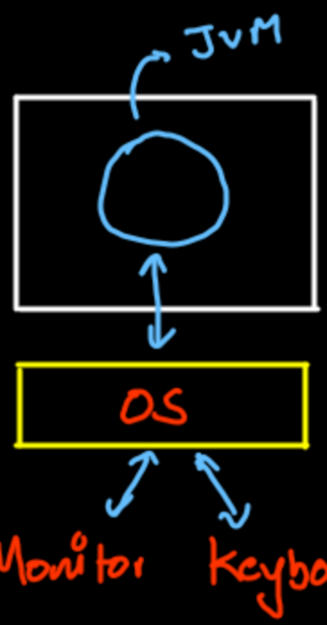
Object Oricnted Programming in Java

Java is platform independent because bytecode is not m/c code.



User Software

Java Code

↓

Compiler JVM (javac)

(.class) bytecode

↓

Run(JRE) machine Lang

JDK → JVM → JRE (Java Run Time Env.)

Java Development ToolKit

Java Virtual Machine

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Pillars of OOPS

- Encapsulation
- Abstration
- Inheritance
- Polymorphism

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```java
class Student {
    int marks;
    String name;
    int rollno;
}
```

↑

Class : Group of data members & member functions

```java
Student guneet = new Student();
guneet.name = "Guneet";
guneet.marks = 10;
guneet.rollno = 1;

Student yash = new Student();
yash.name = "Yash";
yash.marks = 20;
yash.rollno = 2;

        System.out.println("Guneet's Details");
        System.out.println("Name: " +  guneet.name + " Marks: " + guneet.marks + " Roll No: " + guneet.rollno);
        System.out.println("Yash's Details");
        System.out.println("Name: " +  yash.name + " Marks: " + yash.marks + " Roll No: " + yash.rollno);
    }
```

Object = Instance

data member = instance variable

func vs Methods : Methods are nothing but functions inside a class. Since in Java, everything is inside a class hence Java funcs are always called methods.

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```java
class Student {
    int marks;
    String name;
    int rollno;

    void Study(String subject) {
        System.out.println(name + " studies " + subject);
    }
}
```

```java
guneet.Study("DSA");
yash.Study("nothing");
```

output →

```
Finished in 89 ms
Guneet studies DSA
Yash studies nothing
```

data members → properties

member functions → behavior

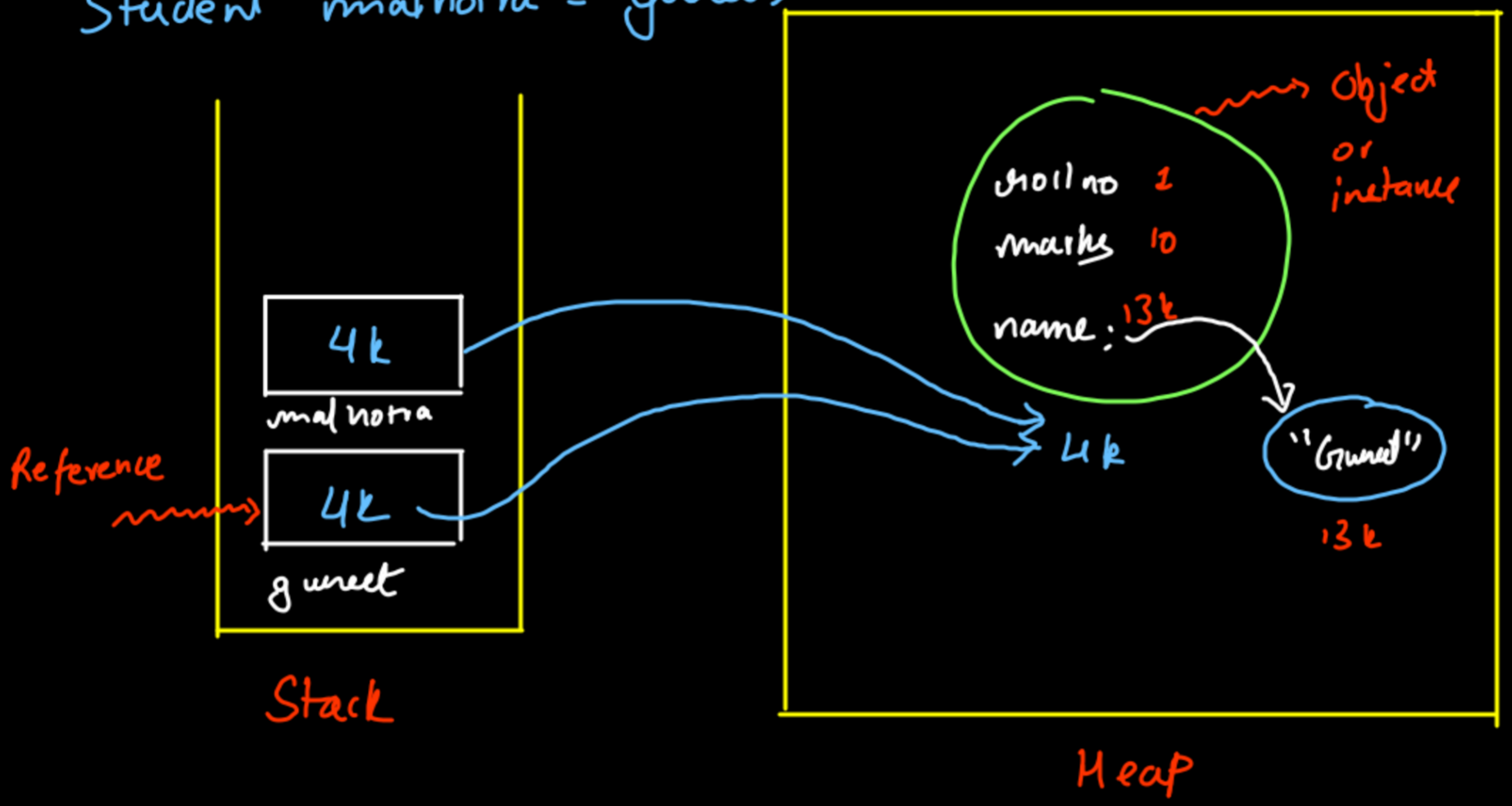
Class → Blueprint

Objects → Physical Entity (Occupies Memory)

Java is not purely Object Oriented Programming Language because of the presence of primitive data types.

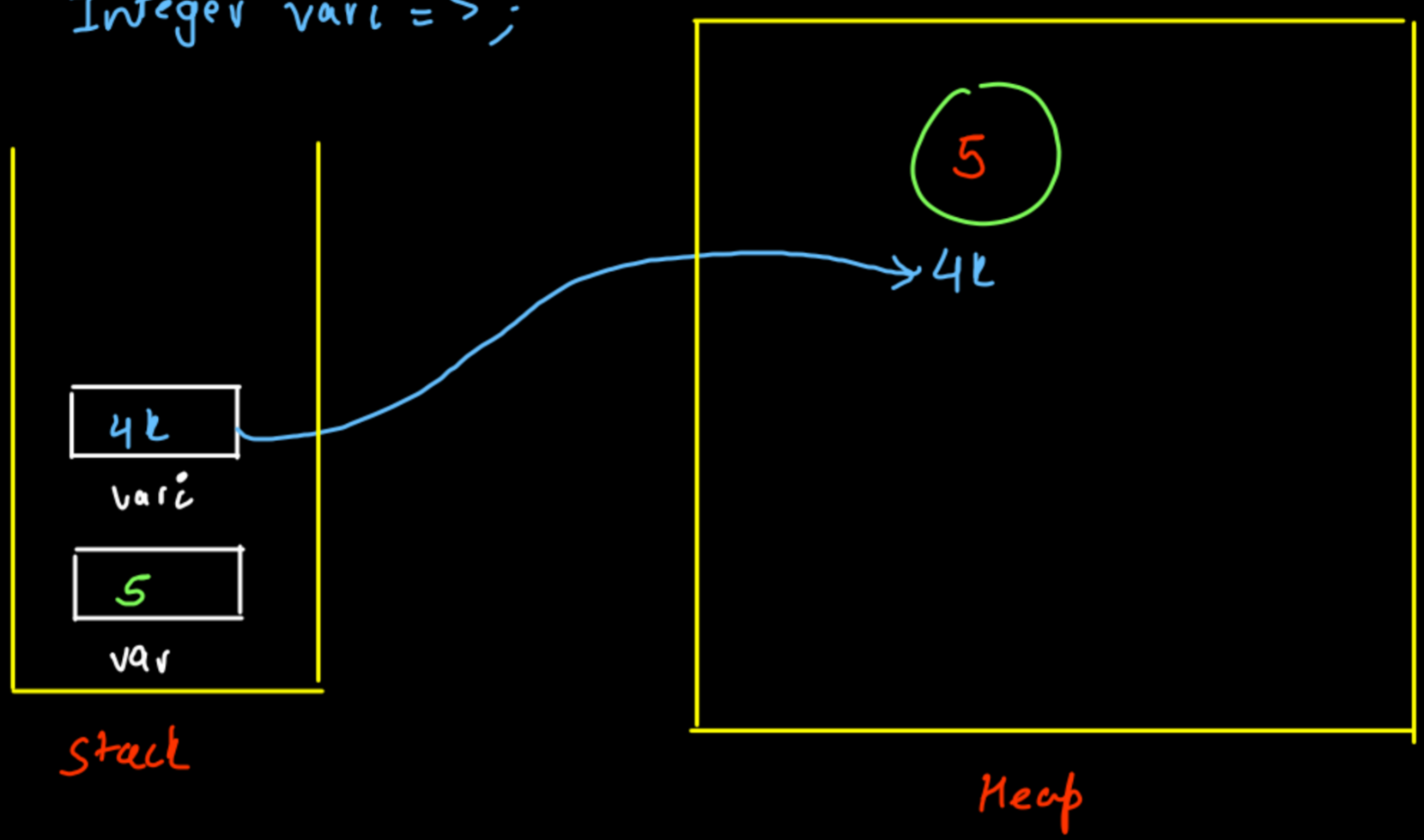
Java has still allowed use of primitive data types because of the speed issues that occur when memory is allocated in the heap.

```
Student guneet = new Student();
Student malhotra = guneet;
```



