# Method Overloading in Java

If a class has multiple methods having same name but different in parameters, it is known as **Method Overloading**.

If we have to perform only one operation, having same name of the methods increases the readability of the program.

Suppose you have to perform addition of the given numbers but there can be any number of arguments, if you write the method such as a(int,int) for two parameters, and b(int,int,int) for three parameters then it may be difficult for you as well as other programmers to understand the behavior of the method because its name differs.

So, we perform method overloading to figure out the program quickly.

### Advantage of method overloading

Method overloading *increases the readability of the program*.


### Different ways to overload the method

There are two ways to overload the method in java

1. By changing number of arguments
2. By changing the data type

> In Java, Method Overloading is not possible by changing the return type of the method only.

## 1) Method Overloading: changing no. of arguments

In this example, we have created two methods, first add() method performs addition of two numbers and second add method performs addition of three numbers.

In this example, we are creating static methods so that we don't need to create instance for calling methods.

```
class Adder{
static int add(int a,int b){return a+b;}
static int add(int a,int b,int c){return a+b+c;}
}
```

```
class TestOverloading1{
public static void main(String[] args){
System.out.println(Adder.add(11,11));
System.out.println(Adder.add(11,11,11));
}}
```

Test it Now

Output:

```
22
33
```

## 2) Method Overloading: changing data type of arguments

In this example, we have created two methods that differs in data type. The first add method receives two integer arguments and second add method receives two double arguments.

```
class Adder{
static int add(int a, int b){return a+b;}
static double add(double a, double b){return a+b;}
}
class TestOverloading2{
public static void main(String[] args){
System.out.println(Adder.add(11,11));
System.out.println(Adder.add(12.3,12.6));
}}
```

Test it Now

Output:

```
22
24.9
```

## Q) Why Method Overloading is not possible by changing the return type of method only?

In java, method overloading is not possible by changing the return type of the method only because of ambiguity. Let's see how ambiguity may occur:

```
class Adder{
static int add(int a,int b){return a+b;}
static double add(int a,int b){return a+b;}
}
class TestOverloading3{
public static void main(String[] args){
System.out.println(Adder.add(11,11));//ambiguity
}}
```

Test it Now

Output:

```
Compile Time Error: method add(int,int) is already defined in class Adder
```

System.out.println(Adder.add(11,11)); //Here, how can java determine which sum() method should be called?

> Note: Compile Time Error is better than Run Time Error. So, java compiler renders compiler time error if you declare the same method having same parameters.

## Can we overload java main() method?

Yes, by method overloading. You can have any number of main methods in a class by method overloading. But JVM calls main() method which receives string array as arguments only. Let's see the simple example:

```
class TestOverloading4{
public static void main(String[] args){System.out.println("main with String[]");}
public static void main(String args){System.out.println("main with String");}
public static void main(){System.out.println("main without args");}
```

```
}
```

Test it Now

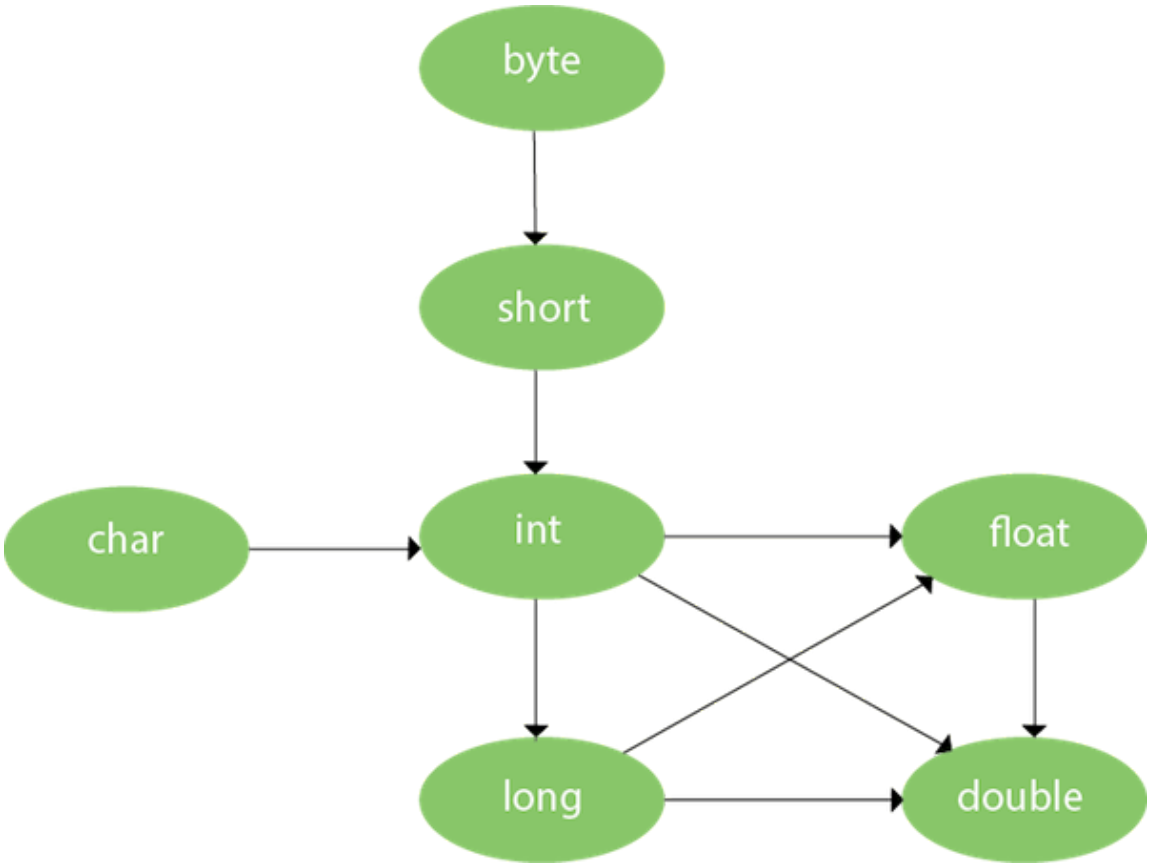
Output:

```
main with String[]
```

## Method Overloading and Type Promotion

One type is promoted to another implicitly if no matching datatype is found. Let's understand the concept by the figure given below:






As displayed in the above diagram, byte can be promoted to short, int, long, float or double. The short datatype can be promoted to int, long, float or double. The char datatype can be promoted to int,long,float or double and so on.

## Example of Method Overloading with TypePromotion

```
class OverloadingCalculation1{
  void sum(int a,long b){System.out.println(a+b);}
  void sum(int a,int b,int c){System.out.println(a+b+c);}

  public static void main(String args[]){
  OverloadingCalculation1 obj=new OverloadingCalculation1();
  obj.sum(20,20);//now second int literal will be promoted to long
  obj.sum(20,20,20);

  }
}
```

Test it Now

```
Output:40
       60
```

## Example of Method Overloading with Type Promotion if matching found

If there are matching type arguments in the method, type promotion is not performed.

```
class OverloadingCalculation2{
  void sum(int a,int b){System.out.println("int arg method invoked");}
  void sum(long a,long b){System.out.println("long arg method invoked");}

  public static void main(String args[]){
  OverloadingCalculation2 obj=new OverloadingCalculation2();
  obj.sum(20,20);//now int arg sum() method gets invoked
  }
}
```

Test it Now

```
Output:int arg method invoked
```

## Example of Method Overloading with Type Promotion in case of ambiguity

If there are no matching type arguments in the method, and each method promotes similar number of arguments, there will be ambiguity.

```
class OverloadingCalculation3{
  void sum(int a,long b){System.out.println("a method invoked");}
  void sum(long a,int b){System.out.println("b method invoked");}

  public static void main(String args[]){
  OverloadingCalculation3 obj=new OverloadingCalculation3();
  obj.sum(20,20);//now ambiguity
  }
}
```

Test it Now

```
Output:Compile Time Error
```

One type is not de-promoted implicitly for example double cannot be depromoted to any type implicitly.

