

# Contents

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- Errors and Exception
- Exception Handling Mechanism
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- Specifying Exceptions

# Quiz 1

## □ What is an error?

- An error is a term used to describe any issue that arises unexpectedly and results in incorrect output.

## □ What are the different types of errors?

- Logical error:
  - Occur due to poor understanding of problem or solution procedure.
- Syntactic error:
  - Arise due to poor understanding of the language itself.

## □ What is an exception?

- Exceptions are run time anomalies or unusual conditions that a program may encounter while executing.

# Exception Handling

- Exceptions are of two types:
  - **Synchronous exceptions**
    - The exceptions which occur during the program execution due to some fault in the input data are known as synchronous exceptions.
    - For example: errors such as out of range, overflow, underflow.
  - **Asynchronous exceptions.**
    - The exceptions caused by events or faults unrelated (external) to the program and beyond the control of the program are called asynchronous exceptions.
    - For example: errors such as keyboard interrupts, hardware malfunctions, disk failure.

# Exception Handling Mechanism

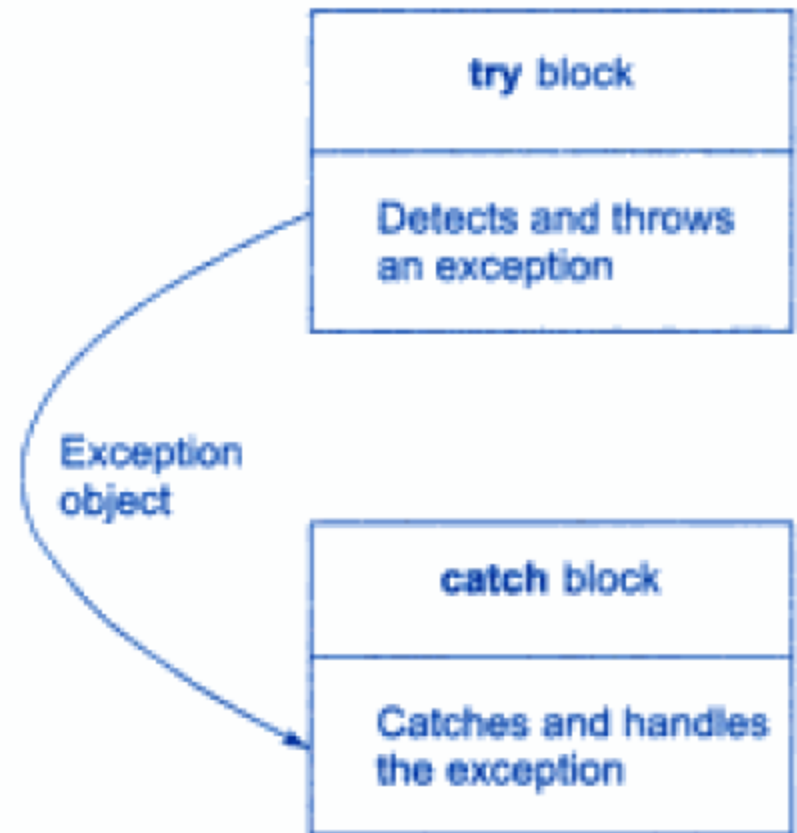
- Exception handling mechanism provides a means to detect and report an exception circumstances.
  - Find the problem (Hit the exception)
  - Inform that an error has occurred (Throw the exception)
  - Receive the error information (Catch the exception)
  - Take corrective actions (Handle the exception)
- The error handling consists of two segments

# Exception Handling Mechanism

- The exception handling mechanism is built upon three keywords:
  - Try
    - Is used to preface a block of statements which may generate exceptions.
  - Throw
    - When an exception is detected, it is thrown using a throw statement in the try block.
  - Catch
    - A catch block defined by the keyword catch catches the exception thrown by the throw statement in the try block and handles it appropriately.

# Exception Handling Mechanism

- When the try block throws an exception the program control leaves the try block and enters the catch statement of the catch block.
- If the type of object thrown matches the arg type in the catch statement the catch block is executed.
- Otherwise the program is terminated with the help of `abort( )` function.

