 1 to 10:");

for (int i = 1; i <= 10; i++) {

System.out.println(i + "! = " + factorial(i));

}

}

// Method to calculate factorial

public static long factorial(int n) {

long result = 1;

for (int i = 2; i <= n; i++) {

result \*= i;

}

return result;

}

}

### **Program - Reverse the integer array without using loops? Using recursion?**

public class ReverseArrayRecursion {

// Method to reverse the array using recursion

public static void reverseArray(int[] arr, int start, int end) {

// Base case: If start index is greater than or equal to end, return

if (start >= end) {

return;

}

// Swap the elements at start and end

int temp = arr[start];

arr[start] = arr[end];

arr[end] = temp;

// Recursively call the method with updated indices

reverseArray(arr, start + 1, end - 1);

}

public static void main(String[] args) {

int[] arr = {1, 2, 3, 4, 5};

System.out.println("Original Array:");

for (int num : arr) {

System.out.print(num + " ");

}

// Call the recursive method to reverse the array

reverseArray(arr, 0, arr.length - 1);

System.out.println("\nReversed Array:");

for (int num : arr) {

System.out.print(num + " ");

}

}

}

### **Program - Perform Overriding methods in parent child**

// Parent class

class Animal {

// Method to be overridden in child class

public void sound() {

System.out.println("Animal makes a sound");

}

}

// Child class (inherits from Animal)

class Dog extends Animal {

// Overriding the sound() method

@Override

public void sound() {

System.out.println("Dog barks");

}

}

class Cat extends Animal {

// Overriding the sound() method

@Override

public void sound() {

System.out.println("Cat meows");

}

}

public class MethodOverridingExample {

public static void main(String[] args) {

// Creating objects of child classes

Animal myDog = new Dog();

Animal myCat = new Cat();

// Calling the overridden methods

myDog.sound(); // Output: Dog barks

myCat.sound(); // Output: Cat meows

}

}

### **Program - Return the student object if gender is male? (filter)**

import java.util.\*;

import java.util.stream.\*;

class Student {

private String name;

private String gender;

// Constructor

public Student(String name, String gender) {

this.name = name;

this.gender = gender;

}

// Getter methods

public String getName() {

return name;

}

public String getGender() {

return gender;

}

@Override

public String toString() {

return "Student{name='" + name + "', gender='" + gender + "'}";

}

}

public class FilterMaleStudents {

public static void main(String[] args) {

// Creating a list of students

List<Student> students = Arrays.asList(

new Student("John", "Male"),

new Student("Alice", "Female"),

new Student("Bob", "Male"),

new Student("Eve", "Female")

);

  // Using Java 8 Stream API to filter male students

Student maleStudent = students.stream()

.filter(student -> student.getGender().equalsIgnoreCase("Male"))

.findFirst() // Returns the first match or an empty Optional

.orElse(null); // Default value if no match is found

// Printing the result

if (maleStudent != null) {

System.out.println("First male student: " + maleStudent);

} else {

System.out.println("No male student found.");

}

}

}

### **Program - Rearrange String**

Problem Definition: Write a program using string, use only single for loop?

Input - String str = "Siddhant Patni";

Output - SiindtdahPata

public class RearrangeString {

public static void main(String[] args) {

String str = "Siddhant Patni";

// Remove whitespaces from the string

str = str.replaceAll("\\s+", "");

StringBuilder result = new StringBuilder();

int start = 0;

int end = str.length() - 1;

// Single for loop to alternate characters from start and end

for (int i = 0; i < str.length(); i++) {

if (i % 2 == 0) {

result.append(str.charAt(start++)); // Append from start

} else {

result.append(str.charAt(end--)); // Append from end

}

}

// Output the result

System.out.println(result.toString());

}

}

### **Program - Given a set of numbers {3, 35, 56, 2, 95, 10, 65, 150, 165, 23, 65, 18, 57}, find all subsets whose sum equals 28.**

import java.util.\*;

public class SubsetsWithGivenSum {

// Helper method to find subsets with a given sum

public static void findSubsetsWithSum(int[] nums, int sum, int index, List<Integer> currentSubset) {

// If we have reached the end of the array

if (index == nums.length) {

// If the sum of the current subset equals the target sum, print the subset

if (currentSubset.stream().mapToInt(Integer::intValue).sum() == sum) {

System.out.println(currentSubset);

}

return;

}

// Include the current element in the subset and move to the next element

currentSubset.add(nums[index]);

findSubsetsWithSum(nums, sum, index + 1, currentSubset);

// Exclude the current element from the subset and move to the next element

currentSubset.remove(currentSubset.size() - 1);

findSubsetsWithSum(nums, sum, index + 1, currentSubset);

}

public static void main(String[] args) {

// Set of numbers

int[] nums = {3, 35, 56, 2, 95, 10, 65, 150, 165, 23, 65, 18, 57};

// Target sum

int targetSum = 28;

// List to store current subset

List<Integer> currentSubset = new ArrayList<>();

// Call helper function to find subsets with the given sum

findSubsetsWithSum(nums, targetSum, 0, currentSubset);

}

}

### **Program - Count set bits in an integer Ex: 13 -> 1101 Print number of 1’s in the given binary number?**

* **Approach – 1**

public class CountSetBits {

// Method to count set bits in the integer

public static int countSetBits(int n) {

int count = 0;

// Loop until n becomes 0

while (n > 0) {

// Increment count if the least significant bit is 1

count += (n & 1);

// Right shift n by 1 to check the next bit

n >>= 1;

}

return count;

}

  public static void main(String[] args) {

int number = 13; // Example number

// Get the number of set bits

int setBitsCount = countSetBits(number);

// Print the result

System.out.println("Number of set bits in " + number + " is: " + setBitsCount);

}

}

**Approach – 2**

public class CountSetBits {

public static void main(String[] args) {

int number = 13; // Example number

// Get the number of set bits using built-in method

int setBitsCount = Integer.bitCount(number);

// Print the result

System.out.println("Number of set bits in " + number + " is: " + setBitsCount);

}

}

### **Program – Check bracket balanced or not**

Problem Definition: Write a program to balancing of the brackets

Example: Input - {[(a+b)+c]+x+y]}

import java.util.Stack;

public class BalancedBrackets {

// Method to check if the brackets are balanced

public static boolean areBracketsBalanced(String expr) {

// Stack to store opening brackets

Stack<Character> stack = new Stack<>();

// Traverse the expression

for (int i = 0; i < expr.length(); i++) {

char ch = expr.charAt(i);

// If the character is an opening bracket, push it onto the stack

if (ch == '{' || ch == '[' || ch == '(') {

stack.push(ch);

}

// If the character is a closing bracket

else if (ch == '}' || ch == ']' || ch == ')') {

// Check if the stack is empty (no matching opening bracket)

if (stack.isEmpty()) {

return false;

}

// Pop the top element from the stack and check for matching pair

char top = stack.pop();

if ((ch == '}' && top != '{') || (ch == ']' && top != '[') || (ch == ')' && top != '(')) {

return false;

}

}

}

// If the stack is empty, the brackets are balanced

return stack.isEmpty();

}

public static void main(String[] args) {

String expression = "{[(a+b)+c]+x+y]}"; // Example input

// Check if the brackets are balanced

if (areBracketsBalanced(expression)) {

System.out.println("The brackets are balanced.");

} else {

System.out.println("The brackets are not balanced.");

}

}

}

### **Program - Print prime factors for given numbers**

public class PrimeFactors {

// Method to print prime factors of a number

public static void printPrimeFactors(int n) {

// First, handle the smallest prime factor 2

while (n % 2 == 0) {

System.out.print(2 + " ");

n /= 2;

}

// Now, check for odd numbers starting from 3 to sqrt(n)

for (int i = 3; i \* i <= n; i += 2) {

while (n % i == 0) {

System.out.print(i + " ");

n /= i;

}

}

// If n is still greater than 2, then it must be prime

if (n > 2) {

System.out.print(n);

}

}

public static void main(String[] args) {

int number = 56; // Example number

// Print prime factors of the number

System.out.print("Prime factors of " + number + " are: ");

printPrimeFactors(number);

}

}

### **Program - Print prime numbers in range? Ex: 24 to 100**

public class PrimeNumbersInRange {

// Method to check if a number is prime

public static boolean isPrime(int num) {

// Handle edge cases

if (num <= 1) {

return false;

}

// Check divisibility from 2 to the square root of num

for (int i = 2; i \* i <= num; i++) {

if (num % i == 0) {

return false; // Not prime if divisible by any number other than 1 and itself

}

}

return true; // Prime if no divisors were found

}

// Method to print all prime numbers in a given range

public static void printPrimesInRange(int start, int end) {

for (int num = start; num <= end; num++) {

if (isPrime(num)) {

System.out.print(num + " ");

}

}

}

public static void main(String[] args) {

int start = 24; // Start of the range

int end = 100; // End of the range

// Print prime numbers in the given range

System.out.println("Prime numbers between " + start + " and " + end + ":");

printPrimesInRange(start, end);

}

}

### **Program - Iterate ArrayList in different ways**

import java.util.ArrayList;

import java.util.Iterator;

import java.util.List;

import java.util.ListIterator;

public class ArrayListIteration {

public static void main(String[] args) {

// Create an ArrayList and add some elements

List<String> list = new ArrayList<>();

list.add("Apple");

list.add("Banana");

list.add("Cherry");

list.add("Date");

// 1. Using a classic for loop (index-based)

System.out.println("Using classic for loop:");

for (int i = 0; i < list.size(); i++) {

System.out.println(list.get(i));

}

// 2. Using enhanced for loop (for-each loop)

System.out.println("\nUsing enhanced for loop:");

for (String fruit : list) {

System.out.println(fruit);

}

// 3. Using Iterator

System.out.println("\nUsing Iterator:");

Iterator<String> iterator = list.iterator();

while (iterator.hasNext()) {

System.out.println(iterator.next());

}

// 4. Using ListIterator (Bidirectional iteration)

System.out.println("\nUsing ListIterator (forward):");

ListIterator<String> listIterator = list.listIterator();

while (listIterator.hasNext()) {

System.out.println(listIterator.next());

}

// Using ListIterator (Backward iteration)

System.out.println("\nUsing ListIterator (backward):");

while (listIterator.hasPrevious()) {

System.out.println(listIterator.previous());

}

// 5. Using Java 8 Streams

System.out.println("\nUsing Streams:");

list.stream().forEach(System.out::println);

}

}

### **Program - Reverse a singly linked list**

// Node class to represent each element in the linked list

class Node {

int data;

Node next;

// Constructor to initialize the node

public Node(int data) {

this.data = data;

this.next = null;

}

}

public class SinglyLinkedList {

Node head;

// Method to reverse the singly linked list

public void reverse() {

Node prev = null;

Node curr = head;

Node next = null;

while (curr != null) {

// Store the next node

next = curr.next;

// Reverse the current node's pointer

curr.next = prev;

// Move the prev and curr pointers one step forward

prev = curr;

curr = next;

}

// After the loop, prev will be the new head

head = prev;

}

// Method to print the linked list

public void printList() {

Node temp = head;

while (temp != null) {

System.out.print(temp.data + " ");

temp = temp.next;

}

System.out.println();

}

// Method to add a node at the end of the list

public void append(int data) {

Node newNode = new Node(data);

if (head == null) {

head = newNode;

return;

}

Node temp = head;

while (temp.next != null) {

temp = temp.next;

}

temp.next = newNode;

}

public static void main(String[] args) {

SinglyLinkedList list = new SinglyLinkedList();

// Add some elements to the list

list.append(10);

list.append(20);

list.append(30);

list.append(40);

list.append(50);

System.out.println("Original List:");

list.printList();

// Reverse the linked list

list.reverse();

System.out.println("Reversed List:");

list.printList();

}

}

### **Program – First repeating number**

Problem Definition: Write a program to print the first occurrence of a repeating element from integer Array? **Input**: [6,10,7,8,9,7,11,12] **Output**: 7

import java.util.HashSet;

public class FirstRepeatingElement {

// Method to find and print the first repeating element

public static void findFirstRepeating(int[] arr) {

// Create a HashSet to store elements we have already seen

HashSet<Integer> seen = new HashSet<>();

// Iterate over the array

for (int num : arr) {

// If the element is already in the set, it's the first repeating element

if (seen.contains(num)) {

System.out.println("First repeating element: " + num);

return; // Exit as we found the first repeating element

}

// Otherwise, add the element to the set

seen.add(num);

}

// If no repeating element is found

System.out.println("No repeating element found.");

}

public static void main(String[] args) {

// Example input array

int[] arr = {6, 10, 7, 8, 9, 7, 11, 12};

// Call the method to find and print the first repeating element

findFirstRepeating(arr);

}

}

### **Program – Print occurrence of each character in String**

Problem Definition: Write a program to print occurrence of each character in the given string

Example: String str = "This is an interview is going on with Amdocs";

import java.util.HashMap;

public class CharacterOccurrence {

// Method to print the occurrence of each character in the string

public static void printCharacterOccurrences(String str) {

// Create a HashMap to store the frequency of each character

HashMap<Character, Integer> charCountMap = new HashMap<>();

// Convert the string to an array of characters and iterate over it

for (char ch : str.toCharArray()) {

// Ignore spaces (optional)

if (ch != ' ') {

charCountMap.put(ch, charCountMap.getOrDefault(ch, 0) + 1);

}

}

// Print the occurrence of each character

for (HashMap.Entry<Character, Integer> entry : charCountMap.entrySet()) {

System.out.println(entry.getKey() + ": " + entry.getValue());

}

}

public static void main(String[] args) {

// Example input string

String str = "This is an interview is going on with Amdocs";

// Call the method to print character occurrences

printCharacterOccurrences(str);

}

}

### **Program – Merge two sorted linked list**

Problem Definition: Merge two sorted linked lists

Input: list1 = 10, 20,30,40;

list2 = 11,13,14,21,22,33,35;

Output: Mergedlist = 10,11,13,20,21,22,30,33,35,40

class ListNode {

int val;

ListNode next;

ListNode(int val) {

this.val = val;

this.next = null;

}

}

public class MergeSortedLinkedLists {

// Method to merge two sorted linked lists

public static ListNode mergeSortedLists(ListNode list1, ListNode list2) {

// Create a dummy node to simplify the process

ListNode dummy = new ListNode(0);

ListNode current = dummy;

// Pointers for both lists

ListNode p1 = list1;

ListNode p2 = list2;

// Traverse both lists and merge them

while (p1 != null && p2 != null) {

if (p1.val < p2.val) {

current.next = p1;

p1 = p1.next;

} else {

current.next = p2;

p2 = p2.next;

}

current = current.next;

}

// If there are remaining nodes in list1 or list2, append them

if (p1 != null) {

current.next = p1;

} else if (p2 != null) {

current.next = p2;

}

return dummy.next; // The merged list starts from dummy.next

}

// Method to print the linked list

public static void printList(ListNode head) {

ListNode current = head;

while (current != null) {

System.out.print(current.val + " ");

current = current.next;

}

System.out.println();

}

// Method to create a linked list from an array of integers

public static ListNode createList(int[] arr) {

if (arr == null || arr.length == 0) return null;

ListNode head = new ListNode(arr[0]);

ListNode current = head;

for (int i = 1; i < arr.length; i++) {

current.next = new ListNode(arr[i]);

current = current.next;

}

return head;

}

public static void main(String[] args) {

// Input lists

int[] list1Array = {10, 20, 30, 40};

int[] list2Array = {11, 13, 14, 21, 22, 33, 35};

// Create linked lists from arrays

ListNode list1 = createList(list1Array);

ListNode list2 = createList(list2Array);

// Merge the two sorted linked lists

ListNode mergedList = mergeSortedLists(list1, list2);

// Print the merged linked list

System.out.print("Merged List: ");

printList(mergedList);

}

}

### **Program - Sort array with decreasing frequency of element**

Problem Definition: Sort array with decreasing frequency of element

Input - 9,5,6,9,6,1,.2,9

Output - 9,9,9,6,6,1,2

import java.util.\*;

public class SortByFrequency {

// Method to sort the array by the frequency of elements in decreasing order

public static int[] sortByFrequency(int[] arr) {

// Create a HashMap to store the frequency of each element

Map<Integer, Integer> frequencyMap = new HashMap<>();

// Count the frequency of each element

for (int num : arr) {

frequencyMap.put(num, frequencyMap.getOrDefault(num, 0) + 1);

}

// Convert the map entries to a list

List<Map.Entry<Integer, Integer>> entryList = new ArrayList<>(frequencyMap.entrySet());

// Sort the list by value (frequency) in descending order, and by key in ascending order if frequencies are equal

entryList.sort((entry1, entry2) -> {

int freqComparison = Integer.compare(entry2.getValue(), entry1.getValue());

if (freqComparison == 0) {

return Integer.compare(entry1.getKey(), entry2.getKey());

}

return freqComparison;

});

// Rebuild the sorted array based on the sorted entries

List<Integer> sortedList = new ArrayList<>();

for (Map.Entry<Integer, Integer> entry : entryList) {

for (int i = 0; i < entry.getValue(); i++) {

sortedList.add(entry.getKey());

}

}

// Convert the sorted list back to an array

int[] sortedArray = new int[sortedList.size()];

for (int i = 0; i < sortedList.size(); i++) {

sortedArray[i] = sortedList.get(i);

}

return sortedArray;

}

// Method to print the array

public static void printArray(int[] arr) {

for (int num : arr) {

System.out.print(num + " ");

}

System.out.println();

}

public static void main(String[] args) {

// Input array

int[] arr = {9, 5, 6, 9, 6, 1, 2, 9};

// Sort the array based on frequency

int[] sortedArray = sortByFrequency(arr);

// Print the sorted array

System.out.print("Sorted Array: ");

printArray(sortedArray);

}

}

### **Program - Remove the duplicate values from HashMap and return the max key from the HashMap.**

import java.util.\*;

public class RemoveDuplicatesAndFindMaxKey {

// Method to remove duplicate values and return the maximum key

public static int removeDuplicatesAndGetMaxKey(Map<Integer, Integer> map) {

// Step 1: Remove duplicate values using a new map

Map<Integer, Integer> uniqueValuesMap = new HashMap<>();

// Iterate through the original map

for (Map.Entry<Integer, Integer> entry : map.entrySet()) {

// If the value is not already in the new map, add it

if (!uniqueValuesMap.containsValue(entry.getValue())) {

uniqueValuesMap.put(entry.getKey(), entry.getValue());

}

}

// Step 2: Find the key with the maximum value

int maxKey = Integer.MIN\_VALUE;

int maxValue = Integer.MIN\_VALUE;

for (Map.Entry<Integer, Integer> entry : uniqueValuesMap.entrySet()) {

if (entry.getValue() > maxValue) {

maxValue = entry.getValue();

maxKey = entry.getKey();

}

}

return maxKey; // Return the key corresponding to the maximum value

}

// Method to print the HashMap

public static void printMap(Map<Integer, Integer> map) {

for (Map.Entry<Integer, Integer> entry : map.entrySet()) {

System.out.println("Key: " + entry.getKey() + ", Value: " + entry.getValue());

}

}

public static void main(String[] args) {

// Input HashMap

Map<Integer, Integer> map = new HashMap<>();

map.put(1, 10);

map.put(2, 20);

map.put(3, 10);

map.put(4, 30);

map.put(5, 20);

System.out.println("Original HashMap:");

printMap(map);

// Remove duplicates and get the maximum key

int maxKey = removeDuplicatesAndGetMaxKey(map);

System.out.println("Key with the maximum value: " + maxKey);

}

}

### **Program - Return the maximum occurrence element from the array?**

Problem Definition: Write a program to return the maximum occurrence element from the array?

Input: int[] arr = {1,5,3,5,6,5};

Output: 5

import java.util.HashMap;

import java.util.Map;

public class MaxOccurrence {

// Method to return the maximum occurrence element

public static int findMaxOccurrence(int[] arr) {

// Create a HashMap to store the frequency of each element

Map<Integer, Integer> frequencyMap = new HashMap<>();

// Count the frequency of each element in the array

for (int num : arr) {

frequencyMap.put(num, frequencyMap.getOrDefault(num, 0) + 1);

}

// Variables to track the element with the maximum frequency

int maxElement = arr[0];

int maxCount = 1;

// Iterate over the map to find the element with the highest frequency

for (Map.Entry<Integer, Integer> entry : frequencyMap.entrySet()) {

if (entry.getValue() > maxCount) {

maxCount = entry.getValue();

maxElement = entry.getKey();

}

}

return maxElement; // Return the element with the highest frequency

}

public static void main(String[] args) {

// Input array

int[] arr = {1, 5, 3, 5, 6, 5};

// Find the element with the maximum occurrence

int maxOccurrenceElement = findMaxOccurrence(arr);

// Print the result

System.out.println("Element with the maximum occurrence: " + maxOccurrenceElement);

}

}

### **Program – Find Highest average score of student**

**Problem Definition:** You are given a list of student test scores, where each entry contains a student’s name and their test score as a string array: [student\_name, test\_score]. Each student may appear multiple times in the list with different scores.

Your task is to write a Java function that calculates the **highest average score** among all students. If a student appears multiple times, their average score should be computed by averaging all of their scores. In case the average is a floating-point number, return the **floor value** of the average (i.e., round down to the nearest integer). If the input list is empty, return 0

* Answer

public class Solution {

public static int bestAverageGrade(String[][] scores) {

if (scores == null || scores.length == 0) return 0;

Map<String, List<Integer>> studentScores = new HashMap<>();

// Step 1: Populate the map with scores per student

for (String[] entry : scores) {

String name = entry[0];

int score = Integer.parseInt(entry[1]);

studentScores.putIfAbsent(name, new ArrayList<>());

studentScores.get(name).add(score);

}

int bestAverage = Integer.MIN\_VALUE;

// Step 2: Calculate averages and track the max

for (Map.Entry<String, List<Integer>> entry : studentScores.entrySet()) {

List<Integer> marks = entry.getValue();

int sum = 0;

for (int score : marks) {

sum += score;

}

int average = (int) Math.floor((double) sum / marks.size());

bestAverage = Math.max(bestAverage, average);

}

return bestAverage == Integer.MIN\_VALUE ? 0 : bestAverage;

}

// Optional main method for testing

public static void main(String[] args) {

String[][] input = {

{"Bobby", "87"},

{"Charles", "100"},

{"Eric", "64"},

{"Charles", "22"}

};

System.out.println(bestAverageGrade(input)); // Output: 87

}

}

### **Program – Find occurrence of Word in String**

Problem Definition: Write a program to return the number of occurrences for a given word in the string. Accept the inputs from the user.

import java.util.\*;

import java.util.function.Function;

import java.util.stream.Collectors;

public class WordOccurrenceCounter {

public static void main(String[] args) {

Scanner scanner = new Scanner(System.in);

// Accept input string

System.out.print("Enter a string: ");

String input = scanner.nextLine();

// Accept the word to search for

System.out.print("Enter the word to find: ");

String wordToFind = scanner.next().toLowerCase();

// Split input string into words

Map<String, Long> wordCount = Arrays.stream(input.toLowerCase().split("\\W+"))

.filter(word -> !word.isEmpty())

.collect(Collectors.groupingBy(Function.identity(), Collectors.counting()));

// Get the count

long count = wordCount.getOrDefault(wordToFind, 0L);

System.out.println("Occurrences of \"" + wordToFind + "\": " + count);

}

}

### **Program – Find the Words which starts with ‘S’ from List of Words**

import java.util.Arrays;

import java.util.List;

public class WordsStartingWithS {

public static void main(String[] args) {

List<String> list = Arrays.asList("Siddhant", "Patni", "Kotak", "Mahindra", "Samsung", "sun");

System.out.println("Words starting with 'S':");

list.stream()

.filter(word -> word.startsWith("S"))

.forEach(System.out::println);

}

}

### **Program – Palindrome Number**

Problem Definition: Write a program to check Palindrome number. Input : 59095

import java.util.stream.IntStream;

public class PalindromeNumber {

// Check if a number is palindrome using Java 8

public static boolean isPalindromeNumber(int number) {

String numStr = String.valueOf(number);

return IntStream.range(0, numStr.length() / 2)

.allMatch(i -> numStr.charAt(i) == numStr.charAt(numStr.length() - 1 - i));

}

public static void main(String[] args) {

// Test numbers

int num1 = 59095;

int num2 = 12345;

System.out.println(num1 + " is Palindrome Number? -> " + isPalindromeNumber(num1));

System.out.println(num2 + " is Palindrome Number? -> " + isPalindromeNumber(num2));

}

}

### **Program – Reverse String without using reverse function (Use brute force approach)**

Problem Definition: Write a program to reverse String without using reverse function (Use brute force approach)

public class ReverseString {

public static String reverse(String input) {

String reversed = "";

for (int i = input.length() - 1; i >= 0; i--) {

reversed += input.charAt(i); // Appending each character from end to start

}

return reversed;

}

public static void main(String[] args) {

String original = "Siddhant";

String reversed = reverse(original);

System.out.println("Original String: " + original);

System.out.println("Reversed String: " + reversed);

}

}

### **Program – Count of each word in a String**

import java.util.Arrays;

import java.util.Map;

import java.util.TreeMap;

import java.util.function.Function;

import java.util.stream.Collectors;

/\*\*

\* @author Siddhant Patni

\*/

public class WordCount {

public static void findWordCount(String input) {

Map<String, Integer> wordCountMap = new TreeMap<>(); // Changed to TreeMap for sorted output

String[] words = input.toLowerCase().split("\\W+");

for (String word : words) {

if (!word.isEmpty()) {

wordCountMap.put(word, wordCountMap.getOrDefault(word, 0) + 1);

}

}

System.out.println("\nWord Occurrences (Basic Approach):");

wordCountMap.forEach((k, v) -> System.out.println(k + " -> " + v));

}

public static void findWordCountUsingStream(String input) {

Map<String, Long> wordFrequency = Arrays.stream(input.toLowerCase().split("\\W+"))

.filter(s -> !s.isEmpty())

.collect(Collectors.groupingBy(Function.identity(), TreeMap::new, Collectors.counting()));

System.out.println("\nWord Occurrence (Java 8 Stream):");

wordFrequency.forEach((k, v) -> System.out.println(k + " -> " + v));

}

public static void main(String[] args) {

String input = "w1 w2 w2 w3 w3 w4";

System.out.println("Input: " + input);

findWordCount(input);

findWordCountUsingStream(input);

}

}

### **Program – Make all elements to Uppercase and create new ArrayList**

Problem Definition: Write a java 8 program to make all elements of the list to uppercase and create a new ArrayList

* Answer

public static void main(String[] args) {

//String str = "w1 w2 w2 w3 w3 w4";

List<String> list = Arrays.asList("w1", "w2", "w2","w3","w4");

List<String> newList = list.stream().map(str -> str.toUpperCase()).forEach(str ->

System.out.println(str + " "));

}

### **Program – PreOrder traversal**

Problem Definition: Write a program in java to print PreOrder Traversal

Input: Given the root of a binary tree, return the preorder traversal of its nodes' values.

import java.util.\*;

// Tree node definition

class TreeNode {

int val;

TreeNode left, right;

TreeNode(int x) {

val = x;

}

}

public class PreOrderTraversal {

// Preorder Traversal: Root -> Left -> Right

public static void preorder(TreeNode root) {

if (root == null) return;

System.out.print(root.val + " "); // Visit root

preorder(root.left); // Traverse left subtree

preorder(root.right); // Traverse right subtree

}

public static void main(String[] args) {

/\*

1

/ \

2 3

/ \ \

4 5 6

\*/

TreeNode root = new TreeNode(1);

root.left = new TreeNode(2);

root.right = new TreeNode(3);

root.left.left = new TreeNode(4);

root.left.right = new TreeNode(5);

root.right.right = new TreeNode(6);

System.out.print("Preorder Traversal: ");

preorder(root);

}

}

### **Program – Calculate average marks of Student and return Student object**

Problem Definition: Write a program to calculate average marks of students and return the student object with average marks

import java.util.\*;

class Student {

private int id;

private String name;

private List<Integer> marks;

private double averageMarks;

// Constructor

public Student(int id, String name, List<Integer> marks) {

this.id = id;

this.name = name;

this.marks = marks;

this.averageMarks = calculateAverage(marks);

}

// Method to calculate average marks

private double calculateAverage(List<Integer> marks) {

if (marks == null || marks.isEmpty()) return 0;

int sum = 0;

for (int mark : marks) {

sum += mark;

}

return (double) sum / marks.size();

}

// Getter methods

public int getId() {

return id;

}

public String getName() {

return name;

}

public List<Integer> getMarks() {

return marks;

}

public double getAverageMarks() {

return averageMarks;

}

// toString method for easy display

@Override

public String toString() {

return "Student{id=" + id + ", name='" + name + "', marks=" + marks + ", averageMarks=" + averageMarks + "}";

}

}

public class AverageMarksCalculator {

public static void main(String[] args) {

// Sample students with marks

List<Student> students = Arrays.asList(

new Student(1, "John", Arrays.asList(80, 90, 85)),

new Student(2, "Jane", Arrays.asList(75, 80, 70)),

new Student(3, "Bob", Arrays.asList(90, 95, 100)),

new Student(4, "Alice", Arrays.asList(60, 65, 70))

);

// Print students with their average marks

for (Student student : students) {

System.out.println(student);

}

}

}

### **Program – Count of each Character in a String**

import java.util.Arrays;

import java.util.Map;

import java.util.TreeMap;

import java.util.function.Function;

import java.util.stream.Collectors;

/\*\*

\* @author Siddhant Patni

\*/

public class ChracterCount {

  public static void findCharacterCount(String input) {

Map<Character, Integer> charCountMap = new TreeMap<>(); // Changed to TreeMap for sorted output

for (char c : input.toCharArray()) {

if (Character.isLetterOrDigit(c)) {

c = Character.toLowerCase(c);

charCountMap.put(c, charCountMap.getOrDefault(c, 0) + 1);

}

}

System.out.println("\nCharacter Occurrences (Basic Approach):");

charCountMap.forEach((k, v) -> System.out.println(k + " -> " + v));

}

public static void findCharacterCountUsingStream(String input) {

Map<Character, Long> charFrequency = input.toLowerCase()

.chars()

.mapToObj(c -> (char) c)

.filter(Character::isLetterOrDigit)

.collect(Collectors.groupingBy(Function.identity(), TreeMap::new, Collectors.counting()));

System.out.println("\nCharacter Occurrence (Java 8 Stream):");

charFrequency.forEach((k, v) -> System.out.println(k + " -> " + v));

}

public static void main(String[] args) {

String input = "This is Java development";

System.out.println("Input: " + input);

findCharacterCount(input);

findCharacterCountUsingStream(input)`;

}

}

### **Program – Find Employee with age greater than 15**

Problem Definition: Write a java 8 code to get the age greater than 15 from the Employee object?