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# Method Overriding in Java

If subclass (child class) has the same method as declared in the parent class, it is known as **method overriding in Java**.

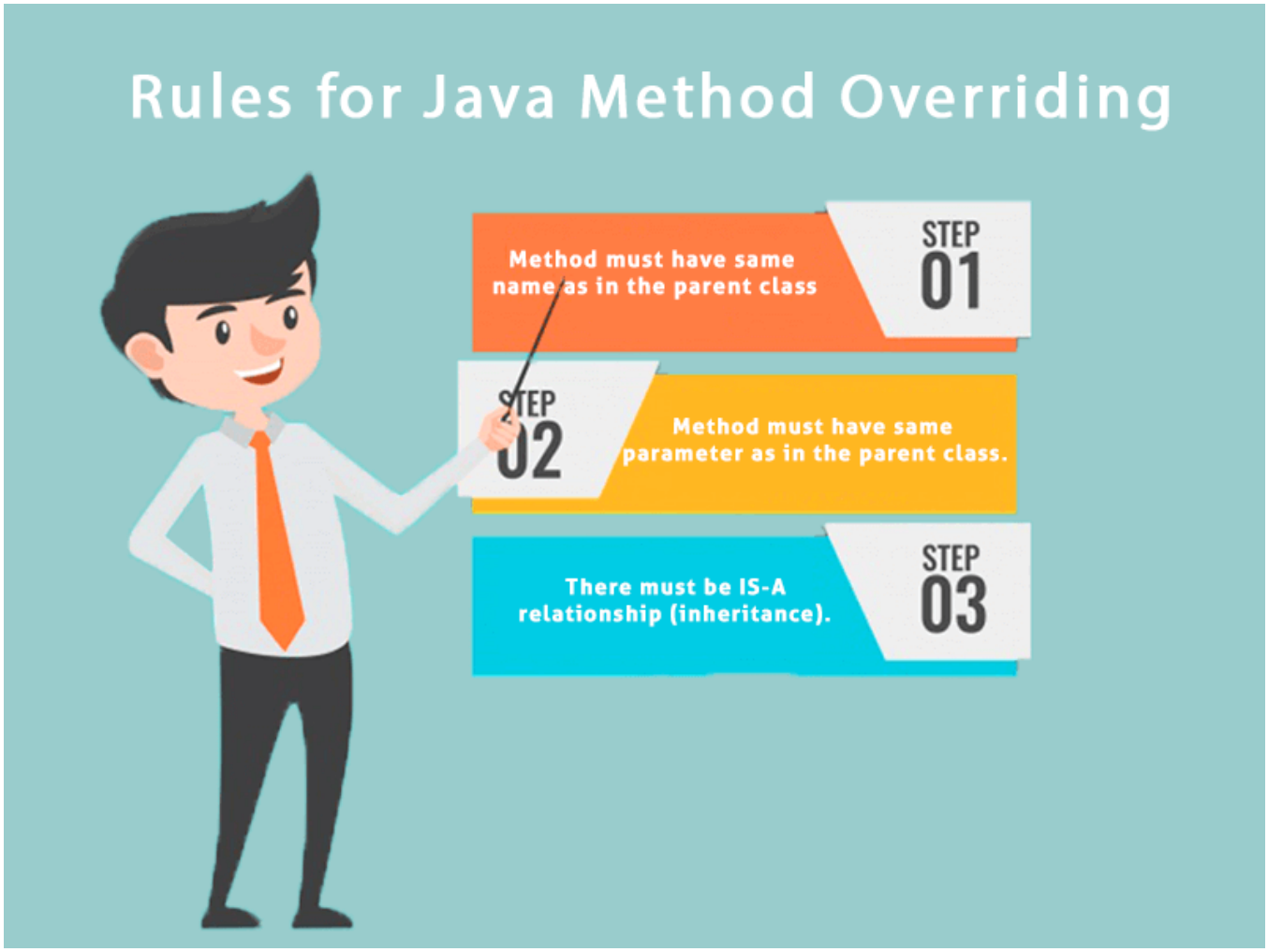
In other words, If a subclass provides the specific implementation of the method that has been declared by one of its parent class, it is known as method overriding.

## Usage of Java Method Overriding

- Method overriding is used to provide the specific implementation of a method which is already provided by its superclass.
- Method overriding is used for runtime polymorphism

## Rules for Java Method Overriding

1. The method must have the same name as in the parent class
2. The method must have the same parameter as in the parent class.
3. There must be an IS-A relationship (inheritance).




## Understanding the problem without method overriding

Let's understand the problem that we may face in the program if we don't use method overriding.

```
//Java Program to demonstrate why we need method overriding
//Here, we are calling the method of parent class with child
//class object.
//Creating a parent class
class Vehicle{
  void run(){System.out.println("Vehicle is running");}
}
//Creating a child class
class Bike extends Vehicle{
  public static void main(String args[]){
  //creating an instance of child class
  Bike obj = new Bike();
  //calling the method with child class instance
  obj.run();
  }
```

```
}
```

Test it Now

Output:

```
Vehicle is running
```

Problem is that I have to provide a specific implementation of run() method in subclass that is why we use method overriding.

## Example of method overriding

In this example, we have defined the run method in the subclass as defined in the parent class but it has some specific implementation. The name and parameter of the method are the same, and there is IS-A relationship between the classes, so there is method overriding.

```
//Java Program to illustrate the use of Java Method Overriding
//Creating a parent class.
class Vehicle{
  //defining a method
  void run(){System.out.println("Vehicle is running");}
}
//Creating a child class
class Bike2 extends Vehicle{
  //defining the same method as in the parent class
  void run(){System.out.println("Bike is running safely");}

  public static void main(String args[]){
  Bike2 obj = new Bike2();//creating object
  obj.run();//calling method
  }
}
```

