C++ Notes Day-7 Date: 12 June 2025

Revision

- Virtual Function and Pure Virtual Function
- Abstract Class and Abstract Function

Templates and Introduction to STL in C++

- Template
  - In C++, if we want to write typesafe generic code then we should use template.
  - template is keyword in C++.
  - In C++, by passing data type as a argument, we can write generic code. Hence paramerized type is called as template.
  - Example:

```
template<typename T> //T: Type Parameter
void swap_object( T &object1, T &object2 ){
T temp = object1;
object1 = object2;
object2 = temp;
}
int main( void ){
char ch1 = 'A';
char ch2 = 'B';
swap_object<char>( ch1, ch2 );
//char: Type argument
//ch1,ch2: function argument
cout << "ch1 : " << ch1 << endl;
cout << "ch2 : " << ch2 << endl;
return 0;
}
```

  - Example:

```
template<typename T>
T Add(T Num1, T Num2)
{
    return Num1+Num2;
}

int main()
{
    int Num1=100;
    int Num2=200;

    int Res=Add(Num1,Num2);
    cout<<"Sum of Two int is :  "<<Res<<endl;
```

```
    float Resf=Add(100.50f, 200.56f);
    cout<<"Sum of Two Float is :    "<<Resf<<endl;


    cout<<"Sum of Two Double is :   "<<Add(345.90,789.90)<<endl;
}
```

- We can use typename and class keyword interchangably.

```
template<class T> //T: Type Parameter
void swap_object( T &object1, T &object2 ){
T temp = object1;
object1 = object2;
object2 = temp;
}
```

- Process of identifing type and passing it as a argument implicilty to the function is called as type inference.

```
swap_object<char>( ch1, ch2 ); //OK
swap_object( ch1, ch2 ); //OK\
```

- Template feature is designed for the data structure.
- Using template, we can not reduce code size or execution time rather we can reduce developers effort/ development time.

- Types of template:
  - Function Template
  - Class Template
- Function template

```
template<class T> //T: Type Parameter
void swap_object( T &object1, T &object2 ){
 T temp = object1;
 object1 = object2;
 object2 = temp;
}
int main( void ){
 int a = 10;
 int b = 20;
 swap_object<int>( a, b );
 cout << "a : " << a << endl;
 cout << "b : " << b << endl;
 return 0;
}
```

- Class Template

```
#include <iostream>
using namespace std;
template<class T>
class MathOperations
{
public:
    T Val1;
    T Val2;
    void GetData()
    {
        cout<<"Enter 1st Element:   "<<endl;
        cin>>this->Val1;
        cout<<"Enter 2nd Element:   "<<endl;
        cin>>this->Val2;
    }
    void CompareData()
    {
        if(this->Val1>this->Val2)
        {
            cout<<"1st Element is Greater"<<endl;
        }
        else if(this->Val1<this->Val2)
        {
            cout<<"2nd Element is Greater"<<endl;
        }
        else
        {
            cout<<"1st and 2nd Element are equal"<<endl;
        }
    }
};
int main()
{
    MathOperations<int> in;
    in.GetData();
    in.CompareData();
    MathOperations<float> fl;
    fl.GetData();
    fl.CompareData();
    return 0;
}
```

Standard Template Library(STL)

- The Standard Template Library (STL) is a set of C++ template classes to provide common programming data structures and functions. STL has 4 components:
    - Algorithms
        - https://en.cppreference.com/w/cpp/algorithm

