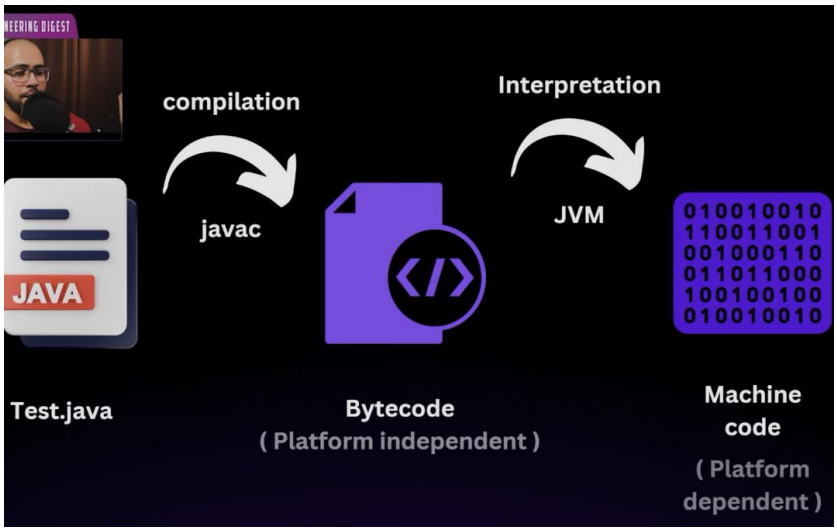
JDK – It includes everything in the JRE, plus tools and utilities for Java development like javac compiler.

JRE – It provides an environment where u can run java programs

JVM – java program runs inside jvm



Javac test.java => produce bytecode in test.class file

Java test => jvm convert to machine code and run it.

JVM also uses JIT compiler to improve performance. Frequently executed code is **compiled to machine code by the JIT compiler** and cached, so subsequent executions are much faster.

```
class Test {
    public static void main(String[] args) {
        System.out.println("Hello world!");
    }
}
```

This is the main method. In Java, the main method is the entry point of a program. It has a specific signature:

public: Access modifier indicating that the method can be accessed from outside the class.

static: Indicates that the method belongs to the class rather than an instance of the class.

void: Specifies that the method does not return any value.
main: The name of the method.

String[] args: The method accepts an array of strings as parameters. This is where command-line arguments can be passed to your program.

Main method is public so that JVM call access this method using ClassName.main() and start executing our program. JVM can call main method without creating object.

```java
public static void main(String[] strings){
        System.out.println("Hello world!");
        System.out.println(strings[0]);
        System.out.println(strings[1]);
}
```

```
C:\Users\Vipul\Documents\Engineering Digest\Java>javac Test.java

C:\Users\Vipul\Documents\Engineering Digest\Java>java Test apple mango
Hello world!
apple
mango
```

Access min and max values like this -

```java
System.out.println(Integer.MIN_VALUE);
System.out.println(Integer.MAX_VALUE);
```

```java
int a = 10; // 4 bytes
long b = a; // 8 bytes
float c = a; // 4 bytes


float f = 1.7f;
int g = f;
```

Java does not automatically convert because there is loss of decimal part, we need to do explicity type casting.

Note :- unsigned right shift (>>>) it fills leftmost bits with 0s

System.out.println(“Arjun”) → out is static member of System class

Println() → it appends new line after printing

Print() → print without appending new line

Printf() → System.out.printf("Name: %s, Age: %d", "Arjun", 25); // Output: Name: Arjun, Age: 25

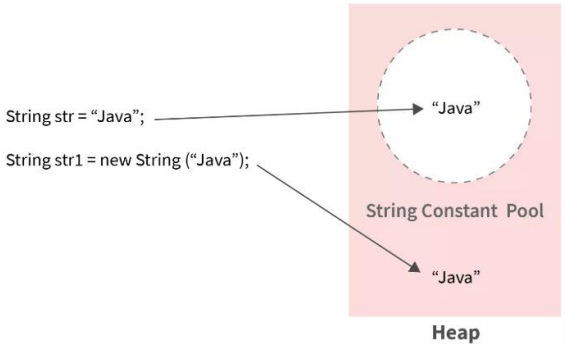
Strings

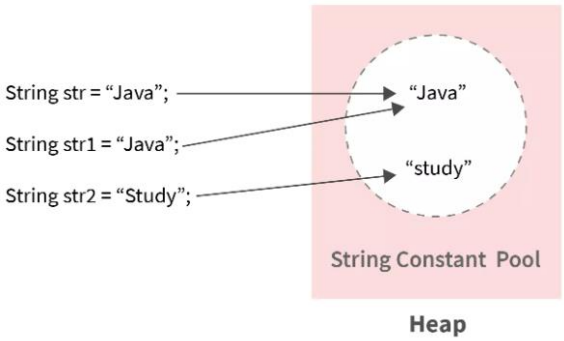
```java
int a=10; // stored in stack memory
Student student = new Student(); // student is reference variable
                                 // memory is allocated in heap
student.name = "Arjun";
student.address = "dda flats";
student.rollno = 16;
```

When we first time write any string literal, then JVM puts that in string pool which is portion in heap memory. And whenever we write that string again, it will point to the same memory location in string pool.

Reference variables are stored in stack memory which points to memory location in heap memory. If a reference variable is an instance variable (i.e., belongs to an object), it is stored in the **heap memory**, as part of the object.

```
String x = "Ram";
String a = new String(x);
String b = new String( original: "Ram");
String c = "Ram";
String d = "Ram";
System.out.println(a == b); // false,   with == we are checking the reference
System.out.println(c == d); // true
```






```
String name = "Ram Sharma";
int length = name.length(); // 10
char c = name.charAt(4); // S
System.out.println("Ram Sharma".equals(name)); // true
System.out.println("ram sharma".equalsIgnoreCase(name)); // true
```

```java
String str1 = "remote";
String str2 = "ramote";
int i = str2.compareTo(str1); // compares lexicographically
System.out.println(i); // -4
System.out.println("AA".compareToIgnoreCase( str: "aa")); // 0

String name = "Arjun Pahadia";
String substring = name.substring( beginIndex: 6); // go till end
String substring2 = name.substring(6, 10); // last index is exclusive
System.out.println(substring); // Pahadia
System.out.println(substring2); // Paha

// these methods create new string, original remains as it is
System.out.println("ARJUN".toLowerCase()); // arjun
System.out.println("arjun".toUpperCase()); // ARJUN
System.out.println("    arjun   ".trim()); // arjun
```

```java
String name = "Amar Panchal";
String newName = name.replace( target: "Panchal", replacement: "Sharma");
System.out.println(newName); // Amar Sharma
System.out.println(name.replace( oldChar: 'a', newChar: 'o').toUpperCase()); // AMOR PONCHOL

System.out.println(name.contains("Pan")); // true
System.out.println(name.startsWith("Am")); // true
System.out.println(name.endsWith("al")); // true
System.out.println("".isEmpty()); // true
System.out.println("    ".isBlank()); // true
System.out.println(name.indexOf('a')); // 2, returns index of first occurrence
System.out.println(name.lastIndexOf( ch: 'a')); // 10
System.out.println(name.indexOf("Pan")); // 5
System.out.println(name.indexOf( str: "a", fromIndex: 5)); // 6
```

```java
int i=10;
String s = String.valueOf(i);
System.out.println(i); // 10
System.out.println(Integer.parseInt( s: "123")); // 123

String formattedStr = String.format("My name is %s and I am %d yrs old", "Arjun", 23);
System.out.println(formattedStr); // My name is Arjun and I am 23 yrs old

String str = "apple,banana,grape";
String[] fruits = str.split( regex: ","); // [apple, banana, grape]

String[] words = {"Java", "is", "awesome"};
String result = String.join( delimiter: " ", words);
System.out.println(result); // Java is awesome

String str1 = "hello";
char[] chars = str1.toCharArray();  // [h, e, l, l, o]
byte[] bytes = str1.getBytes(); // array of Ascii codes of chars
```

Note :-

- A String is immutable, meaning once created, its value cannot be changed. Any modification results in the creation of a new String object. It is thread-safe.
- A StringBuilder is mutable, meaning you can modify its content without creating a new object. It is not thread-safe.
- StringBuffer is mutable, allowing modifications without creating a new object.
  It is thread-safe, meaning all methods are synchronized, making it slower but safe to use in multi-threaded environments.

```java
String s1 = "Hello";
s1 = s1 + ", World"; // new string is created in string pool

StringBuilder sb = new StringBuilder("Hello");
sb.append(", World"); // Modifies the same object

StringBuffer sbf = new StringBuffer("Hello");
sbf.append(", World"); // Modifies the same object
```

Arrays

```java
int array[] = {1,2,3,4,5};
int[] arr = new int[10]; // initial all values 0
// arr is reference variable which points starting address in heap

arr[3] = 100;
System.out.println(arr.length); // 10
for(int i:arr){
    System.out.println(i);
}
System.out.println(Integer.MAX_VALUE); // 2147483647

// 2D array
int[][] arr2 = new int[3][4];
int[][] matrix = {
        {1,2,3},
        {4,5,6},
        {7,8,9}
};

char c[][] = new char[3][];
c[0] = new char[4];
c[1] = new char[3];
c[2] = new char[7];
```

OOPS

It is programming paradigm in which we deals with classes and objects.