int var = 5;

Integer vari = 5;



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```java
class Main {
    public static void main(String args[]) {
        // Your code goes here
        Integer i = 10; //autoboxing
        int x = i; //unboxing
        System.out.println(x);
    }
}
```

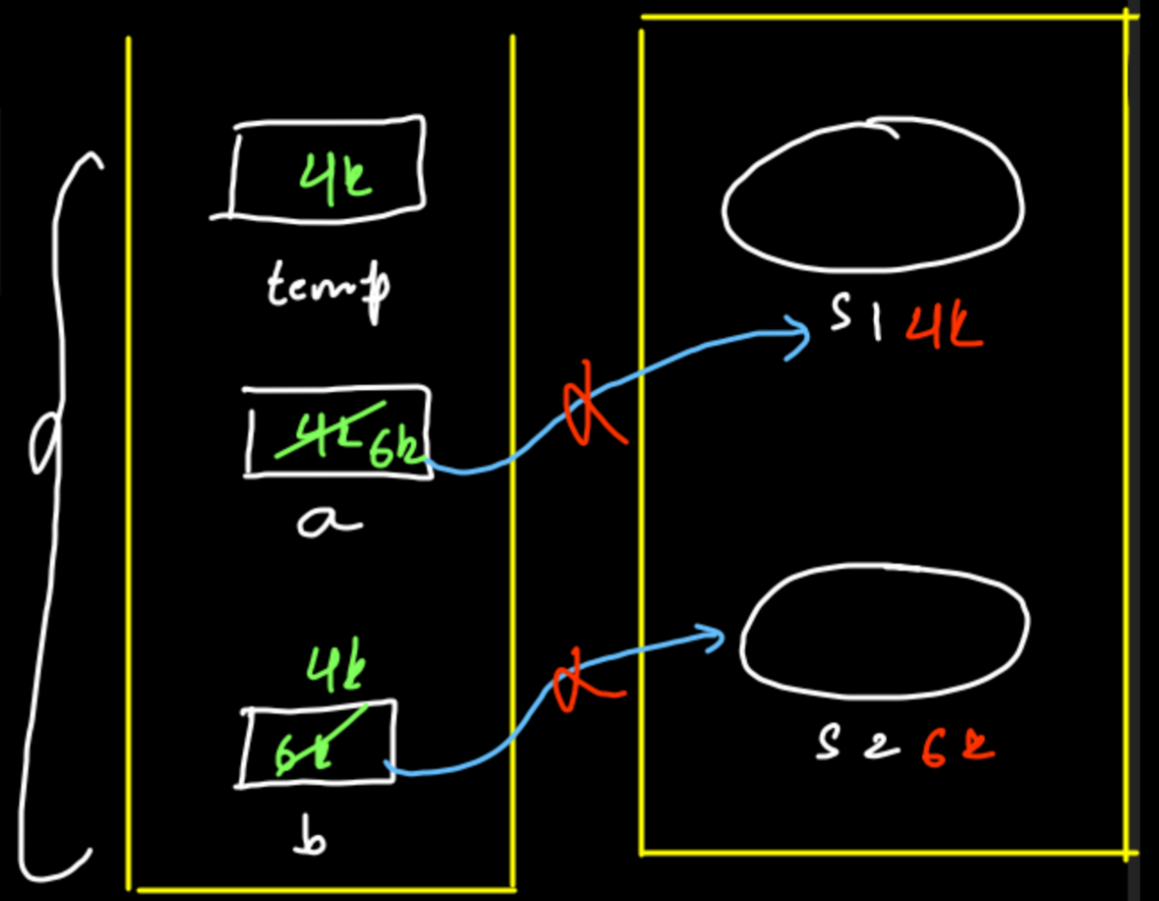
primitive to object automatically

object to primitive automatically

Swap Game 1

```java
public static void swap1(Student a, Student b){
    Student temp = a;
    a = b;
    b = temp;
}
```

Swap happened in references & now when swap1() function gets deleted from stack, references were locally changed hence no swap occurs.

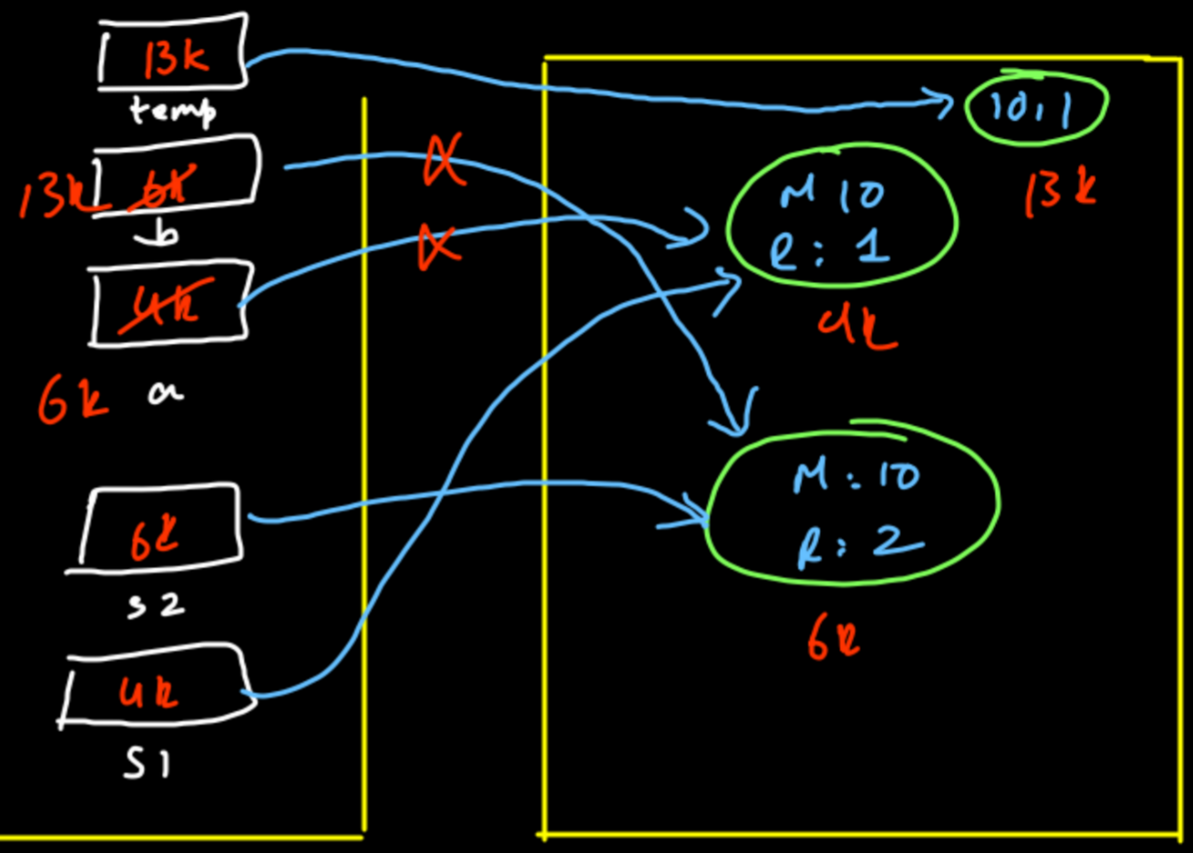


Swap Game 2

