Java SE

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Getting Started

What is Java?

- A general-purpose programming language.
- Invented by **James Gosling**, Patrick Naughton, Chris Warth, Ed Frank and Mike Sheridan at Sun Microsystems.
- Java was released in **May, 1995**.
- Most widely used programming language.
- Mainly used to develop web and enterprise applications.
- Provides "write once and run anywhere" features – Platform independence.
- Influenced by **C and C++**.
- Derives its syntax from C and C++. However, it eliminated features of C++ such as multiple inheritance, operator overloading, friend function etc. that could cause ambiguity.

History of Java

The following are some important versions of Java, when they were released and what features were added.

- Java 1.0 was released in May, 1995. Java was initially called "oak" and then renamed to Java. JDK (Java Development Kit) 1.0 was released on January 23, 1996.
- Java 5.0 was released in 2004 adding annotations and generics.
- Java 8.0 was released in 2014 adding lambda expressions and streams.
- Java 9.0 was released in 2017 adding JShell and JPMS.
- Starting from Java 10, a new version was released every 6 months.
- The most recent release was Java 18 in Mar, 2022.

Editions of Java

Java is provided as three different editions, where each edition is meant for different types of applications.

- ❑ Java Standard Edition – Java SE
- ❑ Java Enterprise Edition – Java EE

Java SE (Standard Edition)

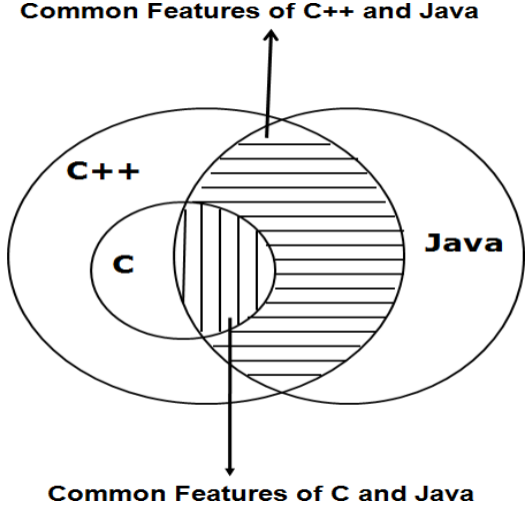
- ❑ This is used to develop Console applications, Applets and Frame-based applications (desktop applications).
- ❑ This edition provides features of language, core API (Application Program Interface) related to IO Stream, Networking, Data structures using Collections Framework etc.
- ❑ This edition comes with Java compiler, JVM and other tools to develop applets and desktop applications.

Java EE (Enterprise Edition)

- ❑ This is used to develop web applications, web services, and enterprise applications. It uses Java Language and core API.
- ❑ It is a set of specifications to be implemented by products. BEA's WebLogic server, IBM's WebSphere, Open-source product JBoss, Glassfish etc. implement Java EE specifications.
- ❑ Major topics of Java EE are Servlets, JSPs, Enterprise Java Beans (EJB), JavaServer Faces (JSF).

Relationship between C, C++ and Java

- C was released in 1970. C++ was released in 1980. Java was released in 1995.
- C and C++ are meant for System programming whereas Java is meant for application programming.
- Java uses control structures such as if, for etc. of C language.
- Java does not support pointers, pointer arithmetic and unions.
- Java and C++ have OOP (Object Oriented Programming) as a common feature.
- However, Java has ignored a lot of features of C++ as these features would cause ambiguity.
- Default function arguments, Operator overloading, Multiple inheritance, Friend functions etc. of C++ are not supported by Java.
- C and C++ concentrated more on providing flexibility and power, but Java's The main focus has been robustness and Internet programming.



Features of Java Language

The following are the major features of the Java language.

Robust	Makes programs robust (free from potential errors). Java detects all potential problems at the time of compiling the program. It also checks for array boundary violation etc. at run time.
Object Oriented	Supports encapsulation, inheritance and polymorphism. Java allows the entire code to be placed only in classes. It doesn't allow any code to be placed outside the class including the main() method.
Dynamic	Allocates memory for arrays and objects at run time and handles allocation and deallocation of memory on its own. Garbage collector is responsible for releasing unused memory blocks.
Multithreaded	Supports creating and managing multiple threads.
Distributed	Supports programs to run on different systems and yet communicate with each other. Provides a mechanism to transmit data from one application to another.
Platform Independent	Allows a compiled program (byte code) to run on any other platform.

Java is Robust

- Java, being a robust language, checks for potential errors both at the time of compilation and at runtime.
- Java is a strongly typed language, where data type of a value cannot be changed to another, and is case-sensitive.
- The following snippets show operations that are allowed in **C** but not in **Java.**

```
01: int a[10];
02: int i, j;      // local variables, not initialized
03: a[10] = 25;    //accessing element outside the bounds
04: i = 10.50;     // assigning float to int
05: j++;           // using without initializing it
```

- Java also checks whether a function that is supposed to return a value is really returning a value.

```
01: /* This function does not compile as it does not
02:  return value when condition is false. */
03: int fun(int v) {
04:     if (v > 10)
05:         return 1;
06:   }
```

- Java checks whether a piece of code is reachable during the execution of a program. If code is not reachable in all paths of execution, then it complains about it.

```
01: /* Unreachable code example */
02: int fun(int v) {
03:    if (v > 10)
04:       return 1;
05:    else
06:       return 0;
07:
08:
09: }   v ++ ;   // cannot be reached.
```

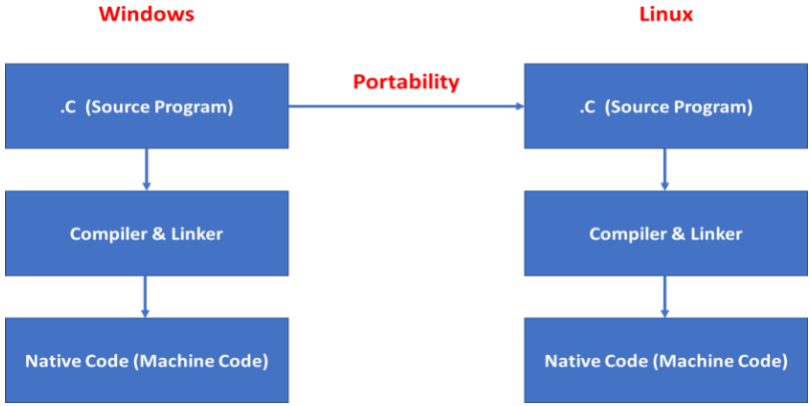
Platform Independent Language

The main feature of the Java language is its **platform independence**. This allows a Java program that is compiled on one platform to run on any other platform.

This is called WORA (Write Once, Run Anywhere).

Platform independence is different from **Portability**.

Portability allows source code to be ported to different platforms. Though the source program is ported we need to compile the source program on the target platform before running it.



All high-level languages have portability.

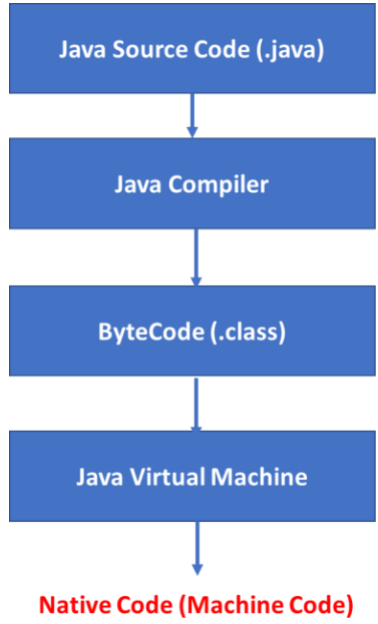
Native code is the code understood by the Microprocessor and operating system of the computer.

NOTE: Platform is the environment in which application programs run. It is typically the combination of operating system and hardware. Platform is generally synonymous with operating systems.

Compiling and running of Java Program

The following figure shows the steps related to compiling and running a Java program. Java programs are NOT compiled to native code and instead they are compiled to **Bytecode**, which is close to native code but not native code of any platform.

Once a Java program is compiled to bytecode then it can be run on any platform where JVM (Java Virtual Machine) is available.



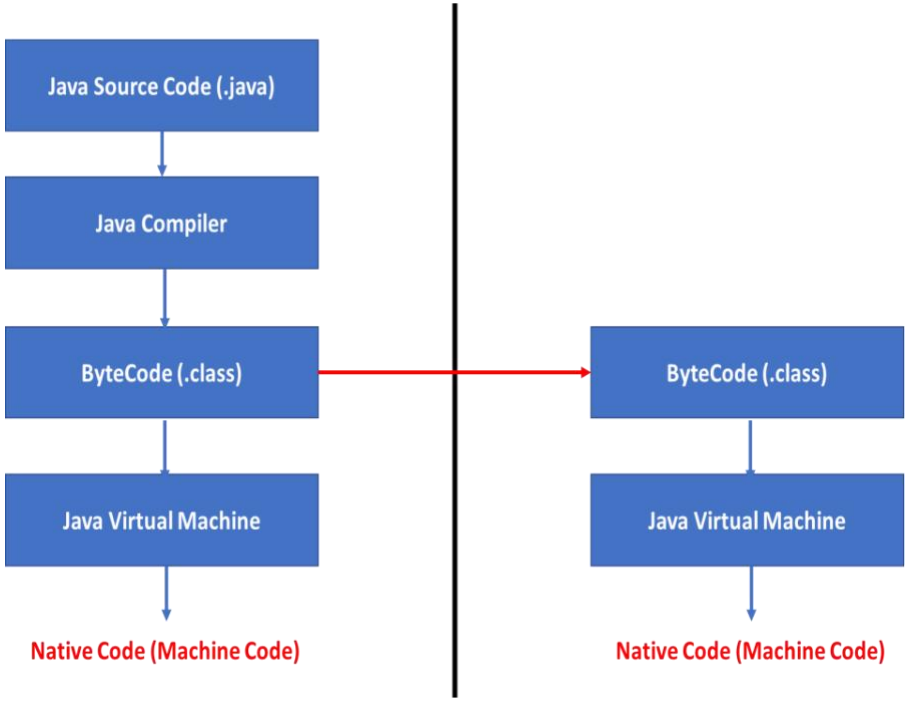
NOTE: Java compiler and JVM are specific to each platform. Only bytecode is platform independent.

Java and Platform Independence

The following picture shows how a Java program that is compiled on a Windows system can run on a Linux system.

Once a Java program is compiled to Bytecode (.class file), it can be executed on any machine where JVM is available.

Most of the modern operating systems provide JVM along with operating systems allowing byte code to run straight away.



Using Java SE

- Download Java SE (a.k.a. JDK – Java Development Kit) from https://www.oracle.com/in/java/technologies/javase-downloads.html
- Installing Java SE is as simple as double clicking on downloaded file (**.exe** file) and following the steps.
- It is better if you install Java SE into a directory like **c:\jdk**, instead of the default directory (which is **program files** directory).

Directory Structure of Java SE

After you install Java SE into a directory (say c:\jdk), the structure of the directory will look like below:

```
c:\jdk
    bin
      javac.exe, java.exe
    include
    lib
       *.jar
    conf
       *.properties
```

Directory	Description
bin	Contains executable files related to JDK. It contains JAVAC.EXE and JAVA.EXE.
include	Includes files for Java Native Interface.
lib	Contains Java libraries, which are in the form of .jar (Java archive) files.
conf	Contains configuration files.

Basic Tools

These tools are the foundation of the JDK. They are the tools you use to create and build applications.

Tool Name	Brief Description
Javac	The compiler for the Java programming language.
Java	The launcher for Java applications (JVM).
Javadoc	API documentation generator.
Jar	Create and manage Java Archive (JAR) files.
Jdb	The Java Debugger.

First Java Program – Hello.java

The following is the smallest possible Java program.

```
01: // Program to print Hello World
02: public class Hello {
03:  public static void main(String args[]) {
04:        System.out.println("Hello World!");
05:  }
06: }
```

The above Java program prints the message *Hello World!,* when you compile and

run it. The following are some of the important components of this program.

- Every function in Java must be inside a class, so we have to create a class **Hello** to put the main**()** function in it.
- Function **main**() must be declared as **static**. It must return nothing (void) and it takes an array of type **String** as argument. All these are mandatory.
- **System**.**out**.**println**() is used to print the given message.

Compiling and running a Java program

To compile a java program using JDK, follow the steps given below:

1. Go to command prompt using programs ☐ accessories ☐ command prompt.
2. Set the PATH command of Windows to the bin directory of **jdk** as follows at the command line.

```
path c:\jdk\bin
```

PATH is required as *javac.exe* and *java.exe* are in the bin directory.

3. Go to the directory where **Hello.java** is saved (c:\jdk\programs).
4. Compile Java program using JAVAC.EXE as follows:

```
javac Hello.java
```

5. Run java program as follows from the command line:

```
java Hello
```

NOTE: PATH command is used to inform Operating System (Windows) where it should search in the file system for executable files. By default, OS searches for executable files only in the current directory. To see the current PATH setting, just type PATH at the command prompt.

Using IDE

It is strongly recommended you use IDE to write Java code.

IDE (Integrated Development Environment) provides a lot of features to make developers more productive.

Eclipse, NetBeans, IntelliJ IDE are some of the most widely used IDEs for Java.

Check this tutorial Getting Started with Eclipse IDE for Java Developers.

Standard or Primitive data types in Java

The table below shows the list of data types available in Java along with number of bytes occupied by the data type and range of values that can be stored in the data type.

Data Type	Size (Bytes)	Range
byte	1	-128 to 127
short	2	-32768 to 32767
int	4	-2147483648 to 2147483647
long	8	-9223372036854775808 to 9223372036854775807
float	4	3.4e-038 to 3.4e+038
double	8	1.7e-308 to 1.7e+308
boolean		true or false
char	2	Supports Unicode characters

- All numeric types in Java are signed.
- The size of **boolean** is JVM dependent.
- Data type **char** occupies two bytes because it supports Unicode, which needs 16 bits to store characters.
- Unicode supports characters of all languages and some languages of Japanese and Chinese have more than 256 characters.
- The size of data types does NOT change from platform to platform.

NOTE: Java doesn't allow an un-initialized variable to be used. By default, local variables are not initialized by Java.

Rules to create Identifier

A name in the program is called an identifier. The following rules are to be followed while creating identifiers.

- Can contain letters, digits, _ (underscore) and $.
- Must NOT begin with a number. Can start with a currency symbol ($) or _ (underscore).
- Keywords of Java cannot be used.

Valid identifiers	first_number, name$, _first, $amount
Invalid identifiers	2num, total-amount

Keywords in Java

The following is the list of Java keywords. All these keywords are in lowercase.

abstract	continue	for	new	switch
assert	default	goto	package	synchronized
boolean	do	if	private	this
break	double	implements	protected	throw
byte	else	import	public	throws
case	enum	instanceof	return	transient
catch	extends	int	short	try
char	final	interface	static	void
class	finally	long	strictfp	volatile
const	float	native	super	while

- true and false are boolean literals
- null is null literal
- var, yield, and record are restricted identifiers

Literals

Literal denotes a constant value, which remains unchanged throughout the program.

- Java has three reserved literals – **null**, **true**, **false**.
- Integer literals are treated as integers unless they are suffixed with L (letter L). Example: 100L
- Java 7.0 onwards we can use **_** (underscore) as a separator between digits.
- Integer literals can be specified in octal (0123) or hexadecimal (oxff). Octal numbers are prefixed with **0** and hexadecimal numbers are prefixed with **0x**.
- Floating point literals are by default taken as **double**. Use suffix **f** to denote float literal. Example: 10.50f**.**
- Starting from Java 7.0, we can have binary literals prefixed with **0b**.
- Escape sequence as well as Unicode values can appear in string literals. For example, *"How are you ...\t Srikanth\u000d"* represents a string that contains a horizontal tab (\t) and carriage return (\u000d in hexadecimal is equal to decimal 13).

Integer	200 -7 1_23_456 0b10001111
Floating point	2.4 -2.5 .5 0.55
Character	'a' '9' ':'
Boolean	true false
String	"one" "123" "work hard"

Escape Sequence Characters

The following are the escape sequence letters supported by Java.

Character	Meaning
\ddd	Three octal digits
\uxxxx	Four hexadecimal digits
\’	Single quote
\”	Double quote
\\	Single backslash
\r	Carriage return
\n	New line (also known as line feed)
\f	Form feed
\t	Tab
\b	Backspace

Text Blocks

- A text block is enclosed in """ (three double-quotes) and """ and can contain multiple lines and quotes.
- Special escape sequence **\s** inserts space and **** suppresses new lines.

```
 String text = """
First Line
\s\sSecond Line \
is here!
\s\sThird Line
""";

System.out.println(text);
```

```
First Line
  Second Line is here!
  Third Line
```

Operators in Java

An operator performs a specific operation on the given value(s) called operands. Operators are divided into different categories based on the operation performed by the operator.

Arithmetic Operators

The following table shows arithmetic operators available in Java. They are shown according to the precedence of the operators.

Operator	Meaning
++	Increment
--	Decrement
*	Multiplication
/	Division
%	Modulus
+	Addition
-	Subtraction

Associativity specifies whether operators are grouped from left to right or right to left. Unary ++ and -– operators are having ***right to left*** *associativity* and other operators are having ***left to right*** *associativity*.

Conversion and Type Casting

- Java allows assignment between variables of compatible types.
- Java promotes all integer types such as **byte** and **short** to **int**.
- When we are converting a large data type to a short data type, explicit **type casting** is required.

```
// will FAIL as 10.50 is taken as double
float f = 10.50;

// Use f as suffix to indicate float
float f = 10.50f;

// converts double to float and then assigns
float f = (float) 10.50;
```

Assignment Operator

Assignment operator (=) is used to assign a value to a variable. The value may be either a literal or an expression.

The variable and result of the expression must be of compatible data types. Java also supports multiple assignments, where you can assign a single value to multiple variables in a single assignment.

```
a = 0;
a = b = c = 0;
```

Relational Operators

- ❑ All relational operators are binary operators.
- ❑ The result of the evaluation is always a boolean.
- ❑ Relational operators have ***left to right associativity***.

Operator	Meaning
==	Equal To
>	Greater than
<	Less than
<=	Less than or equal to
>=	Greater than or equal to
!=	Not Equal To

Logical Operators and Short-circuiting

Logical operators combine two conditions and return a boolean value. The following table shows logical operators.

Operator	Meaning
&	AND
|	OR
^	XOR (exclusive or)
||	Short-circuit OR
&&	Short-circuit AND
!	Unary NOT

Short-circuit Logical Operators (&& and ||)

Short-circuit operators check only the necessary conditions and do NOT check both the conditions always. Evaluation of condition stops once the outcome of the condition is known.

&&	Don't check the second condition if the first condition is false.
||	Don't check the second condition if the first condition is true.

```
if (a > b && a > c) ...
```

Returns false if condition **a > b** is false and doesn't check the second condition (a > c).

```
if (a == b || a == c) ...
```

Returns true if condition a == b is true and doesn't check the second condition.

Bitwise Operators

Bitwise operators operate on bits in integers. They can be used only with integer data types such as int and long.

Operator	Meaning
~	Ones complement
&	Bitwise Anding
|	Bitwise Oring
^	Bitwise XOR (Exclusive OR)
<<	Shifts bits to left by n times by filling 0 on the right
>>	Shifts all bits right by n times, filling left side bits with sign bit
>>>	Shifts all bits right by n times, filling left side bits with 0

The following snippet shows how to use bitwise operators.

```
01: public class BitOperators {
02:   public static void main(String[] args) {
03:     byte a = 10, b = 15;
04:     // 0000 1010 & 0000 1111 = 0000 1010
05:      System.out.printf("%d & %d = %d\n", a, b, a & b);
06:     // 0000 1010 | 0000 1111 = 0000 1111
07:      System.out.printf("%d | %d = %d\n", a, b, a | b);
08:     // 0000 1010 >> 2           = 0000 0010
09:      System.out.printf("%d >> 2 = %d\n", a, a >> 2);
10:     // 0000 1010 << 2           = 0010 1000
11:      System.out.printf("%d << 2 = %d\n", a, a << 2);
12:   }
13: }
```

Control Statements

The following are conditional statements and looping structures available in Java.

if statement

The **if** statement is used to decide whether an operation is to be performed. If the condition is true then statement-1 is executed, otherwise statement-2 is executed. The **else** portion is optional.

```
if (condition)
    statement-1;
[else
   statement-2;]
```

NOTE: If multiple statements are to be executed then enclose statements in braces ({}).

It is possible to have nested if statements (an if statement within another if statement). It is also possible to have multiple if statements with if .. else.. if .. else and so on.

switch statement

The switch statement is used to execute one among many alternatives.

```
switch(expression)
{
  case label-1 : statement; [break];
  [case label-2 : statement; [break];]...
  [default : statement; ]
}
```

The following example takes the same action for code 1 and 2 and different action for 3, and default is used to take action for the rest of the codes.

```
switch(code) {
  case 1 : // falls through to next case
  case 2 : price = 1000; break;
  case 3 : price = 500; break;
  default: price = 100;
}
```

For switch statement, the expression must be a **char**, **byte**, **short**, **int** or an **enum** type.

Starting from Java 7.0, switch supports **string** data type also.

```
String country;
// code to get value into country
 switch(country)
 {
     case "India": // code
     case "China": // code
     case "Japan": // code
     default:    // code
 }
```

The case constant must evaluate to the same type as the expression. The case constant must be a compile time constant.

NOTE: The default case doesn't have to come only at the end of the switch statement; it can be given anywhere.

The switch expression

- A switch expression, introduced in Java 12, returns a value.
- Unlike switch statements, switch expression returns a value for each case using operator **->**.
- To return a value from a block of statements, we can use yield statements from Java 13.
- Switch expression also supports multiple labels for a single case.

The syntax for **case** changes in switch expression as follows:

```
case label_1, label_2,..., label_n ->
        expression; | throw-statement; | block
```

The following switch returns discount rate based on product code:

```
int disrate =
     switch (code) {
          case 1 -> 10;
          case 2 -> 20;
          case 3 -> 25;
          default -> 5;
        };
```

Multiple labels

It is possible to use multiple labels for each case by separating them using comma (,).

The following switch expression returns the number of days based on value of month. It uses multiple values for cases.

```
int days = switch (month) {
      case 2 -> 28;
      case 4, 6, 9, 11 -> 30;
      default -> 31;
};
```

Using yield in switch

It is possible to use **yield** to return a value when a case has a set of statements (block).

The following example demonstrates how to use yield in a case when it is not possible to return value with -> alone.

```
int days = switch (month) {
  case 2 -> {
   if (year % 4 == 0 && year % 100 != 0 || year % 400 == 0)
      yield 29;
   else
      yield 28;
    }
  case 4, 6, 9, 11 -> 30;
  default -> 31;
};
```

The while loop

Repeatedly executes statement(s) as long as the condition is true.

```
while(condition)
    statements;
```

Following example displays all numbers from 1 to 10. To execute multiple statements, enclose statements in braces ({}).

```
int i = 1;
while (i <= 10) {
   System.out.println(i);
   i ++;
}
```

The do .. while loop

Executes the body of the loop and then checks the condition thus guaranteeing the execution of the statement *at least for once*.

```
do {
   statement;
} while (condition);
```

The following program displays numbers from 1 to 10.

```
int i = 1;
 do {
System.out.println(i); i
    ++;
} while (i <= 10);
```

The for loop

The **for** loop executes statements as long as the condition is true. First it executes initialization, then checks whether the condition is true. If condition is true then executes the statements and then increment portion.

```
for (initialization; condition; increment)
    Statement;
```

Variable can be declared within initialization and these variables are available only within the loop.

```
// Variable i is available only within for

for (int i = 1; i <= 10; i ++) {
// body
 }
```

The break statement

The **break** statement is used to terminate the loop from inside the loop. Java provides labeled break and unlabeled break. When a break statement is used without any label, it terminates the current loop.

```
break [label]
```

Labeled break terminates the loop that is associated with the given label. In the following example, break terminates 1st loop as label first is associated with **i** loop.

```
01: first:
02: for(int i = 0; ... ){
03:    second:
04:    for(int j = 0;      {
05:    ...)for(int k = 0; ...)
06:       {
07:          if (cond)
08:             break first;
09:       }
    }
10: }
```

The continue statement

Continue is used to stop the current iteration of the loop body and proceed with the next iteration.

```
continue [label]
```

The following code ignores remaining statements in the j loop when the condition is satisfied and starts the next iteration.

```
01: for(int i = 0 ; i < 10 ; i ++) {
02:   for(int j = 0 ; j < 10 ; j ++) {
03:         if(j < i)
04:            continue;
05:      }
06:  }
```

Printing value using System.out.printf()

Function printf() is similar to the printf() function of the C language. The following are the conversion characters that can be used.

b - boolean, **c** - char, **d** - integer, **f** - floating point, **s** - string.

```
System.out.printf("int %d and float %f \n", i, f);
```

If conversion character and given data do not match then a runtime error occurs. The following will produce a runtime error.

```
System.out.printf("%d",10.50);
```

Reading input using Scanner

Input from users can be taken using Scanner class. The following snippet shows how to use Scanner to read an integer from a user.

```
Scanner s = new Scanner(System.in);
int n = s.nextInt();
```

The following program reads a number from a user using Scanner and displays its factors.

```
01: import java.util.Scanner;
02:
03: public class Factors {
04:   public static void main(String[] args) {
05:       Scanner s = new Scanner(System.in);
06:       System.out.print("Enter a number :");
07:       //read an int from keyboard
08:       int num = s.nextInt();
09:
10:       for(int i = 2; i <= num/2; i ++) {
11:           if(num % i == 0)
12:               System.out.println(i);
13:       }
14:   }
15: }
```

The **import** statement is required to make **Scanner** available to the current program.

Method	Description
nextInt()	Reads next integer
nextDouble()	Reads next double
nextLine()	Reads next line and returns as a string

Creating and using Arrays

- Array is a collection of elements.
- All elements of the array are of the same type.
- All elements are commonly referred to by a single name and individual elements are accessed using index.
- An array in Java is dynamic. We specify the size of the array at runtime.

```
int a1[];    //declare an array
int []a2;    //another syntax to declare an array

// Create an array of 10 elements

a1 = new int[10];
```

Alternatively, you can declare and allocate memory in one step.

```
// Declare and create an array
 int a1[] = new int[10];

/* create an array where size of the array is determined by
 the value of variable n */

int a2[] = new int[n];
```

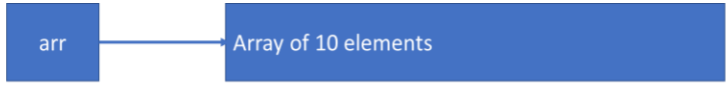
Getting array's length using length property

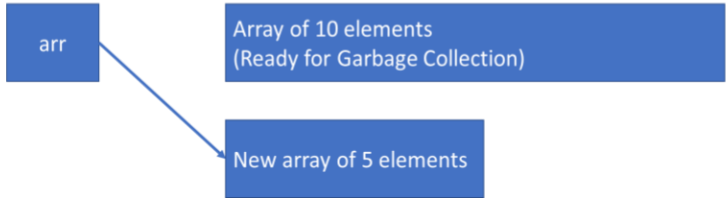
Property **length** of an array can be used to get the number of elements in an array.

```
System.out.printf("Length: %d", a.length);
```

An array name can be used to refer to an array of different sizes at runtime. The following snippet shows how array name **arr** points to an array of 10 elements first and then points to an array of 5 elements.

```
// create an array
int arr[] = new int[10];

//Array arr points to a new array of 5 elements
 arr = new int[5];
```





Old array of 10 elements referred by **arr** is now eligible for garbage collection by Java.

NOTE: Java virtual machine has a garbage collector, which takes care of releasing unused memory blocks.

You can create a double dimensional array using two square brackets as follows:

```
int a[][] = new int[5][5];
```

Enhanced for loop

Java provides an enhanced for loop exclusively to process arrays and collections. It takes one value from the array and assigns it to the loop variable. Executes loop statements and repeats the process until the array is exhausted.

```
for (datatype loopvariable : array)
        Statement;
```

The following example displays all elements of an array using an enhanced for loop. The data type of the loop variable and data type of the array must be the same.

```
int a [] = {10,20,30,40,50};
for (int n : a)
  System.out.println(n);
```

Initializing an array

Java allows an array to be initialized. The following examples show how you can initialize an array in Java.

```
// initializes array a to given three values
int a[] = {10,20,30};
// initializes array b to given five values
int b[] = new int[] {10,20,30,40,50};

// initializes double dimensional array - 2 X 3
int bb[][]= {{1,2,3},{4,5,6}};
```

NOTE: Elements of an array are automatically initialized to default value according to the data type of array.

Variable Number of Arguments

- Java allows a method to take a variable number of arguments.
- The argument is declared with **... (**ellipses**)** after data type and before the name.
- Must be the last argument in a method.
- Argument is treated as an array inside the method.

```
01: public class VaryingArguments {
02:   public static void main(String[] args) {
03:         System.out.println(getSum(10, 20,30));
04:         System.out.println(getSum(100, 200));
05:   }
06:   public static int getSum(int... nums) {
 07:        int total = 0;
08:   for (int n : nums) { 09:
 total += n;
10:   }
11:   return total;
12:   }
13: }
```

Command-line Parameters

- Parameters that are passed at the time of invoking a java program from the command line are called as command line parameters.
- These parameters can be used to provide input to the program.
- These parameters are accessible from ***main*()** through the **args** parameter, which is an array of strings.
- The ***length*** attribute of ***args*** returns the number of parameters passed on the command line.

```
01: // program to display command-line parameters
02: public class CLA {
03:  public static void main(String args[]) {
04:    System.out.printf("Args Count: %d\n", args.length);
05:      // display parameters
06:       for(String s : args)
07:        System.out.println(s);
08:   } // end of main
09: }
```

Call the previous program from command line as shown below:

```
c:\jdk\srikanth>java CLA One Two <Enter>
 Args Count : 2
 One
 Two
```

```
01: public class CLA {
02:   public static void main(String a[]) {
03:         for (String s : a)
04:            System.out.println(s);
05:   }
06: }
```

NOTE: Method main() must have a parameter of type String[]. However, the name of this parameter could be anything. The following code is the same as the code above.