Class is a blueprint for objects. Ex – Car has properties like brand, model, color, max speed and has behaviours like accelerate, brake, etc. These properties and behaviours are defined in a blueprint.

We can create multiple objects of Car from Car class which gives blueprint for it.

4 Pillars of OOPS

- **Encapsulation** – Clubing of data and methods into a single unit called class. It focuses on restricting access to data and methods. We achieves it by:

1. Making fields (variables) private
2. Providing public getter and setter methods to access and modify the private fields.

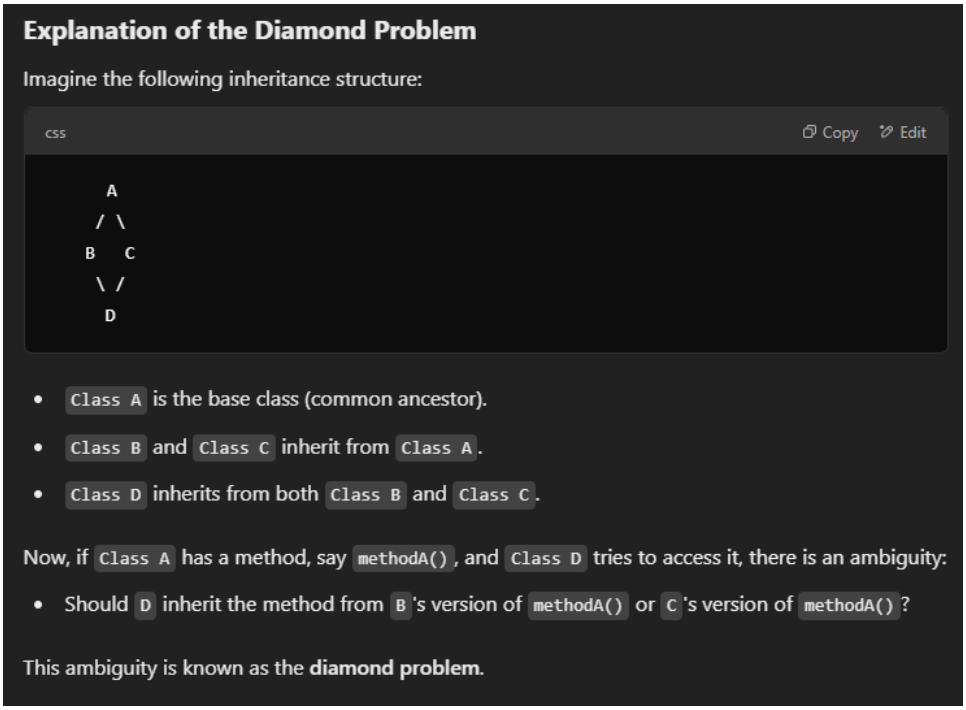
- **Inheritance** – It allows child class to inherit some properties and behaviours from parent class. It helps in code reusability.

Ex -

```java
class Animal{
    String name;
    String age;
}
class Cat extends Animal{
    String breed;
}
```

Types of inheritance :–

1. Single Inheritance - a **child class** inherits from only one **parent class**.
2. Multilevel inheritance - a **class inherits from another class**, and then another class **inherits from it**, forming a chain.
3. Hierarchical inheritance - **multiple child classes inherit from a single parent class**.
4. Multiple Inheritance – Java does not support it to avoid diamond problem. However, Java supports multiple inheritance through interfaces.



Explanation of the Diamond Problem

Imagine the following inheritance structure:

css Copy Edit

```
   A
  / \
 B   C
  \ /
   D
```

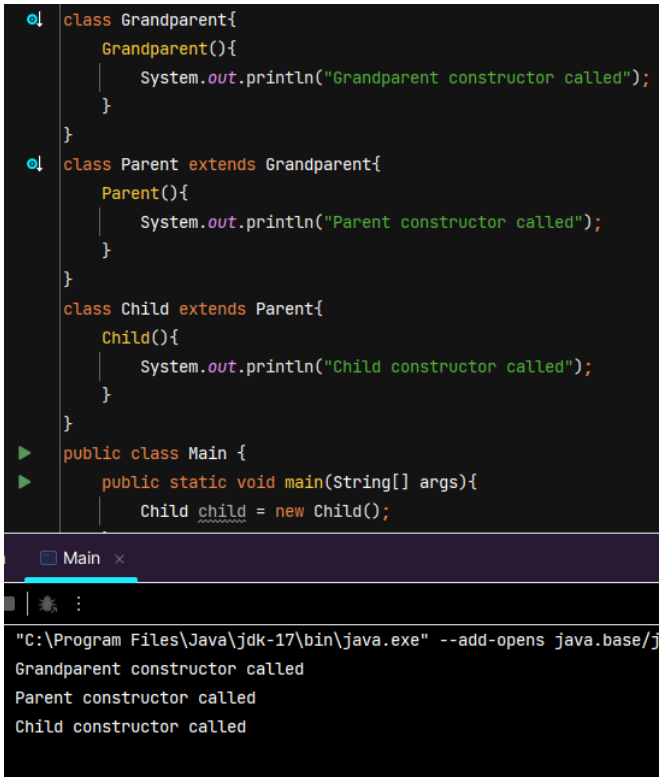
- `Class A` is the base class (common ancestor).
- `Class B` and `Class C` inherit from `Class A`.
- `Class D` inherits from both `Class B` and `Class C`.

Now, if `Class A` has a method, say `methodA()`, and `Class D` tries to access it, there is an ambiguity:

- Should `D` inherit the method from `B`'s version of `methodA()` or `C`'s version of `methodA()`?

This ambiguity is known as the **diamond problem**.

Order of constructor called –



Note :- this keyword refers the current instance of object

Super keyword refers the immediate parent of child class

When a child class constructor is invoked, the compiler **automatically inserts a call to the parent class's no-argument constructor (super())** at the very beginning of the child constructor. We can also do this explicity but it should be done at beginning.

If the parent class does **not** have a no-argument constructor and instead has a parameterized constructor, the compiler **cannot insert super() automatically**. In such cases, you **must explicitly call the appropriate parent class constructor** using super(arguments) and pass the required arguments.

The parent class must initialize its part of the object before the child class can initialize its own fields.

```java
class Parent {
    int data;
    Parent(int n){
        this.data = n;
        System.out.println("Parent constructor called");
    }
    public void parentMethod(){
        System.out.println("Parent method called");
    }
}
class Child extends Parent{
    Child(){
        super( n: 10);
        System.out.println("Child constructor called");
    }
    public void childMethod(){
        System.out.println("child method called");
        super.parentMethod();
    }
}
public class Main {
    public static void main(String[] args){
        Child child = new Child();
        child.childMethod();
    }
}
```

'this' in Parent constructor refers to the child class object as the control flow reached there after we created child class object. No object of parent was created.

O/P →

```
Parent constructor called
Child constructor called
child method called
Parent method called
```

- **Polymorphism** – literally means "many forms". In programming, it means the ability of code to behave differently in different context.

