Object Oriented Programming with JAVA

Module 4-Exception Handling

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Introduction

- An exception is an event, which occurs during the execution of a program, that disrupts the normal flow of the program's instructions.
- An exception is an abnormal condition that arises in a code sequence at run time.
- A Java exception is an object that describes an exceptional (that is, error) condition that has occurred in a piece of code.
- In other words, "An exception is a run-time error."

Exception Handling

- statement 1;
- statement 2;
- statement 3;
- statement 4;
- statement 5;//exception occurs
- statement 6;
- statement 7;
- statement 8;
- statement 9;
- statement 10;
- Suppose there is 10 statementsin your program and there
  occurs an exception at statement 5, rest of the code will not be executed i.e. statement 6 to 10 will not run.
- If we perform exception handling, rest of the statement will be executed. That is why we use exception handling in java.

Exception Handling

- An Exception is a run-time error that can be handled programmatically in the application and does not result in abnormal program termination.
- Exception handling is a mechanism that facilitates programmatic handling of run-time errors.
- In java, each run-time error is represented by an object.

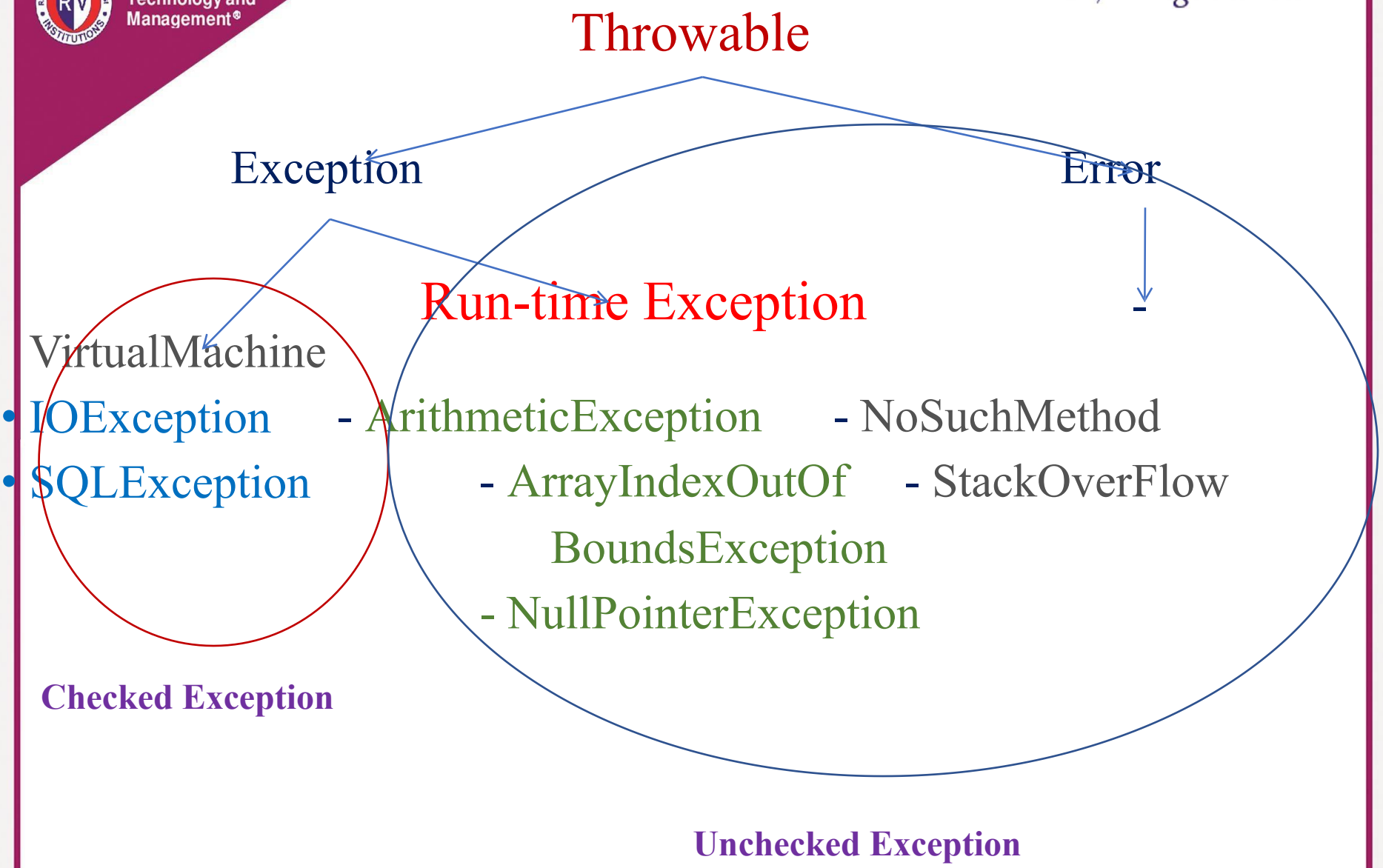
Exception (Class Hierarchy)