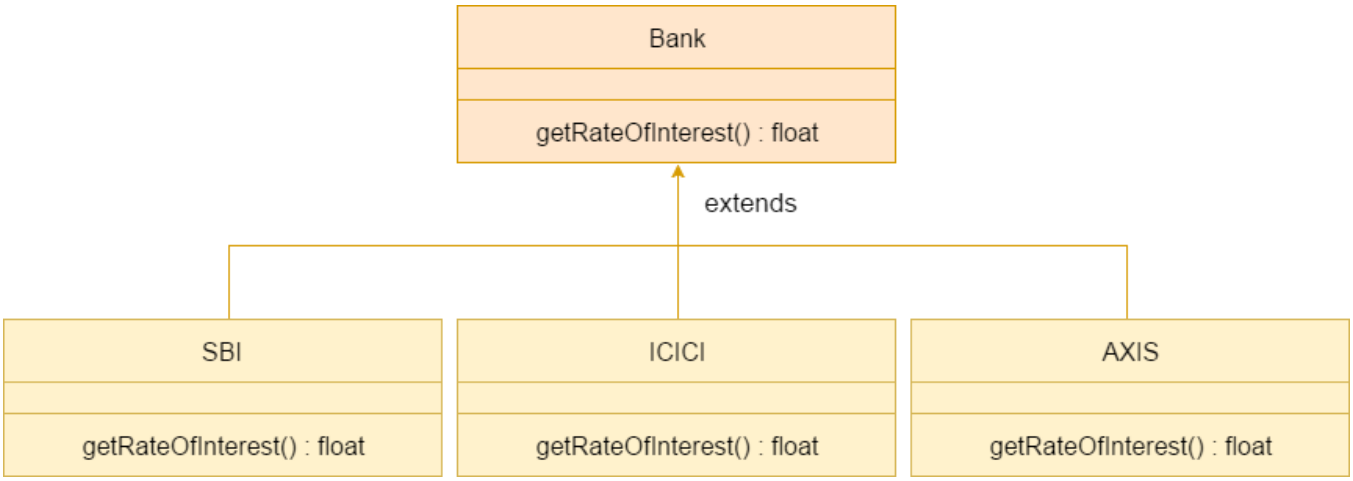
Test it Now

Output:

```
Bike is running safely
```

## A real example of Java Method Overriding

Consider a scenario where Bank is a class that provides functionality to get the rate of interest. However, the rate of interest varies according to banks. For example, SBI, ICICI and AXIS banks could provide 8%, 7%, and 9% rate of interest.




> Java method overriding is mostly used in Runtime Polymorphism which we will learn in next pages.

```
//Java Program to demonstrate the real scenario of Java Method Overriding
//where three classes are overriding the method of a parent class.
//Creating a parent class.
class Bank{
int getRateOfInterest(){return 0;}
}
//Creating child classes.
class SBI extends Bank{
int getRateOfInterest(){return 8;}
}

class ICICI extends Bank{
int getRateOfInterest(){return 7;}
}
class AXIS extends Bank{
```

```
int getRateOfInterest(){return 9;}
}
//Test class to create objects and call the methods
class Test2{
public static void main(String args[]){
SBI s=new SBI();
ICICI i=new ICICI();
AXIS a=new AXIS();
System.out.println("SBI Rate of Interest: "+s.getRateOfInterest());
System.out.println("ICICI Rate of Interest: "+i.getRateOfInterest());
System.out.println("AXIS Rate of Interest: "+a.getRateOfInterest());
}
}
```

**Test it Now**

```
Output:
SBI Rate of Interest: 8
ICICI Rate of Interest: 7
AXIS Rate of Interest: 9
```

## Can we override static method?

No, a static method cannot be overridden. It can be proved by runtime polymorphism, so we will learn it later.

## Why can we not override static method?

It is because the static method is bound with class whereas instance method is bound with an object. Static belongs to the class area, and an instance belongs to the heap area.

## Can we override java main method?

No, because the main is a static method.

# Difference between method Overloading and Method Overriding in java

Click me for the difference between method overloading and overriding

## More topics on Method Overriding (Not For Beginners)

### Method Overriding with Access Modifier

Let's see the concept of method overriding with access modifier.

### Exception Handling with Method Overriding

Let's see the concept of method overriding with exception handling.

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# Covariant Return Type

The covariant return type specifies that the return type may vary in the same direction as the subclass.

Before Java5, it was not possible to override any method by changing the return type. But now, since Java5, it is possible to override method by changing the return type if subclass overrides any method whose return type is Non-Primitive but it changes its return type to subclass type. Let's take a simple example:

> Note: If you are beginner to java, skip this topic and return to it after OOPs concepts.

## Simple example of Covariant Return Type

**FileName:** B1.java

```
class A{
A get(){return this;}
}

class B1 extends A{
@Override
B1 get(){return this;}
void message(){System.out.println("welcome to covariant return type");}

public static void main(String args[]){
new B1().get().message();
}
}
```

Test it Now

**Output:**

```
welcome to covariant return type
```

As you can see in the above example, the return type of the get() method of A class is A but the return type of the get() method of B class is B. Both methods have different return type but it is method overriding. This is known as covariant return type.

## Advantages of Covariant Return Type

Following are the advantages of the covariant return type.

1) Covariant return type assists to stay away from the confusing type casts in the class hierarchy and makes the code more usable, readable, and maintainable.

2) In the method overriding, the covariant return type provides the liberty to have more to the point return types.

3) Covariant return type helps in preventing the run-time *ClassCastExceptions* on returns.

Let's take an example to understand the advantages of the covariant return type.

**FileName:** CovariantExample.java

```
class A1
{
   A1 foo()
   {
      return this;
   }

   void print()
   {
      System.out.println("Inside the class A1");
   }
}



// A2 is the child class of A1
class A2 extends A1
{
   @Override
   A1 foo()
   {
      return this;
```

```
    }

    void print()
    {
        System.out.println("Inside the class A2");
    }
}

// A3 is the child class of A2
class A3 extends A2
{
    @Override
    A1 foo()
    {
        return this;
    }

    @Override
    void print()
    {
        System.out.println("Inside the class A3");
    }
}

public class CovariantExample
{
    // main method
    public static void main(String argvs[])
    {
      A1 a1 = new A1();

      // this is ok
      a1.foo().print();

      A2 a2 = new A2();

      // we need to do the type casting to make it
      // more clear to reader about the kind of object created
```

```
        ((A2)a2.foo()).print();

        A3 a3 = new A3();

        // doing the type casting
        ((A3)a3.foo()).print();

    }
}
```

**Output:**

```
Inside the class A1
Inside the class A2
Inside the class A3
```

**Explanation:** In the above program, class A3 inherits class A2, and class A2 inherits class A1. Thus, A1 is the parent of classes A2 and A3. Hence, any object of classes A2 and A3 is also of type A1. As the return type of the method *foo()* is the same in every class, we do not know the exact type of object the method is actually returning. We can only deduce that returned object will be of type A1, which is the most generic class. We can not say for sure that returned object will be of A2 or A3. It is where we need to do the typecasting to find out the specific type of object returned from the method *foo()*. It not only makes the code verbose; it also requires precision from the programmer to ensure that typecasting is done properly; otherwise, there are fair chances of getting the *ClassCastException*. To exacerbate it, think of a situation where the hierarchical structure goes down to 10 - 15 classes or even more, and in each class, the method *foo()* has the same return type. That is enough to give a nightmare to the reader and writer of the code.

The better way to write the above is:

**FileName:** CovariantExample.java

```
class A1
{
    A1 foo()
    {
        return this;
    }
```

```
    void print()
    {
        System.out.println("Inside the class A1");
    }
}


// A2 is the child class of A1
class A2 extends A1
{
    @Override
    A2 foo()
    {
        return this;
    }

    void print()
    {
        System.out.println("Inside the class A2");
    }
}

// A3 is the child class of A2
class A3 extends A2
{
    @Override
    A3 foo()
    {
        return this;
    }

    @Override
    void print()
    {
        System.out.println("Inside the class A3");
    }
}
```

```
public class CovariantExample
{
   // main method
   public static void main(String argvs[])
   {
      A1 a1 = new A1();

      a1.foo().print();

      A2 a2 = new A2();

      a2.foo().print();

      A3 a3 = new A3();

      a3.foo().print();

   }
}
```

**Output:**

```
Inside the class A1
Inside the class A2
Inside the class A3
```

**Explanation:** In the above program, no typecasting is needed as the return type is specific. Hence, there is no confusion about knowing the type of object getting returned from the method *foo()*. Also, even if we write the code for the 10 - 15 classes, there would be no confusion regarding the return types of the methods. All this is possible because of the covariant return type.