```java
public static void swap2(Student a, Student b){
    Student temp = new Student();
    temp.marks = a.marks;
    temp.rollNo = a.rollNo;

    a = b;
    b = temp;
}
```

swap2()

main()

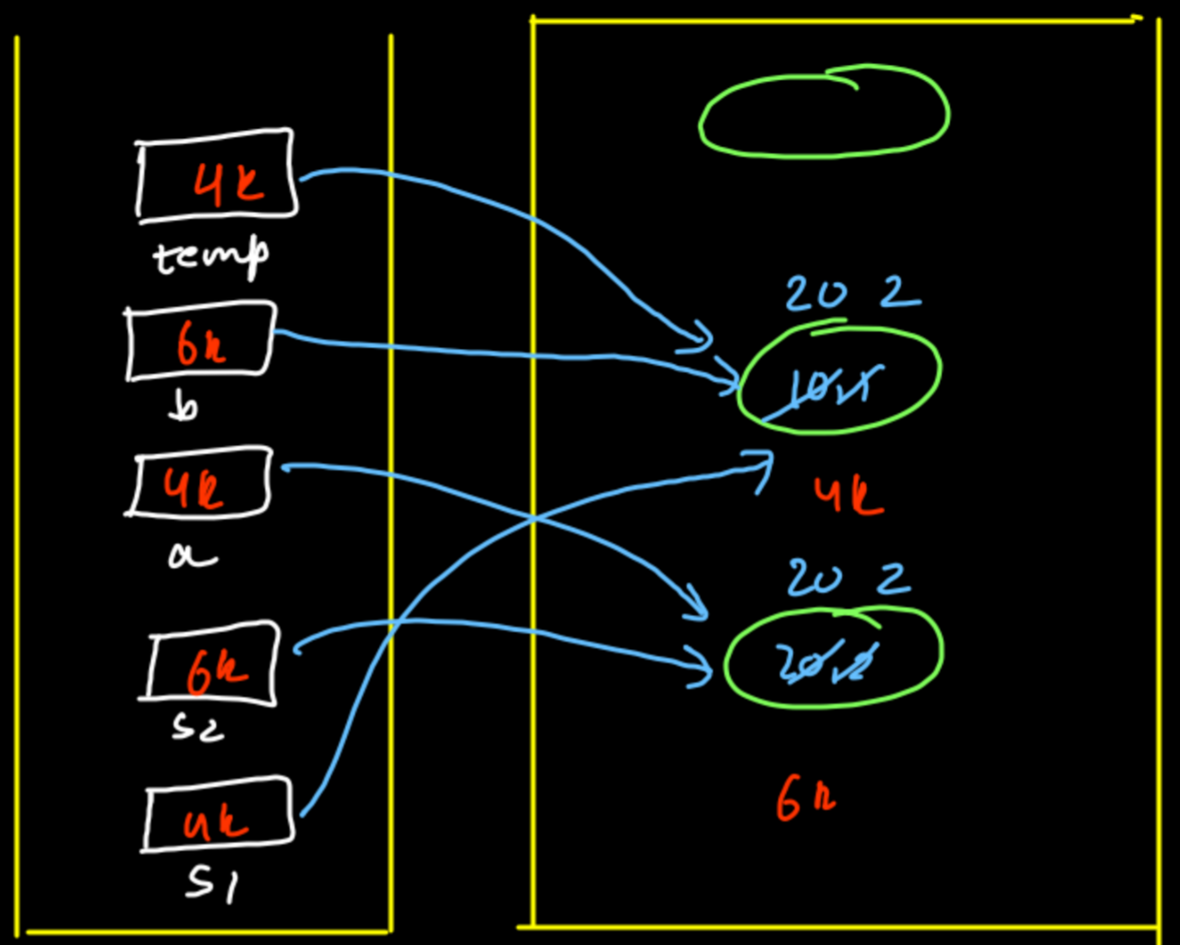


Again, the changes will not persist in main()

Swap Game 3

```java
public static void swap3(Student a, Student b){
    Student temp = a;

    a.marks = b.marks
    a.rollNo = b.rollNo;


    b.marks = temp.marks;
    b.rollNo = temp.rollNo;
}
```

Now, the changes persist because changes were made to heap -



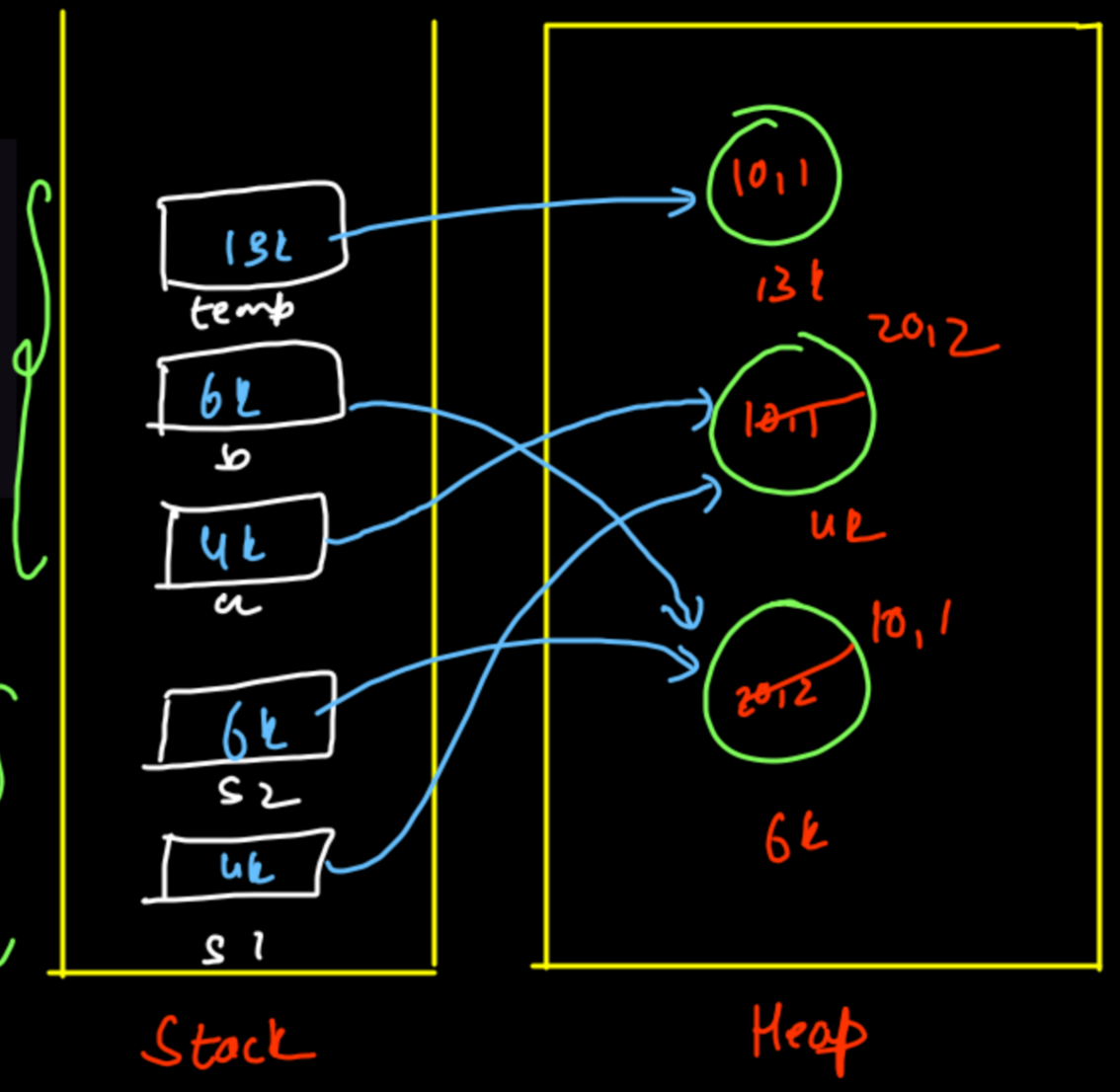
Swap Game 4

```
// public static void swap4(Student a, Student b){
//     Student temp = new Student();
//     temp.marks = a.marks;
//     temp.rollNo = a.rollNo;

//     a.marks = b.marks;
//     a.rollNo = b.rollNo;

//     b.marks = temp.marks;
//     b.rollNo = temp.rollNo;
// }
```

swap4()

Now, the swap has occured and changes will persist because they occur in heap.

main()



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Constructor :

```
// Student(){
//     marks = 100;
//     name = "Pepcoder";
//     rollNo = -1;

//     System.out.println(" Hey a new object of student class is created ");
// }
```

Explicit Default Constructor

① Name as same of Class

② Returns this (we cannot see the return type)

When we write any parameterized constructor, Java removes the default constructor. So, we have to write default const.

