## Exceptional Handling

An exception is a problem that arises during the execution of a program. An exception can occur for many different reasons, including the following:

- A user has entered invalid data.
- A file that needs to be opened cannot be found.
- A network connection has been lost in the middle of communications, or the JVM has run out of memory

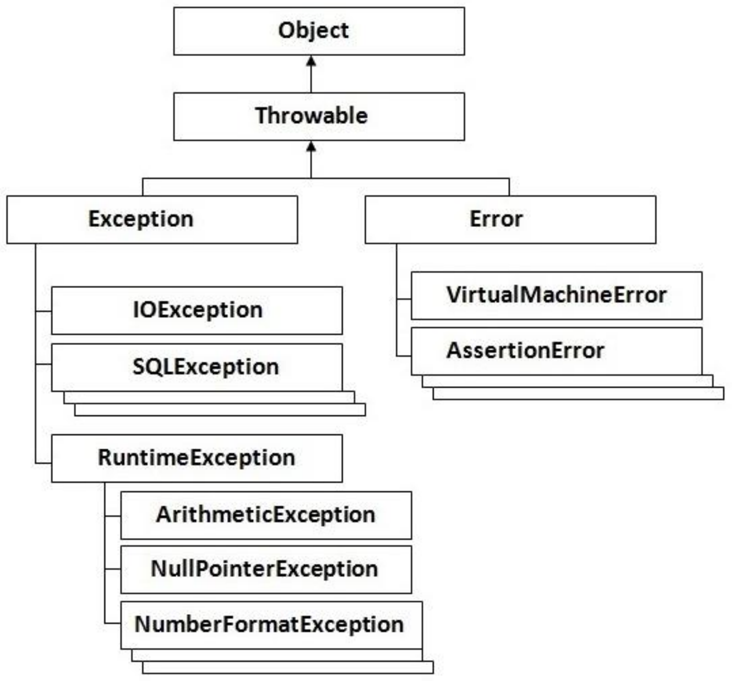
"*Exceptional Handling is a task to maintain normal flow of the program. For this we should try to catch the exception object thrown by the error condition and then display appropriate message for taking corrective actions*"

## Types of Exceptions

1. **Checked Exception:** A checked exception is an exception that is typically a user error or a problem that cannot be foreseen by the programmer. Checked exception can also be defined as "*The classes that extend the Throwable class except RuntimeException and Error are known as Checked Exceptions*". For example, if a file is to be opened, but the file cannot be found, an exception occurs. These exceptions are checked at compile-time and cannot simply be ignored at the time of compilation. Example of Checked Exception are IOException, SQLException etc.
2. **Unchecked Exception:** Also known as Runtime Exceptions and they are ignored at the time of compilation but checked during execution of the program. Unchecked Exceptions can also be defined as "*The Classes that extend the RuntimeException class are known as Unchecked Exceptions*". Example are ArithmeticException, NullPointerException etc.
3. **Error:** These are not exceptions at all, but problems that arise beyond the control of the user or the programmer. Errors are typically ignored in your code because you can rarely do anything about an error. For example, if a stack overflow occurs, an error will arise. They are also ignored at the time of compilation.

## Hierarchy of Exception

All exception classes are subtypes of the java.lang.Exception class. The exception class is a subclass of the Throwable class. Other than the exception class there is another subclass called Error which is derived from the Throwable class.



## Table of JAVA – Built in Exceptions

Following is the list of Java Unchecked RuntimeException

| Exception | Description |
|---|---|
| ArithmeticException | Arithmetic error, such as divide-by-zero. |
| ArrayIndexOutOfBoundsException | Array index is out-of-bounds. |
| ArrayStoreException | Assignment to an array element of an incompatible type. |
| ClassCastException | Invalid cast. |
| IllegalArgumentException | Illegal argument used to invoke a method. |
| IllegalMonitorStateException | Illegal monitor operation, such as waiting on an unlocked thread. |
| IllegalStateException | Environment or application is in incorrect state. |
| IllegalThreadStateException | Requested operation not compatible with current thread state. |
| IndexOutOfBoundsException | Some type of index is out-of-bounds. |
| NegativeArraySizeException | Array created with a negative size. |
| NullPointerException | Invalid use of a null reference. |
| NumberFormatException | Invalid conversion of a string to a numeric format. |
| SecurityException | Attempt to violate security. |
| StringIndexOutOfBounds | Attempt to index outside the bounds of a string. |
| UnsupportedOperationException | An unsupported operation was encountered. |

Following is the list of Java Checked Exceptions Defined in java.lang

| **Exception** | **Description** |
|---|---|
| ClassNotFoundException | Class not found. |
| CloneNotSupportedException | Attempt to clone an object that does not implement the Cloneable interface. |
| IllegalAccessException | Access to a class is denied. |
| InstantiationException | Attempt to create an object of an abstract class or interface. |
| InterruptedException | One thread has been interrupted by another thread. |
| NoSuchFieldException | A requested field does not exist. |
| NoSuchMethodException | A requested method does not exist. |

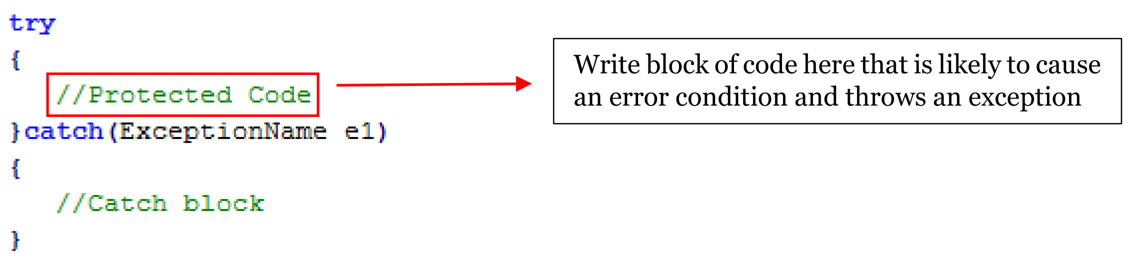
## Handling Exceptions in Java

Following five keywords are used to handle an exception in Java:

1. try
2. catch
3. finally
4. throw
5. throws

### try –catch block

A method catches an exception using a combination of the **try and catch** keywords. A try/catch block is placed around the code that might generate an exception. Code within a try/catch block is referred to as protected code, and the syntax for using try/catch looks like the following:

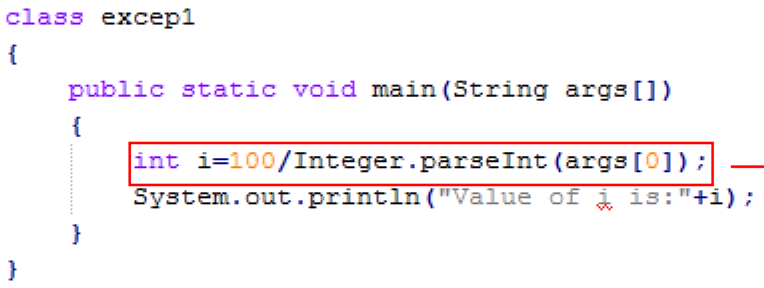


```
try
{
   //Protected Code
}catch(ExceptionName e1)
{
   //Catch block
}
```

Write block of code here that is likely to cause an error condition and throws an exception

A catch statement involves declaring the type of exception you are trying to catch. If an exception occurs in protected code, the catch block (or blocks) that follows the try is checked. If the type of exception that occurred is listed in a catch block, the exception is passed to the catch block much as an argument is passed into a method parameter.

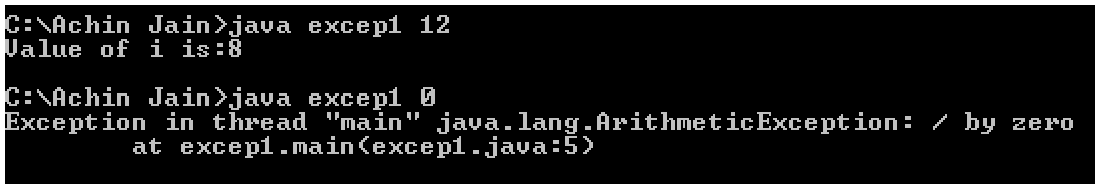
## Example of Program without Exceptional Handling



```
class excep1
{
    public static void main(String args[])
    {
        int i=100/Integer.parseInt(args[0]);
        System.out.println("Value of i is:"+i);
    }
}
```