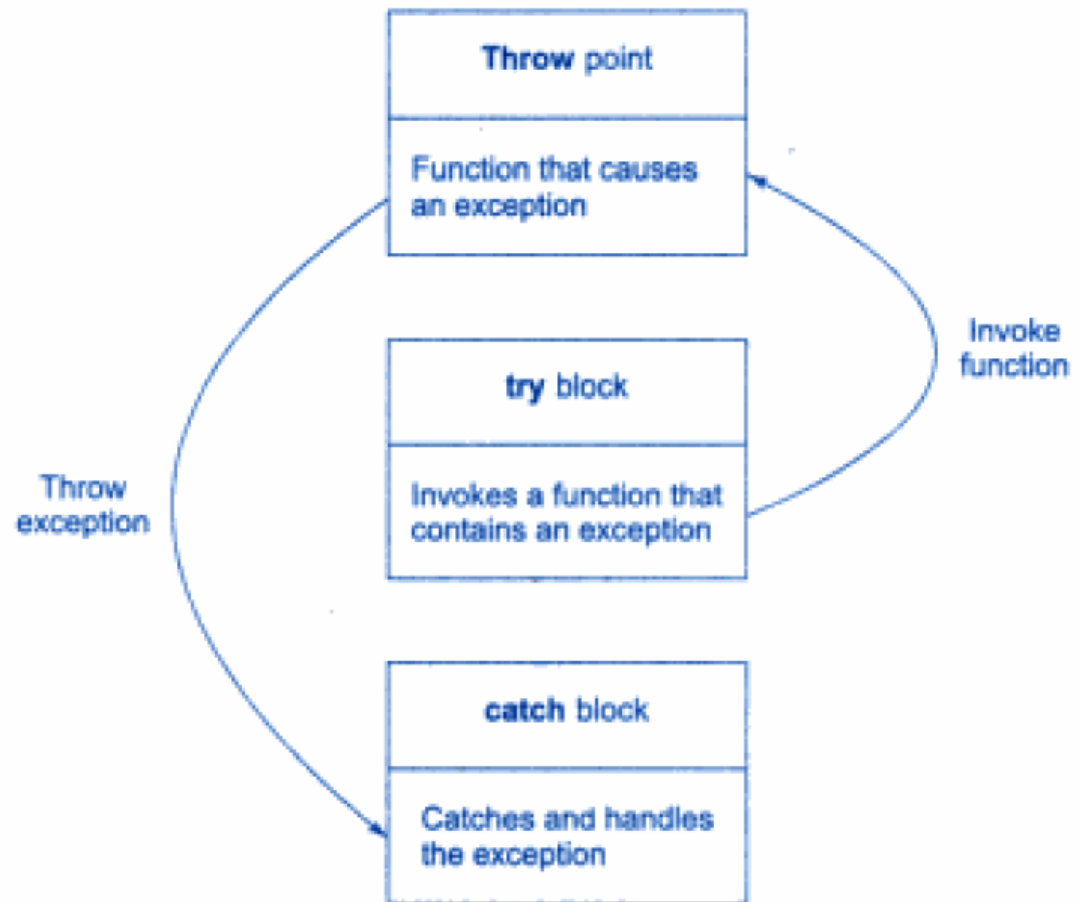


# Try block throwing an exception

```
int main()
{
    int a,b;
    cout<<"enter the values of a
    and b :";
    cin>>a;
    cin>>b;
    int x = a-b;
    try
    {
        if(x != 0)
        {
            cout<<"Result (a/x) ="
                << a/x;
        }
    }
    else
    {
        throw(x);
    }
}
catch(int i)
{
    cout<<"Exception Caught
    :          x = " << x << "\n";
}
return 0;
}
```

# Exceptions thrown by functions

- Mostly exceptions are thrown by functions that are invoked from within the try blocks.
- The point at which the throw is executed is called the throw point.