## How is Covariant return types implemented?

Java doesn't allow the return type-based overloading, but JVM always allows return type-based overloading. JVM uses the full signature of a method for lookup/resolution. Full signature means it includes return type in addition to argument types. i.e., a class can have two or more methods differing only by return type. javac uses this fact to implement covariant return types.

**Output:**

```
The number 1 is not the powerful number.
The number 2 is not the powerful number.
The number 3 is not the powerful number.
The number 4 is the powerful number.
The number 5 is not the powerful number.
The number 6 is not the powerful number.
The number 7 is not the powerful number.
The number 8 is the powerful number.
The number 9 is the powerful number.
The number 10 is not the powerful number.
The number 11 is not the powerful number.
The number 12 is not the powerful number.
The number 13 is not the powerful number.
The number 14 is not the powerful number.
The number 15 is not the powerful number.
The number 16 is the powerful number.
The number 17 is not the powerful number.
The number 18 is not the powerful number.
The number 19 is not the powerful number.
The number 20 is the powerful number.
```

**Explanation:** For every number from 1 to 20, the method *isPowerfulNo()* is invoked with the help of for-loop. For every number, a vector *primeFactors* is created for storing its prime divisors. Then, we check whether square of every number present in the vector *primeFactors* divides the number or not. If all square of all the number present in the vector *primeFactors* divides the number completely, the number is a powerful number; otherwise, not.

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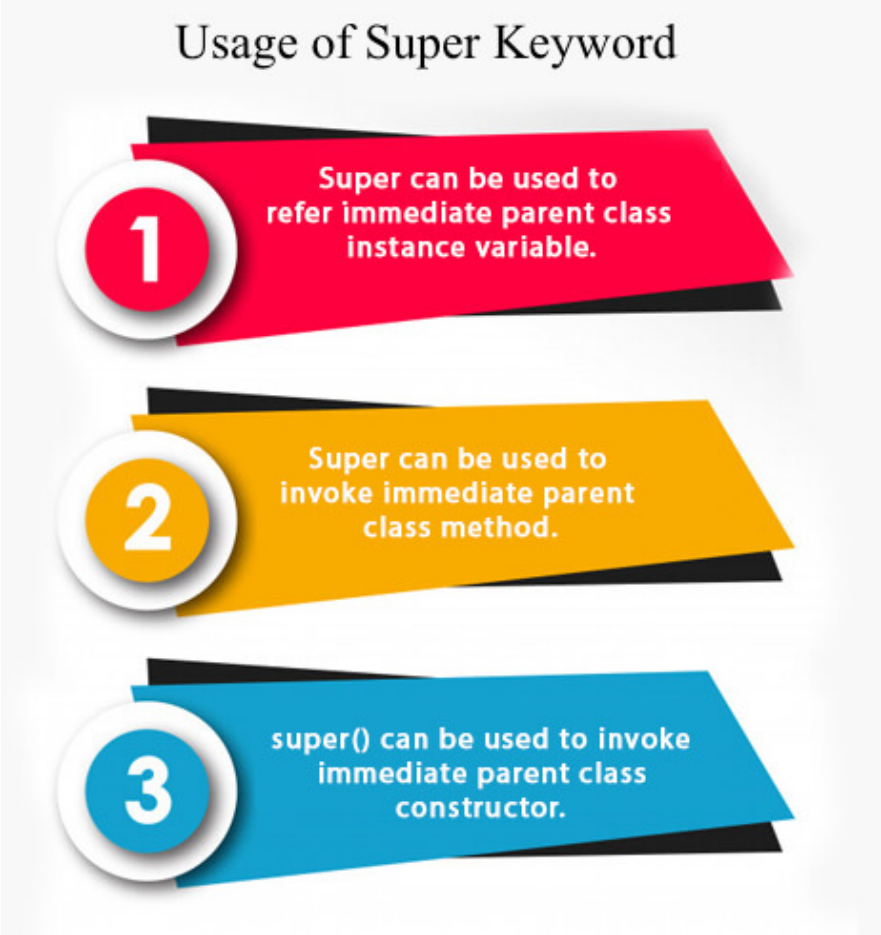
# Super Keyword in Java

The **super** keyword in Java is a reference variable which is used to refer immediate parent class object.

Whenever you create the instance of subclass, an instance of parent class is created implicitly which is referred by super reference variable.

## Usage of Java super Keyword

1. super can be used to refer immediate parent class instance variable.
2. super can be used to invoke immediate parent class method.
3. super() can be used to invoke immediate parent class constructor.




## 1) super is used to refer immediate parent class instance variable.

We can use super keyword to access the data member or field of parent class. It is used if parent class and child class have same fields.

```
class Animal{
String color="white";
}
class Dog extends Animal{
String color="black";
void printColor(){
System.out.println(color);//prints color of Dog class
System.out.println(super.color);//prints color of Animal class
}
}
class TestSuper1{
public static void main(String args[]){
Dog d=new Dog();
d.printColor();
}}
```

Test it Now

Output:

```
black
white
```

In the above example, Animal and Dog both classes have a common property color. If we print color property, it will print the color of current class by default. To access the parent property, we need to use super keyword.

## 2) super can be used to invoke parent class method

The super keyword can also be used to invoke parent class method. It should be used if subclass contains the same method as parent class. In other words, it is used if method is overridden.

```
class Animal{
void eat(){System.out.println("eating...");}
}
class Dog extends Animal{
void eat(){System.out.println("eating bread...");}
void bark(){System.out.println("barking...");}
```

```
void work(){
super.eat();
bark();
}
}
class TestSuper2{
public static void main(String args[]){
Dog d=new Dog();
d.work();
}}
```

Test it Now

Output:

```
eating...
barking...
```

In the above example Animal and Dog both classes have eat() method if we call eat() method from Dog class, it will call the eat() method of Dog class by default because priority is given to local.

To call the parent class method, we need to use super keyword.



## 3) super is used to invoke parent class constructor.

The super keyword can also be used to invoke the parent class constructor. Let's see a simple example:

```
class Animal{
Animal(){System.out.println("animal is created");}
}
class Dog extends Animal{
Dog(){
super();
System.out.println("dog is created");
```

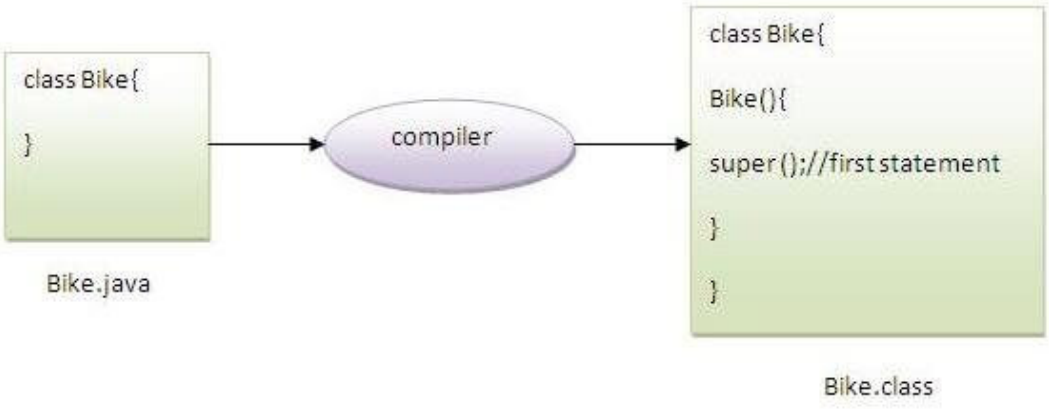
```
}
}
class TestSuper3{
public static void main(String args[]){
Dog d=new Dog();
}}
```

Test it Now

Output:

```
animal is created
dog is created
```

> Note: super() is added in each class constructor automatically by compiler if there is no super() or this().