Input - Employee

id

name

Age

import java.util.\*;

import java.util.stream.\*;

class Employee {

private int id;

private String name;

private int age;

// Constructor

public Employee(int id, String name, int age) {

this.id = id;

this.name = name;

this.age = age;

}

// Getter methods

public int getId() {

return id;

}

public String getName() {

return name;

}

public int getAge() {

return age;

}

// toString method for easy display

@Override

public String toString() {

return "Employee{id=" + id + ", name='" + name + "', age=" + age + "}";

}

}

public class EmployeeFilter {

public static void main(String[] args) {

// Sample list of Employee objects

List<Employee> employees = Arrays.asList(

new Employee(1, "John", 14),

new Employee(2, "Jane", 18),

new Employee(3, "Bob", 12),

new Employee(4, "Alice", 16),

new Employee(5, "Charlie", 22)

);

// Filter employees with age greater than 15 using Java 8 Stream

List<Employee> filteredEmployees = employees.stream()

.filter(employee -> employee.getAge() > 15)

.collect(Collectors.toList());

// Print filtered employees

System.out.println("Employees with age greater than 15:");

filteredEmployees.forEach(System.out::println);

}

}

### **Program – Get a list of files and directories by passing path of directory**

Problem Definition: Write a program to get a list of files and directories by passing the path of the directory

import java.io.File;

import java.util.ArrayList;

import java.util.List;

public class FileDirectoryLister {

public static List<String> listFilesAndDirectories(String directoryPath) {

// Create a list to hold the names of files and directories

List<String> fileAndDirectoryList = new ArrayList<>();

// Create a File object for the given directory path

File directory = new File(directoryPath);

// Check if the given path is a valid directory

if (directory.exists() && directory.isDirectory()) {

// List all files and directories within the specified directory

String[] filesAndDirectories = directory.list();

if (filesAndDirectories != null) {

// Add each file/directory name to the list

for (String item : filesAndDirectories) {

fileAndDirectoryList.add(item);

}

}

} else {

System.out.println("The specified path is not a valid directory.");

}

return fileAndDirectoryList;

}

public static void main(String[] args) {

// Example directory path, replace with a valid path on your system

String directoryPath = "C:/Users/YourUsername/Documents"; // Example for Windows

// Get the list of files and directories

List<String> items = listFilesAndDirectories(directoryPath);

// Print the result

System.out.println("Files and Directories in '" + directoryPath + "':");

items.forEach(System.out::println);

}

}

### **Program – Find Output**

Problem Definition: What is the output of the below snippet if we print str?

String str =”India”;

str = “Bharat”;

String str = "India";

str = "Bharat";

System.out.println(str);

Output: Bharat

**✅ Explanation:**

In Java:

* String is **immutable**, meaning once a String object is created, it cannot be changed.
* However, **you can reassign** the reference variable (str) to point to a new String object.

In the code:

1. String str = "India"; — creates a String object "India" and assigns it to str.
2. str = "Bharat"; — now str points to a **new** String object "Bharat".
3. So when you print str, it refers to "Bharat".

### **Program – Fibonacci series of nth number**

import java.util.Scanner;

public class FibonacciSeries {

// Function to print Fibonacci series up to n terms

public static void printFibonacci(int n) {

int a = 0, b = 1;

System.out.print("Fibonacci Series up to " + n + " terms: ");

for (int i = 1; i <= n; i++) {

System.out.print(a + " ");

// compute next term

int next = a + b;

a = b;

b = next;

}

}

public static void main(String[] args) {

Scanner scanner = new Scanner(System.in);

System.out.print("Enter the number of terms: ");

int n = scanner.nextInt();

printFibonacci(n);

}

}

### **Program – Armstrong number**

import java.util.Scanner;

public class ArmstrongNumber {

public static boolean isArmstrong(int number) {

int original = number;

int result = 0;

int n = String.valueOf(number).length();

while (number > 0) {

int digit = number % 10;

result += Math.pow(digit, n);

number /= 10;

}

return result == original;

}

public static boolean isArmstrong(int num) {

int digits = String.valueOf(num).length();

int sum = String.valueOf(num)

.chars()

.map(Character::getNumericValue)

.map(d -> (int) Math.pow(d, digits))

.sum();

return sum == num;

}

public static void main(String[] args) {

Scanner scanner = new Scanner(System.in);

System.out.print("Enter a number to check if it's an Armstrong number: ");

int number = scanner.nextInt();

if (isArmstrong(number)) {

System.out.println(number + " is an Armstrong number.");

} else {

System.out.println(number + " is NOT an Armstrong number.");

}

}

}

### **Program – Print possible set of Palindrome for given String**

Problem Definition: Write a program to print a possible set of palindromes of a given string?

Input: ABBAAAAABBA

Output: B, BB, AA, AAA, AAAA, AAAAA, ABBA, BAAAAAB, BBAAAAABB,

ABBAAAAABBA

import java.util.ArrayList;

import java.util.List;

public class PalindromicSubstrings {

public static void main(String[] args) {

String input = "ABBAAAAABBA";

List<String> palindromes = findPalindromes(input);

System.out.println("Palindromic substrings:");

palindromes.forEach(System.out::println);

}

public static List<String> findPalindromes(String str) {

List<String> result = new ArrayList<>();

int length = str.length();

for (int i = 0; i < length; i++) {

for (int j = i + 1; j <= length; j++) {

String sub = str.substring(i, j);

if (isPalindrome(sub)) {

result.add(sub);

}

}

}

return result;

}

public static boolean isPalindrome(String s) {

int left = 0;

int right = s.length() - 1;

while (left < right) {

if (s.charAt(left++) != s.charAt(right--)) {

return false;

}

}

return true;

}

}

### **Program – Reverse of given number**

Problem Definition: Write a program to print the reverse of a given number? Input - 1234

public class ReverseNumber {

public static void main(String[] args) {

int number = 1234;

int reversed = 0;

while (number != 0) {

int digit = number % 10; // Get last digit

reversed = reversed \* 10 + digit; // Append digit to reversed

number /= 10; // Remove last digit from number

}

System.out.println("Reversed Number: " + reversed);

}

}

### **Program – Minimum number of platform required for train**

Problem Definition: Write a program to return the minimum number of platforms required for a train?

Input:

12:05 12:50

13:10 14:25

05:30 07:25

05:35 05:55

02:15 02:20

public static int getPlatformDetails(int[] arrival, int[] departure)

{

Arrays.sort(arrival);

Arrays.sort(departure);

int platform=0, finalPlatform=INT\_MIN, i=0, j=0, count =0;;

while(i <arrival.length)

{

if(arrival[i] < departure[j])

{

Platform = Integer.max(platform, ++count);

i++;

} else

{

Count --;

j++;

}

finalPlatform = Integer.max(platform, ++count);;

//here update result

}

return finalPlatform;

for(int i=0; i<num; i++)

{

for(int j= i +1; j< num;j++)

{

if(arrival[i] >= arrival[j] && arrival[i] <= departure[j] )

}

}

}

Public static void main(String[] args)

{

int arrival[] = {1205, 1310, 0530,0535 0215};

int departure[] = {1250, 1425, 0725, 0555, 0220};

int num = 5;

System.out.println(“Platform required are :”+getPlatformDetails(arrival, departure, num));

}

### **Program – Count number of island in a boolean 2D matrix**

Problem Definition: Write a Java program to count islands in a boolean 2D matrix.

Input :

0 0 1 10

0 0 1 0 0

1 0 0 0 0

0 1 0 0 0

1 1 0 1 0

3 connected island

public class CountIslands {

static final int ROW = 5;

static final int COL = 5;

// Directions for 8 possible neighbors

static final int[] rowNbr = {-1, -1, -1, 0, 0, 1, 1, 1};

static final int[] colNbr = {-1, 0, 1, -1, 1, -1, 0, 1};

// Check if cell is valid and safe to visit

static boolean isSafe(int[][] M, int row, int col, boolean[][] visited) {

return (row >= 0) && (row < ROW) &&

(col >= 0) && (col < COL) &&

(M[row][col] == 1 && !visited[row][col]);

}

// Depth-First Search to mark connected 1's

static void DFS(int[][] M, int row, int col, boolean[][] visited) {

visited[row][col] = true;

// Visit all 8 neighbors

for (int k = 0; k < 8; ++k) {

int newRow = row + rowNbr[k];

int newCol = col + colNbr[k];

if (isSafe(M, newRow, newCol, visited)) {

DFS(M, newRow, newCol, visited);

}

}

}

// Main function to count islands

static int countIslands(int[][] M) {

boolean[][] visited = new boolean[ROW][COL];

int count = 0;

for (int i = 0; i < ROW; ++i) {

for (int j = 0; j < COL; ++j) {

if (M[i][j] == 1 && !visited[i][j]) {

DFS(M, i, j, visited);

++count;

}

}

}

return count;

}

public static void main(String[] args) {

int[][] M = new int[][] {

{0, 0, 1, 1, 0},

{0, 0, 1, 0, 0},

{1, 0, 0, 0, 0},

{0, 1, 0, 0, 0},

{1, 1, 0, 1, 0}

};

System.out.println("Number of islands is: " + countIslands(M));

}

}

### **Program – Shorten the given URL**

Problem Definition: Write a program to shorten the given URL?

Input: https://docs.google.com/document/d/1g1CwT8dhCGgjh1LtXSaRBZ1ctREqkldD76lAU4KxPOo/edit

import java.util.HashMap;

import java.util.Map;

public class UrlShortener {

private static final String BASE\_HOST = "http://short.url/";

private static final String CHAR\_MAP = "abcdefghijklmnopqrstuvwxyzABCDEFGHIJKLMNOPQRSTUVWXYZ0123456789";

private static final int BASE = CHAR\_MAP.length();

private static Map<String, String> keyToUrlMap = new HashMap<>();

private static Map<String, String> urlToKeyMap = new HashMap<>();

// Function to encode URL to short key

public static String shortenURL(String longUrl) {

if (urlToKeyMap.containsKey(longUrl)) {

return BASE\_HOST + urlToKeyMap.get(longUrl);

}

int hashCode = Math.abs(longUrl.hashCode());

String shortKey = encodeToBase62(hashCode);

keyToUrlMap.put(shortKey, longUrl);

urlToKeyMap.put(longUrl, shortKey);

return BASE\_HOST + shortKey;

}

// Function to decode key back to original URL

public static String expandURL(String shortUrl) {

String key = shortUrl.replace(BASE\_HOST, "");

return keyToUrlMap.getOrDefault(key, "URL not found");

}

// Base62 encoding (a-z, A-Z, 0-9)

private static String encodeToBase62(int num) {

StringBuilder sb = new StringBuilder();

while (num > 0) {

sb.append(CHAR\_MAP.charAt(num % BASE));

num /= BASE;

}

return sb.reverse().toString();

}

public static void main(String[] args) {

String longUrl = "https://docs.google.com/document/d/1g1CwT8dhCGgjh1LtXSaRBZ1ctREqkldD76lAU4KxPOo/edit";

String shortUrl = shortenURL(longUrl);

System.out.println("Shortened URL: " + shortUrl);

String originalUrl = expandURL(shortUrl);

System.out.println("Expanded URL: " + originalUrl);

}

}

### **Program – Find element closest to given target**

Problem Definition: Write a java program to find element closest to given target

Input - int arr[] = { 1, 2, 4, 5, 6, 6, 8, 9 };

int target = 11;

Output - 9

public class ClosestElementFinder {

public static int findClosest(int[] arr, int target) {

int closest = arr[0];

int minDiff = Math.abs(target - arr[0]);

for (int i = 1; i < arr.length; i++) {

int currentDiff = Math.abs(target - arr[i]);

if (currentDiff < minDiff) {

minDiff = currentDiff;

closest = arr[i];

}

}

return closest;

}

public static void main(String[] args) {

int[] arr = {1, 2, 4, 5, 6, 6, 8, 9};

int target = 11;

int closest = findClosest(arr, target);

System.out.println("Closest element to target " + target + " is: " + closest);

}

}

### **Program – Remove duplicate element from list using java 8**

Problem Definition: If I want to remove the duplicate values from ArrayList then how can we achieve it using java 8?

List<Integer> list = new ArrayList<>(Arrays.asList(1, 10, 1, 2, 2, 3, 10, 3, 3, 4, 5, 5));

List<Integer> newList = list.stream().distinct().collect(Collectors.toList());

### **Program – Sort elements in array without inbuilt methods**

Problem Definition: If you have an array of integers then how will you sort it? Write actual logic without using inbuilt Methods?

public class ManualSort {

public static void bubbleSort(int[] arr) {

int n = arr.length;

for (int i = 0; i < n - 1; i++) { // Number of passes

for (int j = 0; j < n - i - 1; j++) { // Comparisons in each pass

if (arr[j] > arr[j + 1]) {

// swap arr[j] and arr[j + 1]

int temp = arr[j];

arr[j] = arr[j + 1];

arr[j + 1] = temp;

}

}

}

}

public static void main(String[] args) {

int[] arr = {5, 2, 8, 1, 9};

System.out.println("Original Array:");

for (int value : arr) {

System.out.print(value + " ");

}

bubbleSort(arr);

System.out.println("\nSorted Array (Bubble Sort):");

for (int value : arr) {

System.out.print(value + " ");

}

}

}

### **Program – Find distinct ways to reach the nth stair**

Problem Definition: Write a Java function to count the number of distinct ways to reach the nth stair by climbing either 1 or 2 steps at a time, and return the result modulo 10^9+7.

public class StairClimber {

static final int MOD = 1\_000\_000\_007;

public static int countWays(int n) {

if (n <= 1) return 1;

int prev = 1, curr = 1;

for (int i = 2; i <= n; i++) {

int temp = (prev + curr) % MOD;

prev = curr;

curr = temp;

}

  return curr;

}

// Test the function

public static void main(String[] args) {

int n1 = 4;

int n2 = 10;

System.out.println("Ways to climb " + n1 + " stairs: " + countWays(n1)); // Output: 5

System.out.println("Ways to climb " + n2 + " stairs: " + countWays(n2)); // Output: 89

}

}

### **Program – Minimum hops for staircase**

Problem Definition: There is a stair having total no of stairs as n. Requirement is to reach at the top in minimum hop. Each step has some value associated with it which shows how many steps you can move forward from that step. Find the minimum hop required to reach from 0th step to nth step. n= 6 and stairs = {2,0,1,3,1,1};

public class MinimumHops {

public static int minHops(int[] stairs) {

int n = stairs.length;

if (n == 0) return 0;

int hops = 0;

int currentEnd = 0; // The farthest we can reach with the current number of hops

int farthest = 0; // The farthest we can reach at the next hop

for (int i = 0; i < n - 1; i++) {

// Update the farthest we can reach from this step

farthest = Math.max(farthest, i + stairs[i]);

// If we have reached the end of the current jump

if (i == currentEnd) {

// We need to make another hop

hops++;

currentEnd = farthest;

// If we can reach or go beyond the last stair, break

if (currentEnd >= n - 1) {

break;

}

}

}

// If the farthest point we can reach is beyond the last stair

return (currentEnd >= n - 1) ? hops : -1; // Return -1 if it's impossible to reach the last stair

}

public static void main(String[] args) {

int[] stairs = {2, 0, 1, 3, 1, 1}; // Example input

int result = minHops(stairs);

if (result != -1) {

System.out.println("Minimum hops required: " + result);

} else {

System.out.println("It's impossible to reach the last stair.");

}

}

}

### **Program – Sort Student data based on age using java 8**

Problem Definition: How will you sort the Student data based on their Age?

import java.util.Arrays;

import java.util.List;

import java.util.stream.Collectors;

class Student {

private String name;

private int age;

// Constructor

public Student(String name, int age) {

this.name = name;

this.age = age;

}

// Getter methods

public String getName() {

return name;

}

public int getAge() {

return age;

}

@Override

public String toString() {

return "Student{name='" + name + "', age=" + age + "}";

}

}

public class StudentSort {

public static void main(String[] args) {

// Creating a list of students

List<Student> students = Arrays.asList(

new Student("Alice", 22),

new Student("Bob", 20),

new Student("Charlie", 24),

new Student("David", 19)

);

// Sorting students based on age using stream

List<Student> sortedStudents = students.stream()

.sorted(Comparator.comparingInt(Student::getAge))

.collect(Collectors.toList());

// Printing the sorted student data

sortedStudents.forEach(System.out::println);

}

}

### **Program – Explain logic of frequency of each character in String**

**Steps:**

1. Iterate through each character of the string.

Go through the string one character at a time.

1. Use a data structure to store the frequency count.

A good choice is a HashMap where the key is the character and the value is the frequency count.

1. Check if the character is already present in the map.

If the character is already in the map, increment its value by 1.

If the character is not present, add it to the map with a value of 1.

1. Output the frequency count.

Once the iteration is complete, the map will contain each unique character as the key and its frequency as the value.

**Example of Logic**

Input String:

"hello"

Iteration 1: Encounter character 'h'. It's not in the map, so add it with a count of 1.

Iteration 2: Encounter character 'e'. It's not in the map, so add it with a count of 1.

Iteration 3: Encounter character 'l'. It's not in the map, so add it with a count of 1.

Iteration 4: Encounter another character 'l'. It is already in the map, so increment the count to 2.

Iteration 5: Encounter character 'o'. It's not in the map, so add it with a count of 1.

Final frequency count in the map:

'h' -> 1

'e' -> 1

'l' -> 2

'o' -> 1

Code Example

import java.util.HashMap;

import java.util.Map;

public class CharacterFrequency {

public static void main(String[] args) {

String input = "hello";

// Create a map to store frequency of each character

Map<Character, Integer> frequencyMap = new HashMap<>();

// Iterate through each character of the string

for (char c : input.toCharArray()) {

// If the character is already in the map, increment its frequency

frequencyMap.put(c, frequencyMap.getOrDefault(c, 0) + 1);

}

// Print out the frequency of each character

for (Map.Entry<Character, Integer> entry : frequencyMap.entrySet()) {

System.out.println(entry.getKey() + " -> " + entry.getValue());

}

}

}

**Explanation of Code:**

input.toCharArray(): Converts the string into a character array so we can iterate through each character.

frequencyMap.put(c, frequencyMap.getOrDefault(c, 0) + 1):

frequencyMap.getOrDefault(c, 0) retrieves the current count of the character c from the map, or 0 if the character is not present.

We add 1 to this value and update the map with the new count for that character.

for (Map.Entry<Character, Integer> entry : frequencyMap.entrySet()): Iterates over each entry in the map and prints the character and its frequency.

Output:

h -> 1

e -> 1

l -> 2

o -> 1

**Time Complexity:**

Time complexity for iteration: The time complexity for iterating through the string is O(n)O(n)O(n), where n is the length of the string.

Time complexity for map operations: Since the map operations (put and get) have an average time complexity of O(1)O(1)O(1), the overall time complexity is O(n)O(n)O(n).

**Space Complexity:**

Space complexity: The space complexity is O(k)O(k)O(k), where k is the number of unique characters in the string. This is because we're storing the frequency of each unique character in the map.

### **Program – Count of unique character in String**

Problem Definition: Write a code to print the count of unique characters from the String str = “Siddhant Patni”?

import java.util.HashMap;

import java.util.Map;

public class UniqueCharacterCount {

public static void main(String[] args) {

String str = "Siddhant Patni";

// Create a map to store frequency of each character

Map<Character, Integer> frequencyMap = new HashMap<>();

// Iterate through each character of the string

for (char c : str.toCharArray()) {

// Ignore spaces, and if character is not space, add to map

if (c != ' ') {

frequencyMap.put(c, frequencyMap.getOrDefault(c, 0) + 1);

}

}

// Count unique characters (those with frequency 1)

long uniqueCount = frequencyMap.values().stream()

.filter(count -> count == 1)

.count();

// Print the result

System.out.println("Count of unique characters: " + uniqueCount);

}

}

### **Program – ThreeSum**

Problem Definition: Given an integer array nums, return all the triplets [nums[i], nums[j], nums[k]] such that:

i, j, and k are distinct indices, nums[i] + nums[j] + nums[k] == 0. The solution set must not contain duplicate triplets. Input: nums = [-1,0,1,2,-1,-4]

Output: [ [-1,-1,2], [-1,0,1] ]

What is Time complexity and Space complexity?

How can you optimize the time complexity?

import java.util.\*;

public class ThreeSum {

public List<List<Integer>> threeSum(int[] nums) {

List<List<Integer>> result = new ArrayList<>();

Arrays.sort(nums); // Sorting the array to apply two-pointer technique

for (int i = 0; i < nums.length - 2; i++) {

// Skip duplicate elements for the first number

if (i > 0 && nums[i] == nums[i - 1]) {

continue;

}

int left = i + 1; // Start of the second pointer

int right = nums.length - 1; // Start of the third pointer

while (left < right) {

int sum = nums[i] + nums[left] + nums[right];

if (sum == 0) {

result.add(Arrays.asList(nums[i], nums[left], nums[right]));

// Skip duplicates for the second pointer

while (left < right && nums[left] == nums[left + 1]) {

left++;

}

// Skip duplicates for the third pointer

while (left < right && nums[right] == nums[right - 1]) {

right--;

}

// Move both pointers after finding a valid triplet

left++;

right--;

} else if (sum < 0) {

left++; // Need a larger sum, so move left pointer to the right

} else {

right--; // Need a smaller sum, so move right pointer to the left

}

}

}

return result;

}

public static void main(String[] args) {

ThreeSum solution = new ThreeSum();

int[] nums = {-1, 0, 1, 2, -1, -4};

List<List<Integer>> result = solution.threeSum(nums);

System.out.println(result);

}

}

**Time Complexity:**

1. **Sorting the array**: Sorting the array takes O(nlog⁡n)O(n \log n)O(nlogn), where nnn is the number of elements in the array.
2. **Two-pointer approach**: The main logic involves iterating over the array with one pointer and using two pointers to find the triplet. For each element, we do a linear scan with the two pointers, which takes O(n)O(n)O(n) for each iteration of the first loop. The outer loop runs nnn times.

Therefore, the overall time complexity of this algorithm is:

O(n2)(since for each element, we do a linear scan with two pointers)O(n^2) \quad \text{(since for each element, we do a linear scan with two pointers)}O(n2)(since for each element, we do a linear scan with two pointers)

**Space Complexity:**

* The space complexity is O(k)O(k)O(k), where kkk is the number of triplets found. In the worst case, the number of triplets can be O(n2)O(n^2)O(n2), but generally it would be less.
* The space complexity also includes the space for storing the result, which in the worst case is proportional to the number of triplets.

Thus, the space complexity is O(k)O(k)O(k), where kkk is the number of triplets in the result list.

**How to Optimize the Time Complexity?**

The given solution already has an optimal time complexity of O(n2)O(n^2)O(n2). This is the best achievable time complexity for the 3-sum problem because:

* Sorting the array takes O(nlog⁡n)O(n \log n)O(nlogn).
* The two-pointer technique is efficient and linear with respect to the number of elements.

A brute force approach where you try all combinations of three elements would take O(n3)O(n^3)O(n3), so the two-pointer approach is already a significant optimization.

There is no way to improve the time complexity beyond O(n2)O(n^2)O(n2) because you need to check each combination of triplets (although, by sorting the array and skipping duplicates, we reduce unnecessary computations).

### **Program – TwoSum**

Problem Definition: Input: nums = [2,7,11,15], target = 9 Output: [0,1]

Explanation: nums[0] + nums[1] = 2 + 7 = 9, so return [0, 1].

How will you optimize the time complexity?

What is space complexity?

import java.util.HashMap;

public class TwoSum {

public static int[] twoSum(int[] nums, int target) {

// Create a map to store the number and its index

HashMap<Integer, Integer> map = new HashMap<>();

for (int i = 0; i < nums.length; i++) {

int complement = target - nums[i];

// If complement exists in the map, return the pair of indices

if (map.containsKey(complement)) {

return new int[]{map.get(complement), i};

}

// Otherwise, add the current number and its index to the map

map.put(nums[i], i);

}

// If no solution is found (not necessary for this problem as per constraints)

return new int[]{-1, -1};

}

public static void main(String[] args) {

int[] nums = {2, 7, 11, 15};

int target = 9;

int[] result = twoSum(nums, target);

System.out.println("Indices: [" + result[0] + ", " + result[1] + "]");

}

}

**Time Complexity:**

* **Time Complexity**: O(n)O(n)O(n), where nnn is the number of elements in the array.
  + We only need to traverse the array once. In each iteration, checking and inserting an element into the hash map takes constant time, i.e., O(1)O(1)O(1).
* **Space Complexity**: O(n)O(n)O(n), where nnn is the number of elements in the array.
  + We use a hash map to store the indices of the elements, so in the worst case, the space used by the hash map is proportional to the number of elements in the array.

**Why this is Optimized:**

* The naive approach takes O(n2)O(n^2)O(n2) because it checks every pair. By using a hash map, you reduce this to O(n)O(n)O(n), which is much more efficient.
* The space complexity O(n)O(n)O(n) is due to the hash map storing the indices of the elements as we traverse the array.

Thus, this optimized approach provides significant improvements in both time and space efficiency compared to the naive approach.

### **Program – Explain output**

Problem Definition: Explain the output line by line in below code?

class Parent

{

public Parent()

{

System.out.println("in parent Constructor");

}

public void ml()

{

System.out.println("in parent method m1");

}

public static void m2()

{

System.out.println("in parent method m2");

}

}

Class Child extends Parent

{

Public Child()

{

System.out.println("in child Constructor");

}

public void ml()

{

System.out.println("in child method m1");

}

public static void m2()

{

System.out.println("in parent method m2");

}

}

Class Main

{

public static void main (String[] args)

{

Parent p = new Parent();

p.ml();

p.m2();

Child c = new Child();

c.ml();

c.m2();

Child ch = new Parent();

ch.ml();

ch.m2();

Parent pl= new Child();

pl.ml();

pl.m2();

}

}

**Explanation of Output:**

1. **Parent p = new Parent();**
   * The Parent constructor is invoked, so the output is:

in parent Constructor

* + p.ml(); calls the ml() method of the Parent class because the object is of type Parent. The output is:

in parent method ml

* + p.m2(); calls the static m2() method of the Parent class because the method is static. The output is:

in parent method m2

1. **Child c = new Child();**
   * The Child constructor is invoked, which first calls the Parent constructor because the Child constructor implicitly calls super(). The output is:

in parent Constructor

in child Constructor

* + c.ml(); calls the ml() method of the Child class because the object is of type Child. The output is:

in child method ml

* + c.m2(); calls the static m2() method of the Child class because the reference type is Child. The output is:

in child method m2

1. **Parent ch = new Child();**
   * Here, you are upcasting a Child object to a Parent reference.
   * ch.ml(); calls the ml() method of the Child class because the method call is dynamic (runtime polymorphism), so the output is:

in child method ml

* + ch.m2(); calls the static m2() method of the Parent class because static methods are bound at compile time (static binding). The output is:

in parent method m2

1. **Parent pl = new Child();**
   * This is also an upcast, similar to the previous case.
   * pl.ml(); calls the ml() method of the Child class due to runtime polymorphism. The output is:

in child method ml

* + pl.m2(); calls the static m2() method of the Parent class due to static binding. The output is:

in parent method m2

**Final Output:**

in parent Constructor

in parent method ml

in parent method m2

in parent Constructor

in child Constructor

in child method ml

in child method m2

in child method ml

in parent method m2

in child method ml

in parent method m2

**Key Concepts:**

1. **Instance Methods and Runtime Polymorphism**: When a method is called on an object, the actual method that gets invoked depends on the object type (not the reference type). Hence, even though the reference is of type Parent, ml() calls the Child's version when the object is a Child. This is runtime polymorphism.
2. **Static Methods and Compile-Time Binding**: Static methods are bound at compile time, meaning the method that gets called depends on the reference type, not the object type. Therefore, m2() always calls the Parent class's static method when the reference is of type Parent, regardless of the object being a Child.
3. **Constructor Behavior**: When creating an instance of Child, the Parent constructor is called first due to the super() invocation in the Child constructor (implicitly if not explicitly written).