```
//Implicit default constructor
Student(){

}
```

* when we create a param. const. if we are using it.

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Constructor Overloading

student () {

constructor overloading due to diff no of parameters -

```java
Student(int newMarks, String newName, int newRollNo){
    marks = newMarks;
    name = newName;
    rollNo = newRollNo;
}

Student(int newMarks, int newRollNo, String newName){
    marks = newMarks;
    name = newName;
    rollNo = newRollNo;
}
```

due to change in order of arguments.

Copy Constructor

```java
// copy constructor
Student(Student obj){
    this.name = new StringBuilder(obj.name);
    this.marks = obj.marks;
    this.rollNo = obj.rollNo;
}
```

→ deep copy because if new object of StringBuilder is not created, StringBuilder due to being immutable will have references copied & changing one object's sb will change others' sb too.

↳ Also, Java removes copy constructor too if a param const is created like it removes the default const.

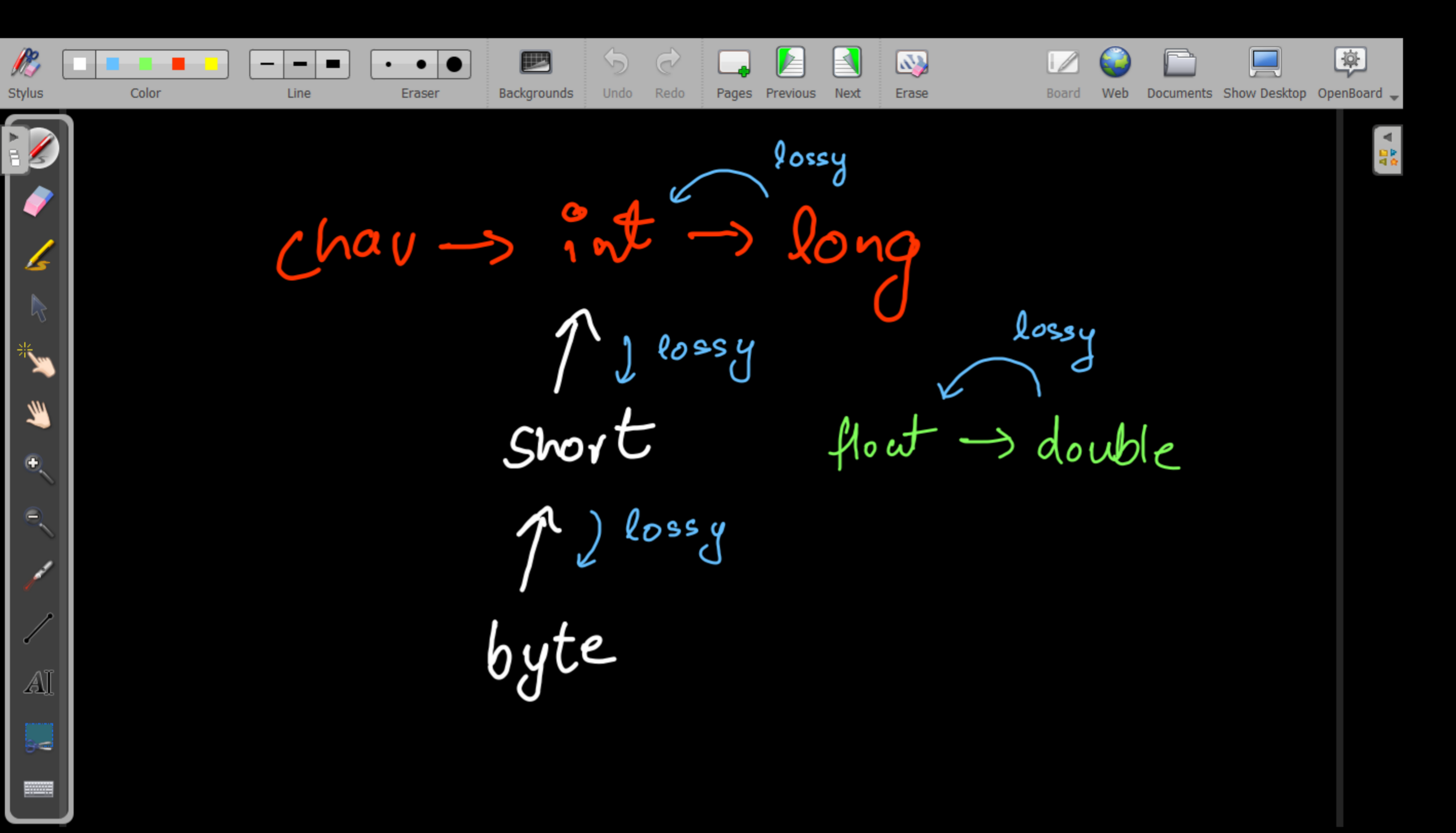
if we put a long or double value as a param in place of int, we will get an error saying no such constructor exists.

```
Student(int newMarks, String newName, int newRollNo){
    marks = newMarks;
    name = newName;
    rollNo = newRollNo;
}
```

Upcasting ✓

Downcasting ✗

This happens because there will be automatic type conversion from Higher Ranged data types (Long or Double) to lower ranged datatype (int) but not vice-versa.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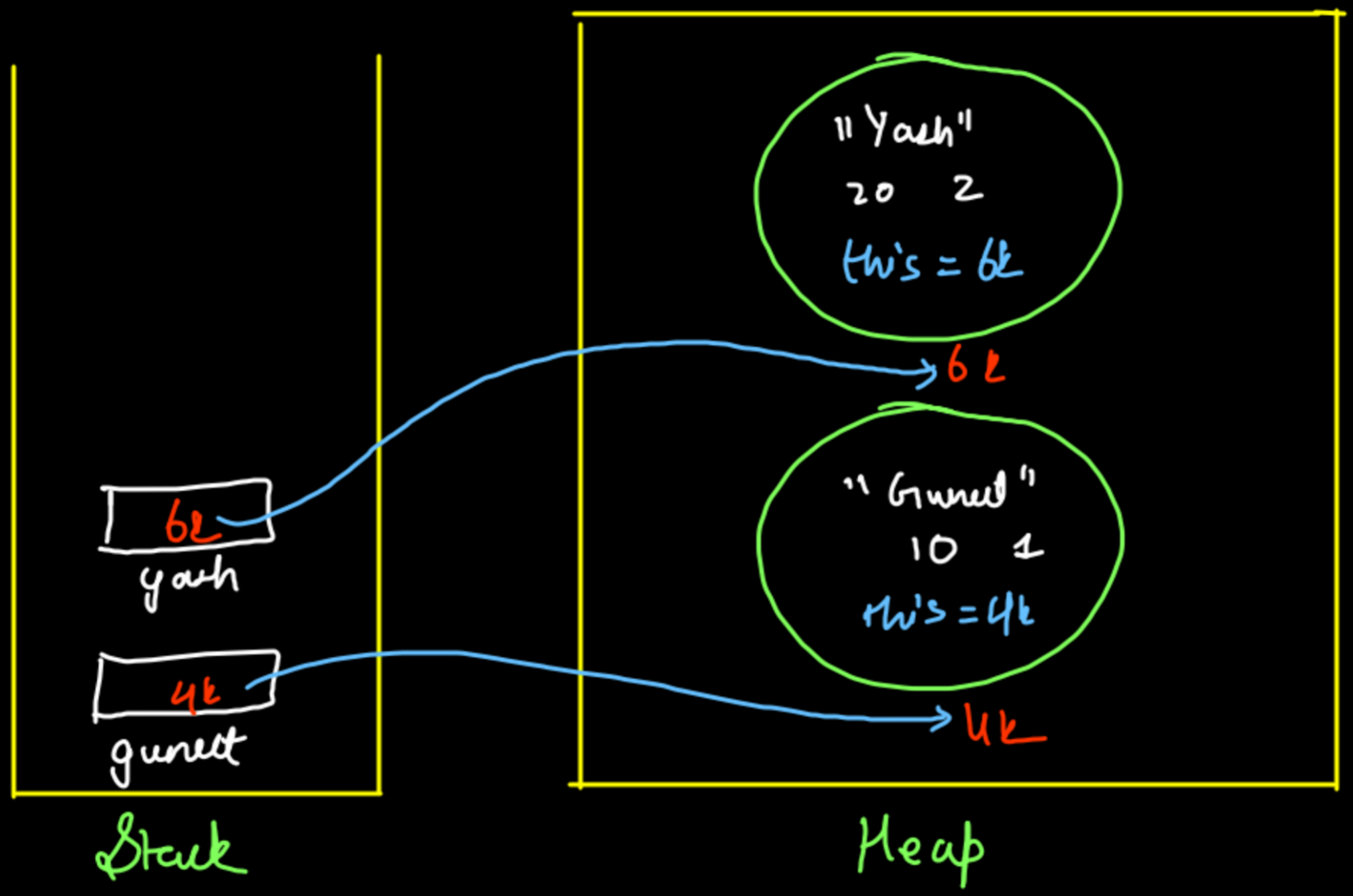
lossy
char → int → long
lossy
lossy
short
float → double
lossy
byte

this Keyword (self referential pointer)



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```
Student (String name, int rollno, int marks) {
    this.marks = marks;
    this.rollno = rollno;
    this.name = name;
}
```

this prevents namespace collision.