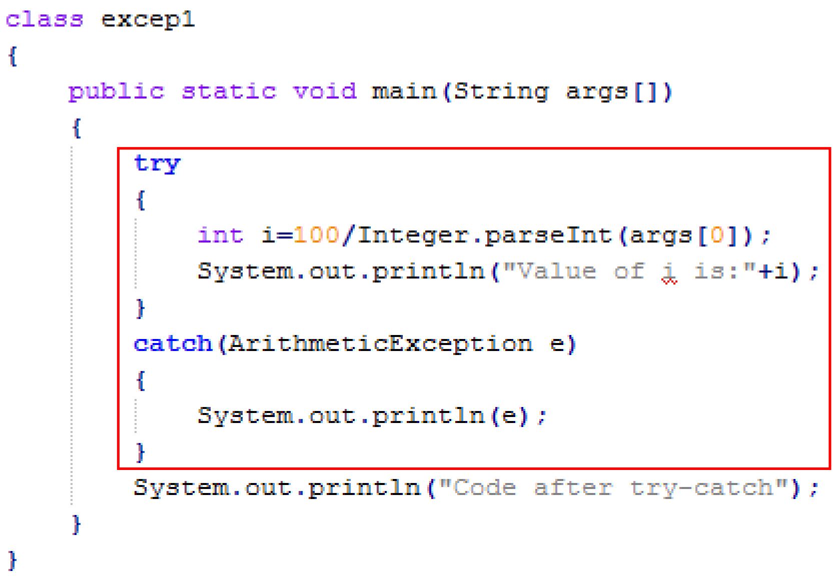
This statement can cause error as divide by Zero is an ArithmeticException

## Output:



```
C:\Achin Jain>java excep1 12
Value of i is:8

C:\Achin Jain>java excep1 0
Exception in thread "main" java.lang.ArithmeticException: / by zero
        at excep1.main(excep1.java:5)
```

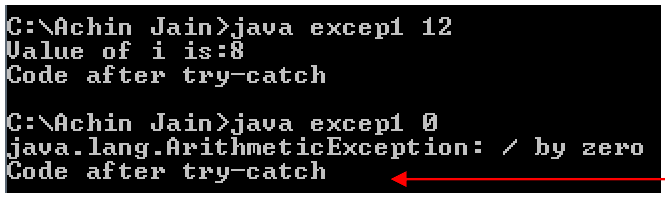
## Same Program with Exception Handling



```
class excep1
{
    public static void main(String args[])
    {
        try
        {
            int i=100/Integer.parseInt(args[0]);
            System.out.println("Value of i is:"+i);
        }
        catch(ArithmeticException e)
        {
            System.out.println(e);
        }
        System.out.println("Code after try-catch");
    }
}
```

Now as the statement which can cause error condition is wrapped under try block and catch block is also present to handle the exception object thrown. In this case even if there is an error rest of the program will execute normally

## Output



```
C:\Achin Jain>java excep1 12
Value of i is:8
Code after try-catch

C:\Achin Jain>java excep1 0
java.lang.ArithmeticException: / by zero
Code after try-catch
```

## Multiple Catch Blocks:

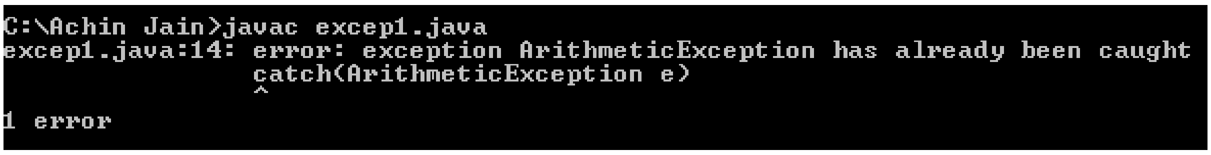
A try block can be followed by multiple catch blocks, but when we use multiple catch statements it is important that exception subclasses must come before any of their superclasses. The reason is "*a catch statement with superclass will catch exceptions of that type plus any of its subclass, thus causing a catch statement with subclass exception a non-reachable code which is error in JAVA*".

## Example:

```
class excep1
{
    public static void main(String args[])
    {
        try
        {
            int i=100/Integer.parseInt(args[0]);
            System.out.println("Value of i is:"+i);
        }
        catch(Exception e1)
        {
            System.out.println(e1);
        }
        catch(ArithmeticException e)
        {
            System.out.println(e);
        }
        System.out.println("Code after try-catch");
    }
}
```

In the example, two catch statement are used but first one is of type Exception which is a superclass of ArithmeticException (used in second catch). So any exception thrown will be caught by first catch block which makes second block unreachable and error is shown during compile time

## Output



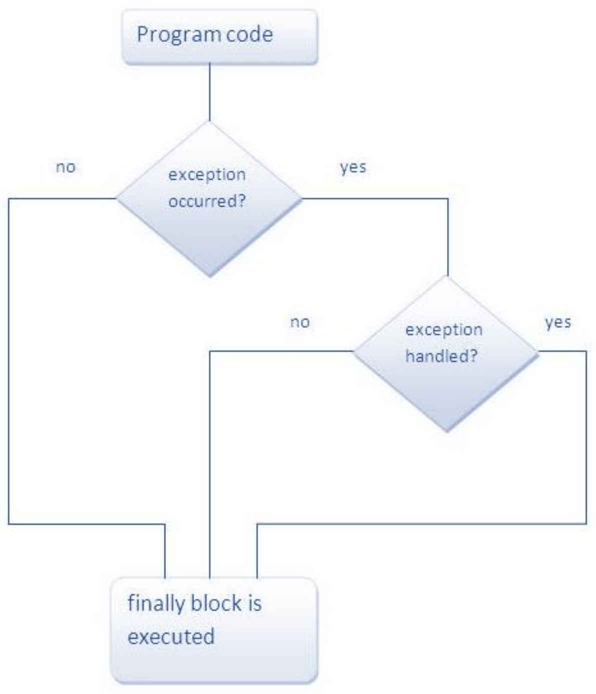
```
C:\Achin Jain>javac excep1.java
excep1.java:14: error: exception ArithmeticException has already been caught
                catch(ArithmeticException e)
                ^
1 error
```

However if the order of the catch blocks is reversed like shown below, then program will execute normally

```
catch(ArithmeticException e)
{
    System.out.println(e);
}
catch(Exception e1)
{
    System.out.println(e1);
}
```

## Finally Block

The finally keyword is used to create a block of code that follows a try block. A finally block of code always executes, whether or not an exception has occurred. Using a finally block allows you to run any cleanup-type statements that you want to execute, no matter what happens in the protected code.

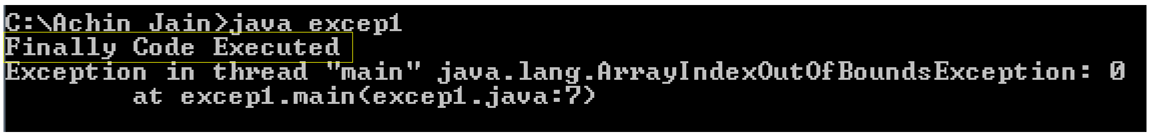


## Example of Finally Statement

```
class excep1
{
    public static void main(String args[])
    {
        try
        {
            int i=100/Integer.parseInt(args[0]);
            System.out.println("Value of i is:"+i);
        }
        catch(ArithmeticException e1)
        {
            System.out.println(e1);
        }
        finally
        {
            System.out.println("Finally Code Executed");
        }
        System.out.println("Code after try-catch");
    }
}
```

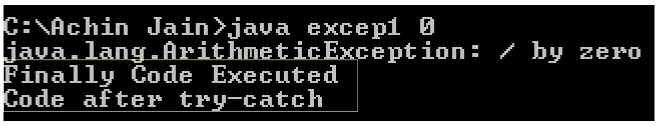
**Output 1**

In the first case no command line arguments are passed which will throw ArrayIndexOutOfBoundsException and in the above code we are handling only ArithmeticException which will cause the system to terminate and remaining program will not run. But in this case also the statement written in the finally block will gets executed as shown below:



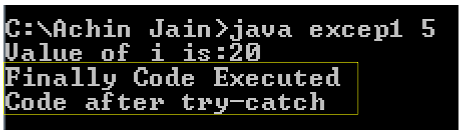
```
C:\Achin Jain>java excep1
Finally Code Executed
Exception in thread "main" java.lang.ArrayIndexOutOfBoundsException: 0
        at excep1.main(excep1.java:7)
```

In second case '0' is passed as command line argument to let program throw ArithmeticException which will eventually be handled by catch block. See the output below which clearly shows that remaining part of the code will also run along with finally statement.



```
C:\Achin Jain>java excep1 0
java.lang.ArithmeticException: / by zero
Finally Code Executed
Code after try-catch
```

In third case '5' is passed as command line argument which is perfectly fine and in this case no exception will be throws. Now see the output below, in this case also finally statement will get executed.