# Exceptions thrown by functions

```
void divide(int x, int y, int z)
{
    if((x-y) != 0)
    {
        int R = z/(x-y);
        cout << "Result = " << R << "\n";
    }
    else
    {
        throw (x-y);
    }
}
```

# Exceptions thrown by functions

```
int main()
{
    try
    {
        divide(10,20,30);
        divide(10,10,20);
    }
    catch(int i)
    {
        cout << "\n Exception caught" ;
    }
    return 0;
}
```

# Throwing Mechanism

- When an exception is desired to be handled is detected, it is thrown using the throw statement.
- Throw statement has one of the following forms:
  - `throw(exception);`
  - `throw exception;`
  - `throw;`
- The operand object exception may be of any type, including constants.

# Catching Mechanism

- A catch block looks like a function definition:

```
catch(type arg)

{

    // statements for managing exceptions.

}
```

- The type indicates the type of exception that catch block handles.
- The catch statement catches an exception whose type matches with the type of catch argument.

# Multiple Catch Statements

- Multiple catch statements can be associated with a try block.
- When an exception is thrown, the exception handlers are searched for an appropriate match.
- The first handler that yields the match is executed.
- After executing the handler, the controls goes to the first statement after the last catch block for that try.

# Multiple Catch Statements

```
void test(int x)
{
    try
    {
        if (x==1) throw x;
        else
            if(x==0) throw 'x';
        else
            if(x== -1) throw 1.0;
        cout<<"\nEnd of try-block";
    }
}
```

```
    catch(char c)    // catch 1
    {
        cout<<"\nCaught a character";
    }
    catch(int m)    // catch 2
    {
        cout<<"\nCaught an integer";
    }
    catch(double d)    // catch 3
    {
        cout<<"\nCaught a double";
    }

    cout<<"\n End of try-catch block";
```

# Multiple Catch Statements

```
int main( )  
{  
    cout<<"\n x == 1";  
    test(1);  
    cout<<"\n x == 0";  
    test(0);  
    cout<<"\n x == -1";  
    test(-1);  
    cout<<"\n x == 2";  
    test(2);  
    return 0;  
}
```

x == 1  
Caught an integer  
End of try-catch system

x == 0  
Caught a character  
End of try-catch system

x == -1  
Caught a double  
End of try-catch system

x == 2  
End of try-block  
End of try-catch system

# Catch all Exceptions

- Sometimes it is not possible to anticipate all possible types of exceptions and therefore not able to design independent catch handlers to catch them.
- A catch statement can also force to catch all exceptions instead of a certain type alone.
- Syntax:  

```
catch (...)  
{  
  // statements for processing all exceptions.  
}
```



# Catch all Exceptions

```
void test(int x)
{
    try
    {
        if (x==1) throw x;
        else
            if(x==0) throw 'x';
        else
            if(x== -1) throw 1.0;
        cout<<"\nEnd of try-
        block";
    }
}
catch(...)
{
    cout<<"\n Caught an
    exception";
}
```

```
int main( )
{
    cout<<"\nTesting generic
    catch";
    test(1);
    test(0);
    test(-1);
    test(2);
    return 0;
}
```

# Re-throwing an Exception

- A handler can re-throw the exception caught without processing it.
- This can be done using **throw** without any arguments.
- Here the current exception is thrown to the next enclosing try/catch block.
- Every time when an exception is re-thrown it will not be caught by the same catch statements rather it will be caught by the catch statements outside the try catch block.

# Re-throwing an Exception

```
void divide(double x, double y)
{
    cout<<"Inside Function";
    try
    {
        if(y == 0.0)
            throw y;
        else
            cout<<"Division = " <<x/y<<"\n";
    }
    catch(double)
    {
        cout<<"\nCaught double inside function";
        throw;
    }
    cout<<"\n End of function";
}
```

```
int main()
{
    cout<<"\n Inside main";
    try
    {
        divide(10.5, 2.0);
        divide(20.0, 0.0);
    }
    catch(double)
    {
        cout<<"\n Caught double   inside
main";
    }
    cout<<"\n End of main";
    return 0;
}
```

# Specifying Exceptions

- It is possible to restrict a function to throw only certain specified exceptions.
- This is done by adding a throw list clause to the function definition.

```
type function(arg-list) throw (type-list)
{
.....
.....
}
```

- The type-list specifies the type of exceptions that may be thrown.
- Throwing other type of exceptions cause abnormal termination of program.