### **Program – Code to add into the list and it should sort on the basis Address**

Problem Definition: Write a code to add into the list and it should sort on the basis Address?

class Emp {

int id, str name , Address addr

Emp(id,name, addr){id= this.id, name =this.name, this.addr= addr}

}

class test{

Emp e1 = new Emp(1,'A','pune');

Emp e2 = new Emp(1,'A','nagpur');

.

.

Emp e100 = new Emp(1,'A','zz');

import java.util.\*;

class Emp {

int id;

String name;

String address;

// Constructor to initialize Emp object

public Emp(int id, String name, String address) {

this.id = id;

this.name = name;

this.address = address;

}

// Getter method for Address

public String getAddress() {

return address;

}

// Override toString() for easy printing of Emp objects

@Override

public String toString() {

return "Emp{id=" + id + ", name='" + name + "', address='" + address + "'}";

}

}

public class Test {

public static void main(String[] args) {

// Create Emp objects

Emp e1 = new Emp(1, "A", "Pune");

Emp e2 = new Emp(2, "B", "Nagpur");

Emp e3 = new Emp(3, "C", "Mumbai");

Emp e4 = new Emp(4, "D", "Delhi");

Emp e5 = new Emp(5, "E", "ZZ");

// Add Emp objects to a list

List<Emp> empList = new ArrayList<>();

empList.add(e1);

empList.add(e2);

empList.add(e3);

empList.add(e4);

empList.add(e5);

// Sort the list based on the Address field

empList.sort(Comparator.comparing(Emp::getAddress));

// Print the sorted list

System.out.println("Sorted list based on Address:");

for (Emp emp : empList) {

System.out.println(emp);

}

}

}

### **Program – What is the output**

Problem Definition: What is the output?

public class Employee {

int id; String name;

Employee(int id, String name){

this.id = id;

this.name = name;

//this.addr = add;

}

}

class test{

public static void main(String[] args)

{

Employee e1 = new Employee(1,"A");

Employee e2 = new Employee(1,"A");

Employee e3 = new Employee(1,"A");

Employee e4 = new Employee(1,"A");

Employee e5 = new Employee(1,"A");

HashMap<Employee,Employee> h = new HashMap();

h.put(e1,e1);

.

.

h.put(e5,e5);

System.out.println("HS size: "+h.size());--1

}

}

In your code, you're using a HashMap to store Employee objects, but there is a key issue. By default, Java uses the equals() and hashCode() methods to compare objects in collections like HashMap. If you do not override these methods in the Employee class, the default behavior of equals() and hashCode() will be used, which is based on the reference equality (i.e., checking if two objects refer to the exact same memory location).

Since each Employee object created in your code (e1, e2, etc.) is a different object (even though they have the same values), the HashMap will treat them as different keys and thus will store all of them in the map. Therefore, the map will contain 5 entries.

**Output Explanation:**

Since the default implementation of equals() and hashCode() in the Object class checks for reference equality, the HashMap will treat each Employee object as a unique key. As a result, there will be **5 unique entries** in the map.

**Fixing the Issue:**

To have the HashMap treat Employee objects with the same id and name as the same key, you need to override the equals() and hashCode() methods in the Employee class. Here's how you can do that:

**Updated Code with equals() and hashCode() Override:**

import java.util.HashMap;

import java.util.Objects;

class Employee {

int id;

String name;

Employee(int id, String name) {

this.id = id;

this.name = name;

}

// Override equals method to compare Employee objects based on id and name

@Override

public boolean equals(Object obj) {

if (this == obj) return true;

if (obj == null || getClass() != obj.getClass()) return false;

Employee employee = (Employee) obj;

return id == employee.id && name.equals(employee.name);

}

// Override hashCode method to ensure consistent hashing for equal objects

@Override

public int hashCode() {

return Objects.hash(id, name);

}

}

public class Test {

public static void main(String[] args) {

Employee e1 = new Employee(1, "A");

Employee e2 = new Employee(1, "A");

Employee e3 = new Employee(1, "A");

Employee e4 = new Employee(1, "A");

Employee e5 = new Employee(1, "A");

HashMap<Employee, Employee> h = new HashMap<>();

h.put(e1, e1);

h.put(e2, e2);

h.put(e3, e3);

h.put(e4, e4);

h.put(e5, e5);

System.out.println("HS size: " + h.size()); // Output will be 1

}

}

**Output with Corrected equals() and hashCode() Methods:**

HS size: 1

**Explanation:**

* Now that we have overridden equals() and hashCode() based on id and name, when you insert e1, e2, e3, etc., into the HashMap, the map will treat all Employee objects with the same id and name as the same object. Therefore, only **one entry** will be added to the HashMap, and the size will be 1.

**Why This Fix Works:**

* **equals()** ensures that two Employee objects are considered equal if they have the same id and name.
* **hashCode()** is used to determine the bucket location in the HashMap. By overriding it to generate the hash code based on id and name, we ensure that objects with the same id and name will have the same hash code, leading to correct behavior in the HashMap.

**Without Overriding equals() and hashCode():**

Without these overrides, the HashMap would store each object as a unique entry, and the output would be 5 because e1, e2, etc., are different objects in memory.

### **Program – What is the output**

public class Employee {

int id; String name;

Employee(int id, String name){

this.id = id;

this.name = name;

//this.addr = add;

}

}

class test{

public static void main(String[] args)

{

Employee e1 = new Employee(1,"A");

Employee e2 = new Employee(1,"A");

Employee e3 = new Employee(1,"A");

Employee e4 = new Employee(1,"A");

Employee e5 = new Employee(1,"A");

HashSet<Employee,Employee> h = new HashSet();

h.add(e1,e1);

.

.

h.add(e5,e5);

System.out.println("HS size: "+h.size());--1

}

}

Your code has a couple of issues:

1. **HashSet Usage**: HashSet is a set, and it only accepts a single argument per element. It should not be used with two arguments like h.add(e1, e1);. The correct usage would be h.add(e1); to add the Employee object into the set.
2. **Employee Class Doesn't Override equals() and hashCode()**: To ensure that HashSet can properly identify whether two Employee objects are equal (based on their id and name), you must override the equals() and hashCode() methods in the Employee class. If you don't, HashSet will rely on the default equals() and hashCode() methods, which compare object references (memory locations) rather than the actual content of the Employee objects.

Here’s a corrected version of the code:

**Corrected Code:**

import java.util.HashSet;

import java.util.Objects;

class Employee {

int id;

String name;

Employee(int id, String name) {

this.id = id;

this.name = name;

}

// Override equals to compare Employee objects based on id and name

@Override

public boolean equals(Object obj) {

if (this == obj) return true;

if (obj == null || getClass() != obj.getClass()) return false;

Employee employee = (Employee) obj;

return id == employee.id && name.equals(employee.name);

}

// Override hashCode to ensure consistent hashing based on id and name

@Override

public int hashCode() {

return Objects.hash(id, name);

}

}

class Test {

public static void main(String[] args) {

Employee e1 = new Employee(1, "A");

Employee e2 = new Employee(1, "A");

Employee e3 = new Employee(1, "A");

Employee e4 = new Employee(1, "A");

Employee e5 = new Employee(1, "A");

HashSet<Employee> h = new HashSet<>();

h.add(e1);

h.add(e2);

h.add(e3);

h.add(e4);

h.add(e5);

// The size will be 1 because all employees are equal based on id and name

System.out.println("HS size: " + h.size());

}

}

**Explanation:**

1. **HashSet<Employee>**: We have used a HashSet that will store Employee objects.
2. **equals() and hashCode()**: We have overridden both methods so that HashSet can compare Employee objects based on their id and name, not just their memory locations. If two Employee objects have the same id and name, they are considered equal.
3. **Adding Employees to HashSet**: When we add the Employee objects (e1, e2, e3, e4, e5) to the HashSet, only one entry will be stored because all of them are considered equal based on equals() and hashCode().

**Output:**

HS size: 1

**Why is the size 1?**

* Since all the Employee objects have the same id and name, they are considered equal.
* The HashSet does not allow duplicates. So, even though we added five Employee objects to the set, only one unique object (based on equals() and hashCode()) is stored.
* Hence, the size of the HashSet is 1.

### **Program – What is the output**

class Simple

{

Simple ( )

{

System.out.println("l am in Simple");

}

public static void main (string[] args)

{

Simple s = new Simple() ;

}

}

The code you've provided has a small issue in the main method. The class name String should be capitalized, so it should be String[] args instead of string[] args.

Here's the corrected version of your code:

**Corrected Code:**

class Simple {

Simple() {

System.out.println("I am in Simple");

}

public static void main(String[] args) {

Simple s = new Simple();

}

}

**Output:**

I am in Simple

**Explanation:**

1. **Constructor Call**: The main method creates an instance of the Simple class by calling the constructor Simple().
2. **Constructor Execution**: When the Simple object is created, the constructor Simple() is called, and the message "I am in Simple" is printed.
3. **Output**: Since there's only one constructor in the Simple class, when you run this program, it prints "I am in Simple".

### **Program – First occurrence of non-repeating character in String**

Problem Definition: Write a program to find the first occurrence of non-repeating character in String

Input: “aabbcdec”

Output: d

import java.util.HashMap;

import java.util.Map;

public class FirstNonRepeatingCharacter {

public static char findFirstNonRepeating(String input) {

// Create a map to store the frequency of each character

Map<Character, Integer> charCount = new HashMap<>();

// Traverse the string and update the count of each character in the map

for (char c : input.toCharArray()) {

charCount.put(c, charCount.getOrDefault(c, 0) + 1);

}

// Traverse the string again to find the first non-repeating character

for (char c : input.toCharArray()) {

if (charCount.get(c) == 1) {

return c; // Return the first non-repeating character

}

}

return '\0'; // Return null character if no non-repeating character is found

}

public static void main(String[] args) {

String input = "aabbcdec";

char result = findFirstNonRepeating(input);

if (result != '\0') {

System.out.println("The first non-repeating character is: " + result);

} else {

System.out.println("No non-repeating character found.");

}

}

}

### **Program – Cinema Booking System**

Problem Definition: Develop a Java program that models a Cinema Booking System with the following

Requirements:

An Auditorium containing multiple Screens.

Each Screen hosts multiple Movie Shows.

Each Movie Show offers seating in three categories: Gold, Silver, and Platinum.

Implement functionality to book tickets, check seat availability, and include additional relevant methods to enhance the booking system.

import java.util.HashMap;

import java.util.Map;

enum SeatCategory {

GOLD, SILVER, PLATINUM

}

class Seat {

private boolean isAvailable;

private SeatCategory category;

public Seat(SeatCategory category) {

this.category = category;

this.isAvailable = true; // Initially available

}

public boolean isAvailable() {

return isAvailable;

}

public void bookSeat() {

if (isAvailable) {

isAvailable = false;

} else {

System.out.println("Seat is already booked.");

}

}

public SeatCategory getCategory() {

return category;

}

@Override

public String toString() {

return category + (isAvailable ? " [Available]" : " [Booked]");

}

}

class MovieShow {

private String movieName;

private Map<SeatCategory, Seat[]> seats;

public MovieShow(String movieName, int goldSeats, int silverSeats, int platinumSeats) {

this.movieName = movieName;

seats = new HashMap<>();

seats.put(SeatCategory.GOLD, new Seat[goldSeats]);

seats.put(SeatCategory.SILVER, new Seat[silverSeats]);

seats.put(SeatCategory.PLATINUM, new Seat[platinumSeats]);

for (int i = 0; i < goldSeats; i++) {

seats.get(SeatCategory.GOLD)[i] = new Seat(SeatCategory.GOLD);

}

for (int i = 0; i < silverSeats; i++) {

seats.get(SeatCategory.SILVER)[i] = new Seat(SeatCategory.SILVER);

}

for (int i = 0; i < platinumSeats; i++) {

seats.get(SeatCategory.PLATINUM)[i] = new Seat(SeatCategory.PLATINUM);

}

}

public void displaySeats() {

System.out.println("Movie: " + movieName);

for (SeatCategory category : SeatCategory.values()) {

System.out.println(category + " Seats:");

for (Seat seat : seats.get(category)) {

System.out.println(seat);

}

}

}

public boolean bookTicket(SeatCategory category, int seatIndex) {

if (seatIndex < 0 || seatIndex >= seats.get(category).length) {

System.out.println("Invalid seat index.");

return false;

}

Seat seat = seats.get(category)[seatIndex];

if (seat.isAvailable()) {

seat.bookSeat();

System.out.println("Successfully booked a " + category + " seat.");

return true;

} else {

System.out.println("Seat already booked.");

return false;

}

}

public boolean checkSeatAvailability(SeatCategory category, int seatIndex) {

if (seatIndex < 0 || seatIndex >= seats.get(category).length) {

System.out.println("Invalid seat index.");

return false;

}

return seats.get(category)[seatIndex].isAvailable();

}

}

class Screen {

private String screenName;

private MovieShow[] movieShows;

public Screen(String screenName, MovieShow[] movieShows) {

this.screenName = screenName;

this.movieShows = movieShows;

}

public void displayAllShows() {

System.out.println("Screen: " + screenName);

for (MovieShow show : movieShows) {

show.displaySeats();

}

}

public boolean bookTicket(String movieName, SeatCategory category, int seatIndex) {

for (MovieShow show : movieShows) {

if (show.movieName.equals(movieName)) {

return show.bookTicket(category, seatIndex);

}

}

System.out.println("Movie not found.");

return false;

}

public boolean checkSeatAvailability(String movieName, SeatCategory category, int seatIndex) {

for (MovieShow show : movieShows) {

if (show.movieName.equals(movieName)) {

return show.checkSeatAvailability(category, seatIndex);

}

}

System.out.println("Movie not found.");

return false;

}

}

class Auditorium {

private String auditoriumName;

private Screen[] screens;

public Auditorium(String auditoriumName, Screen[] screens) {

this.auditoriumName = auditoriumName;

this.screens = screens;

}

public void displayAllScreens() {

System.out.println("Auditorium: " + auditoriumName);

for (Screen screen : screens) {

screen.displayAllShows();

}

}

public boolean bookTicket(String movieName, SeatCategory category, int seatIndex) {

for (Screen screen : screens) {

if (screen.bookTicket(movieName, category, seatIndex)) {

return true;

}

}

System.out.println("Screen not found for the movie.");

return false;

}

public boolean checkSeatAvailability(String movieName, SeatCategory category, int seatIndex) {

for (Screen screen : screens) {

if (screen.checkSeatAvailability(movieName, category, seatIndex)) {

return true;

}

}

System.out.println("Screen not found for the movie.");

return false;

}

}

public class CinemaBookingSystem {

public static void main(String[] args) {

// Creating Movie Shows

MovieShow movieShow1 = new MovieShow("Movie 1", 5, 5, 5);

MovieShow movieShow2 = new MovieShow("Movie 2", 3, 3, 3);

// Creating Screens

Screen screen1 = new Screen("Screen 1", new MovieShow[]{movieShow1});

Screen screen2 = new Screen("Screen 2", new MovieShow[]{movieShow2});

// Creating Auditorium

Auditorium auditorium = new Auditorium("Main Auditorium", new Screen[]{screen1, screen2});

// Display all screens and movie shows

auditorium.displayAllScreens();

// Book a ticket

auditorium.bookTicket("Movie 1", SeatCategory.GOLD, 2);

// Check seat availability

boolean isAvailable = auditorium.checkSeatAvailability("Movie 2", SeatCategory.SILVER, 1);

System.out.println("Seat availability: " + isAvailable);

}

}

### **Program – Movie Booking System related code and data structure**

Problem Definition: Movie booking system related java codes, check availability, book ticket with multiple classes and use of data structures?

* Refer above code

### **Program – Explain User registration functionality**

Problem Definition: Explain the implementation of the User registration method using java? Explain how will you implement it?

1. **User Class**:

public class User {

private String username;

private String password;

private String email;

public User(String username, String password, String email) {

this.username = username;

this.password = password;

this.email = email;

}

public String getUsername() {

return username;

}

public String getPassword() {

return password;

}

public String getEmail() {

return email;

}

}

2. **UserRegistration Class**:

import java.util.regex.\*;

public class UserRegistration {

// Validator for username (non-empty)

public boolean isUsernameValid(String username) {

return username != null && !username.trim().isEmpty();

}

// Validator for email using regex

public boolean isEmailValid(String email) {

String emailRegex = "^[a-zA-Z0-9\_+&\*-]+(?:\\.[a-zA-Z0-9\_+&\*-]+)\*@(?:[a-zA-Z0-9-]+\\.)+[a-zA-Z]{2,7}$";

Pattern pattern = Pattern.compile(emailRegex);

Matcher matcher = pattern.matcher(email);

return matcher.matches();

}

// Validator for password (minimum 8 characters, at least one uppercase, one lowercase, and one number)

public boolean isPasswordValid(String password) {

if (password.length() < 8) {

return false;

}

boolean hasUpper = false, hasLower = false, hasDigit = false;

for (char c : password.toCharArray()) {

if (Character.isUpperCase(c)) hasUpper = true;

if (Character.isLowerCase(c)) hasLower = true;

if (Character.isDigit(c)) hasDigit = true;

}

return hasUpper && hasLower && hasDigit;

}

// Register user if all details are valid

public boolean registerUser(String username, String password, String email) {

if (!isUsernameValid(username)) {

System.out.println("Username is invalid.");

return false;

}

if (!isEmailValid(email)) {

System.out.println("Email format is invalid.");

return false;

}

if (!isPasswordValid(password)) {

System.out.println("Password must be at least 8 characters long and contain an uppercase letter, a lowercase letter, and a number.");

return false;

}

// Simulate saving the user (for example, add to a database or list)

User user = new User(username, password, email);

System.out.println("User " + username + " registered successfully!");

return true;

}

}

3. **Main Class**:

import java.util.Scanner;

public class Main {

public static void main(String[] args) {

Scanner scanner = new Scanner(System.in);

UserRegistration userRegistration = new UserRegistration();

// Get user details from input

System.out.print("Enter username: ");

String username = scanner.nextLine();

System.out.print("Enter password: ");

String password = scanner.nextLine();

System.out.print("Enter email: ");

String email = scanner.nextLine();

// Register the user

boolean isRegistered = userRegistration.registerUser(username, password, email);

if (isRegistered) {

System.out.println("Registration successful!");

} else {

System.out.println("Registration failed. Please try again.");

}

scanner.close();

}

}

### **Program – Write a method to register and check the available user in repo**

import java.util.HashMap;

import java.util.Map;

class User {

private String username;

private String password;

public User(String username, String password) {

this.username = username;

this.password = password;

}

public String getUsername() {

return username;

}

public String getPassword() {

return password;

}

@Override

public String toString() {

return "User{username='" + username + "', password='" + password + "'}";

}

}

class UserRepository {

// In-memory storage for registered users

private Map<String, User> userRepo = new HashMap<>();

// Register a user

public boolean registerUser(String username, String password) {

// Check if the user already exists in the repository

if (userRepo.containsKey(username)) {

System.out.println("User with username " + username + " already exists.");

return false; // User already exists, registration failed

}

// Register the new user

User newUser = new User(username, password);

userRepo.put(username, newUser);

System.out.println("User registered successfully: " + newUser);

return true;

}

// Check if a user is available in the repository

public boolean isUserAvailable(String username) {

return userRepo.containsKey(username); // Returns true if user exists

}

}

public class Main {

public static void main(String[] args) {

UserRepository userRepo = new UserRepository();

// Register users

userRepo.registerUser("john\_doe", "password123");

userRepo.registerUser("jane\_doe", "password456");

// Check if users are available

System.out.println("Is john\_doe available? " + userRepo.isUserAvailable("john\_doe"));

System.out.println("Is alice\_smith available? " + userRepo.isUserAvailable("alice\_smith"));

}

}

### **Program – WhatsApp notification and mobile notification example**

Problem Definition: How can you handle WhatsApp notification and mobile notification after user registration?

**Overview of Approach:**

1. **WhatsApp Notification**:
   * You can use the **Twilio API** or **WhatsApp Business API** to send WhatsApp messages.
   * Twilio provides a service for WhatsApp message sending that can be integrated with your backend.
2. **Mobile Push Notification**:
   * For mobile notifications, you can use services like **Firebase Cloud Messaging (FCM)** to send push notifications to both Android and iOS devices.
   * **Firebase Cloud Messaging** is a free service by Google, which allows you to send notifications to your app's users based on various triggers, such as user registration.

**Step-by-Step Implementation:**

**1. WhatsApp Notification (Using Twilio API):**

To send a WhatsApp notification, you will need to integrate the **Twilio API**.

**Steps for WhatsApp Notification:**

* **Create a Twilio Account** and set up the WhatsApp API.
* **Get the Account SID** and **Auth Token** from Twilio.
* **Send WhatsApp Messages** after user registration.

**Twilio API Integration:**

* First, you need to add Twilio’s Java SDK to your project. You can add it via **Maven**.

<dependency>

<groupId>com.twilio</groupId>

<artifactId>twilio</artifactId>

<version>8.16.0</version>

</dependency>

**Code to Send WhatsApp Notification:**

import com.twilio.Twilio;

import com.twilio.rest.api.v2010.account.Message;

import com.twilio.type.PhoneNumber;

public class WhatsAppNotification {

// Your Twilio credentials

public static final String ACCOUNT\_SID = "your\_account\_sid";

public static final String AUTH\_TOKEN = "your\_auth\_token";

public static void sendWhatsAppMessage(String to, String message) {

Twilio.init(ACCOUNT\_SID, AUTH\_TOKEN);

Message messageSent = Message.creator(

new PhoneNumber("whatsapp:" + to), // WhatsApp recipient

new PhoneNumber("whatsapp:+14155238886"), // Twilio WhatsApp number

message) // The message to send

.create();

System.out.println("Message Sent: " + messageSent.getSid());

}

public static void main(String[] args) {

// Simulate sending a WhatsApp message after registration

sendWhatsAppMessage("+919876543210", "Welcome to our platform! Your registration is successful.");

}

}

**Key Steps:**

* **Twilio.init**: Initializes Twilio with your ACCOUNT\_SID and AUTH\_TOKEN.
* **Message.creator**: Creates and sends the message to the recipient.

**2. Mobile Notification (Using Firebase Cloud Messaging - FCM):**

To send push notifications to a mobile device, we use **Firebase Cloud Messaging** (FCM). This allows your backend to send notifications to the mobile app on Android/iOS.

**Steps for FCM Notification:**

1. **Set Up Firebase**:
   * Create a Firebase project in the Firebase Console (https://console.firebase.google.com/).
   * Enable Firebase Cloud Messaging and get the Server Key from the Firebase Console.
   * Integrate Firebase SDK into your mobile app (both Android and iOS).
2. **Send Notification After User Registration**:
   * Use Firebase’s HTTP API to send the notification from your backend.

**Code to Send FCM Notification:**

You can use **HTTP POST requests** to send notifications via FCM.

**Example Java Code (Backend - Using FCM):**

import java.net.HttpURLConnection;

import java.net.URL;

import java.io.OutputStream;

public class PushNotification {

// Firebase Server Key (from Firebase Console)

private static final String SERVER\_KEY = "your\_firebase\_server\_key";

private static final String FCM\_URL = "https://fcm.googleapis.com/fcm/send";

public static void sendPushNotification(String deviceToken, String message) {

try {

URL url = new URL(FCM\_URL);

HttpURLConnection connection = (HttpURLConnection) url.openConnection();

// Set request method and headers

connection.setRequestMethod("POST");

connection.setRequestProperty("Authorization", "key=" + SERVER\_KEY);

connection.setRequestProperty("Content-Type", "application/json");

connection.setDoOutput(true);

// Create payload to send notification

String payload = "{\n" +

" \"to\": \"" + deviceToken + "\",\n" +

" \"notification\": {\n" +

" \"title\": \"Registration Successful\",\n" +

" \"body\": \"" + message + "\"\n" +

" },\n" +

" \"priority\": \"high\"\n" +

"}";

// Send the notification

try (OutputStream os = connection.getOutputStream()) {

byte[] input = payload.getBytes("utf-8");

os.write(input, 0, input.length);

}

// Get response code

int responseCode = connection.getResponseCode();

System.out.println("Response Code: " + responseCode);

} catch (Exception e) {

e.printStackTrace();

}

}

public static void main(String[] args) {

// Simulate sending a push notification after registration

String deviceToken = "device\_token"; // The FCM device token

sendPushNotification(deviceToken, "Welcome to the app! Your registration is successful.");

}

}

**Key Steps:**

* **HttpURLConnection**: Used to make an HTTP POST request to Firebase Cloud Messaging.
* **Authorization**: Pass the FCM Server Key in the header.
* **Payload**: Create a JSON payload with the device token and message.
* **Device Token**: This should be the unique identifier for the user’s device (you get this from the client-side app after Firebase is initialized).

**Complete Flow After User Registration:**

1. **User Registration**:
   * The user registers by providing their details.
   * The backend system validates the registration and saves the user data.
2. **WhatsApp Notification**:
   * After successful registration, the backend sends a WhatsApp message using the Twilio API to notify the user of the successful registration.
3. **Mobile Notification**:
   * After registration, the backend sends a push notification to the user's mobile device using Firebase Cloud Messaging.

**Summary of the Workflow:**

1. **User provides registration details.**
2. **Backend validates and stores user details**.
3. **Backend sends a WhatsApp message** via Twilio API to the user.
4. **Backend sends a mobile push notification** via Firebase Cloud Messaging (FCM) to the user’s mobile device.

**Time Complexity:**

* **WhatsApp Notification**: Twilio API typically has a response time of about a few milliseconds to seconds, depending on network speed.
* **FCM Notification**: Firebase's push notification also has a similar time complexity, typically O(1) for sending the message.

**Space Complexity:**

* Both notification systems (WhatsApp and mobile push) have negligible space complexity in this context, as they do not require significant memory usage except for the message data itself.

### **Program – Java 8 Stream Program**

Problem Definition: Write a Java code, we have Product and Feature class with Product having model, color, price, location and List<Feature> and Feature class having picture and resolution fields, Write a code using Java 8 Stream API?

1. Print Product which is iPhone 16

2. get the product and its feature which has highest resolution

3. Print number of iPhone15 and iPhone16 count in each location

import java.util.\*;

import java.util.stream.\*;

class Feature {

private String picture;

private int resolution;

public Feature(String picture, int resolution) {

this.picture = picture;

this.resolution = resolution;

}

public int getResolution() {

return resolution;

}

@Override

public String toString() {

return "Feature{picture='" + picture + "', resolution=" + resolution + "}";

}

}

class Product {

private String model;

private String color;

private double price;

private String location;

private List<Feature> features;

public Product(String model, String color, double price, String location, List<Feature> features) {

this.model = model;

this.color = color;

this.price = price;

this.location = location;

this.features = features;

}

public String getModel() {

return model;

}

public String getLocation() {

return location;

}

public List<Feature> getFeatures() {

return features;

}

@Override

public String toString() {

return "Product{model='" + model + "', color='" + color + "', price=" + price + ", location='" + location + "', features=" + features + "}";

}

}

public class Main {

public static void main(String[] args) {

// Sample data

Feature feature1 = new Feature("Picture1", 12);

Feature feature2 = new Feature("Picture2", 18);

Feature feature3 = new Feature("Picture3", 10);

Feature feature4 = new Feature("Picture4", 20);

List<Feature> iphone15Features = Arrays.asList(feature1, feature2);

List<Feature> iphone16Features = Arrays.asList(feature3, feature4);

Product iphone15 = new Product("iPhone 15", "Black", 999.99, "New York", iphone15Features);

Product iphone16 = new Product("iPhone 16", "White", 1099.99, "California", iphone16Features);

List<Product> products = Arrays.asList(iphone15, iphone16);

// 1. Print Product which is iPhone 16

System.out.println("1. Product iPhone 16:");

products.stream()

.filter(product -> "iPhone 16".equals(product.getModel()))

.forEach(System.out::println);

// 2. Get the product and its feature with the highest resolution

System.out.println("\n2. Product and Feature with the highest resolution:");

products.stream()

.map(product -> new AbstractMap.SimpleEntry<>(product,

product.getFeatures().stream().max(Comparator.comparingInt(Feature::getResolution)).orElse(null)))

.max(Comparator.comparingInt(entry -> entry.getValue().getResolution()))

.ifPresent(entry -> System.out.println("Product: " + entry.getKey() + ", Feature: " + entry.getValue()));

// 3. Print the number of iPhone 15 and iPhone 16 count in each location

System.out.println("\n3. Count of iPhone15 and iPhone16 in each location:");

products.stream()

.collect(Collectors.groupingBy(Product::getLocation,

Collectors.groupingBy(Product::getModel, Collectors.counting())))

.forEach((location, modelCountMap) -> {

System.out.println("Location: " + location);

modelCountMap.forEach((model, count) ->

System.out.println(" " + model + ": " + count));

});

}

}

### **Program - Given two Employee objects with the same name, determine the size of a Set after adding these objects, considering whether equals() and hashCode() are overridden in the Employee class.**

Problem Definition: We have 2 Employee object and if I add these objects in Set and check for the size then what will be the output 1 or 2?