data member marks local variable marks

⇒ data member marks me local variable daal diya.

this is used in Constructor Chaining

```java
public Cuboid() {
    // length = breadth = height = 1;
    this(1); → chaining
}

public Cuboid(int length, int breadth, int height) {
    this.length = length;
    this.breadth = breadth;
    this.height = height;
}

public Cuboid(int side) {
    // length = breadth = height = side;
    this(side,side,side); → chaining
}

public Cuboid(int length, int breadth) {
    // this.length = length;
    // this.breadth = breadth;
    // height = 1;
    this(length,breadth,1); → chaining
}
```

Sysco(l+b+h);

Printing will also be done in every constructor coz of chaining.

```
main() {
    Cuboid c = new Cuboid();
}
```

Cuboid() → Cuboid(side) → Cuboid(l,b,h) } Chaining

Overhead is more but code redundancy is reduced

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```java
// Explicit Default Constructor
public Cuboid(){
    System.out.println(" Hi I am before Constructor Chaining ");
    this(1);
    this(1, 1, 1);
}
```

⇒ This gives compile time error - Chaining should be the first statement.

This is also not possible.

Also, this is also passed as a parameter implicitly.

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this can be used to call methods / members of same class

```java
public int area() {
    this.length*this.breadth;
}

public int volume() {
    return (this.area()) * this.height; //use of this reduces overhead
}
```

this can also be returned from a method.

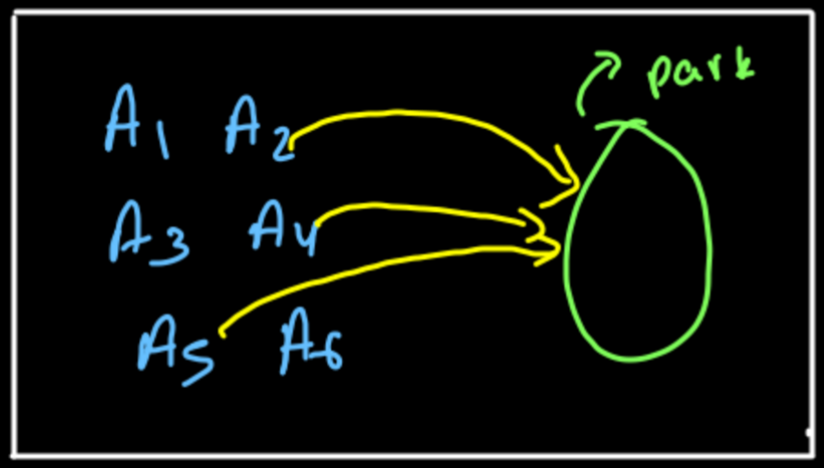
```
public Cuboid join(Cuboid other) {
    this.length += other.length;
    this.breadth += other.breadth;
    this.height += other.height;

    return this;
}
```

```
main()
{
Cuboid c1 = new Cuboid().
Cuboid c2 = new Cuboid(1,2,3);
Cuboid c3 = c1.join(c2);
}
```

Changes are made to c1 & also stored in c3.

Static Keyword

If we want to keep a property in a class which is not associated to any object, static keyword can be used.



All objects (Apartments) can access the static property (park) but it is not the property of any apart. (object) rather the society (class).

```java
class Student {
    int marks;
    String name;
    int rollno;
    static String University  = "IPU";
```

→ property of Student

```java
System.out.println(guneet.University);
System.out.println(yash.University);
```

→

```
Finished in 50 ms
IPU
IPU
```

To make property as immutable, we make it final.

```java
static final String University  = "IPU";
```

⇒ This cannot be changed now anywhere in the code.

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Common To all the Objects

"Gurneet"
1 10

"Yash"
2 20

IPU

obj 3

obj 4

Accessing a static property using Class

Static members

```
+ " " + Student.university);
```

Global variables do not exist in Java because everything is inside a class only.

Syntax:

ClassName.property

Accessing static members using ClassName is a good practice because they are the properties of class only.

Static Methods

```java
static void study() {
    System.out.println("Student studies in " + University);
}
```

```java
System.out.println(guneet.University);
System.out.println(yash.University);

Student.study();
```

output

```
Finished in 71 ms
IPU
IPU
Student studies in IPU
```

Why is main() static?

Running a file (Java) in terminal

java fileName

We do not create any object of the class in which we have main

Hence, main() must be static so that we need not create an object of the Main class.

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Do static methods have this?

No, because static methods are methods of the class not any object.

{Error: non-static member this cannot be accessed from a static context}

Static member (class) calling static member → Yes

Non-static member calling static member → Yes

Non-static member calling non-static member → Yes

Static member calling non-static member → NO (because class ki property object ki property ko use nahi kar paegi because of absence of this)

{using 'has A'}

Think of it using park & apartment

example - Apart me rehne vala park ko access kar sakta hai lekin park me ghoomne vala kisi k apart ko nahi.

Nested Class

```java
public class Main {

    static class Inner {
        //without making object of outer class
        //we can make objects of inner class
    }
```

Encapsulation

"Wrapping together the data members and member functions into a single entity (known as class)"

Implement

Data Hiding

Packages

Access Modifiers

- Public
- Private
- Protected
- Default

Getters & Setters

Encapsulation :

we can implement data hiding.

getters() & setters() are used so that authorised users can access them. (because we make data members private in most of the classes)

→

+ Getters & setters are also called manipulators.

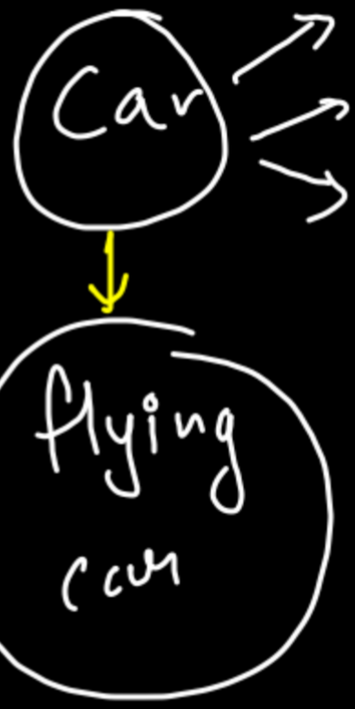
→ private methods / members are accessible only inside a class

→ public methods can be accessed from anywhere.

Inheritance

Passing on properties & methods of Parent (Super) class to child (Sub) class is called inheritance.

- Single
- Multi level
- Heirarchical




```
class flyingCar extends Car{
}
```

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```java
class Car {
    int gear;
    int wheels;
    String engine;
}

class FlyingCar extends Car {
    String wings;

}
```

```java
public class Main {

    public static void main(String[] args) {
        FlyingCar obj = new FlyingCar();
        obj.gear = 5;
        obj.wheels = 4;
        obj.engine = "electric";
        obj.wings ="metallic";
        System.out.println(obj.gear + " " + obj.wheels + " " + obj.engine + " " +
obj.wings);



    }
}
```

Also, it is not possible to access parent class objects, properties from a child classes' object.