# Specifying Exceptions

```
void test(int x) throw (int, double)
```

```
{
```

```
    if (x==0) throw 'x';
```

```
    else
```

```
        if(x==1) throw x;
```

```
    else
```

```
        if(x== -1) throw 1.0;
```

```
    cout<<"\n End of function block";
```

```
}
```

```
int main( )
```

```
{
```

```
    try
```

```
    {
```

```
        cout<<"\nTesting throw restrictions";
```

```
        cout<<"\n x==0";
```

```
        test(0);
```

```
        cout<<"\n x==1";
```

```
        test(1);
```

```
        cout<<"\n x== -1";
```

```
        test(-1);
```

```
        cout<<"\n x== 2";
```

```
        test(2);
```

```
    }
```

```
        Catch(char c)
```

```
        {
```

```
            cout<<"\n Caught a character";
```

```
        }
```

```
        Catch(int m)
```

```
        {
```

```
            cout<<"\n Caught a integer";
```

```
        }
```

```
        Catch(double d)
```

```
        {
```

```
            cout<<"\n Caught a double";
```

```
        }
```

```
        Cout<<"\n End of try catch block";
```

```
        return 0;
```

# Summary

- \_\_\_\_\_ are peculiar problems that a program may encounter at run time.
- Exceptions are of two types \_\_\_\_\_ and \_\_\_\_\_.
- An exception is caused by a faulty statement in \_\_\_\_\_ block, which is caught by \_\_\_\_\_ block.
- We can place two or more catch blocks to catch and handle multiple types of exceptions. (True/ False).
- It is also possible to make a catch statement to catch all types of exception. (True/ False)
- We cannot restrict a function to throw a specified exceptions. (True /

# Short Answer Questions

- What is an exception?
  - Exceptions are run time anomalies or unusual conditions that a program may encounter while executing.
- How is exception handled in C++?
  - In C++ the exception is handled using the three keywords try, throw and catch. Or try-catch mechanism.
- What are the advantages of using exception handling mechanism in a program?
  - The purpose of exception handling mechanism is to provide a means to detect and report an exceptional circumstances so that appropriate action can be taken and prevent abnormal termination of program.

# Short Answer Questions

- When should a program throw an exception?
  - There are some situation when a program come across unexpected errors and cause abnormal termination of program. To handle such errors and prevent program from termination exceptions are thrown and handled.
- What should be placed inside the try block?
  - The statement that may generate an exception are placed in the try block.
- When do we use multiple catch handlers?
  - Multiple catch handlers are used in a situation where a program has more than one condition to throw and exception.



# Short Answer Questions

- Explain under what circumstances the following statements would be used:
  - `throw;`
    - Re-throwing an exception.
  - `void fun1(float x) throw();`
    - Prevent a function from throwing any exception.
  - `catch( ... )`
    - Used to catch all types of exceptions.

# References

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- Object Oriented Programming with C++ by E. Balagurusamy.



# INTRODUCTION

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- Template enable us to define generic classes and functions and thus provides support for generic programming.
- Generic programming is an approach where generic types are used as parameters in algorithms so that they work for a variety of data types.



# INTRODUCTION

---

- A template can be used to create a family of classes or functions.
- For eg: a class template for an array class would enable us to create arrays of various data types such as: int, float etc.
- Templates are also known as parameterized classes or functions.
- Template is a simple process to create a generic class with an anonymous type.



# Class Templates

---

- The class template definition is very similar to an ordinary class definition except the prefix template <class T> and the use of type T.
- A class created from class template is called a template class.
- Syntax:
  - `classname<type> objectname(arglist)`
- The process of creating a specific class from a class template is called instantiation.