Employee e1 = new Employee(“Swapnil”);

Employee e2 = new Employee(“Swapnil”);

* In this scenario, if you add the two Employee objects into a Set, the output for the **size of the set** will depend on how the **Employee class** is implemented, specifically how **equality** is defined.

**Default Behavior:**

By default, **Java’s Set** (like HashSet) uses the equals() and hashCode() methods to determine whether two objects are equal. If these methods are not overridden, two different objects with the same data are considered **different** by default because the **Object class**'s equals() method compares memory references, not the content.

In your case, the Employee class has no custom implementation of equals() and hashCode(), so even though e1 and e2 have the same name ("Swapnil"), they are **considered different objects** by the Set.

Thus, if you add both e1 and e2 to a Set, it will **not remove duplicates** based on the content, and the set will contain both objects.

**Example:**

Set<Employee> employeeSet = new HashSet<>();

employeeSet.add(new Employee("Swapnil"));

employeeSet.add(new Employee("Swapnil"));

System.out.println(employeeSet.size()); // Output will be 2

**Why?**

By default, equals() and hashCode() compare memory addresses (references), so e1 and e2 are considered **distinct objects**.

The Set will allow both e1 and e2 to be added because it does not find them equal based on the default implementation.

**Custom Implementation of equals() and hashCode():**

If you want the Set to treat e1 and e2 as **equal** (because they have the same name), you need to **override equals() and hashCode()** in the Employee class:

public class Employee {

private String name;

public Employee(String name) {

this.name = name;

}

// Override equals and hashCode

@Override

public boolean equals(Object obj) {

if (this == obj) return true;

if (obj == null || getClass() != obj.getClass()) return false;

Employee employee = (Employee) obj;

return name.equals(employee.name);

}

@Override

public int hashCode() {

return name.hashCode();

}

}

Now, when you add e1 and e2 to a Set, the set will consider them **equal** because their names are the same, and it will only keep one of them.

**Example with Custom equals() and hashCode():**

Set<Employee> employeeSet = new HashSet<>();

employeeSet.add(new Employee("Swapnil"));

employeeSet.add(new Employee("Swapnil"));

System.out.println(employeeSet.size()); // Output will be 1

**Conclusion:**

* **Without overriding equals() and hashCode()**: The output will be 2 because the Set treats the two objects as different based on their memory reference.
* **With equals() and hashCode() overridden**: The output will be 1 because the Set considers the two objects equal based on their content.

### **Program – Person Management System, Write model classes**

Problem Definition: You are required to design a basic **Person Management System** in Java that models different types of people within an organization. The system should be able to manage and perform common operations for various person types such as **Managers** and **Drivers**.

Requirements:

Person

- Manager

- Driver

Attributes

- name

- age

- don

- Address

methods

- eat

- doSleep

- doWork

public class PersonManagementSystem {

// Base class

static class Person {

protected String name;

protected int age;

protected String don; // Date of Joining

protected String address;

public Person(String name, int age, String don, String address) {

this.name = name;

this.age = age;

this.don = don;

this.address = address;

}

public void eat() {

System.out.println(name + " is eating.");

}

public void doSleep() {

System.out.println(name + " is sleeping.");

}

public void doWork() {

System.out.println(name + " is working.");

}

}

// Manager class

static class Manager extends Person {

public Manager(String name, int age, String don, String address) {

super(name, age, don, address);

}

@Override

public void doWork() {

System.out.println(name + " is managing the team.");

}

}

// Driver class

static class Driver extends Person {

public Driver(String name, int age, String don, String address) {

super(name, age, don, address);

}

@Override

public void doWork() {

System.out.println(name + " is driving the vehicle.");

}

}

// Main method

public static void main(String[] args) {

Manager manager = new Manager("Alice", 35, "2020-01-01", "New York");

Driver driver = new Driver("Bob", 28, "2022-03-05", "Los Angeles");

System.out.println("--- Manager Actions ---");

manager.eat();

manager.doSleep();

manager.doWork();

System.out.println("\n--- Driver Actions ---");

driver.eat();

driver.doSleep();

driver.doWork();

}

}

### **Program - Flatten a List of Lists using Java 8 Streams**

List<lnteger> listl = new ArrayList<>();

List<lnteger> 11 = Arrays.asList(1,2,3);

List<lnteger> 12 = Arrays.asList(4,5,6);

List<lnteger> 13 = Arrays.asList(7,8,9);

listl.addA11(11);

listl.addA11(12);

listl.addA11(13);

System. out. println(listl);

* Answer

import java.util.\*;

import java.util.stream.Collectors;

public class FlattenListExample {

public static void main(String[] args) {

List<Integer> l1 = Arrays.asList(1, 2, 3);

List<Integer> l2 = Arrays.asList(4, 5, 6);

List<Integer> l3 = Arrays.asList(7, 8, 9);

List<List<Integer>> listOfLists = new ArrayList<>();

listOfLists.add(l1);

listOfLists.add(l2);

listOfLists.add(l3);

// Flattening using flatMap

List<Integer> flatList = listOfLists.stream()

.flatMap(List::stream)

.collect(Collectors.toList());

System.out.println("Flattened List: " + flatList);

}

}

### **Program - How to find the second largest element from the list?**

**1. Java 8 Streams Approach (Cleanest):**

import java.util.\*;

public class SecondLargest {

public static void main(String[] args) {

List<Integer> numbers = Arrays.asList(5, 2, 9, 1, 7, 9);

Optional<Integer> secondLargest = numbers.stream()

.distinct()

.sorted(Comparator.reverseOrder())

.skip(1)

.findFirst();

secondLargest.ifPresentOrElse(

val -> System.out.println("Second Largest: " + val),

() -> System.out.println("Not enough distinct elements")

);

}

}

✅ **2. Classic Iterative Approach (Single Pass, O(n)):**

public class SecondLargest {

public static void main(String[] args) {

int[] arr = {5, 2, 9, 1, 7, 9};

Integer largest = null;

Integer second = null;

for (int num : arr) {

if (largest == null || num > largest) {

second = largest;

largest = num;

} else if ((second == null || num > second) && num != largest) {

second = num;

}

}

if (second != null) {

System.out.println("Second Largest: " + second);

} else {

System.out.println("No second largest element found.");

}

}

}

# Advance Java / J2EE

### **What is servlet?**

* Answer

### **Explain servlet lifecycle?**

* Answer

### **What is a dispatcher servlet?**

* answer

### **What is JSP?**

* answer

### **What is the difference between servlet and JSP?**

* answer

### **What is the JSP lifecycle?**

* answer

### **What is Spring MVC? Explain architecture of spring MVC?**

* Answer

### **What is the singleton design pattern?**

* answer

### **What is the REST API?**

* answer

### **Difference between API and REST?**

* answer

### **Difference between SOAP and REST?**

* answer

### **Which among SOAP and REST is easy?**

* answer

### **Explain REST architecture?**

* answer

### **What do you know about DTD and XSD?**

* answer

### **Explain SOAP Web Service?**

* answer

### **What is Path in XML?**

* answer

### **Write a path for a given xml file?**

* answer

### **What is the use of XSLT?**

* answer

### **How does SOAP work?**

* answer

### **What are the action types of http?**

* answer

### **Explain how you will create a SOAP web service?**

* answer

# Data Structure

### **Find the middle element from the singly linked list without finding the length?**

* Answer

### **Complexity to find length of singly linked list?**

* Answer

### **Do you know how LinkedList works? Can you create a data structure for LinkedList?**

* answer

### **How will you traverse LinkedList? Your List will contains multiple nodes so how will you traverse over it? Can you write a pseudo code? You have your head with you so how will you move to the next node? How will the current node be null?**

* answer

### **Explain Merge Sort??**

* answer

# Design Patterns

### **What is the singleton design pattern? Explain it?**

* answer

### **Explain Factory design pattern?**

* answer

### **What is the Observer design pattern?**

* answer

### **Except for the creational design pattern, can you explain other design patterns?**

* answer

### **Explain Saga design pattern?**

* answer

# Spring

### **What is Spring Framework? What are its advantages?**

* The Spring Framework is a powerful, lightweight, and open-source Java framework used to build enterprise-grade applications. It provides infrastructure support for developing Java applications and promotes loose coupling through Dependency Injection (DI) and Aspect-Oriented Programming (AOP).

**✅ Core Concepts of Spring:**

* **IoC (Inversion of Control):** Spring manages object creation and lifecycle.
* **DI (Dependency Injection**): Promotes loose coupling by injecting dependencies instead of hard-coding them.
* **AOP (Aspect-Oriented Programming):** Separates cross-cutting concerns like logging, security, etc.
* **Modular Architecture:** Includes modules like Spring Core, Spring MVC, Spring Data, Spring Security, etc.

✅ **Advantages of Spring Framework:**

| **Feature** | **Description** |
| --- | --- |
| Lightweight | Spring is lightweight in terms of size and overhead. |
| Loosely Coupled | Uses Dependency Injection to decouple application objects. |
| Modular | Developers can use only the modules they need (e.g., Spring Boot, Spring Security, etc.). |
| Testable | Encourages writing testable code with support for JUnit and Mockito. |
| Integrated with other frameworks | Works well with Hibernate, JPA, JMS, Quartz, etc. |
| Aspect-Oriented Programming (AOP) | Cleanly separates concerns like logging, transactions, and security. |
| Transaction Management | Provides abstraction over various transaction APIs like JTA, JDBC, Hibernate. |
| MVC Web Framework | Spring MVC is a robust model-view-controller web framework. |
| Spring Boot | Rapid application development with embedded servers and auto-configuration. |
| Security | Spring Security offers powerful authentication and authorization mechanisms. |
| Community & Documentation | Large community support and excellent documentation. |

✅ **Spring Modules Overview:**

* spring-core: Core container and DI.
* spring-context: Application context features.
* spring-aop: Aspect-oriented programming.
* spring-jdbc: JDBC and DataSource support.
* spring-tx: Transaction management.
* spring-orm: Integration with ORM tools like Hibernate.
* spring-web: Web integration.
* spring-mvc: Web MVC framework.
* spring-security: Authentication and authorization.
* spring-boot: Simplifies project setup and development.

### **Explain Spring MVC architecture?**

* **Spring MVC** (Model-View-Controller) is a part of the Spring Framework used to build **web applications**. It separates the application into three main components — Model, View, and Controller — to simplify development and promote clean code.

**✅ Spring MVC Architecture Diagram:**

Browser (Client)

↓

[1] DispatcherServlet (Front Controller)

↓

[2] HandlerMapping

↓

[3] Controller

↓

[4] Service Layer (Business Logic)

↓

[5] DAO Layer (Database Access)

↑

[6] Model (Data)

↓

[7] View Resolver

↓

[8] View (JSP/HTML/Thymeleaf)

↓

Response sent to Browser

**✅ Components Explained:**

| **Component** | **Description** |
| --- | --- |
| **1. DispatcherServlet** | The central component of Spring MVC. It receives all HTTP requests and delegates to the appropriate controller. |
| **2. HandlerMapping** | Determines which controller should handle the request based on URL. |
| **3. Controller** | Processes the request, calls the business logic, and returns a ModelAndView object. |
| **4. Service Layer** | Contains business logic and handles processing of data. |
| **5. DAO Layer** | Communicates with the database using technologies like JPA, JDBC, or Hibernate. |
| **6. Model** | Holds data returned from the controller and passed to the view. |
| **7. ViewResolver** | Resolves logical view names (like "home") to actual views (like home.jsp). |
| **8. View** | Renders the final output to the client (JSP, Thymeleaf, etc.). |

**✅ Request Flow Example:**

1. **Client** sends a request (e.g., /getEmployee).
2. DispatcherServlet receives it and checks HandlerMapping.
3. The appropriate @Controller method is invoked.
4. Controller interacts with the **Service** and **DAO** layers.
5. Data is placed in the **Model** object.
6. Controller returns a logical view name.
7. ViewResolver maps it to an actual view (e.g., employee.jsp).
8. View renders the model data and sends the response to the client.

**✅ Annotations Used in Spring MVC:**

| **Annotation** | **Purpose** |
| --- | --- |
| @Controller | Declares a controller class. |
| @RequestMapping | Maps URLs to methods. |
| @GetMapping / @PostMapping | Specific HTTP methods for URL mapping. |
| @ResponseBody | Sends Java object directly as response (usually JSON). |
| @ModelAttribute | Binds request parameters to method parameters. |
| @PathVariable / @RequestParam | Access path or query parameters. |

### **How do you handle exceptions in Spring MVC?**

**✅ 1. Using @ExceptionHandler in Controller**

You can write a method annotated with @ExceptionHandler inside your controller to catch and handle specific exceptions.

@Controller

public class EmployeeController {

@GetMapping("/employee/{id}")

public String getEmployee(@PathVariable int id) {

if (id <= 0) throw new IllegalArgumentException("Invalid ID");

return "employee";

}

@ExceptionHandler(IllegalArgumentException.class)

public String handleIllegalArgumentException(Model model, Exception ex) {

model.addAttribute("error", ex.getMessage());

return "error-page";

}

}

✅ **2. Global Exception Handling with @ControllerAdvice**

This is used to apply exception handling across multiple controllers.

@ControllerAdvice

public class GlobalExceptionHandler {

@ExceptionHandler(Exception.class)

public ModelAndView handleAllExceptions(Exception ex) {

ModelAndView mv = new ModelAndView("error-page");

mv.addObject("errorMessage", ex.getMessage());

return mv;

}

@ExceptionHandler(ResourceNotFoundException.class)

public ModelAndView handleResourceNotFound(ResourceNotFoundException ex) {

ModelAndView mv = new ModelAndView("404-page");

mv.addObject("errorMessage", ex.getMessage());

return mv;

}

}

**✅ 3. Using @ResponseStatus**

You can associate a custom exception with an HTTP status code.

@ResponseStatus(value = HttpStatus.NOT\_FOUND, reason = "Employee Not Found")

public class EmployeeNotFoundException extends RuntimeException {

}

✅ **4. Custom Error Page via web.xml or Spring Boot Config**

In Spring Boot, you can create error.html or error.jsp in /resources/templates or webapp.

<!-- error.html -->

<h2>An error occurred!</h2>

<p th:text="${error}"></p>

**✅ 5. ErrorController Interface (Spring Boot)**

To customize the default error handling in Spring Boot:

@Controller

public class CustomErrorController implements ErrorController {

@RequestMapping("/error")

public String handleError() {

return "custom-error";

}

}

✅ **Summary**

| **Approach** | **Use Case** |
| --- | --- |
| @ExceptionHandler | Controller-specific exceptions |
| @ControllerAdvice | Global exception handling |
| @ResponseStatus | Map custom exceptions to status codes |
| ErrorController | Customize Spring Boot default error page |

### **Explain Spring Dependency Injection (DI)? How is it implemented in Spring?**

* **Dependency Injection** is a design pattern in which an object’s dependencies are **injected** by an external framework rather than the object creating them itself.

**In simple terms:**

Instead of EmployeeService creating its own EmployeeRepository, Spring injects it.

**✅ Why Use Dependency Injection?**

* Promotes **loose coupling**
* Makes code more **testable** and **maintainable**
* Follows **Inversion of Control (IoC)** principle

**✅ How Spring Implements Dependency Injection**

Spring supports two main types of DI:

| **Type** | **Description** |
| --- | --- |
| **Constructor DI** | Dependencies are provided via constructor |
| **Setter DI** | Dependencies are set via setters |

**✅ Example – Constructor Injection**

@Component

public class EmployeeRepository {

public String getData() {

return "Employee Data";

}

}

@Service

public class EmployeeService {

private final EmployeeRepository repo;

@Autowired

public EmployeeService(EmployeeRepository repo) {

this.repo = repo;

}

public void showData() {

System.out.println(repo.getData());

}

}

**✅ Example – Setter Injection**

@Component

public class DepartmentRepository {

public String getDepartment() {

return "IT Department";

}

}

@Service

public class DepartmentService {

private DepartmentRepository repo;

@Autowired

public void setRepo(DepartmentRepository repo) {

this.repo = repo;

}

public void showDepartment() {

System.out.println(repo.getDepartment());

}

}

**✅ Spring DI with XML (Legacy)**

<bean id="employeeService" class="com.example.EmployeeService">

<constructor-arg ref="employeeRepository"/>

</bean>

<bean id="employeeRepository" class="com.example.EmployeeRepository"/>

**✅ DI Annotations Used**

| **Annotation** | **Purpose** |
| --- | --- |
| @Component | Declares a class as a Spring bean |
| @Service | Specialized version of @Component |
| @Repository | For DAO layers |
| @Autowired | Injects dependencies automatically |
| @Qualifier | Resolves ambiguity when multiple beans |
| @Inject / @Resource | Alternatives to @Autowired (from JSR) |

**✅ Summary**

* Spring manages your object dependencies via **IoC Container**.
* You define how components interact, and Spring **wires** them together.
* Reduces tight coupling and improves code reusability and testability.

### **Explain Spring Inversion of Control (IOC)?**

* **Inversion of Control (IoC)** is a principle where the control of object creation and dependency management is **inverted** from the application code to the **Spring container**.

**In plain words:** You don't create objects manually (new keyword); instead, Spring takes care of creating, managing, and injecting dependencies.

**✅ Real-World Analogy**

Imagine you're ordering a pizza:

* **Traditional approach:** You go to the kitchen, make dough, prepare sauce, bake it.
* **IoC approach:** You call the pizza shop, place the order, and it gets delivered to you.

Just like that, in Spring:

* You define what you need (dependencies)
* Spring **injects** them into your class

**✅ How IoC Works in Spring**

Spring has an **IoC container** (like ApplicationContext) that:

* Scans and identifies classes with annotations (@Component, @Service, etc.)
* Instantiates them as **beans**
* Manages their **life cycle**
* Injects them wherever needed

**✅ Example: Without and With IoC**

**Without IoC:**

EmployeeService service = new EmployeeService(new EmployeeRepository());

You are controlling the object creation manually.

**With IoC (Spring):**

@Service

public class EmployeeService {

@Autowired

private EmployeeRepository repository;

}

Spring handles the creation of EmployeeRepository and injects it into EmployeeService.

**✅ Types of IoC in Spring**

| **Type** | **Description** |
| --- | --- |
| **Dependency Injection (DI)** | Primary form used in Spring IoC (via constructor/setter/field) |
| **Event-based IoC** | Spring also handles event listeners for components |

**✅ Spring IoC Containers**

| **Container** | **Description** |
| --- | --- |
| BeanFactory | Lightweight, basic IoC container |
| ApplicationContext | More advanced, supports AOP, internationalization, events, etc. |

**✅ Key Annotations Used**

| **Annotation** | **Purpose** |
| --- | --- |
| @Component | Registers a class as a bean |
| @Autowired | Injects dependencies |
| @Configuration | Used to define bean configuration |
| @Bean | Used to declare a bean manually |

**✅ Summary**

* **IoC** = Giving control to Spring to manage object creation and wiring.
* It reduces **tight coupling**, increases **testability**, and improves **code clarity**.
* Implemented mainly using **Dependency Injection (DI)**.

### **What are the spring bean scopes?**

* A **bean scope** in Spring defines **how long a bean lives** and **how many instances** of the bean are created and maintained by the Spring container.

**✅ Common Bean Scopes in Spring**

| **Scope** | **Description** | **Where Used** |
| --- | --- | --- |
| singleton | (Default) A single shared instance per Spring container | Application-wide |
| prototype | A new bean instance is created **every time** it's requested | Lightweight, stateful objects |
| request | A single bean per **HTTP request** (only in web-aware Spring contexts) | Web apps |
| session | A bean lives for the **lifetime of an HTTP session** | Web apps |
| application | A bean lives for the **lifetime of ServletContext** | Web apps |
| websocket | A bean is tied to the **lifecycle of a WebSocket** | WebSocket apps |

**✅ Example Usage in Code**

@Component

@Scope("prototype")

public class MyPrototypeBean {

public MyPrototypeBean() {

System.out.println("New Instance Created!");

}

}

You can also define scope in XML:

<bean id="myBean" class="com.example.MyBean" scope="prototype"/>

**✅ Singleton vs Prototype**

| **Feature** | **singleton** | **prototype** |
| --- | --- | --- |
| Bean Count | One per container | One per request |
| Life Cycle | Managed by Spring | You manage post-creation |
| Use Case | Stateless shared services | Stateful, non-shared objects |

**✅ Web-Specific Scopes (Request, Session)**

Only available in **Spring Web Applications**, used like:

@Component

@Scope(value = WebApplicationContext.SCOPE\_REQUEST, proxyMode = ScopedProxyMode.TARGET\_CLASS)

public class RequestScopedBean {

// One instance per HTTP request

}

**✅ Summary**

* **Singleton (default):** One bean instance per container
* **Prototype:** New instance each time it's injected/requested
* **Request, Session, etc.:** Useful in web applications
* You can use @Scope annotation to define the scope

### **Explain any scope of spring bean?**

**✅ What is Singleton Bean Scope?**

In Spring, Singleton scope means that only one instance of the bean is created per Spring IoC container. That same instance is shared and injected wherever the bean is required.

**Note:**

This is *not* the same as the Singleton Design Pattern — here, it's managed by the Spring container, not the class itself.

**✅ Key Characteristics**

| **Feature** | **Description** |
| --- | --- |
| Scope | singleton (default) |
| Number of Instances | Only one per Spring container |
| Object Sharing | Same bean instance is shared across the entire application |
| Thread Safety | Not thread-safe by default (you must handle synchronization) |
| Lifecycle Managed by | Spring container |

**✅ Code Example**

@Component // @Scope("singleton") is optional, as it's default

public class MySingletonService {

public MySingletonService() {

System.out.println("Singleton Bean Created");

}

}

If used in a config file:

<bean id="myBean" class="com.example.MyBean" scope="singleton"/>

✅ When to Use Singleton Scope

* When the bean is stateless
* When you want to reuse resources (like DAOs, services, utility classes)
* When you want to avoid object creation overhead

✅ **Example Scenario**

You have a NotificationService bean:

@Service

public class NotificationService {

public void send(String msg) {

System.out.println("Sending notification: " + msg);

}

}

This can safely be a singleton, since it doesn’t hold state specific to any request.

**✅ Important Notes**

* If multiple threads access the singleton bean and modify shared state → you must handle thread safety manually.
* It's container-specific: if you load multiple ApplicationContexts, each will have its own singleton bean.

**✅ Summary**

* @Scope("singleton") or default scope in Spring
* One instance for the entire application context
* Ideal for stateless, shared components
* Not thread-safe by default, so handle carefully if needed

### **How do you define a bean in Spring?**

✅ **1. Using Annotations (@Component, @Service, @Repository, @Controller)**

* This is the most modern and commonly used way (especially in Spring Boot).

@Component

public class MyBean {

public void doSomething() {

System.out.println("Doing something...");

}

}

* Spring will automatically detect and register this bean if **component scanning** is enabled (@ComponentScan or part of a Spring Boot app).
* You can also use more specific stereotypes:

| **Annotation** | **Use For** |
| --- | --- |
| @Component | Generic component |
| @Service | Service layer |
| @Repository | DAO/persistence layer |
| @Controller | MVC web controller |

✅ **2. Using @Bean in a @Configuration Class**

Useful when you need more control over bean creation (e.g., third-party classes).

@Configuration

public class AppConfig {

@Bean

public MyBean myBean() {

return new MyBean(); // Custom logic, if needed

}

}

✅ **3. XML Configuration (Traditional, less used now)**

<beans xmlns="http://www.springframework.org/schema/beans"

... >

<bean id="myBean" class="com.example.MyBean"/>

</beans>

This approach was popular before annotations became widely used.

**💡 Summary**

| **Approach** | **Example Syntax** | **Use When** |
| --- | --- | --- |
| Annotation | @Component, @Service, etc. | Most common, easy to use |
| Java Config | @Bean in @Configuration class | When you need to manually configure bean |
| XML Config | <bean> tag in XML | Legacy code or specific config setups |

### **How to add scope in bean configuration?**

* Bean **scope** determines the **lifecycle and visibility** of a bean — basically how many instances of the bean Spring will create and where they’re shared.

**Common scopes:**

* singleton (default)
* prototype
* request (Web apps only)
* session (Web apps only)
* application (Web apps only)

**✅ 1. Using Annotations**

**➤ With @Scope Annotation**

@Component

@Scope("prototype") // Or "singleton", "request", etc.

public class MyBean {

// Bean logic

}

You can also use @Scope on @Service, @Repository, etc.

If you're using a **web scope** (request, session, etc.), add @Scope with proxyMode:

@Component

@Scope(value = "request", proxyMode = ScopedProxyMode.TARGET\_CLASS)

public class MyRequestScopedBean {

// Scoped to a single HTTP request

}

**✅ 2. Using Java Configuration (@Bean)**

@Configuration

public class AppConfig {

@Bean

@Scope("prototype")

public MyBean myBean() {

return new MyBean();

}

}

**✅ 3. Using XML Configuration**

<bean id="myBean" class="com.example.MyBean" scope="prototype"/>

**✅ Bean Scopes in Summary**

| **Scope** | **Description** |
| --- | --- |
| singleton | One instance per Spring container (default) |
| prototype | New instance every time it's requested |
| request | One instance per HTTP request (web apps) |
| session | One instance per HTTP session (web apps) |
| application | One instance per ServletContext (web apps) |

### **Difference between session and prototype scope?**

* Answer

🔍 **Overview**

| **Aspect** | **prototype Scope** | **session Scope** |
| --- | --- | --- |
| Applies To | All types of applications | Web applications only |
| Instance | A new instance is created every time it's requested | A new instance per HTTP session |
| Managed By | Spring does not manage complete lifecycle | Spring manages the bean for the session |
| Availability | Available wherever beans are injected | Available only during the user session |
| Example Use Case | For stateful beans or objects needing frequent fresh instances | For storing user-specific data like preferences, carts, etc. |

**✅ prototype Scope – Example**

@Component

@Scope("prototype")

public class MyPrototypeBean {

public MyPrototypeBean() {

System.out.println("Prototype bean created");

}

}

Each time you call applicationContext.getBean(MyPrototypeBean.class), a new instance will be created.

**✅ session Scope – Example (Spring MVC / Web)**

@Component

@Scope(value = "session", proxyMode = ScopedProxyMode.TARGET\_CLASS)

public class MySessionBean {

private String userData;

}

Spring creates one instance per user session, which is destroyed when the HTTP session ends.

**🔁 Lifecycle Difference**

* **prototype** beans are not fully managed by Spring — you are responsible for cleanup.
* **session** beans are managed by Spring WebContext and are automatically destroyed with the session.

🧠 **Note:**

In non-web applications, session scope won’t work and will throw an error. Stick with singleton or prototype in such cases.

### **What is the difference between SOAP and REST? Which is more efficient?**

✅ **SOAP (Simple Object Access Protocol)**

| **Feature** | **Description** |
| --- | --- |
| Protocol | It's a protocol. |
| Format | Uses only XML. |
| Transport | Works over HTTP, SMTP, etc. |
| Standards | Has built-in standards for security, transactions, ACID, etc. |
| Contract-based | Uses WSDL (Web Services Description Language) to define contracts. |
| Message Size | Heavy – due to XML and extra SOAP envelope tags. |
| Error Handling | Built-in standard error handling. |

**✅ REST (Representational State Transfer)**

| **Feature** | **Description** |
| --- | --- |
| Architecture Style | It’s an architecture, not a protocol. |
| Format | Supports JSON, XML, HTML, plain text (JSON preferred). |
| Transport | Works only over HTTP/HTTPS. |
| Standards | Lightweight, no strict rules; uses HTTP verbs (GET, POST, PUT, DELETE). |
| Contract-based | No strict contracts (WSDL not used). |
| Message Size | Light – JSON payloads are smaller. |
| Error Handling | HTTP status codes (e.g., 200, 404, 500). |

⚖️ **Which is more efficient?**

✅ REST is generally more efficient for:

* Web/mobile apps
* Performance-critical apps (smaller payloads)
* Scalability and ease of use
* Stateless services

**❌ SOAP is better for:**

* Enterprise-level apps needing robust security, ACID transactions, or asynchronous messaging
* Banking, Telecom, Payment Gateway integrations

**🧠 Summary**

| **Comparison** | **REST** | **SOAP** |
| --- | --- | --- |
| Lightweight | ✅ Yes | ❌ No |
| Easy to use | ✅ Simpler & faster | ❌ Complex |
| Security | ⚠️ Manual (OAuth, JWT) | ✅ Built-in (WS-Security) |
| Flexibility | ✅ JSON, XML | ❌ Only XML |
| Efficiency | ✅ High | ❌ Low |

### **How REST API works?**

* Answer

### **Difference between Spring and Spring Boot?**

* Answer

### **Difference between application context and beanfactory in spring?**

* Answer

### **Explain Spring MVC architecture?**

* Answer

### **Difference between Spring and Spring Boot?**

* Answer

### **What is the use of @Transactional annotation in spring?**

* Answer

### **What are different stereotypes annotations in spring?**

* Answer

### **What is the front controller?**

* answer

### **Difference between ApplicationContext and BeanFactory?**

* answer

### **Explain spring bean life cycle?**

* answer

### **If I have prototype bean and singleton bean, then how can we call prototype beans inside singleton bean?**

* answer

### **What are containers present in the spring?**

* answer

### **How transactions work in spring?**

* answer

### **Do you know the web.xml file? What is the significance of a web.xml file?**

* answer

### **What is the dependency injection?**

* answer

### **What are the different ways of injection?**

* answer

### **Who will take care of objects in Spring?**

* answer

### **What is ApplicationContext and its types in Spring?**

* answer

### **Difference between Filter and Interceptor in Spring MVC?**

* answer

### **Which one has access to spring beans, interceptors or filters?**

* answer

### **Why do interceptors have access to Spring beans?**

* answer

### **Difference between Spring data JPA, Hibernate, JDBC, My batis?**

* answer

### **Why do we use Spring data JPA?**

* answer

### **What is AOP in Spring?**

* answer

### **What are JoinPoint, Advice, Pointcut, and Aspect?**

* answer

### **What is the difference between cross-cutting concern and business logic?**

* answer

# Spring Security

### **What is Spring Security?**

* Spring Security is a **powerful and customizable authentication and access control framework** for Java applications. It provides protection against common threats like:
* Authentication/Authorization
* CSRF
* Session Fixation
* Clickjacking
* URL access restrictions

### **How does Spring Security work internally?**

* It uses a **chain of filters** (FilterChainProxy) to intercept HTTP requests.
* The filters include:
  + UsernamePasswordAuthenticationFilter
  + BasicAuthenticationFilter
  + SecurityContextPersistenceFilter
  + ExceptionTranslationFilter
* Authentication is handled by AuthenticationManager.
* Upon success, an Authentication object is stored in the SecurityContext.