- At the root of the class hierarchy, there is a class named *'Throwable'* which represents the basic features of run-time errors.

- There are two non-abstract sub-classes of Throwable.
  - Exception : can be handled
  - Error : can't be handled

- *RuntimeException* is the sub-class of Exception.

- Each exception is a run-time error but all run-time errors are not exceptions.


Throwable
Exception
Error
Run-time Exception
VirtualMachine
IOException
SQLException
- ArithmeticException
- ArrayIndexOutOf BoundsException
- NullPointerException
- NoSuchMethod
- StackOverFlow
Checked Exception
Unchecked Exception

Checked Exception

- Checked Exceptions are those, that have to be *either caught or declared to be thrown* in the method in which they are raised.

Unchecked Exception

- Unchecked Exceptions are those that are *not* forced by the compiler either to be caught or to be thrown.

- Unchecked Exceptions either represent common programming errors or those run-time errors that can't be handled through exception handling.

Commonly used sub-classes of Exception

- ArithmeticException
- ArrayIndexOutOfBoundsException
- NumberFormatException
- NullPointerException
- IOException

Commonly used sub-classes of Errors

- VirualMachineError
- StackOverFlowError
- NoClassDefFoundError
- NoSuchMethodError

Scenarios where exceptions may occur

1) Scenario where ArithmeticException occurs

If we divide any number by zero, there occurs an ArithmeticException.

```
int a=50/0;//ArithmeticException
```

2) Scenario where NullPointerException occurs

If we have null value in any variable, performing any operation by the variable occurs an NullPointerException.

```
String s=null;

System.out.println(s.length());//NullPointerExcepti
on
```

3) Scenario where NumberFormatException occurs

The wrong formatting of any value, may occur NumberFormatException. Suppose I have a string variable that have characters, converting this variable into digit will occur NumberFormatException.

```
String s="abc";
int i=Integer.parseInt(s);//NumberFormatException
```

4) Scenario where ArrayIndexOutOfBoundsException occurs

If you are inserting any value in the wrong index, it would result ArrayIndexOutOfBoundsException as shown below:

```
int a[]=new int[5];
a[10]=50; //ArrayIndexOutOfBoundsException
```

Uncaught Exceptions


```
class Exception_Demo
{
        public static void main(String args[])
            {
                int d = 0;
                int a = 42 / d;
            }
 }
```

- When the Java run-time system detects the attempt to divide by zero, it constructs a new exception object and then throws this exception.
- Once an exception has been thrown, it must be caught by an exception handler and dealt with immediately.

- In the previous example, we haven't supplied any exception handlers of our own.

- So the exception is caught by the default handler provided by the Java run-time system.

- Any exception that is not caught by your program will ultimately be processed by the default handler.

- The default handler displays a string describing the exception, prints a stack trace from the point at which the exception occurred, and terminates the program.

java.lang.ArithmeticException: / by zero at Exc0.main(Exc0.java:4)

Why Exception Handling?