Types –

1. **Compile time –** for a set of code we'll decide at compile time what operation to perform and its behaviour. It can be achieved by method overloading (decide at compile time which function to call based on the parameter)

Method overloading – same name but different parameter list

Ex-

```
public int sum(int a, int b){
    return a+b;
}
public int sum(int a, int b, int c){
    return a+b+c;
}
public float sum(float a, float b){
    return a+b;
}
```

Note :- we differentiate methods based on signature (name + parameter list) not return type.

Error -

```
public int sum(int a, int b){
    return a+b;
}
public float sum(int a, int b){
    return a+b;
}
```

2. **Runtime –** we decide at runtime what operation to perform and the beaviour of code. It can be achieved by method overriding.
   Ex – Dog & Cat class overrides the makeSound() method of parent class Animal.
   Reference variable of parent class can hold the memory address of child class object.

```
class Animal{
    public void makeSound(){
        System.out.println("Some sound");
    }
}
class Cat extends Animal{
    public void makeSound(){
        System.out.println("Meow!");
    }
}
class Dog extends Animal{
    public void makeSound(){
        System.out.println("Woof!");
    }
}
public class Main {
    public static void main(String[] args){
        Animal dog = new Dog();
        dog.makeSound(); // Woof!
    }
}
```

   JVM will decide on runtime whose makeSound() method to call.

   It is also called dynamic method dispatch or Upcasting.

```java
class Parent {
}
class Child extends Parent{
}
public class Main {
    public static void main(String[] args){
        Parent parent = new Child(); // upcasting
        Child child = (Child) parent; // downcasting
    }
}
```

```java
class Parent {
}
class Child extends Parent{
    public void sayBye(){
        System.out.println("Bye");
    }
}
public class Main {
    public static void main(String[] args){
        Parent parent = new Child();
        parent.sayBye();// we only call parent class methods with reference of parent class
    }
}
```

- **Abstraction** – hiding implementation details from end user. Ex- we press the TV remove button to increase/decrease volume but we don't care how remote works internally. We just care about the fact that on pressing the volume should increase/decrease.

  It can be achieved using abstract class. Abstract class can have 0 or more abstract / concrete methods. We cannot make object of abstract class. But we can write constructors for abstract class as it will be used for doing initial setup when instantiating child class objects.

  Abstract classes should not have public constructors. Constructors of abstract classes can only be called in constructors of their subclasses. So there is no point in making them public. The protected modifier should be enough.

  A class which extends an abstract class should either override the abstract methods of parent class or make the child class also abstract.

  Abstract methods of an abstract class should not be private as they wont be accessible outside class. We'll get ERROR

  If u don't mention access modifier (package private) then its child classes in other packages cannot override it as that won't be accessible there. So making it protected can help. (it will

be accessible within same package and inside child classes). Now child classes can override it and write its own implementation.

```java
public abstract class Animal {
    public abstract void sayHello();

    public void sleep(){
        System.out.println("zzz.....");
    }

    public static void main(String[] args) {
        Animal animal1 = new Dog(); // allowed
        Animal animal2 = new Animal(); // not allowed becoz there is no definition for sayHello()
    }
}
class Dog extends Animal{

    @Override
    public void sayHello() {
        System.out.println("Woof!");
    }
}
```

Access Modifier – keywords which describe the visibility of class, method and instance variables.

Private constructor – useful when u create a Utils class having all static methods and singleton class.

```java
public class Utits {
    no usages
    private Utits(){

    }

    no usages
    public static void sayHello(){
        System.out.println("Hello");
    }
    1 usage
    public static void sayBye(){
        System.out.println("Bye...");
    }
}
```

```java
public class School {

    3 usages
    private static School instance;
    1 usage
    private School(){
    }
    1 usage
    public static School getInstance(){
        if(instance == null){
            instance = new School();
        }
        return instance;
    }

}
```

On class we can only have public or default access modifier.

Protected: The access level is within the package and outside the package through child class. If you do not make the child class, it cannot be accessed from outside the package.

Default: The access level of a default modifier is only within the package. It cannot be accessed from outside the package. If you do not specify any access level, it will be the default.

Context\Access Modifier	private	default (no modifier)	protected	public
Same Class	Yes	Yes	Yes	Yes
Same Package	No	Yes	Yes	Yes
Subclass (same package)	No	Yes	Yes	Yes
Subclass (different package)	No	No	Yes	Yes
Different Package (non-subclass)	No	No	No	Yes

Static Keyword

The static keyword in Java is used for memory management primarily.

It can be applied to variables, methods, blocks, and nested classes.

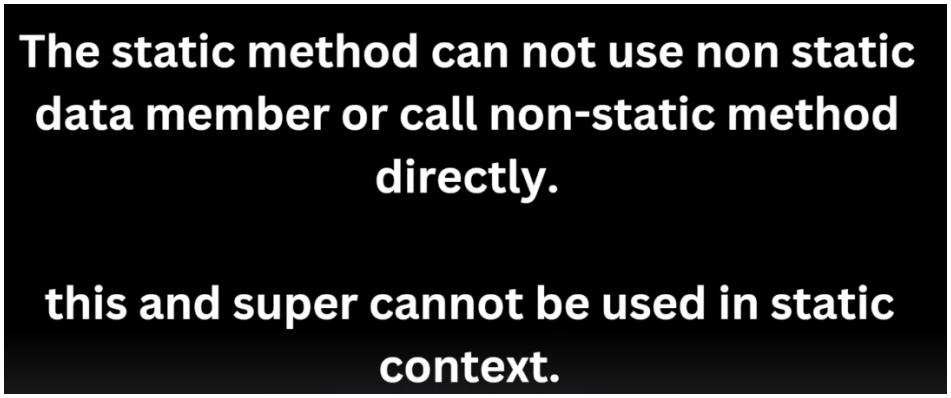
The main concept behind static is that it belongs to the class rather than instances of the class.

Ex –

```
public class Student {

    2 usages
    public static int count = 0;

    5 usages
    public Student() {
        count++;
    }
```

```
Student student1 = new Student();
Student student2 = new Student();
Student student3 = new Student();
Student student4 = new Student();
Student student5 = new Student();
System.out.println(Student.count);
```

O/P → 5



Note :- before any object is created or not, static variables are instantiated first.

Static block is used for performing static initialization, for 1 time setup task.

```java
public class Main {
    public static int count;
    static {
        count = 22;
        System.out.println("Hello from static block");
    }
    public static int getCount(){
        return count;
    }

    public static void main(String[] args){
        System.out.println(Main.getCount());
    }
```

```
Main
"C:\Program Files\Java\jdk-17\bin\java.exe" --add-opens jav
Hello from static block
22
```

Final Keyword

Used with class fields to make them constants.

U can only assign value to a final variable at the time of declaration or in static block or insidde constructor if field is not static.

```
public static final double PI;
static {
    PI = 3.14;
}
```
or
```
public static final double PI = 3.14; // initialise at declaration
static {
    PI = 3.14; // not allowed here
}
```
or
```
public class Main {
    public final double PI ;
    public Main() {
        PI = 3.14;
    }
```

Final keyword can be used with methods if we want that no child class should be alllowed to override the method –

```
class Car{
    public final void airBags(){
        System.out.println("4 airBags");
    }
}
class EV extends Car{
    @Override
    public void airBags(){ // error
        System.out.println("2 airBags");
    }
}
```

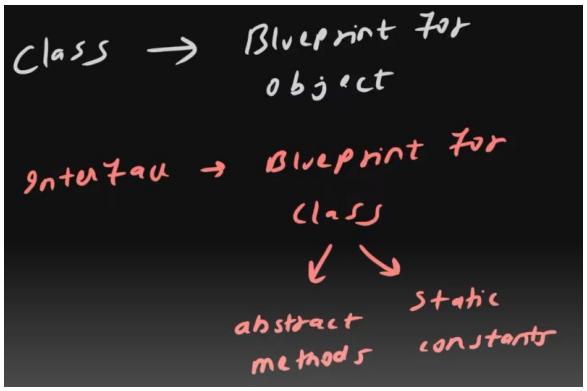
We can also make a class final if we don't want any other class to extend our class –