### **Difference between Authentication and Authorization?**

🔐 **Authentication vs Authorization**

| **Concept** | **Authentication** | **Authorization** |
| --- | --- | --- |
| Definition | Verifying who the user is | Determining what the user can access |
| Example | Logging in with username & password | Checking if the user can access /admin |
| Question Answered | *Are you the right user?* | *Do you have permission?* |
| When it Happens | Before authorization | After authentication |
| Handled via | Credentials (e.g., username, password, token) | Roles, permissions, policies |
| Outcome | User identity is confirmed | Access is granted or denied |

✅ **Authentication Flow (Spring Boot Example)**

1. User logs in via /login (form, basic auth, OAuth, etc.)
2. Spring Security authenticates using a configured provider:
   * UserDetailsService
   * JwtAuthenticationFilter
   * OAuth2Login
3. If successful, a SecurityContext is established.

✅ **Authorization Flow**

1. After authentication, Spring checks what resources the user is allowed to access.
2. This is controlled using:
   * @PreAuthorize("hasRole('ADMIN')")
   * http.authorizeRequests() in the config
   * Role or permission-based policies

🧪 **Example in Spring Boot:**

@Configuration

@EnableWebSecurity

public class SecurityConfig extends WebSecurityConfigurerAdapter {

@Override

protected void configure(HttpSecurity http) throws Exception {

http

.authorizeRequests()

.antMatchers("/admin/\*\*").hasRole("ADMIN")

.antMatchers("/user/\*\*").hasAnyRole("USER", "ADMIN")

.anyRequest().authenticated()

.and()

.formLogin()

.and()

.httpBasic();

}

@Bean

public UserDetailsService userDetailsService() {

var user = User.withUsername("user")

.password("{noop}password")

.roles("USER")

.build();

var admin = User.withUsername("admin")

.password("{noop}admin")

.roles("ADMIN")

.build();

return new InMemoryUserDetailsManager(user, admin);

}

}

🔐 Authentication Types:

* Username/password
* Token-based (JWT)
* OAuth2 / OpenID Connect (Google, GitHub)
* Biometric / SSO

🔑 Authorization Types:

* Role-based (RBAC)
* Permission-based
* Attribute-based access control (ABAC)

🧠 Real-World Analogy:

* Authentication is showing your ID at the gate to prove your identity.
* Authorization is whether you're allowed to enter the VIP lounge.

### **What is the role of UserDetailsService in Spring Security?**

* It is used to **load user-specific data** during authentication. You override it to fetch user details from a **DB, LDAP**, or any source.

public interface UserDetailsService {

UserDetails loadUserByUsername(String username);

}

### **How do you implement Role-Based Authorization?**

* Use method security or HTTP configuration:

// Method level

@PreAuthorize("hasRole('ADMIN')")

// HTTP configuration

.antMatchers("/admin/\*\*").hasRole("ADMIN")

### **What is CSRF and how does Spring Security protect against it?**

* **CSRF (Cross-Site Request Forgery)** is an attack that forces authenticated users to perform unwanted actions.

Spring Security enables CSRF protection by default for non-GET methods.

To disable (not recommended unless you're using stateless APIs like JWT):

http.csrf().disable();

### **What is the use of SecurityContextHolder?**

* It holds the SecurityContext, which contains the authenticated user's Authentication object.

Authentication auth = SecurityContextHolder.getContext().getAuthentication();

### **How is password encryption handled in Spring Security?**

* Use PasswordEncoder:

@Bean

public PasswordEncoder passwordEncoder() {

return new BCryptPasswordEncoder();

}

### **What is the difference between hasRole() and hasAuthority()?**

| **Method** | **Role Format** | **Notes** |
| --- | --- | --- |
| hasRole("USER") | Automatically adds ROLE\_ prefix | Role should be ROLE\_USER in DB |
| hasAuthority("ROLE\_USER") | Explicit | More flexible |

### **How do you secure REST APIs using Spring Security?**

* Use JWT or Basic Auth
* Disable CSRF for stateless APIs
* Example config:

http

.csrf()

.disable()

.authorizeRequests()

.antMatchers("/api/admin/\*\*").hasRole("ADMIN")

.anyRequest().authenticated()

.and()

.httpBasic(); // or JWT filter

### **How to implement JWT in Spring Security?**

* Intercept requests with a custom OncePerRequestFilter
* Validate the token and set the authentication in SecurityContextHolder
* Stateless session

### **What is the difference between stateless and stateful authentication?**

| **Type** | **Description** |
| --- | --- |
| Stateful | Session is stored in server memory |
| Stateless | Token (e.g., JWT) sent with every request |

### **What is OncePerRequestFilter?**

* A base class for filters that should be **invoked only once per request**, often used for:
* Logging
* JWT validation
* Custom security filters

### **How to exclude certain endpoints (like /login, /register) from Spring Security?**

.antMatchers("/login", "/register").permitAll()

### **What is OAuth2 and how is it supported in Spring Security?**

* OAuth2 is an **authorization framework** for token-based access delegation.

Spring Security provides:

* spring-security-oauth2-client for login with Google, GitHub, etc.
* spring-security-oauth2-resource-server for JWT token validation

# Spring Batch

### **What is the Spring batch? Explain where you have used the spring batch in your project?**

* **Spring Batch** is a robust **batch processing framework** built on top of the Spring framework. It is designed to handle large volumes of data and jobs such as:
* Reading from a database, file, or queue
* Processing/transformation of data
* Writing results to a database, file, or other systems

**🔧 Key Features of Spring Batch**

| **Feature** | **Description** |
| --- | --- |
| **Chunk-based processing** | Reads, processes, and writes records in chunks |
| **Retry/Skip logic** | Built-in support for fault tolerance |
| **Job Scheduling** | Integration with schedulers like Quartz, cron, etc. |
| **Transaction Management** | Ensures consistency using Spring transactions |
| **Job Repository** | Tracks job execution status, metadata |
| **Parallel Processing** | Supports multithreading, partitioning, and remote chunking |

**📦 Common Use Cases**

* ETL jobs (Extract, Transform, Load)
* Report generation
* File transformation (CSV/Excel to DB or vice versa)
* Data migration and cleanup tasks

**🧑‍💻 Where Have I Used Spring Batch?**

Here's how you can explain it in an interview:

In my previous project, we implemented **Spring Batch** for processing large CSV files containing transactional data. Each file had over 500,000 records.

Our batch job:

* **Read** data from the CSV
* **Validated** each record using a custom validator
* **Transformed** records (e.g., date formats, enums)
* **Wrote** the cleaned data into a PostgreSQL database

We configured chunk size as 500 and added **fault tolerance** for skipping corrupt records while logging them for review.  
Also, we used JobLauncher to trigger the job from a REST endpoint and integrated the job scheduling with **Spring Boot + Quartz**.

**📘 Spring Batch Architecture**

1. **Job** → Entire batch job
2. **Step** → Single unit of work in a job
3. **ItemReader** → Reads data (from DB, file, etc.)
4. **ItemProcessor** → Transforms data
5. **ItemWriter** → Writes data (to DB, file, etc.)

**🧱 Basic Configuration Example (Java Config)**

@Bean

public Job myJob(JobBuilderFactory jobBuilders, Step myStep) {

return jobBuilders.get("myJob")

.incrementer(new RunIdIncrementer())

.flow(myStep)

.end()

.build();

}

@Bean

public Step myStep(StepBuilderFactory stepBuilders,

ItemReader<MyDTO> reader,

ItemProcessor<MyDTO, MyEntity> processor,

ItemWriter<MyEntity> writer) {

return stepBuilders.get("myStep")

.<MyDTO, MyEntity>chunk(100)

.reader(reader)

.processor(processor)

.writer(writer)

.build();

}

### **How spring batch works?**

* Spring Batch works by defining **jobs** that consist of one or more **steps**. Each step does a **read → process → write** cycle.

**🔄 Spring Batch Core Flow**

1. **Job**  
   A job is a container for steps and represents the entire batch process.
2. **Step**  
   Each step defines a stage in the job: reading, processing, and writing.
3. **ItemReader**  
   Reads one item at a time from a data source (file, DB, etc.)
4. **ItemProcessor (optional)**  
   Transforms the input data (e.g., validation, conversion).
5. **ItemWriter**  
   Writes processed data to a target (file, DB, etc.)
6. **JobRepository**  
   Stores metadata about job execution (status, count, time).
7. **JobLauncher**  
   Triggers the job execution, can be from main class, REST API, or a scheduler.

**🔁 Example: Read CSV → Process → Store to DB**

| **Step** | **Component** | **Role** |
| --- | --- | --- |
| Step 1 | FlatFileItemReader | Reads rows from CSV |
| Step 2 | ItemProcessor | Validates and transforms data |
| Step 3 | JdbcBatchItemWriter | Inserts records into DB |

**📘 Flowchart of Execution**

JobLauncher --> Job --> Step

|

+--> ItemReader --> ItemProcessor --> ItemWriter

**⚙️ Configuration (Java-based)**

@Bean

public Job myJob(JobBuilderFactory jobBuilderFactory, Step step) {

return jobBuilderFactory.get("myJob")

.incrementer(new RunIdIncrementer())

.flow(step)

.end()

.build();

}

@Bean

public Step step(StepBuilderFactory stepBuilderFactory,

ItemReader<MyDTO> reader,

ItemProcessor<MyDTO, MyEntity> processor,

ItemWriter<MyEntity> writer) {

return stepBuilderFactory.get("step")

.<MyDTO, MyEntity>chunk(100)

.reader(reader)

.processor(processor)

.writer(writer)

.build();

}

**🔐 Advanced Features**

* **Fault Tolerance** – skip or retry failed records
* **Listeners** – handle before/after job or step actions
* **Partitioning** – parallelize batch jobs
* **JobParameters** – pass runtime values like file name

**🧠 Real-World Example Use Cases**

* ETL (Extract, Transform, Load) jobs
* Monthly billing or payroll processing
* Data migration or cleansing
* Report generation

### **How to implement the spring batch?**

* Implementing **Spring Batch** involves setting up jobs and steps that follow the read → process → write pattern. Here’s a **step-by-step guide** with a working **Java config-based example** to help you get started quickly:

**✅ Step 1: Add Maven Dependencies**

<dependency>

<groupId>org.springframework.boot</groupId>

<artifactId>spring-boot-starter-batch</artifactId>

</dependency>

<dependency>

<groupId>org.springframework.boot</groupId>

<artifactId>spring-boot-starter-jdbc</artifactId>

</dependency>

<dependency>

<groupId>com.h2database</groupId>

<artifactId>h2</artifactId>

<scope>runtime</scope>

</dependency>

H2 is just for demo. You can replace it with your preferred DB.

**✅ Step 2: Define a Domain Model**

public class Person {

private String firstName;

private String lastName;

// Getters and setters

}

**✅ Step 3: Reader - Read from CSV**

@Bean

public FlatFileItemReader<Person> reader() {

return new FlatFileItemReaderBuilder<Person>()

.name("personItemReader")

.resource(new ClassPathResource("sample-data.csv"))

.delimited()

.names("firstName", "lastName")

.targetType(Person.class)

.build();

}

**✅ Step 4: Processor (Optional)**

public class PersonItemProcessor implements ItemProcessor<Person, Person> {

@Override

public Person process(Person person) {

person.setFirstName(person.getFirstName().toUpperCase());

return person;

}

}

**✅ Step 5: Writer - Write to Console or DB**

@Bean

public ItemWriter<Person> writer() {

return items -> {

for (Person person : items) {

System.out.println("Writing: " + person);

}

};

}

**✅ Step 6: Configure Step**

@Bean

public Step step1(StepBuilderFactory stepBuilderFactory,

ItemReader<Person> reader,

ItemProcessor<Person, Person> processor,

ItemWriter<Person> writer) {

return stepBuilderFactory.get("step1")

.<Person, Person>chunk(10)

.reader(reader)

.processor(processor)

.writer(writer)

.build();

}

**✅ Step 7: Configure Job**

@Bean

public Job importUserJob(JobBuilderFactory jobBuilderFactory, Step step1) {

return jobBuilderFactory.get("importUserJob")

.incrementer(new RunIdIncrementer())

.flow(step1)

.end()

.build();

}

**✅ Step 8: Run the Batch**

In your Application.java, just annotate with @SpringBootApplication and run the app. Spring Boot will auto-trigger the batch job on startup.

**📝 CSV Sample (resources/sample-data.csv)**

John,Doe

Jane,Smith

**💡 Real Projects Use:**

* Reader from **DB**, **Kafka**, or **REST API**
* Writer to **DB**, **File**, **Email**, **Elastic**, etc.
* Use JobLauncher to **manually trigger** a batch job via REST or schedule

# Hibernate

### How data is persisted in database by using hibernate**?**

* Hibernate is an ORM (Object-Relational Mapping) framework that simplifies database operations in Java applications. Here's how data gets persisted to a database using Hibernate:

1. Configuration Setup

First, configure Hibernate to connect to your database:

<!-- hibernate.cfg.xml -->

<hibernate-configuration>

<session-factory>

<!-- Database connection settings -->

<property name="hibernate.connection.driver\_class">com.mysql.jdbc.Driver</property>

<property name="hibernate.connection.url">jdbc:mysql://localhost:3306/mydb</property>

<property name="hibernate.connection.username">root</property>

<property name="hibernate.connection.password">password</property>

<!-- SQL dialect -->

<property name="hibernate.dialect">org.hibernate.dialect.MySQLDialect</property>

<!-- Mapping files -->

<mapping class="com.example.Employee"/>

</session-factory>

</hibernate-configuration>

2. Entity Class Definition

Create a Java class annotated with @Entity:

@Entity

@Table(name = "employees")

public class Employee {

@Id

@GeneratedValue(strategy = GenerationType.IDENTITY)

private Long id;

@Column(name = "emp\_name")

private String name;

private double salary;

// Getters and setters

}

3. Persistence Process

Here's the step-by-step persistence flow:

a) Create SessionFactory

Configuration config = new Configuration().configure("hibernate.cfg.xml");

SessionFactory sessionFactory = config.buildSessionFactory();

b) Open Session

Session session = sessionFactory.openSession();

c) Begin Transaction

Transaction tx = session.beginTransaction();

d) Create Entity Object

Employee emp = new Employee();

emp.setName("John Doe");

emp.setSalary(50000);

e) Save/Persist the Object

session.save(emp); // or session.persist(emp);

f) Commit Transaction

tx.commit();

g) Close Session

session.close();

4. What Happens Internally

When you call **session.save():**

Hibernate checks the entity state - determines if it's transient (new), persistent (managed), or detached

Generates SQL - Hibernate creates the appropriate INSERT statement based on your entity mappings

Executes SQL - The statement is executed against the database

Updates entity state - The transient object becomes persistent

Handles ID generation - If using auto-increment, retrieves the generated ID

5. Transaction Management

Hibernate operations should be performed within transactions:

Session session = sessionFactory.openSession();

try {

Transaction tx = session.beginTransaction();

// Perform operations

Employee emp = new Employee("Jane Smith", 60000);

session.save(emp);

tx.commit(); // Changes are flushed to database here

} catch (Exception e) {

if (tx != null) tx.rollback();

throw e;

} finally {

session.close();

}

6. Different Persistence Operations

**Operation Description**

save() Persists the object, returns generated ID

persist() Similar to save() but doesn't guarantee immediate ID assignment

update() Updates a detached object

merge() Copies state of detached object to persistent object

saveOrUpdate() Either saves or updates based on object state

7. Hibernate Cache Flow

**First Level Cache (Session cache):**

* Exists per session
* All persistent objects are stored here
* Cleared when session closes

**Second Level Cache (Optional):**

* Shared across sessions
* Needs explicit configuration
* Reduces database hits for frequently accessed data

Example Complete Flow

public class HibernateExample {

public static void main(String[] args) {

// 1. Configure and build SessionFactory

SessionFactory sessionFactory = new Configuration()

.configure("hibernate.cfg.xml")

.buildSessionFactory();

// 2. Open session

Session session = sessionFactory.openSession();

Transaction tx = null;

try {

// 3. Begin transaction

tx = session.beginTransaction();

// 4. Create and persist object

Employee newEmployee = new Employee();

newEmployee.setName("Michael Johnson");

newEmployee.setSalary(75000);

// 5. Save to database

Long employeeId = (Long) session.save(newEmployee);

System.out.println("Employee saved with ID: " + employeeId);

// 6. Commit transaction

tx.commit();

} catch (Exception e) {

if (tx != null) tx.rollback();

e.printStackTrace();

} finally {

// 7. Close session

session.close();

sessionFactory.close();

}

}

}

**Key Benefits of Hibernate Persistence:**

* Object-Oriented Approach - Work with objects rather than SQL
* Automatic SQL Generation - No need to write CRUD queries
* Transaction Management - Built-in support for ACID properties
* Caching - Improves performance
* Database Independence - Switch databases with minimal code changes

This is the fundamental process of how Hibernate persists Java objects to relational databases while handling all the underlying JDBC complexity.

### **How to retrieve select query using Hibernate?**

* Answer

### **How to retrieve data through hibernate?**

* Answer

### **Hibernate caching?**

* Answer

### **Explain L1 and L2 cache in Hibernate?**

* Answer

### **Explain the hibernate sessions?**

* Answer

### **Difference between JDBC and Hibernate?**

* Answer

### **What is the difference between get and load method in hibernate?**

* Answer

### **Explain bean scopes?**

* Answer

### **Can we have beans without bean id?**

* Answer

### **Difference between get and load method?**

* Answer

### **Explain Performance tuning and indexing in hibernate?**

* Answer

### **Explain different classes and annotations in hibernate?**

* Answer

### **How to call stored procedures using hibernate?**

* answer

### **What is Many to many associations in hibernate?**

* answer

### **What is JPA?**

* answer

### **What is the many to many associations in hibernate?**

* answer

### **What is a Session factory in hibernate?**

* answer

### **Explain Many to many associations in hibernate?**

* answer

### **If I want to retrieve a few entries from an employee table, how to retrieve employee details through JPA?**

* answer

### **Explain a built-in function in JPA?**

* answer

### **What is lazy loading in hibernate?**

* answer

### **What is circular dependency?**

* answer

### **What is the second level cache in hibernate?**

* answer

### **Can we use Hibernate without JPA?**

* answer

### **What are the advantages of ORM?**

* answer

# Spring Boot

### **What is Spring Boot? Why is it used?**

* Spring Boot is an open-source framework developed by Pivotal that simplifies the development of production-ready Spring applications. It is built on top of the Spring Framework and provides a set of tools and conventions to make it easier to create stand-alone, production-grade Spring-based applications with minimal configuration.

**Key reasons why Spring Boot is used:**

1. **Auto-Configuration:** Automatically configures Spring application based on the dependencies present in the classpath.
2. **Standalone Applications:** Enables building stand-alone applications with an embedded server like Tomcat or Jetty, eliminating the need for external deployment.
3. **Production-Ready Features:** Includes built-in features like health checks, metrics, and monitoring via Spring Boot Actuator.
4. **Minimal Configuration:** Reduces the need for boilerplate code and XML configurations by using sensible defaults.
5. **Rapid Development:** Speeds up the development process with built-in tools like Spring Initializr and developer-friendly defaults.
6. **Easy Integration:** Seamlessly integrates with Spring Cloud, JPA, Kafka, Security, and other Spring ecosystem components.

### **Difference between Spring and Spring Boot?**

**🔹 Spring Framework**

* What it is: A comprehensive, modular framework for building Java applications.
* Purpose: Provides the infrastructure support (like dependency injection, AOP, etc.) for building enterprise-level applications.
* Setup: Requires a lot of boilerplate code and XML or Java-based configurations.
* Web Development: You need to set up the web server manually (like Tomcat).
* Dependency Management: You manually handle dependencies using Maven/Gradle.
* Learning Curve: Steeper due to more setup and configurations.

**🔹 Spring Boot**

* What it is: An extension of the Spring Framework that simplifies application development.
* Purpose: Helps to quickly bootstrap and develop Spring-based applications with minimal configuration.
* Setup: Zero or minimal configuration — uses auto-configuration.
* Web Development: Embedded servers like Tomcat/Jetty come pre-configured.
* Dependency Management: Comes with Spring Boot Starter dependencies that group common dependencies.
* Learning Curve: Easier to get started, ideal for microservices and quick PoCs.

🔁 **Summary Table:**

| **Feature** | **Spring** | **Spring Boot** |
| --- | --- | --- |
| Configuration | Manual, XML/Java-based | Auto-configuration |
| Server | External (Tomcat, Jetty) | Embedded (Tomcat, Jetty, Undertow) |
| Setup Complexity | More complex | Simple and fast |
| Project Structure | Manual | Convention over configuration |
| Microservices Support | Requires setup | Built-in support |
| Use Case | Large enterprise applications | Microservices, REST APIs, POCs |

### **What are the advantages of Spring Boot?**

**✅ 1. Auto Configuration**

* Automatically configures your application based on the dependencies present in the classpath.
* Reduces the need for complex XML or Java config files.

**✅ 2. Embedded Servers**

* Comes with embedded Tomcat, Jetty, or Undertow.
* No need to deploy WAR files — just run the app as a Java application.

**✅ 3. Starter Dependencies**

* Provides starter POMs (like spring-boot-starter-web, spring-boot-starter-data-jpa) to simplify dependency management.
* One-line inclusion instead of multiple individual dependencies.

**✅ 4. Production-Ready Features**

* Built-in support for monitoring and management via Spring Boot Actuator.
* Exposes endpoints to check health, metrics, environment, and more.

**✅ 5. Minimal Boilerplate Code**

* Reduces repetitive code and configuration, making development faster.
* Follows convention over configuration.

**✅ 6. Easy Integration**

* Easily integrates with Spring ecosystem (Spring Data, Spring Security, Spring Cloud, etc.).
* Works seamlessly with external tools like Docker, Kubernetes, and cloud platforms (AWS, GCP, Azure).

**✅ 7. CLI Support**

* Spring Boot CLI allows you to run and test Groovy/Java apps from the command line — useful for quick prototyping.

**✅ 8. Rapid Development & Microservices Friendly**

* Perfect for microservices architecture with lightweight REST services.
* Speeds up development with built-in defaults and reduced setup time.

**✅ 9. Profiles & Environment Support**

* Easily supports different environments (dev, test, prod) using application-{profile}.properties or YAML files.

**✅ 10. Active Community & Documentation**

* Backed by a strong Spring community.
* Well-documented and actively maintained.

### **What is the role of @Controller and @RequestMapping?**

🧩 **@Controller — Marks a class as a Spring MVC Controller**

* Tells Spring that this class will handle web requests (typically HTTP GET/POST).
* Used in the presentation layer to define endpoints for incoming client requests (like /home, /users, etc.).
* Returns:
  + View name (for traditional MVC with JSP/Thymeleaf), or
  + ModelAndView object.

**✅ Example:**

@Controller

public class MyController {

@RequestMapping("/hello")

public String sayHello() {

return "hello"; // View name (hello.jsp or hello.html)

}

}

If you want to return JSON instead of a view, use @RestController (which is a shortcut for @Controller + @ResponseBody).

**🔗 @RequestMapping — Maps HTTP requests to handler methods**

* Can be applied at the class level and/or method level.
* Maps URL paths and HTTP methods (GET, POST, etc.) to specific controller methods.

**✅ Example:**

@Controller

@RequestMapping("/api") // Base path for all methods

public class ApiController {

@RequestMapping("/users") // Handles GET /api/users

public String getUsers() {

return "users";

}

}

🔁 You can also specify HTTP methods:

@RequestMapping(value = "/save", method = RequestMethod.POST)

public String saveUser() {

return "saved";

}

**✅ Summary:**

| **Annotation** | **Purpose** |
| --- | --- |
| @Controller | Marks class to handle web requests |
| @RequestMapping | Maps URLs (and methods) to handler methods |

### **What is a Spring Boot Starter?**

* A **Spring Boot Starter** is a **pre-configured set of dependencies** that you can add to your project to get a specific functionality **quickly and easily**.

Instead of manually including multiple libraries, Spring Boot Starters bundle **common dependencies together**, following the **"convention over configuration"** principle.

**✅ Why Use Starters?**

* **Reduces boilerplate** in build.gradle or pom.xml.
* Automatically brings in compatible versions of libraries.
* Speeds up development and setup.

**🔧 Example: spring-boot-starter-web**

Instead of this 👇:

implementation 'org.springframework:spring-web'

implementation 'org.springframework.boot:spring-boot'

implementation 'com.fasterxml.jackson.core:jackson-databind'

implementation 'org.springframework.boot:spring-boot-starter-tomcat'

Just use:

implementation 'org.springframework.boot:spring-boot-starter-web'

It includes:

* Spring MVC
* Embedded Tomcat
* Jackson for JSON
* Logging (SLF4J + Logback)

**🔥 Common Spring Boot Starters:**

| **Starter** | **Description** |
| --- | --- |
| spring-boot-starter-web | For building web & RESTful apps using Spring MVC |
| spring-boot-starter-data-jpa | For JPA & Hibernate-based database access |
| spring-boot-starter-security | Adds Spring Security |
| spring-boot-starter-test | Testing libraries (JUnit, Mockito, etc.) |
| spring-boot-starter-thymeleaf | Template engine for web views |
| spring-boot-starter-actuator | Monitoring and metrics |

**💡 Note:**

All starters follow the naming convention:  
**spring-boot-starter-<feature>**

### **What is a yaml file in SpringBoot?**

* In Spring Boot, a **YAML file** (application.yml) is an alternative to the traditional application.properties file. It's used to define **application configuration** in a **hierarchical and readable** format.

**✅ Why YAML?**

* Cleaner and more structured than properties files.
* Supports **nested configuration**, arrays, and environment profiles more elegantly.
* Easier to maintain for complex settings (like multiple data sources, Kafka, etc.).

**📁 Common YAML File Name:**

src/main/resources/application.yml

**🔧 Example: application.yml**

server:

port: 8081

spring:

datasource:

url: jdbc:postgresql://localhost:5432/mydb

username: myuser

password: secret

jpa:

hibernate:

ddl-auto: update

show-sql: true

logging:

level:

org.springframework: INFO

**🌐 With Profiles (Environment-based Configs):**

spring:

profiles:

active: dev

---

spring:

profiles: dev

datasource:

url: jdbc:mysql://localhost:3306/devdb

username: dev

password: devpass

---

spring:

profiles: prod

datasource:

url: jdbc:mysql://prod-server:3306/proddb

username: prod

password: prodpass

**🔍 Key Features of YAML in Spring Boot:**

* Uses **indentation** (spaces, not tabs!) for hierarchy.
* Supports **multiple documents** separated by ---.
* Works seamlessly with Spring's @ConfigurationProperties to map config into POJOs.

### **What is application.properties or application.yml used for?**

* Both application.properties and application.yml are **configuration files** in Spring Boot. They're used to **define application settings** and **externalize configuration**, so you can change behavior without touching Java code.

**🎯 Main Purpose:**

To **configure** things like:

* Server port
* Database connection
* Logging levels
* Security settings
* Custom application variables
* Profiles (dev/test/prod)
* Third-party integrations (Kafka, Mail, etc.)