Multilevel Inheritance

```java
class Car {
    int gear;
    int wheels;
    String engine;
}

class FlyingCar extends Car {
    String wings;
}

class FlyingHydroCar extends FlyingCar {
    String pedal;
}
```

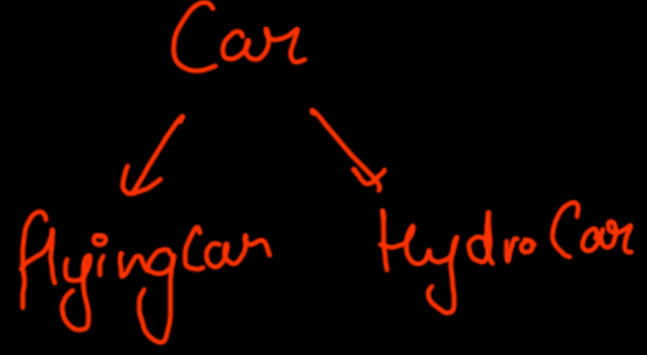
Car
↓
FlyingCar
↓
FlyingHydroCar

Heirarchical Inheritance

```java
class Car {
    int gear;
    int wheels;
    String engine;
}

class FlyingCar extends Car {
    String wings;
}

class FlyingHydroCar extends Car {
    String pedal;
}
```



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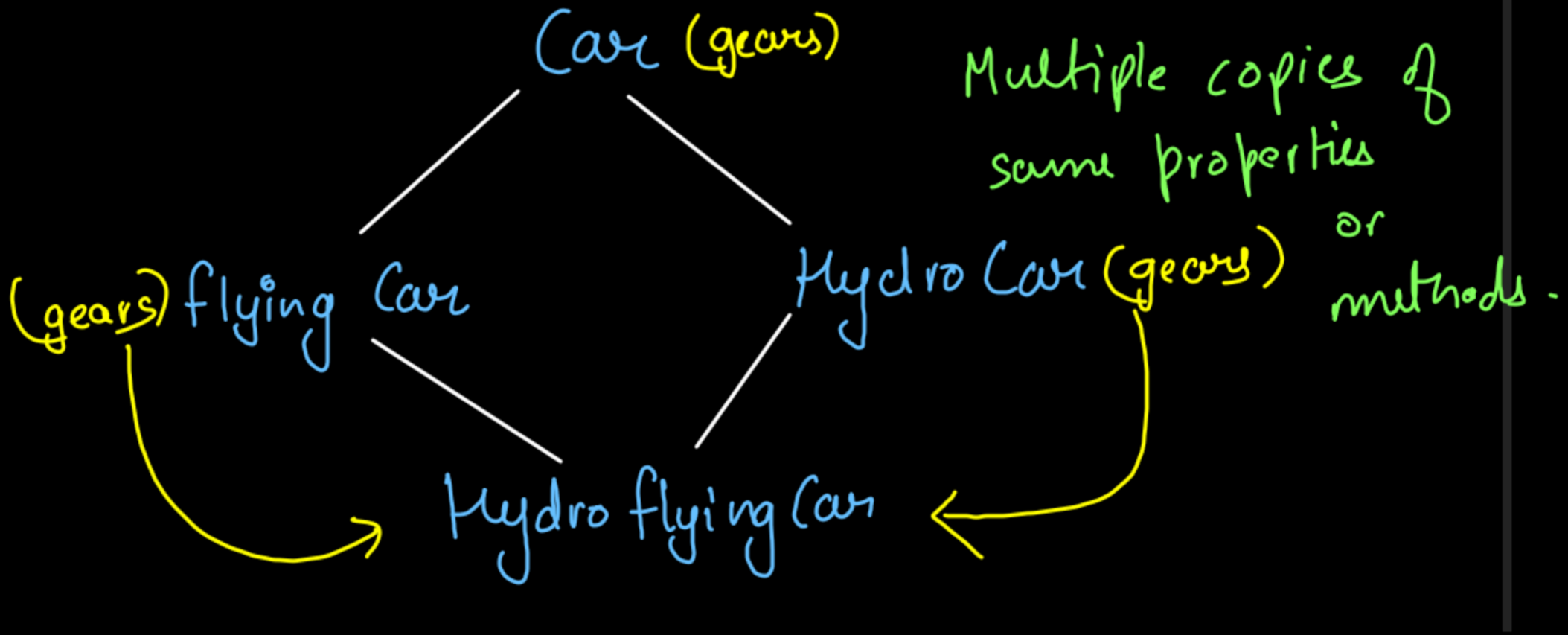
Multiple Inheritance is not possible in Java.

The diamond Problem & Deadly diamond of death problem



Multiple copies of same properties or methods.

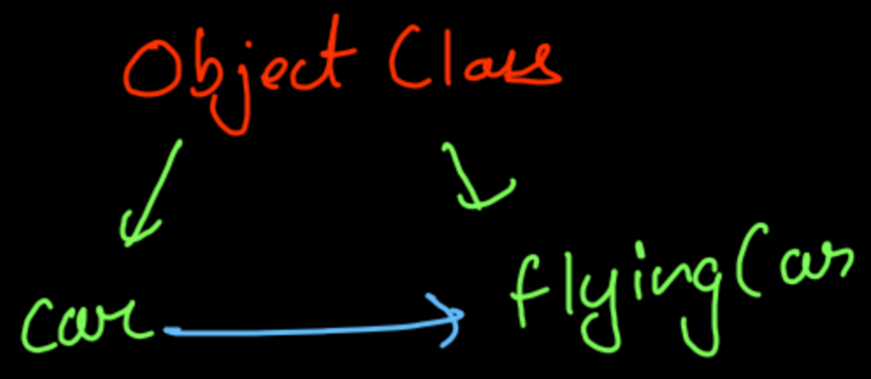
Object Class in Java

Super Class of Every Class in Java.

```java
class Car {
    int gear;
    int wheels;
    String engine;
}

class FlyingCar extends Car {
    String wings;

}
```



This is again diamond problem.

Actually this does not happen.

If a class extends our custom class, it does not extends Object class.

```java
class Car {
    int gear;
    int wheels;
    String engine;
}

class FlyingCar extends Car {
    String wings;

}
```

Object Class

↓

Car

↓

flying Car

This now becomes multi level inheritance

Let us see which all members of Java can be assigned with the access modifiers:

Members of JAVA	Private	Default	Protected	Public
Class	No	Yes	No	Yes
Variable	Yes	Yes	Yes	Yes
Method	Yes	Yes	Yes	Yes
Constructor	Yes	Yes	Yes	Yes
interface	No	Yes	No	Yes

Access Modifiers Table/Chart

Most Restrictive ← → Least Restrictive

Access Modifiers	Private	Default/no-access	protected	public
Inside class	Y	Y	Y	Y
Same Package Class	N	Y	Y	Y
Same Package Sub-Class	N	Y	Y	Y
Other Package Class	N	N	N	Y
Other Package Sub-Class	N	N	Y	Y

Inheritance vs Association

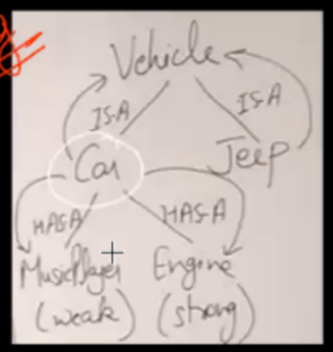
is A relationship
{Inheritance}

VS

has A relationship
{Association}

→ Tightly Coupled Relationship → Direct access through super keyword

Eg



→ loosely coupled Relationship → Accessing using object

Example → Nested class
→ Object Member → LL has a Node

```
LL {
Node head;
}
```

Types of Association
- Aggregation (Weak)
- Composition (Strong)

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```java
class Car{
    int gear;
    int wheels;
    String engine;
    MusicPlayer player;
}

class FlyingCar extends Car{
    String wings;
}
```

Car has-a music player

→ flying Car is a Car

Direct access

Inheritance is tightly coupled relationship → flyingCarobj.gear

Association is a loosely coupled relationship → Carobj.player.radio

Indirect access

Types of Association

Aggregation (Weak)

2 classes are in a relationship & they can exist without one another.

Composition (Strong)

2 classes are in a relationship & one class cannot exist without other.

Super KeyWord

```java
class Car {
    int gear;
    String engine;
}

class FlyingCar extends Car {
    String wings;
}
```

```java
public static void main(String[] args) {
    FlyingCar obj = new FlyingCar();
}
```

Base class constructor is always executed first before the derived class.

① FlyingCar() constructor is called.

② Car() constructor is executed

③ FlyingCar() constructor is executed

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```java
class Car{
    int gear;
    String engine;

    Car(){
        System.out.println("Car Constructor Execution")
    }
}

class FlyingCar extends Car{
    String wings;

    FlyingCar(){
        System.out.println("Flying Car Constructor Execution");
    }
}
```

Output : Car Constructor Execution

Flying Car Constructor Execution

① super keyword is used to call the constructor of Super Class.

(Immediate Super Class not the absolute)

{ first search in immediate parent then upwards & so on }

```
FlyingCar(){
    super(5, "CNG");
    System.out.println("Flying Car Constructor Execution");

}
```

→ Call to super() must be the first line in execution of child class constructor.

** This means that super() will be the first statement by default in Java even if we do not write it.

this(—);
super(—);
} even this() cannot be called before super. foundation should be laid first.

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```java
FlyingCar(int gears, String engine, String wings){
    super(gears, engine);
    this.wings = wings;
}
```

We can set the data members of super class using super() keyword.