As we know well that default constructor is provided by compiler automatically if there is no constructor. But, it also adds super() as the first statement.

**Another example of super keyword where super() is provided by the compiler implicitly.**

```
class Animal{
Animal(){System.out.println("animal is created");}
}
class Dog extends Animal{
Dog(){
System.out.println("dog is created");
```

```
}
}
class TestSuper4{
public static void main(String args[]){
Dog d=new Dog();
}}
```

Test it Now

Output:

```
animal is created
dog is created
```

## super example: real use

Let's see the real use of super keyword. Here, Emp class inherits Person class so all the properties of Person will be inherited to Emp by default. To initialize all the property, we are using parent class constructor from child class. In such way, we are reusing the parent class constructor.

```
class Person{
int id;
String name;
Person(int id,String name){
this.id=id;
this.name=name;
}
}
class Emp extends Person{
float salary;
Emp(int id,String name,float salary){
super(id,name);//reusing parent constructor
this.salary=salary;
}
void display(){System.out.println(id+" "+name+" "+salary);}
}
class TestSuper5{
public static void main(String[] args){
```

```
Emp e1=new Emp(1,"ankit",45000f);
e1.display();
}}
```

Test it Now

Output:

```
1 ankit 45000
```

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# Instance initializer block

**Instance Initializer block** is used to initialize the instance data member. It run each time when object of the class is created.

The initialization of the instance variable can be done directly but there can be performed extra operations while initializing the instance variable in the instance initializer block.

Que) What is the use of instance initializer block while we can directly assign a value in instance data member? For example:

```
class Bike{
   int speed=100;
}
```

## Why use instance initializer block?

Suppose I have to perform some operations while assigning value to instance data member e.g. a for loop to fill a complex array or error handling etc.

## Example of instance initializer block

Let's see the simple example of instance initializer block that performs initialization.

```
class Bike7{
   int speed;

   Bike7(){System.out.println("speed is "+speed);}

   {speed=100;}

   public static void main(String args[]){
   Bike7 b1=new Bike7();
   Bike7 b2=new Bike7();
   }
}
```

Test it Now

```
Output:speed is 100
       speed is 100
```

There are three places in java where you can perform operations:

1. method
2. constructor
3. block

## What is invoked first, instance initializer block or constructor?

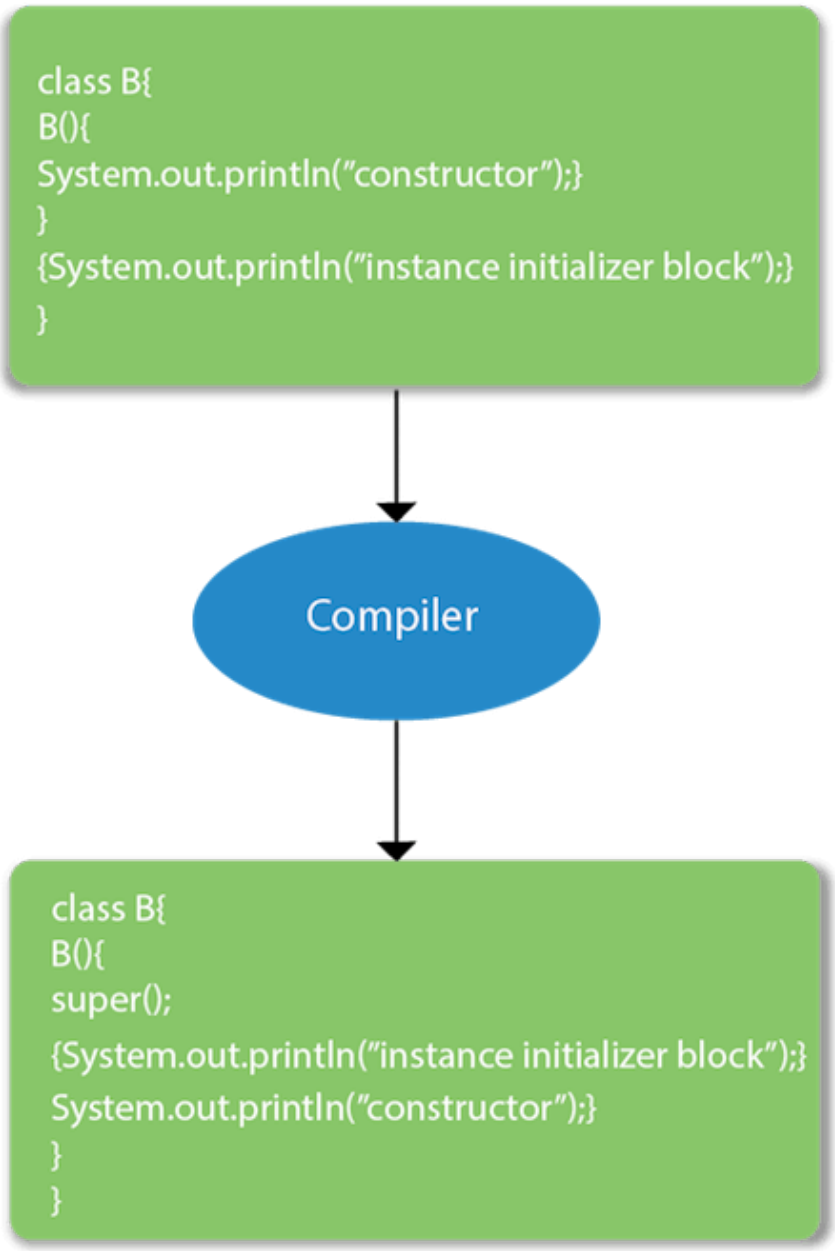
```
class Bike8{
  int speed;

  Bike8(){System.out.println("constructor is invoked");}

  {System.out.println("instance initializer block invoked");}

  public static void main(String args[]){
  Bike8 b1=new Bike8();
  Bike8 b2=new Bike8();
  }
}
```

Test it Now

```
Output:instance initializer block invoked
       constructor is invoked
       instance initializer block invoked
       constructor is invoked
```

In the above example, it seems that instance initializer block is firstly invoked but NO. Instance intializer block is invoked at the time of object creation. The java compiler copies the instance initializer block in the constructor after the first statement super(). So firstly, constructor is invoked. Let's understand it by the figure given below:

Note: The java compiler copies the code of instance initializer block in every constructor.




## Rules for instance initializer block :

There are mainly three rules for the instance initializer block. They are as follows:

1. The instance initializer block is created when instance of the class is created.
2. The instance initializer block is invoked after the parent class constructor is invoked (i.e. after super() constructor call).
3. The instance initializer block comes in the order in which they appear.

