- If you try to access any method of an object, but the object is null; then you'll get an **Null Pointer Exception**.
- **Remember: in java we initialize an array using {} curly braces; not [] square brackets.**
- Consider the following scenario:
  - I have 3 files:
    - Main.java
      - Contains the main method.
      - It has an object of type QuestionService
    - QuestionService.java
      - If has an array of objects.
      - Those objects are of type Question
    - Question.java
      - It is a normal class that contains some variables and getter, setter methods to build a question.
      - Like, id (int), question(String), options (String[]), answer (String)
  - Now, I implemented the **toString()** method inside Question class, so that whenever I print the object of type Question directly, it'll print something meaningful instead of the default *hashcode*.
  - Then I compiled **Main.java** and ran this. But I couldn't see the changes that I did inside **Question.java**.
  - When you compile a **.java** file, it'll generate **.class** file of all those Class which are linked to the **.java** file (in our case, all Classes i.e. Main, QuestionService, Question are linked).
  - Let I run **javac Main.java**
    - Now, it'll compile Main.java and create the Main.class file.
    - And it'll check if there is QuestionService.class and Question.class already present.
    - If present, then don't recompile those; otherwise compile those as well.
    - In my case, I had already QuestionService.class and Question.class present; so it was not re-compiling those classes.
  - So, every-time you do any changes, run the following command:
    - **javac *.java** (it'll re-compile all the .java files present in the current directory)
    - **java Main**

- To read input from users:
  - **Scanner** is used to read the input from the user.

```
Scanner sc = new Scanner(System.in); // initializing scanner to read user input
int i = 0;
for (Question q : questions) {
    System.out.println("Question No: " + q.getId());
    System.out.println(q.getQuestion());
    String[] options = q.getoptions();
    for (String option : options)
        System.out.println(" - " + option);

    this.selections[i++] = sc.nextLine(); // reading user input and storing in array
}
sc.close(); // closing scanner to prevent resource leak
```

  - Here, I created an object of Scanner, and passed **System.in**
    - **System.in** is a static input stream provided by JVM.
    - It represents standard input of your program.
    - Since it is **static final**, there is only **System.in** object per JVM process.
    - Once you close the scanner object using **sc.close()**, you can't read the input again.
  - Below is an example of wrong usage of Scanner:

```
int i = 0;
for (Question q : questions) {
    System.out.println("Question No: " + q.getId());
    System.out.println(q.getQuestion());
    String[] options = q.getoptions();
    for (String option : options)
        System.out.println(" - " + option);

    Scanner sc = new Scanner(System.in); // create a Scanner object
    this.selections[i++] = sc.nextLine(); // read user input
    sc.close(); // close the scanner to prevent resource leak
    // but closing here will close System.in, causing issues on next iteration
}
```

    - Here you'll get an exception after the first iteration, because System.in is already closed in the previous iteration.
  - **sc.close()** is optional by the way.
- **<u>Abstract Class and Abstract Method</u>**
  - In java, empty methods are valid.

```
class Car {
    // this method is valid but doesn't give error
    public void drive() {

    }
    public void playMusic() {
        System.out.println(x:"Playing music");
    }
}
```

- These are some conditions in Java OOP:
  - Abstract method inside Abstract class (✓)
  - Abstract method inside Normal class (✗)
  - Normal method inside Abstract class (✓)
  - Normal method inside Normal class (✓ (default only))
- In short:
  - Abstract method ⇒ class must be abstract
  - Normal methods ⇒ allowed anywhere
- An abstract class may have:
  - Only abstract methods
  - Only normal methods
  - A mix of abstract + normal methods
  - Even no methods at all

```java
abstract class Car {
    public abstract void drive();

    public void playMusic() {
        System.out.println(x:"Playing music");
    }
}

class Tesla extends Car {
    public void drive() {
        System.out.println(x:"Driving Tesla");
    }

    public void show() {
        System.out.println(x:"Show method in Tesla");
    }
}

public class Main {
    Run | Debug
    public static void main(String[] args) {
        Car car = new Tesla();
        car.drive();
        car.playMusic();
        // car.show(); // This will give an error because 'show' is not defined in Car

        Tesla myCar = new Tesla();
        myCar.drive();
        myCar.playMusic();
        myCar.show();
    }
}
```

- If a class is inheriting an abstract class
  - It must implements the abstract methods present inside the abstract class.
  - The normal methods present inside the abstract class need not to be overridden.

- **An abstract class can have constructor.**
  - The constructor can be called from the base classes using **super()**
- **NOTE**
  - An abstract class can inherit another abstract class as well.
  - And in this case, the child *abstract class* need not to implement the *abstract methods* inside the parent abstract class.

```
abstract class Car {
    public abstract void drive();

    public abstract void accelerate();

    public void playMusic() {
        System.out.println(x:"Playing music");
    }
}

abstract class FastCar extends Car {

    public void accelerate() {
        System.out.println(x:"Accelerating FastCar quickly");
    }
}

class Tesla extends FastCar {
    public void drive() {
        System.out.println(x:"Driving Tesla");
    }

    public void show() {
        System.out.println(x:"This is a Tesla car");
    }
}
```

  -

- **Inner Class**
  - An inner class is a class defined inside another class.
  - It is logically associated with its outer class and has access to its members (even private ones).
  - The inner class's type will be: OuterClassName.InnerClassName
  - And to instantiate the inner class, you need an instance of the outer class.
  - To instantiate the inner class, you need to call like.
    - obj.new InnerClassName()
  - There are 4 types of Inner Class

- Non-Static Nested Inner Class
- Static Nested Inner Class
- Local Inner Class
- Anonymous Inner Class

- **Non-Static Nested Inner Class:**

```java
class Outer {
    int age = 5;
    static String name = "Outer Static";

    public void show() {
        System.out.println(x:"in Outer's show");
    }

    class Inner {
        // shadowing occured
        int age = 30;

        public void config() {
            System.out.println("in Inner's config: inner age = " + age); // inner's age
            System.out.println("in Inner's config: outer age = " + Outer.this.age); // outer's age
            // both are correct
            System.out.println("in Inner's config: name = " + name);
            System.out.println("in Inner's config: name = " + Outer.name);
        }
    }
}

public class Main {
    Run | Debug
    public static void main(String[] args) {
        Outer out = new Outer();
        Outer.Inner ob = out.new Inner();

        // Outer.Inner ob = new Outer().new Inner();
        // it is also correct; outer object would be anonymous

        ob.config();

        System.out.println(ob.age);
    }
}
```

- Just imagine a non-static method. You can access this only by an object.
- Just like that, you can access the Non-Static Inner Class using an object of Outer Class only.
- It can access all the instance and static variables of the outer class (even private variables are accessible).
- In the above example, the instance variable **age** got shadowed inside the Inner class. To access the Outer class's age
  - **OuterClassName.this.VariableName**
  - Because, **this.age** would have given InnerClass's variable **age**

- Here we are able to do **OuterClassName.this.VariableName** because the inner class object is *created by the instance* (object) of the Outer class. So, *Inner class instance can access Outer class instance.*
- But, if you write **InnerClassName.this.VariableName** from a method present in the Outer class then it'll not work because the Outer class doesn't have access to any instance of the Inner class.

- Why not **new ob1.Inner()** ?
  - **new** keyword is used before the class name i.e. **new MyClass()** like this.
  - But if we write **new ob.Inner()** then it should be like **ob** should be one class but its an object.
  - So, we write like **ob.new Inner()**
  - In case of static inner class, we use **new Outer.Inner()** because here **Outer** is a class not an object.

- **Static Nested Inner Class:**
  - Declared with the static keyword.
  - It does not need an instance of the outer class.
  - Can access only **static members** of the outer class directly.
  - Just like static method, we can access the static inner class using the Outer class directly without instantiating it.
  - Here, new **Outer.Inner()** (not Outer.new Inner() or new Outer().Inner())
  - Inner static class can have both instance and static variables and methods , as we can create instance of the inner class. Those instance variables can be accessed using this keyword inside the inner class.

```java
class Outer {
    int age;
    static String name = "Outer Static";

    public void show() {
        System.out.println(x:"in Outer's show");
    }

    static class Inner {
        public void config() {
            // // error; as age is an instance variable
            // System.out.println("in Inner's config: age = " + age);
            // both are correct
            System.out.println("in Inner's config: name = " + name);
            System.out.println("in Inner's config: name = " + Outer.name);
        }
    }
}

public class Main {
    Run | Debug
    public static void main(String[] args) {
        Outer.Inner ob = new Outer.Inner();
        // new Outer().Inner() <= wrong

        ob.config();
    }
}
```

```java
class A {
    private int vala = 10;
    static int stata = 39;
    private int vcommon = 20;

    public A() {
        System.err.println(x:"Outer Class: A's constructor");
    }
    static class C {
        private int valc = 15;
        static int statc = 49;
        private int vcommon = 40;

        public C() {
            System.err.println(x:"Inner Class: C's constructor");
        }
        void greetC() {
            System.err.println("stata: " + stata);
            System.err.println("stata (outer): " + A.stata);

            System.err.println("valc: " + valc);
            System.err.println("valc(this): " + this.valc);
            System.err.println("statc: " + statc);
            System.err.println("statc (inner): " + C.statc);
            System.err.println("vcommon: " + vcommon);
            System.err.println("vcommon (this): " + this.vcommon);
            System.err.println();
        }
        public static void showC() {
            System.err.println(x:"showC of inner class C; static method it is;");
        }
    }
}
public class StaticInnerClass {
    Run | Debug
    public static void main(String[] args) {
        A.C obj = new A.C();
        obj.greetC();
        A.C.showC();
    }
}
```

- **Local Inner Class:**
  - When the Inner class is defined inside a method of Outer class, then it is Local Inner Class. **(It has access to outer class's instance variables)**

```java
class Outer {
    int age = 5;
    static String name = "Outer Static";

    private void show() {
        System.out.println(x:"In outer's show..");
    }

    public void show2() {
        System.out.println(x:"in Outer's show2..");

        class Inner {
            int val = 10;

            private void displayVal() {
                System.out.println("displayVal: val inside Inner is: " + val);
            }

            public void displayVal2() {
                System.out.println("displayVal2: val inside Inner is: " + val);
            }
        }
        // it can access both private and public methods of inner class
        Inner obj = new Inner();
        obj.displayVal();
        obj.displayVal2();
    }
}

public class Main {
    Run | Debug
    public static void main(String[] args) {
        Outer ob = new Outer();
        // ob.show(); // error as method is private
        ob.show2();
    }
}
```

  - It is strange that, the **displayVal** method is private; but still it was able to get called from outside of it i.e. inside the **show()** method.
  - As the Inner class comes inside the scope of Outer class, so in this case, **all private things of Outer class and Inner class are accessible to each-other**.
  - But the private method **show()** of the class **Outer** is not accessible outside.
  - Because Inner lives inside the scope of Outer, they can freely access each other's private members.
  - But Main is outside, so it cannot access Outer.show() or Inner.displayVal().