- When the default exception handler is provided by the Java run-time system , why Exception Handling?

- Exception Handling is needed because:
  - It allows to fix the error, customize the message .
  - It prevents the program from automatically terminating

Keywords for Exception Handling

- try
- catch
- throw
- throws
- finally

Keywords for Exception Handling

try

- Java try block is used to enclose the code that might throw an exception. It must be used within the method.

```
try { Statements whose execution may cause an exception
    }
```

Note: try block is always used either with catch or finally or with both.

Keywords for Exception Handling

catch

- catch is used to define a handler.
- It contains statements that are to be executed when the exception represented by the catch block is generated.
- If program executes normally, then the statements of catch block will not executed.
- If no catch block is found in program, exception is caught by JVM and program is terminated.

- It must be used after the try block only.
- You can use multiple catch block with a single try.

Problem without exception handling

```
public class Testtrycatch1
{
public static void main(String args[])
{
   int data=50/0;//may throw exception
   System.out.println("rest of the code...");
}
}
```

Output:

Exception in thread main java.lang.ArithmeticException:/ by zero

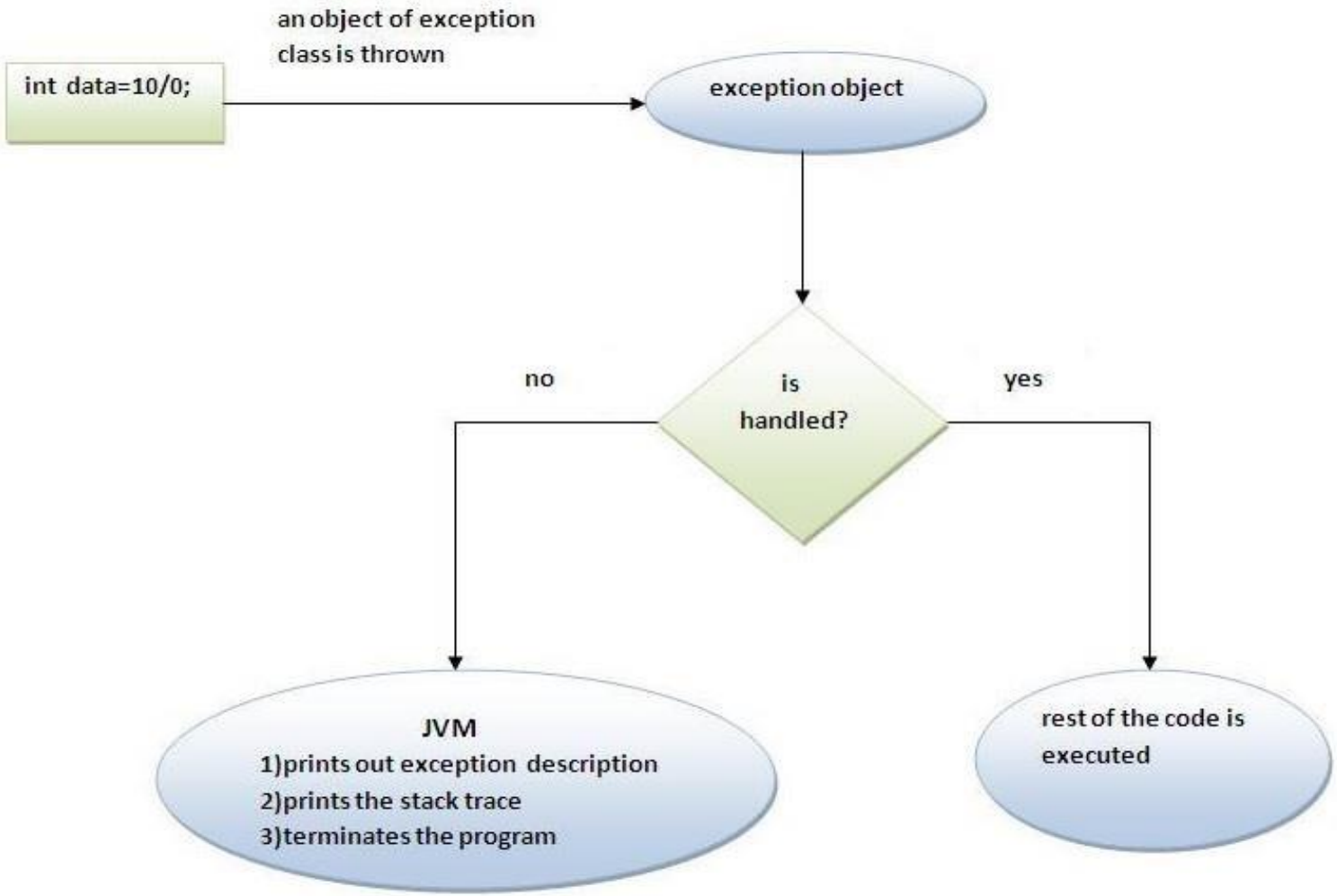
Solution by exception handling

```
public class Testtrycatch2
{
public static void main(String args[])
{
try
{
 int data=50/0;
}
catch(ArithmeticException
e){System.out.println(e);}  System.out.println("rest
of the code...");
}
}
```