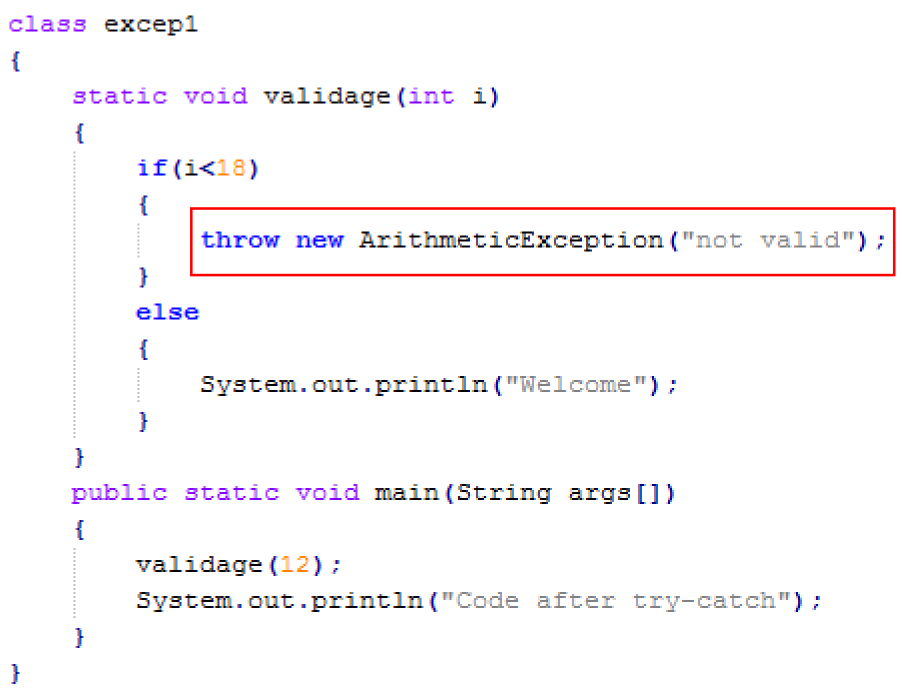
```
C:\Achin Jain>java excep1 5
Value of i is:20
Finally Code Executed
Code after try-catch
```

**Throw Keyword**

The throw keyword is used to explicitly throw an exception. We can throw either checked or unchecked exception. The throw keyword is normally used to throw custom exception.

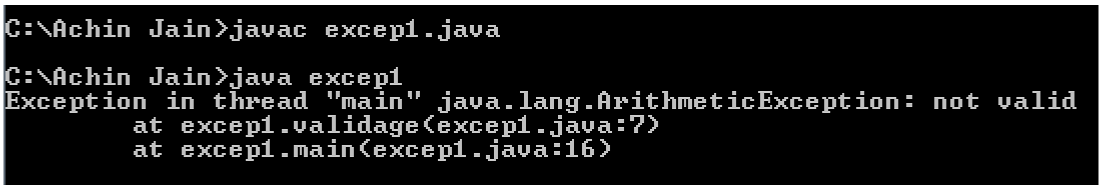
**Example**

In the example shown below a method validage(int i) is used which will check the value of passed parameter *i* and if the value is less than 18 than a ArithmeticException is thrown. Now as you can see when we have called the method no try catch block is used which results in termination of the program and message is displayed as "not valid" which is passed during throwing of ArithmeticException object.



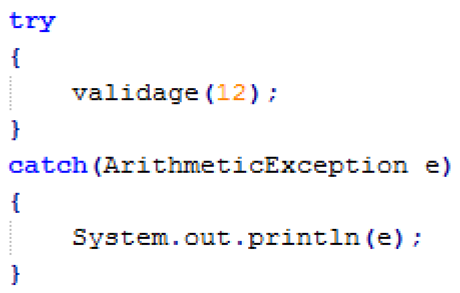
```
class excep1
{
    static void validage(int i)
    {
        if(i<18)
        {
            throw new ArithmeticException("not valid");
        }
        else
        {
            System.out.println("Welcome");
        }
    }
    public static void main(String args[])
    {
        validage(12);
        System.out.println("Code after try-catch");
    }
}
```

**Output**



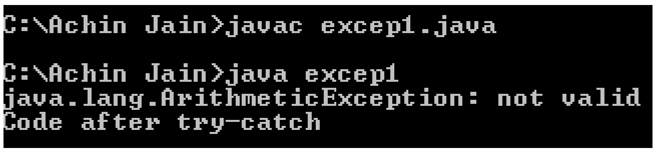
```
C:\Achin Jain>javac excep1.java

C:\Achin Jain>java excep1
Exception in thread "main" java.lang.ArithmeticException: not valid
        at excep1.validage(excep1.java:7)
        at excep1.main(excep1.java:16)
```

However if during call of validage method try-catch block has been used then the program will run normally



```
try
{
    validage(12);
}
catch(ArithmeticException e)
{
    System.out.println(e);
}
```

**Output**



```
C:\Achin Jain>javac excep1.java

C:\Achin Jain>java excep1
java.lang.ArithmeticException: not valid
Code after try-catch
```

## <u>Throws Keyword</u>

The throws keyword is used to declare the exception, it provide information to the programmer that there may occur an exception so during call of that method, and programmer must use exceptional handling mechanism. Throws keyword is also used to propagate checked exception.

## <u>Example</u>

In this example, exception is created by extending Exception class and the custom exception is declared in the method validage(int i)

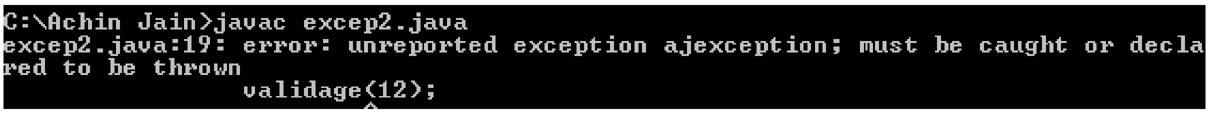
```
class ajexception extends Exception
{
    ajexception(String s)
    {
        super(s);
    }
}
class excep2
{
    static void validage(int i) throws ajexception
    {
        if(i<18)
        {
            throw new ajexception("not valid");
        }
    }
    public static void main(String args[])
    {
        validage(12);
        System.out.println("Code after try-catch");
    }
}
```

Code to create custom exception with name "ajexception"

<u>**Case 1:**</u> During call of validage method exceptional handling is not used and code looks like this and error is displayed in the compilation of the code.

```
public static void main(String args[])
{
    validage(12);
    System.out.println("Code after try-catch");
}
```

## <u>Output</u>

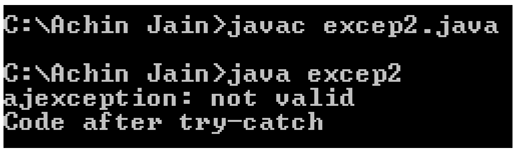


```
C:\Achin Jain>javac excep2.java
excep2.java:19: error: unreported exception ajexception; must be caught or decla
red to be thrown
                validage(12);
```

**Case 2:** During call of method validage exceptional handling is used with try-catch keyword like this and the program runs as expected.

```
try
{
    validage(12);
}
catch(ajexception aj)
{
    System.out.println(aj);
}
```

**Output:**



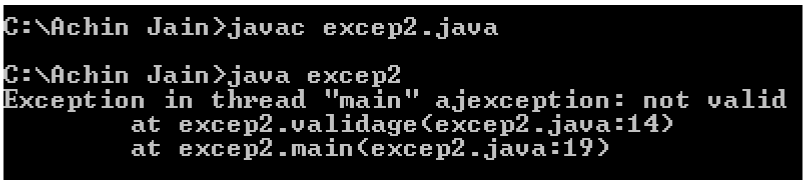
```
C:\Achin Jain>javac excep2.java

C:\Achin Jain>java excep2
ajexception: not valid
Code after try-catch
```

**Case 3:** During call of method validage exceptional handling is used without try-catch keyword and throws keyword is used in main method as shown below

```
public static void main(String args[]) throws ajexception
{
    validage(12);
    System.out.println("Code after try-catch");
}
```

There will be no error now during compile time, but program will gets terminated when exception event takes place.

**Output**

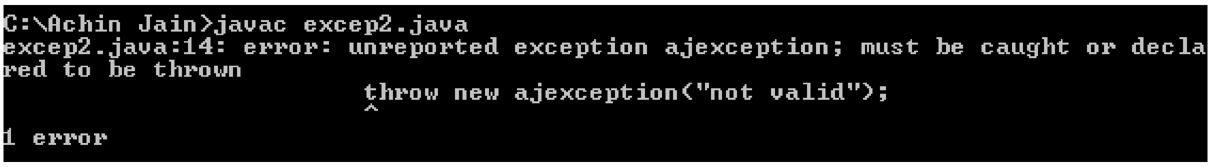


```
C:\Achin Jain>javac excep2.java

C:\Achin Jain>java excep2
Exception in thread "main" ajexception: not valid
        at excep2.validage(excep2.java:14)
        at excep2.main(excep2.java:19)
```

**Case 4:** Try to propagate custom exception not of type RuntimeException without declaring in method using throws keyword. This will give compile time error

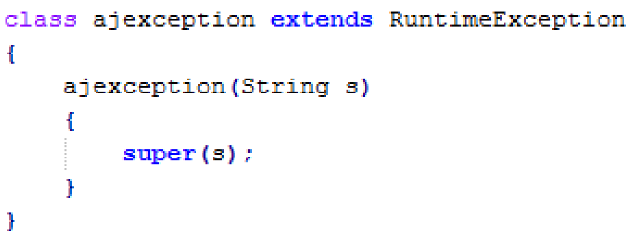
```
static void validage(int i) //throws ajexception
{
    if(i<18)
    {
        throw new ajexception("not valid");
    }
```

**Output:**



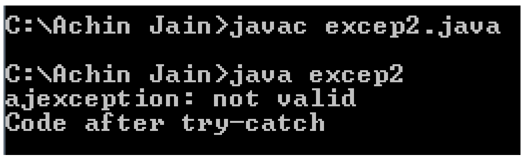
```
C:\Achin Jain>javac excep2.java
excep2.java:14: error: unreported exception ajexception; must be caught or decla
red to be thrown
                        throw new ajexception("not valid");
                        ^
1 error
```

**Case 5:** Make custom exception by extending RunTimeException Class and try the same method as use for Case 4. There will be no error now and the program runs as expected



```
class ajexception extends RuntimeException
{
    ajexception(String s)
    {
        super(s);
    }
}
```

**Output**



```
C:\Achin Jain>javac excep2.java

C:\Achin Jain>java excep2
ajexception: not valid
Code after try-catch
```

## Important Points in Exceptional Handling

- A catch clause cannot exist without a try statement.
- It is not compulsory to have finally clauses whenever a try/catch block is present.
- The try block cannot be present without either catch clause or finally clause.
- Any code cannot be present in between the try, catch, finally blocks.