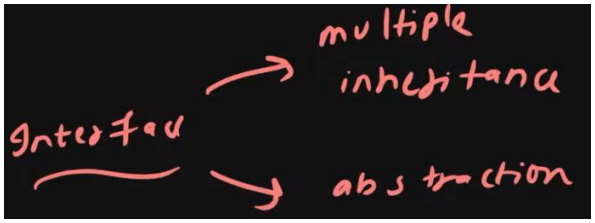
```
final class PremiumCar{
    public final void airBags(){
        System.out.println("4 airBags");
    }
}
class EV extends PremiumCar{ // error
}
```

Using final on constructor makes no sense because we use final to prevent overrriding and constructor is already not inherited. There is not concept of overriding constructors.

```
class PremiumCar{
    public final PremiumCar(){ // error

    }
}
```

Inheritance





Interfaces does not have concrete methods. Classes that implement the interface must provide the implementation for all its abstract methods, ensuring full abstraction.

```java
public interface Animal {
    public static final int MAX_AGE = 100;
    // public, final, static are redundant

    public abstract void eat();
    // modifier public & abstract are redundant

    void sleep();
}
```

Class implementing Animal should either provide implemenation of eat() and sleep() or that class should be declared abstract –

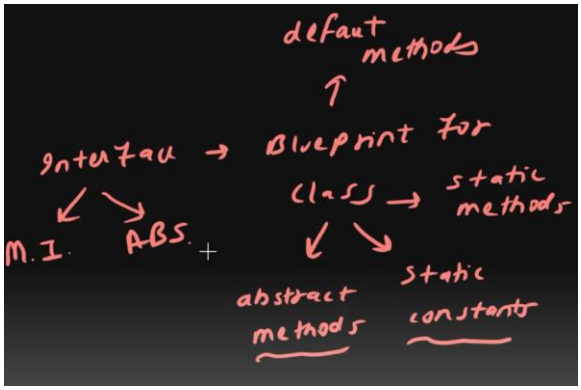
```java
public class Dog implements Animal{
    @Override
    public void eat() {
        System.out.println("dog eat");
    }
    @Override
    public void sleep() {
        System.out.println("dog sleep");
    }
}
```

Or

```java
public abstract class Dog implements Animal{

}
```

```java
public static void main(String[] args){
    Dog dog = new Dog();
    dog.eat();
    System.out.println(Dog.MAX_AGE); // 100
    System.out.println(Animal.MAX_AGE); // 100
}
```

After Java 8, interfaces can have static and default methods –




```java
public interface Animal {
    public static final int MAX_AGE = 100;
    public abstract void eat();
    void sleep();

    public static void info(){
        System.out.println("This is an Animal interface");
    }

    default void run(int n){ // implementation class will inherit default methods
                        // they don't need to override it but can override if they wish

        System.out.println("Running...");
        this.eat(); // here 'this' will point the dog who called run() method
        System.out.println(n);
    }

    public static void main(String[] args) {
        Animal.info(); // This is an Animal interface

        Dog.info(); // Error :- can only be invoked by Interface
        Animal.run(); // not allowed because it is default not static

        Dog dog = new Dog();
        dog.run( n: 10); // Running...
                        // dog eat
                        // 10
    }
}
```

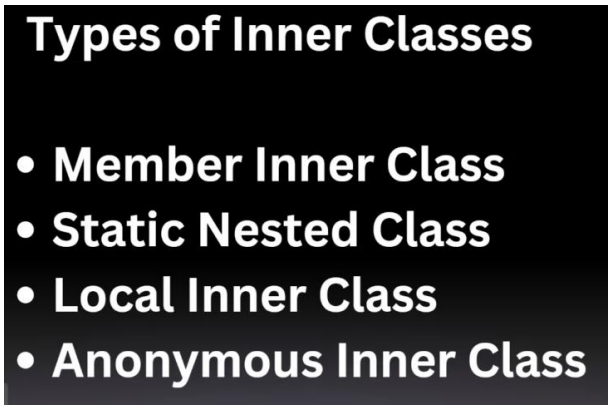
Multiple Inheritance in interfaces –

```java
interface Camera{
    void click();
}
interface MusicPlayer{
    void play();
}
class SmartPhone implements Camera, MusicPlayer{
    @Override
    public void click() {
        System.out.println("photo clicked");
    }
    @Override
    public void play() {
        System.out.println("Playing music");
    }
}
```

Difference between abstract class & Interfaces –

- Abstract class has instance variables and to initialize them it has constructor. But we don't have these in interface
- 1 class only extend only 1 abstract class whereas 1 class and implement multiple interfaces.

Inner Classes



Member Inner Class – Inner will behave as member of outer class. It is associated with instance of outer class. Inside inner class methods we can access fields of outer class.

Engine is acting as a property for Car –

```
public class Car {
    private String model;
    private boolean isEngineOn;
    public Car(String model){
        this.model = model;
        this.isEngineOn = false;
    }

    class Engine{
        void start(){
            if(!isEngineOn){
                isEngineOn = true;
                System.out.println(model + " engine started.");
            }else{
                System.out.println(model + " engine is already on.");
            }
        }

        void stop(){
            if(isEngineOn){
                isEngineOn = false;
                System.out.println(model + " engine stopped.");
            }else{
                System.out.println(model + " engine is already off.");
            }
        }
    }
}
```

```
Car car = new Car( model: "Tata Safari");
Car.Engine engine = car.new Engine();
engine.start();
```

Without using it, our code increases as we need to create separate Engine class having Car as its instance variable –

```
public class Engine {

    9 usages
    private Car car;

    no usages
    public Engine(Car car){
        this.car = car;
    }

    no usages
    public void start() {
        if (!car.isEngineOn()) {
            car.setEngineOn(true);
            System.out.println(car.getModel() + " engine started.");
        } else {
            System.out.println(car.getModel() + " engine is already on.");
        }
    }
```

```
Car car = new Car( model: "Fronx");
Engine engine = new Engine(car);
engine.start();
engine.stop();
```

Static Nested class - It belongs to the outer classs rather than its instance.

```java
public class Computer {
    private String brand;
    private String model;
    private OperatingSystem os;
    public Computer(String brand, String model, String osName) {
        this.brand = brand;
        this.model = model;
        this.os = new OperatingSystem(osName);
    }
    public OperatingSystem getOs() { return os; }

    static class USB{  // it is the part of Class not associated with any instance
        private String type;
        public USB(String type) {
            this.type = type;
        }
        public void displayInfo(){
            System.out.println("USB type: " + type);
        }
    }

    class OperatingSystem{
        private String osName;
        public OperatingSystem(String osName) {
            this.osName = osName;
        }
        public void displayInfo(){
            System.out.println("OS name: " + osName);
        }
    }
}
```

```java
public static void main(String[] args){
    Computer computer = new Computer( brand: "HP",  model: "ABC",  osName: "XYZ");
    computer.getOs().displayInfo();

    Computer.USB usb = new Computer.USB( type: "TYPE-C");
    Computer.USB usb2 = new Computer.USB( type: "TYPE-C");
}
```

Anonymous Inner class – useful when we have to implement an interface without creating its separate implementation class or we have to extend a class without creating its separate child class.

Anonymous because it does not have any name.

Used for creating an object for 1 time use.

```java
interface Payment{
    void pay(double amount);
}

class ShoppingCart{
    private double totalAmount;
    public ShoppingCart(double totalAmount) {
        this.totalAmount = totalAmount;
    }
    public void processPayment(Payment paymentMethod){
        paymentMethod.pay(totalAmount);
    }
}

public class Main {
    public static void main(String[] args){
        ShoppingCart shoppingCart = new ShoppingCart( totalAmount: 150);

        // Creating an object "on the fly" using an anonymous inner class
        shoppingCart.processPayment(new Payment() { // we could create a class implementing
                                                    // Payment interface and then pass its instance
            @Override
            public void pay(double amount) {
                System.out.println("Paying : " + amount + " using PayPal");
            }
        });
    }
```

```java
class Greeting{
    public void sayHello(){
        System.out.println("Hello from Greeting!");
    }
}
public class Main {
    public static void main(String[] args){
        // Creating an anonymous inner class extending Greeting
        Greeting customGreeting = new Greeting(){
            @Override
            public void sayHello(){
                System.out.println("Hello from custom greeting");
            }

            public void sayBye(){
                System.out.println("Bye from custom greeting");
            }
        };
        customGreeting.sayHello(); // Hello from custom greeting
        customGreeting.sayBye();  // ERROR: cannot call new methods of Inner class
                                  // because reference variable is of type Greeting
    }
```

Local Inner Class

Used to encapsulate the logic. Ex - validation logic is tightly coupled with reservation process, so by placing the validation logic inside reserveRoom() we are setting the context that validate() function will only be used inside reserveRoom() method. So place it here only why to keep it outside.