Output:

Exception in thread main java.lang.ArithmeticException:/ by zero

Internal working of java try-catch block



- The JVM firstly checks whether the exception is handled or not. If exception is not handled, JVM provides a *default exception handler* that performs the following tasks:

- Prints out exception description.
- Prints the stack trace (Hierarchy of methods where the exception occurred).
- Causes the program to terminate.

- But if exception is handled by the application programmer, *normal flow* of the application is maintained i.e. rest of the code is executed.

- Rule1: At a time only one Exception is occured and at a time only one catch block is executed.

- Rule2: All catch blocks must be ordered from most specific to most general i.e. catch for ArithmeticException must come before catch for Exception .

```
class TestMultipleCatchBlock1
{
public static void main(String args[])
{
Try
{
int a[]=new int[5];
 a[5]=30/0;
 }
catch(Exception e){System.out.println("common task completed");}
catch(ArithmeticException e){System.out.println("task1 is completed");}
catch(ArrayIndexOutOfBoundsException e){System.out.println("task 2 completed");}
System.out.println("rest of the code...");
 }
}
```

Output:

Compile-time error

Nested try block

Sometimes a situation may arise where a *part of a block may cause one error* and the entire block itself may cause another error. In such cases, exception handlers have to be nested.

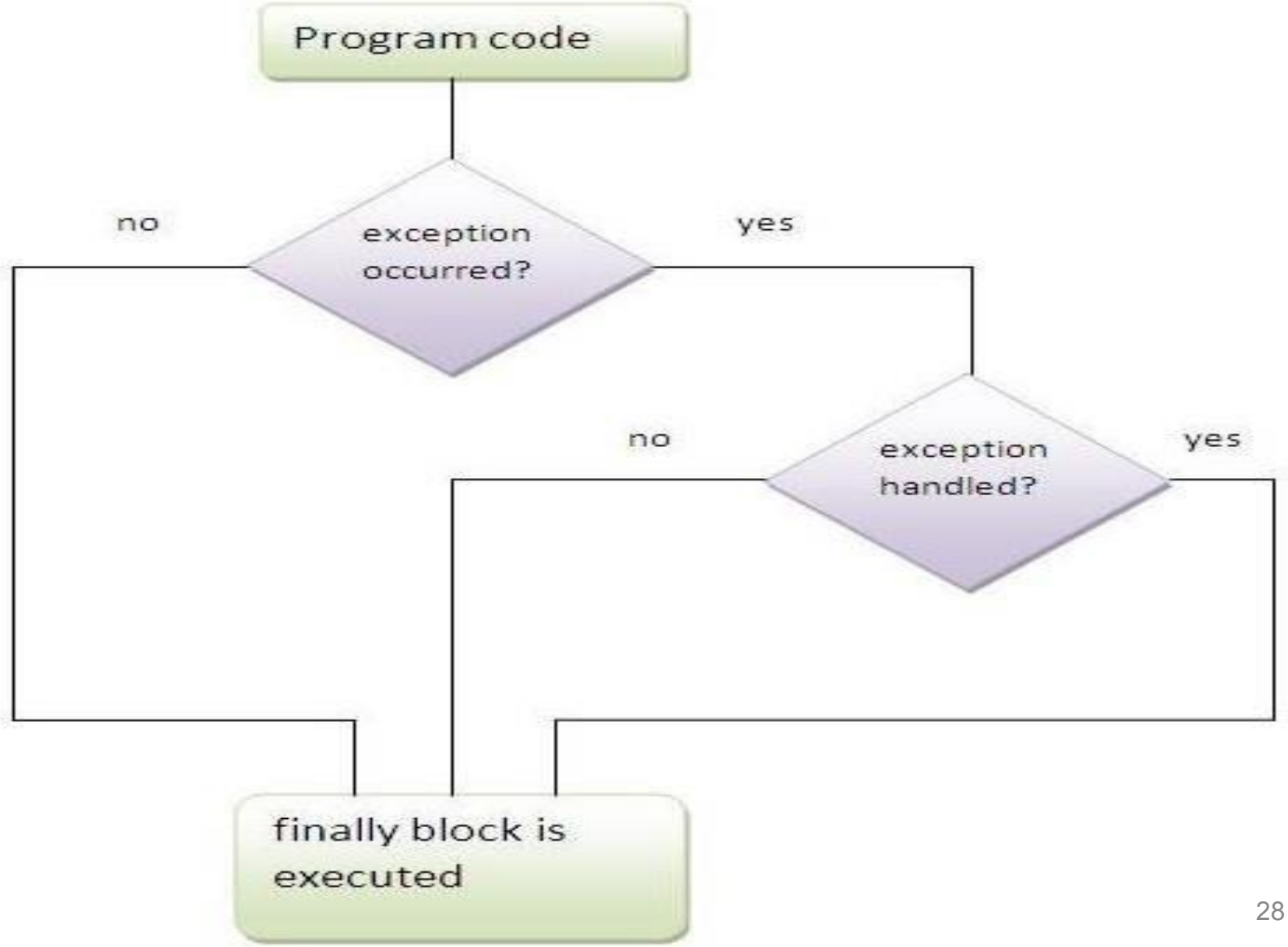
- **Syntax:**
- ....
- try
- {
- statement 1;
- statement 2;
- try
- {
- statement 1;
- statement 2;
- }
- catch(Exception e)
- {
- }
- }
- catch(Exception e)
- {
- }

```
class Excep6{
public static void main(String args[]){
 try{
  try{
   System.out.println("going to divide");
   int b =39/0;
  }catch(ArithmeticException e){System.out.println(e);}

  try{
  int a[]=new int[5];
  a[5]=4;
  }catch(ArrayIndexOutOfBoundsException
  e){System.out.println(e);}

   System.out.println("other statement");
 }catch(Exception e){System.out.println("handeled");}

 System.out.println("normal flow..");
 }
}
```

Java finally block

- Java finally block is always executed whether exception is handled or not.
- **Java finally block** is a block that is used *to execute important code* such as closing connection, stream etc.
- Java finally block follows try or catch block.

Execution of Finally



Example: Exception Doesn't Occur

```
class TestFinallyBlock{
  public static void main(String args[]){
  try{
   int data=25/5;
   System.out.println(data);
  }
  catch(NullPointerException e){System.out.println(e);}
  finally{System.out.println("finally block is always executed");}
  System.out.println("rest of the code...");
  }
}
```

Output:5

finally block is always executed

rest of the code...

