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- Exception Handling Mechanism
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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

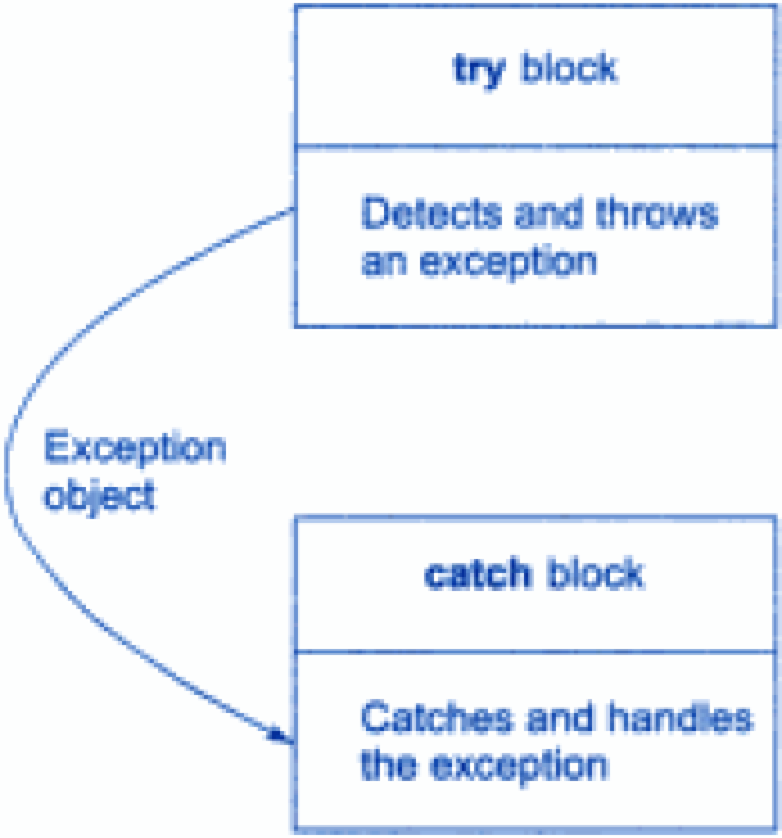
- Exception handling mechanism provides a means to detect and report an exception circumstances.
  - Find the problem (Hit the exception)
  - Inform that an error has occurred (Throw the exception)
  - Receive the error information (Catch the exception)
  - Take corrective actions (Handle the exception)
- 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 statment the catch block is executed.
- Otherwise the program is terminated with the help of abort( ) function.


try block
Detects and throws an exception
Exception object
catch block
Catches and handles the exception

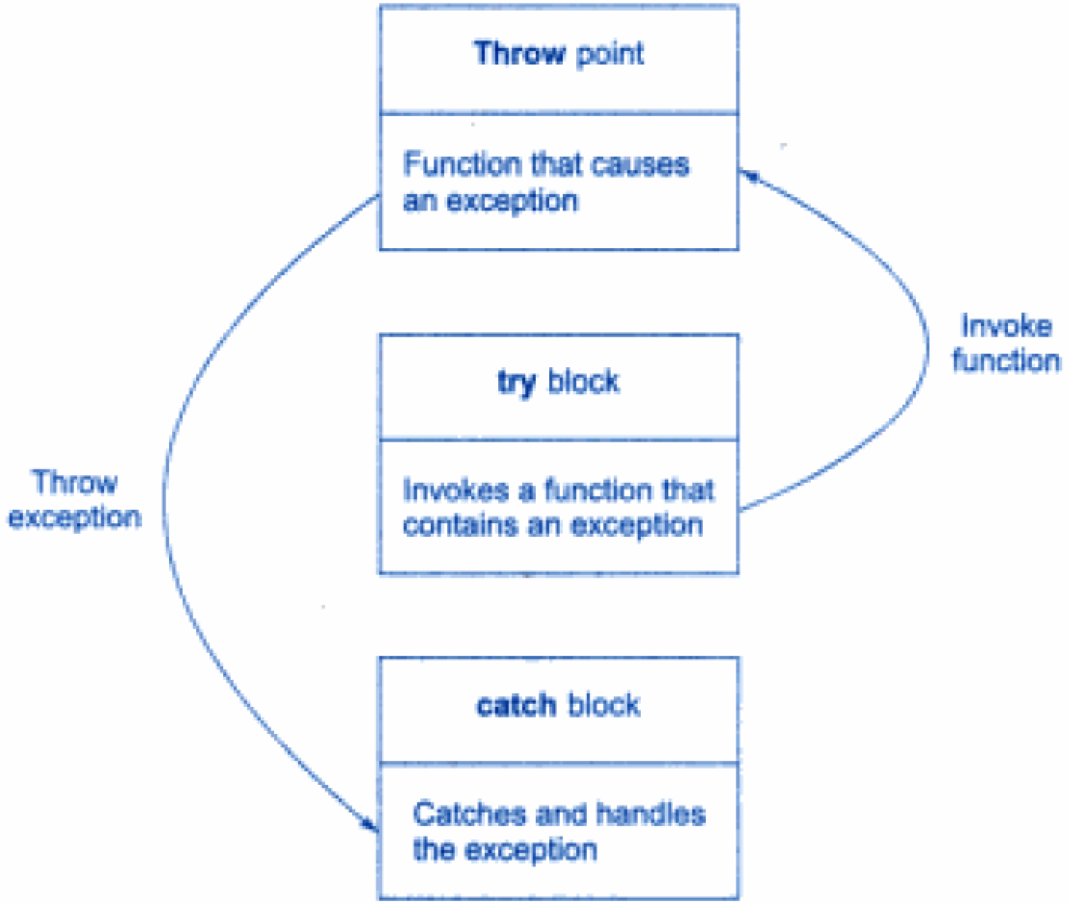
Try block throwing an exception

```
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.


Throw point
Function that causes an exception
Invoke function
try block
Invokes a function that contains an exception
Throw exception
catch block
Catches and handles the exception

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

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

INTRODUCTION

- 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

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

END OF UNIT ….