- **Anonymous Inner Class:**

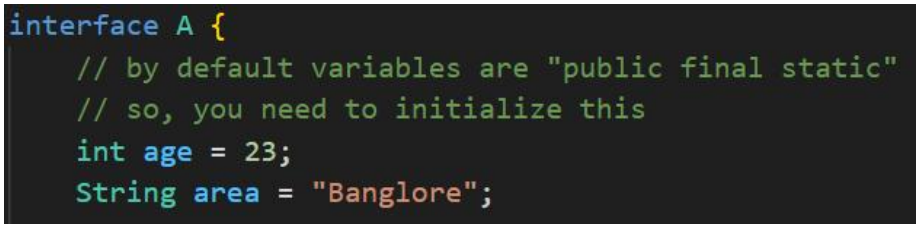
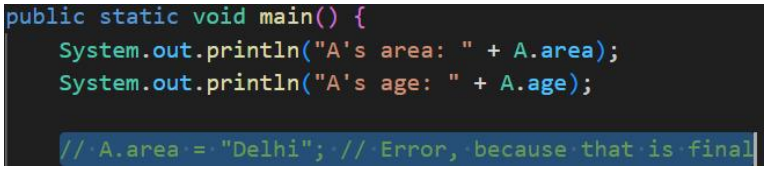
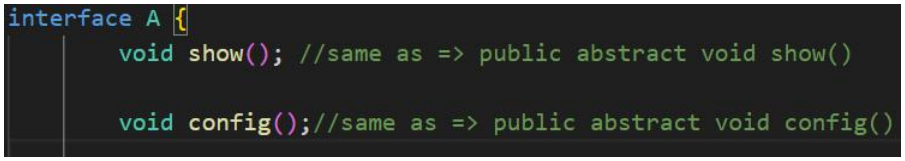
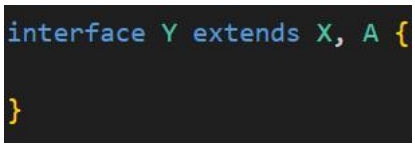
```java
class Test {
    public void greet() {
        System.out.println(x:"Hello from Test!");
    }
}

class Outer {
    int age = 5;
    static String name = "Outer Static";

    public void show() {
        System.out.println(x:"in Outer's show...");

        // case-1
        class AdvTest extends Test {
            public void greet() {
                System.out.println(x:"Hello from AdvTest!");
            }
        }

        Test ob = new AdvTest();
        ob.greet();

        // case-2 (anonymous inner class)
        // --- for this case: Test can be abstract as well ---
        Test ob2 = new Test() {
            public void greet() {
                System.out.println(x:"Hello from Anonymous Test!");
            }
        }; // semicolon is necessary here
        ob2.greet();
    }
}

public class Main {
    Run | Debug
    public static void main(String[] args) {
        Outer ob = new Outer();
        ob.show();
    }
}
```

```java
class Test {
    public void greet() {
        System.out.println(x:"Hello from Test!");
    }
}
class Outer {
    int age = 5;
    static String name = "Outer Static";
    public Test obj = new Test() {
        public void greet() {
            System.out.println(x:"Hello from Outer => Test!");
        }
    };
}
public class Main {
    Run | Debug
    public static void main(String[] args) {
        Outer ob = new Outer();
        ob.obj.greet();
    }
}
```

- Its just like inheriting a Normal/Abstract class and instantiating directly without creating the inherited class.

- **Summary of Inner Classes**
  - In any type of inner class creation, both Outer and Inner classes can access each-other's private members.
  - **Non-Static Inner Class:**
    - Assumption: Inner class's name: **Inner**, Outer class's name: **Outer**
    - Just like non-static method, the Non-Static Inner Class can access both instance variables and static variables of the Outer class.
    - If there is any type of shadowing of Outer class's variable then (let variable name is: **val**)
      - **this.val** ⇒ Inner class's variable *val*
      - **Outer.this.val** ⇒ Outer class's variable *val*
    - Just like Non-Static Method, we need an instance of the class to access the Non-Static Inner Class.
    - As the Inner class's instance will be a part of the Outer class's instance, so to instantiate this:
      - **obOuter.new Inner()**
  - **Static Inner Class:**
    - Assumption: Inner class's name: **Inner**, Outer class's name: **Outer**
    - Just like the Static Methods, the Static Inner Class can only access the *static* members of the Outer class.
    - If there is any shadowing: (let the variale name is **val**)
      - val ⇒Inner class's static variable
      - Outer.val ⇒ Outer class's static variable
  - **Local Inner Class:**
    - The Inner class is defined inside a method of the Outer Class.
    - The scope to access this Inner class is only the scope of that Method.
  - **Anonymous Inner Class:**
    - Its just like extending a class (either Normal or Abstract) and creating an object out of that; without creating the Class.
    - The syntax is:
      - **ClassName** obj = new **ClassName**() { /* override method if want */ }
  -

Interface

- **Interface** can't have **constructor**.
- By default the variables inside interfaces are: **public static final**.
  - So, **static methods** can also access those variables.
  - Static methods can be called as: **InterfaceName.staticMethodName(…args)**
  - So, you need to initialize while declaring it.
  - 
    ```
    interface A {
        // by default variables are "public final static"
        // so, you need to initialize this
        int age = 23;
        String area = "Banglore";
    ```
  - You cannot override the variables that were declared and initialized in interface.
  - 
    ```
    public static void main() {
        System.out.println("A's area: " + A.area);
        System.out.println("A's age: " + A.age);

        // A.area = "Delhi"; // Error, because that is final
    ```
- By default all the methods are **public abstract**; you don't need to explicitly write that.
  - 
    ```
    interface A {
        void show(); //same as => public abstract void show()

        void config();//same as => public abstract void config()
    ```
- **implements** is the keyword that is used to implement a interface to a class.
- Unlike classes, **multiple implementations** are allowed in case of interface.
  - 
    ```
    class B implements A, X {

        public void show() {
    ```
    (multiple implementation)
- Interfaces can inherit another interface.
  - In this case, **multiple inheritance** is allowed.
  - 
    ```
    interface Y extends X, A {

    }
    ```
  - But the class which implements **Y**, has to override all the methods mentioned in interfaces **X** and **A**.

- **NOTE**
  - Interfaces cannot have constructors (because they can't be instantiated).
  - But you can create a reference of an interface type pointing to a class object.
  - Interfaces are used to achieve abstraction and multiple inheritance in Java.

```java
interface A {
    void show();
    void config();
}
interface X {
    void run();
}
class B implements A, X {
    public void show() {
        System.out.println(x:"overridden 'A: show'");
    }
    public void config() {
        System.out.println(x:"overridden 'A: config'");
    }
    public void run() {
        System.out.println(x:"overridden 'X: run'");
    }
}
public class Interface {
    public static void main() {
        A obj = new B();
        obj.show();
        obj.config();
        // obj.run(); // Error: A doesn't have run

        X obj2 = new B();
        // obj.show(); // Error: X doesn't have show
        // obj.config(); // Error: X doesn't have config
        obj2.run();
    }
}
```

  - In case of implementing 2 interfaces, creating object of one interface type and calling the method mentioned in the other interface will not be possible.
  - We had seen this during Upcasting and Downcasting.

- **Need of Interface**
  - You can see the below example code.
  - Here if we didn't have implemented an interface, only **Laptop** or **Desktop** type of objects would have been acceptable inside the **codeApplication** method of **Developer** class.
  - Now we can think, instead of interface, **abstract class** can also be used;
  - But, just to write a abstract method, why to create an abstract class.
  - Interface is here simple and doing all the required things.
  -

```
interface Computer {
    void code();
}

class Laptop implements Computer {
    public void code() {
        System.out.println(x:"Coding started: little slow");
    }
}

class Desktop implements Computer {
    public void code() {
        System.out.println(x:"Coding started: faster");
    }
}

class Developer {
    public void codeApplication(Computer comp) {
        comp.code();
    }
}

class Company {
    Run | Debug
    public static void main(String[] args) {
        Developer alok = new Developer();
        Developer kanha = new Developer();
        // we are giving alok a laptop
        // and kanha a desktop to code
        Computer laptop = new Laptop();
        Computer desktop = new Desktop();

        alok.codeApplication(laptop);
        kanha.codeApplication(desktop);
    }
}
```

- **Enum**
  - enum is a special type of class in Java (its not same as Class; but similar).
  - It's a **final class** which cannot be inherited by any other class.
  -
```
enum Status {
    Running, Failed, Pending, Success;
}

public class Enum {
    Run | Debug
    public static void main(String[] args) {
        Status s = Status.Failed;
        System.out.println("s = " + s); // Failed

        // in Java, the indexing starts from 0 for the enums
        // Running: 0, Failed: 1, Pending: 2, Success: 3
        // the method "ordinal()" returns the index
        Status[] allVals = Status.values();
        for (Status val : allVals)
            System.out.println("index: " + val.ordinal() + ", value: " + val);
    }
}
```
  - **switch case** statement also supports **enum**, so it can be used to check the status.
  - Consider the following example: (more than one constructor can be created)
    -
```
enum Laptop {
    Macbook(price:2000), Dell(price:1200), Acer(price:1400);

    private int price;

    Laptop(int price) {
        this.price = price;
    }

    public int getPrice() {
        return this.price;
    }
}
```
    -
```
final class Laptop extends Enum<Laptop> {
    public static final Laptop Macbook = new Laptop("Macbook", 0, 2000);
    public static final Laptop Dell = new Laptop("Dell", 1, 1200);
    public static final Laptop Acer = new Laptop("Acer", 2, 1400);

    private int price;

    private Laptop(String name, int ordinal, int price) {
        super(name, ordinal); // from java.lang.Enum
        this.price = price;
    }

    public int getPrice() {
        return this.price;
    }
}
```
      - Behind the scene.