**🔧 Example: application.properties**

server.port=8081

spring.datasource.url=jdbc:mysql://localhost:3306/mydb

spring.datasource.username=root

spring.datasource.password=secret

logging.level.org.springframework=INFO

**🔧 Same Example in application.yml**

server:

port: 8081

spring:

datasource:

url: jdbc:mysql://localhost:3306/mydb

username: root

password: secret

logging:

level:

org.springframework: INFO

**🆚 Difference Between the Two:**

| **Feature** | **application.properties** | **application.yml** |
| --- | --- | --- |
| Format | Key-value pairs | Hierarchical & structured |
| Readability | Simple for flat configs | Better for nested structures |
| Profiles | Supported | Cleaner profile handling |

**🧠 Note:**

You can use **either** file, or **both**. Spring Boot reads application.properties and application.yml by default from:

src/main/resources/

### **How does Spring Boot auto-configuration work?**

**⚙️ How does Spring Boot Auto-Configuration work?**

Spring Boot’s auto-configuration feature is what makes it so powerful and easy to use — it automatically configures your application based on the dependencies present on the classpath.

**🧠 In Simple Terms:**

Spring Boot looks at the JARs in your project, and auto-configures beans for you — so you don’t have to write boilerplate configuration code.

**✅ Key Components That Make It Work:**

**1. @EnableAutoConfiguration**

* This is part of @SpringBootApplication.
* It tells Spring Boot to start auto-configuration:

@SpringBootApplication // Includes @EnableAutoConfiguration

public class MyApp {

public static void main(String[] args) {

SpringApplication.run(MyApp.class, args);

}

}

**2. spring.factories (or spring/org.springframework.boot.autoconfigure.AutoConfiguration.imports in Spring Boot 3+)**

* Found inside the Spring Boot JARs (like spring-boot-autoconfigure)
* Lists all the auto-configuration classes:

# META-INF/spring.factories

org.springframework.boot.autoconfigure.EnableAutoConfiguration=\

org.springframework.boot.autoconfigure.jdbc.DataSourceAutoConfiguration,\

org.springframework.boot.autoconfigure.web.servlet.WebMvcAutoConfiguration,\

...

**3. @Conditional Annotations**

Spring Boot only configures what you need, using annotations like:

* @ConditionalOnClass → If a class is on the classpath
* @ConditionalOnMissingBean → Only create if a bean is missing
* @ConditionalOnProperty → Based on values in application.properties/yml

✅ Example:

@Configuration

@ConditionalOnClass(DataSource.class)

public class DataSourceAutoConfiguration {

// Sets up a DataSource bean if JDBC is on the classpath

}

**🔍 Example in Action:**

If you add this dependency:

implementation 'spring-boot-starter-web'

Spring Boot:

* Detects Spring MVC is needed
* Auto-configures:
  + DispatcherServlet
  + Embedded Tomcat
  + Jackson for JSON
  + Default error pages
  + Logging

All without you writing any config!

💡 Can You Override Auto-Config?

Yes! You can override it:

* Define your own @Bean
* Use @ConditionalOnMissingBean
* Disable specific auto-configs using:

@SpringBootApplication(exclude = {DataSourceAutoConfiguration.class})

**🧾 Summary:**

| **Feature** | **Purpose** |
| --- | --- |
| @EnableAutoConfiguration | Enables auto-configuration |
| spring.factories / AutoConfiguration.imports | Lists config classes |
| @Conditional... annotations | Control when config should apply |
| Works based on | Classpath + Config + Context |

### **How do you create a RESTful API in Spring Boot?**

* Answer

### **How do you connect Spring Boot with a database (JPA/Hibernate)?**

* Answer

### **What is what is @transient in spring boot?**

* answer

### **What are the types of propagation?**

* Answer

### **What @Qualifier in spring? What is the use of @Qualifier?**

* answer

### **What are the advantages of Spring boot?**

* answer

### **How to create multiple modules using spring boot?**

* answer

### **What are all methods present in the controller?**

* answer

### **Explain annotations in Spring boot?**

* answer

### **What is the query parameter?**

* answer

### **How to change the server in Spring boot?**

* answer

### **Difference between @Controller and @RestController?**

* answer

### **What is the use of @Responsebody annotation?**

* answer

### **Explain @RestController annotation in Spring boot?**

* answer

### **Which two annotations are used in built by @RestController?**

* answer

### **How to access application.properties properties in java code?**

* answer

### **Explain Spring boot application? How does it work?**

* answer

### **What is the use of @Service annotation in spring?**

* answer

### **What is the use of @Component annotation in spring?**

* answer

### **What is the use of @Repository annotation in spring?**

* answer

### **What is the difference between @Service and @Controller annotation?**

* answer

### **What is @ComponentScan?**

* answer

### **What is the use of @Autowired annotation?**

* answer

### **Write a REST API to accept user name as input, return the response with message as "Hello, user" and status as "success" and Endpoint - /api/message?**

* answer

### **How to handle Exceptions in Spring boot?**

* answer

### **How to provide security to spring boot applications?**

* answer

### **What is @ControllerAdvice in Spring boot?**

* answer

### **How to retrieve query parameters in Spring boot?**

* answer

### **How is the data persisted in DB with the REST API?**

* answer

### **Explain GET and POST methods?**

* answer

### **Write a SQL or JPQL to retrieve the data from DB?**

* answer

### **How will you add Employee object data in the DB using POST call?**

* answer

### **What is the size of Spring in your project? Who will decide that?**

* answer

### **Explain about spring security?**

* answer

### **Explain the flow of REST api?**

* answer

### **What will happen when we replace @Service instead of @Repository?**

* answer

### **Explain uses of SpringBoot application?**

* answer

### **How is https used in SpringBoot applications?**

* answer

### **Difference between RequestMapping and GetMapping?**

* answer

### **If you have to create a Spring boot application? What steps will you follow?**

* answer

### **What is a starter kit in spring boot application?**

* answer

### **What are the starters in Spring boot application?**

* answer

### **What are Actuators in spring boot applications?**

* answer

### **What are custom exceptions? How do you define your own custom exception?**

* answer

### **Have you worked on Unit testing? Which framework have you used in your project?**

* answer

### **What is the difference between lazy loading and eager loading?**

* answer

### **Difference between PUT and PATCH?**

* answer

### **Can we use @RequestMapping at class level and method level both?**

* Answer

### **What will happen if I use @RequestMapping at method level?**

* answer

### **How to map Service class to RestController?**

* answer

### **What is Spring security? Have you used Spring security in your project?**

* answer

### **What are Profiles in Spring boot?**

* answer

### **How will you do CRUD operations using spring boot applications?**

* answer

### **How to change from JAR to WAR in Spring boot?**

* answer

### **Where will you give database details in the spring boot application?**

* answer

### **How will you give database details for the individual environment?**

* answer

### **What is a JPA repository?**

* answer

### **What is the use of @SpringBootApplication annotation in Spring boot?**

* answer

### **How will the Spring boot application know whether its JAR or WAR type?**

* answer

### **How are you providing security to your services?**

* answer

### **As an end user how can I consume your services?**

* answer

### **How to validate a token?**

* answer

### **Explain a few security algorithms?**

* answer

### **What is native queries in Spring boot?**

* answer

### **Where do you use native queries?**

* answer

### **Suppose I am having different microservices, if I want to invoke different microservice so how can we interact?**

* answer

### **What kind of information are you passing to the GET method?**

* answer

### **Suppose I want to start a spring boot application, so what are all the steps?**

* answer

### **How to configure a custom server in a Spring boot application?**

* answer

### **How to configure multiple databases in a Spring boot application?**

* answer

### **How does your application know I am using a particular database?**

* answer

### **What is the use of @Qalifier annotation?**

* answer

### **How are REST calls intercepted in our project? How is the call happening?**

* answer

### **When I hit a URL how data will be invoked with your application?**

* answer

### **How is the DTO getting invoked with REST endpoints?**

* answer

### **I have a URL and I hit the URL, so which is the first class which is invoked in our product?**

* answer

### **If you have to expose a new endpoint, what steps will you follow?**

* answer

### **What is the difference between @Bean and @Configuration?**

* answer

### **What is the difference between RequestParam and path variable? Give me one example with one URL?**

* answer

### **How to change the port of the embedded tomcat server in Spring boot? Write a syntax for that?**

* answer

### **What are Profiles in Spring boot applications? Give one example?**

* answer

### **Which annotations are we using in order to use the Exception?**

* answer

### **What is the default scope for spring beans?**

* answer

### **Which database have you used? How do you integrate databases with JPA?**

* answer

### **How to communicate between two spring boot applications using asynchronous calls?**

* answer

### **Have you worked messaging services?**

* answer

### **How will you handle errors / exceptions in your project?**

* answer

### **What are Actuators?**

* answer

### **How are you keeping track of logs in your project?**

* answer

### **If you have millions of data then how will you manage it?**

* answer

### **What is the difference between REST API and Http?**

* answer

### **Explain @Autowired usage?**

* answer

### **How does the REST API work?**

* answer

### **How can we handle a yaml file when it is exposed?**

* answer

### **How to externalize variables in spring boot?**

* answer

### **What is the Spring reactive framework?**

* answer

### **Why should we use Spring reactive?**

* answer

### **What is the use of block and subscribe?**

* answer

### **What is a novel based server?**

* answer

### **How will the findById or findByName method in the repository work with name? When we go with camelcase then where is it implemented internally?**

* answer

### **How does the JPA Repository know there is a class?**

* answer

### **How does the Spring Boot application work internally?**

* answer

### **How will you authenticate API in Spring Boot?**

* answer

### **In the Spring REST API what is the White label error accessing from the browser? What is the status code you will get?**

* answer

### **What is Actuator in Spring Boot?**

* answer

### **Difference between @Entity, @Table, and @Id in JPA?**

* answer

### **How do you secure a Spring Boot application?**

* answer

### **How do you write unit tests in Spring Boot?**

* answer

### **What is @SpringBootTest used for?**

* answer

### **How do you configure multiple environments (dev, prod)?**

* answer

# Microservices

### **Monolith vs Microservices differences and when to choose which?**

**🧱 Monolithic Architecture**

**✅ What is it?**

A single unified application where all modules (UI, business logic, data access) are tightly coupled and deployed together.

**🔍 Characteristics:**

* Single codebase and deployment unit.
* All features share the same memory space and process.
* Easy to develop initially and suitable for small teams.

**🧩 Microservices Architecture**

**✅ What is it?**

An application is divided into a collection of small, loosely coupled services that communicate via APIs (usually REST or messaging systems like Kafka).

**🔍 Characteristics:**

* Each service is independently deployable.
* Each microservice has its own data store (DB per service pattern).
* Services can be written in different programming languages (polyglot).

**🆚 Monolith vs Microservices: Key Differences**

| **Feature** | **Monolithic** | **Microservices** |
| --- | --- | --- |
| Architecture | Single application unit | Distributed system with many services |
| Codebase | One large codebase | Multiple small codebases |
| Deployment | Deployed as a single unit | Each service deployed independently |
| Scalability | Vertical (scale the whole app) | Horizontal (scale individual services) |
| Development Speed | Faster initially | Slower initially, but scales well |
| Technology Stack | Same tech across the app | Each service can use a different stack |
| Testing | Easier end-to-end | Complex due to inter-service dependencies |
| Failure Impact | Entire app may go down | One service failure doesn’t necessarily affect others |
| Database | Shared DB | Decentralized DB per service |
| Communication | In-process calls | API or messaging-based communication |

**📌 When to Choose Monolithic:**

**✅ Go for Monolith when:**

* The team is small (startups, MVPs).
* The application is simple and won’t grow much.
* Quick development and deployment is required.
* You’re in the prototyping or early stage.

**🚀 When to Choose Microservices:**

**✅ Go for Microservices when:**

* Application is large, complex, and will grow over time.
* Different parts of the system need to scale independently.
* You have multiple teams working in parallel.
* You need high availability, fault tolerance, and agility.
* You want flexibility in tech stacks or deployment pipelines.

🛠 **Example Use Case:**

**Monolith:** Blogging platform, early-stage ERP, internal admin tools.

**Microservices:** E-commerce platforms, fintech apps, enterprise SaaS, streaming platforms.

### **How to design a microservice from scratch?**

* Designing a microservice from scratch requires a thoughtful approach that involves domain modeling, technology selection, infrastructure setup, and ensuring principles like loose coupling, scalability, and independent deployment.

🧠 **Step-by-Step: Designing a Microservice from Scratch**

**1️ Understand the Business Requirement**

* Clarify the problem the microservice needs to solve.
* Identify the boundaries of the service (Single Responsibility Principle).
* Use DDD (Domain-Driven Design) to define aggregates and entities.

**2️ Define the Microservice Scope**

**Ask:**

* What is this microservice responsible for?
* What data does it own?
* What other services does it need to communicate with?

📌 **Example:** For an E-commerce app, microservices could be:

* Product Service
* Order Service
* Payment Service
* Inventory Service

**3️ Choose Tech Stack**

**Depending on your ecosystem:**

✅ Common choices:

* **Language:** Java (Spring Boot), Node.js, Go, Python
* **Database:** PostgreSQL, MongoDB, Redis (each service should manage its own DB)
* **Communication:** REST APIs, gRPC, Kafka, RabbitMQ

**4️ Define the API Contract**

Use OpenAPI/Swagger to define:

* Endpoints
* HTTP Methods
* Input/Output models
* Status codes

**Example:**

* POST /orders
* GET /orders/{id}

**5️ Design the Database (DB per service pattern)**

Each microservice should own its own data.

**Example (Order Service DB):**

Order(id, userId, productId, status, createdDate)

Use Liquibase or Flyway for DB migrations.

**6️ Build the Microservice (Spring Boot Example)**

**✅ Common Layers:**

* Controller – REST endpoints
* Service – Business logic
* Repository – DB access (JPA)
* DTOs – For input/output models
* Exception Handling – Custom exceptions + Global handler

**7️ Inter-Service Communication**

* Synchronous: REST, gRPC
* Asynchronous: Kafka, RabbitMQ (for decoupled event-driven designs)

Example: Order Service publishes an event to Kafka after order is placed.

**8️ Add Cross-Cutting Concerns**

* Logging – SLF4J, Logback
* Monitoring – Prometheus + Grafana
* Tracing – OpenTelemetry, Zipkin
* Security – OAuth2/JWT (Spring Security)

**9️ Write Tests**

* Unit tests for services and utils
* Integration tests for REST endpoints
* Use tools like JUnit, Mockito, Testcontainers

**10 Containerize with Docker**

FROM openjdk:21

COPY target/order-service.jar app.jar

ENTRYPOINT ["java", "-jar", "app.jar"]

🔁 **Deploy to Kubernetes (Optional)**

* Create Deployment, Service, and Ingress YAMLs
* Use Helm for templating

🚧 **Best Practices**

* Follow 12-factor app principles
* Avoid shared databases
* Automate build & deploy via CI/CD (GitHub Actions, Jenkins, etc.)
* Use API Gateway (like Spring Cloud Gateway) for routing/authentication
* Apply circuit breakers, retry, and rate limiting

### **API Gateway pattern and its advantages?**

**🧰 API Gateway Pattern**

An API Gateway is a server that acts as a single entry point for all client requests to a system of microservices. It routes requests, handles common functionalities (like authentication, rate limiting, logging), and often aggregates responses from multiple services.

**📌 Why Use an API Gateway?**

In a microservices architecture, clients would otherwise need to:

* Know the locations of multiple services
* Handle different protocols
* Make multiple calls for a single operation

➡️ This leads to complexity, tight coupling, and redundancy.

The API Gateway pattern solves this by centralizing access control and request routing.

**🗂 Common Responsibilities of API Gateway**

| **Responsibility** | **Description** |
| --- | --- |
| Request Routing | Forwards requests to the appropriate backend microservice |
| Authentication & AuthZ | Validates JWT tokens, API keys, OAuth2 credentials |
| Rate Limiting & Throttling | Controls traffic to prevent abuse or DDoS attacks |
| Load Balancing | Distributes load across multiple instances |
| Request/Response Transformation | Modifies headers, URL paths, or payloads |
| Caching | Reduces backend load by returning cached responses |
| Logging and Monitoring | Logs all incoming/outgoing traffic for auditing and monitoring |
| Response Aggregation | Combines results from multiple services into one response |
| Protocol Translation | Converts protocols (e.g., HTTP to WebSocket, gRPC, etc.) |

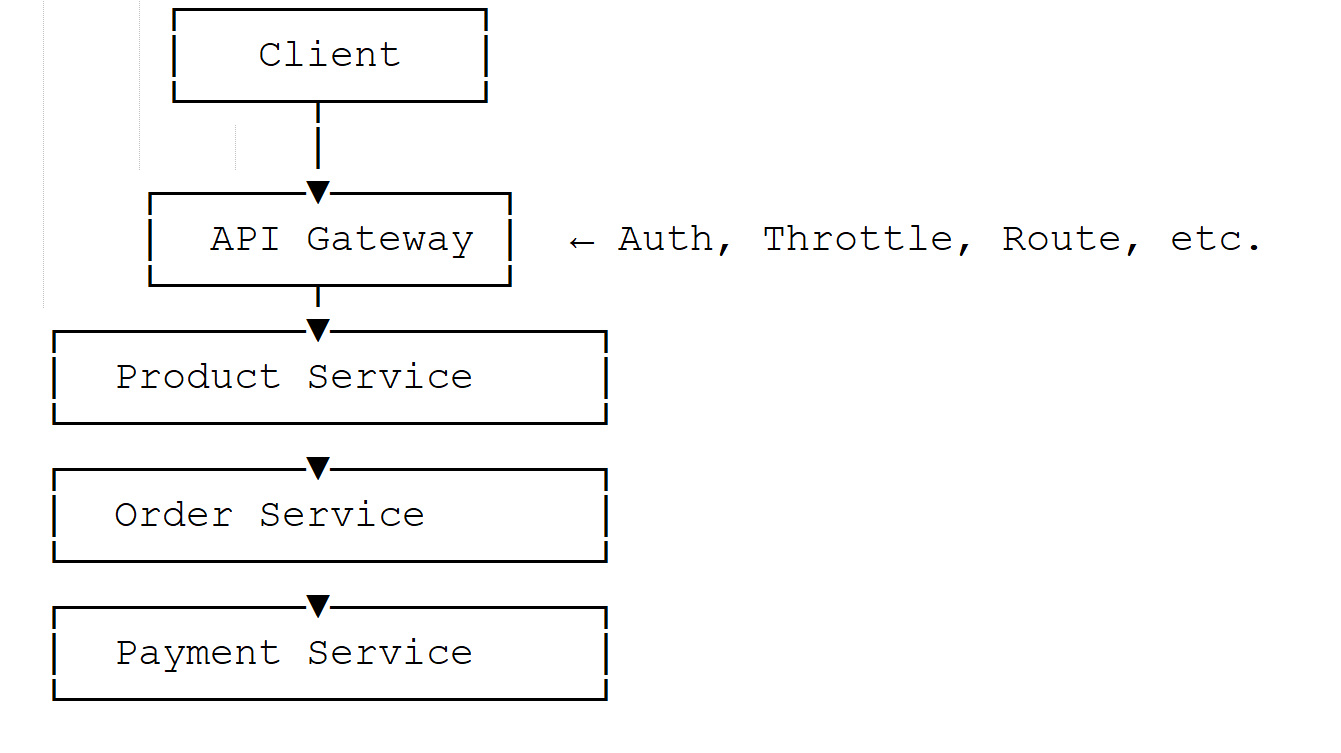
**✅ Advantages of API Gateway Pattern**

| **Advantage** | **Explanation** |
| --- | --- |
| ✅ Centralized Access Point | Clients interact with one endpoint instead of many microservices |
| ✅ Simplifies Client Logic | API Gateway hides microservice topology and protocols |
| ✅ Improved Security | All requests go through a secure, audited, and controlled gateway |
| ✅ Scalability | Can scale API Gateway independently of the backend services |
| ✅ Performance Optimization | Through caching, compression, and rate-limiting |
| ✅ Flexible Routing | Can perform routing based on request data like headers, path, or payload |
| ✅ Decoupling | Helps decouple frontend clients from backend service implementations |

🛠️ **Popular API Gateway Tools**

| **Tool/Framework** | **Description** |
| --- | --- |
| Spring Cloud Gateway | Java-based, for Spring Boot microservices |
| Netflix Zuul (legacy) | Older gateway, succeeded by Spring Cloud Gateway |
| Kong | Open-source, Lua-based, highly extensible |
| NGINX | Widely used, highly performant |
| AWS API Gateway | Managed gateway service for AWS environments |
| Apigee | Google Cloud’s enterprise API management |
| Istio Ingress Gateway | Used with service mesh architecture |

🧱 **Example Architecture with API Gateway**



### **Inter-service communication: REST vs Messaging?**

**🔁 Inter-Service Communication: REST vs Messaging**

**🟦 REST (Synchronous Communication)**

REST uses HTTP protocols (usually over JSON) for communication between microservices.

**✅ Pros:**

* Simple and widely adopted
* Easy to debug and test (Postman, curl)
* Works well when immediate response is needed (e.g., GET /orders/1)

**❌ Cons:**

* Tightly coupled: if Service B is down, Service A fails
* Increased latency with chained service calls
* Harder to scale under heavy load

**🟨 Messaging (Asynchronous Communication)**

Uses message brokers (like Kafka, RabbitMQ, ActiveMQ) to send/receive messages between services.

**✅ Pros:**

* Loose coupling: services don’t need to know each other’s availability
* High scalability and throughput
* Great for event-driven architecture (e.g., “OrderPlaced” event)

**❌ Cons:**

* More complex to set up and monitor
* Eventual consistency (response is not immediate)
* Harder to trace/debug (needs distributed tracing)

🆚 **REST vs Messaging: Comparison Table**

| **Feature** | **REST (HTTP)** | **Messaging (Kafka, RabbitMQ)** |
| --- | --- | --- |
| Communication Type | Synchronous | Asynchronous |
| Coupling | Tight | Loose |
| Availability Dependency | Service must be up | Sender and receiver can be decoupled |
| Data Consistency | Strong consistency | Eventual consistency |
| Reliability | Less reliable (network failure) | More reliable (can retry, durable) |
| Scalability | Limited by sync calls | Highly scalable |
| Latency | Low (if successful) | Can be delayed |
| Error Handling | Needs retries or fallbacks | Built-in retry, dead-letter queues |
| Use Case | Real-time requests/responses | Background jobs, event notification |

**📦 When to Use What?**

**✅ Use REST when:**

* Real-time response is required (e.g., Login, Search)
* Simpler integration with frontends
* Request/response fits a client-server pattern

**✅ Use Messaging when:**

* You want decoupled, event-driven architecture
* Operations can be processed asynchronously (e.g., Order confirmation, Email sending)
* High volume of traffic or batching is expected

**🎯 Hybrid Approach (Best Practice)**

* Most production-grade microservice systems use both:
* Use REST for synchronous, real-time operations
* Use messaging/event streams for decoupled, asynchronous workflows

**⚙️ Example:**

Order Service:

* REST: POST /order → creates order
* Event: publishes OrderCreated to Kafka

Inventory Service:

* Listens to OrderCreated → updates stock

Notification Service:

* Listens to OrderCreated → sends email/SMS

### **Circuit Breaker pattern and its implementation using Resilience4j?**

**🧯 Circuit Breaker Pattern in Microservices**

The Circuit Breaker pattern is a resilience design pattern used to prevent a system from making repeated calls to a failing service, thereby avoiding system overload and allowing time for recovery.

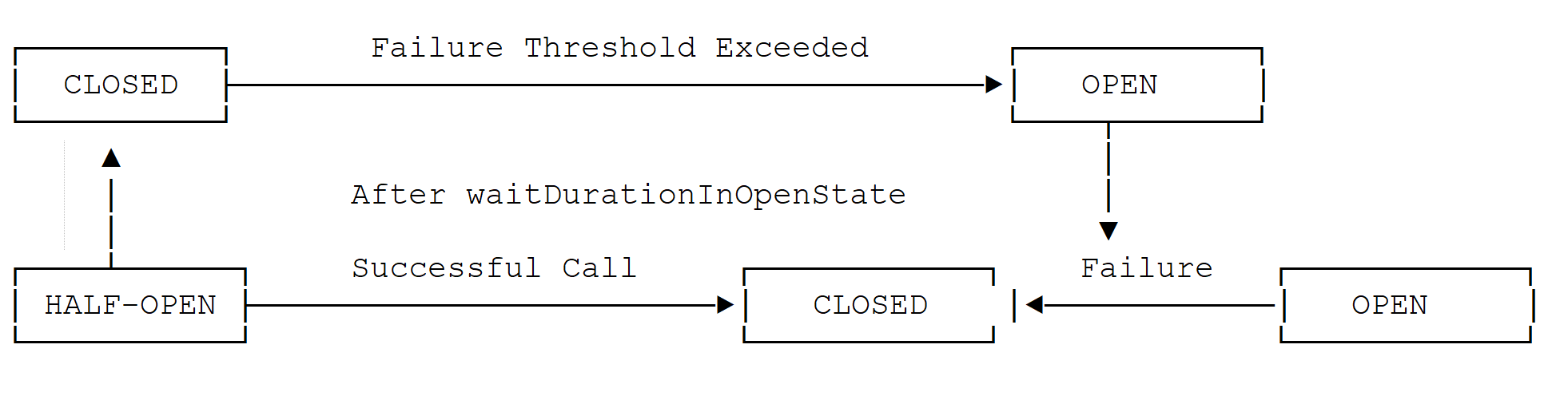
**🧠 Why Circuit Breaker?**

Imagine Service A calls Service B. If B is down or slow, A will keep waiting and retrying, leading to:

* High latency
* Resource exhaustion
* Cascading failures

➡️ Circuit Breaker helps by "breaking" the connection temporarily after a failure threshold is reached.

**🔁 Circuit Breaker States**



**⚙️ Resilience4j Implementation in Spring Boot**

Resilience4j is a lightweight fault tolerance library designed for Java 8+ and functional programming.

✅ Features:

* Circuit Breaker
* Rate Limiter
* Retry
* Bulkhead
* Time Limiter
* Cache

🚀 **Step-by-Step: Circuit Breaker using Resilience4j**

**1️ Add Dependency (Gradle)**

implementation 'io.github.resilience4j:resilience4j-spring-boot3:2.1.0'

implementation 'org.springframework.boot:spring-boot-starter-aop'

***For Maven:***

<dependency>

<groupId>io.github.resilience4j</groupId>

<artifactId>resilience4j-spring-boot3</artifactId>

<version>2.1.0</version>

</dependency>

**2️⃣ Sample Service Layer with Circuit Breaker**

@Service

public class ProductService {

@CircuitBreaker(name = "productServiceCB", fallbackMethod = "fallbackGetProducts")

public List<String> getProducts() {

// Simulate failure or call external service

if (new Random().nextInt(10) < 8) {

throw new RuntimeException("Service is down!");

}

return List.of("Laptop", "Phone", "Tablet");

}

// Fallback method must have same signature + Throwable parameter

public List<String> fallbackGetProducts(Throwable ex) {

return List.of("Fallback Product 1", "Fallback Product 2");

}

}

**3️ Application Properties**

resilience4j.circuitbreaker.instances.productServiceCB:

slidingWindowSize: 5

minimumNumberOfCalls: 3

failureRateThreshold: 50

waitDurationInOpenState: 10s

permittedNumberOfCallsInHalfOpenState: 2

automaticTransitionFromOpenToHalfOpenEnabled: true

**4️ Controller Layer**

@RestController

@RequestMapping("/api/products")

public class ProductController {

@Autowired

private ProductService productService;

@GetMapping

public ResponseEntity<List<String>> getProducts() {

return ResponseEntity.ok(productService.getProducts());

}

}

📊 **Monitoring with Spring Actuator + Resilience4j Dashboard (Optional)**

**Add these to monitor circuit breaker metrics:**

implementation 'org.springframework.boot:spring-boot-starter-actuator'

implementation 'io.github.resilience4j:resilience4j-micrometer'

implementation 'io.micrometer:micrometer-registry-prometheus'

Then you can expose endpoints like /actuator/metrics/resilience4j.circuitbreaker.calls.

✅ **Advantages of Circuit Breaker Pattern**

| **Benefit** | **Description** |
| --- | --- |
| 🔒 Prevents overload | Stops calling a failed service until it recovers |
| ⚡ Improves response time | Returns fallback immediately instead of waiting |
| 🔁 Enables graceful degradation | Users get default or cached response |
| 📊 Helps monitoring | Tracks failure rates and transition states |

### **Load balancing in microservices using Spring Cloud Load Balancer?**

🚀 **What is Load Balancing in Microservices?**

When you have multiple instances of a microservice running (for fault tolerance, scalability, etc.), load balancing ensures that requests are evenly distributed among those instances.

**⚙️ Spring Cloud LoadBalancer**

Spring Cloud LoadBalancer is a lightweight, client-side load balancer that replaces Netflix Ribbon (now deprecated). It allows you to call microservices via service names instead of hardcoded URLs.