Example: Exception Occurs & Not Handled

```
class TestFinallyBlock1{
  public static void main(String args[]){
  try{
   int data=25/0;
   System.out.println(data);
  }
  catch(NullPointerException e){System.out.println(e);}
  finally{System.out.println("finally block is always executed");}
  System.out.println("rest of the code...");
  }
}
```

Output:finally block is always executed

Exception in thread main java.lang.ArithmeticException:/ by zero

Java throw Exception

- The Java throw keyword is used to explicitly throw an exception.
- We can throw either checked or unchecked exception in java by throw keyword. The throw keyword is mainly used to throw *custom exception.*
- If you are *creating your own Exception* that is known as custom exception or user-defined exception. Java custom exceptions are used to customize the exception according to user need.
- By the help of custom exception, you can have your own exception and message.
- The syntax of java throw keyword is given below.

```
throw exception;
```

throw

- used for explicit exception throwing.

throw(Exception obj);

'throw' keyword can be used:

- to throw user defined exception
- to customize the message to be displayed by predefined exceptions
- to re-throw a caught exception

- Note: System-generated exceptions are automatically thrown by the Java run-time system.

Example


```
public class TestThrow1
{
 static void validate(int age)
{
  if(age<18)
throw new ArithmeticException("not valid");
 else
System.out.println("welcome to vote");
 }
public static void main(String args[])
{
 validate(13);
System.out.println("rest of the code...");
}
}
```

Output:

Exception in thread main java.lang.ArithmeticException: not valid

Java throws keyword

- The **Java throws keyword** is used to *declare an exception*.

- It gives an information to the programmer that there may occur an exception so it is better for the programmer to *provide the exception handling code* so that normal flow can be maintained.

- Exception Handling is mainly used to handle the checked exceptions.

- If there occurs any unchecked exception such as NullPointerException, it is programmers fault that he is not performing check up before the code being used.

- **Syntax of java throws**

```
return_type method_name() throws exception_class_name
{
//method code
}
```

- **Which exception should be declared**
- **Ans)** ***checked exception only***, because:
- **unchecked Exception:** under your control so correct your code.
- **error:** beyond your control e.g. you are unable to do anything if there occurs VirtualMachineError or StackOverflowError.
- **Advantage of Java throws keyword**
- Now Checked Exception can be propagated (forwarded in call stack).
- It provides information to the caller of the method about the exception.

- **Rule: If you are calling a method that declares an exception, you must either caught or declare the exception.**

- There are two cases:
- **Case1:**You caught the exception i.e.*handle the exception using try/catch.*
- **Case2:**You declare the exception i.e. *specifying throws with the method.*

• Case2: Declare the exception

- A)In case you declare the exception, if exception does not occur, the code will be executed fine.

- B)In case you declare the exception if exception occures, an exception will be thrown at runtime because throws does not handle the exception.

A)Program if exception does not occur

```
import java.io.*;
class M
    {
            void method()throws IOException
            {
                    System.out.println("device operation performed");
            }
    }
class Testthrows3
    {
            public static void main(String args[])throws IOException
                    {//declare exception
                            M m=new M();
                            m.method();
                            System.out.println("normal flow...");
                    }
    }
```

Output: device operation performed

normal flow...

B)Program if exception occurs

```
import java.io.*;
class M
{
    void method()throws IOException
    {
            throw new IOException("device error");
    }
}
class Testthrows4
{
     public static void main(String args[]) throws IOException
            {//declare exception
                    M m=new M();
                     m.method();
                    System.out.println("normal
                    flow...");
             }
}
```

Output:Runtime Exception

Difference between throw and throws

No.	throw	throws
1)	Java throw keyword is used to explicitly throw an exception.	Java throws keyword is used to declare an exception.
2)	Checked exception cannot be propagated using throw only.	Checked exception can be propagated with throws.
3)	Throw is followed by an instance.	Throws is followed by class.
4)	Throw is used within the method.	Throws is used with the method signature.
5)	You cannot throw multiple exceptions.	You can declare multiple exceptions e.g. public void method()throws IOException,SQLException.