```java
enum Laptop {
    // these are objects of Laptop class itself
    // as you are passing some value, so you need to create a constructor
    Macbook(price:2000), Dell(price:1200), Acer(price:1400);

    public int price;

    Laptop(int price) {
        this.price = price;
    }

    public int getPrice() {
        return this.price;
    }
}

public class Enum {
    Run | Debug
    public static void main(String[] args) {
        Laptop lap = Laptop.Macbook;
        System.out.println(lap.getClass()); // class Laptop
        System.out.println(lap.getClass().getSuperclass()); // class java.lang.Enum

        System.out.println("s = " + lap); // Macbook
        System.out.println("price = " + lap.getPrice()); // 2000

    }
}
```

- **enum** only supports **private constructor.**

```java
enum Status {
    STARTED, IN_PROGRESS, COMPLETED, FAILED;
}

class Status2 {
    private String name;
    private int ordinal;

    static Status2 STARTED = new Status2(name: "STARTED", ordinal: 1);
    static Status2 IN_PROGRESS = new Status2(name: "IN_PROGRESS", ordinal: 2);
    static Status2 COMPLETED = new Status2(name: "COMPLETED", ordinal: 3);
    static Status2 FAILED = new Status2(name: "FAILED", ordinal: 4);

    public String toString() {
        return this.name;
    }

    private Status2(String name, int ordinal) {
        this.name = name;
        this.ordinal = ordinal;
    }
}
```

- Manual creation of Enum (not proper; just to understand)

- **Annotations**
  - Provides information to the compiler, tools, or runtime.
  - Think of it as a special marker/label you attach to classes, methods, variables, etc.
  - For example **@Override**
    - It tells the compiler: "this method is supposed to override a method from its super-class."
    - If it doesn't, the compiler will show an error.

```
class A {
    public void greet() {
        System.out.println(x:"Hello from class A");
    }
}

class B extends A {
    public void greeet() {
        System.out.println(x:"Hello from class B");
    }
}
```

  - Here you can see, I have made a *spelling error* in Class B.
  - Instead of **greet** I have written **greeet**

```
class A {
    public void greet() {
        System.out.println(x:"Hello from class A");
    }
}

class B extends
    @Override
    public void greeet() {
        System.out.println(x:"Hello from class B");
    }
}
```

The method greeet() of type B must override or im

void B.greeet()

View Problem (Alt+F8) Quick Fix... (Ctrl+.) Fix (Ctrl+I)

    - Now I used the annotation **@Override** , so now the compiler is showing me the error that this method doesn't exists in the superclass.

- **Types of Interface**
  - **Normal Interface**
    - Interface having **2 or more** methods
  - **Functional Interface / SAM** (Single Abstract Method)
    - Interface having only **1** method.
  - **Marker Interface**
    - Interface having **no** method.
    - used for tagging or marking classes (e.g., Serializable).
  - **Functional Interface:**
    -
```java
@FunctionalInterface
interface A {
    void show();

    private static int add(int a, int b) {
        return a + b;
    }

    default void display() {
        System.out.println(add(a:4, b:5));
    }
}
```
      - Abstract method should be only **1**.
      - Remaining static or default methods can be there.
      - Annotation: **@FunctionalInterface**
    -
```
cInterface.java  Invalid '@FunctionalInterface' annotation; A is not a functional inte
                 A
@Functiona       View Problem (Alt+F8)  Quick Fix... (Ctrl+.)  Fix (Ctrl+I)
interface A {
    void show();
    void config();

    private static int add(int a, int b) {
        return a + b;
    }

    default void display() {
        System.out.println(add(a:4, b:5));
    }
}
```
      - I added one more Abstract method, so it is showing me error.

- **Lambda Expression**

```
@FunctionalInterface
interface A {
    void show();
}

public class FuncInterface {
    Run | Debug
    public static void main(String[] args) {
        // anonymous inner class concept
        A obj = new A() {
            public void show() {
                System.out.println(x:"in show A");
            }
        };
        obj.show();
    }
}
```

- This code is proper and it'll work fine.

```
public class FuncInterface {
    Run | Debug
    public static void main(String[] args) {
        // anonymous inner class concept
        A obj = new A() {
            public void show() {
                System.out.println(x:"in show A");
            }
        };
        obj.show();

        // lambda expression
        A obj2 = () -> {
            System.out.println(x:"in show A");
        };
        obj2.show();

        // if there is only single expression
        A obj3 = () -> System.out.println(x:"in show A");
        obj3.show();
    }
}
```

```
@FunctionalInterface
interface A {
    void show(int a);
}

public class FuncInterface {
    Run | Debug
    public static void main(String[] args) {
        // if there is only single expression
        A obj3 = (int a) -> System.out.println("in show A: " + a);
        obj3.show(a:4);
    }
}
```

- You can also pass the arguments.

```java
@FunctionalInterface
interface A {
    void show(int a);
}

public class FuncInterface {
    Run | Debug
    public static void main(String[] args) {
        // if there is only single expression
        A obj = (a) -> System.out.println("in show A: " + a);
        obj.show(a:4);
    }
}
```

- You don't even need to provide the data type; it'll take from the interface directly.

```java
@FunctionalInterface
interface A {
    void show(int a);
}

public class FuncInterface {
    Run | Debug
    public static void main(String[] args) {
        // if there is only single expression
        A obj = a -> System.out.println("in show A: " + a);
        obj.show(a:4);
    }
}
```

- If you have only one argument, don't need to give the *parenthesis* as well.

```java
@FunctionalInterface
interface A {
    int add(int a, int b);
}

public class FuncInterface {
    Run | Debug
    public static void main(String[] args) {
        // if there is only single expression
        A obj = (a, b) -> a + b;
        int res = obj.add(a:4, b:5);
        System.out.println("Sum = " + res);
    }
}
```

- You can directly return the values like this.

- **Lambda Expression** only works with the **Functional Interface.**
- Because if there are more than one method, which will be implemented.

- **Exceptions**
  - Compile time error and Logical Errors can be fixed;
  - But Run Time error should be handled. So that the application won't stop in between.
  - Exception Handling is nothing but handling these Run Time error.

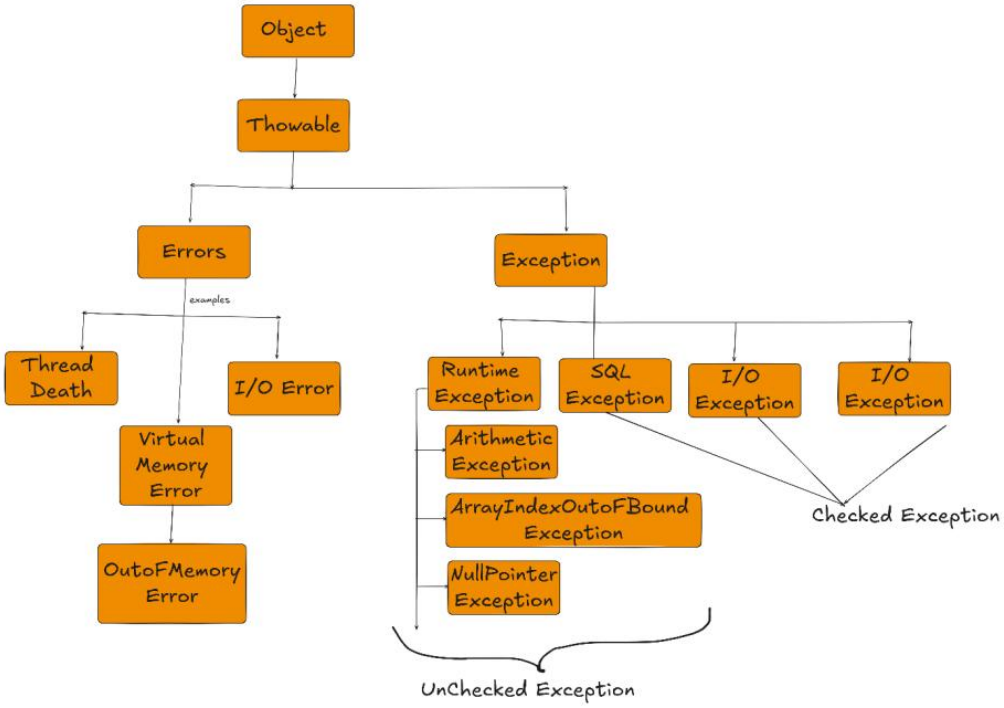
```java
public class Exceptionss {
    Run | Debug
    public static void main(String[] args) {
        int i = 0, j = 0;

        try {
            j = 20 / i; // as i is 0, it'll throw an error
        } catch (Exception e) {
            System.out.println("Something went wrong: " + e);
        }
        System.err.println(x:"Bye");
    }

}
```

  - Handling Exceptions using **try catch** block.

```
$ java Exceptionss
Something went wrong: java.lang.ArithmeticException: / by zero
Bye
```

```java
public class Exceptionss {
    Run | Debug
    public static void main(String[] args) {
        int i, j;
        i = 5;
        j = 1;

        int[] nums = new int[5];

        try {
            j = 20 / i;
            System.err.println(nums[1]);
            System.err.println(nums[5]); // error bcs out of bound
        } catch (ArithmeticException e) {
            System.out.println("divided by zero\n" + e);
        } catch (ArrayIndexOutOfBoundsException e) {
            System.err.println("Out of bound\n" + e);
        } catch (Exception e) { // if some other exception occured
            System.err.println("Something went wrong\n" + e);
        }
        System.err.println(x:"Bye");
    }

}
```

  - Using multiple **catch** blocks to catch different types of Exceptions.



- This is the hierarchy of Exception classes.
- **Checked** means the exceptions that are checked during compile-time. i.e. IOException, ClassNotFoundException, SQLException
- **Unchecked** means the exceptions that are occur during the run-time i.e. NullPointerException, ArithmeticException, ArrayIndexOutOfBoundException ..etc etc

```
class MyException extends Exception {
    public MyException(String msg) {
        super(msg);
    }
}
public class Demo {
    Run | Debug
    public static void main(String[] args) {

        int i = 6, j = 2;
        try {
            if (j == 1)
                throw new MyException(msg:"Denominator is not allowed to be 1");
            i = i / j;
        } catch (ArithmeticException e) {
            System.out.println(x:"arithmetic exception");
            e.printStackTrace();
        } catch (MyException e) {
            System.out.println(x:"my custom exception");
            e.printStackTrace();
        } catch (Exception e) {
            System.out.println(x:"default exception");
            e.printStackTrace();
        } finally {
            System.out.println(x:"and yayy! finally block got executed.");
        }
```

- **throw Keyword**

```
public class Exceptionss {
    Run | Debug
    public static void main(String[] args) {
        int i = 5, j = 0;

        try {
            if (j == 0)
                throw new ArithmeticException(s:"J cannot be zero!");
            j = 20 / i;
        } catch (ArithmeticException e) {
            j = 20 / 1;
            System.err.println("Set j's value as default: " + e);
        } catch (Exception e) {
            System.err.println("Something went wrong\n" + e);
        }
        System.err.println("j = " + j);
        System.err.println(x:"Bye");
    }

}
```

- We can throw any kind of exception we want by giving some customized error message.