```java
void display(){
    System.out.println(this.wings + " " + super.gear + " " + super.engine);
}
```

Overhead will be reduced a little bit. {Same logic as in this}

Parameters of super class can also be accessed using super.

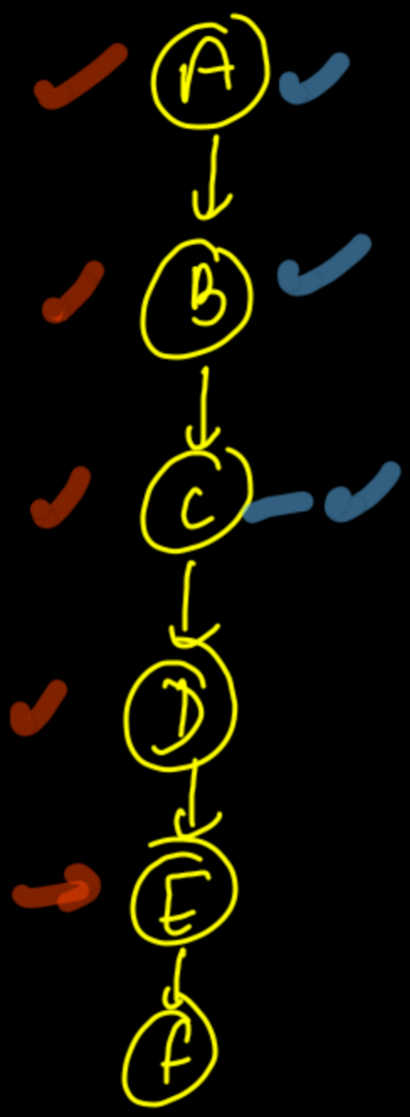
```java
class FlyingCar extends Car{
    String wings;
    int gear;

    FlyingCar(){
        super(5, "Petrol");
    }

    FlyingCar(String wings){
        super(5, "Petrol");
        this.wings = wings;
    }

    FlyingCar(int gear, String engine, String wings){
        super(gear, engine);
        this.wings = wings;
    }

    void display(){
        System.out.println(this.wings + " " + gear + " " + super.engine);
    }
}
```

→ gear is present in superclass also

this.gear will be displayed. If we want to distinguish & print gear of superclass, use super.gear.

```java
public static void main(String[] args){
    FlyingCar obj = new FlyingCar(5, "Electric", "Aluminium");
    System.out.println(obj.engine);
    obj.display();
}
```

⟹ This logically creates 2 objects. Object of Car is logically inside flying Car.



{ Class can access properties & methods of only classes above it }

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Polymorphism → one action in many ways/forms

Types of Polymorphism

cpp → .cc → .o → .exe

Compile-Time Polymorphism
or
Static polymorphism

{ Method Overloading }

- Number of arguments ✓
- Order of arguments ✓
- Return type ✗

Automatic type conversion

Run-time polymorphism
or
Dynamic Polymorphism
or { Dynamic Method Dispatch }

{ Method overriding }

- Same
  - No. of arguments
  - Type of arguments
  - Return type

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```
int n = scn.nextInt();

int [] arr = new int[n];
```

} Static Memory Allocation

[static only due to fixed size]

$ Memory is allocated at Run Time }

function Overloading / Static Polymorphism / Compile-Time Poly

(Method)

```
void display(){
    System.out.println(this.wings + " " + super.gear + " " + super.engine);
}

void display(int height){
    System.out.println(this.wings + " " + super.gear + " " + super.engine + " " + height);
}
```

In main() only if we call any method,

the method which is to be called is decided at the time of compilation. Execution will be done at run-time only.

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Method Overloading happens

- ↳ no of arguments ✓
- ↳ order of arguments ✓
- ↳ return type ✗

? should be different

Runtime Poly / Dynamic Poly / Method Overriding

{ Dynamic Method Dispatch }

drive() is in both the classes & Car as well as FlyingCar

```
Car obj1 = new Car();
obj1.drive();

FlyingCar obj2 = new FlyingCar();
obj2.drive();

Car obj3 = new FlyingCar();
obj3.drive();

FlyingCar obj4 = new Car();
obj4.drive();
```

Car C)
{ drive C)
& car is running
}}

flying (car ()
{ drive() {car is flying}

```
Car obj1 = new Car();
obj1.drive();

FlyingCar obj2 = new FlyingCar();
obj2.drive();

Car obj3 = new FlyingCar();
obj3.drive();

FlyingCar obj4 = new Car();
obj4.drive();
```

→ Parent class ref & parent class Obj (Running)

→ Child class ref & child class obj (flying)

→ Parent class ref child class obj (flying)

→ Child class ref parent class object (NOT ALLOWED)

→ This is Run Time Poly.

Jiska object create hua hai. usi ka method call hoga.

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Parent class Reference → Child class object

⇓ only

But the properties & methods of reference will be allowed

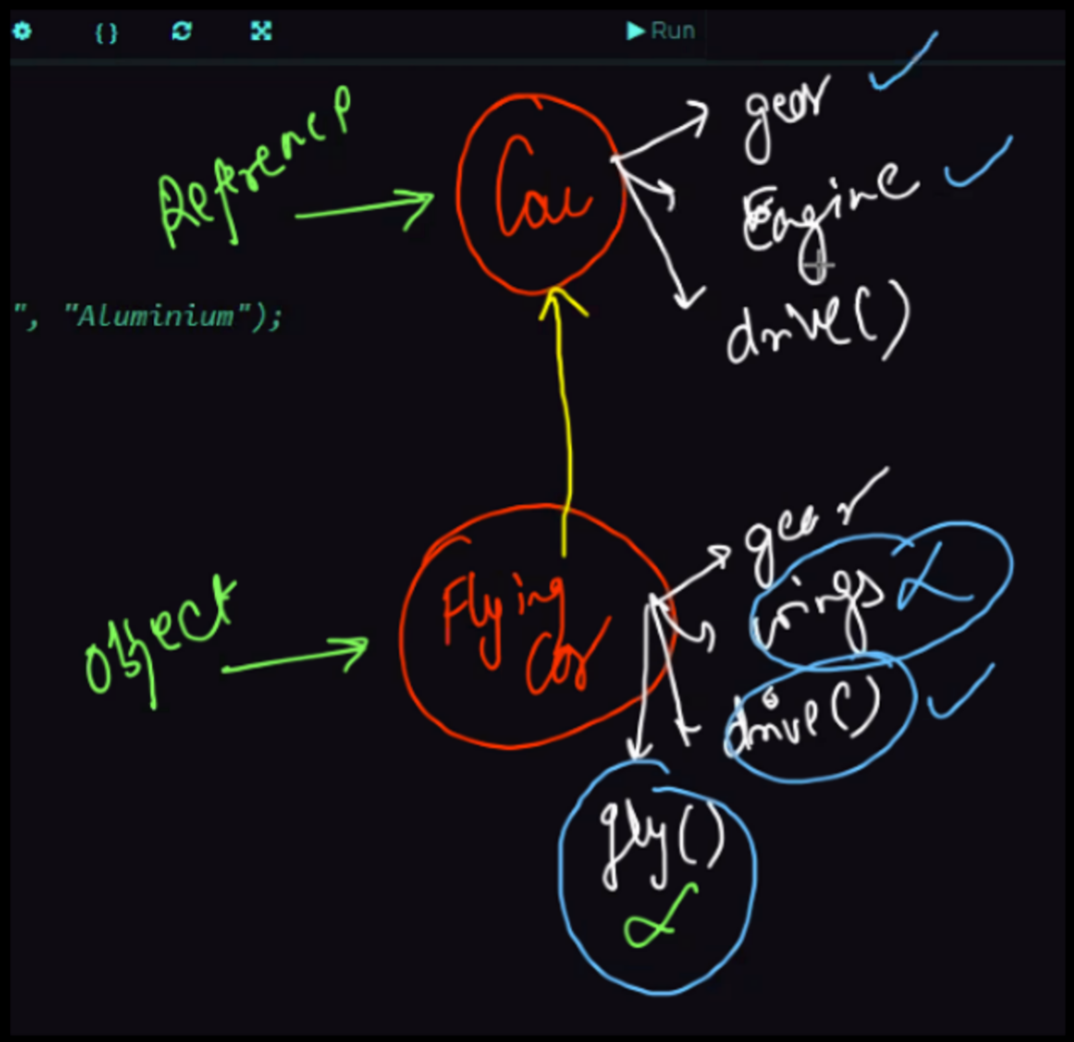
Car ✓ gear
✓ engine

flying car can access gear & engine.

car cannot access wings

flying Car ✓ wings

(wings are not accessible to Car even if object is of flying Car)



Method of child class will be accessed but properties of parent class itself will be accessed.

ClassName referenceName = new ObjectName();

→ gives the functions which we can call

→ provides the implementation of those funcs

This class should be same as the reference class or it's child class.

A → B

A: parent class, B: child class

A obj = new A();
B obj = new B();
A obj = new B(); } ✓ Possible → Runtime polymorphism

B obj = new A(); } ⇒ Not possible → Why?