## Declaring your Own Exceptions

You can create your own exceptions in Java. Keep the following points in mind when writing your own exception classes:

- All exceptions must be a child of Throwable.
- If you want to write a checked exception that is automatically enforced by the Handle or Declare Rule, you need to extend the Exception class.
- If you want to write a runtime exception, you need to extend the RuntimeException class.

**Example to create custom exception** is shown in the section above.

## Multithreading

Multithreading is a conceptual programming concept where a program (process) is divided into two or more subprograms (process), which can be implemented at the same time in parallel. A multithreaded program contains two or more parts that can run concurrently. Each part of such a program is called a thread, and each thread defines a separate path of execution. A ***process*** consists of the memory space allocated by the operating system that can contain one or more threads. A thread cannot exist on its own; it must be a part of a process.

There are two distinct types of **Multitasking** i.e. Processor-Based and Thread-Based multitasking.

**Q:** What is the difference between thread-based and process-based multitasking?

**Ans:** As both are types of multitasking there is very basic difference between the two. **Process-Based multitasking** is a feature that allows your computer to run two or more programs concurrently. For example you can listen to music and at the same time chat with your friends on Facebook using browser. In Thread-based multitasking, thread is the smallest unit of code, which means a single program can perform two or more tasks simultaneously. For example a text editor can print and at the same time you can edit text provided that those two tasks are perform by separate threads.

**Q:** Why multitasking thread requires less overhead than multitasking processor?

**Ans:** A multitasking thread requires less overhead than multitasking processor because of the following reasons:

- Processes are heavyweight tasks where threads are lightweight
- Processes require their own separate address space where threads share the address space
- Interprocess communication is expensive and limited where Interthread communication is inexpensive, and context switching from one thread to the next is lower in cost.

## Benefits of Multithreading

1. Enables programmers to do multiple things at one time

2. Programmers can divide a long program into threads and execute them in parallel which eventually increases the speed of the program execution
3. Improved performance and concurrency
4. Simultaneous access to multiple applications

## Life Cycle of Thread

A thread can be in any of the five following states

1. **Newborn State:** When a thread object is created a new thread is born and said to be in Newborn state.
2. **Runnable State:** If a thread is in this state it means that the thread is ready for execution and waiting for the availability of the processor. If all threads in queue are of same priority then they are given time slots for execution in round robin fashion
3. **Running State:** It means that the processor has given its time to the thread for execution. A thread keeps running until the following conditions occurs
    a. Thread give up its control on its own and it can happen in the following situations
        i. A thread gets suspended using **suspend()** method which can only be revived with **resume()** method
        ii. A thread is made to sleep for a specified period of time using **sleep(time)** method, where time in milliseconds
        iii. A thread is made to wait for some event to occur using **wait ()** method. In this case a thread can be scheduled to run again using **notify ()** method.
    b. A thread is pre-empted by a higher priority thread
4. **Blocked State:** If a thread is prevented from entering into runnable state and subsequently running state, then a thread is said to be in Blocked state.
5. **Dead State:** A runnable thread enters the Dead or terminated state when it completes its task or otherwise terminates.

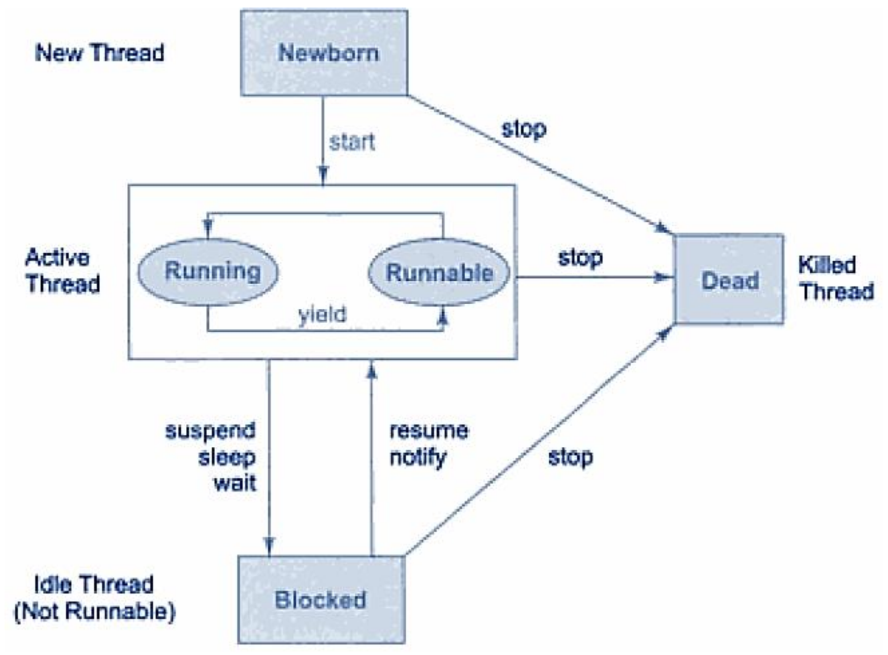


**Fig: Life Cycle of Thread**

## Main Thread

Every time a Java program starts up, one thread begins running which is called as the *main thread* of the program because it is the one that is executed when your program begins.

- Child threads are produced from main thread
- Often it is the last thread to finish execution as it performs various shut down operations

## Creating a Thread

Java defines two ways in which this can be accomplished:

- You can implement the Runnable interface.
- You can extend the Thread class, itself.

## Create Thread by Implementing Runnable

The easiest way to create a thread is to create a class that implements the Runnable interface. To implement Runnable, a class need only implement a single method called **run( )**, which is declared like this:

```
public void run( )
```

You will define the code that constitutes the new thread inside **run()** method. It is important to understand that **run()** can call other methods, use other classes, and declare variables, just like the main thread can.

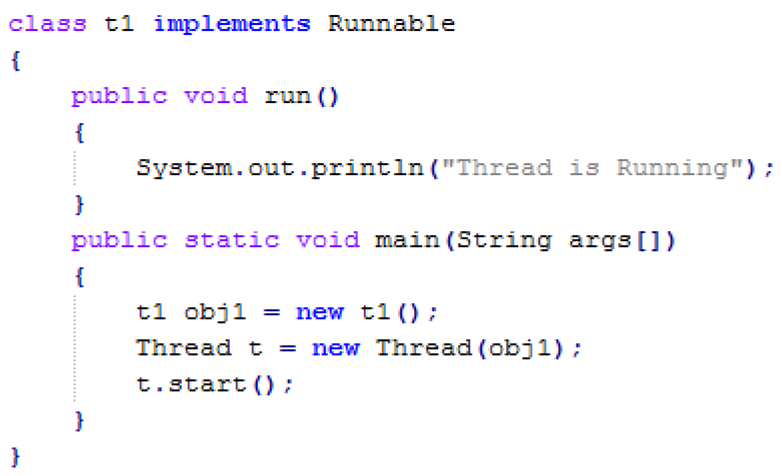
After you create a class that implements Runnable, you will instantiate an object of type Thread from within that class. Thread defines several constructors. The one that we will use is shown here:

```
Thread(Runnable threadOb, String threadName);
```

Here threadOb is an instance of a class that implements the Runnable interface and the name of the new thread is specified by threadName. After the new thread is created, it will not start running until you call its **start( )** method, which is declared within Thread. The start( ) method is shown here:

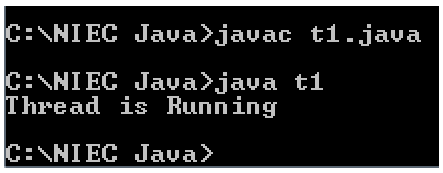
```
void start( );
```

## Example to Create a Thread using Runnable Interface



```
class t1 implements Runnable
{
    public void run()
    {
        System.out.println("Thread is Running");
    }
    public static void main(String args[])
    {
        t1 obj1 = new t1();
        Thread t = new Thread(obj1);
        t.start();
    }
}
```