**🔧 Setup and Usage**

**1. Add Dependencies**

In your Spring Boot app, include:

// build.gradle

implementation 'org.springframework.cloud:spring-cloud-starter-loadbalancer'

Also make sure you have service discovery (e.g., Eureka):

implementation 'org.springframework.cloud:spring-cloud-starter-netflix-eureka-client'

**2. Enable Discovery Client**

@SpringBootApplication

@EnableDiscoveryClient

public class MyApp {

public static void main(String[] args) {

SpringApplication.run(MyApp.class, args);

}

}

**3. Inject LoadBalanced RestTemplate**

@Configuration

public class AppConfig {

@Bean

@LoadBalanced

public RestTemplate restTemplate() {

return new RestTemplate();

}

}

**4. Call Another Microservice**

@RestController

public class MyController {

@Autowired

private RestTemplate restTemplate;

@GetMapping("/get-data")

public String getData() {

String response = restTemplate.getForObject("http://user-service/users", String.class);

return response;

}

}

✅ user-service is the service name registered in Eureka, and Spring Cloud LoadBalancer will resolve its IPs and apply a round-robin strategy.

**⚖️ Supported Load Balancing Strategies**

You can customize the strategy:

spring:

cloud:

loadbalancer:

ribbon:

enabled: false

loadbalancer:

hint:

user-service: round-robin

Or use Java-based configuration with your own strategy (e.g., weighted, random, zone-aware).

**🔄 Alternatives to RestTemplate**

**WebClient (recommended in reactive apps):**

@Bean

@LoadBalanced

public WebClient.Builder webClientBuilder() {

return WebClient.builder();

}

**🧠 Behind the Scenes**

* @LoadBalanced tells Spring to intercept HTTP calls and resolve service names to real IPs.
* It communicates with Eureka to get service instance details.
* It uses round-robin as default load balancing.

**✅ Benefits:**

* Automatic client-side load balancing
* No hardcoded URLs
* Integrates with Eureka, Consul, etc.
* Easy to extend and customize

🛡️ **Summary**

| **Feature** | **Spring Cloud LoadBalancer** |
| --- | --- |
| Type | Client-side |
| Default Strategy | Round-Robin |
| Service Discovery | Required (e.g., Eureka) |
| Replacement for | Netflix Ribbon |
| Works with | RestTemplate, WebClient |

### **How Spring Cloud Config helps in centralized configuration management?**

📦 **What is Spring Cloud Config?**

Spring Cloud Config is a part of the Spring Cloud ecosystem that provides server-side and client-side support for externalized configuration in a distributed system.

**🔑 Core Idea:**

Keep all your configuration files (application.yml/properties) for different microservices in one centralized Git repository, and let microservices fetch their configs from there.

**💡 Why Centralized Configuration?**

**Without centralized config:**

* Each microservice maintains its own config
* Difficult to manage multiple environments (dev, test, prod)
* Changes require service restarts or redeployments

**With centralized config:**

* Easier updates
* Environment separation
* Consistent versioning
* Reloadable configs

**🧩 Components of Spring Cloud Config**

**1. Config Server**

Hosts the configuration files centrally.

**2. Config Client**

Each microservice acts as a client and fetches config from the config server.

**🔧 How to Set It Up**

**🔹 Step 1: Create a Git Repo**

Structure:

my-config-repo/

├── application.yml

├── user-service-dev.yml

├── order-service-prod.yml

**🔹 Step 2: Create a Spring Cloud Config Server**

@SpringBootApplication

@EnableConfigServer

public class ConfigServerApp {

public static void main(String[] args) {

SpringApplication.run(ConfigServerApp.class, args);

}

}

**application.yml:**

server:

port: 8888

spring:

cloud:

config:

server:

git:

uri: https://github.com/my-org/my-config-repo

**🔹 Step 3: Configure Microservices (Config Clients)**

**Add dependency:**

implementation 'org.springframework.cloud:spring-cloud-starter-config'

**Client bootstrap.yml:**

spring:

application:

name: user-service

cloud:

config:

uri: http://localhost:8888

profile: dev

**🔁 Refresh Config at Runtime**

**Add this to your microservice:**

implementation 'org.springframework.boot:spring-boot-starter-actuator'

**Enable refresh:**

@RefreshScope

@RestController

public class SomeController {

@Value("${custom.property}")

private String value;

}

**Call:**

POST http://localhost:{port}/actuator/refresh

✅ **Benefits of Spring Cloud Config**

| **Feature** | **Benefit** |
| --- | --- |
| 🔄 Centralized Config | One place to manage all properties |
| 🌐 Git-based Versioning | Rollbacks & audits made easy |
| 🔁 Dynamic Refreshing | No restarts needed (with @RefreshScope) |
| 🏗️ Environment Specific Config | Supports dev, test, prod environments |
| 🧩 Integrates with Eureka etc. | Works seamlessly with other Spring Cloud modules |

**🔐 Advanced Features**

* Support for Vault for secrets
* Can pull config from file system, Git, SVN
* Can be secured with OAuth2 or JWT
* Works well with Spring Boot Admin and Actuator

**🔚 Conclusion**

Spring Cloud Config helps you centralize and manage configurations across all microservices — making your system more flexible, maintainable, and environment-aware. 💼📁

### **Service discovery using Eureka or Consul?**

* answer

### **Feign Client vs WebClient: Which one to use and why?**

* answer

### **Event-driven architecture and Kafka integration?**

* answer

### **Database per service vs Shared Database: Pros and cons?**

* answer

### **Saga Pattern for distributed transactions in microservices?**

* answer

### **JWT-based authentication and OAuth2 in microservices?**

* answer

### **How to handle security in an API Gateway?**

* answer

### **Observability: Logging, tracing, and monitoring best practices?**

* answer

### **Role of Prometheus and Grafana in microservices monitoring?**

* answer

### **Kubernetes deployment strategies for microservices?**

* answer

### **Blue-Green and Canary deployments in microservices?**

* answer

### **When to use WebFlux for reactive microservices?**

* answer

### **CQRS and Event Sourcing: When and why to use them?**

* Answer

### **Difference between Monolithic and Microservice architecture?**

* answer

### **Explain Microservices architecture?**

* answer

### **Where are you deploying your microservice?**

* answer

### **What are different Aggregation patterns in Microservices?**

* answer

### **What are challenges in Microservice architecture?**

* answer

### **How are you handling load in your microservices?**

* answer

### **How will you handle resilience and fault tolerance in microservice?**

* answer

### **Can you explain Event driven microservice and how you have used it in your project?**

* answer

# SQL

### **Difference between Primary Key and Unique key?**

* Answer

### **What is ordered by and range in the database?**

* Answer

### **Write a SQL query to get the second highest salary of an employee from the employee table?**

* Answer

### **Write a SQL query to print employee id, employee\_name, depatment\_name Employee - employee\_id, employee\_name, department\_id**

### **Department - department\_id, department\_name?**

* Answer

### **SQL query to find department name and number of employees in that department?**

* Answer

**SELECT** d.department\_name, **COUNT**(e.employee\_id) **AS** employee\_count  
**FROM** employees e  
**JOIN** departments d **ON** e.department\_id = d.department\_id  
**GROUP BY** d.department\_name;

### **What is a collision in the oracle database?**

* Answer

### **If you create multiple folders one inside another and store one file into the last folder then how can you implement using database tables in oracle? How many tables are required?**

* answer

### **What are DDL and DML commands?**

* Answer

### **Write a query to update data in the table?**

* Answer

### **What is the use of joins in the database?**

* Answer

### **Explain ACID properties in the database?**

* Answer

### **Explain Normalization?**

* Answer

### **What are the types of Normalization?**

* Answer

### **What is Denormalization?**

* Answer

### **What is the use of join?**

* Answer

### **Write a SQL query to return the 7th highest salary of an employee?**

* Answer

### **What is Union in SQL?**

* Answer

### **Can we perform union operations on one table?**

* Answer

### **Difference between where and let?**

* Answer

### **What is Semaphore?**

* Answer

### **What is View and Index in SQL?**

* Answer

### **What is Trigger in SQL? What is the use of Trigger in SQL?**

* Answer

### **What is inner join in SQL?**

* Answer

### **Write a SQL query to get emp\_sal > 5000 and company\_name = "Kotak"**

Table :

1. Company

- company\_id

- company\_name

2. Employee

- emp\_id

- company\_id

- emp\_name

- emp\_sal?

* Answer

Select e.emp\_sal, c.company\_name

From Employee e

join Company c

On c.company\_id = e.company\_id

Where e.emp\_sal > 5000 and c.company\_name = "Kotak";

### **Write a JPA query to retrieve the above result?**

* answer

### **What is an index in SQL?**

* answer

### **Explain different types of Index?**

* answer

### **Explain different types of joins?**

* answer

### **Difference between Outer join and Full outer join?**

* answer

### **Write a SQL query to find the name of a city which has more than one customer in it?**

Example: Customer

Customer\_name

Customer\_city?

* answer

### **Write SQL query to display 10th highest salary of employee?**

* answer

### **What is the difference between DDL and DML commands?**

* answer

### **Difference between Inner join and Outer join?**

* answer

### **Difference between left outer join and right outer join?**

* answer

### **What are Triggers?**

* answer

### **SQL query to get the youngest employee from the employee table?**

* answer

### **SQL query to get list of employees from Finance department?**

* answer

### **What is Indexing in SQL?**

* answer

### **What are the disadvantages of Index?**

* answer

### **What is the difference between primary key and unique key?**

* answer

### **What is the difference between implicit cursor and explicit cursor?**

* answer

### **What is a correlated subquery?**

* answer

### **What is the left outer join?**

* answer

### **What is the use of stored procedure?**

* answer

### **Explain the database schema for Students and Course table?**

* answer

### **What is UNION ALL?**

* answer

### **SQL query to get second highest salary?**

* answer

### **Write a SQL query to display a list of students which have a Mathematics subject?**

Input - Student

student\_id

student\_name

Subject\_id

Subject

subject\_id

Subject\_name

Where subject=Mathematics?

* answer

### **What is Normalization?**

* answer

### **Can you explain different forms of Normalization with one example?**

* answer

### **What kind of fetching strategy are you using in hibernate?**

* answer

### **What is OneToMany mapping?**

* answer

### **Write a SQL query to get the 3rd highest salary of an employee?**

* answer

### **What is dense and rank in SQL?**

* answer

### **What is the difference between SQL and NoSQL?**

* answer

### **Difference between Stored Procedure and Function?**

* answer

### **What is Transaction in SQL?**

* answer

### **Write a SQL query:**

Consider 2 tables, find out 3 employees who are earning the highest salary in each department?

Employees

employee\_id (primary key)

first\_name

last\_name

department\_id (foreign key to departments.id)

salary

Hire\_date

Departments

id (primary key)

department\_name?

* answer

### **SQL query that categorizes employees based on their salary into different percentage ranges.**

emp

id Name Salary

1 A 10

2 B 100

3 C 4

4 D 60

5 E 70

6 F 40

---------------------

id name sal Percentage

2 B 100 greater than 90

5 E 70 greater than 50

4 D 60 greater than 50

1 A 40 less than 50

3 C 10 less than 10

6 F 5 less than 10

--4 cate--

greater than 90

greater than 50

less than 50

less than 10?

* answer

### **Write a SQL query to find the department name who does not have an employee? (Employee and Department table given)?**

* answer

### **What is the difference between Primary Key and Unique Key?**

* answer

### **What is the Composite key?**

* answer

### **What is Self join?**

* answer

### **We have Table A (2 columns and 4 rows) and Table B (2 columns and 4 rows) and I want to print all 8 rows? Write a query for it? (Use Union All)?**

* answer

### **What is the difference between SQL Union and Union All?**

* answer

### **Write a SQL query and print the employee name which does not have any department?**

* answer

### **Write a query - Employee table and add one extra column in output as category? Let's say if salary is in 1 to 4000 then Category 1, 4000 - 7000 then category 2, 7000 - 10000 then category 3?**

* answer

# Kafka

### **What is Apache Kafka?**

* **Apache Kafka** is a **distributed event streaming platform** used for building **real-time data pipelines** and **streaming applications**. It can handle **high throughput** of data with **low latency** in a **scalable**, **durable**, and **fault-tolerant** way.

**✅ Key Concepts:**

| **Component** | **Description** |
| --- | --- |
| **Producer** | Sends (publishes) messages to Kafka topics |
| **Consumer** | Reads messages from Kafka topics |
| **Topic** | A category/feed name to which messages are sent and from which they're received |
| **Broker** | A Kafka server that stores data and serves clients |
| **Cluster** | A group of brokers working together |
| **Zookeeper** | Used for managing Kafka metadata (Note: Kafka 3.x+ is moving towards removing Zookeeper) |
| **Partition** | Topics are split into partitions for scalability |
| **Offset** | Unique ID for each message within a partition |

**🔄 Kafka Workflow:**

1. **Producer** sends messages to a **Topic**.
2. Topic is split into **Partitions** (for parallelism).
3. **Brokers** store partitioned messages.
4. **Consumers** read messages using **Offsets**.
5. **Zookeeper** (older versions) manages coordination.

**🧠 Why Use Kafka?**

* 🔄 **Real-time data streaming**
* 💥 **High throughput & low latency**
* 🧱 **Scalable** and **distributed**
* 💾 **Durable and fault-tolerant**
* 📊 Use cases: Logging, metrics, IoT, financial systems, chat systems, etc.

**🔧 Common Use Cases:**

* **Log Aggregation**
* **Real-Time Analytics**
* **Microservices Communication**
* **Event Sourcing / CQRS**
* **Stream Processing** (with Kafka Streams or Apache Flink)

### **Why does Kafka compare to RabbitMQ?**

**✅ Apache Kafka vs RabbitMQ**

| **Feature** | **Apache Kafka** | **RabbitMQ** |
| --- | --- | --- |
| **Type** | Distributed **event streaming platform** | Traditional **message broker / message queue** |
| **Message Model** | **Pull-based** (Consumers pull data) | **Push-based** (Broker pushes to consumers) |
| **Performance** | High **throughput**, designed for big data | Low **latency**, better for low-volume, fast delivery |
| **Durability** | Messages stored on disk with replication | Messages stored in memory or disk (optional) |
| **Ordering** | Guaranteed within a partition | Ordering is not guaranteed unless specifically handled |
| **Replay capability** | ✅ Yes – Consumers can **re-read** from any offset | ❌ No – Once consumed, message is gone unless persisted manually |
| **Retention** | Time-based/log-based retention | Messages removed after acknowledged |
| **Routing** | Simple pub-sub with partitioning | Rich routing with exchanges (direct, fanout, topic) |
| **Use case fit** | Real-time analytics, data pipelines, logs, IoT | Task queues, short-lived jobs, transactional systems |
| **Latency** | Millisecond-level (higher than RabbitMQ) | Very low (suitable for real-time communication) |
| **Complexity** | Requires more setup (brokers, zookeeper or quorum) | Easier to set up |
| **Consumer Scaling** | Partition-based parallelism | Competing consumers for queues |
| **Maturity** | Designed by LinkedIn, optimized for throughput | Mature AMQP implementation, widely adopted |

**🔍 Which to Choose?**

**👉 Choose Kafka if:**

* You need **high throughput**, **distributed data streaming**
* You want **message replay**, **fault-tolerance**, **event sourcing**
* You're working with **big data**, **microservices**, **IoT**

**👉 Choose RabbitMQ if:**

* You need **low latency**, quick and reliable **message delivery**
* You have **complex routing requirements** or need **prioritized queues**
* You're handling **task queues**, **background jobs**, or **RPC-like** systems

**💡 Real-World Examples:**

| **Scenario** | **Recommendation** |
| --- | --- |
| Logging platform / Metrics | Kafka |
| Chat application / Notification system | RabbitMQ |
| ETL Pipelines / Real-time dashboards | Kafka |
| Email sending service / Order processing | RabbitMQ |

### **Explain the key components of Kafka (Producer, Consumer, Broker, Topic, Partition, and Consumer Group) and how they interact in a Kafka-based system?**

**1. Producer**

* **Definition**: A **producer** is an application that sends messages (or records) to a Kafka topic. Producers write data into Kafka topics. Each record consists of a key, a value, and optional metadata like headers.
* **Role**: The producer is responsible for creating and sending messages to Kafka brokers. It pushes records to topics, and it can decide which partition to write the record to, either based on a partition key or using Kafka’s default partitioning mechanism.
* **Producer Responsibilities**:
  + Decides the topic and partition where the message should be sent.
  + Ensures message reliability via configurations like acks (acknowledgments).
  + Handles backpressure by buffering records when necessary.

**How it interacts with other components**:

* The producer sends records to a **Kafka broker**.
* Kafka brokers then store the records in the corresponding **partition** within the topic.

**2. Consumer**

* **Definition**: A **consumer** is an application that reads messages (or records) from Kafka topics.
* **Role**: Consumers subscribe to one or more Kafka topics and read messages from them. Consumers can read messages in a **pull** model, meaning they request messages from a broker.
* **Consumer Responsibilities**:
  + Pulls records from Kafka brokers.
  + Keeps track of the offset (i.e., position) of the messages that it has processed.

**How it interacts with other components**:

* Consumers read messages from **partitions** in a **topic**. Each consumer can read from one or more partitions.
* Consumers belong to a **consumer group** for load balancing and fault tolerance.

**3. Broker**

* **Definition**: A **broker** is a Kafka server that stores and serves Kafka topics. A Kafka cluster consists of one or more brokers.
* **Role**: The broker is responsible for storing data and managing the consumers' requests for reading and writing messages. It is the core component of Kafka's architecture.
* **Broker Responsibilities**:
  + Manages message storage for each partition of each topic.
  + Handles requests from producers and consumers.
  + Ensures message replication to provide fault tolerance.
  + Tracks consumer offsets and handles failover scenarios.

**How it interacts with other components**:

* Brokers store messages for each partition in a topic.
* They serve both **producers** (by receiving messages) and **consumers** (by serving messages).
* Brokers communicate with other brokers to ensure data replication (across multiple brokers in the cluster).

**4. Topic**

* **Definition**: A **topic** is a logical channel to which messages are published by producers and consumed by consumers. Kafka topics are the primary unit of message organization and serve as the "category" of messages.
* **Role**: A topic holds records/messages in the form of logs, and each message is written to a partition within a topic.
* **Topic Responsibilities**:
  + Organizes and categorizes messages.
  + Supports multiple partitions for parallelism and scalability.

**How it interacts with other components**:

* A **producer** sends messages to a specific **topic**.
* A **consumer** subscribes to one or more **topics** to receive messages.

**5. Partition**

* **Definition**: A **partition** is a unit of parallelism in Kafka. A topic is split into multiple partitions to allow Kafka to scale and enable multiple consumers to read the data in parallel. Each partition is an ordered, immutable sequence of records.
* **Role**: Partitions allow Kafka to distribute data across multiple brokers and handle high throughput. Each partition can be independently read by different consumers.
* **Partition Responsibilities**:
  + Holds messages ordered by offset.
  + Partitions allow parallel data processing and balancing load between brokers and consumers.
  + Each partition can be replicated to provide fault tolerance.

**How it interacts with other components**:

* A **producer** sends messages to a specific **partition** within a **topic**.
* **Consumers** read messages from specific **partitions** within a **topic**.
* Partitions are replicated across multiple **brokers** for high availability.

**6. Consumer Group**

* **Definition**: A **consumer group** is a group of consumers that work together to consume messages from a Kafka topic. Each consumer in a group is assigned one or more partitions, and each message is consumed by only one consumer in the group.
* **Role**: The main role of consumer groups is to allow multiple consumers to share the load of reading messages from Kafka topics while ensuring that each message is processed only once by the group. This enables parallel message processing while maintaining message ordering within a partition.
* **Consumer Group Responsibilities**:
  + Distributes the load of consuming messages among multiple consumers.
  + Ensures that each message in a partition is processed only once (no duplication).
  + Allows for horizontal scaling (more consumers) in the processing pipeline.

**How it interacts with other components**:

* **Consumers** join a **consumer group** and subscribe to a **topic**.
* Kafka assigns **partitions** to consumers in the group, and each consumer reads messages from a specific partition of the topic.
* **Offsets** are managed per consumer group to track consumption progress.

**How They All Interact in a Kafka-Based System**

* **Producers** send messages to a **Kafka broker**, which stores them in **partitions** of a **topic**.
* The **Kafka broker** is responsible for managing message storage and serving **consumers** who request messages.
* **Consumers** subscribe to one or more **topics** and consume messages from the partitions. They are usually part of a **consumer group** for distributed processing.
* **Consumer groups** ensure that messages from each partition are read by only one consumer within the group, providing load balancing and fault tolerance.
* Kafka’s architecture allows horizontal scaling: More **producers** can send messages, more **consumers** can read messages, and more **brokers** can handle the load.

**Example Flow:**

1. **Producer** sends a message to the Kafka broker for **Topic A**.
2. The Kafka broker writes the message to **Partition 0** of **Topic A**.
3. A **consumer group** with two consumers, **Consumer 1** and **Consumer 2**, subscribes to **Topic A**.
4. **Consumer 1** reads messages from **Partition 0** of **Topic A**.
5. **Consumer 2** can either consume messages from another partition of **Topic A** or from the same partition if there's more than one partition.

Kafka's architecture ensures **scalability**, **fault tolerance**, and **parallelism** by leveraging producers, brokers, topics, partitions, and consumer groups effectively.

This interaction ensures Kafka's power as a highly scalable and fault-tolerant distributed event streaming platform used in many real-time data processing and event-driven architectures.

### **How to scale up Kafka?**

* Scaling **Apache Kafka** efficiently is crucial when handling high throughput, large amounts of data, and ensuring high availability. Kafka provides several strategies to scale, both horizontally and vertically, based on your use case and infrastructure requirements.

**Scaling Kafka: Key Strategies**

1. **Scale Kafka Brokers Horizontally (Increase Brokers)**
   * **Add more brokers** to the Kafka cluster to distribute the load and improve availability.
   * Kafka uses **partitioning** to distribute data across brokers, so adding more brokers helps distribute the data more evenly.
   * Brokers also replicate data, so adding more brokers ensures better fault tolerance and data redundancy.

**Steps:**

* + Add new brokers to the cluster.
  + Update **server.properties** for each new broker (e.g., broker.id, listeners, log.dirs).
  + Rebalance partitions (distribute data evenly across brokers) using the Kafka partition reassignment tool.

1. **Increase Partitions for Topics**
   * Kafka scales by dividing data into **partitions**, which can be distributed across multiple brokers.
   * Increasing the number of partitions allows for better parallelism and higher throughput.
   * Each partition is handled by a single broker, and more partitions mean more consumers can read in parallel, thus improving scalability.

**Steps:**

* + Increase the partition count for a specific topic using the kafka-topics command (Note: this can only increase the number of partitions, not decrease).

bash

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kafka-topics.sh --alter --topic <topic-name> --partitions <new-partition-count> --bootstrap-server <broker>

* + You can monitor the partition distribution across brokers and rebalance them if necessary.

1. **Scale Consumers**
   * Kafka supports **horizontal scaling** for consumers. You can add more **consumer instances** within a **consumer group** to handle more partitions in parallel.
   * Each consumer in the group reads from one or more partitions. More consumers allow better load balancing and parallel processing.

**Steps:**

* + Increase the number of consumers in the consumer group.
  + Ensure that there are enough partitions for each consumer to consume from. Kafka allows multiple consumers to consume data from separate partitions in parallel, but the number of consumers should not exceed the number of partitions.

1. **Scale Kafka Producers**
   * Kafka producers can handle high throughput by making use of **asynchronous writes** and **batching**. As more producers are added, they can write data in parallel.
   * Tuning the producer configurations (e.g., **batch.size**, **linger.ms**, **acks**) can help scale up production throughput.

**Steps:**

* + Optimize producer configurations for high throughput and low latency.
  + Distribute load by having multiple producers send messages to different partitions.

1. **Use Kafka Connect for Horizontal Scaling**
   * **Kafka Connect** is a framework to scale **data integration** with external systems (e.g., databases, file systems, etc.). You can use Kafka Connect to horizontally scale the ingestion and extraction of data to and from Kafka.
   * Kafka Connect has the concept of **worker nodes**, which can be scaled horizontally to increase the number of connectors handling the data flow.
2. **Tune Kafka's Configuration for Scalability**
   * Kafka has many configuration options that can be tuned to increase throughput and reduce latency. Common configurations to tune for scaling include:
     + **log.segment.bytes**: Adjust the segment size of Kafka logs for faster I/O operations.
     + **log.retention.ms**: Set a retention policy based on time to manage disk usage.
     + **num.replica.fetchers**: Increase the number of fetchers for replica synchronization.
     + **num.network.threads**: Increase network threads to handle more network requests simultaneously.
     + **num.io.threads**: Increase I/O threads for better disk throughput.
     + **zookeeper.session.timeout.ms**: Tune for a larger cluster to handle coordination between brokers and Zookeeper.
3. **Replication Factor & Fault Tolerance**
   * Ensure that each topic has an appropriate **replication factor** (number of copies of data across brokers). A higher replication factor improves fault tolerance but also increases network and disk load.
   * Kafka allows you to configure **replication** per topic. For larger clusters, you might increase the replication factor to ensure high availability and minimize the risk of data loss during broker failures.
4. **Use Partition Rebalancing Tools**
   * As the number of brokers and partitions grows, partition distribution can become uneven. Kafka provides tools to **rebalance** partitions across brokers to ensure that the load is distributed effectively.
   * The **Kafka Reassignment Tool** can be used to rebalance partitions across brokers.

**Steps:**

* + Generate a reassignment plan using the tool.
  + Apply the reassignment plan to ensure partitions are evenly distributed across brokers.

**Best Practices for Scaling Kafka**

* **Monitor Cluster Health:** Use Kafka's monitoring tools (JMX, Kafka Manager, Confluent Control Center, etc.) to track cluster health and performance.
* **Avoid Too Many Partitions:** While partitions scale horizontally, having too many partitions (e.g., thousands) can lead to operational overhead and disk space issues. Balance the partition count based on the workload.
* **Kafka Zookeeper Optimization:** If you're using Zookeeper (older Kafka versions), optimize its setup for performance and reduce the number of Zookeeper nodes as the Kafka cluster grows.
* **Dedicated Hardware or Cloud Setup:** Ensure that your hardware or cloud infrastructure can handle the I/O and storage requirements for Kafka, especially if you have large retention periods and high throughput.

**Conclusion**

Kafka scales well horizontally by adding brokers, increasing partitions, and scaling producers and consumers. Configuring it for high throughput, fault tolerance, and replication while managing resource allocation ensures it can handle massive amounts of real-time data effectively.

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### **What are the default partitions in kafka?**

* In Apache Kafka, the **default number of partitions** for a topic is **1**, unless specified otherwise when creating the topic.

**Default Partition Behavior in Kafka:**

* When you create a new topic without explicitly specifying the number of partitions, Kafka will create it with a **default number of partitions** set by the broker's configuration.
* This default value is controlled by the broker configuration setting **num.partitions**.

**Configuration Parameter:**

* **num.partitions**: This parameter determines the default number of partitions that will be used when a new topic is created without a specified partition count.

**Example:**

If the num.partitions is set to 3, any new topic created without a specified number of partitions will have 3 partitions by default.

**To check or set the default number of partitions:**

1. **Check Current Configuration**: You can view the default partition setting by checking your Kafka broker's configuration file (server.properties), where you'll find:

properties

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num.partitions=1

1. **Set the Default Partitions**: You can change this value to any desired number of partitions. For example:

properties

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num.partitions=3

After modifying this property, restart the Kafka broker for the changes to take effect.

1. **Create a Topic with Specific Partitions**: When creating a topic using the kafka-topics command, you can specify the number of partitions as well, overriding the default:

bash

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kafka-topics.sh --create --topic my-topic --partitions 5 --replication-factor 1 --bootstrap-server <broker>

**Why Partitions Matter:**

* Kafka partitions are fundamental to scaling. They allow Kafka to distribute data across multiple brokers, enabling parallel processing and high availability.
* More partitions allow for better parallelism and throughput since Kafka consumers can read from different partitions in parallel.

**Default Partition Usage:**

* If your Kafka topic does not specify partitions, it will default to the broker setting, which could potentially lead to lower parallelism in the absence of custom configuration.

**Key Notes:**

* **Increasing partitions** is an effective way to scale Kafka and improve throughput. However, once a topic is created with a certain number of partitions, it cannot be reduced (though you can add more partitions).
* Always consider the number of partitions based on your application's throughput and scalability requirements.

### **Difference between topic and partition in Kafka?**

* In **Apache Kafka**, **topics** and **partitions** are fundamental concepts that help in organizing and managing data. Here's a detailed breakdown of the **difference between a topic and a partition** in Kafka:

**Topic in Kafka**

* A **topic** in Kafka is a logical channel to which producers write data and from which consumers read data.
* Kafka topics allow messages to be categorized and managed. It is essentially a stream of records that you can publish to and consume from.
* Topics are **multi-producer** and **multi-consumer**, meaning multiple producers can write data to the same topic, and multiple consumers can read data from it.
* Topics are **named entities** in Kafka and serve as a logical grouping for messages.
* In Kafka, when you send a message, you specify a topic name, and Kafka brokers handle the distribution of these messages to the appropriate partitions under the topic.