## Program of instance initializer block that is invoked after super()

```
class A{
A(){
System.out.println("parent class constructor invoked");
}
}
class B2 extends A{
B2(){
super();
System.out.println("child class constructor invoked");
}

{System.out.println("instance initializer block is invoked");}

public static void main(String args[]){
B2 b=new B2();
}
}
```

Test it Now

```
Output:parent class constructor invoked
       instance initializer block is invoked
       child class constructor invoked
```

## Another example of instance block

```
class A{
A(){
System.out.println("parent class constructor invoked");
}
```

```
}

class B3 extends A{
B3(){
super();
System.out.println("child class constructor invoked");
}

B3(int a){
super();
System.out.println("child class constructor invoked "+a);
}

{System.out.println("instance initializer block is invoked");}

public static void main(String args[]){
B3 b1=new B3();
B3 b2=new B3(10);
}
}
```

Test it Now

```
parent class constructor invoked
instance initializer block is invoked
child class constructor invoked
parent class constructor invoked
instance initializer block is invoked
child class constructor invoked 10
```

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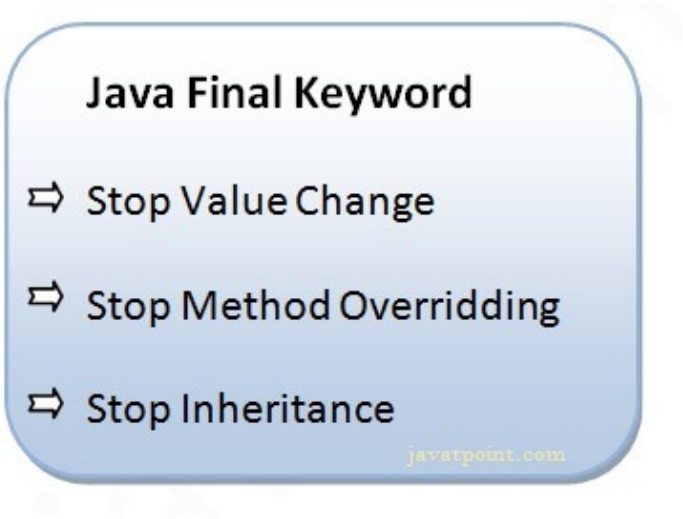
# Final Keyword In Java

The **final keyword** in java is used to restrict the user. The java final keyword can be used in many context. Final can be:

1. variable
2. method
3. class

The final keyword can be applied with the variables, a final variable that have no value it is called blank final variable or uninitialized final variable. It can be initialized in the constructor only. The blank final variable can be static also which will be initialized in the static block only. We will have detailed learning of these. Let's first learn the basics of final keyword.

## 1) Java final variable




If you make any variable as final, you cannot change the value of final variable(It will be constant).

### Example of final variable

There is a final variable speedlimit, we are going to change the value of this variable, but It can't be changed because final variable once assigned a value can never be changed.

```
class Bike9{
 final int speedlimit=90;//final variable
 void run(){
  speedlimit=400;
 }
 public static void main(String args[]){
 Bike9 obj=new  Bike9();
 obj.run();
 }
}//end of class
```

Test it Now

```
Output:Compile Time Error
```

## 2) Java final method

If you make any method as final, you cannot override it.

### Example of final method

```
class Bike{
  final void run(){System.out.println("running");}
}

class Honda extends Bike{
   void run(){System.out.println("running safely with 100kmph");}

   public static void main(String args[]){
   Honda honda= new Honda();
   honda.run();
   }
}
```

Test it Now

```
Output:Compile Time Error
```

## 3) Java final class

If you make any class as final, you cannot extend it.

### Example of final class

```
final class Bike{}

class Honda1 extends Bike{
  void run(){System.out.println("running safely with 100kmph");}
```

```
  public static void main(String args[]){
  Honda1 honda= new Honda1();
  honda.run();
  }
}
```

Test it Now

```
Output:Compile Time Error
```

## Q) Is final method inherited?

Ans) Yes, final method is inherited but you cannot override it. For Example:

```
class Bike{
  final void run(){System.out.println("running...");}
}
class Honda2 extends Bike{
   public static void main(String args[]){
    new Honda2().run();
   }
}
```

Test it Now

```
Output:running...
```

## Q) What is blank or uninitialized final variable?

A final variable that is not initialized at the time of declaration is known as blank final variable.

If you want to create a variable that is initialized at the time of creating object and once initialized may not be changed, it is useful. For example PAN CARD number of an employee.

It can be initialized only in constructor.

## Example of blank final variable

```
class Student{
int id;
String name;
final String PAN_CARD_NUMBER;
...
}
```

### Que) Can we initialize blank final variable?

Yes, but only in constructor. For example:

```
class Bike10{
  final int speedlimit;//blank final variable

  Bike10(){
  speedlimit=70;
  System.out.println(speedlimit);
  }

  public static void main(String args[]){
    new Bike10();
 }
}
```

Test it Now

```
Output: 70
```

## static blank final variable

A static final variable that is not initialized at the time of declaration is known as static blank final variable. It can be initialized only in static block.

## Example of static blank final variable

```
class A{
  static final int data;//static blank final variable
```

```
  static{ data=50;}
  public static void main(String args[]){
    System.out.println(A.data);
 }
}
```

### Q) What is final parameter?

If you declare any parameter as final, you cannot change the value of it.

```
class Bike11{
  int cube(final int n){
   n=n+2;//can't be changed as n is final
   n*n*n;
  }
  public static void main(String args[]){
    Bike11 b=new Bike11();
    b.cube(5);
 }
}
```

Test it Now

```
Output: Compile Time Error
```

## Q) Can we declare a constructor final?

No, because constructor is never inherited.

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# Polymorphism in Java

**Polymorphism in Java** is a concept by which we can perform a *single action in different ways*. Polymorphism is derived from 2 Greek words: poly and morphs. The word "poly" means many and "morphs" means forms. So polymorphism means many forms.

There are two types of polymorphism in Java: compile-time polymorphism and runtime polymorphism. We can perform polymorphism in java by method overloading and method overriding.

If you overload a static method in Java, it is the example of compile time polymorphism. Here, we will focus on runtime polymorphism in java.

## Runtime Polymorphism in Java

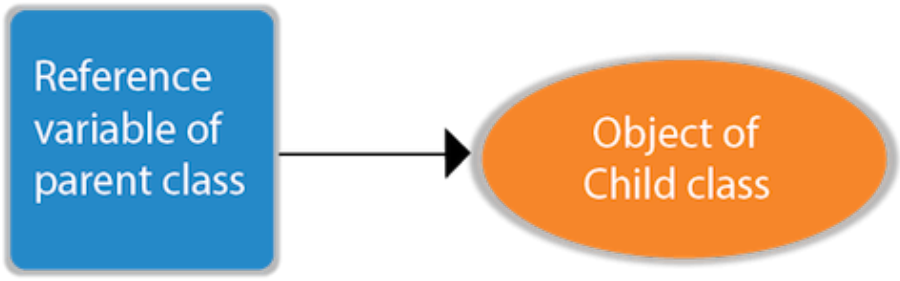
**Runtime polymorphism** or **Dynamic Method Dispatch** is a process in which a call to an overridden method is resolved at runtime rather than compile-time.

In this process, an overridden method is called through the reference variable of a superclass. The determination of the method to be called is based on the object being referred to by the reference variable.

Let's first understand the upcasting before Runtime Polymorphism.