**Output:**

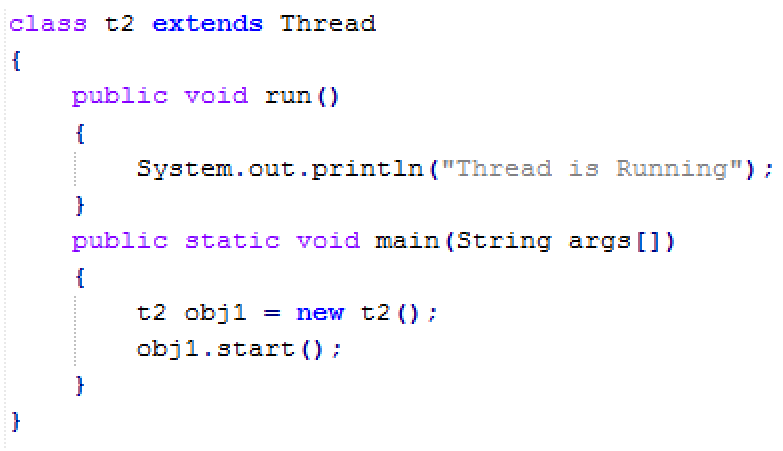


```
C:\NIEC Java>javac t1.java

C:\NIEC Java>java t1
Thread is Running

C:\NIEC Java>
```

## Create Thread by Extending Thread

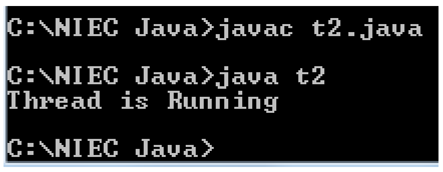
The second way to create a thread is to create a new class that extends Thread, and then to create an instance of that class. The **extending class must override the run( ) method**, which is the entry point for the new thread. It must also call start( ) to begin execution of the new thread.

**<u>Example to Create a Thread by Extending Thread Class</u>**



```
class t2 extends Thread
{
    public void run()
    {
        System.out.println("Thread is Running");
    }
    public static void main(String args[])
    {
        t2 obj1 = new t2();
        obj1.start();
    }
}
```

**Output:**



```
C:\NIEC Java>javac t2.java

C:\NIEC Java>java t2
Thread is Running

C:\NIEC Java>
```

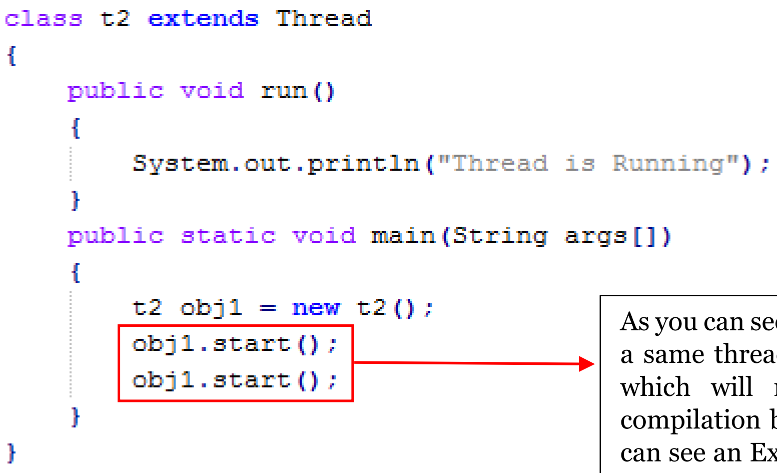
**<u>Thread Methods</u>**

| SN | Methods with Description |
|---|---|
| 1 | **public void start()**<br>Starts the thread in a separate path of execution, then invokes the run() method on this Thread object. |
| 2 | **public void run()**<br>If this Thread object was instantiated using a separate Runnable target, the run() method is invoked on that Runnable object. |
| 3 | **public final void setName(String name)**<br>Changes the name of the Thread object. There is also a getName() method for retrieving the name. |
| 4 | **public final void setPriority(int priority)**<br>Sets the priority of this Thread object. The possible values are between 1 and 10. |
| 5 | **public final void setDaemon(boolean on)**<br>A parameter of true denotes this Thread as a daemon thread. |
| 6 | **public final void join(long millisec)**<br>The current thread invokes this method on a second thread, causing the current thread |

| | |
|---|---|
| | to block until the second thread terminates or the specified number of milliseconds passes. |
| 7 | **public void interrupt()**<br>Interrupts this thread, causing it to continue execution if it was blocked for any reason. |
| 8 | **public final boolean isAlive()**<br>Returns true if the thread is alive, which is any time after the thread has been started but before it runs to completion. |

**Q:** Can we start a thread twice?

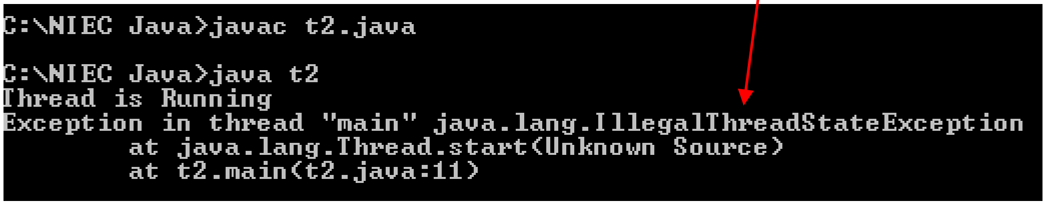
**Ans:** No, if a thread is started it can never be started again, if you do so, an illegalThreadStateException is thrown. Example is shown below in which a same thread is coded to start again



```
class t2 extends Thread
{
    public void run()
    {
        System.out.println("Thread is Running");
    }
    public static void main(String args[])
    {
        t2 obj1 = new t2();
        obj1.start();
        obj1.start();
    }
}
```

As you can see two statements to start a same thread is written in the code which will not give error during compilation but when you run it you can see an Exception as shown in the Output Screenshot.

**Output:**

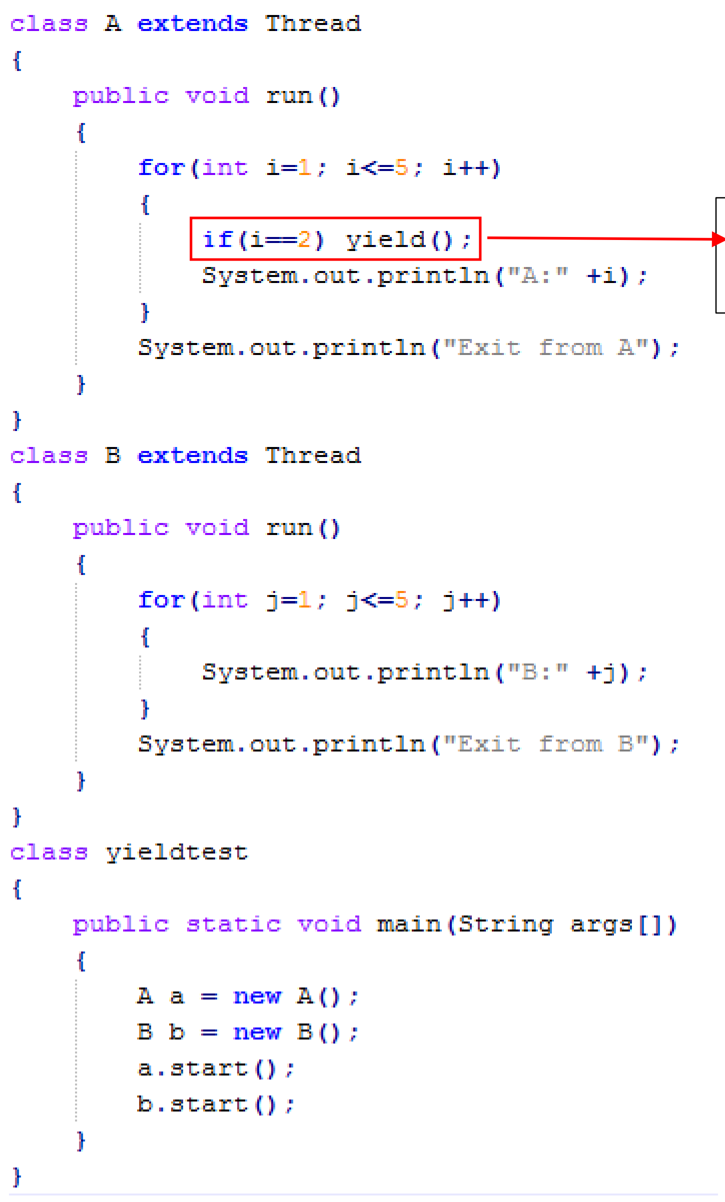


```
C:\NIEC Java>javac t2.java

C:\NIEC Java>java t2
Thread is Running
Exception in thread "main" java.lang.IllegalThreadStateException
        at java.lang.Thread.start(Unknown Source)
        at t2.main(t2.java:11)
```