**Partition in Kafka**

* A **partition** is a **subdivision** of a Kafka topic. Each topic is divided into partitions for scalability and parallelism.
* Partitions allow Kafka to **distribute data** across multiple brokers in a Kafka cluster and enable **parallel processing** by consumers.
* Kafka ensures that each partition is an ordered, immutable sequence of records, and each record within a partition is assigned a unique **offset**.
* Each partition can reside on different Kafka brokers in the cluster, enabling **horizontal scalability**.
* A partition also allows Kafka to **distribute work** among consumers. Each consumer within a **consumer group** reads from one or more partitions, ensuring that records are processed in parallel.

**Key Differences between Topic and Partition in Kafka**

| **Aspect** | **Topic** | **Partition** |
| --- | --- | --- |
| **Definition** | A topic is a logical name or category for messages. It is the channel to which producers write and consumers read. | A partition is a physical subdivision of a topic where data is distributed for scalability. |
| **Data Storage** | A topic stores the logical grouping of data. It doesn’t physically store the data itself but organizes messages. | A partition is where data for a topic is physically stored. Data is divided into partitions. |
| **Scalability** | Topics provide a way to group data logically. Scaling is achieved by adding more partitions. | Partitions enable horizontal scalability by distributing data across multiple brokers. |
| **Ordering Guarantees** | Ordering is guaranteed only within a partition, not across partitions of a topic. | Data in each partition is strictly ordered. The order of messages in different partitions is not guaranteed. |
| **Storage Location** | A topic itself doesn’t determine the location of the data; partitions within a topic are spread across brokers. | Partitions are distributed across multiple brokers in the Kafka cluster. |
| **Parallelism** | A topic can have multiple partitions to enable parallelism in data processing. | Partitions enable parallelism, with each consumer in a group reading from different partitions. |
| **Consumer Access** | Multiple consumers can subscribe to a topic, but they consume data from its partitions. | Consumers within a consumer group can consume data from different partitions. |
| **Producer Write** | Producers write data to a topic, but the partition is determined by the partitioner. | Producers write data to partitions based on partitioning logic (e.g., round-robin or key-based). |
| **Number of Instances** | A topic exists once in the Kafka cluster. | A topic can have multiple partitions (default is 1 unless specified), and each partition is a separate log. |

**How Kafka Works with Topics and Partitions**

1. **Producers**:
   * Producers publish messages to a **topic**. Each message is assigned to a partition based on a **partitioning strategy**.
   * If a **key** is provided with the message, Kafka uses the **key** to determine the partition to which the message belongs (usually by applying a hashing algorithm). If no key is provided, Kafka uses a round-robin approach.
2. **Consumers**:
   * Consumers subscribe to a **topic** and read from its **partitions**. Each **consumer group** can have multiple consumers, with each consumer reading from different partitions.
   * Kafka guarantees that each partition is consumed by only **one consumer** in a consumer group at a time. If there are more consumers than partitions, some consumers will be idle.
3. **Scalability and Fault Tolerance**:
   * Kafka scales horizontally by adding **more partitions**. More partitions allow higher parallelism, meaning multiple consumers can read from the topic simultaneously, thus improving throughput.
   * Partitions also enable **fault tolerance**. Kafka replicates each partition across multiple brokers, ensuring that even if a broker fails, the data is available from other replicas.
4. **Replicas**:
   * Each partition has a **replica**. These replicas are maintained on different brokers to ensure fault tolerance. If one broker fails, Kafka can retrieve the data from another replica of the partition.

**Conclusion**

* **Topic**: A logical categorization for data streams in Kafka.
* **Partition**: A physical storage unit for the topic's data, enabling parallelism, scalability, and fault tolerance.

### **Is there any ordering of messages in partitions in kafka?**

* **Yes,** **message ordering** is **guaranteed within a partition** in **Apache Kafka**.

**Key Points about Ordering of Messages in Kafka Partitions:**

1. **Ordering within a Partition**:
   * Kafka guarantees that **messages within a single partition are strictly ordered**. This means that the order in which messages are written to a partition is the same as the order in which they are read by consumers.
   * Each message in a partition is assigned a **unique offset** that represents its position in the partition. Consumers can use these offsets to read messages in the exact order they were produced.
2. **No Ordering Across Partitions**:
   * Kafka does **not guarantee any ordering** across multiple partitions of a topic. If a topic has multiple partitions, Kafka does not ensure that messages in one partition will be read in order relative to messages in another partition.
   * For example, if a producer sends messages to two partitions, one message in partition 1 could be consumed before another message in partition 2, but Kafka will not guarantee the order between these partitions.
3. **Why Ordering is Guaranteed within Partitions**:
   * Kafka's design is based on partitioning data for scalability. Each partition is an independent log file, and the ordering is maintained because the log is written sequentially.
   * Consumers read data sequentially based on offsets, so each consumer reading from a partition will always get messages in the same order in which they were produced.

**Example:**

Suppose you have a topic with two partitions (partition 0 and partition 1). If messages are produced as follows:

* Partition 0: Message 1, Message 2, Message 3
* Partition 1: Message 4, Message 5, Message 6
* The order of messages within partition 0 is guaranteed:
  + Consumer 1 will read Message 1, then Message 2, then Message 3 from partition 0.
* The order of messages within partition 1 is also guaranteed:
  + Consumer 2 will read Message 4, then Message 5, then Message 6 from partition 1.

However, **Kafka does not guarantee** that Message 1 will be consumed before Message 4 since they are in different partitions.

**Practical Considerations:**

* **Producers** can control which partition they send messages to, usually by using a **key**. If the same key is used for related messages, they will end up in the same partition, ensuring that related messages maintain the correct order.
* If strict message ordering is required across different types of messages, you should use a **single partition** for those messages, but keep in mind that this may limit the scalability of your Kafka cluster.

**Summary:**

* **Yes**, ordering is guaranteed **within a partition**.
* **No**, ordering is **not guaranteed across partitions**.

### **How does partition assignment happen? What method is used?**

* In **Apache Kafka**, **partition assignment** refers to the process of determining which consumer in a **consumer group** should consume messages from which partition. This assignment is crucial for ensuring that messages are distributed across consumers, enabling **parallel processing** and **load balancing**.

**How Partition Assignment Happens:**

When a **consumer group** is created and consumers join that group, Kafka automatically assigns partitions to the consumers in the group based on certain algorithms. The key goals are to ensure that each partition is assigned to exactly one consumer within the group and that the load is balanced among all consumers.

**Key Points of Partition Assignment:**

1. **Each Partition Is Assigned to One Consumer in a Consumer Group**:
   * Each partition of a topic is assigned to **only one consumer** in a **consumer group**. This ensures that each message within a partition is consumed only once.
   * If a consumer fails or leaves the group, Kafka will reassign the partitions to the remaining consumers.
2. **Rebalancing**:
   * When a new consumer joins or an existing consumer leaves the group, Kafka performs a **rebalance** to reassign partitions.
   * During a rebalance, Kafka ensures that partitions are evenly distributed across available consumers.
3. **Partition Assignment Strategies**: Kafka uses different strategies to determine how to assign partitions to consumers within a group. The two main partition assignment strategies in Kafka are:
   * **Range Assignor** (Default):
     + The **Range Assignor** assigns a range of partitions to each consumer. If there are 6 partitions and 3 consumers, the partitions will be divided into ranges, with each consumer being responsible for a set of contiguous partitions.
     + Example:
       - Consumer 1: Partitions 0-2
       - Consumer 2: Partitions 3-4
       - Consumer 3: Partitions 5
   * **RoundRobin Assignor**:
     + The **RoundRobin Assignor** distributes partitions to consumers in a round-robin fashion. This ensures that partitions are distributed more evenly, regardless of how many partitions there are.
     + Example:
       - Consumer 1: Partition 0
       - Consumer 2: Partition 1
       - Consumer 3: Partition 2
       - Consumer 1: Partition 3
       - Consumer 2: Partition 4
       - Consumer 3: Partition 5
4. **Custom Partition Assignment**:
   * Kafka allows you to implement custom partition assignment strategies if the default strategies do not meet your needs.
   * You can implement your own PartitionAssignor interface, which provides methods to control how partitions are assigned to consumers.

**Methods Used for Partition Assignment:**

* **assign() Method** (for manual assignment):
  + You can manually assign partitions to consumers using the **assign()** method. This method is useful when you want explicit control over which partitions each consumer consumes from.
  + Example (manual assignment):

KafkaConsumer<String, String> consumer = new KafkaConsumer<>(props);

consumer.assign(Arrays.asList(new TopicPartition("my-topic", 0), new TopicPartition("my-topic", 1)));

* + In this case, partitions 0 and 1 of the topic my-topic are explicitly assigned to the consumer.
* **subscribe() Method** (for automatic assignment):
  + When using the **subscribe()** method, Kafka will automatically assign partitions to consumers in the group based on the partition assignment strategy.
  + Example (automatic assignment):

KafkaConsumer<String, String> consumer = new KafkaConsumer<>(props);

consumer.subscribe(Arrays.asList("my-topic"));

* + The consumer will then subscribe to the topic and Kafka will handle the partition assignment based on the chosen strategy (either Range or RoundRobin).

**Steps in Partition Assignment Process:**

1. **Consumer Joins the Group**:
   * When a consumer joins the consumer group, it sends a request to the Kafka broker to fetch the list of partitions for the subscribed topic.
2. **Partition Assignment Algorithm**:
   * Kafka then uses the **assigned strategy** (Range or RoundRobin) to determine how the partitions should be distributed across the consumers in the group.
3. **Assign Partitions**:
   * The partitions are assigned to the consumers as per the chosen strategy. The Kafka broker sends back the partition assignments to the consumer.
4. **Rebalancing**:
   * If a new consumer joins or an existing consumer leaves, Kafka triggers a **rebalance**. This involves redistributing the partitions among the available consumers. The rebalance ensures that partitions are still evenly distributed and no partition is left unassigned.

**Summary of Methods:**

* **assign()**: Manually assign specific partitions to a consumer.
* **subscribe()**: Kafka automatically handles partition assignment using the selected assignment strategy (Range or RoundRobin).

**Conclusion:**

Partition assignment in Kafka ensures that partitions are evenly distributed across consumers in a consumer group, which is essential for parallel processing. Kafka uses different strategies, such as **Range Assignor** and **RoundRobin Assignor**, to distribute partitions to consumers. The assignment process is automatic by default but can be manually controlled using the assign() method for explicit partition management.

### **What is offset and partition in Kafka?**

* In **Apache Kafka**, **offset** and **partition** are two critical concepts used to manage and track the flow of messages in Kafka topics. They play a key role in ensuring message delivery and the processing order of messages.

**1. Partition in Kafka:**

A **partition** is a unit of data storage and message distribution in Kafka. Kafka topics are divided into one or more partitions, which allow Kafka to scale horizontally, providing fault tolerance and parallel processing.

**Key Points about Partitions:**

* **Scalability**: A partition allows Kafka to distribute the data across multiple servers (brokers). Each partition can be hosted on different Kafka brokers, enabling Kafka to scale horizontally.
* **Distributed**: Kafka topics are split into partitions to distribute the data and load among multiple brokers. Each partition is replicated across brokers to provide fault tolerance.
* **Parallelism**: Partitions allow Kafka consumers to read messages in parallel. Each consumer in a **consumer group** will be assigned one or more partitions to consume messages from, improving parallel processing and throughput.
* **Independent Logs**: Each partition is essentially an independent log of messages. These logs are append-only, meaning messages are added sequentially to the end of a partition.

**Example:**

* If you have a topic called orders, you can configure it to have multiple partitions (e.g., 3 partitions). Each partition will store a subset of the messages for that topic.
  + Partition 0: Stores a subset of orders data.
  + Partition 1: Stores another subset of orders data.
  + Partition 2: Stores yet another subset of orders data.

**2. Offset in Kafka:**

An **offset** is a unique identifier for each message within a partition. It represents the position of a message within a partition and allows consumers to read messages in order. The offset is **persistent** and **monotonically increasing** within a partition.

**Key Points about Offsets:**

* **Unique per Partition**: Offsets are unique within a partition, not across partitions. Each partition maintains its own sequence of offsets starting from 0 for the first message in that partition.
* **Message Tracking**: The offset helps Kafka consumers to track which messages have been consumed and allows them to pick up from the last consumed message if needed. Consumers can commit their offsets to Kafka, allowing them to resume consumption from the last processed message.
* **No Ordering Across Partitions**: Offsets are ordered within a single partition. However, there is **no global offset** across all partitions, meaning that the offset is only meaningful within the context of a specific partition.
* **Consumer State**: The offset is often used by consumers to maintain their position (state) in the message log. Consumers can choose to commit offsets (store them in Kafka or an external system), which allows them to resume from that point in the event of a failure or restart.

**Example:**

* If a partition has 10 messages, the offsets for these messages will be from 0 to 9.
  + Message 1: Offset 0
  + Message 2: Offset 1
  + Message 3: Offset 2
  + ...
  + Message 10: Offset 9

Consumers track their progress by keeping track of the last offset they processed. If a consumer processes messages up to offset 4, it can commit that offset and, if it fails or restarts, it can resume from offset 4.

**Key Differences Between Partition and Offset:**

| **Aspect** | **Partition** | **Offset** |
| --- | --- | --- |
| **Definition** | A partition is a unit of data storage in Kafka topics. | An offset is a unique ID representing a message in a partition. |
| **Purpose** | Enables horizontal scaling and parallel processing. | Tracks the position of a consumer in a partition's message log. |
| **Scope** | Each topic can have multiple partitions. | Each partition has its own sequence of offsets. |
| **Replication** | Partitions are replicated across multiple brokers. | Offsets are stored within partitions. |
| **Ordering** | Messages within a partition are ordered. | Offsets maintain the order of messages in a partition. |
| **Management** | Managed by Kafka for distributing data across brokers. | Managed by consumers to keep track of which messages have been consumed. |

**How Partition and Offset Work Together:**

1. **Producer Side**:
   * Producers send messages to a specific partition in a topic (using a partition key, such as message key). Kafka assigns a partition based on the producer's logic or a round-robin strategy.
2. **Consumer Side**:
   * Consumers read messages from partitions. The **offset** is used to determine the position from where the consumer starts reading. Consumers can commit their offsets to Kafka, so they can continue processing from the last consumed message if the consumer is restarted.
   * Kafka ensures **message order within partitions** using the offset but does not guarantee ordering across partitions.

**Summary:**

* **Partition**: A partition is a logical unit of data storage and helps Kafka scale horizontally. It allows for parallel processing and is the basic unit of data distribution.
* **Offset**: An offset is a unique identifier within a partition that helps track which messages have been consumed. It enables consumers to read messages sequentially and resume from a specific point.

Both **partitions** and **offsets** are crucial in Kafka’s design for message processing, scalability, and fault tolerance.

### **What are Kafka topics, and how are they used?**

* Answer

### **Explain Kafka topics and how data is stored in topics and consumed by consumers?**

* Answer

### **What is a Kafka producer, and how does it send messages?**

* Answer

### **Describe the Kafka producer role and how it sends messages to Kafka topics, including partitioning and message key concepts?**

* Answer

### **What is a Kafka consumer, and how does it consume messages?**

* Answer

### **Describe the Kafka consumer role and how it reads messages from topics and manages offsets?**

* Answer

### **What is a Kafka Broker?**

* Answer

### **Define a Kafka broker and its role in managing topics, partitions, and message replication?**

* Answer

### **What is a Kafka Consumer Group?**

* Answer

### **Explain the concept of a Kafka consumer group and how it allows multiple consumers to scale and consume messages from topics?**

* Answer

### **What are Kafka producers’ message guarantees (at most once, at least once, and exactly once)?**

* Answer

### **Explain the three message delivery guarantees in Kafka and how they are implemented?**

* Answer

### **What are Kafka partitions, and why are they used?**

* Answer

### **Discuss the concept of Kafka partitions, how they enable parallel processing, and the benefits of distributing data across multiple partitions?**

* Answer

### **Explain the concept of Kafka offset and how it is managed by consumers?**

* Answer

### **Define offset in Kafka, how it is assigned, and how Kafka consumers track their consumption position?**

* Answer

### **How does Kafka ensure data reliability and fault tolerance?**

* Answer

### **Explain Kafka’s replication mechanism and how data is replicated across brokers to prevent data loss?**

* Answer

### **What is the retention policy in Kafka, and how can it be configured?**

* Answer

### **Describe how Kafka retains messages and the different retention policies available (time-based, size-based, etc.)?**

* Answer

### **How can you monitor a Kafka cluster?**

* Answer

### **Discuss tools and techniques for monitoring Kafka performance and health (e.g., JMX metrics, Kafka Manager, Burrow, Prometheus)?**

* Answer

### **What is Kafka’s log compaction feature?**

* Answer

### **Explain log compaction in Kafka, how it helps manage the log size, and the use cases for log compaction?**

* Answer

### **Compare Kafka with traditional messaging systems in terms of architecture, message durability, scalability, and performance?**

* Answer

### **What are Kafka Streams, and how are they different from regular Kafka consumers?**

* Answer

### **Explain the Kafka Streams API, its use cases for stream processing, and how it differs from regular Kafka consumers in terms of functionality?**

* Answer

### **What is the Kafka Connect framework, and how does it help in data integration?**

* Answer

### **Discuss Kafka Connect and how it allows for easy integration between Kafka and external systems (e.g., databases, HDFS, and external message queues)?**

* Answer

### **What is the purpose of Kafka's ZooKeeper, and can Kafka work without ZooKeeper?**

* Answer

### **Explain the role of ZooKeeper in Kafka, its responsibility for managing broker metadata, and the current move towards KRaft (Kafka Raft) mode that removes the dependency on ZooKeeper?**

* Answer

### **How does Kafka handle backpressure?**

* Answer

### **Discuss how Kafka handles backpressure and the role of consumer lag and producer rate limits in managing this?**

* Answer

### **Explain Kafka’s exactly-once semantics. How is it implemented, and why is it important?**

* Answer

### **Explain Kafka’s exactly-once semantics, the configuration required to achieve it, and the scenarios where this feature is critical?**

* Answer

### **What is the impact of Kafka's producer buffer size on message delivery?**

* Answer

### **Discuss how buffer sizes in the Kafka producer affect message delivery, latency, and throughput?**

* Answer

### **How does Kafka handle message ordering within a partition?**

* Answer

### **Explain how Kafka ensures message order within a partition and the implications of partitioning on message order?**

* Answer

### **What are Kafka Streams and how do they differ from Spark Streaming?**

* Answer

### **Compare Kafka Streams with Spark Streaming, highlighting the advantages of using Kafka Streams for real-time stream processing?**

* Answer

### **How do you handle message duplication in Kafka?**

* Answer

### **Discuss the techniques to prevent message duplication in Kafka and how idempotence and exactly-once semantics help with this?**

* Answer

### **What would you do if a Kafka consumer is lagging behind?**

* Answer

### **Describe how you would troubleshoot and resolve consumer lag issues, including identifying the root cause and optimizing consumer performance?**

* Answer

### **How would you optimize Kafka performance in a production environment?**

* Answer

### **Discuss strategies to optimize Kafka, including tuning broker configurations, optimizing producer and consumer settings, and ensuring adequate hardware resources?**

* Answer

### **What are common Kafka issues and how can they be fixed?**

* Answer

### **List common Kafka problems, such as disk full errors, under-replicated partitions, and slow consumers, and explain how to resolve them?**

* Answer

### **What is Kafka’s Consumer Rebalance, and how do you handle it in a large-scale system?**

* Answer

### **Explain Kafka's consumer rebalance process and strategies for handling it when scaling out consumer groups?**

* Answer

### **What is the role of Kafka's Producer Acknowledgments?**

* Answer

### **Discuss the different acknowledgment levels (acks=0, acks=1, acks=all) in Kafka producers and their impact on message delivery reliability?**

* Answer

### **What is the significance of "log.retention.ms" and "log.segment.bytes" configurations in Kafka?**

* Answer

### **Explain the role of these configurations in managing message retention and log segment sizes, and how they influence performance and disk space?**

* Answer

### **How do you ensure Kafka data consistency across distributed clusters?**

* Answer

### **Discuss strategies for ensuring data consistency and replication across Kafka clusters, such as cross-data-center replication and the use of Kafka MirrorMaker?**

* Answer

# GitHub

### **What is Version control i.e. Git?**

* Answer

### **How to push and commit code in git using commands?**

* Answer

### **Difference between rebase and merge?**

* answer

### **Which versioning tool are you using? Explain a few Git commands?**

* answer

### **What is the Git command to create a new branch from an existing branch?**

* answer

### **If we have more consumer groups than partitions and how will it manage?**

* answer

# Docker

### **Explain use cases of Docker?**

* answer

### **You have 2 containers 1 and 2, can they communicate with each other?**

* answer

### **If both are with different hosts then whether they will be able to communicate with each other or not?**

* answer

### **What is the host in this case?**

* answer

### **Imagine you have one volume and you want to share it with multiple containers? How will you do it?**

* answer

### **Where does an object get stored when created inside a docker container?**

* answer

### **What is the process of Docker?**

* answer

### **How is Docker helpful?**

* answer

### **What is the use of Docker?**

* answer

# Kubernetes

### **What are Kubernetes Secrets??**

* answer

# AWS

### **Explain AWS services?**

**☁️ What is AWS?**

Amazon Web Services (AWS) is a cloud computing platform offering on-demand resources like servers, databases, storage, and more. It follows a pay-as-you-go model.

**🚀 Core AWS Services (by Category)**

**1. 🖥️ Compute Services**

| **Service** | **Description** |
| --- | --- |
| EC2 (Elastic Compute Cloud) | Virtual servers in the cloud. You can choose OS, size, and performance. |
| Lambda | Run code without provisioning servers (serverless). Supports auto-scaling, pay-per-use. |
| Elastic Beanstalk | Platform-as-a-Service (PaaS) for deploying apps (e.g., Java, Node.js). |
| ECS / EKS | Container services: ECS (Amazon managed), EKS (Kubernetes). |
| Lightsail | Simplified VPS service for small apps/websites. |

**2. 🗃️ Storage Services**

| **Service** | **Description** |
| --- | --- |
| S3 (Simple Storage Service) | Object storage for files, backups, media, etc. |
| EBS (Elastic Block Store) | Block storage for EC2, like virtual hard drives. |
| EFS (Elastic File System) | Shared file storage across multiple EC2 instances. |
| Glacier | Long-term, low-cost archival storage. |

**3. 🛢️ Database Services**

| **Service** | **Description** |
| --- | --- |
| RDS | Managed relational databases (MySQL, PostgreSQL, Oracle, SQL Server, MariaDB). |
| Aurora | High-performance, MySQL/PostgreSQL-compatible cloud DB. |
| DynamoDB | Serverless NoSQL database, key-value store. |
| Redshift | Data warehousing for analytics. |
| ElastiCache | In-memory caching (Redis/Memcached). |

**4. 🌐 Networking & CDN**

| **Service** | **Description** |
| --- | --- |
| VPC (Virtual Private Cloud) | Isolated virtual network for AWS resources. |
| Route 53 | DNS and domain name management. |
| CloudFront | Content Delivery Network (CDN) to serve static and dynamic content globally. |
| API Gateway | Expose REST/HTTP APIs to the internet or internal apps. |
| Load Balancer (ALB/ELB/NLB) | Distribute traffic across EC2 or containers. |

**5. 🛡️ Security & Identity**

| **Service** | **Description** |
| --- | --- |
| IAM (Identity and Access Management) | User/role management and fine-grained permission control. |
| KMS (Key Management Service) | Encryption key management. |
| Secrets Manager / Parameter Store | Store and manage secrets like API keys, DB credentials. |
| Cognito | User authentication and access control for web/mobile apps. |

**6. 📈 Monitoring & DevOps**

| **Service** | **Description** |
| --- | --- |
| CloudWatch | Monitor logs, metrics, and set alerts. |
| CloudTrail | Audit AWS API calls and account activity. |
| CodePipeline | CI/CD pipeline orchestration. |
| CodeBuild / CodeDeploy | Build and deploy automation. |
| CloudFormation | Infrastructure as Code (IaC) using YAML/JSON templates. |
| Elastic Container Registry (ECR) | Container image storage and versioning. |

**7. 🧠 AI/ML Services**

| **Service** | **Description** |
| --- | --- |
| SageMaker | End-to-end machine learning platform. |
| Rekognition | Image and video analysis (face, objects, text). |
| Comprehend | Natural Language Processing (sentiment, entity recognition). |
| Lex | Build conversational interfaces (chatbots). |
| Translate / Polly / Textract | Language translation, speech synthesis, text extraction. |

**8. 🛠️ Developer Tools**

| **Service** | **Description** |
| --- | --- |
| AWS CLI | Command-line tool for managing AWS resources. |
| AWS SDKs | Language-specific libraries (Java, Python, Node.js, etc.). |
| Cloud9 | Online IDE integrated with AWS. |

**9. 📦 Other Popular Services**

| **Service** | **Description** |
| --- | --- |
| SQS (Simple Queue Service) | Message queuing for decoupling systems. |
| SNS (Simple Notification Service) | Pub/Sub for notifications (SMS, email, Lambda, etc.). |
| Step Functions | Workflow orchestration service. |

### **What is cloud computing?**

* answer

### **Explain services provided by cloud computing?**

* answer

### **How to deploy service to AWS?**

* answer

### **Which services have you used?**

* answer

### **What are different services in EKS?**

* answer

### **What is the benefit of Serverless services? Is EKS serverless?**

* answer

# Azure

### **question?**

* answer

# Angular

### **What are the components in the Angular?**

* answer

### **How to pass data from components in Angular?**

* answer

### **What does the component.ts file contain in angular?**

* answer

### **Explain two way data binding in angular?**

* answer

### **How to make backend calls in angular?**

* answer

### **What is authguard in angular?**

* answer

### **What is interpolation in angular?**

* answer

### **How to create components in angular?**

* answer

### **Explain angular directives?**

* answer

### **What are observables in angular?**

* answer

### **How to implement dependency injection in angular?**

* answer

### **What are different components of Angular?**

* answer

### **How to handle caching in Angular?**

* answer

# React

### **Features of ReactJS?**

* answer

### **How does Virtual DOM work?**

* answer

### **Features of Virtual DOM?**

* answer

### **What is reducing modifications in Virtual DOM?**

* answer

### **What do you call the backend API from ReactJS?**

* answer

### **What are other Hooks in React?**

* answer

### **What is the purpose of Hook?**

* answer

### **What is the dependency array in useEffect?**

* answer

### **What is the use and significance of dependency arrays?**

* answer

### **How to make a call to an external API from ReactJS?**

* answer

### **What is an alternative to Axios?**

* answer

# Others

### **Explain Jira?**

* answer

### **What is the output of below program?**

#include<stdio.h>

int main()

{

int a =0;

1 + 1 - 1 + 1

a=a++ + ++a - a++ + ++a;

printf(“%d\n”,a);

return 0;

}

* answer

### **What is https protocol?**

* answer

### **How does https internally work?**

* answer

### **What is a certificate?**

* Answer

### **Difference between http and https?**

* answer

### **What is a Sprint retrospective?**

* answer

### **Do you know anything about CI/CD?**

* answer

### **How will Jenkins' job work? Explain the process?**

* answer

### **What is Node JS?**

* answer

### **How is your application getting deployed? Which platform are you using in your project?**

* answer

### **What do you know about Asynchronous communication?**

* answer

### **What are the measure objects i.e key things in order to make Asynchronous calls?**

* answer

### **If I have two different technologies then how can we achieve asynchronous communication?**

* answer

### **Do you have exposure in AI and ML?**

* answer

### **Examples of Fund Transfer are Synchronous or Asynchronous?**

* answer

### **Is WhatsApp Synchronous or Asynchronous?**

* answer

### **Difference between 2 Tier and 3 Tier Architecture?**

* answer

### **Have you heard about the log4j vulnerability?**

* answer

### **What is https protocol?**

* answer

### **Difference between http and https?**

* answer

### **Suppose in server one job at 9 AM and copy json file and paste it in temp folder another job 6 PM read it and load in db and no one should change the file. How to prevent file from any Change?**

* answer

### **If we increase timeout then how can we resolve it? Deployment related issue and how will you handle it?**

* answer

# Linux

### **Explain Linux commands?**

* answer

### **Command - Read a file and print first two lines from file Ans. head -2 filename?**

* answer

### **Search a word from a file?**

* grep 'word' filename ack 'pattern' /path/to/file.txt

### **Why do you want to change your current organization?**

* answer

# Puzzles

### **Puzzle – 1**

Weighing the 9 balls puzzle, find the heavier ball among 9 balls. How many max iterations will it be required to find the heavier ball?

* answer

### **Puzzle – 2**

You are doing some gardening, and need exactly 4 litres of water to mix up some special formula for your award-winning roses. But you only have a 5-liter and a 3-liter bowl, but do have access to plenty of water.

How would you measure exactly 4 litres?

* Fill the 5-liter bowl. Then fill the 3-liter bowl from the 5-liter bowl. You will now have 2 litres left in the 5 litres bowl. Empty the 3-liter bowl, and then transfer the 2 litres from the 5-liter bowl into it. Now fill the 5-liter bowl again, then pour water carefully from the 5-liter bowl into the 3-liter bowl until it is full - exactly one more litre. The 5-liter bowl now has exactly 4 litres.

### **Puzzle – 3**

Divide square in 5 equal parts?