Program - Prime.java

This program checks whether the number given on the command line is a prime number or not. Prime number is a number which has no factors other than 1 and itself.

```
01: // program to check whether a number is prime
02: public class Prime {
03:     public static void main(String[] args) {
04:         // check whether number is passed
05:         if (args.length == 0)  {
06:            System.out.println("Number is missing!");
07:            return;
08:         }
09:         // convert args[0] to int
10:         int n = Integer.parseInt(args[0]);
11:         boolean prime = true;
12:
13:         for (int i = 2; i <= n/2; i ++) {
14:           if (n % i == 0) {
15:             prime = false;
16:             break;
17:           }
18:         } // end of for
19:
20:         if (prime)
21:           System.out.println("Prime Number");
22:         else
23:           System.out.println("Not a prime number");
24:     } // end of main
25: }
```

Prime program does the following:

1. It checks whether a command line argument is given. If not, it terminates **main**() by using return statements.
2. Converts first command line argument to an int.
3. Sets a loop that runs from 2 to n/2.
4. If a number in the range 2 to n/2 can divide the number without any remainder then it breaks the loop after setting the prime variable to false.
5. If no number in the range 2 to n/2 can divide a number without any reminder then the loop terminates but the prime variable's value remains true.
6. At the end it displays a message based on the value of the prime variable.

Run this program with a number on command line as shown below:

```
C:\jdk\srikanth>java Prime 23 <enter>
 Prime Number
```

Exercises

Try to write programs to accomplish the following tasks.

1. Display first 10 Fibonacci numbers.
2. Display all palindrome numbers in the range 1000 to 2000.
3. Write a program to take a number from the user and display whether it is a perfect number.
4. Accept ten numbers from the user and display the largest of the given numbers.
5. Accept two numbers and display the GCD of the numbers.
6. Accept two numbers on the command line and raise base (first number) to power (second number).
7. Accept a number and display its highest factor.
8. Accept a number and display the digits in reverse order.
9. Create a function that takes a set of integers using varying length arguments and returns the average of all the numbers.
10. Create an array of 10 elements. Read values from the keyboard and fill the array. Interchange the first 5 elements with the last 5 elements and display the array.

Object Oriented Programming Part - 1

Object Oriented Programming

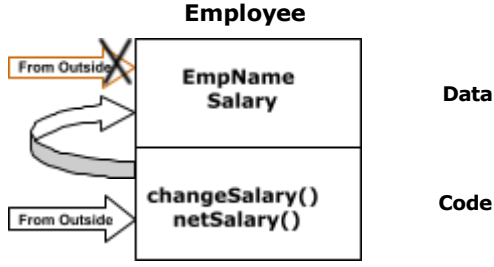
- Java is an object-oriented programming language. So, it is important to understand what object-oriented programming is.
- OOP allows programs to be divided into objects, where each object contains data and code to process data.
- These objects of the program map to real-world objects like an account in a bank, a student in college etc.

Three basic principles of OOP are:

- **Encapsulation**
- **Inheritance**
- **Polymorphism**

Encapsulation

- Binds or encapsulates data and code that processes data.
- Protects instance variables (data) by not allowing them to be accessed from outside the object.
- Provides a set of functions (methods) that are accessed from other objects.
- Increases control as each object is independent with its data, which is private, and a set of functions, which can be called from other objects.
- A class in Java defines data and code that is to be encapsulated.



In the above example the class **Employee** has two instance variables – EmpName and Salary and two methods – changeSalary() and netSalary().
Instance variables can be accessed only by methods that are part of the class – changeSalary() and netSalary().

Class vs. Object

Class is the description of a collection of similar objects. Class defines the instance variables and methods to be encapsulated.

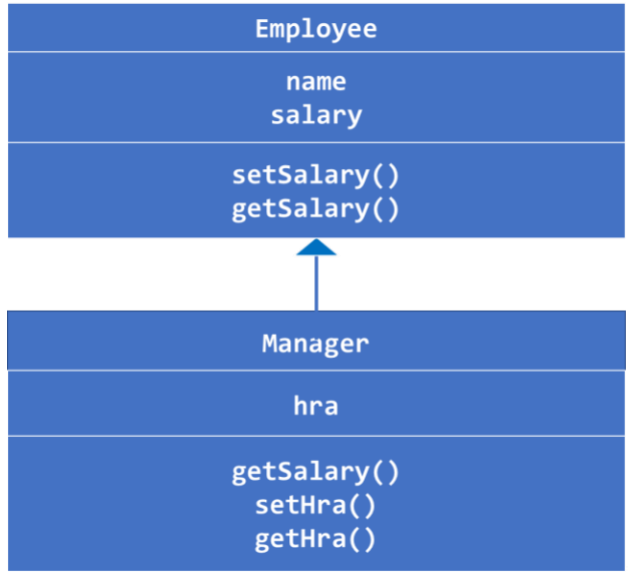
Class denotes a category of objects. It is a blueprint for creating objects. Example: Employee, Product, Student etc.

Instance variables are used to store data and **methods** perform operations on the data.

Object is an instance of the class. Memory is allocated only when an object of the class is created. Methods are called using an object. Example: An employee, a student etc.

Inheritance

- Allows a class to be created from another class thereby inheriting all members of another class.
- Allows reusability of existing classes.
- New classes may add new members and override existing members of the inherited class.
- Class being inherited is called a superclass and the class created from the existing class is called a subclass.
- Inheritance represents “IS A” relationship between classes. For example, Manager is extending Employee because Manager is an Employee. A SavingsAccount extends Account because SavingsAccount is an Account.
- Hierarchies can be built using inheritance.



In the above example, **Manager** class inherits all the data members and methods of **Employee** class. It adds **hra** and **setHra**() members and overrides **getSalary**() method.

Overriding is the process where the subclass (Manager) is creating a method with the same signature as a method in the superclass (Employee).

Java allows a class to extend only one class – **single inheritance**.

Multiple inheritance, where a class can be created from multiple classes, is NOT permitted in Java.

Polymorphism

- Allows multiple methods performing the same operation to have the same name.
- Compiler invokes one of the multiple methods depending upon the context (parameters passed to method).
- Programmers need not remember multiple names.

In the following example, all three functions returning a maximum of two values are given the same name.

```
max(int ,int)
max(long, long)
max(String,String)
```

Depending upon which data type is passed as the parameter to **max** function, one of the three functions is invoked by the compiler.

Polymorphism may be implemented either at compile-time (method overloading) or at run-time (dynamic method dispatch).

Creating a Class

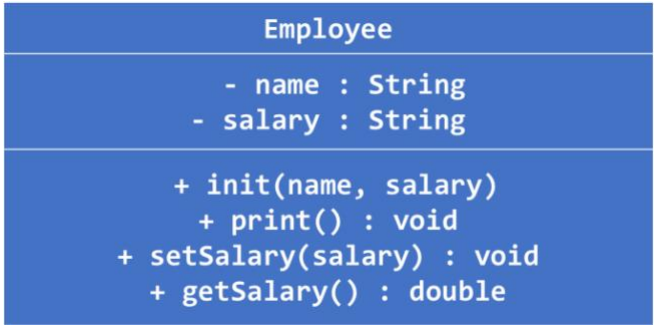
A class is like a user-defined data type. A class describes data to be stored and processed. The following is the syntax used to create a class.

```
access class classname
{
   [access] instance-variable-declaration;
   [[access instance-variable-declaration] ] . . .

   [access] returntype methodname ([parameterlist])
   {
      // body of the method
   }
   .
   .
```

Access may be *private*, *public*, *protected* or *default* (no access) for instance variables and methods.

NOTE: Generally, class names are created using Pascal case naming convention - first letter of each word in uppercase and remaining in lowercase. Method names are created using Camel case naming convention – first word in lowercase and first letter of remaining words in uppercase and remaining letters in lowercase.

The following is the **UML** (Unified Modeling Language) diagram to represent the Employee class. Minus (-) sign denotes **private** access and plus (+) sign denotes **public** access.



NOTE: Name of .java file and public class name must be the same. A single .java file can have multiple classes (but only one of them can be public). When you compile. java file, each class in the file will have a corresponding .class file.

Employee.java

This file contains definitions for class Employees.

```
01: public class Employee {
02:   private String name;
03:   private int salary;
04:   public void init(String n, int sal) {
05:         name = n;
06:         salary = sal;
07:   }
08:   public void print() {
09:   System.out.println(name);
10:   System.out.println(salary);
11:   }
12:   public void setSalary(int sal) {
13:         salary = sal;
14:   }
15:   public int getSalary() {
16:         return salary;
17:   }
18: }
```

TestEmployee.java

This file contains the definition for class TestEmployee. Function main() in TestEmployee does the following:

- Creates an object reference of **Employee** class.
- Creates an object of Employee class.
- Calls methods of Employee class using object reference.

```
01: public class TestEmployee {
02:     public static void main(String[] args) {
03:       Employee e;         //object reference
04:       e = new Employee(); //create an object of Employee
05:
06:       e.init("Jonathan", 35000);
07:       e.print();
08:       e.setSalary(55000);
09:
10:       if (e.getSalary() > 50000)
11:           System.out.println("Fat salary");
12:   }
13: }
```

If you compile **Employee.java**, **TestEmployee.java** and run, it generates the following output:

```
Jonathan
 35000
Fat salary
```

Object Reference **Object**

Constructor

- A method in the class with the same name as the class name.
- Invoked automatically whenever an object of the class is created.
- Used to initialize instance variables of the class.
- Doesn't contain any return type – not even void.

```
01: public class Number {
02:   private int num;
03:   // constructor
04:   public Number() {
05:         num = 1;
06:   }
07: }
```

In the above, **Number** class has a constructor that is used to initialize instance variable *num*. When an object of the **Number** class is created, Java automatically calls the constructor.

```
Number n = new Number(); // calls constructor
```

Constructor can take parameters and use those parameters for initializing instance variables.

```
01: public class Number {
02:   private int num;
03:   public Number(int n) {
04:         num = n;
05:   }
06: }
```

The above constructor is called whenever an object is created.

```
Number n = new Number(10);
```

NOTE: If no constructor is explicitly created then Java creates a constructor with no parameters (default constructor). But Java doesn't provide this constructor once a user-defined constructor is created in the class.

The following is **Employee** class with constructor instead of **init**() method :

```
01: class Employee {
02:   private String name;
03:   private int salary;
04:   public Employee(String n, int sal) {
05:         name = n;
06:         salary = sal;
07:   }
08:   // remaining code
09: }
```

```
01: class UseEmployee {
02:   public static void main(String[] args) {
03:         Employee e = new Employee("Jonathan", 25000);
04:   }
05: }
```

Overloading Methods

- It is possible to define two or more methods with the same name within the same class provided the parameters of the methods are different.
- Overloading methods is one way of implementing polymorphism.
- Methods can be overloaded based on type/number of parameters.
- Methods cannot be overloaded based on return type.

The following example demonstrates overloading methods in a class.

```
01: class  Test {
02:    void  m1(int n) { }
03:    void  m1(String  s) { }
04:    void  m1(String s, int n) { }
05:    void  m1(int n, String s) { }
06:    // Not allowed as methods differ only by return type
07:    int   m2(int n)  {}
08:    long  m2(int n)  {}
09: }
```

Overloading Constructors

Just like how it is possible to overload methods of a class, it is also possible to overload constructors of the class.

```
01: public class Number {
02:    int num;
03:    public Number() {
04:          num = 1;
05:    }
06:    public Number(int n) {
07:          num = n;
08:    }
09: }
```

First constructor is called when an object is created without passing any parameter and second constructor is called when an object is created by passing a single **int** as parameter.

```
Number n1 = new Number();    // calls constructor Number()
Number n2 = new Number(100); // calls Number(int)
```

NOTE: It is NOT possible to create an object unless Java can invoke one of the constructors.

```
01: class A {
02:   int n;
03:   public A(int num) {
04:         n = num;
05:   }
06:   public A(String s) {
07:     n=Integer.parseInt(s);
08:   }
09: }
```

Third line doesn't compile as Java cannot call any constructor.

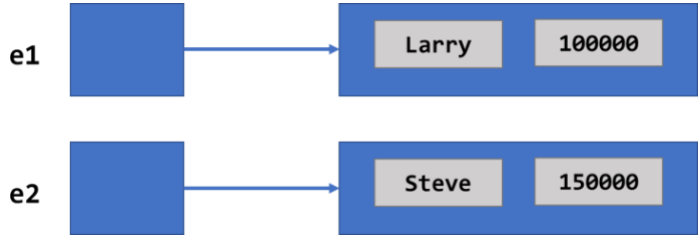
```
A obj1 = new A(10);
A obj2 = new A("99");
A obj2 = new A(); // not possible
```

In order to create an object without passing any parameter at the time of creation, the class must have a constructor that takes no parameter or it must have a default constructor.

Object Reference

Object reference is a variable that references an object. An object in Java is accessed using object reference.

```
Employee e1; // create object reference of Employee class
// create an object and make e1 referencing it
e1 = new Employee("Larry",100000);

//create object reference and object
Employee e1 = new Employee("Larry",100000);
Employee e2 = new Employee("Steve",150000);
```



Comparing object references

If two object references of the same class are compared, only references are compared but NOT contents of the objects.

```
Employee e1 = new Employee("Jason",25000);
Employee e2 = new Employee("Jason",25000);
if (e1 == e2) // only references are compared, NOT objects
     System.out.println("Equal");
```

NOTE: If you compare two object references, only the references are compared and not the contents of the object that they point to.

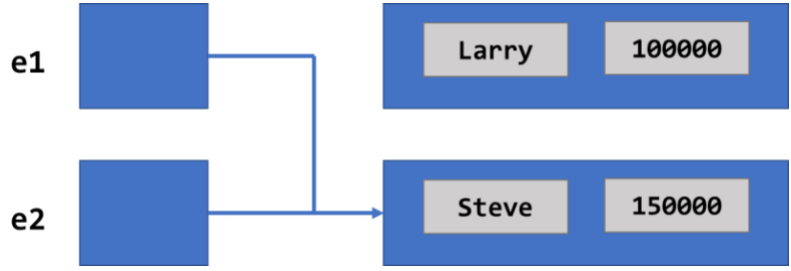
NOTE: Only == and != relational operators are allowed with object references.

Assignment between two object references

It is possible to assign one object reference to another. But what we effectively copy is not the contents of an object to another, instead one object reference to another.

The following example and picture demonstrate what happens when an object reference is copied to another.

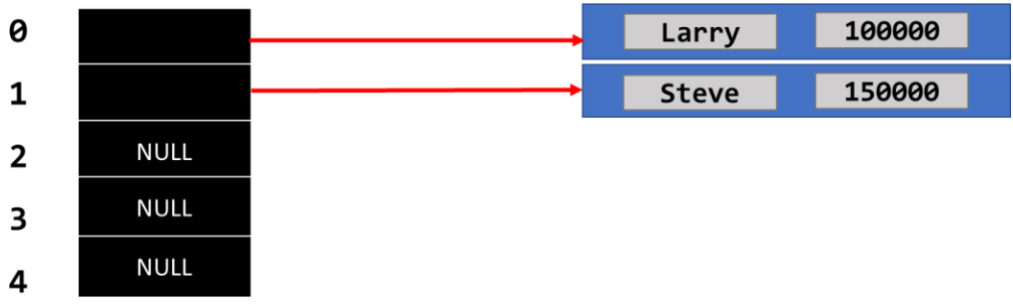
```
Employee e1, e2;

e1 = new Employee("Larry",100000); e2 =
       new Employee("Steve",150000);
e1 = e2; // e1 and e2 point to same object
```



Array of objects

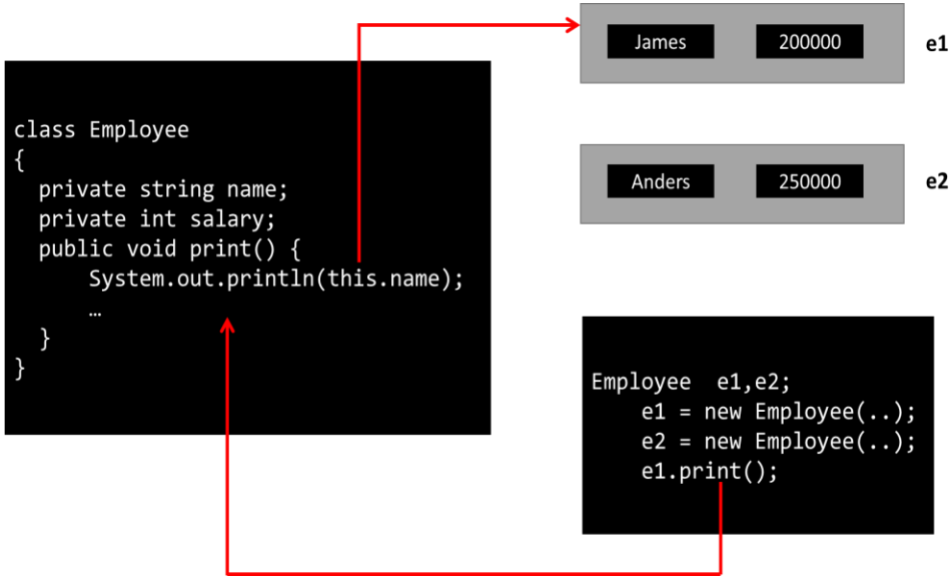
- Java supports arrays of objects of a class.
- When an array of objects is created only object references that can point to objects of class are created.
- The default value of each element is null and object reference must be made to point to an object explicitly before it is used.

```
Employee [] e;
// Create an array of 5 Employee object
references e = new Employee[5];
e[0] = new Employee("Larry",100000);
e[1] = new Employee("Steve",150000);
```



The this reference

- Keyword ***this*** references invoking object.
- Used by methods to implicitly access members of the calling object.
- Used to access instance variables when parameters and instance variables have the same names.
- The **this** reference is made available to each non-static method automatically.
- Used to call a constructor from another constructor.



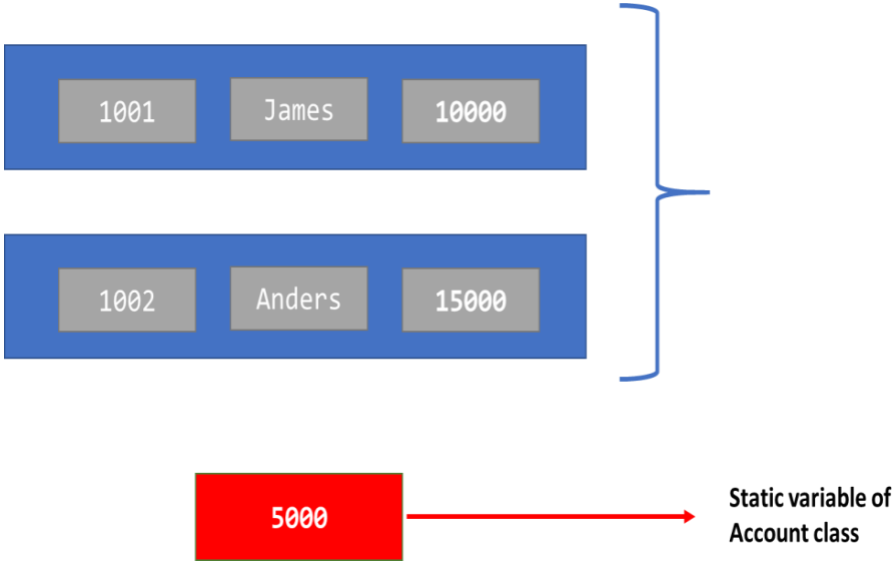
The following constructor uses this reference to access instance variables as parameters and instance variables have the same names.

NOTE: When instance variables and parameters are having the same name, parameters of the method take precedence over instance variables. In general, local variables always take precedence over non-local variables.

```
01: class Employee {
02:       private String name;
03:       private int salary;
04:       public  Employee(String name, int salary) {
05:           this.name = name;
06:           this.salary = salary;
07:       }
08: }
```

Static Variables

- A static variable, otherwise known as class variable, is a variable that is associated with class and not an object.
- Defined using keyword **static.**
- Exist only for once for the entire class.
- Static variables that are declared as **final** are used as constants.



Static Methods

- Static methods are the same as normal methods except that they can be invoked with class names and need not be invoked by any object.
- Defined using keyword **static**.
- Do not have **this** reference.
- Static methods cannot invoke non-static methods and cannot access instance variables as they do not have access to any specific object (this reference) – refer to code below.
- Generally used to access and manipulate static variables.

```
01: public class StaticTest {
02:   private int iv;
03:   private static int sv;
04:   public static void main(String[] args) {
05:         iv = 10; // not valid
06:   StaticTest obj = new StaticTest();
07:   obj.iv = 10; //valid as we use object to access iv
08:   }
09: }
```

Why main() is a static method?

Function **main**() must be declared as static as it is called using the class name by JVM. For example, when you invoke

```
Java Hello
```

It will be converted to a call to main as follows:

```
Hello.main(parameter)
```

Other examples for static members are **Integer**.**parseInt**(), **Math**.**abs**() and **System**.**out**.

NOTE: Java does not allow any function to be defined outside the class. Methods that can be used without creating an object are declared static, so that they can be called using class names. This also saves the time taken to create and release an object.

	Variable	
Method	**Static**	**Instance**
Instance	✓	✓
Static	✓	✗

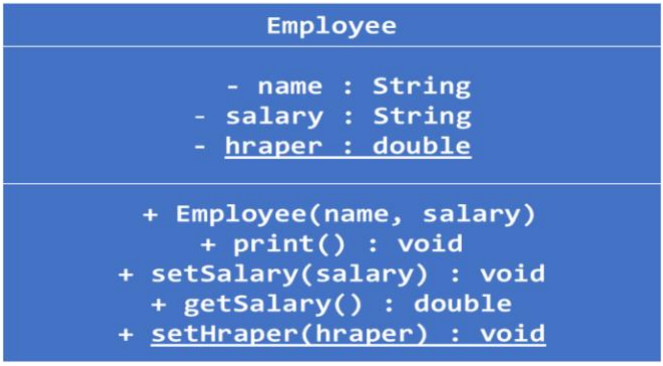
Final Variable

- Java allows variables to be declared as final using the final keyword.
- Final variables cannot change value once they are assigned a value.
- Final variables are generally static variables as it generally makes no sense to have the same value for a variable in each object of the class.
- Final variables must be assigned a value before the constructor of the object is completed.

```
class Account {
  public static final int MINBAL = 500;
 }
```

Variable MINBAL is accessed using class name from outside the class as it is static and public variable. Minbal cannot be changed as it is final and initialized to 500.

```
System.out.println(Account.MINBAL);
```



In the above UML diagram, static members – **hraper** variable and **setHraper**() method are ***underlined*** to indicate that they are static members of the class.

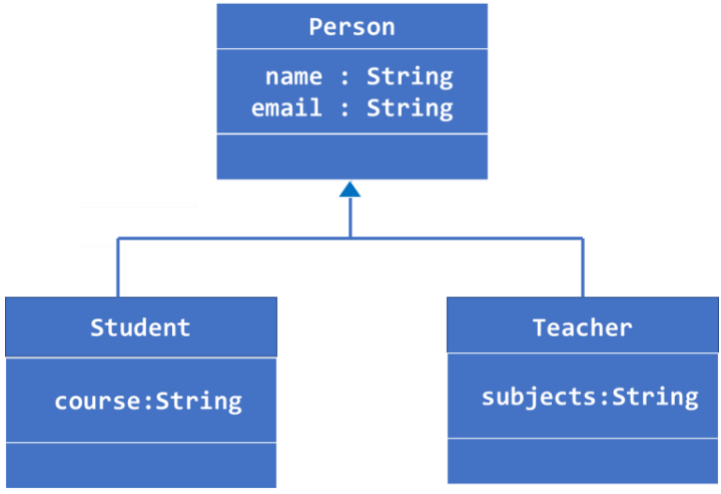
The following code shows how to implement Employee class with static variables – **hraper** and static method **setHraper**().

```
01: public class Employee {
02:   private String name;
03:   private double salary;
04:   private static double hraper = 20;
05:   public Employee(String name,double salary) {
06:         this.name = name;
07:         this.salary = salary;
08:   }
09:   public void setSalary(double salary) {
10:         this.salary = salary;
11:   }
12:   public double getSalary() {
13:         return this.salary +
14:   this.salary * Employee.hraper / 100;
15:   }
16:   public static void setHraper(double hra) {
17:         Employee.hraper = hra;
18:   }
19: }
```

```
01: public class UseEmployee {
02:   public static void main(String[] args) {
03:     Employee e = new Employee("Jason", 30000);
04:     System.out.println(e.getSalary());
05:     Employee.setHraper(25);
06:     System.out.println(e.getSalary());
07:   }
08: }
```

Inheritance

- Allows a new class to be created from an existing class.
- Keyword **extends** is used to create a new class that extends an existing class.
- Existing class is called a superclass and the new class is called a subclass.
- Inheritance represents **Is A** relationship. For example, Student is a Person, Car is a Vehicle etc.

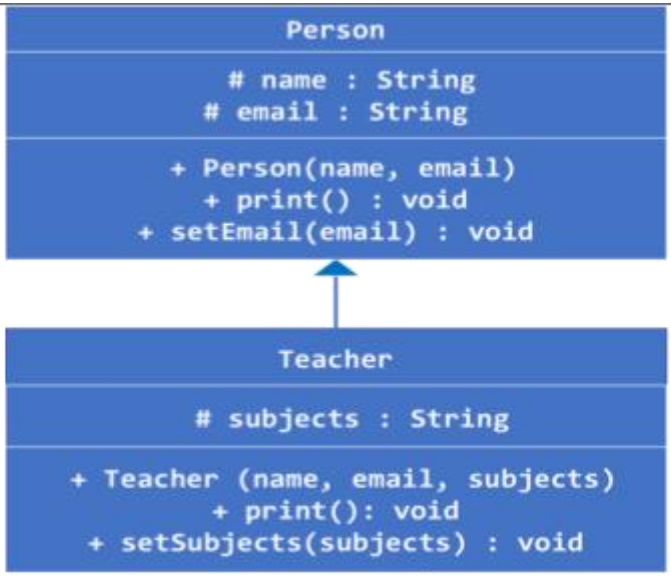


The following code demonstrates creating **Person** class and **Teacher** classes.

```
01: class Person {
02:   protected String name, email;
03:   public Person(String name, String email) {
04:         this.name = name;
05:         this.email = email;
06:   }
07:   public void print() {
08:   System.out.println(this.name);
09:   System.out.println(this.email);
10:   }
11:   public void setEmail(String email) {
12:         this.email = email;
13:   }
14: }
```

NOTE: Access **protected** allows the members to be accessed from subclasses also.

```
01: class Teacher extends Person{
02:   protected String subjects;
03:   public Teacher(String name, String email,
04:                          String subjects) {
05:         super(name,email); //must be first statement
06:         this.subjects = subjects;
07:   }
08:   @Override
09:   public void print() { // overrides print() of Person
10:         super.print();
11:         System.out.println(subjects);
12:   }
13:   public void setSubjects(String subjects) {
14:         this.subjects = subjects;
15:   }
16: }
```



NOTE: Symbol # in the UML diagram specifies protected access.

```
01: class TestPerson {
02:   public static void main(String args[]) {
03:    Teacher t = new Teacher("Srikanth",
04:         "srikanthpragada@yahoo.com", "Java, .Net");
05:  t.print();
06:  t.setEmail("srikanthpragada@gmail.com");
07:  t.setSubjects("Java, .Net, Python, DS");
08:  }
09: }
```

Constructors in Inheritance

When an object of a subclass is created then Java automatically calls the default constructor of the super class from the constructor of the subclass.

But, when there is no default constructor in superclass, we must explicitly call the constructor of superclass using **super** keyword and required parameters (as we did in **Teacher** class).

Overriding Methods

When a method in the subclass has the same name and signature of a method in superclass, the method in subclass is said to be overriding the method in superclass.

Method **print**() of **Person** class is overridden in subclass **Teacher**.

Rules related to overriding:

- The arguments list must match exactly. Otherwise, it becomes overloaded.
- Return type must be the same as, or a subclass of, the return type of the original method.
- Access level CANNOT be more restrictive than the original. For example, if the superclass method is public, then the subclass method cannot be protected.
- A final method cannot be overridden.
- Static method cannot be overridden.
- Only inherited methods can be overridden. Private methods of superclass cannot be overridden as they are not inherited.

@Override Annotation

Annotation **Override** indicates that a method declaration in a subclass is intended to override a method declaration in a superclass.

If a method annotated with this annotation does not override a superclass method, the compiler generates an error message.

Overloading vs. Overriding

When you create a method in a subclass with the same name as a method in a superclass but with a different set of parameters, it is called overloading and not overriding.

The following example shows the difference between overriding and overloading.

```
01: class C1{
02:   public void m1(String msg) {
03:   }
04:   public void m2(int n) {
05:   }
06: }
07:
08: class C2 extends C1 {
09:     // overloads m1() in class C1
10:     public void m1() {
11:     }
12:
13:     // overrides m2() in class C1
14:     public void m2(int n) {
15:     }
16: }
```

Using super keyword to access superclass version

The **super** keyword in subclass is used to access superclass. The super keyword can be used to:

- ❑ Access a method of superclass that is overridden by a member in the subclass.
- ❑ Invoke the constructor of super class from the constructor of subclass.
- ❑ The super keyword can refer only to the immediate super class in the hierarchy.