Local Inner class can access all the instance variables of object.

```
class Hotel{
    private String name;
    private int totalRooms;
    private int reservedRooms;
    public Hotel(String name, int totalRooms, int reservedRooms) {
        this.name = name;
        this.totalRooms = totalRooms;
        this.reservedRooms = reservedRooms;
    }
    public void reserveRoom(String guestName, int noOfRooms){
        class ReservationValidator{
            boolean validate(){
                if(guestName==null || guestName.isBlank() || noOfRooms<0 || reservedRooms + noOfRooms > totalRooms){
                    return false;
                }
                return true;
            }
        }
        ReservationValidator validator = new ReservationValidator();
        if(validator.validate()){
            reservedRooms += noOfRooms;
            System.out.println("reservation success");
        }else{
            System.out.println("reservation failed");
        }
    }
}
public class Main {
    public static void main(String[] args){
        Hotel hotel = new Hotel( name: "Sunshine Hotel",  totalRooms: 10,  reservedRooms: 5);
        hotel.reserveRoom( guestName: "Akshit",  noOfRooms: 3); // reservation success
        hotel.reserveRoom( guestName: "Aakash",  noOfRooms: 5); // reservation failed
    }
```

Note :- Java is not a pure object oriented language because it still has primitive data types like int, float, double, etc. In Collection we cannot use primitve data types.

Wrapper Classes – used to wrap primitive data types into an object so that we can use methods on it.

```
int a = 1; // a is primitive variable, data stored in stack memory
Integer b = 2; // b is reference variable of Integer class, data stored in heap
Integer c = Integer.valueOf( i: 3);  // behind the scene this is happening
                                     // we doing explicit boxing which is not needed
Integer n = 4; // Java do Autoboxing
int i = n.intValue(); // Unboxing, this is also done by Java automatically
                      // no need to do explicitly
int j = n;

Integer x = null; // allowed
int y = null; // ERROR

Boolean isAdult = true;
Character ch = 'a';
Float f = 1.2f;
Double d = 1.2;
Long l = 100L;
```

```
public class Test {
    public static void main(String[] args) {
        Student x = new Student();
        x.id = 1;
        fun(x);
        System.out.println(x.id);
    }

    1 usage
    private static void fun(Student a) {
        Student student = new Student();
        student.id = 2;
        a = student;
    }
```

O/P → 1

```
public static void main(String[] args){
    Integer a = 1;
    fun(a);
    System.out.println(a);
}

private static void fun(Integer b) {
    b = 3; // b will start pointing to 3
}
```

O/P → 1

In Java, the Integer class is immutable, meaning its values cannot be changed once they are set. However, when you perform operations on an Integer, a new instance is created to hold the result.

```java
Integer a = 1000, b = 1000, c=1, d=1;
System.out.println(a==b); // false
System.out.println(c==d); // true
// this is because inside Integer.java there is an inner private class, IntegerCache.java
// that caches all Integer objects between -128 and 127.
// If the value is in the range -128 to 127, it returns same instance from the cache.

// comparing values
System.out.println(a.equals(b)); // true
```

Enums – used for storing fixed set of constants

```java
public class Day {
    public static final String SUNDAY = "SUNDAY";
    public static final String MONDAY = "MONDAY";
    public static final String TUESDAY = "TUESDAY";
    public static final String WEDNESDAY = "WEDNESDAY";
    public static final String THURSDAY = "THURSDAY";
    public static final String FRIDAY = "FRIDAY";
    public static final String SATURDAY = "SATURDAY";
}



public enum Day {
    SUNDAY, MONDAY, TUESDAY, WEDNESDAY, THURSDAY, FRIDAY, SATURDAY
}
```

SUNDAY is a Day, MONDAY is a Day, …. They are final instances of Day class

On compile time, Day enum becomes a final class which extends Enum<Day> class –

```java
public final class Day extends java.lang.Enum<Day> {
    public static final Day SUNDAY = new Day("SUNDAY", 0);
    public static final Day MONDAY = new Day("MONDAY", 1);
    public static final Day TUESDAY = new Day("TUESDAY", 2);
    public static final Day WEDNESDAY = new Day("WEDNESDAY", 3);
    public static final Day THURSDAY = new Day("THURSDAY", 4);
    public static final Day FRIDAY = new Day("FRIDAY", 5);
    public static final Day SATURDAY = new Day("SATURDAY", 6);

    private static final Day[] VALUES = { SUNDAY, MONDAY, TUESDAY, WEDNESDAY, THURSDAY, FRIDAY, SATURDAY };

    private Day(String name, int ordinal) {
        super(name, ordinal);
    }

    public static Day[] values() {
        return VALUES.clone();
    }

    public static Day valueOf(String name) {
        for (Day day : VALUES) {
            if (day.name().equals(name)) {
                return day;
            }
        }
        throw new IllegalArgumentException("No enum constant " + name);
    }
```

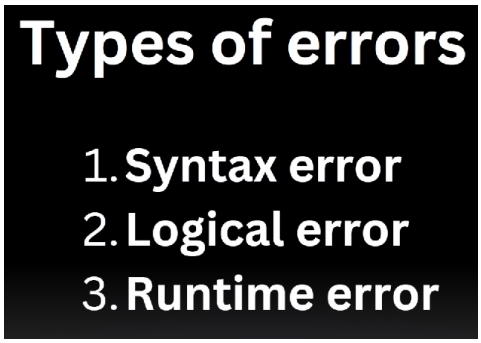
Note :- In enum, the first thing you write should be enum constants. After that we can add fields and methods.

```java
enum Day{
    SUNDAY( lower: "sunday"),
    MONDAY( lower: "monday"),
    TUESDAY( lower: "tuesday"),
    WEDNESDAY( lower: "wednesday"),
    THURSDAY( lower: "thursday"),
    FRIDAY( lower: "friday"),
    SATURDAY( lower: "saturday");

    private String lower;
    private Day(String lower){
        System.out.println("Our custom constructor called");  // this will be printed 7 times
        // by enum constants which are basically objects of Day class are instantiated with parameter
        // and parameterized constructor is called

        this.lower = lower;
    }

    public String getLower() {
        return lower;
    }

    public void display(){
        System.out.println("Today is " + this.name());
    }
}
```

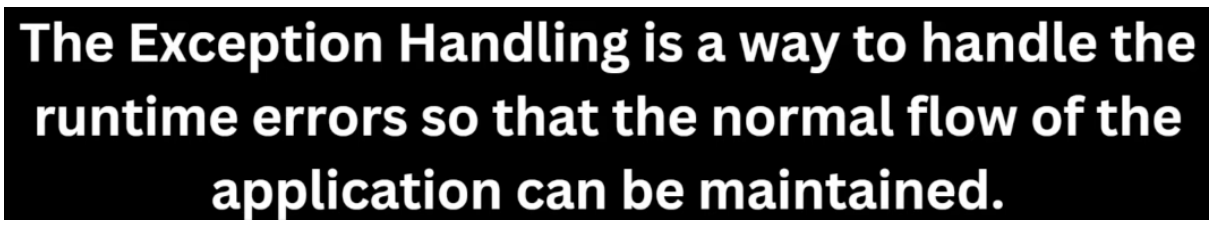
```java
public class Main {
    public static enum Months{ // 'static' is redundant for inner enums
        JAN, FEB, MARCH, APRIL, MAY, JUNE, JULY, AUG, SEPT, OCT, NOV, DEC
    }
    public static void main(String[] args) {
        System.out.println(Months.MAY); // MAY

        Day monday = Day.MONDAY;
        int ordinal = monday.ordinal();
        System.out.println(ordinal); // 1
        System.out.println(monday.name()); // MONDAY
        System.out.println(monday.toString()); // MONDAY

        Day enumDay = Day.valueOf( name: "MONDAY"); // converting string into ENUM
        // if not possible then error

        System.out.println(enumDay); // MONDAY
        enumDay.display(); // Today is MONDAY
        System.out.println(enumDay.getLower()); // monday
```

```java
public static void main(String[] args) {
    Day[] values = Day.values();
    for(Day i: values){
        System.out.println(i); // it will print all
    }

    Day d = Day.MONDAY;
    switch (d){
        case MONDAY:{
            System.out.println("Today is monday");
            break;
        }
        case TUESDAY:{
            System.out.println("Today is tuesday");
            break;
        }
        default:{
            System.out.println("Weekend!!");
        }
    }

    // new switch case syntax after jdk12 return value
    String res = switch (d){
        case MONDAY -> "M";
        case TUESDAY -> "T";
        default -> "weekend";
    };
```

Exception Handling



Program will crash during run time errors.