### Upcasting

If the reference variable of Parent class refers to the object of Child class, it is known as upcasting. For example:




```
class A{}
class B extends A{}
```

```
A a=new B();//upcasting
```

For upcasting, we can use the reference variable of class type or an interface type. For Example:

```
interface I{}
class A{}
class B extends A implements I{}
```

Here, the relationship of B class would be:

```
B IS-A A
B IS-A I
B IS-A Object
```

Since Object is the root class of all classes in Java, so we can write B IS-A Object.

## Example of Java Runtime Polymorphism

In this example, we are creating two classes Bike and Splendor. Splendor class extends Bike class and overrides its run() method. We are calling the run method by the reference variable of Parent class. Since it refers to the subclass object and subclass method overrides the Parent class method, the subclass method is invoked at runtime.

Since method invocation is determined by the JVM not compiler, it is known as runtime polymorphism.

```
class Bike{
  void run(){System.out.println("running");}
}
class Splendor extends Bike{
  void run(){System.out.println("running safely with 60km");}

  public static void main(String args[]){
    Bike b = new Splendor();//upcasting
    b.run();
  }
```

```
}
```

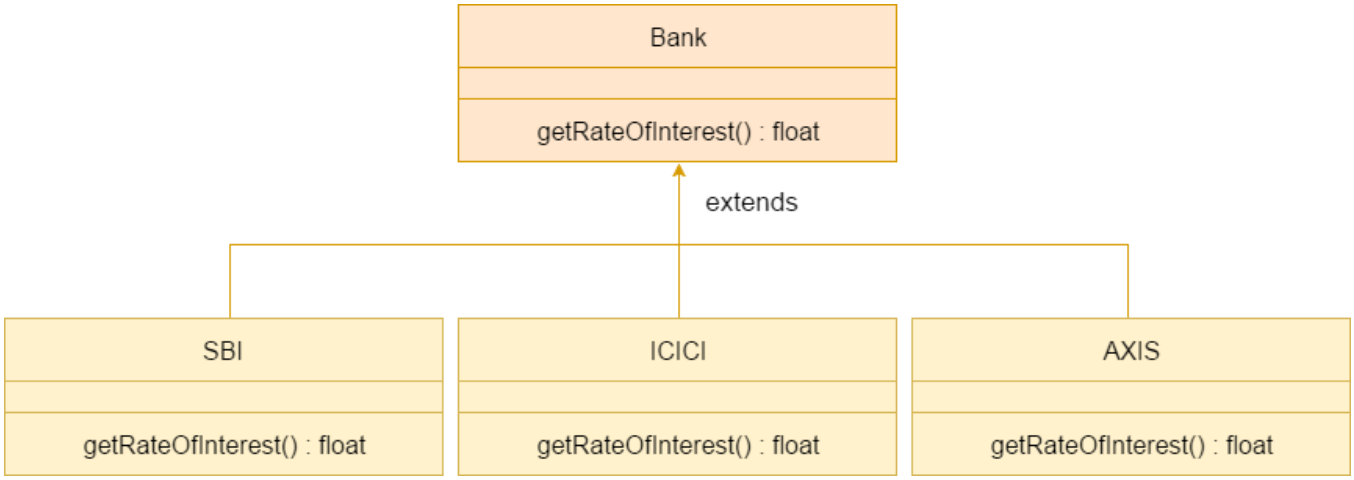
Test it Now

Output:

```
running safely with 60km.
```

## Java Runtime Polymorphism Example: Bank

Consider a scenario where Bank is a class that provides a method to get the rate of interest. However, the rate of interest may differ according to banks. For example, SBI, ICICI, and AXIS banks are providing 8.4%, 7.3%, and 9.7% rate of interest.




> Note: This example is also given in method overriding but there was no upcasting.

```
class Bank{
float getRateOfInterest(){return 0;}
}
class SBI extends Bank{
float getRateOfInterest(){return 8.4f;}
}
class ICICI extends Bank{
float getRateOfInterest(){return 7.3f;}
}
class AXIS extends Bank{
float getRateOfInterest(){return 9.7f;}
```

```
}
class TestPolymorphism{
public static void main(String args[]){
Bank b;
b=new SBI();
System.out.println("SBI Rate of Interest: "+b.getRateOfInterest());
b=new ICICI();
System.out.println("ICICI Rate of Interest: "+b.getRateOfInterest());
b=new AXIS();
System.out.println("AXIS Rate of Interest: "+b.getRateOfInterest());
}
}
```

Test it Now

Output:

```
SBI Rate of Interest: 8.4
ICICI Rate of Interest: 7.3
AXIS Rate of Interest: 9.7
```

## Java Runtime Polymorphism Example: Shape

```
class Shape{
void draw(){System.out.println("drawing...");}
}
class Rectangle extends Shape{
void draw(){System.out.println("drawing rectangle...");}
}
class Circle extends Shape{
void draw(){System.out.println("drawing circle...");}
}
class Triangle extends Shape{
void draw(){System.out.println("drawing triangle...");}
}
class TestPolymorphism2{
public static void main(String args[]){
```

```
Shape s;
s=new Rectangle();
s.draw();
s=new Circle();
s.draw();
s=new Triangle();
s.draw();
}
}
```

Test it Now

Output:

```
drawing rectangle...
drawing circle...
drawing triangle...
```



## Java Runtime Polymorphism Example: Animal

```
class Animal{
void eat(){System.out.println("eating...");}
}
class Dog extends Animal{
void eat(){System.out.println("eating bread...");}
}
class Cat extends Animal{
void eat(){System.out.println("eating rat...");}
}
class Lion extends Animal{
void eat(){System.out.println("eating meat...");}
}
class TestPolymorphism3{
public static void main(String[] args){
```

```
Animal a;
a=new Dog();
a.eat();
a=new Cat();
a.eat();
a=new Lion();
a.eat();
}}
```

Test it Now

Output:



```
eating bread...
eating rat...
eating meat...
```

## Java Runtime Polymorphism with Data Member

A method is overridden, not the data members, so runtime polymorphism can't be achieved by data members.

In the example given below, both the classes have a data member speedlimit. We are accessing the data member by the reference variable of Parent class which refers to the subclass object. Since we are accessing the data member which is not overridden, hence it will access the data member of the Parent class always.

> Rule: Runtime polymorphism can't be achieved by data members.

```
class Bike{
 int speedlimit=90;
}
class Honda3 extends Bike{
 int speedlimit=150;
```

```
 public static void main(String args[]){
  Bike obj=new Honda3();
  System.out.println(obj.speedlimit);//90
}
```

Test it Now

Output:

```
90
```

## Java Runtime Polymorphism with Multilevel Inheritance

Let's see the simple example of Runtime Polymorphism with multilevel inheritance.

```
class Animal{
void eat(){System.out.println("eating");}
}
class Dog extends Animal{
void eat(){System.out.println("eating fruits");}
}
class BabyDog extends Dog{
void eat(){System.out.println("drinking milk");}
public static void main(String args[]){
Animal a1,a2,a3;
a1=new Animal();
a2=new Dog();
a3=new BabyDog();
a1.eat();
a2.eat();
a3.eat();
}
}
```

Test it Now

Output:

```
eating
eating fruits
drinking Milk
```

## Try for Output

```
class Animal{
void eat(){System.out.println("animal is eating...");}
}
class Dog extends Animal{
void eat(){System.out.println("dog is eating...");}
}
class BabyDog1 extends Dog{
public static void main(String args[]){
Animal a=new BabyDog1();
a.eat();
}}
```

**Test it Now**

Output:

```
Dog is eating
```

Since, BabyDog is not overriding the eat() method, so eat() method of Dog class is invoked.