## <u>Use of Yield() Method</u>

Causes the currently running thread to yield to any other threads of the same priority that are waiting to be scheduled

**Example**

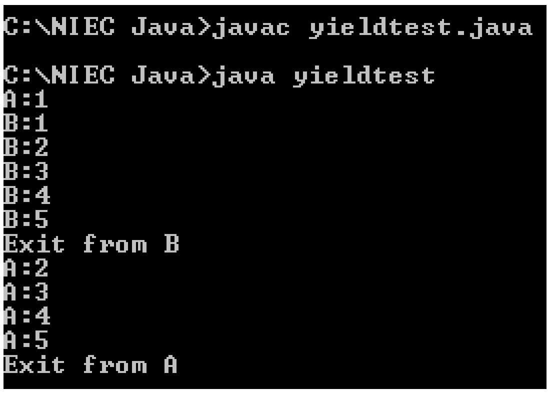


```
class A extends Thread
{
    public void run()
    {
        for(int i=1; i<=5; i++)
        {
            if(i==2) yield();
            System.out.println("A:" +i);
        }
        System.out.println("Exit from A");
    }
}
class B extends Thread
{
    public void run()
    {
        for(int j=1; j<=5; j++)
        {
            System.out.println("B:" +j);
        }
        System.out.println("Exit from B");
    }
}
class yieldtest
{
    public static void main(String args[])
    {
        A a = new A();
        B b = new B();
        a.start();
        b.start();
    }
}
```

Condition is checked and when i==2 yield() method is evoked taking control to thread B

As you can see in the output below, thread A gets started and when condition if(i==2) gets satisfied yield() method gets evoked and the control is relinquished from thread A to thread B which run to its completion and only after that thread a regain the control back.

**Output**



```
C:\NIEC Java>javac yieldtest.java

C:\NIEC Java>java yieldtest
A:1
B:1
B:2
B:3
B:4
B:5
Exit from B
A:2
A:3
A:4
A:5
Exit from A
```

## Use of stop() Method

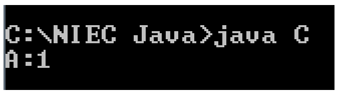
The stop() method kills the thread on execution

**Example**

```
class C extends Thread
{
    public void run()
    {
        for(int i=1; i<=5; i++)
        {
            if(i==2) stop();
            System.out.println("A:" +i);
        }
        System.out.println("Exit from A");
    }
    public static void main(String args[])
    {
        C c = new C();
        c.start();
    }
}
```

Condition is checked and when i==2 stop() method is evoked causing termination of thread execution

**Output**



```
C:\NIEC Java>java C
A:1
```

## Use of sleep() Method

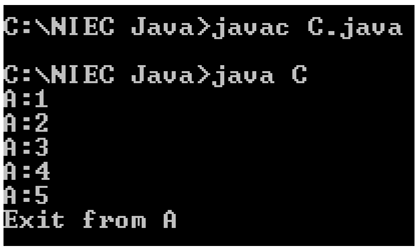
Causes the currently running thread to block for at least the specified number of milliseconds. You need to handle exception while using sleep() method.

**Example**

```
class C extends Thread
{
    public void run()
    {
        for(int i=1; i<=5; i++)
        {
            try
            {
                if(i==2) sleep(1000);
            }
            catch(Exception e)
            {
            }
            System.out.println("A:" +i);
        }
        System.out.println("Exit from A");
    }
    public static void main(String args[])
    {
        C c = new C();
        c.start();
    }
}
```

Condition is checked and when i==2 sleep() method is evoked which halts the execution of the thread for 1000 milliseconds. When you see output there is no change but there is delay in execution.

**Output**



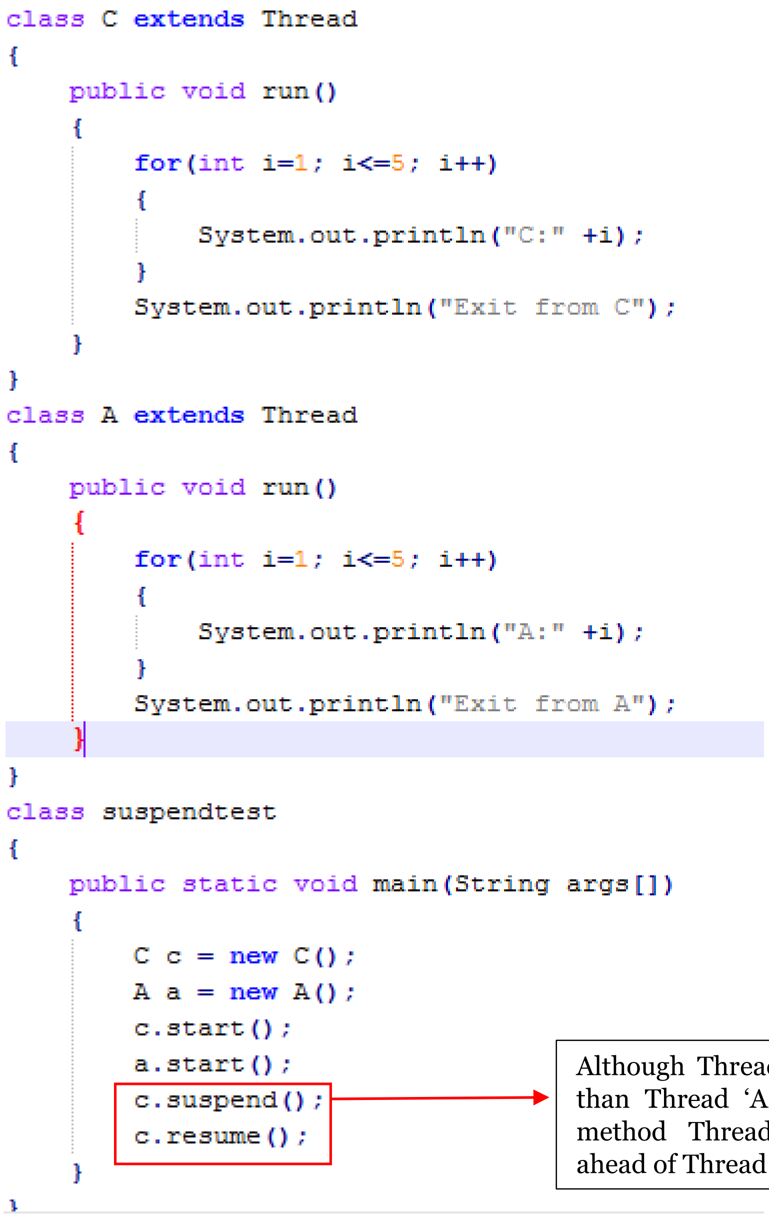
```
C:\NIEC Java>javac C.java

C:\NIEC Java>java C
A:1
A:2
A:3
A:4
A:5
Exit from A
```

**<u>Use of suspend() and resume() method</u>**

A suspended thread can be revived by using the resume() method. This approach is useful when we want to suspend a thread for some time due to certain reason but do not want to kill it.

Following is the example in which two threads C and A are created. Thread C is started ahead of Thread A, but C is suspended using suspend() method causing Thread A to get hold of the processor allowing it to run and when Thread C is resumed using resume() method it runs to its completion.

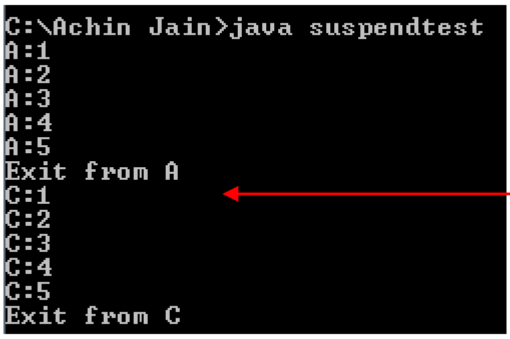
## Example



```
class C extends Thread
{
    public void run()
    {
        for(int i=1; i<=5; i++)
        {
            System.out.println("C:" +i);
        }
        System.out.println("Exit from C");
    }
}
class A extends Thread
{
    public void run()
    {
        for(int i=1; i<=5; i++)
        {
            System.out.println("A:" +i);
        }
        System.out.println("Exit from A");
    }
}
class suspendtest
{
    public static void main(String args[])
    {
        C c = new C();
        A a = new A();
        c.start();
        a.start();
        c.suspend();
        c.resume();
    }
}
```

Although Thread 'C' is started earlier than Thread 'A' but due to suspend method Thread 'A' gets completed ahead of Thread 'C'

## Output



```
C:\Achin Jain>java suspendtest
A:1
A:2
A:3
A:4
A:5
Exit from A
C:1
C:2
C:3
C:4
C:5
Exit from C
```

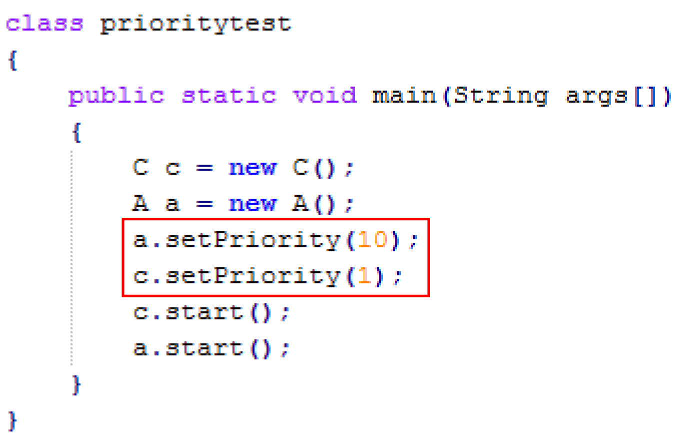
## Thread Priority

Every Java thread has a priority that helps the operating system determine the order in which threads are scheduled.