Exception is an event that disrupts the normal flow of the program. It is an object which is thrown at runtime.

```java
public static int divide(int a, int b) {
    try{
        return a / b;
    }catch (ArithmeticException e){
        System.out.println(e);
        return -1;
    }
}
```

sout() uses toString() method to print object,

```java
public class Student extends Object{
```

2 usages

Class 'Student' explicitly extends 'java.lang.Object'

Remove redundant 'extends Object' Alt+Shift+Ente

Every class extends Object class.

```
java.lang.Object
  └─ java.lang.Throwable
      ├─ java.lang.Error
      |   ├─ java.lang.VirtualMachineError
      |   |   ├─ java.lang.OutOfMemoryError
      |   |   ├─ java.lang.StackOverflowError
      |   ├─ java.lang.LinkageError
      |   |   ├─ java.lang.ClassFormatError
      |   |   ├─ java.lang.NoClassDefFoundError
      └─ java.lang.Exception
          ├─ java.lang.RuntimeException
          |   ├─ java.lang.ArithmeticException
          |   ├─ java.lang.NullPointerException
          |   ├─ java.lang.IndexOutOfBoundsException
          |   ├─ java.lang.IllegalArgumentException
          ├─ java.io.IOException
          |   ├─ java.io.FileNotFoundException
          |   ├─ java.io.EOFException
          ├─ java.sql.SQLException
          ├─ java.lang.reflect.InvocationTargetException
          ├─ java.net.SocketException
          ├─ java.net.UnknownHostException
```

```java
public static int divide(int a, int b) {
    try {
        return a / b;
    } catch (RuntimeException e) {
        System.out.println(e);
        return -1;
    }
}
```

Reference variable of type RuntimeException can point to the object of ArithmeticException.

```java
try {
    Student student = null;
    student.setId(123);
    System.out.println(student.getId());
    return a / b;
} catch (Exception e) {
    System.out.println(e);
    return -1;
}catch (NullPointerException e){
    System.out.println("Null pointer exception :(");
    return -1;
}catch (ArithmeticException e){
    System.out.println("Arithmetic exception :(");
    return -1;
}
```

Error :- exception has already been caught

```java
try {
    Student student = null;
    student.setId(123);
    System.out.println(student.getId());
    return a / b;
}catch (NullPointerException e){
    System.out.println("Null pointer exception :(");
    return -1;
}catch (ArithmeticException e){
    System.out.println("Arithmetic exception :(");
    return -1;
} catch (Exception e) {
    System.out.println(e);
    return -1;
}
```

Correct way of catching exception

```java
try {
    return a/b;
}catch (ArithmeticException | NullPointerException e){
    System.out.println("Some common message");
}
```

Catch multiple exceptions like this.

```java
try {
    return a/b;
}catch (ArithmeticException | RuntimeException e){
    System.out.println("Some common message");
}
```

Error :- Types in multi-catch must be disjoint: 'java.lang.ArithmeticException' is a subclass of 'java.lang.RuntimeException'

Unchecked Exceptions – These exceptions are not being checked at compile time. Ex- ArrayIndexOutOfBound, NullPointerException, etc.

Checked Exceptions – which are checked at compile time.

It will say to handle the exception.

```java
try{
    FileReader fileReader = new FileReader( fileName: "a.txt");
}catch (IOException e){

}
```

Throws – using it we put the responsibility on caller of method to take care of exception. Caller should either use try-catch or throw the exception or else JVM will handle it by terminating the program.

```java
public static void method2() throws FileNotFoundException{
    method1();
}

public static void method1() throws FileNotFoundException{
    FileReader fileReader = new FileReader( fileName: "a.txt");
}
```

Throw – used to forcefully throw exception

```java
public static void method1() throws FileNotFoundException {
    try {
        FileReader fileReader = new FileReader( fileName: "a.txt");
    } catch (FileNotFoundException e) {
        System.out.println("FILE NOT FOUND");
        throw new FileNotFoundException("oops");
    }
}
```

```java
public static void method1() throws FileNotFoundException {
    throw new FileNotFoundException();
}
```
Here we have to use **throws** keyword also because FileNotFoundException is checked exception so we need to make the caller aware about it so that caller will handle it.

But if we **throw** unchecked exception then using **throws** is not necessary –

```java
public static void method1(){
    throw new ArithmeticException();
}
```

When throwing **Exception** we need to use throws because its parent class for checked exceptions -

```java
public static void method1() throws Exception{
    throw new Exception();
}
```

Finally –

```java
try {
    System.out.println("Inside try block");
    int result = 10 / 0;
} catch (ArithmeticException e) {
    System.out.println("Exception caught: " + e);
} finally {
    System.out.println("Inside finally block");
}
```

```
com.engineeringdigest.corejava.innerclasses.Test
C:\Users\Vipul\.jdks\corretto-17.0.11\bin\java.exe "-javaagent:C:\Progr
Inside try block
Exception caught: java.lang.ArithmeticException: / by zero
Inside finally block
```

```java
try {
    return a / b;
} catch (Exception e) {
    return -1;
} finally {
    System.out.println("Bye");
}
```

Object of BufferedReader must be closed, we can do it in finally block –

```
BufferedReader reader = null;
try {
    reader = new BufferedReader(new FileReader( fileName: "example.txt"));
    String line;
    while ((line = reader.readLine()) != null) {
        System.out.println(line);
    }
} catch (IOException e) {
    System.out.println("IOException caught: " + e.getMessage());
} finally {
    try {
        if (reader != null) {
            reader.close();
        }
    } catch (IOException e) {
        System.out.println("Error closing reader: " + e.getMes
    }
}
```

Try-with-resource - no need of writing finally for closing resources

```
try (BufferedReader reader = new BufferedReader(new FileReader( fileName: "example.txt"))) {
    String line;
    while ((line = reader.readLine()) != null) {
        System.out.println(line);
    }
} catch (IOException e) {
    System.out.println("IOException caught: " + e.getMessage());
}
```

Object created within () will be closed automatically if that object class implements AutoCloseable interface.