    - Containers
        - https://en.cppreference.com/w/cpp/container
    - Functors
        - https://en.cppreference.com/w/cpp/utility/functional
    - Iterators
        - https://en.cppreference.com/w/cpp/iterator
- C++ STL Containers
    - A container is an object that stores a collection of objects of a specific type.
    - Types of STL Container in C++
        - Sequential Containers
        - Associative Containers
        - Unordered Associative Containers
- Demo of Menu-Driven Student Management Application in C++ using

```
#include <iostream>
#include <vector>
using namespace std;

class Student
{
public:
    int RollNo;
    string Name;
    int Age;
    float Fees;

    Student()
    {
        this->RollNo=0;
        this->Name="";
        this->Age=0;
        this->Fees=0.0f;
    }
    Student(int RollNo, string Name, int Age, float Fees)
    {
        this->RollNo=RollNo;
        this->Name=Name;
        this->Age=Age;
        this->Fees=Fees;
    }

    void DisplayStudent()const
    {
        cout<<"Roll No: "<<this->RollNo<<" Name: "<<this->Name<<" Age: "<<this-
>Age<<" Fees: "<<this->Fees<<endl;
    }
};
class Admin
{
private:
    vector<Student> students;       //Statically created object,
```

```
Association:Coupling
    //vector<Student> stu=new vector<Student>();    //Dynamically created object
public:
Admin()
{
    students.push_back(Student(101,"Malkeet",34,45678.89f));
    students.push_back(Student(102,"Shubham",24,145678.89f));
    students.push_back(Student(103,"Ravi",25,5678.89f));
    students.push_back(Student(104,"Zeenat",21,9978.89f));
}
void AddStudent();
void DeleteStudent();
void UpdateStudent();
void GetAllStudent();
};
void Admin::AddStudent()
{
    Student s;
    cout<<"Enter Roll No: "<<endl;
    cin>>s.RollNo;
    cout<<"Enter Name: "<<endl;
    cin>>s.Name;
    cout<<"Enter Age: "<<endl;
    cin>>s.Age;
    cout<<"Enter Fees: "<<endl;
    cin>>s.Fees;

    students.push_back(s);
    cout<<"Student Added"<<endl;

}
void Admin::DeleteStudent()
{
    int rno;
    bool flag=false;
    cout<<"Enter the Roll No:"<<endl;
    cin>>rno;

    for(unsigned int i=0;i<students.size();i++)
    {
        if(students[i].RollNo==rno)
        {
            flag=true;
            students.erase(students.begin()+i);
            cout<<"Student Deleted"<<endl;
            break;
        }
    }
    if(flag==false)
    {
        cout<<"Student Not Found"<<endl;
    }

}
```

```
void Admin::UpdateStudent()
{
    int rno=0;
    bool flag=false;
    cout<<"Enter Roll No:"<<endl;
    cin>>rno;
    for(unsigned int i=0;i<students.size();i++)
    {

        if(students[i].RollNo==rno)
        {

            cout<<"Enter Name: "<<endl;
            cin>>students[i].Name;
            cout<<"Enter Age: "<<endl;
            cin>>students[i].Age;
            cout<<"Enter Fees: "<<endl;
            cin>>students[i].Fees;
            cout<<"Student Updated"<<endl;
            flag=true;
            break;
        }
    }
    if(flag==false)
    {
        cout<<"Student Not Found"<<endl;
    }

}
void Admin::GetAllStudent()
{
    for(Student s:students)
    {
        s.DisplayStudent();
    }
}
int main()
{
    int choice=0;
    Admin *ptr=new Admin();

    do
    {
        cout<<"----------------------------Student Admin-------------------------
-----"<<endl;
        cout<<"Press 1 to Add Student"<<endl;
        cout<<"Press 2 to Delete Student"<<endl;
        cout<<"Press 3 to Update Student"<<endl;
        cout<<"Press 4 to View All Student"<<endl;
        cout<<"Press 5 to Exit The Program"<<endl;
        cout<<"------------------------------------------------------------------
-----"<<endl;
        cout<<"Enter Your Choice: "<<endl;
        cin>>choice;
```

```
        switch(choice)
        {
        case 1:
            ptr->AddStudent();
            break;
        case 2:
            ptr->DeleteStudent();
            break;
        case 3:
            ptr->UpdateStudent();
            break;
        case 4:
            ptr->GetAllStudent();
            break;
        case 5:
            cout<<"Exiting the Program"<<endl;
            break;
        default:
            cout<<"Invalid choice"<<endl;
        }
    }while(choice!=5);
    delete ptr;
    ptr=nullptr;
    return 0;
}
```

Dynamic Memory Allocation in C/C++

Dynamic Memory Management in C

- Below functions are declared in stdlib header file.
    - void* malloc(size_t size);
    - void* calloc(size_t count, size_t size);
    - void* realloc(void *ptr, size_t size);
    - void free(void *ptr);
- malloc, calloc and realloc are used to allocate memort whereas free function is used to deallocate memory.

malloc function

- malloc is a function declared in header file.
- prototype:

```
void* malloc(size_t size);
```

- It is designed to allocate memory for single variable / single object. But we can use it to allocate memory for array too.
- Using malloc function, we can allocate memory on only heap section.