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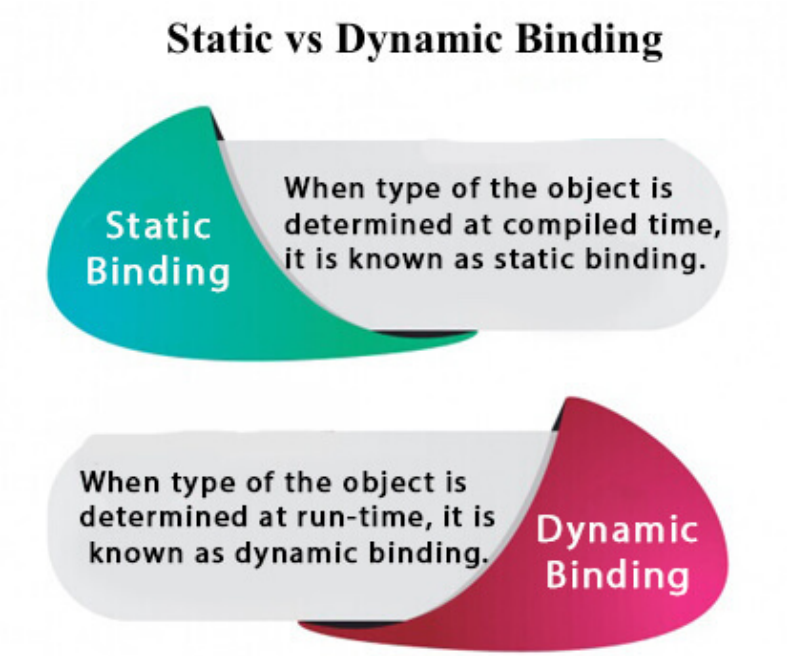
# Static Binding and Dynamic Binding


Connecting a method call to the method body is known as binding.

There are two types of binding

1. Static Binding (also known as Early Binding).
2. Dynamic Binding (also known as Late Binding).




## Understanding Type

Let's understand the type of instance.

### 1) variables have a type

Each variable has a type, it may be primitive and non-primitive.

```
int data=30;
```

Here data variable is a type of int.

### 2) References have a type

```
class Dog{
 public static void main(String args[]){
  Dog d1;//Here d1 is a type of Dog
 }
}
```

### 3) Objects have a type

An object is an instance of particular java class,but it is also an instance of its superclass.

```
class Animal{}

class Dog extends Animal{
 public static void main(String args[]){
  Dog d1=new Dog();
 }
}
```

Here d1 is an instance of Dog class, but it is also an instance of Animal.

## static binding

When type of the object is determined at compiled time(by the compiler), it is known as static binding.

If there is any private, final or static method in a class, there is static binding.

## Example of static binding

```
class Dog{
 private void eat(){System.out.println("dog is eating...");}

 public static void main(String args[]){
  Dog d1=new Dog();
  d1.eat();
 }
```

```
}
```

## Dynamic binding

When type of the object is determined at run-time, it is known as dynamic binding.

## Example of dynamic binding

```
class Animal{
 void eat(){System.out.println("animal is eating...");}
}

class Dog extends Animal{
 void eat(){System.out.println("dog is eating...");}

 public static void main(String args[]){
  Animal a=new Dog();
  a.eat();
 }
}
```

Test it Now

```
Output:dog is eating...
```

In the above example object type cannot be determined by the compiler, because the instance of Dog is also an instance of Animal.So compiler doesn't know its type, only its base type.

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# Java instanceof

The **java instanceof operator** is used to test whether the object is an instance of the specified type (class or subclass or interface).

The instanceof in java is also known as type *comparison operator* because it compares the instance with type. It returns either true or false. If we apply the instanceof operator with any variable that has null value, it returns false.

## Simple example of java instanceof

Let's see the simple example of instance operator where it tests the current class.

```
class Simple1{
 public static void main(String args[]){
 Simple1 s=new Simple1();
 System.out.println(s instanceof Simple1);//true
 }
}
```

Test it Now

```
Output:true
```

An object of subclass type is also a type of parent class. For example, if Dog extends Animal then object of Dog can be referred by either Dog or Animal class.

## Another example of java instanceof operator

```
class Animal{}
class Dog1 extends Animal{//Dog inherits Animal

 public static void main(String args[]){
 Dog1 d=new Dog1();
 System.out.println(d instanceof Animal);//true
 }
}
```

Test it Now

```
Output:true
```

## instanceof in java with a variable that have null value

If we apply instanceof operator with a variable that have null value, it returns false. Let's see the example given below where we apply instanceof operator with the variable that have null value.

```
class Dog2{
 public static void main(String args[]){
  Dog2 d=null;
  System.out.println(d instanceof Dog2);//false
 }
}
```

Test it Now

```
Output:false
```

## Downcasting with java instanceof operator

When Subclass type refers to the object of Parent class, it is known as downcasting. If we perform it directly, compiler gives Compilation error. If you perform it by typecasting, ClassCastException is thrown at runtime. But if we use instanceof operator, downcasting is possible.

```
Dog d=new Animal();//Compilation error
```

If we perform downcasting by typecasting, ClassCastException is thrown at runtime.

```
Dog d=(Dog)new Animal();
//Compiles successfully but ClassCastException is thrown at runtime
```

### Possibility of downcasting with instanceof

Let's see the example, where downcasting is possible by instanceof operator.

```
class Animal { }

class Dog3 extends Animal {
 static void method(Animal a) {
  if(a instanceof Dog3){
    Dog3 d=(Dog3)a;//downcasting
    System.out.println("ok downcasting performed");
  }
 }

 public static void main (String [] args) {
  Animal a=new Dog3();
  Dog3.method(a);
 }

}
```

Test it Now

```
Output:ok downcasting performed
```

## Downcasting without the use of java instanceof

Downcasting can also be performed without the use of instanceof operator as displayed in the following example:

```
class Animal { }
class Dog4 extends Animal {
 static void method(Animal a) {
    Dog4 d=(Dog4)a;//downcasting
    System.out.println("ok downcasting performed");
 }
  public static void main (String [] args) {
  Animal a=new Dog4();
  Dog4.method(a);
 }
```

```
}
```

Test it Now

```
Output:ok downcasting performed
```

Let's take closer look at this, actual object that is referred by a, is an object of Dog class. So if we downcast it, it is fine. But what will happen if we write:

```
Animal a=new Animal();
Dog.method(a);
//Now ClassCastException but not in case of instanceof operator
```

## Understanding Real use of instanceof in java

Let's see the real use of instanceof keyword by the example given below.

```
interface Printable{}
class A implements Printable{
public void a(){System.out.println("a method");}
}
class B implements Printable{
public void b(){System.out.println("b method");}
}

class Call{
void invoke(Printable p){//upcasting
if(p instanceof A){
A a=(A)p;//Downcasting
a.a();
}
if(p instanceof B){
B b=(B)p;//Downcasting
b.b();
}

}
```

```
}//end of Call class

class Test4{
public static void main(String args[]){
Printable p=new B();
Call c=new Call();
c.invoke(p);
}
}
```

Test it Now

```
Output: b method
```

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