```
class MyException extends Exception {
    public MyException(String string) {
        super(string);
    }
}

public class Exceptionss {
    Run | Debug
    public static void main(String[] args) {
        int i = 5, j = 0;

        try {
            if (j == 0)
                throw new MyException(string:"J cannot be zero!");
            j = 20 / i;
        } catch (MyException e) {
            j = 20 / 1;
            System.err.println("Set j's value as default: " + e);
        } catch (Exception e) {
            System.err.println("Something went wrong\n" + e);
        }
        System.err.println("j = " + j);
        System.err.println(x:"Bye");
    }

}
```

- It is a **custom exception**.

- You need to inherit the **Exception** class or can also inherit **RuntimeException** class; and pass the string to the super class's constructor because those Exception classes handles this message.

```
$ java Exceptionss
Set j's value as default: MyException: J cannot be zero!
j = 20
Bye
```

- **throws keyword** (written in **method** level, not **class** level)
  - **throws** required only for **checked** exception. For **unchecked** exception by default it populate back.
  - Let suppose, in a method **A** , you are calling 2 methods **B** and **C**.
  - **B** and **C** both are having a critical expression that might throw the same Exception.
  - So, instead of handling those inside **B** and **C** both, we can handle those inside **A** directly.
  - For this, **throws** keyword will be used in **B** and **C**.
  - It is used to forward the Exception to the method where the current method is called.
  - Lets **A** is being called in some another method **X**, if you mention the keyword **throws** in the method **A** as well, then the Exception occurred from **B** and **C** will go to **A** then it'll go to **X**.

```
class A {
    public void show() {
        try {
            Class.forName(className:"NoClass");
            System.err.println(x:"Class found!");
        } catch (ClassNotFoundException e) {
            System.err.println("Not able to find the class; " + e);
        }
    }
}

public class Exceptionss {
    Run | Debug
    public static void main(String[] args) {
        A obj = new A();
        obj.show();
    }

}
```

  - Simple code only; exception will be thrown inside the **show()** method and will be handled there only.

```java
class A {
    public void show() throws ClassNotFoundException {
        Class.forName(className:"NoClass");
    }
}

public class Exceptionss {
    Run | Debug
    public static void main(String[] args) {
        A obj = new A();

        try {
            obj.show();
            System.err.println(x:"Class found!");
        } catch (ClassNotFoundException e) {
            System.err.println("Not able to find the class; " + e);
        }
    }

}
```

- So, like this you can use **throws** to forward the Exception to calling method.

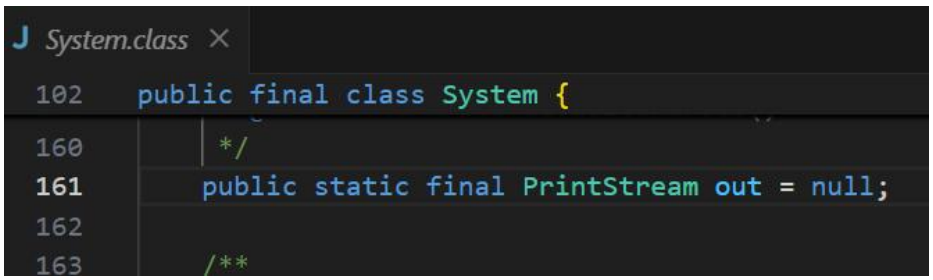
```java
class A {
    public void showA() throws ClassNotFoundException {
        Class.forName(className:"NoClass");
    }
}
class B {
    public void showB() throws ClassNotFoundException {
        A obj = new A();
        obj.showA();
    }
}
class C {
    public void showC() throws ClassNotFoundException {
        B obj = new B();
        obj.showB();
    }
}
public class Exceptionss {
    Run | Debug
    public static void main(String[] args) {
        C obj = new C();

        try {
            obj.showC();
            System.err.println(x:"Class found!");
        } catch (ClassNotFoundException e) {
            System.err.println("Not able to find the class; " + e);
        }
    }
}
```

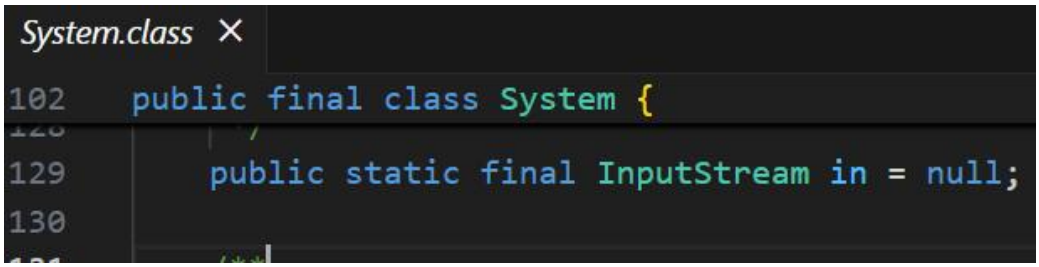
- Here the exception flows from A to Exceptionss class:
  - A's showA ⇒ B's showB ⇒ C's showC ⇒ Exceptionss's main

- In the following case it'll give error.

```
public static void methodC() throws Exception {
    System.out.println(x: "Inside methodC");
    throw new ClassNotFoundException(s: "nothing found!");
}

public static void methodB() throws ClassNotFoundException {
    System.out.println(x: "Inside methodB");
    methodC();
}

public static void methodA() throws ClassNotFoundException {
    System.out.println(x: "Inside methodA");
    methodB();
}
```

- Here **method** is throwing **Exception** (superclass) but **methodB** only handling **ClassNotFoundException** which is one child class of **Exception**.

- **User Input**
  - When we write **System.out.println("…")** it prints something in the CLI.
  - Here, **System** is a class where there is a *static variable* which is **out**.
    - 

  - And, this **out** variable is of type **PrintStream**.
    - Inside the class **PrintStream**, there is a method which is **println**,
    - This is how, **System.out.println** works.
  - Just like that **out** variable, another variable is there inside the **System** class which is **in**
    - 

    - It is of type **InputStream**
  - Inside the class **InputStream**, so many methods are there like *read, readAllBytes* etc etc.
  - 

    - As we can see, it is saying that **read** method might throw **IOException** (it is a checked exception; so it'll give error during compilation)
  - Just to handle this temporarily, I am appending the **throws** keyword in the main method (It is not at all preferable; because if the **main** method throws the exception, it'll go to JVM directly and the application will stop).

```java
import java.io.IOException;

public class UserInput {

    Run | Debug
    public static void main(String[] args) throws IOException {
        System.out.println(x:"Hello");

        int val = System.in.read();
        System.out.println("val = " + val);
    }
}
```

- Now the compilation error gone.

```
alokr@Alok MINGW6
 (main)
$ java UserInput
Hello
abcd
val = 97
```

  - It'll just return the ASCII value of the first character (here 'a')

```java
public static void main(String[] args) throws IOException {
    BufferedReader bf = new BufferedReader(new InputStreamReader(System.in));
    System.out.print(s:"Enter a string: ");
    String line = bf.readLine();
    System.out.println("line = " + line + "\n");

    System.out.print(s:"Enter a number: ");
    int val = Integer.parseInt(bf.readLine());
    System.out.println("val = " + val + "\n");

    BufferedReader bf2 = new BufferedReader(new FileReader(fileName:"./test.txt"));
    System.out.println(x:"Reading a file....");
    String fileLine = bf2.readLine();
    while (fileLine != null) {
        System.out.println("fileLine = " + fileLine);
        fileLine = bf2.readLine();
    }

    bf.close();
    bf2.close();
}
```

```
$ java UserInput
Enter a string: Alok Ranjan
line = Alok Ranjan

Enter a number: 974545
val = 974545

Reading a file....
fileLine = it is alok
fileLine = it is a normal text file.
```

(Output)

- It is how we can take input from user using **BufferedReader**.
- **BufferedReader** constructor takes an Reader type argument.
  - First case, I took **InputStreamReader**, it'll be used to take user's input from terminal.
  - Second case, I took **FileReader**, it'll be used to read a file.
- Here **bf** and **bf2** (BufferedReader instance) are resources. So whenever you create these, you have to close it as well.
  - It'll not give any error, but it is a good idea to close the resources.

```
public static void main(String[] args) throws IOException {
    Scanner sc = new Scanner(System.in);

    System.out.print(s:"Enter a number: ");
    int num = sc.nextInt();
    System.out.println("num = " + num + "\n");

    sc.nextLine();

    System.out.print(s:"Enter a string: ");
    String str = sc.nextLine();
    System.out.println("str = " + str + "\n");

    sc.close();
```

```
$ java UserInput
Enter a number: 8547
num = 8547

Enter a string: abcdef
str = abcdef
```

(Output)

- Here you must be thinking why we have written **sc.nextLine()** in between.
  - When you give input and hit *Enter*, the next **sc.nextLine()** will take that as its input.
  - So, you can't take the input for the string here because it'll take that ***\n*** *(Enter)* as its input.

```
$ java UserInput
Enter a number: 9475
num = 9475

985
Enter a string: str =


alokr@Alok MINGW64 /c/
```

(it would have occurred without that middle **sc.nextLine()**)

- **Try with Resources**
  - There is a keyword **finally**; this block executes even if the Exception occurred (catch) or not (try).
  - Even you can just run **try** and **finally** without **catch**.
  - The finally block is mostly used to *close the resources*.
  - Without this **finally** block, we would have to close the resources on both **try** and **catch** blocks.

```
public static void main(String[] args) {
    Scanner sc = null;
    try {
        sc = new Scanner(System.in);
        System.out.print(s:"Enter a number: ");
        int num = sc.nextInt();
        System.out.println("num = " + num + "\n");
    } finally {
        System.out.println(x:"Closing the resource...");
        sc.close();
    }
```

  - This is how we can use the finally block to close the resources.

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

    try (Scanner sc = new Scanner(System.in)) {
        System.out.print(s:"Enter a number: ");
        int num = sc.nextInt();
        System.out.println("num = " + num + "\n");
    }
```

  - It is a short syntax.
  - Here, after the try block is completed, the resource will be closed automatically.
  -
```
public final class Scanner implements Iterator<String>, Closeable {
```
  -
```
public interface Closeable extends AutoCloseable {
```
  - You can see, the Scanner class's ancestor is the AutoClosable interface, so it'll be automatically closed.