    - Everything on heap section is anonymous. In other words, dynamic object created using malloc is anonymous.
- If we allocate memory using malloc function then memory gets initialized with garbage value.
- If malloc function fails to allocate memory then it returns NULL.
- malloc(0):
    - Some implementations of malloc will return a null pointer when we request to allocate zero bytes. This is a way to handle the situation gracefully and indicate that no memory has been allocated.
    - In other implementations, malloc(0) may return a valid, non-null pointer that you can use to manipulate memory. However, this can lead to unexpected behavior and should generally be avoided because it doesn't allocate any usable memory.
- memory allocated using malloc function should be deallocate using free() function.
- Example 1:

```
void *ptr = malloc( 4 );
//or
void *ptr = malloc( sizeof( int ) );
```

- If dereferencing is required then we must take specific pointer.
- Example 2:

```
void *ptr1 = malloc( sizeof( int ) );
//*ptr1 = 10; //Not OK
int *ptr2 = ( int* )ptr1; //Type casting is required.
*ptr2 = 10; //OK
```

- Example 3:

```
int *ptr = ( int* )malloc( sizeof( int ) );
*ptr = 10; //OK
free( ptr );
```

calloc function

- calloc is a function declared in header file.
- prototype:

```
void* calloc(size_t count, size_t size);
```

- It is designed to allocate memory for array. But we can use it to allocate memory for variable / single object too.
- Using calloc function, we can allocate memory on only heap section.

- If we allocate memory using calloc function then memory gets initialized with zero(0) value.
- If calloc function fails to allocate memory then it returns NULL.
- memory allocated using calloc function should be deallocate using free() function.

realloc function

- realloc is a function declared in header file.
- prototype:

```
void* realloc(void *ptr, size_t size);
```

- The realloc() function tries to change the size of the allocation pointed to by ptr to size, and returns ptr.
- If there is not enough room to enlarge the memory allocation pointed to by ptr, realloc() creates a new allocation, copies as much of the old data pointed to by ptr as will fit to the new allocation, frees the old allocation, and returns a pointer to the allocated memory.
- If ptr is NULL, realloc() is identical to a call to malloc() for size bytes.
- If size is zero and ptr is not NULL, a new, minimum sized object is allocated and the original object is freed.
- memory allocated using real.loc function should be deallocate using free() function.

free function

- free is a function declared in header file.
- prototype:

```
void free(void *ptr);
```

- The free() function deallocates the memory allocation pointed to by ptr.
- If ptr is a NULL pointer, no operation is performed.
- Memory allocation and deallocation for single variable using malloc/free function.

```
#include<iostream>
#include<cstdlib>
using namespace std;
int main( void ){
 //Memory allocation for single integer variable
 int *ptr = (int*)malloc( sizeof( int ) );
 //Dereferencing
 *ptr = 123;
 cout<<"Value : "<< *ptr << endl; //Dereferencing
 //Memory deallocation for single integer variable
 free( ptr );
 return 0;
}
```

- Memory allocation and deallocation for single variable using calloc/free function.

```
#include<iostream>
#include<cstdlib>
using namespace std;
int main( void ){
 //Memory allocation for single integer variable
 int *ptr = (int*)calloc( 1, sizeof( int ) );
 //Dereferencing
 *ptr = 123;
 cout<<"Value : "<< *ptr << endl; //Dereferencing
 //Memory deallocation for single integer variable
 free( ptr );
 return 0;
}
```