# Class Templates

---

- General format of class template is:

```
template <class T>
```

```
class classname
```

```
{
```

```
    //.....
```

```
    //class member specification with
```

```
    //anonymous type T wherever appropriate
```

```
    //.....
```

```
};
```

# Class Templates (Example)

```
class vector
```

```
{  
    int *v;  
    int size;  
    public:  
        vector (int m)  
        {  
            v= new int [ size = m];  
            for(int i=0; i<size; i++)  
                v[i]=0;  
        }  
        vector (int * a)  
        {  
            for(int i=0; i<size; i++)  
                v[i]=a[i];  
        }  
        int operator * (vector &y)  
        {  
            int sum=0;  
            for (int i=0; i<size; i++)  
                sum += this -> v[i] * y . v[i];  
            return sum;  
        }  
}
```

```
int main()
```

```
{  
    int x[3] = {1,2,3};  
    int y[3]= {4,5,6};  
  
    vector v1(3);  
    vector v2(3);  
  
    v1 = x ;  
    v2 = y ;  
  
    int R = v1 * v2 ;  
    cout<< " R = " << R ;  
  
    return 0;  
}
```

# Class Templates (Example)

```
const size = 3;
template<class T>
class vector
{
    T * v;
public:
    vector()
    {
        v=new T[size];
        for(int i=0; i<size; i++)
            v[i] = 0;
    }
    vector(T * a)
    {
        for(int i=0; i<size; i++)
            v[i] = a[i] ;
    }
}
```

```
T operator * (vector & y)
{
    T sum = 0;
    for(int i=0; i<size; i++)
    {
        sum += this->v[i] * y.v[i];
    }
    return sum;
}
}
```



# Class Templates (Example)

---

```
int main()
{
    int x[3] = {1,2,3};
    int y[3] = {4,5,6};
    vector<int> V1;
    vector<int> V2;
    V1 = x;
    V2 = y;
    int R = V1 * V2;
    cout << "R = " << R;
    return 0;
}
```

# Class Templates with Multiple Parameters

---

- We can use more than one generic data type in a class template.
- Syntax:

```
template <class T1, class T2>
```

```
    class classname
```

```
    {
```

```
        .....
```

```
        .....
```

```
        .....
```

```
    };
```

# Class Templates with Multiple Parameters

```
template<class T1, class T2>
class Test
{
    T1 a;
    T2 b;
public:
    Test(T1 x, T2 y)
    {
        a = x;
        b = y;
    }
    void show()
    {
        cout<<a;
        cout<<b;
    }
};
```

```
int main()
{
    Test <float, int> test1(1.23,123);
    Test <int, char> test2(100,'W');

    test1.show();
    test2.show();

    return 0;
}
```

Output:  
1.23  
123  
100  
W

# Function Templates

---

- Function templates are used to create a family of functions with different argument types.

- Syntax:

```
template <class T>
```

```
returntype functionname (arguments of type T)
```

```
{
```

```
.....
```

```
.....
```

```
}
```

# Function Template

---

```
Template <class T>
void swap (T &x, T &y)
{
    T temp = x;
    x = y;
    y = temp;
}
```

```
void fun(int m, int n,
        float a, float b)
{
    swap(m, n);
    swap(a, b);
}
```

```
int main()
{
    fun(100, 200, 11.22, 33.44);
    return 0;
}
```

# Function Template with Multiple Parameters

---

- We can have more than one generic data type in the function template.

```
template < class T1, class T2>
```

```
returntype functionname(arguments of type T1, T2...)
```

```
{
```

```
..... (Body of function)
```

```
.....
```

```
}
```

# Function Template with Multiple Parameters

---

```
template <class T1, class T2>
void display(T1 x, T2 y)
{
    cout<<x <<" " << y << "\n";
}
int main()
{
    display(1999, "XYZ");
    display (12.34, 1234);
    return 0;
}
```



# Overloading of Template Functions

---

- A template function may be overloaded either by template functions or ordinary functions of its name.
- The overloading is accomplished as follows:
  - Call an ordinary function that has an exact match.
  - Call a template function that could be created with an exact match.
  - Try normal overloading to ordinary function and call the one that matches.