- **Threads**
  - There is a class **Thread** in java, which has a method called **start()**.
    - This **start()** method call a method whose name is **run()**.
    - So, if you want to run a method in a thread, then you need to give **run** as the method name.
    - Below is the example of threads:

```
class A extends Thread {
    public void run() {
        for (int i = 1; i <= 20; i++)
            System.err.println(x:"--A--A--A--");
    }
}

class B extends Thread {
    public void run() {
        for (int i = 1; i <= 20; i++)
            System.err.println(x:"B--B--B--B");
    }
}

public class ThreadPractice {
    Run | Debug
    public static void main(String[] args) {
        A ob1 = new A();
        B ob2 = new B();

        ob1.start();
        ob2.start();
    }
}
```

```
B--B--B--B
--A--A--A--
--A--A--A--
--A--A--A--
--A--A--A--
--A--A--A--
--A--A--A--
--A--A--A--
--A--A--A--
--A--A--A--
--A--A--A--
B--B--B--B
B--B--B--B
B--B--B--B
```

      - Output is not continuous like --A--, --B--, --A--, --B-- like this
    - If your CPU has **n** cores, then **n** threads can be run at a same time.
      - In modern systems, *1* core may be able to run *2 or more* threads at a same time.

```
A ob1 = new A();
B ob2 = new B();

System.err.println(ob1.getPriority()); // 5
System.err.println(ob2.getPriority()); // 5
```

    - The priority range is from **0 to 10**.
      - **0** is least priority and **10** is highest priority.
    - To set the priority, we can use **setPriority** method.

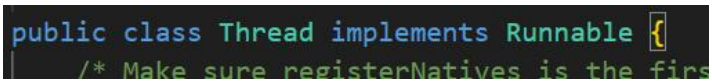
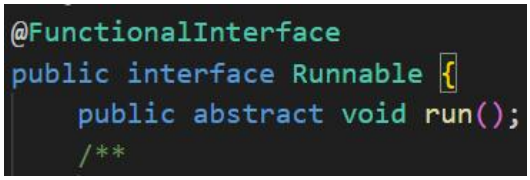
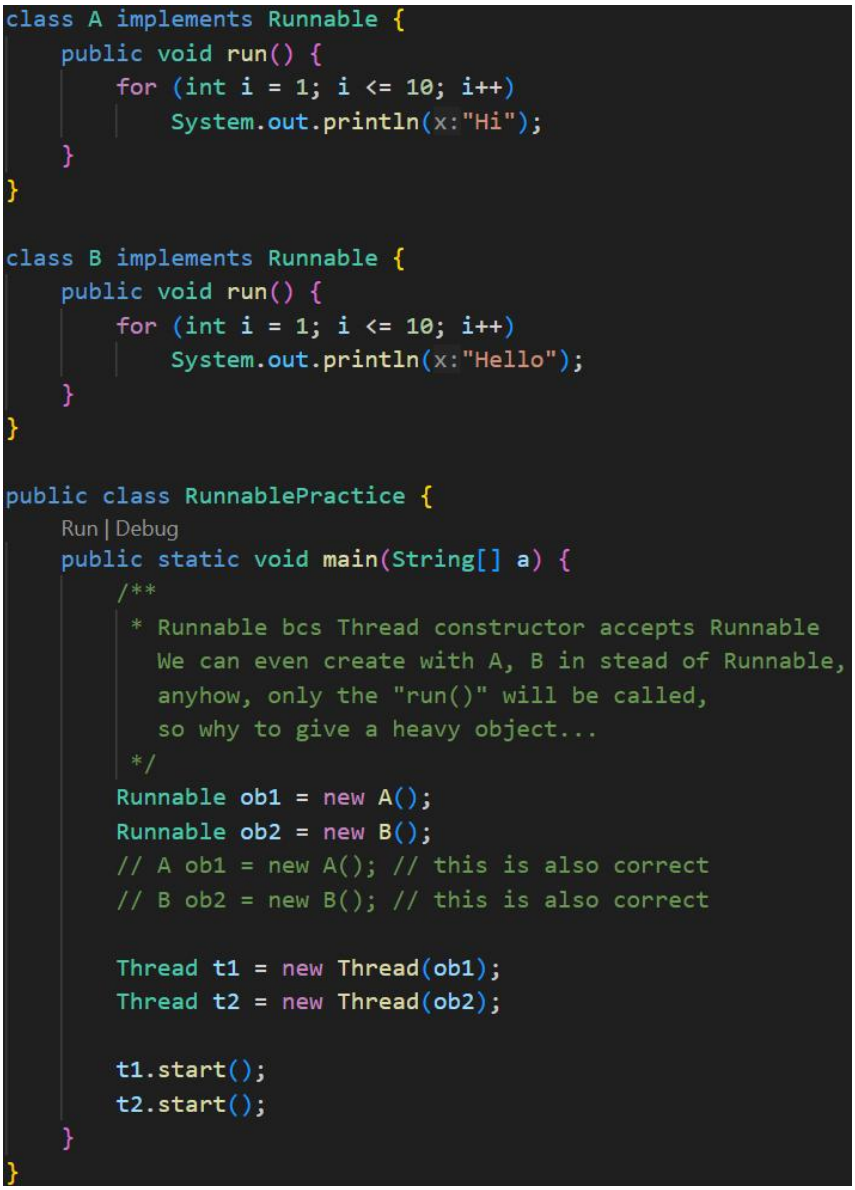
```java
class A extends Thread {
    public void run() {
        for (int i = 1; i <= 10; i++) {
            System.err.println(x:"Hi");
            try {
                Thread.sleep(millis:10);
            } catch (InterruptedException e) {
                e.printStackTrace();
            }
        }
    }
}
class B extends Thread {
    public void run() {
        for (int i = 1; i <= 10; i++) {
            System.err.println(x:"Hello");
            try {
                Thread.sleep(millis:10);
            } catch (InterruptedException e) {
                e.printStackTrace();
            }
        }
    }
}
```

```java
public class ThreadPractice {
    Run | Debug
    public static void main(String[] a) {
        A ob1 = new A();
        B ob2 = new B();
        ob1.setPriority(Thread.MAX_PRIORITY);

        ob1.start();
        ob2.start();
    }
}
```

- (System.out, not System.err (minor mistake :))
- Here, I gave some sleep to make the output alternate Hi, Hello, Hi, Hello.. like this.

```
Hello
Hi
Hi
Hello
Hi
Hello
```

- (you can just optimize it; how it'll work can't control)
- In above case, might be both the run came to the scheduler to get executed after their respective sleep of 10 milliseconds (mentioned in code), then scheduler might have given someone.

- **Runnable vs Thread**
  - It is not a good idea to inherit the **Thread** class to make a thread.
  - Because, if the class has to inherit some other class, then it can't be done in this case.
  - 
    ```
    public class Thread implements Runnable {
        /* Make sure registerNatives is the firs
    ```
    - The **Thread** class implements an *functional* interface **Runnable**, and the **run** method is present inside the **Runnable** interface only.
    - 
      ```
      @FunctionalInterface
      public interface Runnable {
          public abstract void run();
          /**
      ```
  - 
    ```
    class A implements Runnable {
        public void run() {
            for (int i = 1; i <= 10; i++)
                System.out.println(x:"Hi");
        }
    }

    class B implements Runnable {
        public void run() {
            for (int i = 1; i <= 10; i++)
                System.out.println(x:"Hello");
        }
    }

    public class RunnablePractice {
        Run | Debug
        public static void main(String[] a) {
            /**
             * Runnable bcs Thread constructor accepts Runnable
               We can even create with A, B in stead of Runnable,
               anyhow, only the "run()" will be called,
               so why to give a heavy object...
             */
            Runnable ob1 = new A();
            Runnable ob2 = new B();
            // A ob1 = new A(); // this is also correct
            // B ob2 = new B(); // this is also correct

            Thread t1 = new Thread(ob1);
            Thread t2 = new Thread(ob2);

            t1.start();
            t2.start();
        }
    }
    ```
  - It is how **Runnable** and **Thread** work.

```java
public class RunnablePractice {
    Run | Debug
    public static void main(String[] a) {
        Runnable ob1 = () -> {
            for (int i = 1; i <= 10; i++)
                System.out.println(x:"Hi");
        };
        Runnable ob2 = () -> {
            for (int i = 1; i <= 10; i++)
                System.out.println(x:"Hello");
        };

        Thread t1 = new Thread(ob1);
        Thread t2 = new Thread(ob2);

        t1.start();
        t2.start();
    }
}
```

(using lambda expression)

- **Some subtle links between Thread and Runnable**

```java
public Thread(ThreadGroup group, Runnable target, String name,
              long stackSize) {
    this(group, target, name, stackSize, acc:null, inheritThreadLocals:true);
}
```

  - This is the main constructor of the Thread class.
  - **target** is of **Runnable** type.
- When we extend the Thread class by any custom class, by default the default constructor of the Thread class (non-parameterized constructor) gets called.

```java
public Thread() {
    this(group:null, target:null, "Thread-" + nextThreadNum(), stackSize:0);
}
```

  - It is the default constructor of Thread class.
  - Here we can see, the target is null.
- So, when we extends Thread class from our class, the **target** is **null**.
- Also there is a **run()** method inside the Thread class which overrides the **run()** method of the interface **Runnable**.

```java
@Override
public void run() {
    if (target != null) {
        target.run();
    }
}
```

- In case of extending Thread class, we override this **run()** method, so that our **run()** method (present in our class) will get executed.

- One more constructor inside Thread is there which accepts **target** .

```
public Thread(Runnable target) {
    this(group:null, target, "Thread-" + nextThreadNum(), stackSize:0);
}
```

- So, if we are not extending the class, we need to pass a **Runnable** type object inside the Thread constructor while initializing.
- Our custom class can implement the **Runnable** interface and that object can be passed inside the **Thread** class's constructor.