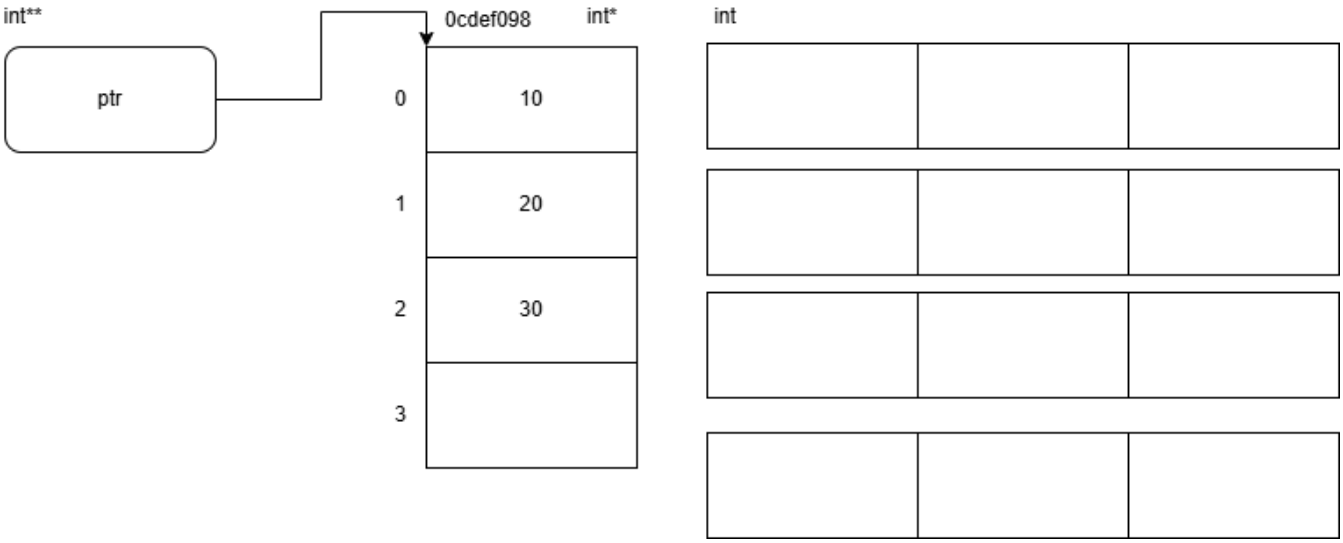
- Memory allocation and deallocation for array using malloc/free function.

```
#include<iostream>
#include<cstdlib>
using namespace std;
int main( void ){
 //Memory allocation for integer array
 int *ptr = (int*)malloc( 3 * sizeof( int ) );
 //Dereferencing
 ptr[ 0 ] = 10; //*( ptr + 0 ) = 10
 ptr[ 1 ] = 20; //*( ptr + 1 ) = 20
 ptr[ 2 ] = 30; //*( ptr + 2 ) = 30
 //Dereferencing
 for( int index = 0; index < 3; ++ index )
 cout << ptr [ index ] <<endl; //cout << *( ptr + index ) <<endl;
 //Memory deallocation array
 free( ptr );
 return 0;
}
```

- Memory allocation and deallocation for array using calloc/free function.

```
#include<iostream>
#include<cstdlib>
using namespace std;
int main( void ){
 //Memory allocation for integer array
 int *ptr = (int*)calloc( 3 , sizeof( int ) );
 //Dereferencing
 ptr[ 0 ] = 10; //*( ptr + 0 ) = 10
 ptr[ 1 ] = 20; //*( ptr + 1 ) = 20
 ptr[ 2 ] = 30; //*( ptr + 2 ) = 30
```

```
 //Dereferencing
 for( int index = 0; index < 3; ++ index )
 cout << ptr [ index ] <<endl; //cout << *( ptr + index ) <<endl;
 //Memory deallocation array
 free( ptr );
 return 0;
}
```



- Memory allocation and deallocation for multidimensional array using malloc/free function.

```
#include<iostream>
#include<cstdlib>
using namespace std;
int main( void ){
 int **ptr = (int**)malloc( 2 * sizeof( int ) );
 for( int index = 0; index < 2; ++ index )
 ptr[ index ] = ( int* ) malloc( 3 * sizeof( int* ) );
 //TODO: accept and print record
 for( int index = 0; index < 2; ++ index )
 free( ptr[ index ] );
 free( ptr );
 return 0;
}
```

- Memory allocation and deallocation for multidimensional array using calloc/free function.

```
#include<iostream>
#include<cstdlib>
using namespace std;
int main( void ){
 int **ptr = (int**)calloc( 2 * sizeof( int ) );
 for( int index = 0; index < 2; ++ index )
 ptr[ index ] = ( int* ) calloc( 3 * sizeof( int* ) );
 //TODO: accept and print record
```

```
 for( int index = 0; index < 2; ++ index )
 free( ptr[ index ] );
 free( ptr );
 return 0;
}
```

Dynamic Memory Management in C++

- In C++, new is operator which is used to allocate memory and delete is a operator which is used to deallocate memory.
- Consider memory allocation and deallocation for single integer variable.
- Example 1:

```
int *ptr = new int; //Here memory will be initialized to garbage value
//int *ptr = ( int* )::operator new ( sizeof( int ) );
cout << "Value : " << *ptr << endl;
delete ptr;
//::operator delete( ptr );
```

- Example 2:

```
int *ptr = new int( 123 ); //Here memory will be initialized to 123 value
//int *ptr = ( int* )::operator new ( sizeof( int ) );
cout << "Value : " << *ptr << endl;
delete ptr;
//::operator delete( ptr );
```