Java priorities are in the range between **MIN_PRIORITY (a constant of 1)** and **MAX_PRIORITY (a constant of 10)**. By default, every thread is given priority **NORM_PRIORITY (a constant of 5)**.

Threads with higher priority are more important to a program and should be allocated processor time before lower-priority threads. However, thread priorities cannot guarantee the order in which threads execute and very much platform dependent.

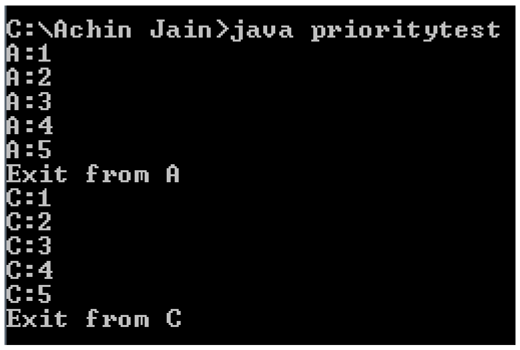
**Example**



```
class prioritytest
{
    public static void main(String args[])
    {
        C c = new C();
        A a = new A();
        a.setPriority(10);
        c.setPriority(1);
        c.start();
        a.start();
    }
}
```

In the above code, you can see Priorities of Thread is set to maximum for Thread A which lets it to run to completion ahead of C which is set to minimum priority.

**Output:**



```
C:\Achin Jain>java prioritytest
A:1
A:2
A:3
A:4
A:5
Exit from A
C:1
C:2
C:3
C:4
C:5
Exit from C
```

## Use of isAlive() and join() method

The java.lang.Thread.isAlive() method tests if this thread is alive. A thread is alive if it has been started and has not yet died. Following is the declaration for java.lang.Thread.isAlive() method

**public final boolean isAlive()**

This method returns true if this thread is alive, false otherwise.

**join() method** waits for a thread to die. It causes the currently thread to stop executing until the thread it joins with completes its task.

**Example**

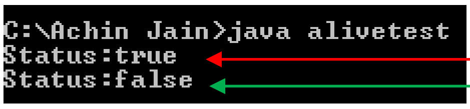
```
class A extends Thread
{
    public void run()
    {
        System.out.println("Status:" + isAlive());
    }
}
class alivetest
{
    public static void main(String args[])
    {
        A a = new A();
        a.start();
        try
        {
            a.join();
        }
        catch(InterruptedException e)
        {}
        System.out.println("Status:" + a.isAlive());
    }
}
```

At this point Thread A is alive so the value gets printed by **isAlive()** method is "***true***"

join() method is called from Thread A which stops executing of further statement until A is Dead

Now isAlive() method returns the value false as the Thread A is complete

**Output**



```
C:\Achin Jain>java alivetest
Status:true
Status:false
```

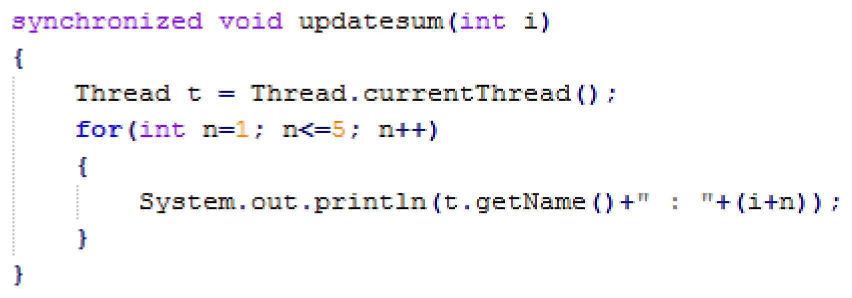
## Synchronization

When two or more threads need access to a shared resource, they need some way to ensure that the resource will be used by only one thread at a time. The process by which this synchronization is achieved is called thread synchronization. The synchronized keyword in Java creates a block of code referred to as a critical section. Every Java object with a critical section of code gets a lock associated with the object. To enter a critical section, a thread needs to obtain the corresponding object's lock.

***synchronized(object)***
***{***
  ***// statements to be synchronized***
***}***

## Problem without using Synchronization

In the following example method updatesum() is not synchronized and access by both the threads simultaneously which results in inconsistent output. Making a method synchronized, Java creates a “monitor” and hands it over to the thread that calls the method first time. As long as the thread holds the monitor, no other thread can enter the synchronized section of the code.  Writing the method as synchronized will make one thread enter the method and till execution is not complete no other thread can get access to the method.

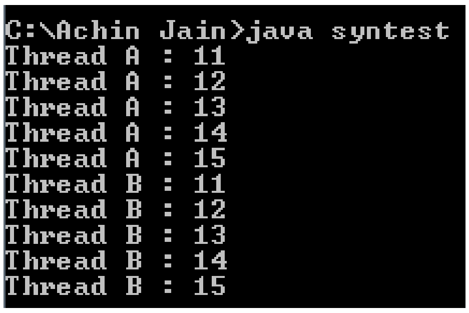


```
synchronized void updatesum(int i)
{
    Thread t = Thread.currentThread();
    for(int n=1; n<=5; n++)
    {
        System.out.println(t.getName()+" : "+(i+n));
    }
}
```

```
class update
{
    void updatesum(int i)
    {
        Thread t = Thread.currentThread();
        for(int n=1; n<=5; n++)
        {
            System.out.println(t.getName()+" : "+(i+n));
        }
    }
}
class A extends Thread
{
    update u = new update();
    public void run()
    {
        u.updatesum(10);
    }
}
class syntest
{
    public static void main(String args[])
    {
        A a = new A();
        Thread t1 = new Thread(a);
        Thread t2 = new Thread(a);
        t1.setName("Thread A");
        t2.setName("Thread B");
        t1.start();
        t2.start();
    }
}

}
```

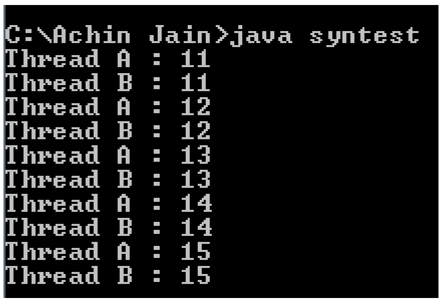
```
synchronized void updatesum(int i)
```

Output when method is declared as synchronized



```
C:\Achin Jain>java syntest
Thread A : 11
Thread A : 12
Thread A : 13
Thread A : 14
Thread A : 15
Thread B : 11
Thread B : 12
Thread B : 13
Thread B : 14
Thread B : 15
```

**Output**



```
C:\Achin Jain>java syntest
Thread A : 11
Thread B : 11
Thread A : 12
Thread B : 12
Thread A : 13
Thread B : 13
Thread A : 14
Thread B : 14
Thread A : 15
Thread B : 15
```