- In simple words:
  - **start()** method will trigger the **run()** method of **Thread** class.
  - In case of inheriting, the **run()** method of **Thread** class is overridden by our own class. So, our **run()** method gets executed.
    - Runnable's run() --- Thread's run() --- CustomClass's run()
      - This is the **overriding** hierarchy.
  - In case of implementing runnable, the **run()** method of **Thread** class doesn't get overridden, so the **start()** method will call **run()** method of **Thread** class as it is. As this **run()** method is running **target.run()**, i.e. its running the **run()** method of the **Runnable**, (and our own class has overridden the **run()** method of runnable), so our **run()** method gets executed.
    - Runnable's run() --- CustomClass's run()
      - These are same as **Thread's target.run**

- **Race Condition**
  - When 2 threads are running, they should not modify one variable at the same time.
  - Like imagine transacting to 2 different persons from the same bank account at the same time, it'll cause issues.
  - When you start the threads in side a method, the method doesn't stop there and execute the remaining code after starting the thread.
    - If you want to execute the statements after the threads are complete, then use **join()** method.

```
class Counter {
    int count;
    Counter() {
        this.count = 0;
    }
    public void increment() {
        this.count++;
    }
}
public class RacePractice {
    Run | Debug
    public static void main(String[] args) throws InterruptedException {
        Counter c = new Counter();

        Runnable ob1 = () -> {
            for (int i = 1; i <= 5000; i++)
                c.increment();
        };
        Runnable ob2 = () -> {
            for (int i = 1; i <= 5000; i++)
                c.increment();
        };

        Thread t1 = new Thread(ob1);
        Thread t2 = new Thread(ob2);

        t1.start();
        t2.start();

        t1.join();
        t2.join();

        System.err.println(c.count);
    }
}
```

    - This code should give the output *10000*, but the output will not be consistent.

```
$ for((i=1;i<=5;i++)); do java RacePractice; done
10000
8631
10000
10000
8705
```

- I ran for 5 times, the results are inconsistent.

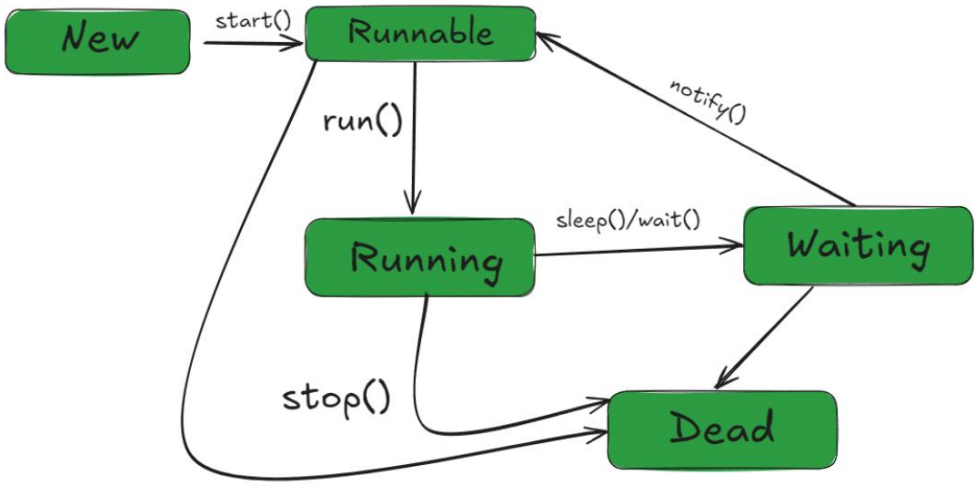
- It is happening because, at sometimes, both the threads are executing the **increment()** method at same time;
  - Lets value of count was *100* at a time, both executed *increment()* method at that time.
  - So, now, instead of 102, the value of count became 101.
  - This is the cause of the inconsistent result.
- There is a keyword called **synchronized**, it doesn't allow the method to be called 2 times at once.

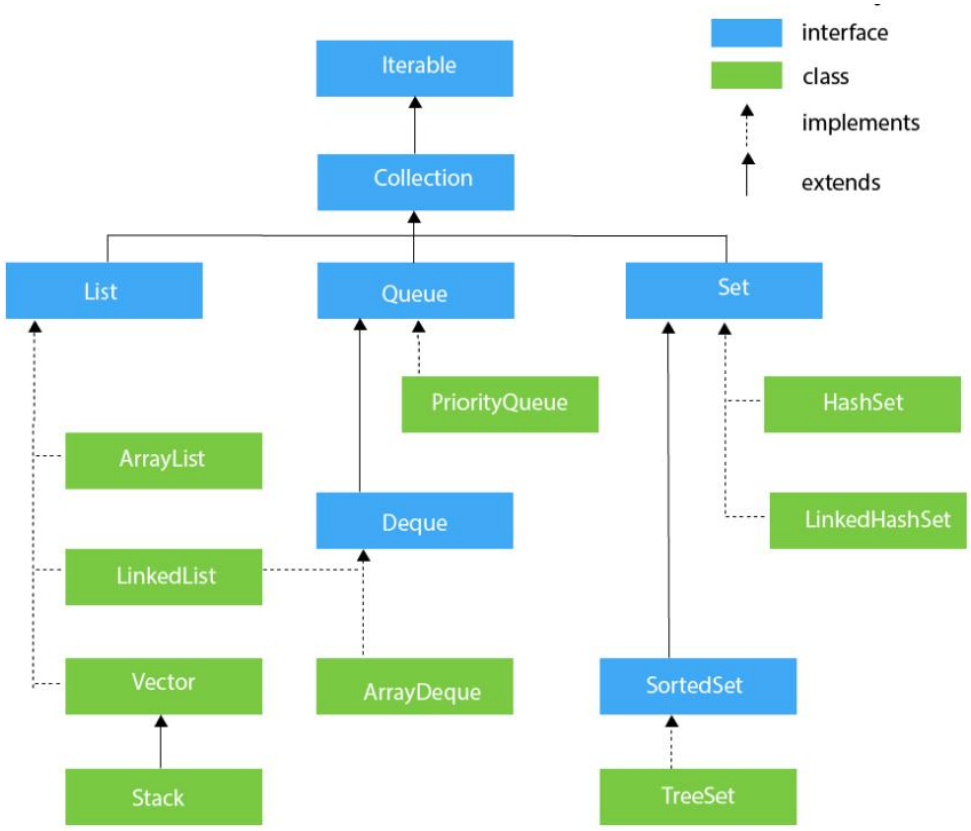
```
public synchronized void increment() {
    this.count++;
}
```

```
dv_java (main)
$ for((i=1;i<=5;i++)); do java RacePractice; done
10000
10000
10000
10000
10000
```

- Now, the result is consistent.

Thread States



- **Collection API**
  - Collection API : concept
  - Collection : interface
  - Collections : class
  - 

- **ArrayList**

```
public static void main(String[] args) {
    Collection nums = new ArrayList();
    for (int i = 1; i <= 10; i++)
        nums.add(i);

    System.err.println(nums);
}
```

  - Here, you can directly print the object.

```
$ java ArrayListPractice
[1, 2, 3, 4, 5, 6, 7, 8, 9, 10]
```

  - Here you can't access the values like **nums[2]**
  - You can use **nums.get(2)** to get the value at index-2.
  - In the above code, we have taken **nums** as **Collection** type. In that *Collection* interface, there is no method called **get()**.
  - The type of nums should be **List** or **ArrayList** or something like that.

```
public static void main(String[] args) {
    Collection<Integer> nums = new ArrayList<Integer>();
    for (int i = 1; i <= 10; i++)
        nums.add(i);

    System.err.println(nums);
}
```

  - The warning that was coming before, was due to not specifying the type.
  - Note: here you can use Wrapper type (Integer, Double etc.) not primitive type (int, double etc).

```
public static void main(String[] args) {
    List<Integer> nums = new ArrayList<Integer>();
    for (int i = 1; i <= 10; i++)
        nums.add(i);

    for (int i = 0; i <= nums.size(); i++)
        nums.get(i);
}
```

  - Now we used **List** in place of **Collection**, so we can use the **get()** method now.

- **Set**
  - Whenever you add some values in a set, sometimes it looks like sorted; but it is **concidence**.
    - Internally, it stores elements in a hash table based on the element's hash code.
    - The iteration order you see depends on how the hash table buckets are organized.
  -
```
public static void main(String[] args) {
    Set<Integer> st = new HashSet<Integer>();
    int[] arr = { 62, 54, 82, 21 };

    for (int x : arr)
        st.add(x);

    for (int val : st)
        System.err.println(val);
}
```
  -
```
$ java SetPr
82
21
54
62
```
    - **Set** is interface; **HashSet** is class
  - If you want a sorted set, then go for **TreeSet** instead of **HashSet**
    -
```
public static void main(String[] args) {
    Set<Integer> st = new TreeSet<Integer>();
    int[] arr = { 62, 54, 82, 21 };

    for (int x : arr)
        st.add(x);

    for (int val : st)
        System.err.println(val);
}
```
```
$ java
21
54
62
82
```

- **Map**

```
public static void main(String[] args) {
    Map<String, Integer> students = new HashMap<>();

    students.put(key:"Alok", value:24);
    students.put(key:"Kanha", value:28);
    students.put(key:"Ram", value:30);

    System.err.println(students); // {Alok=24, Kanha=28, Ram=30}
    System.err.println(students.get(key:"Alok")); // 24

    for (String key : students.keySet())
        System.err.print(key + " "); // Alok Kanha Ram
    System.err.println();

    for (int value : students.values())
        System.err.print(value + " "); // 24 28 30
    System.err.println(x:"\n");

    for (String key : students.keySet())
        System.err.println(key + " : " + students.get(key));
    // Alok : 24
    // Kanha : 28
    // Ram : 30

}
```

  - The **HashMap** is not **synchronized**.
  - To use **synchronized** version, use **HashTable**.