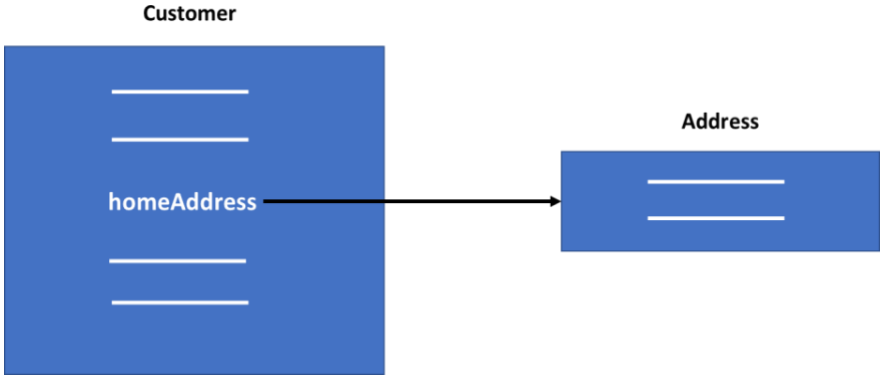
NOTE: While calling the constructor of the superclass from subclass's constructor, the call must be the first statement in the constructor of the subclass.

"Has A" Relationship

When a class contains a variable that refers to another class, the class is said to have a "Has A" relationship with the other class.

In the following example, **Customer** class has "has a" relationship with **Address** class as it has a variable of class **Address**.

```
class Address {
// instance variables & methods
 }
class Customer {
     private Address homeaddress;
// other variables and methods
 }
```

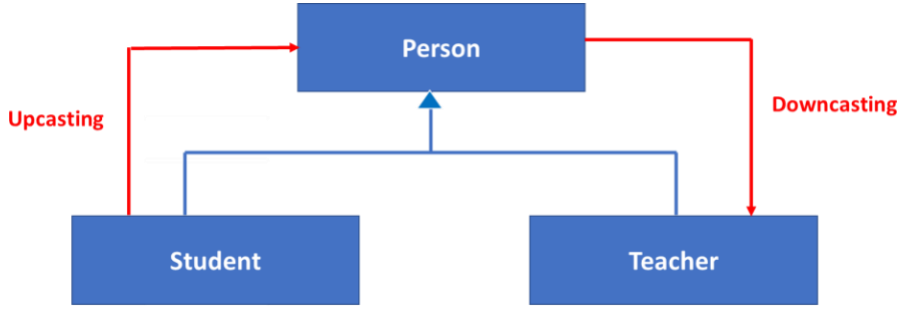


Downcasting and Upcasting

Java allows an object reference of superclass to refer to an object of subclass. This is the heart of runtime-polymorphism in Java.

Superclass is a more general form of subclass. Subclass is a more specific form of superclass. Person is a more general form of Student. In other words, a Student is always a Person. So, wherever Java expects Person, a Student can be used.

NOTE: Remember superclass and subclass share IS A relationship. A Student is always a Person.



Upcasting is casting an object to a class higher in the inheritance tree. When an object of the Teacher is assigned to a Person, it is called upcasting. Upcasting is implicit in Java.

```
Teacher f = new Teacher("Hunter","hunter@servlets.com",
                                 "servlets, jsp");
Person p = f; // Upcasting is done implicitly
Person p = (Person) f; // explicit casting, but NOT required
```

Downcasting is casting an object to a class down in the ***hierarchy tree***. When an object of Person is cast to Teacher, it is called Downcasting.

Downcasting must be done explicitly using type casting syntax as follows:

```
Person p = new
Teacher("Hunter","hunter@servlets.com","Java");
Teacher f = p; // doesn't compile
Teacher f = (Teacher) p; // Downcasting explicitly
```

NOTE: Downcasting is explicit and Upcasting is implicit. Downcasting is possible between a superclass and subclass only. For example, it is not possible to convert a String object to Person object as String and Person classes are not related.

The instanceof operator

Operator **instanceof** is used to check whether an object reference refers to an object of specified class or one of its subclasses.

```
object-reference instanceof class
```

```
Person p = new Teacher("abc","abc@gmail.com","java");
System.out.println(p instanceof Teacher);
System.out.println(p instanceof Person);
System.out.println(p instanceof Student);
```

Pattern matching for instanceof

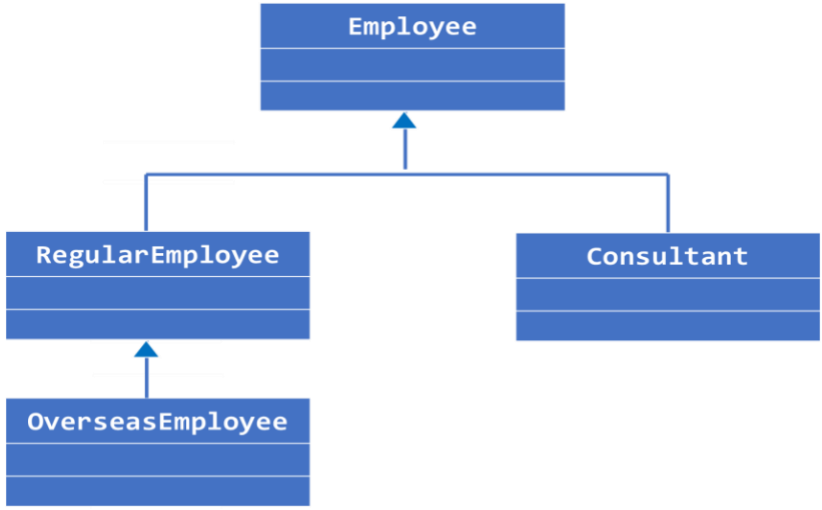
- Pattern matching is a feature finally standardized in Java 16, though it was introduced as a preview feature earlier.
- It converts superclass object reference to subclass if it points to specified subclass.
- Variables created by **instanceof** can be used only in the current block.

The following program checks whether object reference p points to Student object and if so, converts it to Student object:

```
Person p = new Teacher("Mike","mike@gmail.com","Java");
if (p instanceof Teacher t) {
 t.setSubjects("Java, Java EE");
}
```

Multi-level inheritance

Java supports multi-level inheritance. In this, a class is extended by another class, which is again extended by another class. The following picture shows multi-level inheritance.



In the above example, **Employee** class is inherited into **RegularEmployee** class, which in turn is inherited into **OverseasEmployee**.

Constructors of classes in inheritance must be called in the order of inheritance.

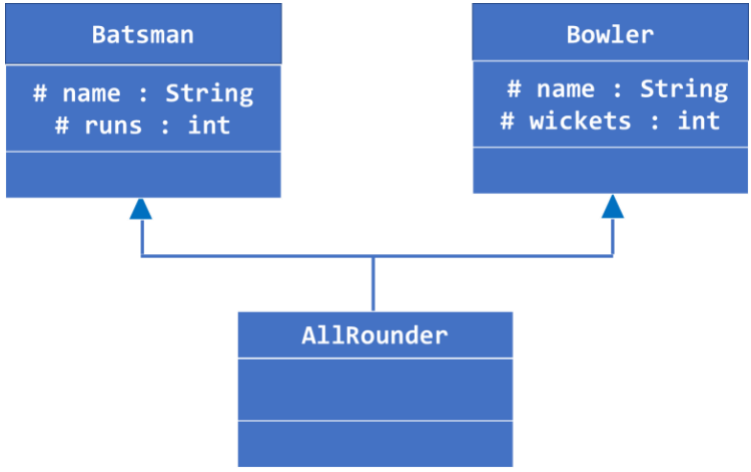
When you create an object of **OverseasEmployee**, constructor of the Employee class is called first then constructor of **RegularEmployee** and then finally constructor of **OverseasEmployee**.

Java tries to call the constructor of a superclass from the subclass's constructor using the super() statement. However, if that is not adequate, you must explicitly call constructor of superclass using super keyword by passing required parameters.

Multiple Inheritance

Java **does NOT** support multiple inheritance, where a single class extends two or more classes. It means, Java doesn't allow two or more classes to be inherited into a single class.

In the following diagram, **AllRounder** is extending **Batsman** and **Bowler**, which is not supported by Java.



The reason for Java to avoid multiple inheritance is the ambiguity caused by multiple inheritance. For example, **AllRounder** has two instances of the name variable as one comes from **Batsman** and another comes from **Bowler**. This leads to *ambiguity*.

Runtime Polymorphism

- It is the process by which a call to an overridden method is resolved at runtime instead of compile-time.
- It is based on the concept that an object reference of the super class can refer to an object of any subclass in the hierarchy.
- Runtime polymorphism occurs when an overridden method is called using an object reference of superclass.
- Java decides which method to call (superclass or subclass) based on the object pointed by object reference of superclass.
- Also called as ***late binding*** or ***dynamic method dispatch***.

```
class Person {
  public void print() {
          . . .
     }
 }
class Teacher extends Person {
   @Override
 public void print() {
          . . .
    }
 }
```

The following code shows how Java calls appropriate methods depending on the object pointed by object reference.

```
Person p;
p = new Person(...);
p.print();

/ / object ref. of superclass points to object of
subclass p = new Teacher(...);
/* call to print() method calls print() of subclass as p
points to object of subclass. */
p.print(); // calls print() of subclass
```

NOTE: Dynamic method dispatch is applied only to methods that are defined in superclass, overridden in subclass and invoked using an object reference of superclass.

Abstract Method

- Keyword **abstract** is used to create abstract methods.
- Abstract method doesn't contain the body.
- Must be overridden in subclass. Otherwise, subclasses must be declared abstract.
- If there is any abstract method in the class then class must be declared as abstract.
- Mutually exclusive with final method – a method cannot be declared as final and abstract.

Abstract Class

When a class contains one or more abstract methods, it must be defined as an abstract class using keyword abstract.

- Defined using **abstract** keywords.
- Cannot instantiate (create) objects of abstract class.
- However, an object reference of abstract class can be declared.
- Generally, it contains one or more abstract methods.
- A class can be declared as abstract even though it doesn't contain any abstract methods.
- Can contain other non-abstract members such as methods and instance variables.

Final Variable, Method, Class and Parameter

- Keyword **final** is used to declare final variables, methods and classes.
- A final variable is a variable whose value cannot be changed once the variable is assigned a value.
- Final method is a method that cannot be overridden in the subclass.
- Final class cannot be extended (inherited). There is no subclass for final class.
- You can declare parameters as **final** to ensure that the value of the parameter doesn't change during the execution of the method.

```
public void fun(int x, final int y) { }
```

The following example demonstrates how to use abstract method, abstract class, final method and runtime polymorphism.

```
01: abstract class Employee {
02:     protected String name, desg;
03:     public Employee(String name, String desg) {
04:         this.name  = name;
05:         this.desg = desg;
06:     }
07:     final public String getDesg() {
08:         return desg;
09:     }
10:     final public void setDesg(String desg) {
11:         this.desg  = desg;
12:     }
13:     final public String getName() {
14:         return name;
15:     }
16:     public abstract int getPay();
17: }
```

```
18: class RegularEmployee extends Employee {
19:   protected int salary;
20:   public RegularEmployee(String name, String desg,
21:         int salary) {
22:   super(name, desg);
23:         this.salary =salary;
24:   }
25:   @Override
26:   public int getPay() {
27:         return salary;
28:   }
29: }
30:
31: class Consultant extends Employee {
32:   protected int nohours, hourrate;
33:   public Consultant(String name, String desg,
34:         int nohours, int hourrate) {
35:    super(name, desg);
36:         this.nohours =nohours;
37:   this.hourrate=hourrate;
38:   }
39:   @Override
40:   public int getPay() {
41:      return nohours*hourrate;
42:   }
43: }
```

```
44: public class TestEmployee {
45:   public static void main(String[] args) {
46:         Employee employees [] =
47:   {new RegularEmployee("Steve", "Programmer", 25000),
48:         new Consultant("Kevin", "DBA",10,500),
49:   new RegularEmployee("Tom", "System Analyst", 45000)
50:   };
51:   for(Employee e: employees)
52:   System.out.printf("%s:%d\n",
53:   e.getName(), e.getPay());
54:   }
55: }
```

```
Steve:25000
 Kevin:5000
 Tom:45000
```

Sealed Classes

- Sealed classes let you restrict class hierarchies to only certain classes.
- Sealed classes are declared with modifier **sealed** and specify which classes are permitted to extend the class using **permits** modifier.
- Only the classes defined after the keyword **permits** are allowed to extend the sealed class.
- Classes mentioned after permits must be in the same package or module.
- Every permitted subclass must explicitly extend the sealed class.
- Every permitted subclass must use one of the modifiers - **final**, **sealed**, or **non-sealed**.
- Concrete subtypes are implicitly **final**.

```
01: sealed class Course permits OnlineCourse, OfflineCourse{
02:
03: }
04:
05: final class OnlineCourse extends Course {
06:
07: }
08:
09: non-sealed class OfflineCourse extends Course {
10:
11: }
12:
13: class WeekendCourse extends OfflineCourse {
14:
15: }
```

Initialization Blocks

- Object initialization block is executed when an object is created.
- Static initialization block is executed when the class is loaded.
- Initialization block is run after the super-constructor has run.
- Blocks are run in the order in which they appear in the class.
- Initialization blocks cannot have parameters and cannot return any value.
- Object initialization blocks are executed irrespective of which constructor is executed. So, they can be used to contain code that all constructors need to share.

```
01: class A {
02:     // Object initialization block
03:     {
04:         System.out.println("Init Block In A");
05:     }
06:     public A() {
07:         System.out.println("Constructor of A");
08:     }
09:
10:     // Static initialization block
11:     static {
12:         System.out.println("Static Init Block Of A");
13:     }
14: }
15:
16: class B extends A
17: {
18:     public B() {
19:         System.out.println("Constructor of B");
20:     }
21:     public B(String message){
22:         System.out.println("Constructor with message: "
23:                                                 + message);
24:     }
```

```
25:     // Object initialization block
26:     {
27:         System.out.println("First Init Block In B");
28:     }
29:
30:     {
31:        System.out.println("Second Init Block In B");
32:     }
33:
34:     static {
35:        System.out.println("Static Init Block Of B");
36:    }
37: }
38:
39: public class InitBlockDemo {
40:   public static void main(String[] args) {
41:         B obj = new B();
42:    System.out.println("========================");
43:   B obj2 = new B("Second Object");
44:   }
45: }
```

When you run the above program, you will get the following output:

```
Static Init Block Of A
 Static Init Block Of B
 Init Block In A
 Constructor of A
First Init Block In B
 Second Init Block In B
 Constructor of B
 ============================
Init Block In A
 Constructor of A First
 Init Block In B Second
 Init Block In B
Constructor with message: Second Object
```

Java Library
Part - 1

Object class

- Object class is one of the standard classes in Java API.
- All other classes in Java are subclasses of the Object class.
- A class declaration without **extends** clause, implicitly extends **Object** class.
- So, a reference to **Object** class can refer to an object of any class in Java.

Method	Meaning
Object clone()	Creates a new object that is the same as the object being cloned. Default implementation does shallow copying – only primitive values and references are copied. Override this method to provide *deep copying*.
boolean equals(Object)	Compares the contents of two objects and returns true if the contents are the same. Default implementation compares only references and not contents. Override this method to provide value-based comparison.
void finalize()	Called before an unused object is released by garbage collector. Default implementation does nothing.
int hashCode()	Returns the hash code associated with the invoking object. Hash code is used when object is used with hashing - HashSet. When two objects are equal then hash codes for those two objects must also be equal.
String toString()	Returns a string that describes the object. Default implementation returns classname@hashcode-in-hex.
final class getClass()	Returns an object of type **Class** related to the object.

NOTE: If two objects are equal according to the **equals** (Object) method, then calling the **hashCode**() method on each of the two objects must produce the same integer result.

The following **final** methods of Object class are related to multithreading.

final void notify()	Resumes execution of the thread that is waiting to be notified.
final void notifyAll()	Resumes execution of all threads that are waiting to be notified.
final void wait()	Causes the current thread to wait until the object notifies the thread.

The following program shows default implementation of methods in **Object** class.

```
01: class Time {
02:   private int hours, mins, secs;
03:   public Time(int hours, int mins, int secs) {
04:         this.hours = hours;
05:   this.mins = mins;
06:         this.secs = secs;
07:   }
08: }
09: public class TestTime {
10:     public static void main(String[] args) {
11:         Time t1 = new Time(10,20,30);
12:         Time t2 = new Time(10,20,30);
13:
14:         System.out.println(t1.toString());
15:         System.out.println(t2.equals(t1));
16:    }
17: }
```

The above program generates the following output:

```
Time@19821f
 false
```

In the following example, we override **equals**(), **hashCode**(), and **toString**() methods.

```
01: // class to override methods in Object
class 02: class Time {
03:   private int hours, mins, secs;
04:   public Time(int hours, int mins, int secs) {
05:     this.hours = hours;
06:    this.mins  =  mins;
07:    this.secs  =  secs;
08:  }
09:   public int getTotalSeconds() {
10:     return hours * 60 * 60 + mins * 60 + secs;
11:   }
12:   @Override
13:   public int hashCode() {
14:     return hours;
15:   }
16:   @Override
17:   public boolean equals(Object obj) {
18:     if (obj instanceof Time) {
19:      Time t = (Time) obj;
20:      return t.getTotalSeconds()==this.getTotalSeconds();
21:     }
22:     else
23:      return false;
24:   }
25:   @Override
26:   public String toString() {
27:   return String.format
28:         ("%02d:%02d:%02d", hours, mins, secs);
29:   }
30: }
```

```
31: public class TestTime {
32:     public static void main(String[]args)  {
33:        Time t1 = new Time(10, 20, 30);
34:        Time t2 = new Time(10, 20, 30);
35:        Time t3 = new Time(15, 15, 15);
36:
37:        System.out.println(t1.toString());
38:        System.out.println(t1.equals(t2));
39:        System.out.println(t1.equals(t3));
40:     }
41: }
```

Output generated by the above program is as follows:

```
10:20:30
true
false
```

Records

- A record is a class for which the following artifacts are automatically defined by Java:
  - ✔ The constructor that takes all fields mentioned
  - ✔ Getter methods with field names
  - ✔ toString()
  - ✔ hashCode() and equals()
- Fields of records are automatically made final.
- **Record** is the common base class of all Java language record classes.
- A record class declaration does not have an **extends** clause.
- A record class is implicitly **final**, and cannot be **abstract**.
- The fields derived from the record components are **final**.
- A record class can declare static methods, fields, and initializers.
- A record class can declare instance methods.
- A record class can implement interfaces.

```
public record Contact(String name, String email,
String mobile) {
 }
```

```
var c1 = new Contact("A", "a@gmail.com", "123456");
var c2 = new Contact("A", "a@gmail.com", "123456");
System.out.println(c1.toString());
System.out.println(c1.equals(c2));
System.out.println(c1.email());    // getter method
```

```
Contact[name=A, email=a@gmail.com, mobile=123456]
true
a@gmail.com
```

String Class

- ❑ String is one of the standard classes of Java.
- ❑ An object of String class represents a collection of characters (string).
- ❑ Provides methods required to manipulate a string.

NOTE: String represented by String class is **immutable**. That means once we create a string, its value cannot be modified.

```
String()
String(char[])
String(String)
```

The following are important methods of **String** class.

Method	Meaning
char charAt(int)	Returns the character at the given position.
boolean endsWith(String)	Returns true if string ends with the given string.
String concat(String)	Appends string to invoking string and returns concatenated string.
boolean Contains(String)	Returns true if the string contains the given string.
int indexOf(String)	Returns the position of the substring in the main string or -1 on failure.
int indexOf (String, frompos)	Same as above, but starts search at the given position.
int lastIndexOf (String)	Returns position of the substring from the end of the main string.
int lastIndexOf(String, frompos)	Same as above, but starts search at the given position.
int length()	Returns the length of the string.
String join(String delimiter, String... elements)	Returns a string by joining given string with delimiter.

boolean startsWith (String)	Returns true if string starts with the given string.
String substring (int from, int to)	Returns a substring that starts at *from* and ends at *to* in the main string.
String toLowerCase()	Returns the string after converting it to lowercase.
String toUpperCase()	Returns the string after converting it to uppercase.
String trim()	Trims spaces on both sides of the string.
String replace (char old,char new)	Replaces *old* character in the string with *new* character.
static String valueOf (T v)	Converts the given value to string.
String [] split(String delims)	Splits a string into multiple strings based on the given delimiter.
String indent(int n)	Adjusts the indentation of each line of this string based on the value of n.
boolean isBlank()	Returns true if the string is empty or contains only white space codepoints, otherwise false.
Stream<String> lines ()	Returns a stream of lines extracted from this string, separated by new line char.
String repeat (int count)	Returns a string whose value is the concatenation of this string repeated count times.
String strip()	Returns a string whose value is this string, with all leading and trailing whitespaces removed.
String stripLeading()	Returns a string whose value is this string, with all leading whitespaces removed.
String stripTrailing()	Returns a string whose value is this string, with all trailing whitespaces removed.

```
01: public class StringDemo {
02:   public static void main(String args[]) {
03:    String s1 = new String("Java Language");
04:    String s2 = "Java EE";
05:
06:    // comparing two strings based on values
07:    if(s1.equals(s2))
08:       System.out.println("Equal");
09:
10:
11:    System.out.println(s1.charAt(0)) ;        // J
12:    System.out.println(s1.startsWith("Java"));// true
13:    System.out.println(s1.endsWith("Java")); // false
14:    System.out.println(s1.indexOf("a"));      // 1
15:    System.out.println(s1.indexOf("a", 4));   // 6
16:    System.out.println(s1.lastIndexOf("a")); // 10
17:    System.out.println(s1.substring(0,4));    // Java
18:    System.out.println(s1.toUpperCase());// JAVA LANGUAGE
19:    // original string remains the same
20:    System.out.println(s1);                //      Language
21:    Java
22:
23:    // split the string based on space
24:    String words[] = s1.split(" ");
25:    System.out.println("\nWords\n");
26:    for (String w : words)
27:           System.out.println(w);
```

```
28:     String langs = String.join(",","Java","Python","C#");
29:     System.out.println(langs); // Java, Python,C#
30:
31:     System.out.println("   Java SE ".strip());  //Java SE
32:     System.out.println("Java SE\nJava EE".indent(5));
33:     //     Java SE
34:     //     Java EE
35:     System.out.println("*".repeat(5));   // *****
36:     System.out.println("  ".isBlank());  // true
37:   }
38: }
```

StringBuffer Class

StringBuffer represents a mutable character string thus allowing string to be modified.

```
StringBuffer(String)
StringBuffer(int capacity)
StringBuffer()
```

Method	Meaning
void setCharAt(index,char)	Changes character at the given position.
StringBuffer append(String)	Appends string at the end.
StringBuffer append(char)	Appends character at the end.
StringBuffer append(char[])	Appends a character array at the end of the buffer.
StringBuffer insert(offset,data)	Inserts the given data at the given offset in the buffer.
StringBuffer deleteCharAt(index)	Removes character at the index.
StringBuffer delete (int start, int end)	Removes characters from *start* to *end*.
StringBuffer reverse()	Reverses string buffer.

```
01: public class SBDemo {
02:   public static void main(String args[]) {
03:    StringBuffer sb = new StringBuffer("Java ");
04:    sb.append("EE");
05:    System.out.println(sb);      // Java EE
06:    sb.insert(0,"Oracle ");
07:    System.out.println(sb);      // Oracle Java EE
08:    sb.delete(0,6);
09:    System.out.println(sb);      // Java EE
10:   }
11: }
```

NOTE: StringBuilder class was introduced in Java 5.0. It is the same as StringBuffer except that it is NOT synchronized. So StringBuilder is not thread-safe but could be faster than StringBuffer.

StringJoiner Class

StringJoiner is used to construct a sequence of strings separated by a delimiter and optionally prefix and suffix.

```
StringJoiner(String delimiter)
StringJoiner(String delimiter, String prefix, String suffix)
```

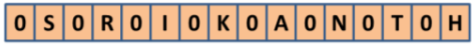
Method	Meaning
StringJoiner add (CharSequence value)	Adds a copy of the given CharSequence value as the next element of the StringJoiner value.
StringJoiner merge (StringJoiner other)	Adds the contents of the given StringJoiner without prefix and suffix as the next element.
StringJoiner setEmptyValue (CharSequence value)	Sets the value to be used when no elements have been added yet, that is, when it is empty.

```
StringJoiner sj = new StringJoiner(",","[","]");
sj.add("Java");
sj.add("C#");
sj.add("Python");

System.out.println(sj.toString()); // [Java,C#,Python]
```

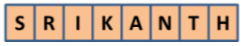
Compact String

- Compact string is a string that uses only one byte for character instead of 2 bytes as it is the case in Java 8 and before.
- Java decides whether to use byte[] or char[] to store strings based on the character set used.
- For LATIN-1 representation, a byte array is used and in other cases char array is used (UTF-16 representation).
- To know whether a string is using char[] or byte[], a field called coder is used internally.
- The whole implementation is automatic and transparent to the developer.
- Compact strings reduce the amount of memory occupied by strings by half.

String in Java 8



String in Java 9



Math Class

Math class contains a set of **static** methods to support common mathematical functions. It is a final class and cannot be extended.

Static Method	Meaning
T abs(T number)	Returns absolute value.
T min(T n1, T n2)	Returns the least of two numbers.
T max(T n1, T n2)	Returns greater of two numbers.
long round(double)	Returns the number after rounding it.
double pow(double base, double power)	Returns base raised to power.
double random()	Returns a random number that is >=0 and < 1.0.

NOTE: In the above methods T indicates the data type used.

```
01: public class MathDemo {
02: public static void main(String[] args) {
03:  System.out.println(Math.abs(-10));
04:  System.out.println(Math.min(10, 20));
05:  System.out.println(Math.round(10.636));
06:  System.out.println(Math.round(Math.random()*100));
07: }
08: }
```

Arrays Class

Arrays class provides static methods to search, sort, fill and compare arrays. It provides methods that work on arrays of any type.

Method	Meaning
int binarySearch (T array[], T v)	Searches for value using binary search algorithm.
boolean equals (T array[], T array[])	Compares whether the contents of two arrays are equal.
void fill(T array[], T value)	Fills all elements of an array with the given value.
void sort(T array[])	Sorts the given array.
String toString(T array[])	Returns a string that contains all elements of the array.
T [] copyOf (T array[], int newlength)	Makes a copy of an existing array to new array with the specified size and returns a new array.

```
01: // import Arrays class from java.util package
02: import java.util.Arrays;
03: class ArraysDemo {
04:   public static void main(String...args) {
05:    long a[] = new long[5];
06:    for (int i = 0 ; i < 5; i ++)
07:         a[i] = Math.round (Math.random() * 100);
08:    Arrays.sort(a);
09:    for (long n : a)
10:         System.out.println(n);
11:
12:    int pos = Arrays.binarySearch(a,30);
13:    if (pos >= 0)
14:         System.out.printf("Found at : %d", pos);
15:    else
16:         System.out.println("Not found");
17:   }    }
```

Calendar Class

Calendar class provides methods and fields to obtain information about date and time. Calendar is an abstract class and an example for its subclass is ***GregorianCalendar***.

Static method ***getInstance***() is used to return an object of Calendar class that contains system date and time.

Method	Meaning
int get(what)	Returns the value specified by ***what***.
void add (int what, int value)	Adds ***value*** which is specified by ***what*** parameter.
void set (year, month, days, hours, minutes, seconds)	Sets date and time to given values.
void setTime(Date)	Sets time to the given **Date** object.

```
01: import java.util.*;
02: public class CalendarDemo {
03:  public static void main(String [] args)
04:                                throws Exception {
05:    //Get system date and time
06:    Calendar cal = Calendar.getInstance();
07:    cal.add(Calendar.MONTH,10);
08:    System.out.printf ("Year :%d  Month:%d  Day:%d",
09:         cal.get(Calendar.YEAR), cal.get(Calendar.MONTH),
10:         cal.get(Calendar.DAY_OF_MONTH));
11:   }
12: }
```

Date Class

An instance of Date class represents a single date and time. Internally date and time is stored as long integer. It is the number of milliseconds from Jan 1, 1970.

Creating an object of **Date** class fills it with system date and time. You can get date and time using **getTime**() method, set date and time using **setTime**() method.

An object of **Date** class is used mainly with **DateFormat** class as its **format**() methods expect an object of Date class.

DateFormat Class

DateFormat is an abstract class used to format dates. You get an instance of DateFormat class to format either date or time by using one of the following methods:

```
DateFormat getDateInstance()
DateFormat getDateInstance(int style)
DateFormat getTimeInstance()
DateFormat getTimeInstance(int style)
```

Argument **style** could be – DEFAULT, SHORT, MEDIUM, LONG or FULL.

Method **format**() is used to format the date or time. It takes an object of the Date class as a parameter.

NumberFormat Class

- It is an abstract base class for all number formats.
- Provides the interface for formatting and parsing numbers.
- Supports locale.

```
static NumberFormat    getCurrencyInstance()
static NumberFormat    getCurrencyInstance(Locale
inLocale) static NumberFormat      getInstance()
static NumberFormat    getInstance(Locale inLocale)
```

Compact Number Format

- Method **getCompactNumberInstance**() returns an object that can be used to format numbers to get the compact value of the given number.
- It returns 1K for 1000, and 1M for 1000000 etc.

```
NumberFormat nf = NumberFormat.getCompactNumberInstance()
 nf.format(1000)  // 1k
nf.format(1000000) // 1M
```

SimpleDateFormat Class

It is used to format date and time using custom format. It is a concrete subclass of the DateFormat class. The following characters can be used to format date and time. For a complete list of format characters, see Java Documentation.