Java throw example

```
void m()
{
throw new
ArithmeticException("sorry");
}
```

- **Java throws example**

```
void m()throws ArithmeticException
{
//method code
}
```

- **Java throw and throws example**

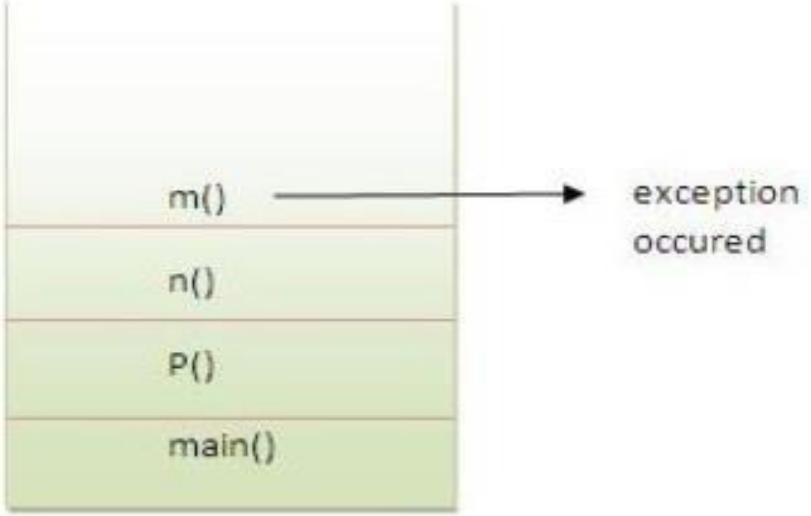
```
void m()throws ArithmeticException
{
throw new
ArithmeticException("sorry");
}
```

Java Exception Propagation

- An exception is first thrown from the top of the stack and if it is not caught, it drops down the call stack to the previous method,If not caught there, the exception again drops down to the previous method, and so on until they are caught or until they reach the very bottom of the call stack. This is called exception propagation.

- **Rule: By default Unchecked Exceptions are forwarded in calling chain (propagated).**

- In the above example exception occurs in m() method where it is not handled,
- So it is propagated to previous n() method where it is not handled, again it is propagated to p() method where exception is handled.
- Exception can be handled in any method in call stack either in main() method,p() method,n() method or m() method.



Call Stack

Defining Generalized Exception Handler

- A generalized exception handleris onethatcan handle the exceptions of all types.

- If a class has a generalized as well as specific exception handler, then the generalized exception handler must be the last one.

```
class Divide{
    public static void main(String arr[]){
                try {
                        int a= Integer.parseInt(arr[0]);
                        int b=
                        Integer.parseInt(arr[1]);
                        int c = a/b;
                       System.out.println("Result is: "+c);
                    }
                catch (Throwable e)
                    {
                        System.out.println(e);
                    }
            }
}
```

Defining Custom Exceptions

- We can create our own Exception sub-classes by inheriting Exception class.
- The Exception class does not define any methods of its own.
- It inherits those methods provided by Throwable.
- Thus, all exceptions, including those that we create, have the methods defined by Throwable available to them.

Constructor for creating Exception

- Exception( )
- Exception(String msg)

- A custom exception class is represented by a subclass of *Exception / Throwable.*

- It contains the above mentioned constructor to initialize custom exception object.

```
class Myexception extends Throwable
    {
     public Myexception(int i)
       {
        System.out.println("you have entered ." +i +"   : It
  exceeding  the limit");
       }
     }
```

Try with Resource Statement

- JDK 7 introduced a new version of try statement known as try-with-resources statement.
- This feature add another way to exception handling with resources management
- It is also referred to as automatic resource management.

Syntax:

```
try(resource-specification)
        { //use the resource }
catch(Exception ex) {...}
```

Try with Resource Statement

- The try statement contains a parenthesis in which one or more resources is declared.
- Any object that implements java.lang.AutoCloseable or java.io.Closeable, can be passed as a parameter to try statement.
- A resource is an object that is used in program and must be closed after the program is finished.
- The try-with-resources statement ensures that each resource is closed at the end of the statement, you do not have to explicitly close the resources.