- **Comparator vs Comparable**
  - The **Collections** class contains **static methods** that operate or returns collections.
  - ```
    @SuppressWarnings({"unchecked", "rawtypes"})
    public static <T> void sort(List<T> list, Comparator<? super T> c) {
        list.sort(c);
    }
    ```
  - This is the **sort()** method.
  - Here **Comparator** is there; Comparator is nothing but a *Functional Interface* containing a **compare()** method.
  - ```
    @FunctionalInterface
    public interface Comparator<T> {
        int compare(T o1, T o2);
    }
    ```
  - In the below code snippet, the list nums will be sorted according to its values.
  - ```
    $ java Demo
    [43, 31, 72, 29]
    [29, 31, 43, 72]
    ```
  - ```
    public static void main(String[] args) {
        List<Integer> nums = new ArrayList<Integer>();
        nums.add(e:43);
        nums.add(e:31);
        nums.add(e:72);
        nums.add(e:29);

        System.err.println(nums);

        // Collection(s); not Collection
        Collections.sort(nums);

        System.err.println(nums);
    }
    ```

- I want to sort the values by their right most digit:

```
public static void main(String[] args) {
    List<Integer> nums = new ArrayList<Integer>();
    nums.add(e:43);
    nums.add(e:31);
    nums.add(e:72);
    nums.add(e:29);

    System.err.println(nums);

    Comparator<Integer> comp = new Comparator<Integer>() {
        @Override
        public int compare(Integer v1, Integer v2) {
            return (v1 % 10) - (v2 % 10);
        }
    };
    Collections.sort(nums, comp); // [31, 72, 43, 29]

    System.err.println(nums);
}
```

```
public static void main(String[] args) {
    List<Integer> nums = new ArrayList<Integer>();
    nums.add(e:43);
    nums.add(e:31);
    nums.add(e:72);
    nums.add(e:29);

    System.err.println(nums);

    Collections.sort(nums, (v1, v2) -> (v1 % 10) - (v2 % 10)); // [31, 72, 43, 29]

    System.err.println(nums);
}
```

  - Using lambda expression.

```
public static void main(String[] args) {
    List<Student> students = new ArrayList<Student>();
    students.add(new Student(age:21, name:"Alice"));
    students.add(new Student(age:19, name:"Bob"));
    students.add(new Student(age:22, name:"Charlie"));
    students.add(new Student(age:20, name:"Diana"));

    for (Student st : students)
        System.err.println(st);

    System.err.println();

    Collections.sort(students);
```

- Here, in case of a list of objects, **sort()** method is not working without passing the **comparator**.

```java
@SuppressWarnings("unchecked")
public static <T extends Comparable<? super T>> void sort(List<T> list) {
    list.sort(c:null);
}
```

- It is the **sort()** method, it requires that the Type (i.e. Integer, Double etc etc) should be of **Comparable**.

```java
@jdk.internal.ValueBased
public final class Integer extends Number
        implements Comparable<Integer>, Constable, ConstantDesc {
    /**
```

- You can see, Integer is implementing **Comparable**; so it can be used in the **sort()** method without passing the *comparator*.

```java
class Student implements Comparable<Student> {
    int age;
    String name;

    public Student(int age, String name) {
        this.age = age;
        this.name = name;
    }

    @Override
    public String toString() {
        return "Student [age=" + age + ", name=" + name + "]";
    }

    @Override
    public int compareTo(Student that) {
        if (this.age > that.age)
            return 1;
        return -1;
    }
}
```

- Now, we implemented the **Comparable** interface in the **Student** class, and overridden the **compareTo** method inside it.
- Now, when we sort without using **comparator**, it'll not give any error.

- **forEach method**

```
default void forEach(Consumer<? super T> action) {
    Objects.requireNonNull(action);
    for (T t : this) {
        action.accept(t);
    }
}
```

  - It accepts a Consumer typed object.
  - **Consumer** is a **functional interface.**
  - **<? super T>** means, type should be T or any of its super class.

```
@FunctionalInterface
public interface Consumer<T> {

    /**
     * Performs this operation on the giver
     *
     * @param t the input argument
     */
    void accept(T t);
```

  - This the abstract method that is to be overridden.

```
public static void main(String[] args) {
    Integer[] nums = { 3, 4, 2, 5, 3, 5 };
    List<Integer> ls = new ArrayList<Integer>();
    for (Integer num : nums)
        ls.add(num);

    ls.forEach(new Consumer<Integer>() {
        public void accept(Integer val) {
            System.err.println(val);
        }
    });
}
```

  - It can also be written like this.

- **Stream API**
  - You'll get a method in the **List** objects called **stream()**.
  - It'll create a **Stream** object containing all the methods that **List** has.
  - Even if you change something inside that **Stream** object, nothing will affect the original list.
  - But the condition is: the Stream object can be used **once**. If you use it more than once, it'll give **Run time exception**.

```
public static void main(String[] args) {
    List<Integer> ls = Arrays.asList(...a:4, 3, 5, 6, 4, 3, 5, 3, 5);

    Stream<Integer> strm = ls.stream();

    strm.forEach(val -> System.err.print(val + " "));
    System.err.println();
    strm.forEach(val -> System.err.print(val + " "));
```

```
$ java Demo
4 3 5 6 4 3 5 3 5
Exception in thread "main" java.lang.IllegalStateException:
stream has already been operated upon or closed
        at java.base/java.util.stream.AbstractPipeline.sourc
eStageSpliterator(AbstractPipeline.java:279)
        at java.base/java.util.stream.ReferencePipeline$Head
.forEach(ReferencePipeline.java:762)
        at Demo.main(Demo.java:15)
```

  - Run-Time exception. Only once the **Stream** object can be used.
  - Using of stream provides so many methods like **map**, **filter**, **flatMap**, **sorted**, ..etc. These are part of **Stream API**, not part of the List or something like that.

```
public static void main(String[] args) {
    List<Integer> ls = Arrays.asList(...a:4, 3, 5, 6, 4, 3, 5, 3, 5);

    Stream<Integer> s1 = ls.stream();
    Stream<Integer> s2 = s1.filter(val -> val % 2 == 0);
    // s1 is used now; can't use it again

    s2.forEach(val -> System.err.print(val + " "));
    // s2 is used now; can't use it again
```

```java
public static void main(String[] args) {
    List<Integer> ls = Arrays.asList(...a:4, 3, 5, 6, 4, 10, 5, 8, 5);

    Integer res = ls.stream()
            .filter(n -> n % 2 == 0)
            .map(n -> n * 2)
            .reduce(identity:0, (a, b) -> a + b);
    System.err.println(res);
```

- As the return types of these **stream api's methods** are Stream only, so we can chain these kind of methods.

- **parallelStream in Java**

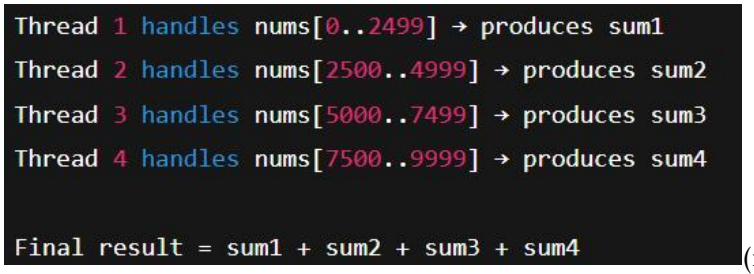
```java
public static void main(String[] args) {
    int size = 10_000; // just to make it eye catching
    List<Integer> nums = new ArrayList<Integer>(size);
    Random ran = new Random();
    for (int i = 1; i <= size; i++)
        nums.add(ran.nextInt(bound:100));

    long t1 = System.currentTimeMillis();
    int sum1 = nums.stream()
            .map(n -> {
                try {Thread.sleep(millis:3);} catch (Exception e) {}
                return n * 2;
            })
            .reduce(identity:0, (a, b) -> a + b);
    long t2 = System.currentTimeMillis();
    int sum2 = nums.parallelStream()
            .map(n -> {
                try {Thread.sleep(millis:3);} catch (Exception e) {}
                return n * 2;
            })
            .reduce(identity:0, (a, b) -> a + b);
    long t3 = System.currentTimeMillis();

    System.err.println("sum1 = " + sum1 + ", sum2 = " + sum2);
    System.err.println("stream : " + (long) (t2 - t1));
    System.err.println("parallelStream : " + (long) (t3 - t2));
}
```

```
$ java Demo
sum1 = 998040, sum2 = 998040
stream : 38450
parallelStream : 2445
```

- parallelStream ran faster (as multiple threads)

- 

(it works like this)

- **Optional class**
  - It's a class just to avoid the **Null Pointer Exception**.
  - ```
    public static void main(String[] args) {
        List<String> names = Arrays.asList(...a:"Alok", "Laxmi", "Ram", "Hari");

        Optional<String> name = names.stream().filter(str -> str.contains(s:"x"))
                .findFirst();
        System.err.println(name.orElse(other:"Not found!"));

        // same only; findFirst() returns a object of tyoe "Optional"
        String name2 = names.stream().filter(str -> str.contains(s:"x"))
                .findFirst().orElse(other:"Not Found");
        System.err.println(name2);
    }
    ```
  -
    ```

- **Method Reference**

```
public static void main(String[] args) {
    List<String> names = Arrays.asList(...a:"Alok", "Laxmi", "Ram", "Hari");
    // converting all to upper case
    List<String> uNames = names.stream()
            .map(str -> str.toUpperCase())
            .toList();
    System.err.println(uNames);
}
```

  - Here, in the **lambda** expression passed inside the **map()** method, we are just calling a **method** i.e. **toUpperCase()** present inside that object i.e. **str**.
  - So, when you are just calling a method of an object, no need to write the full lambda expression. Just pass the reference of that method.

```
public static void main(String[] args) {
    List<String> names = Arrays.asList(...a:"Alok", "Laxmi", "Ram", "Hari");
    // converting all to upper case
    List<String> uNames = names.stream()
            .map(String::toUpperCase)
            .toList();
    System.err.println(uNames);
}
```

  - **::** is used to reference a instance method of a class.

```
public static void main(String[] args) {
    List<String> names = Arrays.asList(...a:"Alok", "Laxmi", "Ram", "Hari");
    names.forEach(System.out::println);
```

  - Now the confusion is: in both the cases, it is acting differently.
    - In first case, its calling that method using the str i.e. str.toUpperCase()
    - But in second case, its calling that method using the object (System.out) provided and passing the str inside it.

    - **NOTE**
    - If the reference is in the form **ClassName::methodName**, the method is called on the object provided by the function (e.g., str.toUpperCase()).
    - If the reference is in the form **objectName::methodName**, the method is called on that object, with the function-provided value passed as an argument (e.g., System.out.println(str)).
    -

- **Constructor Reference**

```
public static void main(String[] args) {
    List<String> names = Arrays.asList(...a:"Alok", "Laxmi", "Ram", "Hari");

    List<Student> students = new ArrayList<Student>();

    students = names.stream()
            .map(name -> new Student(name))
            .toList();

    System.err.println(students);
}
```

  - Here, I am creating a **ArrayList** of type **Student**, from a **List** of type **String**, using **map** function.