Format	What it presents	Example
y	Year	1996; 96
M	Month in year	July; Jul; 07
W	Week in month	2
d	Day in month	10
H	Hour in day (0-23)	0
h	Hour in am/pm (1-12)	12
m	Minute in hour	30
s	Second in minute	55

```
01: import java.text.*;
02: import java.util.Date;
03: public class DateFormatExample {
04:   public static void main(String[] args){
05:         Date d = new Date();
06:         DateFormat df =
07:            DateFormat.getTimeInstance(DateFormat.FULL);
08:   System.out.println(df.format(d));
09:         DateFormat tf =
10:            DateFormat.getDateInstance(DateFormat.FULL);
11:   System.out.println(tf.format(d));
12:         SimpleDateFormat sdf =
13:            new SimpleDateFormat("d-MMM-yy HH:mm:ss");
14:         System.out.println(sdf.format(d));
15:   }
16: }
```

```
1:53:45 pm India Standard Time
 Saturday, 1 May, 2021
1-May-21 13:53:45
```

New Date and Time API

- ❑ The Date-Time API uses the calendar system defined in ISO-8601 as the default calendar.
- ❑ The core classes are LocalDate, LocalTime, LocalDateTime, ZonedDateTime, and OffsetDateTime.
- ❑ Most of the classes in the Date-Time API create objects that are immutable. This makes objects thread safe.
- ❑ Packages java.time, java.time.format, java.time.zone contain new classes.

DayOfWeek Enum

The DayOfWeek enum consists of seven constants that describe the days of the week: MONDAY through SUNDAY. The integer values of the DayOfWeek constants range from 1 (Monday) through 7 (Sunday).

Month Enum

The Month enum includes constants for the twelve months, JANUARY through DECEMBER. The integer value of each constant corresponds to the ISO range from 1 (January) through 12 (December).

LocalDate Class

A LocalDate represents a year-month-day in the ISO calendar and is useful for representing a date without a time. You might use a LocalDate to track a significant event, such as a birth date or wedding date.

Method	Meaning
LocalDateTime atTime (int hour, int minute, int second)	Combines this date with a time to create a LocalDateTime.
String format (DateTimeFormatter formatter)	Formats this date using the specified formatter.
int get(TemporalField field)	Gets the value of the specified field from this date as an int.
int getDayOfMonth()	Gets the day-of-month field.
DayOfWeek getDayOfWeek()	Gets the day-of-week field, which is an enum DayOfWeek.
int getDayOfYear()	Gets the day-of-year field.
int getMonthValue()	Gets the month-of-year field from 1 to 12.
int getYear()	Gets the year field.
boolean isLeapYear()	Check if the year is a leap year.
LocalDate minusDays(long daysToSubtract)	Returns a copy of this LocalDate with the specified number of days subtracted.
LocalDate minusMonths(long monthsToSubtract)	Returns a copy of this LocalDate with the specified number of months subtracted.
LocalDate minusYears(long yearsToSubtract)	Returns a copy of this LocalDate with the specified number of years subtracted.
LocalDate plusDays(long daysToAdd)	Returns a copy of this LocalDate with the specified number of days added.
LocalDate plusMonths(long monthsToAdd)	Returns a copy of this LocalDate with the specified number of months added.
LocalDate plusYears(long yearsToAdd)	Returns a copy of this LocalDate with the specified number of years added.
Stream<LocalDate> datesUntil (LocalDate endExclusive)	Returns a sequential ordered stream of dates.

Static Method	Meaning
LocalDate now()	Obtains the current date from the system clock in the default time-zone.
LocalDate of(int year, int month, int dayOfMonth)	Obtains an instance of LocalDate from a year, month and day.
LocalDate parse(CharSequence text)	Obtains an instance of LocalDate from a text string such as 2007-12-03.
LocalDate parse(CharSequence text, DateTimeFormatter formatter)	Obtains an instance of LocalDate from a text string using a specific formatter.

```
LocalDate date = LocalDate.of(1998, Month.OCTOBER, 24);
LocalDate newdate = date.plusDays(100);
System.out.println(newdate);

LocalDate dob=LocalDate.parse("1998-02-28"); //ISO format
System.out.println(dob);

LocalDate dob2=LocalDate.parse("09-10-2002",
                DateTimeFormatter.ofPattern("dd-MM-uuuu"));
System.out.println(dob2);
```

LocalTime Class

LocalTime represents a time without a timezone.

```
LocalTime now = LocalTime.now();
 LocalTime singtime =
LocalTime.now(ZoneId.of("Asia/Singapore"));
```

Method	Meaning
int getHour()	Gets the hour-of-day field.
int getMinute()	Gets the minute-of-hour field.
int getSecond()	Gets the second-of-minute field.
boolean isAfter (LocalTime other)	Checks if this time is after the specified time.
boolean isBefore (LocalTime other)	Checks if this time is before the specified time.
LocalTime minusHours (long hours)	Returns a copy of this LocalTime with the specified number of hours subtracted.
LocalTime minusMinutes (long minutes)	Returns a copy of this LocalTime with the specified number of minutes subtracted.
LocalTime minusSeconds (long seconds)	Returns a copy of this LocalTime with the specified number of seconds subtracted.
LocalTime plusHours (long hours)	Returns a copy of this LocalTime with the specified number of hours added.
LocalTime plusMinutes (long minutes)	Returns a copy of this LocalTime with the specified number of minutes added.
LocalTime plusSeconds (long seconds)	Returns a copy of this LocalTime with the specified number of seconds added.
int toSecondOfDay()	Extracts the time as seconds of day, from 0 to 24 * 60 * 60 - 1.

Static Method	Meaning
LocalTime now()	Obtains the current time from the system clock in the default time-zone.
LocalTime now (ZoneId zone)	Obtains the current time from the system clock in the specified time-zone.
LocalTime of (int hour, int min, int sec)	Obtains an instance of LocalTime from an hour, minute and second.
LocalTime parse (CharSequence text)	Obtains an instance of LocalTime from a text string such as 10:15.
LocalTime parse (CharSequence text, DateTimeFormatter formatter)	Obtains an instance of LocalTime from a text string using a specific formatter.

LocalDateTime Class

This class handles both date and time, without a time zone. This class is used to represent date (month-day-year) together with time (hour-minute-second-nanosecond) and is, in effect, a combination of LocalDate with LocalTime.

YearMonth, MonthDay and Year Classes

- YearMonth represents the month of a specific year.
- MonthDay represents the day of a particular month, such as New Year's Day on January 1.
- Year represents a year.

ChronoUnit Enum

- The ChronoUnit enum provides a set of standard units based on date and time, from milliseconds to millennia.
- Available constants are DAYS, HOURS, MICROS, MILLENNIA, MILLIS, MINUTES, MONTHS, SECONDS, WEEKS, YEAR.

```
01: import java.time.LocalDate;
02: import java.time.Period;
03: import java.time.temporal.ChronoUnit;
04: import java.util.Scanner;
05: public class AgeCalculator{
06:   public static void main(String[] args) {
07:   System.out.print("Enter DOB [yyyy-mm-dd]:");
08:   Scanner s = new Scanner(System.in);
09:   String dobstr = s.nextLine();
10:   LocalDate dob = LocalDate.parse(dobstr);
11:   LocalDate now = LocalDate.now();
12:   long years =ChronoUnit.YEARS.between(dob,now);
13:   System.out.println(years);
14:   Period p = Period.between(dob,now);
15:   System.out.printf
16:       ("%d years, %d months and %d days old!\n",
17:        p.getYears(), p.getMonths(),p.getDays());
18: }
19: }
```

```
Enter DOB [yyyy-mm-dd]:1998-10-24
 22
22 years, 6 months and 7 days old!
```

DateTimeFormatter Class

- Provides format for printing and parsing date-time objects.
- The following methods are used to obtain an object of DateTimeFormatter:
  - ofLocalizedDate(format)
  - ofLocalizedTime(format)
  - ofLocalizedDateTime(format,format)
  - ofPattern(customFormat)

```
01: import java.time.LocalDate;
02: import java.time.format.DateTimeFormatter;
03: import java.time.format.FormatStyle;
04:
05: public class DateTimeFormatterExample {
06:   public static void main(String[] args){
07:    DateTimeFormatter df =
08:    DateTimeFormatter.ofLocalizedDate(FormatStyle.FULL);
09:    LocalDate today = LocalDate.now();
10:    System.out.println(today.format(df));
11:
12:    DateTimeFormatter inputFormat =
13:      DateTimeFormatter.ofPattern("dd-MM-uuuu");
14:    LocalDate transDate =
15:      LocalDate.parse("24-10-1998", inputFormat);
16:    System.out.println(transDate);
17:
18:    DateTimeFormatter format =
19:       DateTimeFormatter.ofPattern("dd-MMM-uuuu H:m:s");
20:    System.out.println
21:       (LocalDateTime.now().format(format));
22:   }
23: }
```

```
Saturday, 1 May, 2021
1998-10-24
01-May-2021 14:3:30
```

Symbol	Meaning	Presentation	Example
u	year	Year	2004; 04
y	year-of-era	Year	2004; 04
D	day-of-year	number	189
M/L	month-of-year	number/text	7; 07; Jul; July; J
d	day-of-month	number	10
Q/q	quarter-of-year	number/text	3; 03; Q3; 3rd quarter
W	week-of-month	number	4
E	day-of-week	Text	Tue; Tuesday; T
a	am-pm-of-day	Text	PM
h	clock-hour-of-am-pm (1-12)	number	12
H	hour-of-day (0-23)	number	0
m	minute-of-hour	number	30
s	second-of-minute	number	55

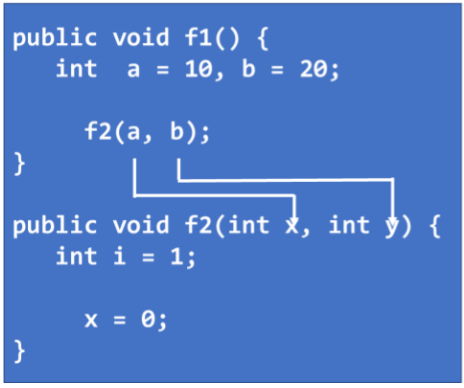
Other classes

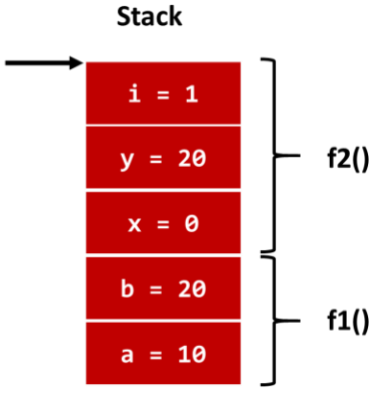
- **ZoneId** specifies a time zone identifier and provides rules for converting between an Instant and a LocalDateTime.
- **ZoneOffset** specifies a time zone offset from Greenwich/UTC time.
- **ZonedDateTime** handles a date and time with a corresponding time zone with a timezone offset from Greenwich/UTC.
- **OffsetDateTime** handles a date and time with a corresponding time zone offset from Greenwich/UTC, without a time zone ID.
- **OffsetTime** handles time with a corresponding time zone offset from Greenwich/UTC, without a time zone ID.

Standard Datatypes vs. Objects

Java treats standard data types (also called as primitive types) and objects of classes differently.

Standard data types are allocated memory on the **stack**. Parameters of primitive type are always **passed by value.**





In the above picture, variables **a** and **b** are created on stack when control enters into **f1().** When function **f2()** is called, **formal parameters x** and **y** are created and assigned values from **actual parameters** – **a** and **b**.

However, changes to **x** and **y** will not change **a** and **b** as they occupy different locations in memory.

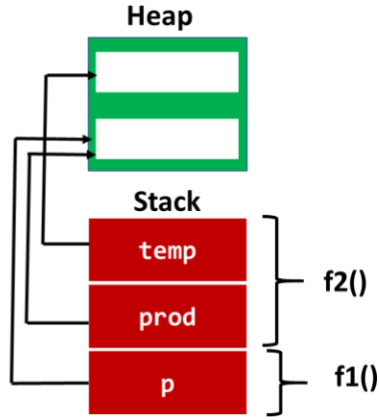
NOTE: Passing parameters of standard data types is always pass-by-value.

How objects are handled by Java?

Objects of classes are allocated memory dynamically on **heap** and they are released by garbage collector when they are not required.

Object is allocated memory on the heap. However, an object reference is allocated memory on stack. When an object is passed to a function, only reference of the object is passed but not the object itself.

```
public void f1() {
  Product p;
     p = new Product(…);
     f2(p);
}

public void f2(Product prod) {
  Product temp;
     temp = new Product(…);
     prod.setPrice(1000);
}
```



NOTE: An object is always passed by reference.

In the above figure, object references **p** in **f1()** and **prod** in function **f2()** both refer to the same object. Object reference **temp** points to a new object.

When control comes out of **f2**(), an object pointed by **temp** will be ready for garbage collection as it is no longer pointed by any object reference.

Wrapper Classes

Primitive types such as int and double are not objects in Java. Wrapper classes are used to convert primitive types to objects. Java provides a wrapper class for each primitive type (8 in total).

NOTE: Wrapper classes are declared as **final** and their values cannot be changed.

The following are the wrapper classes provided by Java and their corresponding primitive (standard) type.

Standard Type	Wrapper Class	Method to convert object to primitive type
boolean	Boolean	booleanValue()
byte	Byte	byteValue()
short	Short	shortValue()
int	Integer	intValue()
long	Long	longValue()
float	Float	floatValue()
double	Double	doubleValue()
char	Character	charValue()

Boxing and Unboxing

The following code shows how to use wrapper class Integer to convert an int to object (boxing) and back to int (unboxing).

```
01: int x =100;
02:    // convert int to an object
03:    Integer iobj = new Integer(x); // boxing
04:
05:    // get int from object
06:    x = iobj.intValue();          // unboxing
```

Autoboxing and Autounboxing

When a primitive data type is to be used as an object, it is to be **boxed** to an object of corresponding **wrapper** class. When the primitive value is to be taken from a wrapper class object then the value is to be **unboxed** from the object by using a method of wrapper class.

Starting from Java 5.0, Java does **boxing** and **unboxing** automatically. The following example shows how boxing and unboxing take place.

```
01: public static void main(String[] args) {
02:    int i = 100;
03:    Integer iobj = i;                    // autoboxing
04:    System.out.println(iobj.toString());
05:    i = iobj;                            // autounboxing
06:    System.out.println(i);
07: }
```

JSHELL

- Also known as REPL (Read Evaluate Print Loop).
- Used to execute any java code from command prompt.
- Allows small code to be executed without having to create a class and main method.
- Start by entering **jshell** at command prompt.
- We can give any Java statement or expression at the jshell prompt (jshell>).
- Results of expressions are stored in a variable named as $n where n is a number. These variables are called internal variables.
- Code can be typed in multiple lines.
- Commands of jshell start with / (slash). For example, **/help** and **/exit.**
- It supports TAB for completion of expression.
- It automatically imports some packages. We can get the list of packages imported using the **/imports** command.

Tab Completion

When entering snippets, commands, subcommands, command arguments, or command options, use the **Tab** key to automatically complete the item. If the item can't be determined from what was entered, then possible options are provided.

Command abbreviations

An abbreviation of a command is accepted if the abbreviation uniquely identifies a command.

History navigation

A history of what was entered is maintained across sessions. Use the *up* and *down* arrows to scroll through commands and snippets from the current and past sessions.

History search

Use the *Ctrl+R* key combination to search the history for the string entered. The prompt changes to show the string and the match. Ctrl+R searches backwards from the current location in the history through earlier entries. *Ctrl+S* searches forward from the current location in the history through later entries.

Command	Meaning
/drop	Drops a snippet
/edit	Opens an editor
/exit	Exits jshell
/history	Displays what was entered in this session
/help	Displays information about commands and subjects
/imports	Displays active imports
/list	Displays list of snippets and their ID
/methods	Lists methods that were created
/open file	Opens the file and reads the snippet into jshell. In place of *file*, you can give DEFAULT, JAVASE or PRINTING.
/reset	Resets the session
/save file	Saves snippets and commands to the file specified
/set	Sets configuration information
/types	Displays types created in session
/vars	Displays variables created in session

Object Oriented Programming Part - 2

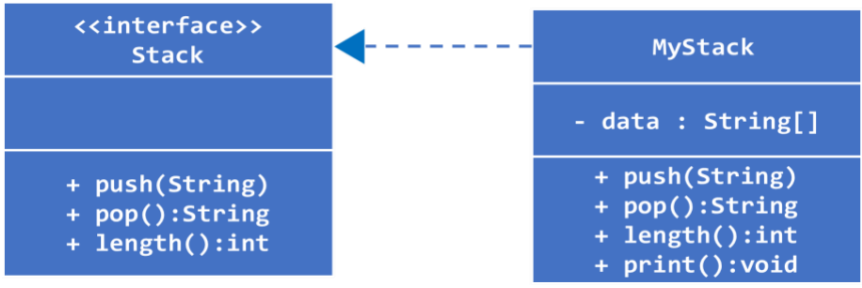
Interfaces

- An interface is a collection of methods that must be implemented by the implementing class.
- An interface defines a contract regarding what a class must do, without saying anything about how the class will do it.
- Interfaces can contain declaration of methods and variables.
- Implementing class must define all the methods declared in the interface.
- If a class implements an interface and does not implement all the methods then the class itself must be declared as abstract.
- Variables in interface automatically become static and final variables of the implementing class.
- Members of interface are implicitly public, so need not be declared as public.

```
access interface  name  [ extends interface [,interface] ]
{
   returntype method([parameters]);
   datatype finalvariable = value;
}
```

NOTE: In UML, the interface resembles a class. One way to differentiate an interface from a class is to use **<<interface>>** stereotype as shown above.

The following example shows how to declare an interface and how a class implements the interface.



```
interface Stack {
void push(String value);
String pop();
int length();
 }
```

Stack is a data structure that stores data in such a way that the last value pushed is the first value to be popped (LIFO).

Implementing an Interface

The following class - **MyStack**, implements **Stack** interface and provides definition for methods in the interface. It also adds a new method – print() to print all values in the stack.

```
01:  class MyStack implements Stack {
02:  private String data[] = new String[10];
03:  private int top = 0;
04:  public void push(String value) {
05:        data[top] = value;
06:  top++;
07:  }
08:  public String pop() {
09:        top --;
10:  return data[top];
11:  }
12:  public int length() {
13:        return top;
14:  }
15:  public void print() {
16:  for (int i = 0; i < top ; i ++) {
17:        System.out.println(data[i]);
18:  }
19:  }
20: }
```

The following **main**() creates an object of **MyStack** class and calls its methods.

```
01: class UseMyStack {
02:   public static void main(String[] args) {
03:         MyStack ms = new MyStack();
04:   ms.push("First");
05:   ms.push("Second");
06:   ms.print();
07:   System.out.println(ms.pop());
08:   }
09: }
```

NOTE: A class can neither narrow the accessibility of an interface method nor specify new exceptions in the method's ***throws*** clause. For example, a method declared in interface cannot be overridden with any access narrower than public as it is implicitly declared as public in interface.

Using object reference of an Interface

An object reference of an interface can refer to an object of its implementing class or any subclass of implementing class.

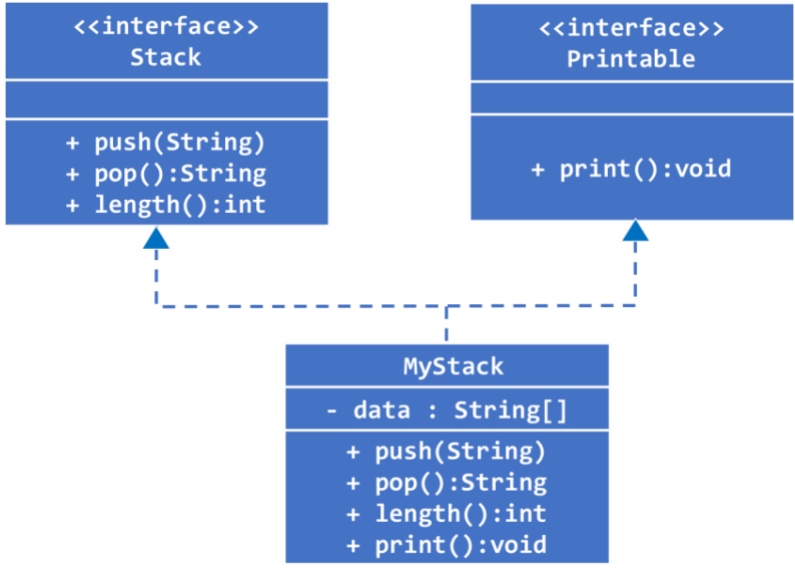
For example, an object reference of **Stack** interface can refer to an object of **MyStack** class as it implements Stack interface. However, only methods that are present in the interface can be called using object reference of interface even though the reference refers to the object of implementing class.

The following code snippet shows how to use object reference of Stack interface.

```
Stack s;
s = new MyStack();
 s.push("10");
 System.out.println(s.pop());
// Cannot call print() as it is NOT a method of interface
 Stack
s.print();
```

NOTE: An object reference of an interface can reference an object of implementing class. However, only methods in interface can be called using object reference of interface.

A single class can implement multiple interfaces. *Multiple inheritance* is supported using interfaces.



```
interface Printable {
    void print();
}
class MyStack implements Stack, Printable {
 ...
}
```

An Interface extending another

- An interface can extend **one or more** interfaces.
- A class implementing the interface must define all the methods in the entire inheritance chain.
- The interface being extended is called a superinterface and the one extending is called a subinterface.

```
interface A {
   void m1();
}
interface B extends A {
   void m2();
}
class c1 implements B {
// implements both m1 and m2
}
```

Default Methods in Interface

- Default methods enable you to add new functionality to the interfaces and ensure binary compatibility with code written for older versions of those interfaces.
- You specify that a method definition in an interface is default with the **default** keyword at the beginning of the method signature.
- All method declarations in an interface, including default methods, are implicitly public, so you can omit the public modifier.
- When you extend an interface that contains a default method, you can do the following:
  - ✔ Not mention the default method at all, which lets your extended interface inherit the default method.
  - ✔ Redeclare the default method, which makes it abstract.
  - ✔ Redefine the default method, which overrides it.

Static Methods in Interface

- You can define static methods in interfaces using **static** keyword.
- You can keep static methods specific to an interface, in the same interface rather than in a separate class.
- Static methods of interface can be called using interface name followed by method name. Ex. Counter.printAuthor()
- To call static method we don't need any implementation of interface or inheritance.

```
01: public interface Counter {
02:   void increment();
03:   void decrement();
04:   int getValue();
05:   default int getIncrement() {
06:         return 1;
07:   }
08:   static void printAuthor() {
09:   System.out.println("Srikanth Pragada");
10:   }
11: }
```

```
01: public class OneCounter implements Counter {
02:   private int value;
03:   @Override
04:   public void increment() {
05:         value += getIncrement();
06:   }
07:   @Override
08:   public void decrement() {
09:         value -= getIncrement();
10:   }
11:   @Override
12:   public int getValue() {
13:         return value;
14:   }
15: }
```

```
01: public class TenCounter implements Counter {
02:   private int value;
03:   @Override
04:   public void increment() {
05:         value += getIncrement();
06:   }
07:   @Override
08:   public void decrement() {
09:         value -= getIncrement();
10:   }
11:   // Override default implementation
12:   @Override
13:   public int getIncrement() {
14:         return 10;
15:   }
16:   @Override
17:   public int getValue() {
18:         return value;
19:   }
20: }
```

```
01: public class TestCounter {
02:     public static void main(String[] args) {
03:        Counter.printAuthor();
04:
05:        Counter c = new OneCounter();
06:        c.increment();
07:        System.out.println(c.getIncrement());
08:        System.out.println(c.getValue());
09:
10:        c = new TenCounter();
11:        c.increment();
12:        System.out.println(c.getValue());
13:     }
14: }
```

Functional Interface

- An interface that contains only one abstract method is called a functional interface.
- Functional interface can have default methods, but must have only one abstract method.
- An interface can be explicitly marked as a functional interface using **@FunctionalInterface** annotation. However, the compiler will treat any interface meeting the definition of a functional interface as a functional interface regardless of whether or not a FunctionalInterface annotation is present on the interface declaration.
- Instances of functional interfaces can be created with lambda expressions, method references, or constructor references.
- Examples are **Runnable**, **Comparable** and **Comparator**.

```
01: @FunctionalInterface
02: public interface Printable {
03:   void print(String mgs);
04:   default String newline() {
05:         return "\n";
06:   }
07: }
```

Abstract Class vs. Interface

- Both interface and abstract class cannot have objects, but can have object references.
- In the case of interface, object reference can reference an object of implementing class. An object reference of abstract class can reference an object of subclass.
- However, abstract classes can have instance variables, but interfaces cannot have instance variables.

Null Interface

- Java allows interfaces to be empty. An empty interface contains no variables and methods. It is used to tag or mark a class as having certain properties or behavior.
- For example,a **Serializable** interface is a null interface.
- Null interface is also known as **marker interface**.

Private Methods in Interface

- Interfaces can have private methods that can be called from other methods of the interface.
- Private methods in interface cannot be called from implementing class.
- Provides more reusability in interfaces as these private methods can be called from other default methods.
- Must be declared with a **private** keyword and must contain a body.

```
01: public interface Logger {
02:  private void log(String message, String target) {
03:      // log message to target
04:  }
05:
06:  default void logToFile(String message) {
07:      log(message, "file");
08:  }
09:
10:  default void logToDatabase(String message) {
11:      log(message, "database");
12:  }
13: }
```

Nested Classes

Nested class is a class defined in another class. Nested class may be any one of the following types:

- **Static member class**
- **Non-static member class**
- **Method-local inner class**
- **Anonymous inner class**

Static member Class

A class created in another class with a static modifier is called a static member class. It can be used just like a normal class.

However, to access it from outside of the enclosing class, we have to use the name of the enclosing class as the prefix for static member class.

```
01: // Top level class
02: class TLC {
03:   // static member class
04:    static public class SMC {
05:         public void print(){
06:            System.out.println("SMC");
07:           }
08:   }
09:   public void print() {
10:   System.out.println("TLC");
11:   }
12: }
13: public class TLCClient {
14:   public static void main(String ... args) {
 15:        TLC.SMC srec = new TLC.SMC();
16:   srec.print();
17:   }
18: }
```

Non-static member class (inner class)

A class defined within another class without a static modifier is called a non-static member class. It is also called the inner class.

Inner class has access to all of the variables and methods of its outer class and can refer to them directly. Inner classes were introduced in version 1.1 of Java, mainly to help handle events in AWT and Swing applications.

```
01: class OuterClass {
02: private int m1 = 10;
03: class InnerClass {
04:  private int m2 = 20; 05:
public void print() {
06:        System.out.printf("m1 = %d, m2 = %d", m1,m2);
07:  }
08: }
09: public void print() {
10:  InnerClass obj = new InnerClass();
11:  obj.print();
12: }
13: }
14: public class InnerTest {
15:  public static void main(String args[]) {
16:        OuterClass obj = new OuterClass();
17:        obj.print();
18:  }
19: }
```

```
m1 =10, m2 =20
```

Method-local Inner Class

A class declared inside a method is called as local class. Only the method, in which the class is defined, can create an instance of the class.

Just like any other inner class, a local inner class can access members of its outer class directly.

```
01: class TLC {
02:  private int v = 10;
03:
04:  public void somemethod() {
05:   class LocalClass {
06:    public void print() {
07:     System.out.printf("Local class.
08:                          Outer class value %d\n", v);
09:    }
10:   }
11:   // use class here
12:   LocalClass  obj = new LocalClass();
13:   obj.print();
14:  } // end of method
15: } // end of TLC
16:
17: public class LocalTest {
18:   public static void main(String[] args) {
19:         TLC obj = new TLC();
20:   obj.somemethod();
21:   }
22: }
```

```
Local class. Outer class value 10
```

Anonymous Inner Class

Anonymous inner class combines the process of defining an inner class and creating an object of the inner class into one step. It is a class without any name (anonymous).

```
new <superclass or interface> (optional arguments) {
   Members definition
}
```

The optional arguments are passed to the constructor of super class.

Anonymous class can extend either a class or implement an interface. No **extends** or **implements** keyword is required. The name given after keyword **new** is taken as class or interface.

If an anonymous class implements an interface, then no arguments are passed as interfaces do not have constructor.

NOTE: Anonymous classes cannot have any constructors as they don't have a name.

```
01: interface Task {
02:   void process();
03: }
04:
05: public class AnonymousDemo {
06:   public static void main(String[] args) {
07:
08:     Task task = new Task() {
09:         public void process() {
10:           System.out.println("Do the process!");
11:         }
12:     };
13:
14:     task.process();
15:   }
16: }
```

Packages

- Package is a collection of classes and interfaces.
- Package allows you to store your classes and interface without name collision as two packages may have same names for classes and interfaces.
- Packages are stored in a hierarchical manner. A package may be nested in another package. For example, **java**.**util**, **java**.**lang** etc. In **java**.**util**, **util** is a package that is in another package **java**.
- A package is a *folder* in the underlying operating system.

NOTE: All the classes that are not explicitly stored in any package are stored in **default package** or unnamed package, which is the current directory. And these classes are accessed directly without any package prefix.