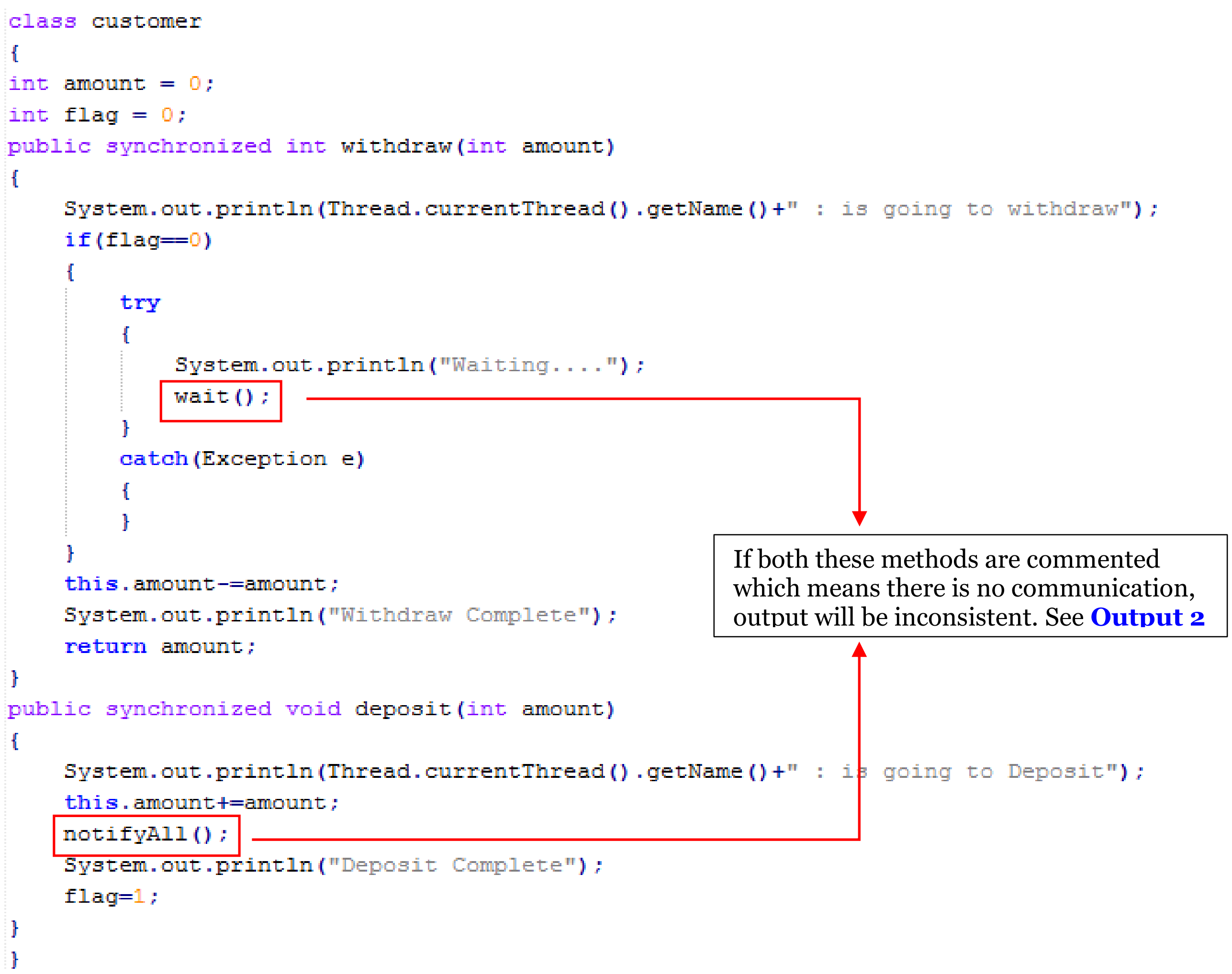
## Interthread Communication

It is all about making synchronized threads communicate with each other. It is a mechanism in which a thread is paused running in its critical section and another thread is allowed to enter in the same critical section to be executed. It is implemented by the following methods of Object Class:

- **wait( ):** This method tells the calling thread to give up the monitor and go to sleep until some other thread enters the same monitor and calls notify( ).
- **notify( ):** This method wakes up the first thread that called wait( ) on the same object.
- **notifyAll( ):** This method wakes up all the threads that called wait( ) on the same object. The highest priority thread will run first.

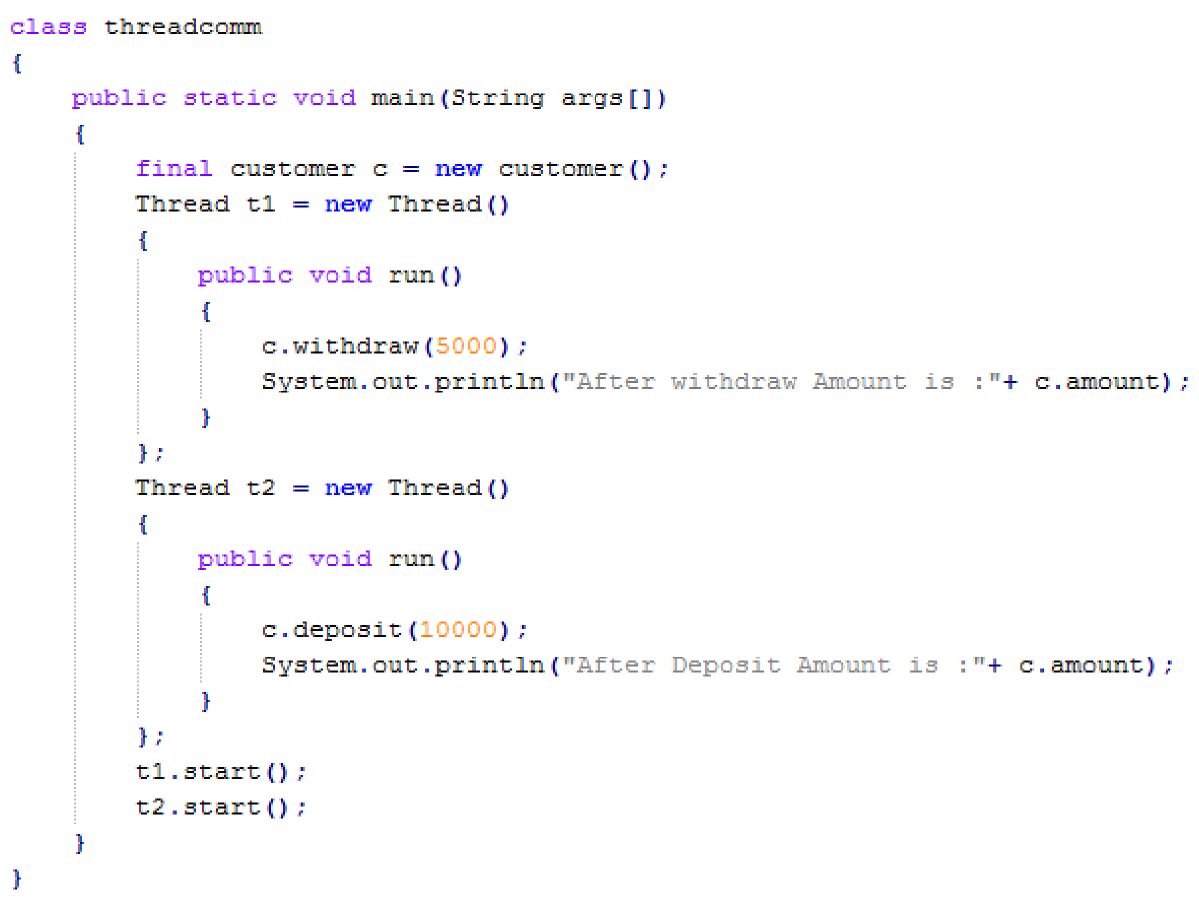
These methods are implemented as final methods in Object, so all classes have them. All three methods can be called only from within a synchronized context.

### Example



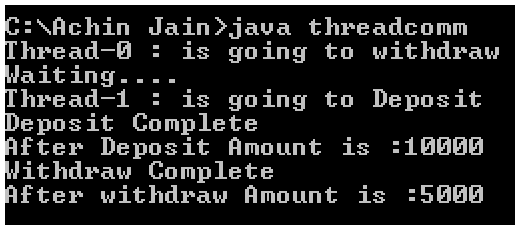
```
class customer
{
int amount = 0;
int flag = 0;
public synchronized int withdraw(int amount)
{
    System.out.println(Thread.currentThread().getName()+" : is going to withdraw");
    if(flag==0)
    {
        try
        {
            System.out.println("Waiting....");
            wait();
        }
        catch(Exception e)
        {
        }
    }
    this.amount-=amount;
    System.out.println("Withdraw Complete");
    return amount;
}
public synchronized void deposit(int amount)
{
    System.out.println(Thread.currentThread().getName()+" : is going to Deposit");
    this.amount+=amount;
    notifyAll();
    System.out.println("Deposit Complete");
    flag=1;
}
}
```

If both these methods are commented which means there is no communication, output will be inconsistent. See **Output 2**



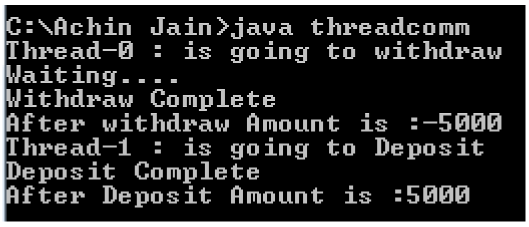
```
class threadcomm
{
    public static void main(String args[])
    {
        final customer c = new customer();
        Thread t1 = new Thread()
        {
            public void run()
            {
                c.withdraw(5000);
                System.out.println("After withdraw Amount is :"+ c.amount);
            }
        };
        Thread t2 = new Thread()
        {
            public void run()
            {
                c.deposit(10000);
                System.out.println("After Deposit Amount is :"+ c.amount);
            }
        };
        t1.start();
        t2.start();
    }
}
```

**Output 1:**



```
C:\Achin Jain>java threadcomm
Thread-0 : is going to withdraw
Waiting....
Thread-1 : is going to Deposit
Deposit Complete
After Deposit Amount is :10000
Withdraw Complete
After withdraw Amount is :5000
```

**Output 2:**



```
C:\Achin Jain>java threadcomm
Thread-0 : is going to withdraw
Waiting....
Withdraw Complete
After withdraw Amount is :-5000
Thread-1 : is going to Deposit
Deposit Complete
After Deposit Amount is :5000
```