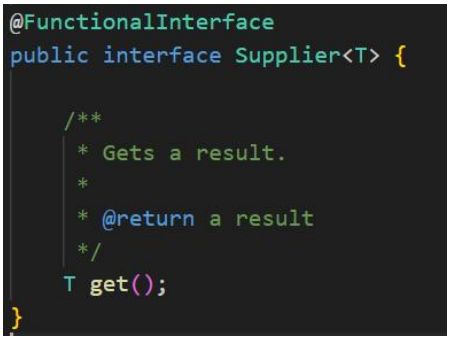
```
public static void main(String[] args) {
    List<String> names = Arrays.asList(...a:"Alok", "Laxmi", "Ram", "Hari");

    List<Student> students = new ArrayList<Student>();

    students = names.stream()
            .map(Student::new)
            .toList();

    System.err.println(students);
}
```

  - It'll do the work.

- **Supplier interface**
  - It is a *functional interface* that provides a **get** method to create something.
  - 

```
@FunctionalInterface
public interface Supplier<T> {

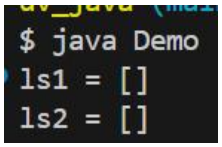
    /**
     * Gets a result.
     *
     * @return a result
     */
    T get();
}
```

  - 

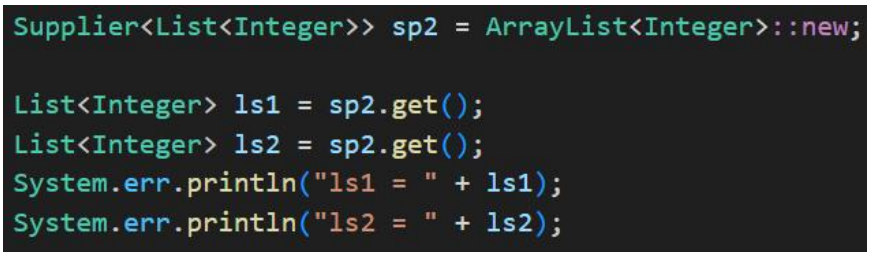
```
Supplier<List<Integer>> sp1 = new Supplier<List<Integer>>() {
    public List<Integer> get() {
        return new ArrayList<Integer>();
    }
};

Supplier<List<Integer>> sp2 = () -> new ArrayList<Integer>();

List<Integer> ls1 = sp2.get();
List<Integer> ls2 = sp2.get();
System.err.println("ls1 = " + ls1);
System.err.println("ls2 = " + ls2);
```

    - Here, I used **sp2** to create 2 **ArrayList<Integer>**
    - 

```
$ java Demo
ls1 = []
ls2 = []
```

  - 

```
Supplier<List<Integer>> sp2 = ArrayList<Integer>::new;

List<Integer> ls1 = sp2.get();
List<Integer> ls2 = sp2.get();
System.err.println("ls1 = " + ls1);
System.err.println("ls2 = " + ls2);
```

    - It can also be written like this using the **Constructor reference**.

- **NOTE:**
  - If you don't specify the type in array list, it'll take that as **raw** type. Means different data type values can be added in the **ArrayList**.
    -
```
ArrayList list1 = new ArrayList();

list1.add(e: "Hello");
list1.add(e: 23);
list1.add(e: 45.56);
list1.add(e: 34.5f);
list1.add(e: 'a');

for (Object val : list1) { // Object bcs there is no specific type defined
    System.out.println(val);
}
```
    -
```
$ javac Test.java && java Test
Note: Test.java uses unchecked or unsafe operations.
Note: Recompile with -Xlint:unchecked for details.
Hello
23
45.56
34.5
a
```

Reflection in Java

- Lets say we have created one object of a class. When we call the method **getClass()** it'll return the **class object** of the class out of which the object is created.
  - For example: lets say the class name is **Car** and we created one object **carObj**.
  - **carObj.getClass()** will give the object which is **Car.class**
  - **Car.class** is the class object of **Car** class.
- The class object is used for reflection.
- Reflection means **inspecting/modifying** classes at **runtime**.
  - Reading fields
  - Modifying fields
  - Invoking methods
  - Listing constructors
  - Creating objects dynamically
  - Reading annotations
- Sometimes you'll get some object at runtime, but you don't know which class does that belong to.
  - In that case you can use **?** type generic
  - ```
    Class<?> clazz = obj.getClass();
    ```
  - ```
    SomeClass obj = new SomeClass();

    Class<?> clazz = obj.getClass();
    Class<?> clazz2 = SomeClass.class;

    System.out.println(clazz == clazz2);  // true
    ```
- There are 2 fields: **getField()** and **getDeclaredField()**
  - **getField()**
    - It cannot access *private* or *protected* fields.
    - It *searches for the field in super classes* as well.
  - **getDeclaredField()**
    - It can access all type of fields.
    - It **doesn't** search in super classes.
  - ```
    Field nameField = clazz.getField(name: "name");
    Field nameField2 = clazz.getDeclaredField(name: "name");
    ```
  - In the class, **name** is a private field of type *String*.
  - **getField()** will not be able to get this. But **getDeclaredField()** can access this.
    ```

```
Field nameField = clazz.getDeclaredField(name: "name");
nameField.setAccessible(flag: true);
```

- Now, I extracted the field **name** from the class using **getDeclaredField()**
- Then I set it accessible using **setAccessible(**true**)** method.
- NOTE: **setAccessible(**true**)** doesn't mean you are making the field public. It just allows you to read/write after getting it.

```
SomeClass obj = new SomeClass();
Class<?> clazz = obj.getClass();

Field nameField = clazz.getDeclaredField(name: "name");
System.out.println(nameField.get(obj));
```

  - This will give error because the **name** field is private.

```
Field nameField = clazz.getDeclaredField(name: "name");
nameField.setAccessible(flag: true);
System.out.println(nameField.get(obj));
```

  - Now it can be accessible because we made it accessible using the method **setAccessible**.

- I have written 2 private methods in the class named as **display** and **randomMethod**

```
private void display() {
    System.out.println(x: "hello");
}

private String randomMethod(String name, int age) {
    return name + " " + age;
}
```

  - Both are private

```
SomeClass obj = new SomeClass();
Class<?> clazz = obj.getClass();

Method displayMethod = clazz.getDeclaredMethod(name: "display");
displayMethod.setAccessible(flag: true);
displayMethod.invoke(obj);
```

  - Here I am getting the **display** method using the function **getDeclaredMethod()** and making it accessible
  - Then **invoke** means it'll run the function. You need to pass the **instance of the class** as it's a non static method.

```
Method otherMethod = clazz.getDeclaredMethod(name: "randomMethod",
                                    ...parameterTypes: String.class, int.class);

otherMethod.setAccessible(flag: true);

Object res = otherMethod.invoke(obj, ...args: "Alok", 34);
System.out.println(res);
```

- As the other method is returning something and also it has some arguments, so we need to pass the **class object** of all the *arguments*.
  - Here *String.class*, *int.class*
- And the **invoke** method returns a Object type value so the *res* is of type Object.
- We can also **downcast** here.

```
Method otherMethod = clazz.getDeclaredMethod(name: "randomMethod",
                    ...parameterTypes: String.class, int.class);

otherMethod.setAccessible(flag: true);

String res = (String) otherMethod.invoke(obj, ...args: "Alok", 34);
System.out.println(res);
```

Reflection in Spring

- Spring uses reflection to inspect classes, discover annotations, create objects, inject dependencies, and call methods — all at runtime.
- Dependency Injection

```
@Autowired
private EmployeeService service;
```
(we write like this)

```
Field f = clazz.getDeclaredField("service");
f.setAccessible(true);
f.set(object, dependencyBean);
```
(internal of spring)

- Reading Annotations

```
@Controller
@Service
@Entity
@Autowired
@RequestMapping
```
(we write these)

```
clazz.getAnnotations();
field.getAnnotations();
method.getAnnotations();
```
(spring does this)

- **ReflectionUtils** is a Spring utility class that makes using Java Reflection easier, safer, and cleaner.
  - Java Reflection = raw, low-level, verbose
  - Spring ReflectionUtils = wrapper that simplifies reflection
- Comparision
  - ```
    Field field = ReflectionUtils.findField(Employee.class, "name");
    ```
    - Spring ReflectionUtils
  - ```
    Field field = Employee.class.getDeclaredField("name");
    ```
    - Java Reflection
- Some advantages of Spring **ReflectionUtils** over Java Reflections
  - It handles exceptions by itself
  - It marks **setAccessible(true)** by default
  - Handles super class traversal as well.
  - Provides iteration helpers
    - ```
      ReflectionUtils.doWithFields(clazz, field -> {
          System.out.println(field.getName());
      });
      ```

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      ```

synchronized

- It is used to lock **class, object, instance method, static method** to make those thread safe.
- Synchronized block with **Class object**.
  - ```
    synchronized (Singleton.class) {
        // class-level lock
    }
    ```
  - It is **class level**, not object level
- Synchronized block with **objects**
  - Synchronized block with **this** (lock itself)
    - ```
      synchronized (this) {
          // same as instan
      }
      ```
    - It is **object level**
  - Synchronized block with **3rd party object** (lock another object)
    - ```
      synchronized (lockObject) {
          // critical section
      }
      ```
    - here **lockObject** is another object
      - ```
        Object lock = new Object();

        synchronized (lock) {
            // thread-safe code
        }
        ```
- Synchronized **instance method**
  - Method can be called once at a time.
  - ```
    public synchronized void method() {
        // critical section
    }
    ```
- Synchronized **static method**
  - Static method can be called once at a time
  - ```
    public static synchronized void method() {
        // critical section
    }
    ```

- **this** vs **3rd party object** **synchronized**
  - **this**
    -
```
class A {
    void m1() {
        synchronized (this) {
            // critical section
        }
    }
}
```
      - Here it is using **this** means this object (object of ***A***) itself will be locked.
      - So, if a thread has called **obA.m1()** then no other method can use **obA** ; different instance of Account can be used.
    -
```
A obj = new A();

Thread T1:
synchronized (obj) {
    // holding obj's lock
}

Thread T2:
obj.m1(); // tries synchronized(this)
```
(pseudocode; not syntax)
      - Here, **T2** will not run, as **obj.m1()** requires the lock on this object **obj** itself, but it is locked by **T1**,
  - **lockObject**
    -
```
class A {
    private final Object lockObject = new Object();

    void m1() {
        synchronized (lockObject) {
            // critical section
        }
    }
}
```
      - Here, **lockObject** (3rd party object present inside class A) is only locked, but **obA** can be used by other threads as this is not locked.

```
A obj = new A();

Thread T1:
synchronized (obj) {
    // holding obj's lock
}

Thread T2:
obj.m1(); // synchronized(lockObject)
```

ع

- Here, **T2** will run because **obj.m1()** requires lock on **lockObject**, and **T1** has locked **obj**.
- **obj** is object of class **A**; **lockObject** is a object present inside class **A**;

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