Creating a Package and placing a Class in it

- Use a package statement to specify the package to which classes and interfaces belong to.
- The **package** statement is applied to all classes and interfaces in the source file.
- A folder, in the file system of Operating System, with the same name as the package is to be created.
- The .class file must be stored in the package (directory).
- Once a class is placed in a package, it must always be accessed using package name as prefix – *packagename*.*classname*.

```
package <fully qualified package name>
```

The following example shows how to create a class in a package called **library**. The package **library** must be created by creating a folder with that name.

```
01: package library; //Book class belongs to library package
02: public class Book {
03:  // class code
04: }
```

NOTE: If a package statement is used then it must be the first statement in the source file.

Class **Book** belongs to the package **library**. Apart from using package statements in .java file (as shown above), **Book.class** must be placed in the folder **library** to make **Book** class belong to the library package.

NOTE: A class with **public** access may be accessed from outside the package, whereas a class with **default** access (no access) is confined to the package in which it is defined.

If you want two public classes to belong to the same package then each class must be placed in a different .java file as shown below.

```
01: // Book.java
02: package library;
03: public class Book {
04:   // body of Book class
05: }
```

```
01: // Member.java
02: package library;
03: public class Member {
04:   // body of Member class
05: }
```

Accessing Classes of a Package

You can access a member of the package by using package name followed by dot (.). A member of the package must be prefixed with package name. The following code shows how to access Book class of library package.

```
01: public class UseLibrary {
02:     public static void main(String[] args) {
03:         library.Book  b = new library.Book();
04:     }
05: }
```

A package can be accessed only from its parent directory (unless CLASSPATH is used). In the above example, the package library can be accessed only from the programs folder.

Import Statement

Use **import** statement to import specified classes or packages into the current source file.

```
import pkg1[.pkg2...].{classname|*}
```

***** means all classes of the package are to be imported, but it does not import subpackages of the package.

NOTE: The **import** statement must be given after the **package** statement in the source file if both exist.

The following examples import all members of package **st**, **Date** class in **java**.**util** package and all classes of **java**.**text** package**.**

```
import st.*;
import java.util.Date;
import java.text.*;
```

NOTE: Importing a package only imports classes in the package, but not nested packages in the package. So, classes in each nested package are to be explicitly imported.

NOTE: Package java.lang is automatically imported. So, its classes like String, System, Integer etc. can be used without importing them.

CLASSPATH variable

- Contains the list of directories where Java will look for classes and packages.
- Java compiler and runtime use CLASSPATH variable to get the list of folders and .**jar** files that are to be searched for the required classes and packages.
- By default, java searches for the specified classes in the current directory and in the standard library.
- But once CLASSPATH is set then Java uses only the directories in CLASSPATH and standard library to search for classes and does NOT search in the current directory.

The following example sets CLASSPATH to current directory (**.**) and **c:\jdk\Imaginnovate** folder.

```
c:>set classpath=.;c:\jdk\Imaginnovate
```

SET command is an operating system command. **CLASSPATH** is a variable used by Java compilers and JVM to locate packages and classes.

JAR (Java Archive) File

A JAR file contains packages, classes and interfaces. By including a .jar file in CLASSPATH we can make its packages, classes and interfaces available to Java.

JAR utility, which is provided with JDK, is used to create and extract JAR files. This tool is invoked from the command prompt.

The following command creates a JAR file to contain all .class files in the library folder. Flag **c** stands for create, **f** stands for file and **v** stands for verbose.

```
C:\jdk\Imaginnovate>jar cfv library.jar library\*.class
```

You can see the content of a JAR file by using flag **t** (table of content) as follows:

```
c:\jdk\Imaginnovate>jar ft library.jar
```

You need not extract the JAR file to use its packages and classes. Just including the .jar file in CLASSPATH will do.

So, to use **library.jar** that is placed in **c:\java** folder, we need to set classpath as follows:

```
c:>set classpath=.;c:\jdk\Imaginnovate;c:\java\library.jar
```

Access Modifiers

Access modifiers specify from where a member can be accessed. The following are the available access modifiers for members of a class and their meaning.

Access Modifier	Meaning
private	Allows member to be accessed only from the class in which it is defined.
protected	Allows member to be accessed from the class and all its subclasses and also from any class in the same package.
default	Allows members to be accessed throughout the package to which the class belongs. If no access modifier is given then Java uses *default* as access modifier.
public	Allows a member to be accessed from anywhere.

NOTE: For top level classes, only **public** and **default** access modifiers are applicable. However, inner classes can have **private** and **protected** modifiers also.

The following example demonstrates how access modifiers influence the access of members from subclasses, other classes in the same package and other packages.

The following table summarizes access methods and their impact.

Where	Private	Default	Protected	Public
Same class	Yes	Yes	Yes	Yes
Subclass in same package	No	Yes	Yes	Yes
Non subclass in same package	No	Yes	Yes	Yes
Subclass in different package	No	No	Yes	Yes
Non-subclass in different package	No	No	No	Yes

A.java

```
01: package p1;
02: public class A {
03:     private int v1;
04:     protected int v2;
05:     public int v3;
06:     int v4;            // default access
07: }
```

B.java

```
01: package p1;
02: public class B extends A {
03: public void print() {
04:   // can access v2, v3, v4
05: }
06: }
07: class C {
08:   public void print() {
09:         A obj = new A();
10:   //can access v2,v3,v4 of obj
11:   }
12: }
```

D.java

```
01: package p2;
02: import p1.A;
03: public class D extends A {
04:   public void print() {
05:         //can access v2,v3
06:   }
07: }
08: class E {
09:   public void print()  {
10:     A obj = new A();
11:     // can access v3 of obj only
12:   }
13: }
```

Static Import

- It allows static members of a class to be imported.
- Once the static members are imported, they may be used without qualification.
- Fully qualified names of the members must be used in import static statements.
- Should be used sparingly, otherwise it causes loss of readability.

```
01: import static java.lang.Math.PI;
02: import static java.lang.Math.abs;
03: import static java.lang.System.out;
04:
05: public class StaticImport {
06:     public static void main(String[] args)  {
07:         out.println (PI);
08:         out.println (abs(-100));
09:     }
10: }
```

Enumeration

- Enumeration is a collection of constants. Java provides support for enumeration through keyword **enum**.
- An **enum** is internally converted to a full-fledged class.
- Values in enumeration can be compared and assigned.
- Enumeration can be used with switch statements and enhanced for loop.

```
01: enum Languages {
02:   C, CPP, JAVA, CSHARP
03: };
04: public class EnumDemo {
05:   public static void main(String[] args) {
06:         Languages lang;
07:
08:         lang = Languages.JAVA;
09:         if (lang == Languages.JAVA)
10:               System.out.println("Next is Java EE");
11:         System.out.println("Value of lang = " + lang);
12:         switch (lang) {
13:         case C:
14:               System.out.println("Java or C++");
15:               break;
16:         case CPP:
17:               System.out.println("Java");
18:               break;
19:         case JAVA:
20:               System.out.println("Java EE");
21:               break;
22:         case CSHARP:
23:               System.out.println("ASP.NET");
24:               break;
25:         }
26:   } // end of main
27: } // end of class
```

```
Next is Java EE
 Value of lang = JAVA
 Java EE
```

Exception Handling

- An Exception is an abnormal condition (runtime error).
- When an exceptional event occurs, Java throws an exception.
- An exception is an object of a class that is created from **java.lang.Exception** class.
- Depending upon the error (exceptional event), an object of the exception class is created and thrown.
- If the exception is not handled then the program is terminated abnormally.
- Exceptions can be thrown by Java Runtime System or by the code.

The following code demonstrates what happens when you run code that throws an exception.

```
01: public class Test {
02:     public static void main(String[] args) {
03:     int n;
04:
05:       n = Integer.parseInt(args[0]);
06:       if (99 % n == 0) {
07:          System.out.printf("%d is a factor of 99", n);
08:       }
09:     }
10: }
```

If the above program is run with a command line parameter that cannot be converted to int (such as *abc*) then exception **NumberFormatException** is thrown.

```
java Test abc
Exception in thread "main" java.lang.NumberFormatException:
For input string: "ABC" at
java.lang.NumberFormatException.forInputString(Unknown
Source) ...
```

When an exception is thrown, the program is terminated at the line that caused the exception.

The following are the keywords related to exception handling in Java.

Keyword	Meaning
try	Specifies the block in which you want to monitor for exceptions.
catch	Catches an exception and takes necessary action.
finally	Contains the code that must be executed before leaving the try block.
throws	Specifies the exceptions that a method might throw.
throw	Throws the given exception.

The following is the general syntax for try, catch and finally blocks.

```
try {
// try block
 }
catch(<exceptiontype> <parameter>) {
// catch block
 }
finally {
// finally block
 }
```

NOTE: After try block either catch or finally or both may be given. But you cannot avoid both.

Handling exception using try and catch

If you want to handle the exception that is likely to be thrown then place the code in the try block and handle the exception in the catch block as shown below.

```
01: public class Test {
02: public static void main(String[] args) {
03:   int n;
04:   try{
05:   n = Integer.parseInt(args[0]);
06:   if (99 % n == 0)
07:         System.out.printf("%d is a factor of 99", n);
08:   }
09:   catch (NumberFormatException ex) {
10:   System.out.println("Invalid number!");
11:   }
12: } // end of main
13: } // end of class
```

Handling multiple exceptions

It is also possible to handle more than one exception. If the code in the try block is likely to throw more than one exception then you have to handle all potential exceptions using multiple catch blocks.

However, note that a try block can throw only one exception at a time. Because once an exception is thrown, the code after the statement causing the exception will not be executed.

The following code shows how to handle two exceptions – *NumberFormatException* and *ArrayIndexOutOfBoundsException*.

```
01: public class Test {
02:   public static void main(String[] args) {
03:         int n;
04:   try{
05:   n = Integer.parseInt(args[0]);
06:   if (99 % n == 0)
07:         System.out.printf("%d is a factor of 99", n);
08:   }
09:   catch (NumberFormatException ex) {
10:   System.out.println("Invalid number!");
11:   }
12:   catch (ArrayIndexOutOfBoundsException ex) {
13:    System.out.println("Number parameter is missing");
14:    }
15:   }
16: }
```

In the code above, try block will throw *ArrayIndexOutOfBoundsException* if no parameter is passed on command line (as args[0] is not available). The other exception that will be thrown if string in args[0] cannot be converted to an integer is *NumberFormatException.*

Multi-Catch

Prior to Java 7, we had to catch only one exception type in each catch block. So whenever we needed to handle more than one specific exception, but take the same action for all exceptions, then we had to have more than one catch block containing the same code.

In the following code, we have to handle two different exceptions, but take the same action for both. So, we need two different catch blocks as of Java 6.0.

```
try {
int v = Integer.parseInt(num); int
    result = 100 / v;
    System.out.println(result);
 }
catch (NumberFormatException ex) {
// take action
 }
catch (ArithmeticException ex) {
// take action
 }
```

Starting from Java 7.0, it is possible for a single catch block to catch multiple exceptions by separating exception with **|** (pipe) symbol in catch block.

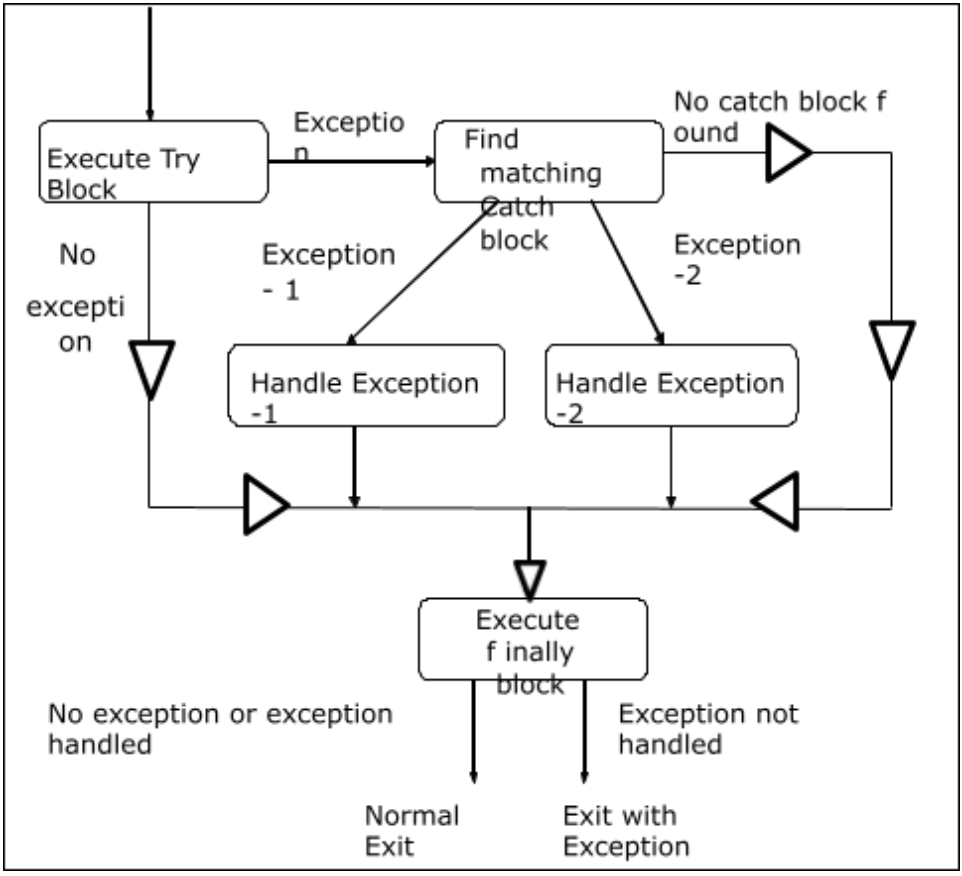
```
try {
int v = Integer.parseInt(num); int
     result = 100 / v;
     System.out.println(result);
 }
// multi-catch
 catch (NumberFormatException | ArithmeticException ex) {
// take action
 }
```

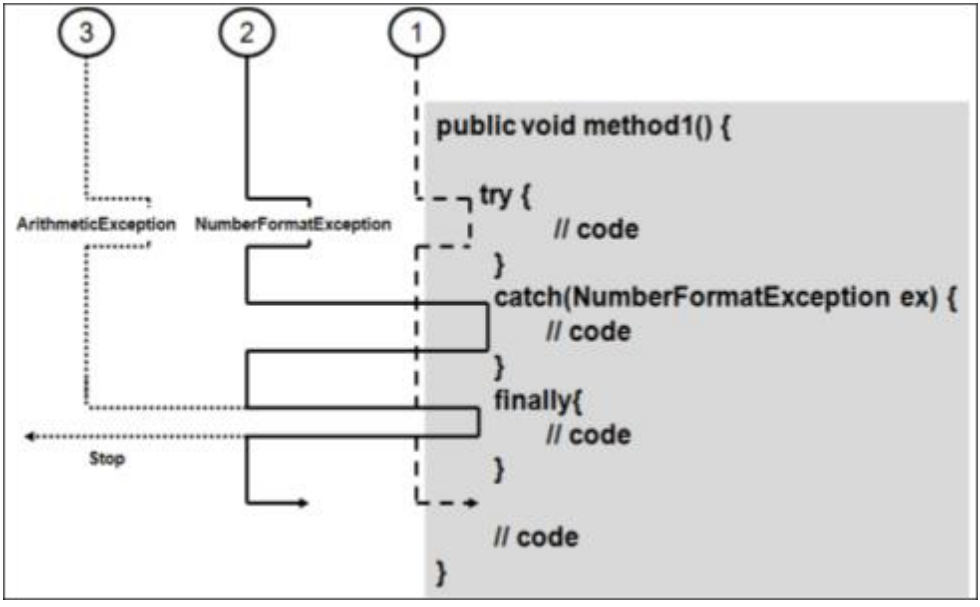
A catch block that handles multiple exception types creates no duplication in the bytecode generated by the compiler; the bytecode has no replication of exception handlers.

The finally block

- Used to execute code that is to be executed after a try/catch block has completed and before the code following try/catch is executed.
- Can be used to perform any operation that must be done before you leave try/catch block – clean up code.
- The **finally** clause is optional. If it is given, it must be given either after catch block(s), if it exists, or after try block.

```
try {
// code
 }
finally {
// code
 }
```


Execute Try Block
Exceptio n
Find matching Catch block
No catch block f ound
No excepti on
Exception - 1
Exception -2
Handle Exception -1
Handle Exception -2
Execute f inally block
No exception or exception handled
Exception not handled
Normal Exit
Exit with Exception



The following snippet demonstrates how to use **finally** block.

```
public void m1() {
  try {
// code
  }
catch(NumberFormatException ex) {
// exception code
  }
finally {
// place cleanup code
  }
 }
```

The following are the cases in which the finally block in the above snippet is executed:

- When try block is successfully executed without any exceptions then control goes to finally block after try block.
- When *NumberFormatException* is thrown in the try block, the exception is handled by the catch block and then control goes to the finally block.
- When try block throws an uncaught exception then also control goes to finally block and then program is terminated. But in this case the program is terminated after the finally block is executed.

Run the code below and see the output (shown below) to understand flow of control with try, catch and finally blocks.

```
01: public class FinallyTest {
02:     public static void main(String[] args) {
03:        method("5");
04:        method("abc");
05:        method("0");
06:     } // end of main()
07:
08:     public static void method(String value){
09:      try {
10:        int n = Integer.parseInt(value);
11:        System.out.println(100 / n);
12:      }
13:      catch(NumberFormatException ex) {
14:        System.out.println("Invalid number!");
15:      }
16:      finally {
17:        System.out.println("Finally block.");
18:      }
19:
20:      System.out.println("**Method Completed**");
21:     } // end of method()
22: }
```

```
20
Finally block.
**Method Completed**
 Invalid number!
Finally block.
**Method Completed**
 Finally block.
Exception in thread "main" java.lang.ArithmeticException: /
 by zero
at FinallyTest.method(FinallyTest.java:13) at
        FinallyTest.main(FinallyTest.java:8)
```

Exception may be thrown by JVM or by methods in classes (API). In the above program ***NumberFormatException*** is thrown by **parseInt**() of ***Integer*** class, which is Java API.

Exceptions ArithmeticException and ArrayIndexOutOfBoundsException are thrown by JVM.

Types of Exceptions – checked and unchecked

There are two types of exceptions - Unchecked or Implicit exceptions and Checked or Explicit exceptions.

Unchecked Exceptions

Handling unchecked exceptions is not mandatory. Some of these exceptions are thrown by JVM and others by Java API. However, you may want to handle unchecked exceptions to prevent program from getting terminated and handle exceptional events.

All exceptions that extend **RuntimeException** class are unchecked exceptions.

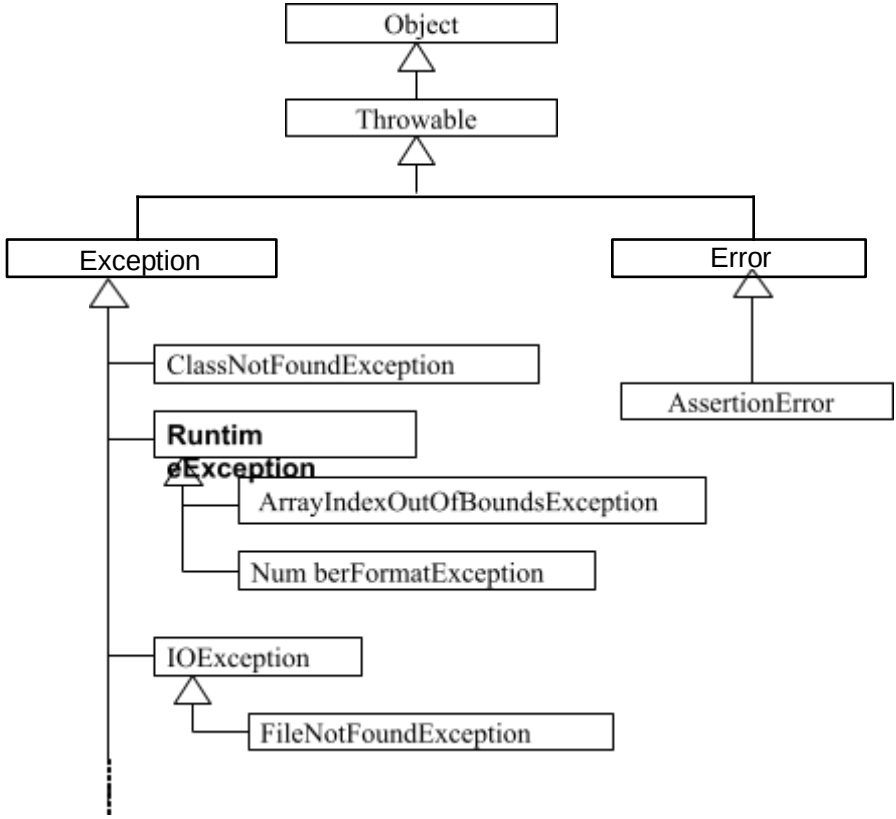
Checked Exceptions

Checked exceptions are thrown by methods. These exceptions must be handled by the code calling the method using try and catch blocks.

In method declaration, we have to specify the checked exceptions that the method is likely to throw using **throws** clause.

Methods that might throw a checked exception must be called from try block where catch block handles the checked exception. Or the calling method must declare a checked exception that might be thrown by the called method in its **throws** clause.

NOTE: Checked exceptions are always thrown from methods and never by JVM.


Object
Throwable
Exception
Error
ClassNotFoundException
AssertionError
Runtim
eException
ArrayIndexOutOfBoundsException
Num berFormatException
IOException
FileNotFoundException

The following code snippet shows how to handle or propagate checked exceptions.

```
01: public class TestChecked {
02:     public void m1() throws AmountException {
03:       // code
04:     }
05:     public void m2() throws AmountException {
06:       m1();
07:     }
08:     public void m3() {
09:       try {
10:         m1();
11:       }
12:       catch(AmountException ex){
13:       }
14:    }
15: }
```

The following are the points related to above program:

- Method m1() is likely to throw a checked exception, **AmountException,** and it must be handled by methods calling m1().
- Method m2() compiles even though it calls m1() without handling AmountException as it declares **AmountException** in its throws clause.
- Method m3() handles **AmountException** that is likely to be thrown by m1() using try and catch blocks.

Invalid vs. Valid order of catch blocks

Understanding the hierarchy of exception classes is important. Most specific exceptions must be handled first and then less specific.

The following snippet shows invalid order for exception handling and will result in compilation error.

```
try{
   …
}
catch(Exception ex) { }
 catch(RuntimeException ex) { }
 catch(NumberFormatException ex) { }
```

Any exception is a match to *Exception* class. So giving catch block with Exception class first will not allow other catch blocks to ever get control and makes those catch blocks unreachable.

Valid order of catch blocks

The following is valid order of catch blocks. Most specific exception – *NumberFormatException* is handled first and most general, *Exception,* is handled last.

```
try{
     …
 }
catch(NumberFormatException ex){ }
 catch(RuntimeException ex){ }
 catch(Exception ex) { }
```

Creating user-defined exception

It is possible to create a new exception by creating a class. User-defined exceptions can be thrown and caught just like ready-made exceptions. However, unlike JVM exceptions, which are thrown by Java Runtime, user-defined exceptions are to be explicitly thrown by methods.

To create a user-defined exception, create a class that extends **Exception** class directly or indirectly.

The exception class need not create any method of its own since it inherits methods of **Exception** class. The following code shows how to create a user-defined exception and how to throw and catch.

```
01: class StackFullException extends Exception {
02:    public StackFullException()  {
03:      super("Stack is full");  // exception message
04:    }
05: }
06: class Stack {
07:    public void push(int v)  throws StackFullException {
08:      if(condition)
09:            throw new StackFullException();
10:    }
11: }
```

User-defined exception *StackFullException* will be thrown by the push method in case of an error. Any code calling the **push** method must make sure it catches *StackFullException* as it is given in the **throws** clause of push method. The following snippet shows how to handle the push method.

```
try {
s.push(10);
     ...
 }
 catch(StackFullException ex) {
     System.out.println (ex.getMessage());
 }
```

Exception class

The following are the methods available in *Exception* class. In fact, all these methods are actually derived from *Throwable* class and *Exception* class has no methods of its own.

Method	Meaning
getMessage()	Returns description of the exception. The message is passed to Exception class by its subclass using constructor of Exception class.
printStackTrace()	Displays the stack trace providing all methods that are invoked from the beginning to the point of error.

User-defined exceptions example

Here is a complete example to demonstrate creating, throwing and handling user-defined exceptions using Account class.

```
01: public class InvalidAmountException extends Exception {
02:  public InvalidAmountException() {
03:        super("Invalid Transaction Amount!");
04:  }
05:  public InvalidAmountException(String msg) {
06:        super(msg);
07:  }
08: }
```

```
01: public class InsufficientAmountException
02:   extends Exception {
03:   public InsufficientAmountException() {
04:         super("Insufficient Balance!");
05:   }
06:   public InsufficientAmountException(String msg) {
07:         super(msg);
08:   }
09: }
```

```
01: public class Account {
02: String acno;
03: double balance;
04: public Account(String acno, double balance) {
05:   this.acno = acno;
06:   this.balance = balance;
07: }
08: public void deposit(double amount)
09:         throws InvalidAmountException {
10:   if (amount < 100) {
11:         throw new InvalidAmountException();
12:   }
13:   balance += amount;
14: }
15: public void withdraw(double amount) throws
16:   InvalidAmountException,InsufficientAmountException{
17:   if (amount < 100) {
18:         throw new InvalidAmountException();
19:   }
20:   if (balance < amount) {
21:         throw new InsufficientAmountException();
22:   }
23:   balance -= amount;
24: }
25: }
```

```
01: public class UseAccount {
02:   public static void main(String[] args) {
03:       Account a = new Account("1002", 10000);
04:        try {
05:   a.deposit(1000);
06:   System.out.println("Deposited 1000");
07:   a.deposit(50);
08:   }
09:   catch(InvalidAmountException ex) {
10:   System.out.println(ex.getMessage());
11:   }
12:   try {
13:   a.withdraw(5000);
14:   System.out.println("Withdrew 5000");
15:   a.withdraw(8000);
16:   System.out.println("Withdrew 8000");
17:   }
18:   catch(Exception ex) {
19:         ex.printStackTrace();
20:   }
21:   }
22: }
```

```
Deposited 1000
Invalid Transaction Amount!
 Withdrew 5000
 InsufficientAmountException: Insufficient Balance!
         at Account.withdraw(Account.java:26)
at UseAccount.main(UseAccount.java:24)
```

Assertions

- Assertions can be used to validate assumptions made about state of the program.
- Each assertion is associated with a Boolean condition. If a condition fails it means the assumption fails and assertion error occurs.
- Assertions are **disabled** by default. So, you must enable assertions at the time of running the program.
- Assertions are part of the development process. They should not be included in the final version of your code.

```
assert <boolean expression>
assert <boolean expression> : message
```

When a boolean expression results in false, Java throws **AssertionError**. If it results in true, execution of the program continues normally.

If a message is given then it is displayed in stack trace when assertion error occurs. The following code shows how to use assertion to validate parameters of a private method.

```
01: public class AssertionTest {
02:
03:     private void print(int count) {
04:         assert count > 0: "Invalid count for print()";
05:     }
06:
07:     public static void main(String[] args) {
08:         AssertionTest t = new AssertionTest();
09:         t.print(1);
10:         t.print(0);
11:     }
12: }
```

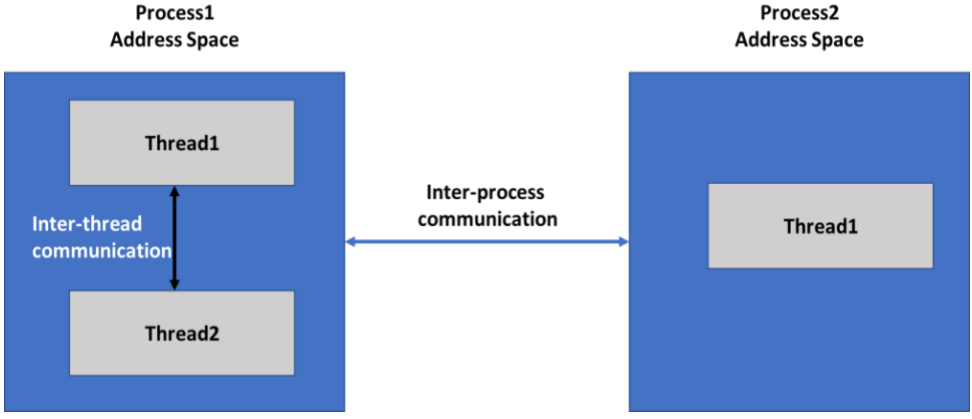
If you run the previous program by enabling assertions using **–ea** flag of JVM as shown below then the following will result:

```
>java -ea AssertionTest
Exception in thread "main" java.lang.AssertionError: Invalid
 count for print()
  ...
```

NOTE: Assertions must be used in such a way that, even though assertions are disabled, the functionality of the program does not change. And also remember assertions are only debugging aids.

Multithreading

- An independent sequential path of execution within a program is called a thread.
- When a program contains two or more parts that run concurrently, it is called multithreading.
- Java's libraries are designed with multithreading in mind.
- Each thread is also called a lightweight process and the overheads are low compared with a process.
- A thread may exist in any of the states such as running, ready, blocked etc., during its lifetime.
- All the threads of a process run within the same address space.
- Context switching between threads is less expensive and faster than context switching between processes.
- **Thread** object in Java represents a thread.



Process

- A process has a self-contained execution environment.
- A process generally has a complete, private set of basic run-time resources; in particular, each process has its own memory space.
- Processes are often seen as synonymous with programs or applications.
- Most implementations of the Java virtual machine run as a single process.