# Overloading of Template Functions

---

```
template < class T>
void display(T x)
{
    cout<<"Template Display : " << x << "\n";
}
void display(int x)
{
    cout << "Explicit Display: " << x << "\n";
}
int main()
{
    display(100);
    display(12.34);
    display('C');
    return 0;
}
```

# Member Function Template

---

- Member functions of the template classes themselves are parameterized by the type argument.
- Thus, member functions must be defined by the function templates.
- Syntax:

```
Template <class T>
```

```
returntype classname <T> :: functionname(arglist)
```

```
{
```

```
..... // function body
```

```
.....
```

```
}
```

# Member Function Template (Example)

---

```
template<class T>
class vector
{
    T *v;
    int size;
    public:
    vector(int m);
    vector(T * a);
    T operator *(vector & y);
};
```

# Member Function Template (Example)

---

//member function templates....

```
template <class T>
vector<T> :: vector(int m)
{
    v = new T[size = m];
    for(int i=0; i<size; i++)
        v[i] = 0;
}
template <class T>
vector<T> :: vector(T * a)
{
    for(int i=0; i<size; i++)
        v[i] = a[i];
}
```

```
template <class T>
T vector<T> :: operator * (vector &y)
{
    T sum = 0;
    for (int i=0; i<size; i++)
        sum += this -> v[i] * y.v[i];

    return sum;
}
```

# Non-Type Template Arguments

---

- It is also possible to use non-type arguments.
- In addition to the type argument T, we can also use other arguments such as strings, int, float, built-in types.
- Example:

```
template <class T, int size>
class array
{
    T a[size];
    .....
    .....
};
```

# Non-Type Template Arguments

---

- This template supplies the size of the array as an argument.
- The argument must be specified whenever a template class is created.
- Example:
  - `array <int, 10> a1;      // Array of 10 integers`
  - `array <float, 5> a2;      // Array of 5 floats`
  - `array <char, 20> a3;      // String of size 20`



# Summary

---

- C++ supports template to implement the concept of \_\_\_\_\_.
- \_\_\_\_\_ allows to generate a family of classes or functions to handle different data types.
- A specific class created from a class template is called \_\_\_\_\_.
- The process of creating a template class is known as \_\_\_\_\_.
- Like other functions, template functions can be overloaded. (True/False)
- Non-type parameters can also be used as an arguments templates. (True/False)



# Short Answer Questions

---

- What is generic programming? How it is implemented in C++?
  - Generic programming is an approach where generic types are used as parameters in algorithms so that they work for a variety of data types.
  - Generic programming is implemented using the templates in C++.
- A template can be considered as a kind of macro. Then, what is the difference between them.
  - Macros are not type safe, that is a macro defined for integer operations cannot accept float data.





# Short Answer Questions

---

- Distinguish between overloaded functions and function templates.
  - Function templates involve telling a function that it will be receiving a specified data type and then it will work with that at compile time.
  - The difference with this and function overloading is that function overloading can define multiple behaviours of function with the same name and multiple/various inputs.



# Short Answer Questions

---

- Distinguish between class template and template class.
  - **Class template** is generic **class** for different types of objects. Basically it provides a specification for generating **classes** based on parameters.
  - Template classes are those classes that are defined using a class template.



# Short Answer Questions

---

- A class template is known as a parameterized class. Comment.
  - As template is defined with a parameter that would be replaced by a specified data type at the time of actual use of class it is also known as parameterized class.

# Short Answer Questions

---

- Write a function template for finding the minimum value contained in an array.

```
template <class T>
T findMin(T arr[],int n)
{
    int i;
    T min;
    min=arr[0];
    for(i=0;i<n;i++)
    {
        if(min > arr[i])
            min=arr[i];
    }
    return(min);
}
```

Example Program



# References

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- Object Oriented Programming with C++ by E. Balagurusamy.



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