→ Constructor of B never called

⇒ B's data members never initialized

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Reference → Stack

→ AddLast()

→ RemoveLast()

Queue ← Reference

→ AddLast()

→ RemoveFirst()

Deque ← Object

→ addFirst()

→ addLast()

→ removeFirst()

→ removeLast()

Queue q = new ArrayDeque<>();

Deque q = new ArrayDeque<>();

2

4

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for Run Time Poly

- order of arguments
- no of arguments
- return type

} should be same

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Early Binding VS Late Binding

→ Normal Methods { W/o inheritance }

→ Method overloading

→ Method Overriding

note :→ Static methods cannot be overrided

because
↳ Static does not depend on object
whereas overriding depends on objects type

```java
class A{
    public void earlyBind(){
        System.out.println("Early Bind");
    }

    public void lateBind(){
        System.out.println("Late Bind in Parent Class");
    }
}

class B extends A{
    @Override
    public void lateBind(){
        System.out.println("Late Bind in Child Class");
    }
}

public class Main{
    public static void main(String[] args){
        A obj = new B();
        obj.earlyBind();→ Early
        obj.lateBind();→ Child
    }
}
```

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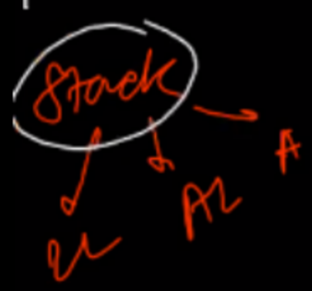
Abstraction

→ Hiding unnecessary details / complexity of class for the outside world & providing abstract views { showing necessary details }

{ Heap vs Priority Queue } => Heap is implementation of PQ. PQ is abstract view of Heap.

+



Implementation → Abstract classes { Partial Abstraction }

→ Interface { Full Abstraction }

Abstract class

↳ If a class has atleast one abstract method, then class needs to be abstract.

↳ objects/instances of abstract class cannot be created!

↳ Only function prototype not definition.

↳ Such methods must be over-riden

Abstract class cannot have

- → abstract constructor { concrete constructor can be there }
- → this keyword
- → abstract static methods { Note only static methods are allowed }

Abstract classes cannot be final.

Abstract class

↳ atleast one method abstract

↳ we cannot create object of this class

(because kisi method(s) ka code he nahi hai, so this will be wrong)

So, object class cannot be instantiated

```java
public abstract class Queue {
    public abstract void addLast(int val);
    public abstract int removeFirst();
}
```

Even if one method of a class is abstract, class has to abstract for the reason:

If it is not made abstract, this means we are allowing the class to be instantiated.

```java
abstract class Queue{
    public abstract void addLast(int val);
    public abstract int removeFirst();
}

class Child extends Queue{
    @Override
    public void addLast(int val){
        System.out.println("Add last is overrided / implemented");
    }
}
```

→ This class should also be abstract because removeFirst() is not overrided here.

** Child class of an abstract class should override all the methods to be concrete itself.

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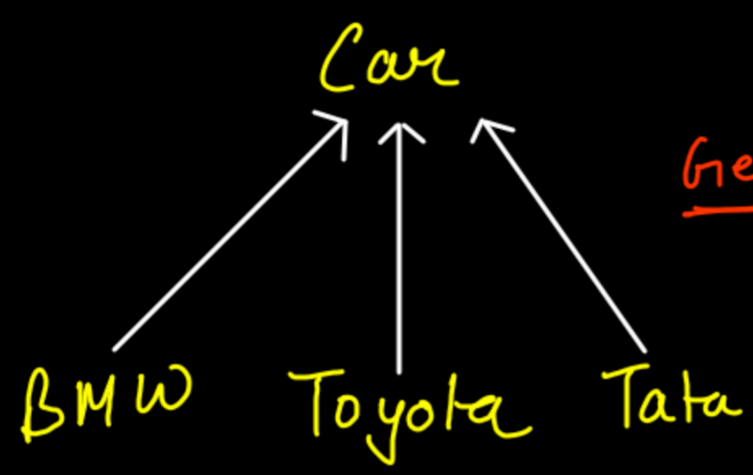
```java
public static void main(String[] args){
    Deque obj = new Deque();
    obj.addLast(10);
    obj.removeFirst();
    obj.addFirst(20);
    obj.removeLast();

    Queue obj2 = new Deque();
    obj2.addLast(10);
    obj2.removeFirst();

    // Queue obj3 = new Queue(); // Queue is abstract, hence queue cannot be instantiated.
    // Deque obj3 = new Queue(); // Child Class Reference & Parent Class Object, and also Queue is abstract
```

* 4 Also, we can have an abstract class without having even a single method abstract i.e abstract class can have concrete members too.



Generalisation

Abstraction

→ Abstract class (Partial abstraction)

↗ Can also be made full abstraction.

→ Interface (full abstraction)

** One class can implement multiple Interfaces.

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```java
class Deque implements Queue, Stack{
    public void addFirst(int val){
        System.out.println("Add first is overrided / implemented");
    }

    public int removeLast(){
        System.out.println("Remove last is overrided / implemented");
        return 0;
    }

    @Override
    public void addLast(int val){
        System.out.println("Add last is overrided / implemented");
    }

    @Override
    public int removeFirst(){
        System.out.println("Remove First is overrided / implemented");
        return 0;
    }
}
```

Diamond problem solved because abstract methods in both the interfaces got overriden.

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```java
abstract class Stack{
    public void addLast(int val){
        System.out.println("Hello");
    }
    public abstract int removeLast();
}

abstract class Queue{
    public void addLast(int val){
        System.out.println("hi");
    }
    public abstract int removeFirst();
}

class Deque extends Queue, Stack{
    public void addFirst(int val){
        System.out.println("Add first is overrided / implemented");
    }

    public int removeLast(){
        System.out.println("Remove last is overrided / implemented");
        return 0;
    }


    @Override
    public void addLast(int val){
        System.out.println("Add last is overrided / implemented");
    }

    @Override
    public int removeFirst(){
        System.out.println("Remove First is overrided / implemented");
        return 0;
    }
```

→ concrete

→ abstract

↑ Which one to overide ? (Diamond Problem)

Abstract methods cannot be static.

Abstract class does not have this keyword. (Because it's obj is not created)

Constructor cannot be abstract (Obviously because object cannot be created)

Class can implement multiple interfaces.

Interface ⇒ blue print of a class

all methods are public & abstract by default

cannot be instantiated {same as abstract class}

variables are static & final by default

from Java 8 and 9 onwards, interface can have default (concrete) method, private method, static method.

Interface can extend other interface
Interfaces can be nested.

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** One Interface can extend multiple Interfaces.

HW

Implement Stack
fixed ✓ Dynamic ↓

Implement Queue
fixed ✓ Dynamic ↓

Implement Deque

Stack using Queue

Queue using Stacks

→ Exception Handling
→ Inheritance, Polymorphism
→ Access Modifiers → private data (Getters & Setters)
→ Abstract Data type

More Points of Exploration

→ FINAL keyword
- Data Members → constant
- Reference variables → Reinitialize/update to other objects
- Classes → childclass avoid
- Methods → override avoid

"final class cannot be inherited"

→ Garbage Collector
- Automatic GC → delete unreachable objects → Avoids memory leak
- finalize method → {Similar to destructor in C++}
- Requesting GC { System.gc() method }
- Multithreading → daemon thread { always running in background }

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Packages

- grouping together classes & interfaces or nested packages.
- Built in packages
  - java.lang → Primitive datatypes, operators
  - java.util → collection framework
  - java.io → input/output, BufferReader, etc.
- User defined packages {import statement}

Advantages

- Avoid name collision
- Collaborative project development
- Implement Data Abstractn & Hiding

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```java
class Singleton{
    private Singleton(){}

    Singleton obj;
    public static Singleton getInstance(){
        if(obj == null){
            obj = new Singleton();
        }
        return obj;
    }
}

public class Main{

    public static void main(String[] args){
        Singleton obj1 = Singleton.getInstance();
        Singleton obj2 = Singleton.getInstance();
        Singleton obj3 = Singleton.getInstance();

        System.out.println(obj1.hashCode());
        System.out.println(obj2.hashCode());
        System.out.println(obj3.hashCode());
```

Singleton Class design pattern

If you want to have only 1 object for a class, make the constructor private.

→ Singleton class Design Pattern
  → Private Constructor
  → limiting the number of objects of a class to one!

→ Generics & collection framework
  - Abstract Data Types (ADT) like AL, LL, S&Q, etc.
  - Iterable → Iterator
  - Comparable & Comparator
  - lambda expression (Coarrow function)
  - user defined class of hashmap & heap