Main Thread

- Main thread is the first thread to start in a Java program.
- This is the thread from where other threads are created and started.
- It is typically the last thread to terminate. When the main thread terminates then the program terminates unless other threads spawned by the main thread still run.
- This thread is created by JVM to run the main() method.

```
01: public class MainThread {
02:     public static void main(String[] args) {
03:         Thread t = Thread.currentThread();
04:
05:         System.out.println(t.getName());
06:         System.out.println(t.getPriority());
07:     }
08: }
```

The following are two different ways in which a new thread can be created.

- By extending **Thread** class.
- By implementing interface **Runnable**.

Creating a new thread by extending Thread class

You can create a new thread by creating an object of a class that extends **Thread** class. The following are the steps to be followed:

- ✔ Create a class that extends **Thread** class.
- ✔ Override **run** () method of **Thread** class.
- ✔ Create an object of subclass of **Thread** class and invoke **start()** method to start running the thread, which in turn calls **run**() method.

```
01: //Multi-threading using subclass of Thread class
02: class ChildThread extends Thread {
03:     @Override
04:     public void run() {
05:       for (int i = 1; i <= 50; i ++) {
06:        System.out.println("Child -> " + i);
07:       }
08:    } // end of run
09: } // end of ChildThread
10:
11: public class MainThread {
12:    public static void main(String args[]){
13:     System.out.println("In Main");
14:     ChildThread ct1 = new ChildThread();
15:     ct1.start(); // run thread
16:
17:     System.out.println("In Main again");
18:     for (int i = 1; i <= 50; i ++) {
19:      System.out.println("Main -->" + i);
20:     } // end of for
21:
22:    System.out.println("End of main");
23:    } // end of main()
24: }
```

Creating a new thread using Runnable interface

A new thread can be created by using an object of **Thread** class and a class that implements **Runnable** interface. Follow the steps below to create a thread:

- ❑ Create a class that implements **Runnable** interface.
- ❑ Implement **run**() method of **Runnable** interface.
- ❑ Create an object of **Thread** class and send an object of the class which implements Runnable interface as parameter to the constructor of **Thread** class.
- ❑ Call **start**() method of **Thread** class. It then calls the run() method of the object that is passed as parameter to the constructor of the **Thread** class.

NOTE: Runnable interface has a single **run**() method. **Thread** class also implements **Runnable** interface.

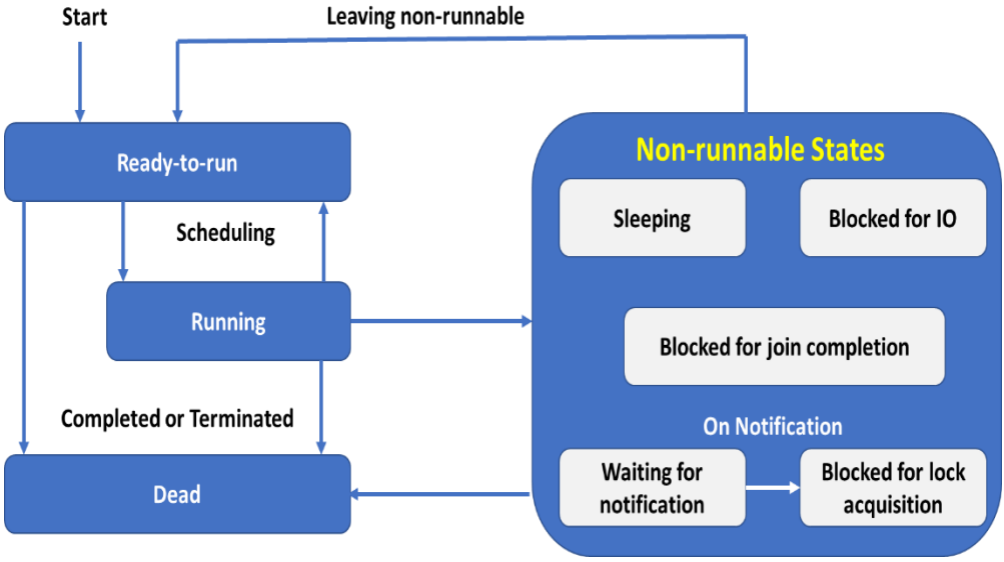
```
01: class ThreadCode implements Runnable {
02:      public void run()  {
03:        for (int i = 1; i <= 50; i ++) {
04:            System.out.println(i);
05:        }
06:      } // end of run
07: } // end of ThreadCode
08:
09: public class RunnableThread {
10:  public static void main(String args[]) {
11:    ThreadCode  code = new ThreadCode();
12:    Thread  t = new Thread(code);
13:    t.start();  // Calls run() method of code object
14:
15:    for (int i = 1; i <= 50; i ++)
16:       System.out.println("Main --> " + i);
17:   }
18: }
```

Thread States – life cycle of a thread

A thread can exist in different states at different points of time. A thread passes from one state to another state since it is started using the **start**() method.

The following table and figure discuss different states and the transitions in the life cycle of a thread.

State	Meaning
New	A new thread object is created and not yet started.
Ready to run	Thread is started using **start**() method. In this state, the thread is ready to run, but control is not given. If control is given then it starts running. Apart from being in this state in the beginning, a thread enters into this state from other states as well.
Running	Thread is currently running.
Sleep	Method **sleep**() is invoked and thread is sleeping for the given number of milliseconds.
Blocked for IO	Thread has initiated some IO operation and is waiting for completion of the operation.
Blocked for join	Thread awaits completion of another thread.
Waiting for notification	Thread awaits notification from another thread. Thread has executed the wait() method of an object. It will wait until another thread invokes **notify**() or **notifyAll**() method of that object on which it invoked **wait**(). This is related to inter-thread communication.
Blocked for lock acquisition	Thread waits to acquire the lock of an object. Once a thread is notified by another thread, it will wait until it can acquire a lock on an object. This is related to inter-thread communication.
Dead	Thread is terminated.



Thread priority

- Each thread is associated with a priority.
- Priority is used by the thread scheduler to decide which of the available threads should be given control.
- Priority is relative and not absolute. That means the priority of the other thread will decide whether the current thread gets control.
- Use **setPriority**(int) and **getPriority**() methods to set and get priority of a thread.
- Thread class has three static members (MIN_PRIORITY, NORM_PRIORITY, MAX_PRIORITY), which can be used to set priority of the thread.
- Default priority of a thread is normal priority, which is represented as number 5.
- A thread inherits the priority of its parent thread.

```
ChildThread t = new ChildThread();

t.setPriority(Thread.MAX_PRIORITY);
 if (t.getPriority() == Thread.MAX_PRIORITY)
            System.out.println("Thread with max priority");
```

Thread class

Thread class is used to create a new thread. Every thread in Java is an object of the Thread class. Thread class provides static and non-static methods that perform operations on threads.

static int MAX_PRIORITY	The maximum priority that a thread can have.
static int MIN_PRIORITY	The minimum priority that a thread can have.
static int NORM_PRIORITY	The default priority that is assigned to a thread.

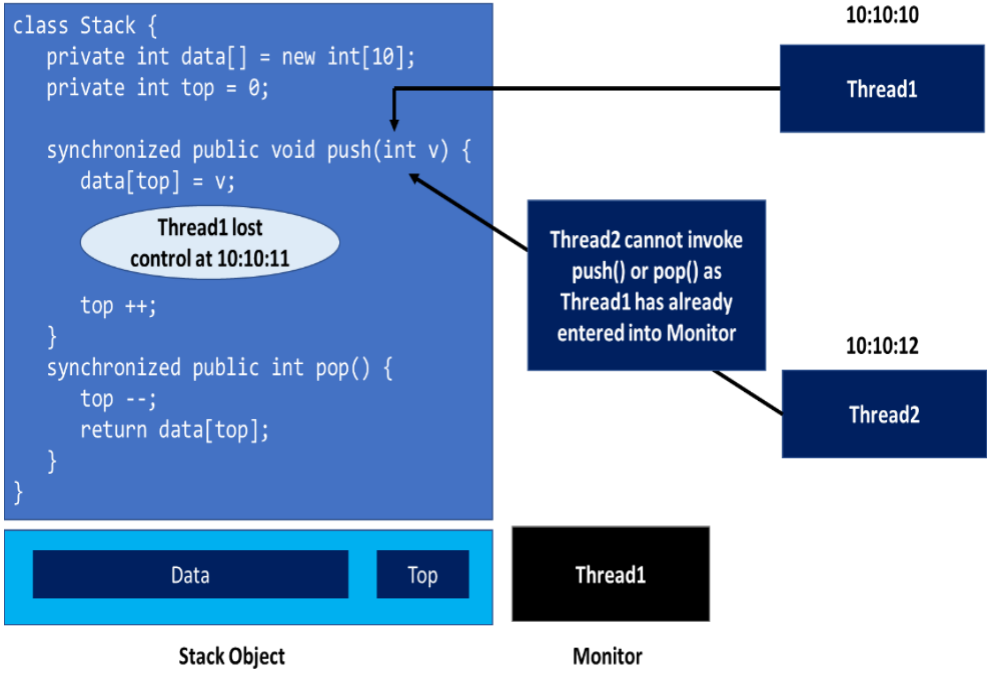
```
Thread()
Thread(Runnable target)
Thread(Runnable target, String name)
Thread(String name)
```

Method	Meaning
static Thread currentThread()	Returns a reference to the currently executing thread object.
void destroy()	Destroys this thread, without any cleanup.
String getName()	Returns this thread's name.
int getPriority()	Returns this thread's priority.
void interrupt()	Interrupts this thread.
boolean isAlive()	Tests if this thread is alive.
boolean isDaemon()	Tests if this thread is a daemon thread.
void join()	Waiting for this thread to die.
void join(long millis)	Waits at most millis milliseconds for this thread to die.
void run()	Specifies the code to be executed. It is overridden by subclass of Thread class.
void setDaemon (boolean on)	Marks this thread as either a daemon thread or a user thread. Must be done before thread is started.
void setName(String name)	Changes the name of this thread to be equal to the argument name.
void setPriority(int priority)	Changes the priority of this thread.
static void sleep(long millis)	Causes the currently executing thread to sleep (temporarily cease execution) for the specified number of milliseconds.
void start()	Causes this thread to begin execution. The Java Virtual Machine calls the run method of this thread.
static void yield()	Causes the currently executing thread object to temporarily pause and allow other threads to execute.

```
01: class DaemonThread extends Thread {
02:
03:      public void run() {
04:          // code
05:      }
06: }
07:
08: class ThreadMethods {
09:   public static void main(String args[]) {
10:     System.out.println("waiting...");
11:     try {
12:       Thread.sleep(1000); // will wait for 1000 MS
13:       // do something
14:     }
15:     catch (InterruptedException ex){
16:     }
17:     // make a thread a daemon
18:     DaemonThread dt = new DaemonThread();
19:     dt.setDaemon(true);
20:     dt.start(); //starts daemon
21:
22:    ChildThread ct = new ChildThread();
23:     ct.start();
24:     try {
25:       ct.join(); // current thread waits till ct is dead
26:       System.out.println("Child completed");
27:     }
28:     catch(InterruptedException ex){
29:     }
30:   }
31: }
```

Synchronization

- This is the process by which Java ensures that a shared resource is accessed only by one thread at a time.
- Java provides synchronization as part of language using synchronized methods and synchronized statements.
- A monitor is an object that is used as a mutually exclusive lock, or *mutex*. Only one thread can enter into a monitor at a given time. When a thread acquires a lock, it is said to have entered the monitor.
- When a thread invokes a synchronized method, it locks the object (enters the monitor) preventing other threads from invoking any synchronized method of the object.

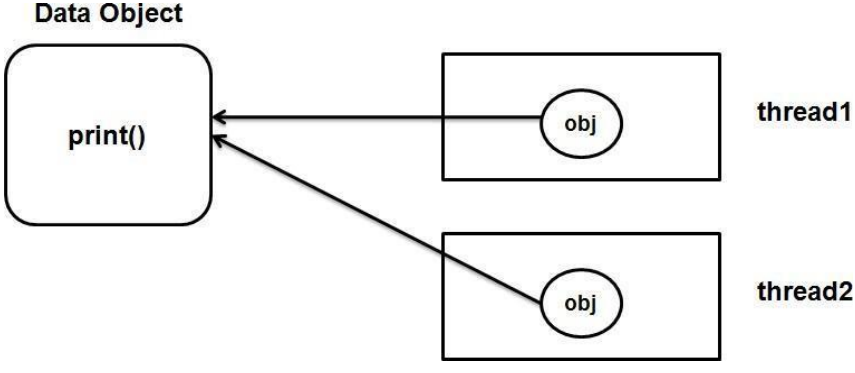


The scenario shown by above figure is as follows:

- Thread1 and Thread2 both access the same object of Stack class.
- At 10:10:10 Thread1 called **push()** method of stack object.
- By calling **push()** method, which is synchronized, Thread1 entered into the monitor of the stack object. It means the stack object is now locked.
- After executing the first statement in the **push()** method, at 10:10:11 Thread1 lost control and control was given to Thread2.
- Upon receiving control, Thread2 tries to enter into the **push()** method at 10:10:12, but cannot enter into it as the monitor of stack object still has Thread1.

NOTE: To enter into any synchronized method of an object, a thread must first enter into the monitor of the object. Object of the class that has at least one synchronized method is associated with a monitor.

The following example shows the importance of synchronizing a method when two or more threads are accessing the same object.



```
01: class Data {
02:   synchronized public void print() {
03:      for(int i = 1; i <= 5; i ++) {
04:        System.out.println(i);
05:        try {
06:          Thread.sleep(100);
07:        }
08:        catch(Exception ex) {}
09:      }
10:    }
11: } // end of data
12:
13: class CThread extends Thread{
14:    Data obj;
15:    public CThread (Data obj) {
16:      this.obj = obj;
17:    }
18:    public void run() {
19:      obj.print();
20:    }
21: } // end of CThread
22:
23: public class SyncTest {
24: public static void main (String args[]) {
25:     CThread thread1, thread2;
26:     Data obj = new Data();
27:     // make two threads access the same object
28:     thread1 = new CThread(obj);
29:     thread2 = new CThread(obj);
30:     thread1.start();
31:     thread2.start();
32:   } // end of main
33: }
```

Synchronized statement

Synchronized statement allows you to implement synchronization even when you cannot make a method synchronized. This is required when you have to synchronize a method in a class whose source code is available to you (only .class file is available).

```
synchronized (object) {
// invoke methods to be synchronized
  }
```

The **object** used with synchronized statements is the object whose methods are to be synchronized. Synchronized block ensures that a call to a method, which is a member of an object used with a synchronized statement, occurs only after the current thread has successfully entered the object's monitor.

Change **run**() method of **CThread** class as follows to use synchronization. The rest of the program remains the same as shown in the previous case.

```
01: class CThread extends Thread {
02:
03:    public void run(){
04:    synchronized(obj) {
05:    obj.print();
06:    }
07:    }
08: } // end of CThread
```

Java Library
Part - 2

Input-Output Streams

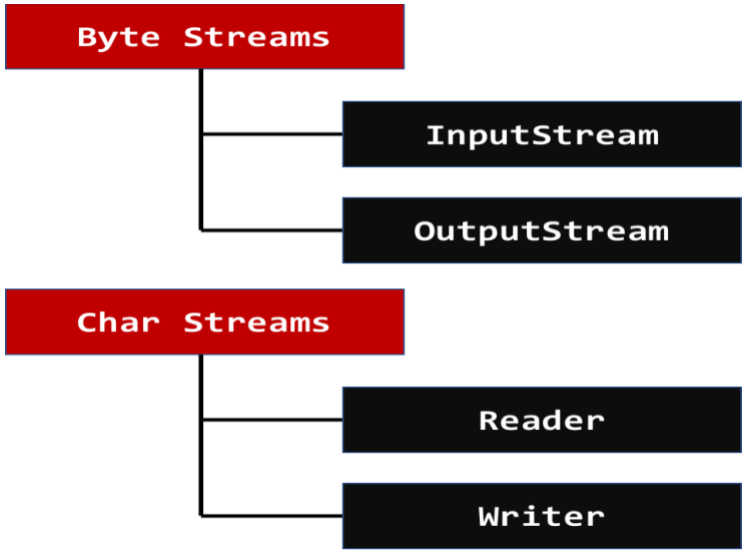
- A stream is an ordered sequence of bytes of undetermined length.
- An input stream moves data from external source and output stream sends data to external target.
- All streams behave in the same manner even if the actual physical devices are different.
- A stream that is linked to a file on the disk or printer or a network connection behaves in the same manner irrespective of the differences between the devices it is connected to.
- All classes and interfaces related to IO Streams are in **java.io** and **java.nio** packages.
- Java classifies streams as byte streams and character streams.

Byte Streams

- Treat the stream as a collection of bytes.
- Used when data that is input or output is to be treated as bytes.
- All byte streams are derived from either **InputStream** or **OutputStream**.

Character Streams

- Treat the stream as a collection of characters.
- They use Unicode and therefore, can be internationalized.
- At the top of the hierarchy there are two abstract classes – **Reader** and **Writer**.



Predefined Streams

- **System** class of **java.lang** package contains three static variables – **in**, **out** and **err**.
- **System.out** refers to the standard output stream, which is console by default.
- **System.in** refers to the standard input stream, which is a keyboard by default.
- **System.err** refers to the standard error stream, which is console by default.
- System.in is of type InputStream.
- System.out and System.err are objects of type PrintStream.

Reader Class

Reader is an **abstract** class in **java.io** package. This class provides the most fundamental methods related to reading data from a text stream.

Method	Meaning
int read()	Read a character. Returns -1 on EOF. It returns Unicode of the character.
int read(char buf[])	Reads characters into the array. Returns the number of bytes read. But *buf* may not be filled completely, if end-of-file is encountered before the array is filled.
long skip(long n)	Skips the specified number of characters.
void close()	Closes the stream.
boolean markSupported()	Returns true if stream supports mark operation. Used to check whether the stream supports marking.
void mark (int readAheadLimit)	Mark the present position in the stream. Parameter *readaheadlimit* specifies the number of characters that may be read while still preserving the mark.
void reset()	If the stream has been marked, it attempts to reposition it at the mark.

FileReader Class

- **FileReader** class is a subclass of **InputStreamReader** class, which is subclass of **Reader** class. Its constructor takes the name of the file to be opened.
- It is used to read characters from a file. File may be given either as a string or as an object of **File** class.

```
FileReader(File file)
FileReader(String fileName)
```

The following program takes filename from the user and displays its content on the screen.

```
01: import java.io.FileReader;
02: import java.util.Scanner;
03:
04: public class ReadFile {
05: public static void main(String args[]){
06:   try {
07:    Scanner s = new Scanner(System.in);
08:    System.out.println("Enter filename :");
09:    String filename = s.nextLine();
10:    FileReader fr = new FileReader(filename);
11:    int ch; //must be an int as read() returns int
12:    while (true) {
13:       ch = fr.read();
14:       if (ch == -1) break;
15:       System.out.print((char)ch);
16:    }
17:    fr.close();
18:   }
19:   catch(Exception ex) {
20:    System.out.println(ex.getMessage());
21:   } //catch  } // main } //class
```

Exercise: Count the number of words in a given file.

BufferedReader Class

- ❑ It improves performance by buffering characters to provide efficient reading of characters.
- ❑ It is derived from the **Reader** class.
- ❑ Buffer size may be specified using parameters to the constructor or default size may be used.

```
BufferedReader(Reader in)
BufferedReader(Reader in, int buffersize)
```

readLine() method

It reads a line of text from the Reader provided as a parameter to the constructor. A line is considered to be terminated by linefeed (ASCII code 10) or carriage return (ASCII code 13) or by both.

It returns **null** on end-of-file (EOF).

```
01: import java.io.*;
02: public class LineRead {
03:  public static void main(String...args) throws
04:  Exception{
05:   FileReader fr = new FileReader("c:\\names.txt");
06:   BufferedReader br = new BufferedReader(fr);
07:
08:   String line;
09:   line = br.readLine();
10:   while(line !=null)  {
11:     System.out.println(line);
12:     line = br.readLine();
13:   }
14:   br.close();
15:   fr.close();
16:  } // end of main
17: } // end of class
```

Exercise: Accept a filename, a string and display all lines in the file that contain the given string.

InputStreamReader Class

- This class is used as a bridge between byte stream and character stream.
- It reads data from **InputStream**, which is passed as parameter to its constructor, and provides them in the form of characters as it is derived from **Reader** class.

```
InputStreamReader(InputStream source)
```

It can be used to convert **System.in**, which is of type **InputStream,** as a **Reader**. Once System.in is converted to Reader, it can be passed to **BufferedReader** to read

one line at a time.

```
// read a line from keyboard
Reader r = new InputStreamReader (System.in);
 BufferedReader br = new BufferedReader(r);
 String line = br.readLine();
```

NOTE: InputStreamReader is a subclass of Reader class. So, an object of InputStreamReader can be passed wherever a Reader is expected.

LineNumberReader Class

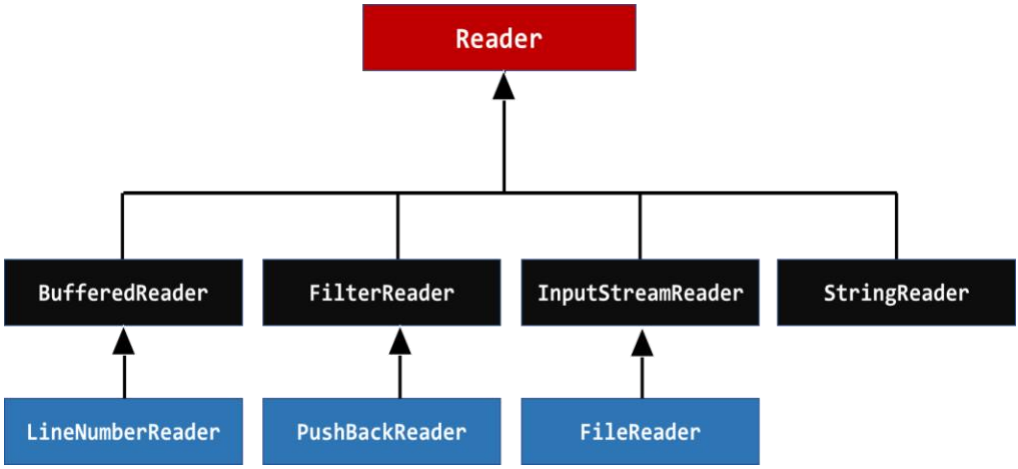
This class extends **BufferedReader** and provides methods to get and set line numbers.

```
LineNumberReader(Reader)

int getLineNumber()
void setLineNumber(int)
```

Exercise: Display only non-blank lines of the given file along with line numbers.

Hierarchy of Reader Classes

The following is the hierarchy of Reader and its subclasses.



PushbackReader Class – Unread char

- This class allows you to push back a character after reading it from the stream.
- This is a **FilterReader**, which provides additional functionality to the base stream from where it takes data.

```
PushbackReader(Reader)
```

```
void unread(int c)
```

Automatic Resource Management (ARM)

- Resources are closed by Java automatically calling **close**() method at the end of try block.
- This feature is also called **try-with-resources**.
- Generally, closing of a resource is done explicitly in the finally block.
- Any resource used with ARM must implement **AutoCloseable** interface and define **close**() method, which is the only method in the interface, so that Java invokes that method.

```
try (resources creation) {
    // process resource
}
catch(..) {
    // handle exceptions
}
```

Try with resource can now use a resource that is already declared outside the Try-With-Resource Statement as final or effectively final.

```
resource = create resource
try (resource)
{
    // process resource
}
catch(..) {
    // handle exceptions
}
```

```
Scanner s = new Scanner(System.in);
 try(s) {
// code
 }
```

Writer Class

This is an abstract class for writing characters to a stream. It allows either writing individual characters or strings. But while writing strings you have to write new line (\n) characters explicitly.

Method	Meaning
void close()	Closes the stream, flushing it first.
void flush()	Writes pending data to stream.
void write(int c)	Writes a single character.
void write(String str)	Writes a string.

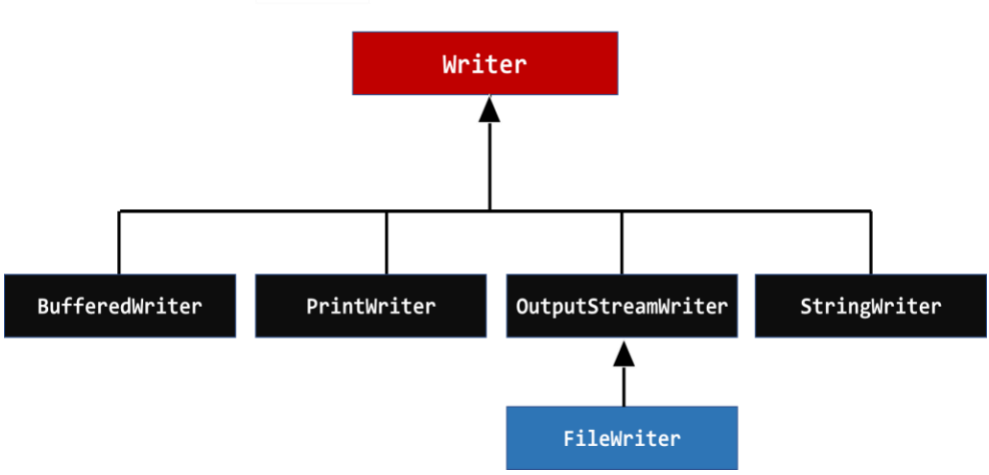
In order to improve the performance of writing, data written to a stream from the program is first held in a **buffer** and then the content of the buffer is written to the stream.

The following are the cases in which the buffer is written to stream:

- ❑ When buffer is filled.
- ❑ When stream is closed.
- ❑ When **flush**() method is called.

Hierarchy of Writer Classes

The following diagram shows hierarchy of Writer and its subclasses.



FileWriter Class

- Used to write characters to a stream that is connected to a file.
- **FileWriter** is derived from **OutputStreamWriter**, which is derived from **Writer**.

```
FileWriter(File file) FileWriter(File
file, boolean append)
FileWriter(String fileName)
FileWriter(String fileName, boolean append)
```

If **append** is true, then output is added to the end of the file.

The following program reads data from source file and writes it into target file after converting each line to uppercase.

```
01:import java.io.*;
02:importjava.util.Scanner;
03:public class ConvertToUpper {
04:   public static void main(String[] args){
05:      Scanner s = new Scanner(System.in);
06:      System.out.println("Enter source filename:");
07:      String srcfile = s.nextLine();
08:      System.out.println("Enter target filename:");
09:      String trgfile = s.nextLine();
10:
11:      try (FileReader fr = new FileReader(srcfile);
12:         FileWriter fw = new FileWriter(trgfile)) {
13:         BufferedReader br = new BufferedReader(fr);
14:         String line;
15:         while(true) {
16:           line = br.readLine();
17:           if(line ==null)
18:                break;
19:           fw.write(line.toUpperCase() + "\n");
20:          }
21:      }
22:      catch (Exception ex) {
23:        ex.printStackTrace();
24:      }
25:   }
26:}
```

PrintWriter Class

- Prints the given data after formatting it to a text-output stream. This class implements all the print methods found in **PrintStream**.
- Methods in this class never throw I/O exceptions. The client may inquire as to whether any errors have occurred by invoking **checkError**() method.

```
PrintWriter(OutputStream out)
PrintWriter(OutputStream out, boolean autoFlush)
PrintWriter(Writer out)
PrintWriter(Writer out, boolean autoFlush)
```

AutoFlush parameter specifies whether output is to be automatically flushed when a newline (\n) character is written.

Method	Meaning
void print(value)	Prints the given value to the stream.
void println(value)	Prints the given value along with new line.

RandomAccessFile Class

- Represents random access file, where you can read and write data from anywhere in the stream.
- RandomAccessFile writes data in binary format. When you write an integer, it writes the memory image of integer as-it-is into file. So, it writes 4 bytes for an integer, irrespective of the actual value.
- Implements **DataInput** and **DataOutput** interfaces, which contain methods to read and write primitive types from and to stream.
- Allows pointer to be placed at a specific position using offset (in bytes) from the beginning of the file.

```
RandomAccessFile (String name, String mode)
RandomAccessFile (File obj, String mode)
```

Mode may be either **"r"** for reading or **"rw"** for read and write.

Method	Meaning
long length()	Returns the length of this file.
type read<type>()	Reads the specified value. <type> is one of the primitive types such as int, long etc.
void seek(long pos)	Sets the pointer to the specified location. The *pos* is number of bytes from the beginning of the file.
void write<type>(value)	Writes the specified value. <type> is one of the primitive types.

The following example shows how to use random access file to write an array of integers into a file and then read the numbers randomly.

```
01: importjava.io.RandomAccessFile;
02: public class RandomAccessDemo {
03: public static void main(String[] args)
04:          throws Exception {
05: int phonenumbers[]={1111111, 2222222, 3333333, 444444};
06: RandomAccessFile raf = new RandomAccessFile
07: ("c:\\java\\numbers.dat","rw");
08: // write numbers into file
09: for(int n : phonenumbers)
10:     raf.writeInt(n);
11: // read numbers from file
12: raf.seek(0); // start at the beginning
13: int count =(int) raf.length() / 4 ;
14:
15: for(int i = 0; i < count; i ++)
16:     System.out.println(raf.readInt());
17:
18: // modify a number in the file
19: raf.seek(2 * 4); // go to third number
20:raf.writeInt(9999999); // write new number
21:
22: // display numbers once again
23: raf.seek(0);
24: for(int i = 0; i < count; i ++)
25:     System.out.println(raf.readInt());
26: }
27: }
```

File Class

- ❑ Represents a file or directory in file system.
- ❑ The file or directory may not be present physically.
- ❑ Provides methods to get information about the absolute pathname.
- ❑ Contains methods to create, delete, and rename files and directories.

```
File(String pathname)
File(String parent, String child)
File(File parent, String child)
```

Constructor is used to create a new **File** instance by converting the given pathname or parent and child names into an abstract pathname.