Custom Exception Class

```
class BankAccount{
    private double balance;
    public BankAccount(double amount){
        this.balance = amount;
    }
    public void withdraw(double amount) throws InsufficientBalanceException {
        if(amount > balance){
            throw new InsufficientBalanceException(amount);
        }
        balance -= amount;
    }
}
class InsufficientBalanceException extends Exception{
    private double amount;
    InsufficientBalanceException(double amount){
        super("insufficient exception");
        this.amount = amount;
    }
    public double getAmount() {
        return amount;
    }
}
public class Main {
    public static void main(String[] args) {
        BankAccount bankAccount = new BankAccount( amount: 10);
        try {
            bankAccount.withdraw( amount: 11);
        } catch (InsufficientBalanceException e) {
            System.out.println(e);
            System.out.println(e.getAmount());
        }
    }
}
```

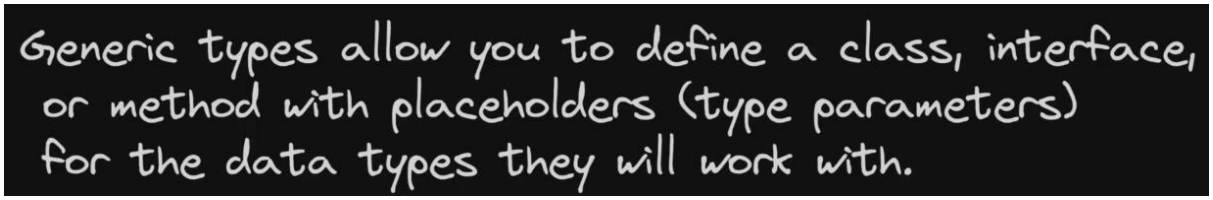
Generics

Ex- ArrayList stores array of Object class instances -

```
ArrayList list = new ArrayList();
list.add("Hello");
list.add(123);
list.add(3.14);

String str = (String) list.get(0);
String integer = (String) list.get(1);
```

ClassCastException at runtime

Issues without generics -



It helps avoid duplication of code and giving compile time error making it type safe.

```
class Box<T>{
    private T value;
    public T getValue() { return value; }
    public void setValue(T value) { this.value = value; }
}
public class Main {
    public static void main(String[] args) {
        Box<Integer> box = new Box<>(); // Box is now type safe
        box.setValue(1);
        String i = box.getValue(); // compile time error
        // Inconvertible types; cannot cast 'java.lang.Integer' to 'java.lang.String'
```

```java
class  Pair<K, V>{
    private K key;
    private V value;
    public Pair(K key, V value){
        this.key = key;
        this.value = value;
    }
    public K getKey(){
        return key;
    }
    public V getValue(){
        return value;
    }
}
public class Main {
    public static void main(String[] args) {
        Pair<String, Integer> pair = new Pair<>("age", 30);
```

Generic Interface –

```java
interface Container<T>{
    void add(T item);
    T get();
}
class StringContainer implements Container<String>{
    private String item;
    @Override
    public void add(String item) { this.item = item; }
    @Override
    public String get() { return item; }
}

class GenericContainer<T> implements Container<T>{
    private T item;
    @Override
    public void add(T item) { this.item = item; }
    @Override
    public T get() { return item; }
}
```

Bounded type parameters –

```
class Box<T extends Number>{
    private T value;
    public T getValue(){
        return value;
    }
    public void setValue(T value){
        this.value = value;
    }
}
public class Main {
    public static void main(String[] args) {
        Box<Integer> box = new Box<>();
        Box<String> stringBox = new Box<>(); // Error becoz String class doesn't extends Number
```

Multiple bounds –

```
interface Printable{
    void print();
}

class MyNumber extends Number implements Printable{
    private final int value;
    public MyNumber(int value) {
        this.value = value;
    }
    @Override
    public void print() { System.out.println("MyNumber: " + value); }
    @Override
    public int intValue() { return value; }
    @Override
    public long longValue() { return value; }
    @Override
    public float floatValue() { return value; }
    @Override
    public double doubleValue() { return value; }
}
```

```java
class Box<T extends Number & Printable>{  // first should be class then interface
                            // if bound is on interface then also use 'extends Printable'
    private T item;
    public Box(T item){
        this.item = item;
    }
    public void display() { item.print(); }
    public T getItem() { return item; }
}
public class Main {
    public static void main(String[] args) {
        MyNumber myNumber = new MyNumber( value: 12);
        Box<MyNumber> box = new Box<>(myNumber);
        box.display();
    }
}
```

Generics in Enum → enums are already type safe

```java
enum Day {
    SUNDAY, MONDAY, TUESDAY, WEDNESDAY, THURSDAY, FRIDAY, SATURDAY;
}

public class Main {
    public static void main(String[] args) {
        Day day = Day.MONDAY;
        Day day1 = "MONDAY"; // compilation error
```

```java
enum Operation{
    ADD, SUBTRACT, MULTIPLY, DIVIDE;
    public <T extends Number> double apply(T a, T b){
        switch (this){
            case ADD: return a.doubleValue() + b.doubleValue();
            case SUBTRACT: return a.doubleValue() - b.doubleValue();
            case MULTIPLY: return a.doubleValue() * b.doubleValue();
            case DIVIDE: return a.doubleValue() / b.doubleValue();
            default: throw new AssertionError( detailMessage: "Unknown operation: " + this);
        }
    }
}
public class Main {
    public static void main(String[] args) {
        double res1 = Operation.ADD.apply( a: 10,  b: 15);
        System.out.println(res1); // 25.0
```

Generics Constructors – a non generic class can have generic constructor

```
class Box{
    public <T extends Number> Box(T value){
    }

    public static void main(String[] args) {
        Box box = new Box( value: 10);
    }
}
```

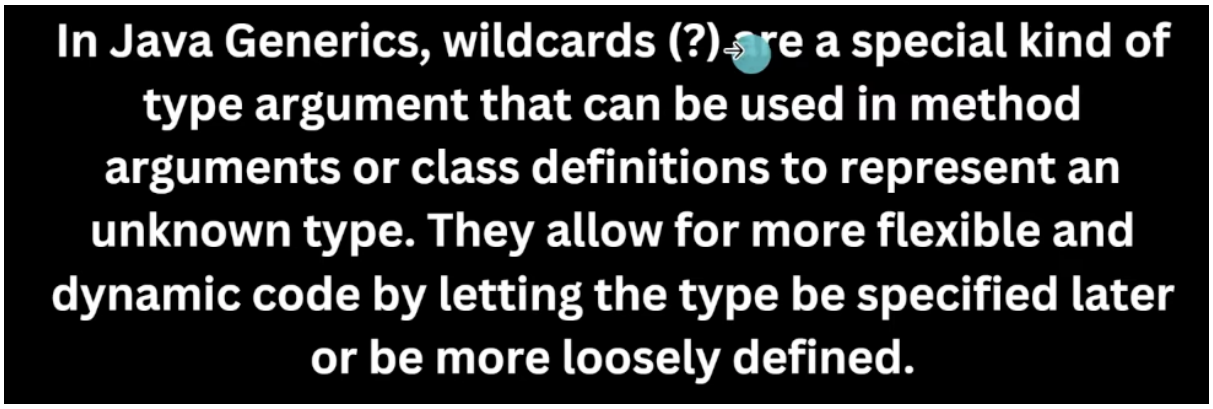
Generic Methods –

```
public static void main(String[] args) {
    Integer[] intArray = {1,2,3,4};
    String[] stringArray = {"Hello", "World"};
    printArray(intArray);
    printArray(stringArray);
}
public static <T> void printArray(T[] array){
    for(T element : array){
        System.out.print(element + " ");
    }
    System.out.println();
}
```

Method overloading –

```
public static void main(String[] args) {
    display( element: 10); // Integer display: 10
    display( element: 10.12); // Generic display: 10.12
}
public static <T> void display(T element){
    System.out.println("Generic display: " + element);
}
public static void display(Integer element){
    System.out.println("Integer display: " + element);
}
```

Wildcard –



If the method is read only and does not return a value or perform any write operation, then mentioning T is not necessary and we can use ? wildcard just for simplicity.

When we return something we'll use T to maintain type safety.

```
public void printArrayList(ArrayList<?> list){
    for(Object o : list){
        System.out.println(o);
    }
}
public <T> T getFirst(ArrayList<T> list){
    return list.get(0);
}
```

We'll get error if doing write operation with wildcard –

```
public static void main(String[] args) {
    ArrayList<?> list = new ArrayList<String>();
    list.add("arjun"); // ERROR
}
public void copy(ArrayList<?> source, ArrayList<?> dest){
    for(Object item : source){
        dest.add(item); // ERROR
    }
}
```

Boundation with wildcard –

```java
public static void main(String[] args) {
    System.out.println(sum(Arrays.asList(1,2.2,22))); // 25.2
    List<Number> list = new ArrayList<>();
    list.add(10); list.add(20);
    System.out.println(sum(list)); // 30

    printNumbers(Arrays.asList(1,2,3));
    printNumbers(new ArrayList<String>()); // not allowed
}
public static double sum(List<? extends Number> numbers){ // upper bound
    // any subclass of Number (such as Integer, Double, Float, etc), including Number itself
    double sum=0;
    for(Number o : numbers){
        sum += o.doubleValue();
    }
    return sum;
}
public static void printNumbers(List<? super Integer> list){ // lower bound
    // class that is a supertype of Integer (Object, Number, etc), including Integer itself
    for(Object obj : list){
        System.out.println(obj);
    }
}
```

```java
List<? extends Number> list = Arrays.asList(1,2,3);
list.add(10); // not allowed
list.add(null); // allowed

List<? super Number> list2 = Arrays.asList(1,2,3);
list2.add(123); // allowed
list2.add(null);
```

In super it will get added as Object, but in extends we don't know what exactly is the type that's why it doesn't allow to add.