Method	Meaning
boolean canRead()	Tests whether the application can read the file.
boolean canWrite()	Tests whether the application can modify the file.
boolean createNewFile()	Automatically creates a new, empty file named by this abstract pathname, if and only if a file with this name does not yet exist.
boolean delete()	Deletes the file or directory denoted by this abstract pathname.
boolean exists()	Tests whether the file denoted by this abstract pathname exists.
String getAbsolutePath()	Returns the absolute pathname.
String getName()	Returns the name of the file or directory.
String getParent()	Returns the pathname string of this abstract pathname's parent, or null if this pathname does not name a parent directory.
boolean isAbsolute()	Tests whether this abstract pathname is absolute.
boolean isDirectory()	Tests whether the pathname is a directory.
boolean isFile()	Tests whether the pathname is a normal file.

boolean isHidden()	Tests whether the file is a hidden file.
long lastModified()	Returns the time that the file was last modified.

long length()	Returns the length of the file denoted by pathname.
File[] listFiles()	Returns an array of pathnames denoting the files in the directory.
boolean mkdir()	Creates the directory named by the pathname.
boolean renameTo(File dest)	Renames the file denoted by this abstract pathname.
long getTotalSpace()	Returns total size in bytes for the given drive or partition.
long getUsableSpace()	Returns the number of bytes available in the given partition or drive.

Exercise: Accept path from user and display list of files from the given path.

Files Class

- It consists exclusively of static methods that operate on files, directories, or other types of files.
- It is part of **java.nio.file** package.

Method	Description
Path copy(Path source, Path target, CopyOption... options)	Copies a file to a target file.
void delete(Path path)	Deletes a file.
boolean deleteIfExists(Path path)	Deletes a file if it exists.
boolean isDirectory(Path path, LinkOption... options)	Tests whether a file is a directory.
Stream<String> lines(Path path)	Reads all lines from a file as a Stream.
Path move(Path source, Path target, CopyOption... options)	Moves or renames a file to a target file.
Stream<Path> list(Path path)	Returns a Stream, the elements of which are the entries in the directory.
long mismatch(Path path1, Path path2)	Finds and returns the position of the first mismatched byte in the content of two files, or -1L if there is no mismatch.
DirectoryStream<Path> newDirectoryStream(Path dir)	Opens a directory, returning a DirectoryStream to iterate over all entries in the directory.
List<String> readAllLines(Path path, Charset cs)	Reads all lines from a file.
String readString(Path path)	Reads all content of a file and returns it.
long size(Path path)	Returns the size of a file (in bytes).
Path walkFileTree(Path start, FileVisitor<? super Path> visitor)	Walks a file tree.

Path writeString(Path path, String text, Charset cs)	Writes a CharSequence to a file.
Stream<Path> walk(Path start)	Returns a Stream that is lazily populated with Path by walking the file tree from *start*.

Path interface

A Path object represents a path that is hierarchical and composed of a sequence of directory and file name elements separated by a special separator or delimiter.

Method	Description
Path getFileName()	Returns the name of the file or directory denoted by this path as a Path object.
FileSystem getFileSystem()	Returns the file system that created this object.
Path getName(int index)	Returns a name element of this path as a Path object.
int getNameCount()	Returns the number of name elements in the path.
Path getParent()	Returns the parent path, or null if this path does not have a parent.
Iterator<Path>iterator()	Returns an iterator over the name elements of this path.
Path toAbsolutePath()	Returns a Path object representing the absolute path of this path.
File toFile()	Returns a File object representing this path.
URI toUri()	Returns a URI to represent this path.

Static Method	Description
Path of (String first, String … more)	Returns a Path by converting a path string, or a sequence of strings that when joined form a path string.

Path of(URI uri)	Returns a Path by converting a URI.

Paths Class

This class consists exclusively of static methods that return a Path by converting a path string or URI.

Method	Meaning
Path get (String first, String... more)	Converts a path string, or a sequence of strings that when joined form a path string, to a Path.
Path get(URI uri)	Converts the given URI to a Path object.

Removing blank lines from a File

The following program is used to remove blank lines from a file. At the end of the process, the given source file should not have any blank lines. In order to achieve that, we adopt the following algorithm:

- Open source file using BufferedReader.
- Create a temporary target file using FileWriter.
- Read a line from source file. If it is not blank line then write it into target file.
- At the end, close both source and target files.
- Move target file to source file.

```
01: import java.io.*;
02: import java.nio.file.*;
03: import java.util.Scanner;
04:
05: public class RemoveBlankLines {
06: public static void main(String[]args) throws Exception{
07:     Scanner s = new Scanner(System.in);
08:     System.out.println("Enter Source Filename :");
09:     String srcfile = s.nextLine();
10:     Path src = Paths.get(srcfile);
11:     BufferedReader br = Files.newBufferedReader(src);
12:
13:     Path trg = Paths.get("tempfile.txt");
14:     BufferedWriter bw=Files.newBufferedWriter
15:                         (trg, StandardOpenOption.CREATE);
16:     while(true) {
17:       String line =br.readLine();
18:       if(line == null)
19:         break;
20:        if(line.length() > 0)     // non blank line
21:         bw.write(line + "\n");
22:     }
23:     bw.close();
24:     br.close();
25:     Files.move(trg, src,
26:                 StandardCopyOption.REPLACE_EXISTING);
27:     s.close();
28:   }
29: }
```

Serialization

- Serialization is the process of writing the state of an object (values of instance variables) to a byte stream.
- Serialization allows object data to be stored on disk and later retrieved using deserialization process.
- Serialization is also used in distributed applications to send and receive object data across network from one system to another – for example it is used in RMI (Remote Method Invocation).

Serializable Interface

In order to serialize an object of a class, the class must implement **Serializable** interface. Serializable is a null interface – an interface with no methods. By implementing Serializable interface, a class informs to Java that objects of the class can be serialized.

ObjectOutput and ObjectInput Interfaces

ObjectOutput interface extends **DataOutput** interface and supports object serialization by providing **writeObject**() method.

ObjectInput interface extends **DataInput** interface and supports object deserialization using **readObject**() method.

ObjectOutputStream and ObjectInputStream Classes

ObjectOutputStream class implements *ObjectOutput* interface and extends *OutputStream* class.

ObjectInputStream class implements *ObjectInput* interface and extends *InputStream* class.

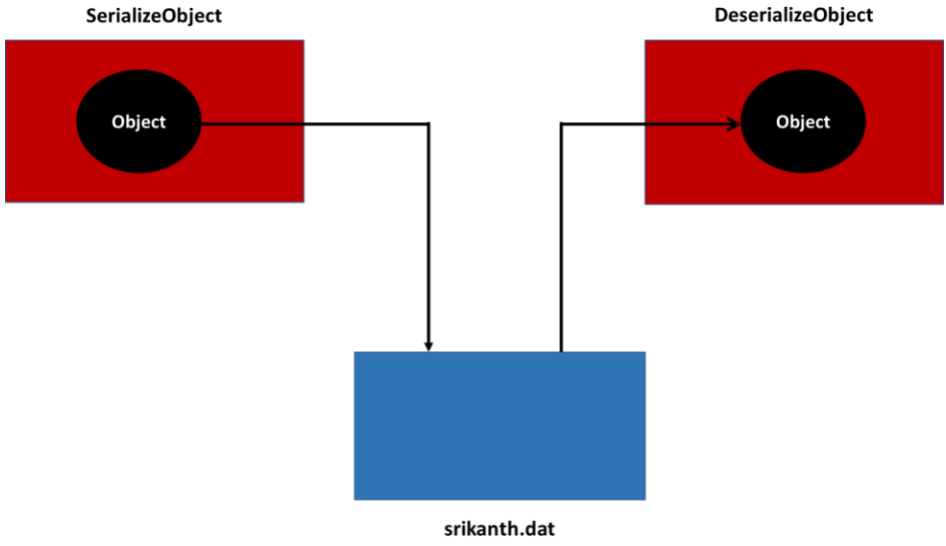
The following are the constructors of these classes:

```
ObjectOutputStream (OutputStream)
ObjectInputStream (InputStream)
```

OutputStream is the stream to which object data is to be written and *InputStream* is the stream from where object data is to be read.

```
01: import java.io.Serializable;
02: class Person implements Serializable {
03:   private String name, email;
04:   public Person(String name, String email) {
05:         this.name = name;
06:   this.email=email;
07:   }
08:   public String toString() {
09:         return name +","+email;
10:   }
11: }
```

```
01: import java.io.*;
02: public class SerializeObject {
03:  public static void main(String ...args) {
04:   Person p=new Person("Sri", "sri@gmail.com");
05:   try(FileOutputStream output =
06:             new FileOutputStream("srikanth.dat")) {
07:       ObjectOutputStream  outstream =
08:             new ObjectOutputStream(output);
09:       outstream.writeObject(p);
10:    }
11:    catch(Exception ex){
12:       System.out.println(ex);
13:    }
14: }
```




```
01: import java.io.FileInputStream;
02: import java.io.ObjectInputStream;
03: public class DeserializeObject {
04:   public static void main(String[] args){
05:       // deserialize the object
06:       try (FileInputStream input =
07:           new FileInputStream("srikanth.dat")) {
08:           ObjectInputStream instream =
09:                   new ObjectInputStream(input);
10:           //read object from stream and cast to Person
11:           Person p = (Person) instream.readObject();
12:           System.out.println(p.toString());
13:       }
14:       catch(Exception ex){
15:           System.out.println(ex);
16:       }
17:   }
```

Char Streams vs. Byte Streams

The following table shows character streams and their corresponding byte streams.

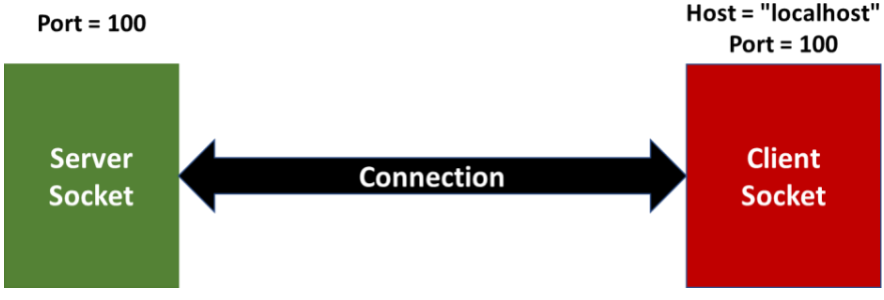
Character Stream	Byte Stream
Reader	InputStream
Writer	OutputStream
FileReader	FileInputStream
FileWriter	FileOutputStream
BufferedReader	BufferedInputStream
BufferedWriter	BufferedOutputStream
PrintWriter	PrintStream
FilterReader	FilterInputStream
LineNumberReader	LineNumberInputStream
PushbackReader	PushbackInputStream

Networking

- Java provides classes which allow you to program internet or TCP/IP network.
- All classes are made available through **java.net** package.
- Data transfer between Java programs, running on different systems, is done using IO streams.
- Server can use multi-threading to handle multiple clients at the same time.

Socket programming

- Sockets enable communication between two programs running in the same JVM or different JVMs.
- Server socket is associated with a number called **port** number.
- In order to access a server socket, client socket has to provide the name of machine on which server socket runs and the port number at which server socket listens.
- Port number is an integer to uniquely identify each server socket on a system. Name of the system and port number uniquely identify a server socket in a network.
- Once you establish a connection with socket, you can take **InputStream** to read data from socket and **OutputStream** to write data to socket.



The following table shows some of the common internet applications and their port numbers.

Port	Application/Protocol
21	File Transfer Protocol (FTP)
23	Telnet Protocol
25	Simple Mail Transfer Protocol (SMTP)
80	Hypertext Transfer Protocol (HTTP)
110	Post office protocol (POP3)

Socket Class

- Socket class represents a client socket. A client socket connects to a server socket, which is created using **ServerSocket** class.
- Connect to a server socket by specifying the name of the computer and port number of server socket.
- Address of server is specified either by using IP address or the name of the computer.

```
Socket(InetAddress address, int port)
Socket(String host, int port)
```

Method	Meaning
void close()	Closes this socket.
InetAddress getInetAddress()	Returns the address of the machine to which the socket is connected.
InputStream getInputStream()	Returns an input stream for this socket.
OutputStream getOutputStream()	Returns an output stream for this socket.
int getPort()	Returns the remote port to which this socket is connected.

ServerSocket Class

- Creates a server socket with the given port number.
- A server socket waits for a request to come from clients and processes the requests.

```
ServerSocket(int port) ServerSocket(int
port, int queuelength)
```

Port specifies the port number at which server socket listens.

Queuelength specifies the maximum number of clients that can wait while socket is busy.

Method	Meaning
Socket accept()	Waits for a request and returns client socket.
void close()	Closes this socket.
InetAddress getInetAddress()	Returns the local address of this server socket.
int getLocalPort()	Returns the port on which this socket is listening.

The following program creates a server socket that waits for a request to come from client and sends system date and time back to client.

```
01: import java.io.PrintWriter;
02: import java.net.*;
03: import java.util.Date;
04: public class TimeServer{
05:   public static void main(String args[])
06:                                 throws Exception {
07:     ServerSocket ss = new ServerSocket(2000); 08:
Sys.out.println("TimeServer is ready..."); 09:
while (true) {
10:        Socket cs = ss.accept(); // wait for client
11:        PrintWriter pw = new PrintWriter
12:               (cs.getOutputStream(), true);
13:        pw.println(new Date().toString()); //toclient
14:       } // end of while
15:     } // end of main
16: } // end of class
```

The following program connects to server socket - TimeServer - and then reads the data sent from server.

```
01: import java.io.InputStream;
02: import java.net.Socket;
03: importjava.util.Scanner;
04: public class TimeClient{
05: public static void main(String[]args) throws Exception{
06:
07:    // connect to server at port number 2000
08:    Socket cs = new Socket("localhost",2000);
09:    // get stream to read data from server
10:    InputStream is = cs.getInputStream();
11:    // Use Scanner to read a line
12:   Scanner scanner = newScanner(is);
13:   String line = scanner.nextLine();
14:   System.out.println(line);
15:   }
16: }
```

InetAddress Class

- This class represents an IP address and domain name.
- **InetAddress** class has factory methods (static methods that return instance of the class) which return an object of InetAddress for the given name with the required details.
- Provides methods to get name and host address (IP address) of a system.

Method	Meaning
static InetAddress[] getAllByName (String host)	Determines all the IP addresses of the given host's name.
static InetAddress getByName (String host)	Determines the IP address of the given host name.
String getHostAddress()	Returns the IP address string "%d.%d.%d.%d".
String getHostName()	Returns the hostname for this address.
static InetAddress getLocalHost()	Returns the local host.

URL Class

- Represents a Uniform Resource Locator.
- URL is used to uniquely identify a resource in Internet or network.

```
URL(String spec)
URL(String protocol, String host, String file)
URL(String protocol, String host, int port, String
```

A URL contains the following components:

Protocol	It represents protocol used to access the resource. Common protocols are HTTP, FTP, File etc. Default protocol is HTTP.
Host	Name of the system. System may be referred either by name or by IP address.
Port number	Port number of server socket to be accessed. If none is given then port number 80 (http) is taken.
File Specification	File to be accessed on the server. The path must be understood by the server processing the URL.

The following are important methods of URL class:

Method	Meaning
boolean equals(Object obj)	Compares two URLs.
String getFile()	Returns the file name of this URL.
String getHost()	Returns the host name of this URL, if applicable.
int getPort()	Returns the port number of this URL.
String getProtocol()	Returns the protocol name of this URL.
URLConnection openConnection()	Returns a URLConnection object that represents a connection to the remote object referred to by the URL.
InputStream openStream()	Opens a connection to this URL and returns an InputStream.

The following is an example of a complete URL. It has the following components.

http://www.srikanthtechnologies.com:80/aboutus.aspx

The following program takes a URL and a filename from user and copies the content of the URL into the given file. It opens an input stream for given URL and reads one byte at a time and writes it into target file.

```
01:import java.net.*;
02:import java.io.*;
03:importjava.util.Scanner;
04:class Download {
05: public static void main(Stringargs[]) throws Exception{
06:    Scanner s = new Scanner(System.in);
07:    System.out.print("Enter URL : ");
08:    String fromurl = s.nextLine();
09:    System.out.print("Enter filename : ");
10:    String filename = s.nextLine();
11:    URL urlobj = new URL(fromurl);
12:    InputStream is = urlobj.openStream();
13:    FileOutputStream fo = new FileOutputStream(filename);
14:    while(true){
15:     int ch =is.read();
16:     if(ch == -1)
17:         break;
18:      fo.write(ch);
19:    }
20:    fo.close();
21:    is.close();
22: }
23:}
```

Collections Framework

Collections framework provides classes to implement useful data structures (such as linked list) and algorithms (such as sorting). The following are advantages of using Collections Framework:

- **Reduces programming effort** by providing useful data structures like linked list and hash table, and algorithms like searching and sorting, so that you don't have to write them yourself. This saves a lot of programmer's time allowing programmer to spend more time on business logic and rules.
- **Increases performance** by providing high-performance implementations of useful data structures and algorithms.
- **Reduces the effort required to learn APIs** by eliminating the need to learn multiple ad hoc collection APIs.

The following are the core interfaces provided by Collections Framework and their implementing classes (concrete classes):

Interface	Meaning	Implementing classes
Collection	Provides basic operations required to a collection of objects.	
Set	Extends Collection and provides unique set of values.	HashSet
SortedSet	Extends Set and ensures elements are in sorted order.	TreeSet
List	Extends Collection and allows elements to be accessed by position.	ArrayList Vector LinkedList
Map	Provides method to maintain a collection of pairs, where each pair contains a key and value.	HashMap HashTable
SortedMap	Extends Map interface and ensures pairs are sorted on key.	TreeMap
Queue	Extends Collection and adds methods to insert, extract and inspect.	LinkedList PriorityQueue

Collection Interface

- This is the most basic interface. Contains methods to add, remove, search and iterate over list.
- Provides methods that collection related classes should provide.

Method	Meaning
boolean add(Object)	Adds an object to collection.
boolean addAll (Collection col)	Adds all elements of the collection.
void clear()	Clears all elements from the collection.
boolean contains (Object obj)	Returns true if the given object is found in the collection.
boolean containsAll (Collection col)	Returns true if all elements of parameter collection are present in the current collection.
boolean isEmpty()	Returns true if collection is empty.
Iterator iterator()	Returns an iterator, which is used to iterate over items of collection.
boolean remove (Object obj)	Removes the given object.
boolean removeAll (Collection col)	Removes all elements from the collection that are present in parameter collection.
boolean retainAll (Collection col)	Retains only the elements in the list that are in the parameter collection.
int size()	Returns number of elements.
Object [] toArray()	Returns an array containing all the elements of the collection.
boolean removeIf (Predicate)	Removes all elements that satisfy given predicate.
Stream<E> stream()	Returns a sequential Stream.
Stream<E> parallelStream()	Returns a parallel Stream.

NOTE: Methods removeAll(), retainAll(), addAll() return true if source list is changed as the result of the operation, otherwise they return false.

NOTE: Though by default, parameters are of type Object for many methods, using generics, we can specify the type of objects the parameters must support.

List Interface

- Extends **Collection** interface.
- An ordered collection (also known as a *sequence*).
- Allows elements to be accessed by their position (index).
- Classes ArrayList, LinkedList and Vector implement List interface.

Method	Meaning
void add(int index, Object value)	Inserts the given object at the specified position.
Object get(int index)	Returns object from the specified position in this list.
int indexOf(Object value)	Returns the index of the first occurrence of the specified object or -1 if object is not found.
ListIterator listIterator()	Returns a list iterator of the elements in this list.
Object set(int index, Object newvalue)	Replaces the object at the specified position with the new object.
void replaceAll(UnaryOperator<E>)	Replaces each element of the list with the result of the operator.
void sort(Comparator)	Sorts the list according to order induced by Comparator.

List<E> subList(int from, int to)	Returns a list between from (inclusive) and to (exclusive) elements.
Object remove(int index)	Removes element at the specified position.

ArrayList Class

- Implements **List** interface.
- Each **ArrayList** instance has a *capacity*. The capacity is the size of the array used to store the elements in the list. It is always at least as large as the list size. As elements are added to an *ArrayList*, its capacity grows automatically.
- One of the constructors allows you to specify initial capacity of the list.

```
ArrayList()
ArrayList(Collection c)
ArrayList(int initialCapacity)
```

NOTE: It is important for classes whose objects are used with collections to override equals() method.

```
01: import java.util.*;
02: public class ArrayListDemo {
03:    public static void main(String args[]) {
04:     ArrayList nl = new ArrayList();
05:     nl.add("Ronaldo");
06:     nl.add("Messi");
07:     nl.add("Modric");
08:     nl.add(1,"Hazard");
09:     // display the list
10:     for (Object obj : nl)
11:         System.out.println(obj);
12:     nl.remove("Ronaldo");
13:     System.out.println(nl.indexOf("Messi"));
14:    }
15:
16: }
```

Generics

- Allow you to specify to compiler the type of object you want to store in a collection.
- Generics make collection classes type-safe by ensuring a collection supports only one type of objects.
- At the time of creating an object of a collection class, we can specify which type of objects the collection supports.
- Eliminates the need to typecast the object taken from collection – makes it convenient and faster.

```
01: // Code without Generics
02: ArrayList al = new ArrayList();
03: al.add("First");
04: al.add(new Integer(100));
05: String st;
06: st = (String) al.get(0); // typecasting is required
07: System.out.println(st.toUpperCase());
08: st = (String) al.get(1); // results in Exception
```

In the above code, when you try to typecast *al.get(1)* to *String*, it results in **ClassCastException**, because *al.get(1)* actually refers to an object of type *Integer* and it cannot be converted to *String*.

The following example demonstrates how generics make collections type-safe and convenient to use.

```
01: // Code using Generics
02: ArrayList<String> al = new ArrayList<String>();
03: al.add("First");
04: // al.add(new Integer(100));    // compile-time error
05: al.add("Second");
06: String st;
07: st = al.get(0); // typecasting is NOT required
08: System.out.println(st.toUpperCase());
09: // can be used with enhanced for loop
10: for (String s : al)
11:   System.out.println(s.toLowerCase());
```

Generics allow you to specify the type of object you want a data structure like **ArrayList** to support. Compiler checks whether objects used with ArrayList **al** are of type **String**. If any other type of object other than **String** is used with **al** then it is taken as a compile-time error.

Set Interface

- **Set** interface represents a collection that contains no duplicate elements.
- It extends **Collection** interface**.**
- This doesn't add any new methods to *Collection* interface. A class implementing Set interface must make sure the elements are unique.
- **HashSet** and **LinkedHashSet** classes implement Set interface.

HashSet Class

- Implements the **Set** interface.
- It does not guarantee the order of elements.

```
HashSet()
HashSet(Collection c)
```

NOTE: Class LinkedHashSet is same as HashSet except that it orders elements according to insertion order.

NOTE: For objects that are used with HastSet, LinkedHashSet and TreeSet, it is important to override hashCode() method.

The following program demonstrates usage of **LinkedHashSet**. It displays unique lines (ignoring duplicates) of a file.

```
01: import java.nio.file.Files;
02: import java.nio.file.Path;
03: import java.util.LinkedHashSet;
04:
05: public class UniqueLines {
06:  public static void main(String[]args) throws Exception{
07:    Path path = Path.of("c:\\classroom\\names.txt");
08:
09:    var lines = Files.readAllLines(path);
10:    var uniqueLines = new LinkedHashSet<String>(lines);
11:     for (var line : uniqueLines)
12:     System.out.println(line);
13:   }
14: }
```

SortedSet Interface

- **SortedSet** extends **Set** and ensures the elements are always in the ascending order.
- It provides the following methods to retrieve elements from first, last and subset from head, tail or middle**.**
- Class **TreeSet** implements **SortedSet** interface.

Method	Meaning
Object first()	Returns first value in the list.
Object last()	Returns last value in the list.
SortedSet headSet (Object toElement)	Returns a list consisting of values that are less than toElement.
SortedSet tailSet (Object fromElement)	Returns a list consisting of values that are greater than or equal to fromElement.
SortedSet subset (Object fromElement, Object toElement)	Returns a list consisting of values that are from fromElement, inclusive, to toElement, exclusive.

The following program is to display common lines (intersection) of two files.

```
01:import java.nio.file.Files;
02:import java.nio.file.Path;
03:import java.nio.file.StandardCopyOption;
04:import java.util.LinkedHashSet;
05:
06:public class IntersectFiles {
07: public static void main(String[]args) throws Exception{
08: Path oldNamesPath=Path.of("c:\\classroom\\names.txt");
09: Path newNamesPath=Path.of("c:\\classroom\\names2.txt");
10: var oldNames = new LinkedHashSet<String>
11:                 (Files.readAllLines(oldNamesPath));
12: var commonNames = new LinkedHashSet<String>();
13: for(String name : Files.readAllLines(newNamesPath)) {
14:       if (oldNames.contains(name))
15:           commonNames.add(name);
16:   }
17:   for(String name :commonNames)
18:       System.out.println(name);
19:   }
20:}
```

TreeSet Class

- This class implements **SortedSet** interface.
- It is based on balanced tree data structure.
- Objects being used must be comparable (by implementing **Comparable** interface, which contains **compareTo**() method).

```
TreeSet()
TreeSet(Comparator)
```

It ensures objects are sorted according to natural order. In case, you specify

Comparator (using second constructor), which is an object of a class that

implements **Comparator** interface, the objects are sorted according to order specified by *Comparator.*

```
01:import java.util.TreeSet;
02:class Person implements Comparable<Person>{
03: private String name;
04: private int age;
05: public Person(String name, int age) {
06:   this.name = name;
07:   this.age =age;
08: }
09: public int compareTo(Person other) {
10:  return this.name.compareTo(other.name);
11: }
12: public String toString() {
13:   return name + " - " + age;
14: }
15:}
16:
17:public class SortPersons {
18: public static void main(String args[]) {
19:   var people = new TreeSet<Person>();
20:
21:   people.add(new Person("Larry", 34));
22:   people.add(new Person("Bill", 44));
23:   people.add(new Person("Bill", 44));
24:   people.add(new Person("Mark",25));
25:   for (var p : people)
26:     System.out.println(p);
27: }
28:}
```

Comparator<T> Interface

Comparator allows you to implement compare method so that program can specify the precise order for sorting.

```
int compare<T>(T o1, T o2)
```

The return value of **compare**() method must be one of the following **.**

Return value	What it means?
Zero (0)	Both the objects are equal.
Greater than 0 (> 0)	First object is greater than second object.
Less than 0 (< 0)	First object is less than second object.

Queue Interface

- This interface extends Collection interface and provides methods to add and retrieve values from queue.
- Classes **LinkedList** and **PriortyQueue** implement **Queue** interface.

Method	Meaning
Object element()	Retrieves, but does not remove, the head of the queue. Throws exception – NoSuchElementException – if queue is empty.
boolean offer (Object)	Inserts an element into queue, if possible.
Object poll()	Retrieves and removes the head of the queue or returns null if queue is empty.
Object remove()	Retrieves and removes the head of this queue. Throws exception if queue is empty.
Object peek()	Retrieves, but does not remove, the head of this queue, returns null if this queue is empty.

LinkedList Class

- Doubly-Linked list implementation of the **List** interface.
- Can be used as a stack, queue or double-ended queue (deque).
- Starting from Java 5.0, it implements **Queue** interface also.
- This implementation is not synchronized.

```
LinkedList()
LinkedList(Collection c)
```

Apart from methods in **List** and **Queue** interfaces, it provides the following extra methods.

Method	Meaning
void addFirst(Object o)	Inserts the given element at the beginning of the list.
void addLast(Object o)	Appends the given element to the end of this list.
Object getFirst()	Returns the first element of this list.
Object getLast()	Returns the last element of this list.
Object removeFirst()	Removes and returns the first element from this list.
Object removeLast()	Removes and returns the last element from this list.

NOTE: Class PriorityQueue implements Queue interface and orders elements by natural order. Elements of PriorityQueue must be comparable – implement Comparable interface, which contains compareTo() method.

Vector Class

- Vector is one of the legacy classes but recreated to implement **List** interface in version 1.2.
- It retained old methods of Vector class such as **addElement**() etc. and also provides methods of **List** interface.
- It is **synchronized**. It should be considered instead of ArrayList, if multiple threads use a single vector.