Type Erasure –

```
class Box<T>{
    private T value;
    public T getValue() { return value;}
    public void setValue(T value) { this.value = value; }
}
public class Main {
    public static void main(String[] args) {
        Box<String> stringBox = new Box<>();
        stringBox.setValue("Hello");
        String value = stringBox.getValue();
```

When u add value compiler will check whether u r adding String or not. But in bytecode, there are no Generics. Box<String>, the String gets erased. So after doing type checking compiler will erase information of generics.

Internally after compilation, it will look like –

```
class Box{
    private Object value;
    public Object getValue() { return value;}
    public void setValue(Object value) { this.value = value; }
}
public class Main {
    public static void main(String[] args) {
        Box stringBox = new Box();
        stringBox.setValue("Hello");
        String value = (String) stringBox.getValue();
    }
```

Ex2 –

```
class NumberBox<T extends Number>{
    private T number;
    public void setNumber(T number){ this.number = number; }
    public T getNumber(){ return number; }
}
public class Main {
    public static void main(String[] args) {
        NumberBox<Integer> intBox = new NumberBox<>();
        intBox.setNumber(10);
        Integer value = intBox.getNumber();
    }
```

After compilation -

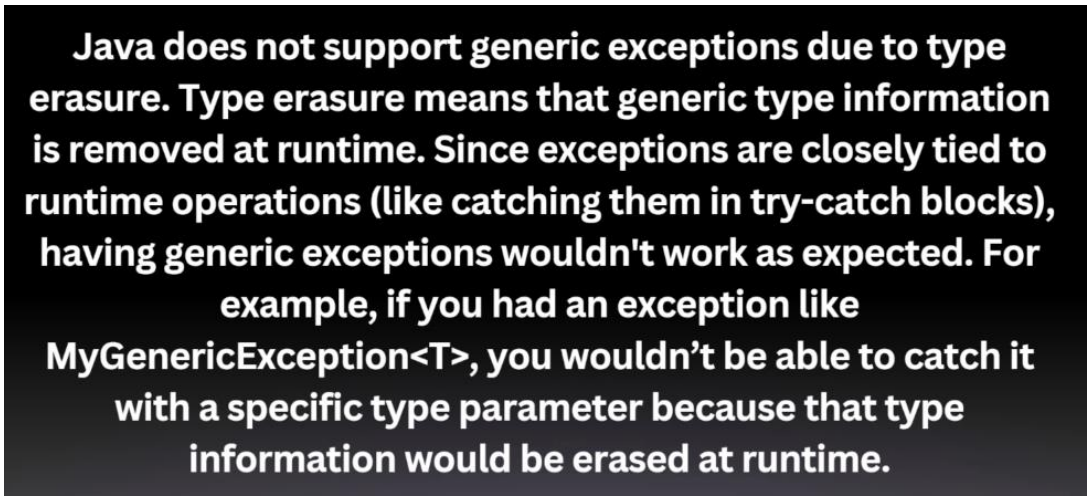
```
class NumberBox{
    private Number number;
    public void setNumber(Number number){ this.number = number; }
    public Number getNumber(){ return number; }
}
public class Main {
    public static void main(String[] args) {
        NumberBox intBox = new NumberBox();
        intBox.setNumber(10);
        Integer value = (Integer) intBox.getNumber();
```

Generics Exception -

It becomes little bit complicated because Exceptions are thrown at runtime and on runtine there is no generic information due to type erasure but JVM needs exact type to create exception object.

```
class GenericException<T> extends Exception{

}
```

Compilation Error



Workaround –

```
class MyException extends Exception{
    public <T> MyException(T value) {
        super("Exception related to value :" +
                value.toString() + " of type: " +
                value.getClass().getName());
    }
}
```

```java
public class Main {
    public static void main(String[] args) {
        try{
            throw new MyException("string");
        }catch (MyException e){
            System.out.println(e.getMessage());
        }

        try{
            throw new MyException(123);
        }catch (MyException e){
            System.out.println(e.getMessage());
        }
```

O/P →

```
Exception related to value :string of type: java.lang.String
Exception related to value :123 of type: java.lang.Integer
```

Passing variable arguments –

```java
public static void main(String[] args){
    System.out.println(sum( ...a: 1,2,3,4,5)); //15
}
public static int sum(int... a){
    int sum=0;
    for(int i:a) sum+=i;
    return sum;
}
```

```java
public static void main(String[] args){
    System.out.println(sum(new int[]{1,2,3,4,5})); //15
}
public static int sum(int[] a){
    int sum=0;
    for(int i:a) sum+=i;
    return sum;
}
```

```java
System.out.println(Math.max(4,90));
System.out.println(Math.min(634, 6));
System.out.println(Math.abs(-39));
System.out.println(Math.ceil(1.24)); // 2.0
System.out.println(Math.floor(1.24));// 1.0
System.out.println(Math.round(1.52));// 2
System.out.println(Math.sqrt(25)); // 5.0
System.out.println(Math.pow(12, 2)); // 144.0
System.out.println((int)(Math.random()*11)); // random no between 1 to 10
```

Note :- In a **switch case statement** in Java, if you do not use the break; statement at the end of a case, the program will continue executing the body of all subsequent cases until it encounters a break statement or reaches the end of the switch block.

A **constructor** is a special method in a class that is used to **initialize objects** of that class. It has the following unique properties:

- Its **name is the same as the class name**.
- It **does not have a return type**, not even void.

Types of constructor –

- Default
- Parameterized

We can also overload constructors.

Once you define a **parameterized constructor** in a class, the **default constructor** (provided by Java automatically) becomes no longer available.

Optional – needed to avoid null checks everytime

```
public static void main(String[] args) {
    String name = getName( id: 2);
    System.out.println(name.toUpperCase());
}
private static String getName(int id){
    // get from db
    return null;
}
```

O/P → NullPointerException

```
public static void main(String[] args) {
    Optional<String> name = getName( id: 2);
    if(name.isPresent()){
        System.out.println(name.get()); // Ram
    }

    name.ifPresent(x -> System.out.println(x)); // Ram
    name.ifPresent(System.out::println); // Ram
}
private static Optional<String> getName(int id){
    String name = "Ram";
    return Optional.of(name); // still can throw NPE if name = null
}
```

Better to use -

```
private static Optional<String> getName(int id){
    String name = null;
    return Optional.ofNullable(name); // No NPE
}
```

```java
public static void main(String[] args) {
    Optional<String> name = getName( id: 2);
    if(name.isEmpty()){
        System.out.println("empty box"); // empty box
    }
}
private static Optional<String> getName(int id){
    return Optional.empty();
}
```

```java
public static void main(String[] args) {
    Optional<String> name = getName( id: 2);
    String nameToBeUsed = name.isPresent() ? name.get() : "NA";
    nameToBeUsed = name.orElse( other: "NA"); // returns the value if present, otherwise returns default
    System.out.println(nameToBeUsed); // NA
}
private static Optional<String> getName(int id){
    return Optional.empty();
}
```

```java
Optional<String> name = getName( id: 2);
String nameToBeUsed = name.orElseGet(()->"NA");
// If a value is present, returns the value,
// otherwise returns the result produced by the supplying function
```

```java
String nameToBeUsed = name.orElseThrow(()->new NoSuchElementException());
// If a value is present, returns the value,
// otherwise throws an exception produced by the exception supplying function
```

```java
public static void main(String[] args) {
    Optional<String> optional = getName( id: 2);
    Optional<Integer> optional1 = optional.map(x -> x.length());
    // apply mapping function if value present, otherwise return empty optional

    optional1.ifPresent(System.out::println); // 3
}
private static Optional<String> getName(int id){
    return Optional.ofNullable( value: "ram");
}
```