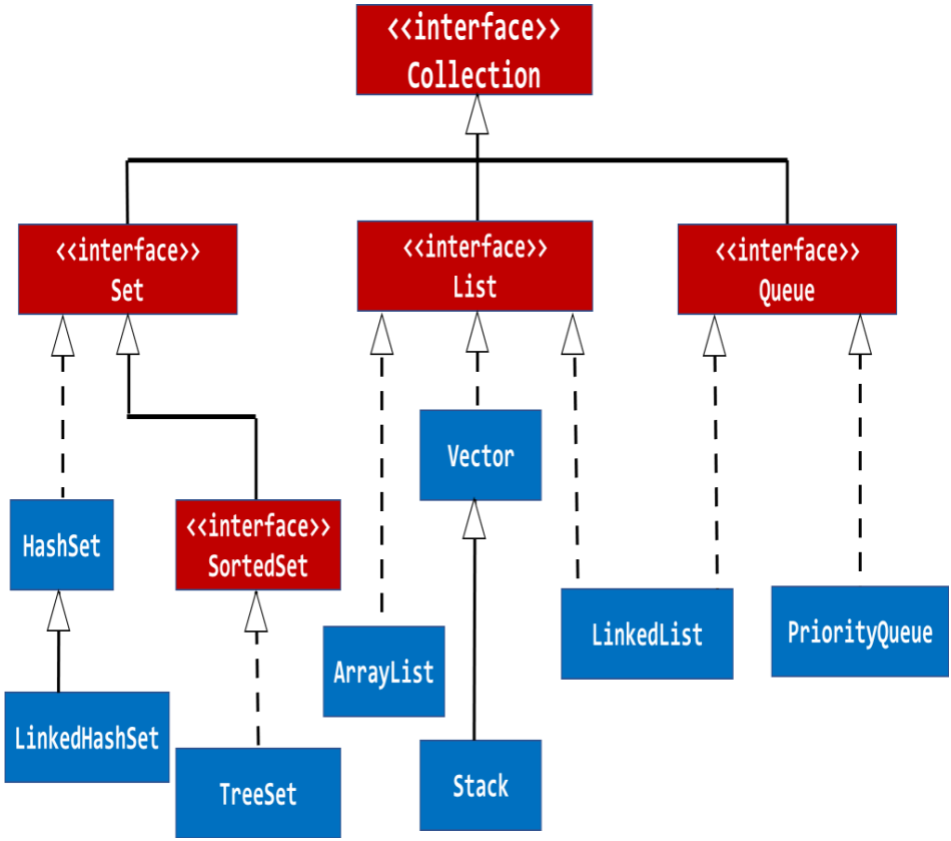
```
Vector()
Vector(Object[])
Vector(Collection)
```

Method	Meaning
void addElement(Object obj)	Adds the component at the end of the vector.
Object elementAt(int index)	Returns element at the given index.
void removeElementAt(int index)	Deletes the component at the specified index.
void insertElementAt (Object obj, int index)	Inserts the specified object as a component in this vector at the specified index.
void setElementAt (Object obj, int index)	Sets the component at the specified index to the specified object.
Enumeration elements()	Returns an enumeration of the elements.

Enumeration Interface

- Allows you to access elements of a **Vector**.
- New implementations should consider using Iterator instead of Enumeration.

Method	Meaning
boolean hasMoreElements()	Returns true if it contains more elements.
Object nextElement()	Returns the next element of this enumeration.


<<interface>>
Collection
<<interface>>
Set
<<interface>>
List
<<interface>>
Queue
HashSet
<<interface>>
SortedSet
Vector
ArrayList
LinkedList
PriorityQueue
LinkedHashSet
TreeSet
Stack

Stack Class

- Represents a last-in-first-out (LIFO) stack of objects.
- Extends **Vector** class and provides the following extra methods related to stack.

Method	Meaning
boolean empty()	Tests if this stack is empty.
Object peek()	Returns the object at the top of this stack without removing it.
Object pop()	Removes the object at the top of this stack and returns that object.
Object push(Object item)	Pushes an item onto the top of this stack.
int search(Object o)	Returns the 1-based position where an object is on this stack.

Exercise: Accept file name from user and display contents of file in reverse order - first line last.

Map Interface

- Allows keys to map values.
- A map does not allow duplicate keys. Each key can map to at most one value.
- **HashMap** and **HashTable** implement **Map** interface.

Method	Meaning
void clear()	Clears the map.
boolean containsKey(Object key)	Returns true if the given key exists.
Object get(Object key)	Returns the value of key.
boolean isEmpty()	Returns true if this map is empty.
Set keySet()	Returns a set view of the keys contained in this map.
Object put (Object key, Object value)	Places the key and the value.
Object remove (Object key)	Removes the mapping for this key from this map if present.
boolean remove (Object key, Object value)	Removes value for the key if it contains the given value.
int size()	Returns the number of keys.
Collection values()	Returns a collection view of the values contained in this map.
void forEach(BiConsumer<K,V>)	Performs the given action for each element.
V getOrDefault (Object key, V defaultValue)	Returns the value for key or *defaultValue* if key not found.
V putIfAbsent(K key, V value)	If key is not associated with a value, then puts value and returns null, else returns current value.
V replace(K key, V value)	Replaces value of given *key* to *value*.
boolean replace (K key, V oldValue, V newValue)	Replaces the value of key to new value if it contains old value.

HashMap Class

- ❑ This class implements **Map** interface.
- ❑ It does not guarantee the order of keys.

```
HashMap()
HashMap(Map)
```

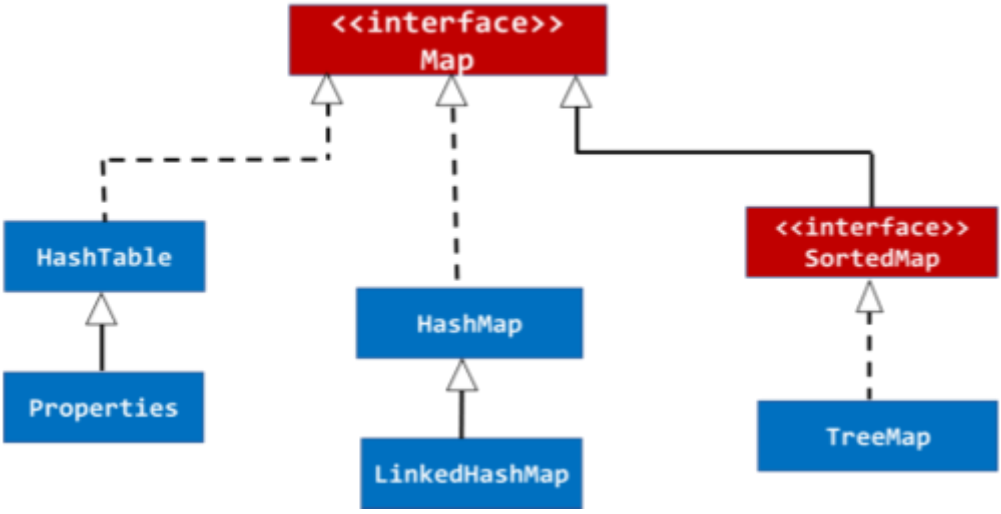
NOTE: HashTable class is same as HashMap class, but it is synchronized. LinkedHashMap class extends HashMap class and arranges keys in the order of insertion.

SortedMap Interface

This interface extends **Map** interface to provide sorted keys.

The following are the methods that are added in **SortedMap** interface compared with **Map** interface.

Method	Meaning
Object first()	Returns the first element.
Object last()	Returns the last element.
SortedSet headMap (Object toKey)	Returns list up to the specified element and not including it.
SortedSet tailMap (Object fromKey)	Returns list from the specified element up to end of the list.
SortedSet subMap(object fromKey, object toKey)	Returns list that contains elements from the given *fromKey* to *toKey* but not including it.



TreeMap Class

- This class implements **SortedMap** interface. It arranges keys in the sorted order.
- Order of keys is either natural order or specified by **Comparator.**

```
TreeMap()
TreeMap(Comparator)
```

The following program uses HashMap, LinkedHashMap and TreeMap to show the way these classes arrange keys.

```
01: import java.util.HashMap;
02: import java.util.LinkedHashMap;
03: import java.util.TreeMap;
04:
05: public class MapDemo {
06:   public static void main(String[] args) {
07:     HashMap<String, String> hm = new HashMap<>();
08:         hm.put("java", "Language");
09:         hm.put("dotnet", "Framework");
10:         hm.put("c#", "Language");
11:     System.out.println("HashMap Output");
12:         for (String key : hm.keySet())
13:            System.out.printf("%s:%s\n",key,hm.get(key));
14:
15:         //Arranges keys in insertion order
16:         LinkedHashMap<String,String> lhm
17:                         = new LinkedHashMap<>();
18:         lhm.put("java", "Language");
19:         lhm.put("dotnet", "Framework");
20:         lhm.put("c#", "Language");
21:         System.out.println("LinkedHashMap Output");
22:         for (String key : lhm.keySet())
23:           System.out.printf("%s:%s\n",key,lhm.get(key));
24:
25:         // Arranges keys in ascending order
26:     TreeMap<String, String> tm = new TreeMap<>();
27:         tm.put("java", "Language");
28:         tm.put("dotnet", "Framework");
29:         tm.put("c#", "Language");
30:     System.out.println("TreeMap Output");
31:         for (String key : tm.keySet())
32:           System.out.printf("%s:%s\n",key,tm.get(key));
33:   }
34: }
```

Properties Class

- Represents a persistent set of properties.
- Properties can be saved to a stream or loaded from a stream.
- Each key and its corresponding value in the property list is a string.
- Properties class extends **HashTable** class.

Method	Meaning
String getProperty (String key)	Searches for the property with the specified key in this property list.
void list (PrintWriter out)	Prints this property list out to the specified output stream.
void load (Reader reader)	Reads a property list (key and element pairs) from the input character stream in a simple line-oriented format.
Object setProperty (String key, String value)	Adds a new property.
void store (Writer writer, String comments)	Writes this property list (key and element pairs) in this Properties table to the output character stream in a format suitable for using the load method.

```
01: import java.util.Properties;
02: import java.io.*;
03: public class PropertyDemo {
04: public static void main(String[]args) throws Exception{
05:    Properties p = new Properties();
06:    p.setProperty("name","Srikanth");
07:    p.setProperty("email","srikanth@gmail.com");
08:   p.setProperty("phone","9059057000");
09:    for(Object k : p.keySet())
10:      System.out.printf("%s : %s\n", k, p.get(k));
11:
12:    p.store(new FileWriter("c:\\java\\sri.properties"),
13:                            "Srikanth Details");
14:    Properties p2= new Properties();
15:    p2.load(new FileReader("c:\\java\\sri.properties"));
16:    for(Object k : p2.keySet())
17:      System.out.printf("%s : %s\n", k, p2.get(k));
18: }
19:}
```

Collections Class

- It contains a collection of static methods that operate on collections provided as parameters of the collection.
- Implements various algorithms related to collections.

Method	Meaning
int binarySearch(List l, Object v)	Implements binary search algorithm to search.
void copy(List dest, List src)	Copies content of one list to another.
void fill(List list, Object obj)	Fills the list with the given value.
Object max (Collection c)	Returns maximum value in collection.
Object min (Collection c)	Returns minimum value in collection.
void reverse(List l)	Reverses the list.
void shuffle(List l)	Shuffles the list with default randomness.
void sort(List l)	Sorts the list.
void sort(List l, Comparator c)	Sorts the list with order specified by Comparator.

```
01: import java.util.*;
02: public class CollectionsDemo {
03: public static void main(String args[]) {
04:   ArrayList<String> names = new ArrayList<>();
05:   names.add("James Goodwill");
06:   names.add("Jason Hunter");
07:   names.add("Roman");
08:   Collections.sort(names);
09:   printList(names);
10:   int pos = Collections.binarySearch(names, "Roman");
11:   System.out.printf("Roman is found at: %d\n", pos);
12:   System.out.printf("Max:%s\n", Collections.max(names));
13:
14:   System.out.println("Reverse Order");
15:   Collections.reverse(names);
16:   printList(names);
17: }
18: public static void printList(List<String> list) {
19:   for (String s: list) {
20:     System.out.println(s);
21:   }
22: }
23: }
```

Immutable Collections

- Collection is immutable i.e., we can't add, delete or modify elements.
- Nulls are not allowed.
- Serializable if all elements are serializable.
- We can create a list of up to 10 elements as there are 10 parameters for of() method.
- List.<E>of (E…elements) can take any number of parameters including an array.

The following are methods to create immutable collections:

```
List.of()
List.of(values)
Set.of()
Set.of(values)
Map.of()
Map.of(key, value, key, value,...)
Map.ofEntries(Map.Entry ... entries)
```

```
// Immutable Empty List List<String>
 emptyList = List.of();

// Immutable List
List<String> immutableList= List.of("one","two","three");
```

```
 // Immutable Empty Map
 Map<String, String> emptyMap = Map.of();

 // Immutable Map using Map.of()
 Map<String,String> phones =
      Map.of("Bill","39393393988","Larry","9988776655");

 // Immutable Map using Map.ofEntries()
 Map<Integer,String> map =
       Map.ofEntries(Map.entry(1,"One"),Map.entry(2,"Two"));
```

Generic Methods

- All generic method declarations have a type parameter section delimited by angle brackets (< and >) that precedes the method's return type (<T> in this example).
- Note that type parameters can represent only reference types—not primitive types (like int, double and char).
- Type parameter can be declared only once in the type parameter section but can appear more than once in the method's parameter list.

Bounded Type Parameter

- To declare a bounded type parameter, list the type parameter's name, followed by **extends** keyword, followed by upper bound.
- Note that, in this context, **extends** is used in a general sense to mean either "extends" (as in classes) or "implements" (as in interfaces).

```
01: import java.util.*;
02: public class GenericMethods {
03:    public static <T> void print(T a[]) {
04:       for(T v : a)
05:         System.out.println(v);
06:    }
07:    public static<T extends Comparable<T>>
08:     boolean contains(T a[], T v) {
09:       for (T value: a)
10:               if(value.compareTo(v) == 0)
11:             return true;
12:       return false;
13:    }
14:    public static void main(String args[]) {
15:       String names[]={"Steve","Joe","Bob","James"};
16:       print(names);
17:       System.out.println(contains(names,"Joe"));
18:    }
19: }
```

Regular Expressions

- Regular expressions are a way to describe a set of strings based on common characteristics shared by each string in the set.
- They can be used to search, edit, or manipulate text and data.
- You must learn a specific syntax to create regular expressions — one that goes beyond the normal syntax of the Java programming language.

Character Classes

The following are the available character classes.

The left-hand column specifies the regular expression constructs, while the right-hand column describes the conditions under which each construct will match.

[abc]	a, b, or c (simple class)
[^abc]	Any character except a, b, or c (negation)
[a-zA-Z]	a through z, or A through Z, inclusive (range)
[a-z&&[^bc]]	a through z, except for b and c: [ad-z] (subtraction)
[a-z&&[^m-p]]	a through z, and not m through p: [a-lq-z] (subtraction)

Predefined character classes

The following are the predefined character classes.

.	Any character (may or may not match line terminators)
\d	A digit: [0-9]
\D	A non-digit: [^0-9]
\s	A whitespace character: [\t\n\x0B\f\r]
\S	A non-whitespace character: [^\s]
\w	A word character: [a-zA-Z_0-9]
\W	A non-word character: [^\w]

Quantifiers

The following are the available quantifiers.

X?	X, once or not at all
X*	X, zero or more times
X+	X, one or more times
X{n}	X, exactly n times
X{n,}	X, at least n times
X{n,m}	X, at least n but not more than m times

Pattern Class

- A Pattern object is a compiled representation of a regular expression.
- The Pattern class provides no public constructors.
- To create a pattern, you must first invoke one of its public static compile methods, which will then return a Pattern object.
- These methods accept a regular expression as the first argument.

Method	Meaning
static Pattern compile(String regex)	Compiles the given regular expression into a pattern.
Matcher matcher (CharSequence input)	Creates a matcher that will match the given input against this pattern.
static boolean matches(String regex, CharSequence input)	Compiles the given regular expression and attempts to match the given input against it.
String pattern()	Returns the regular expression from which this pattern was compiled.
String[] split (CharSequence input)	Splits the given input sequence around matches of this pattern.

```
01: import java.util.Scanner;
02: import java.util.regex.Pattern;
 03: public class MobileNumber {
04:   public static void main(String[] args) {
 05:        Scanner s = new Scanner(System.in);
06:   System.out.print("Enter mobile number : "); 07:
 String mobile = s.nextLine();
08:   // other way is: mobile.matches("^\\d{10}$") 09:
 if (Pattern.matches("^\\d{10}$", mobile)) 10:
 System.out.println("Valid mobile number!"); 11:
 else
12:        System.out.println("Invalid mobile number!");
 13:  }
14: }
```

```
01: import java.util.regex.Pattern;
 02: public class SplitDemo {
03: public static void main(String[] args) {
 04:  Pattern p = Pattern.compile("\\d");
05:    String[] items=p.split("one9two4three7four1five");
 06:  for(String s : items)
07:   System.out.println(s);
08:   }
09: }
```

Matcher Class

- A Matcher object is the engine that interprets the pattern and performs match operations against an input string.
- Like the Pattern class, Matcher defines no public constructors.
- You obtain a Matcher object by invoking the matcher method on a Pattern object.

Method	Meaning
int end()	Returns the index of the last character matched, plus one.
boolean find()	Attempts to find the next subsequence of the input sequence that matches the pattern.
String group()	Returns the input subsequence matched by the previous match.
boolean matches()	Attempts to match the entire input sequence against pattern.
Pattern pattern()	Returns the pattern that is interpreted by this matcher.
String replaceAll (String replacement)	Replaces every subsequence of the input sequence that matches the pattern with the given replacement string.
String replaceFirst (String replacement)	Replaces the first subsequence of the input sequence that matches the pattern with the given replacement string.
int start()	Returns the start index of the previous match.

```
01: import java.util.regex.*;
02: public class MatcherDemo
{
03: public static void main(String[] args) {
04:     Pattern p = Pattern.compile("[a-z]+");
05:     Matcher m = p.matcher("123bbc4343pqr3433");
06:     while(m.find()) {
07:        System.out.println("start(): " + m.start());
08:        System.out.println("end(): "+ m.end());
09:        System.out.println("group(): " + m.group());
10:     }
11:     // pattern replacement
12:     p = Pattern.compile("-+");
13:     m = p.matcher("----12345    ");
14:     String output =
m.replaceAll("*"); 15:
System.out.println(output);
16: }
17: }
```

```
start(): 3
end(): 6
 group(): bbc
 start(): 10
end(): 13
 group(): pqr
*12345*
```

Lambda Expressions

- Lambda expression allows functionality to be passed as argument to a method.
- It is a replacement for Anonymous class that implements single abstract method (SAM) interface – functional interface.

Components of Lambda Expression

- A comma-separated list of formal parameters enclosed in parentheses.
- You can omit parentheses if there is only one parameter.
- The arrow token **->** also known as *lambda operator.*
- A body, which consists of a single expression or a statement block.
- If you specify a single expression, then the Java runtime evaluates the expression and then returns its value. No return statement is required.
- Statement block must be enclosed in statements in braces ({ }), and must have a return statement.

```
(parameters) -> expression
```

```
(int n1, int n2) -> n1 > n2
 (n1, n2) -> n1 > n2
```

Variable Scoping

- Lambdas are lexically scoped. They do not introduce a new level of scoping.
- The **this** variable refers to the outer class, not to the anonymous inner class that the lambda is turned into.
- There is no need for **OuterClass.this** variable unless lambda is inside a normal inner class.
- Lambdas cannot introduce new variables with same name as variables in

method that creates the lambda.

- However, lambdas can refer to (but not modify) local variables from the surrounding code.
- Lambdas can still refer to (and modify) instance variables from the surrounding class.

```
01: interface Test {
02:   boolean eval(int n1, int n2);
03: }
04: public class LambdaDemo1 {
05:     public static void main(String[] args) {
06:      // Old Anonymous inner class demo
07:      Test t = new Test() {
08:          @Override
09:          public boolean eval(int n1, int n2) {
10:              return n1 > n2;
11:          }
12:      };
13:      System.out.println(t.eval(20,10));
14:      // Lambda expression
15:      Test t2 = (int n1, int n2) -> n1 > n2;
16:      System.out.println(t2.eval(20,10));
17:
18:      // type inference, no need to mention data types
19:      Test t3 = (n1,n2) -> n1 > n2;
20:      System.out.println(t3.eval(20,10));
21:     }
22:
23: }
```

Method Reference

- We use lambda expressions to create anonymous methods. However, when a lambda expression does nothing but call an existing method, we can use method reference.
- Method references are compact, easy-to-read lambda expressions for methods that already have a name.

The following example shows how to use method reference to create a new thread.

```
01: public class ThreadWithLambda {
02:   public static void main(String[] args){
03:     // New thread with lambda expression
04:     Thread t1 = new Thread(() -> {
05:        for(int i=1; i <= 10; i++)
06:              System.out.println(i);
07:     });
08:     t1.start();
09:
10:     // Method reference
11:     Thread t2 = new Thread(ThreadWithLambda::print);
12:     t2.start();
13:   }
14:   static public void print() {
15:     for (int i = 1; i <= 10; i++) {
16:       System.out.println(i);
17:     }
18:
19: }
```

Kinds of Method References

The following are four kinds of method references.

Reference to a static method	ContainingClass::staticMethodName
Reference to an instance method of a particular object	ContainingObject::instanceMethodName
Reference to an instance method of an arbitrary object of a particular type	ContainingType::methodName
Reference to a constructor	ClassName::new

```
01: public class MyTime {
02:     private int hours, mins, secs;
03:     public MyTime(int hours, int mins, int secs)
{ 04:       this.hours = hours;
05:         this.mins = mins;
06:         this.secs = secs;
07:     }
08:     @Override
09:     public String toString() {
10:         return "MyTime{" + "hours=" + hours + ",
11:                     mins=" + mins + ", secs=" + secs +
'}'; 12:                 }
13:     public int totalSeconds() {
14:         return hours * 3600 + mins * 60 + secs;
15:     }
16:   public static int compare(MyTime t1, MyTime t2) {
17:     return t1.totalSeconds() - t2.totalSeconds(); 18:
}
19: }
```

```
01: import java.util.*;
02: public class SortWithLambda {
03:   public static void main(String[] args) { 04:
        ArrayList<MyTime> times = new ArrayList();
05:     times.add(new MyTime(10,10,20));
06:     times.add(new MyTime(5,30,20));
07:     times.add(new MyTime(20,5,10));
08:     Collections.sort(times,
09:        (t1,t2)->
t1.totalSeconds()-t2.totalSeconds()); 10:     for(MyTime t
: times)
11:
System.out.println(t.toString()); 12:  //
Method reference
13:     Collections.sort(times, MyTime::compare);
14:     for(MyTime t : times)
15:        System.out.println(t.toString());
16:   }
17: }
```

Built-in Functional Interfaces

- The Java 8 API contains many built-in functional interfaces.
- Some of them are well known from older versions of Java like **Comparable**, **Comparator** or **Runnable**.
- New ones are added in **java**.**util**.**function** package.
- Many of these functional interfaces have default methods other than functional (abstract) method.

Interface	Description
Consumer<T>	Represents an operation that accepts a single input argument and returns no result. Functional method is **accept**(T).
Function<T,R>	Represents a function that accepts one argument and produces a result. Functional method is **apply**(T) and returns R.
Predicate<T>	Represents a predicate (boolean-valued function) of one argument. Functional method is **test**(T) and returns Boolean.
Supplier<T>	Represents a supplier of results. Functional method is **get**() that returns T.
UnaryOperator<T>	Applies a unary operation to an object of type T and returns T. The method is **apply**(T).
BinaryOperator<T>	Applies an operation to two objects of type T and returns the result of type T. Method is **apply**(T, T).

```
01: import java.util.function.*;
02: public class BuiltInFunctionalInterfaces {
 03: public static void main(String[] args) {
 04:  Consumer<String> c=(s) ->
05:   System.out.println(s.toUpperCase());
06:   c.accept("Srikanth");
07:   Predicate<String> p = (s) -> s.length() > 5;
 08:  System.out.println(p.test("Java"));
09:   Function<Integer,String> f=(n)->n.toString();
10:   System.out.println(f.apply(100));
11: }
12: }
```

Streams

- A stream is a sequence of elements supporting sequential and parallel aggregate operations.
- Unlike a collection, stream is not a data structure that stores elements. Instead, a stream carries values from a source through a pipeline of operations.
- Stream operations are either *intermediate* or *terminal*.
- Source of stream could be a collection, an array, a generator function, or an I/O channel.
- An intermediate operation, such as filter, produces a new stream.
- A terminal operation, such as **forEach**, produces a non-stream result, such as a primitive value (like a double value), a collection, or in the case of forEach, no value at all. They are also called as *reduction operations*.
- Starting from Java 8, the java collections have methods that return Stream.
- Streams support Aggregate Operations and common aggregate operations are filter, map, reduce, find, match, and sort. These operations can be executed in series or in parallel.

Method	Description
boolean allMatch (Predicate<? super T> predicate)	Returns whether all elements of this stream match the provided predicate.
boolean anyMatch (Predicate<? super T> predicate)	Returns whether any element of this stream matches the provided predicate.
long count()	Returns the count of elements in this stream.
Stream<T> distinct()	Returns a stream consisting of the distinct elements (according to Object.equals(Object)) of this stream.
static<T>Stream<T> empty()	Returns an empty sequential Stream.
Stream<T>filter (Predicate<? super T> predicate)	Returns a stream consisting of the elements of this stream that match the given predicate.

Optional<T>findAny()	Returns an Optional describing some element of the stream, or an empty Optional if the stream is empty.
Optional<T>findFirst()	Returns an Optional describing the first element of this stream, or an empty Optional if the stream is empty.
void forEach (Consumer<? super T> action)	Performs an action for each element of this stream.
void forEachOrdered (Consumer<? super T> action)	Performs an action for each element of this stream, in the encounter order of the stream if the stream has a defined encounter order.
Stream<T> limit(long maxSize)	Returns a stream consisting of the elements of this stream, truncated to be no longer than maxSize in length.
Stream map (Function <? super T, ? extends R> mapper)	Returns a stream consisting of the results of applying the given function to the elements of this stream.
Optional<T>max (Comparator<? super T> comp)	Returns the maximum element of this stream according to the provided Comparator.
Optional<T>min (Comparator<? super T> comp)	Returns the minimum element of this stream according to the provided Comparator.
boolean noneMatch (Predicate<? super T> predicate)	Returns whether no element of this stream matches the provided predicate.
Stream<T>skip(long n)	Returns a stream consisting of the remaining elements of this stream after discarding the first n elements of the stream.

Stream<T>sorted()	Returns a stream consisting of the elements of this stream, sorted according to natural order.
Stream<T>sorted (Comparator<? super T> comp)	Returns a stream consisting of the elements of this stream, sorted according to the provided Comparator.
Object[] toArray()	Returns an array containing the elements of this stream.
Stream<T> iterate (T seed, Predicate<? super T> hasNext, UnaryOperator<T> next)	Returns a sequential ordered Stream produced by iterative application of the given next function to an initial element, conditioned on satisfying the given hasNext predicate.
Stream<T> takeWhile (Predicate<? super T> predicate)	Returns a stream with all the values from the beginning of the stream as long as condition is true.
Stream<T> dropWhile (Predicate<? super T> predicate)	Returns a stream with values from first value where condition is false.

forEach() Limitations

- ❑ Cannot loop twice as it consumes the elements of the stream.
- ❑ Cannot break out of the loop.
- ❑ Can't change surrounding local variables.

Stream.of() Method

It is possible to build a stream by providing values to **of**() method in Stream interface.

```
// Build a stream
 Stream.of(10,21,22,35,55,30)
.filter(n -> n % 2==0).forEach(System.out::println);
```

Streams from Arrays

An array can be source of stream. Arrays.stream() method can be used to build a stream from an array.

```
String [] names = {"Joe", "Andy", "Steve", "Bob", "Jason"};
 Arrays.stream(names)
.filter(n -> n.length() > 3).forEach(System.out::println);
```

```
01: import java.util.*;
02: import java.util.stream.Stream;
03: public class StreamsDemo {
04: public static void main(String[] args) {
05:   ArrayList<MyTime> times=new
ArrayList<MyTime>(); 06:    times.add(new
MyTime(20,45,55));
07:   times.add(new MyTime(10,34,30));
08:   times.add(new MyTime(14,15,20));
09:   times.add(new MyTime(7,10,50));
10:   times.stream()
11:       .filter(t -> t.getHours() > 10).limit(2)
12:       .forEach(System.out::println);
13:   // Convert object to int
14:   double average=times.stream()
15:       .mapToInt(MyTime::totalSeconds)
16:       .average().getAsDouble();
17:   System.out.println(average);
18:   System.out.println("Any Hours > 12 ? " +
19:       times.stream().anyMatch(t->t.getHours()>12));
20:   System.out.println("All Hours > 12 ? " +
21:       times.stream().allMatch(t->t.getHours()>12));
22:   System.out.println("Count = " +
23:       times.stream().count());
24:   Optional<MyTime> mintime=times.stream()
25:
.min((t1,t2)->t1.totalSeconds()-t2.totalSeconds());  26:
```

```
System.out.println("Minimum = " + mintime.get());
27: }
28: }
```

Streams from IO

The following example shows how to create a stream from lines of a file and sort the stream before printing lines.

```
var lines =
 Files.lines(Paths.get("c:\\classroom\\names.txt"));
 lines.sorted().forEach(System.out::println);
 lines.close();
```

Using takeWhile(), dropWhile() and iterate()

The following snippets show how to use takeWhile(), dropWhile() and iterate()

```
 Stream<Integer> nums= Stream.of(10,22,31,34,87,12);
 var evenNums = nums.takeWhile(n -> n % 2 == 0);
 evenNums.forEach(System.out::println);   // 10 22

var nums = nums.dropWhile(n -> n % 2 == 0);
 nums.forEach(System.out::println); // 31 34 87 12

var oddNums = Stream.iterate(1, v -> v < 10, v -> v + 2);
 oddNums.forEach(System.out::println);    // 1 3 5 7 9
```

Parallelism in Streams

- Parallel computing involves dividing a problem into subproblems, solving those problems simultaneously (in parallel, with each subproblem running in a separate thread), and then combining the results of the solutions to the subproblems.
- It is possible to obtain a parallel stream from a source that provides a stream using method **parallelStream**().
- When a stream executes in parallel, the Java runtime partitions the stream into multiple substreams. Aggregate operations iterate over and process these substreams in parallel and then combine the results.

```
values.parallelStream().sorted()
.forEach(System.out::println);
```