- Example 3:

```
 int *ptr = new int; //Here memory will be initialized to garbage value
 //int *ptr = ( int* )::operator new ( sizeof( int ) );
 *ptr = 123; //dereferencing
 cout << "Value : " << *ptr << endl;
 delete ptr;
 //::operator delete( ptr );
```

- Example 4:

```
int main( void ){
//Memory allocation for single integer variable
//int *ptr = new int; //Dyanamic memory allocation: Garbage Value
//int *ptr = new int( ); //Dyanamic memory allocation: 0
int \*ptr = new int( 123 ); //Dyanamic memory allocation: 123
 cout << "Value : " << *ptr << endl; //Dereferencing
```

```
 //Memory deallocation for single integer variable
 delete ptr; //Dynamic memory deallocation
 ptr = nullptr;
 return 0;
}
```

- Consider memory allocation and deallocation for array.
- Example 5:

```
 int *ptr = new int[ 3 ];
 //int *ptr = ( int* )::operator new[ ] ( 3 * sizeof( int ) );
 for( int index = 0; index < 3; ++ index ){
 cout << "Enter number : ";
 cin >> ptr[ index ];
 }
 for( int index = 0; index < 3; ++ index )
 cout << ptr[ index ] << endl;
 delete[ ] ptr;
 //::operator delete[ ]( ptr );
```

- Consider memory allocation and deallocation for multi dimensional array.
- Example 6:

```
 //Memory Allocation
 int *ptr = new int*[ 2 ];
 for( int index = 0; index < 2; ++ index )
 ptr[ index ] = new int[ 3 ];
 //Accept record for multi dimensional array
 //Print record for multi dimensional array
 //Memory Deallocation
 for( int index = 0; index < 2; ++ index )
 delete[] ptr[ index ];
 delete[ ] ptr;
```

- Example 7:

```
 int *ptr1 = new int; //Single variable. Memory will be initialized to garbage
value
 int *ptr2 = new int(3); //Single variable. Memory will be
initialized to 3
 int *ptr3 = new int[3]; //Array. Memory will be initialized to garbage value
```

- Difference between malloc and new
    - malloc is function and new is operator.
    - In case of failure malloc returns NULL but new operator throws bad_alloc exception.

    - If we create dyanmic object using malloc then contructor do not call but if we create dynamic object using new operator then constructor gets called.
    - Using malloc function, we can allocate space only on heap section but using new operator, we can allocate space on free store(stack section /data segment/heap section);

Array

- Collection: Array/Stack/Queue/LinkedList/Tree/Graph/Hashtable etc.
- value stored inside collection is called as element.
- Array is linear data structure in which we can store multiple elements of same type in continous memory location.
- Types of array:
    - Single dimensional array
    - Multidimensional array
- To access elements of the array we should use integer index. Array index always begins with zero.
- Advantage of array
    - We can access elements of array randomly.
- Limitations of array
    - It requires continous memory location.
    - We can not resize array dynamically.
    - Insertion and deletion of element in array is a time consuming task.
    - Using assignment operator, we can not copy contents of array into another array.
    - Solution:
        - Use Linked List.
- Encapsulate array inside class and perform operations on its object by considering it as a array.
- Example:

```
class Array{
private:
int arr[ 3 ];
};
int main( void ){
Array a1; //a1 is object
return 0;
}
```

Destructor

- Destructor is a member function of the class which is used to release the resources hold by the object.
- Destructor do not deallocate memory of object.
- Destructor is considered as special function of the class due to following reasons:
- Its name is same as class name which precedes with tild(~) operator.
- It doesnt take any parameter or return any value.
- It is designed to call implicitly.
- Example:

```
#include<iostream>
using namespace std;
class Array{
private:
int size;
int *arr;
public:
//Array *const this = &a1
Array( void ){
this->size = 0;
this->arr = nullptr;
}
//Array *const this = &a1
Array( int size ){
cout << "Array( int size )" << endl;
this->size = size;
this->arr = new int[ size ];
}
//Array *const this = &a1
void acceptRecord( void ){
for( int index = 0; index < this->size; ++ index ){
cout << "Enter element : ";
cin >> this->arr[ index ];
}
}
//Array *const this = &a1
void printRecord( void ){
for( int index = 0; index < this->size; ++ index )
cout << this->arr[ index ] << endl;
}
//Array *const this = &a1
~Array( void ){ //Destructor
if( this->arr != nullptr ){
delete[] this->arr;
this->arr = nullptr;
}
}
};
int main( void ){
Array a1(3); //Static memory allocation for object
a1.acceptRecord( );
a1.printRecord( );
return 0;
}
```

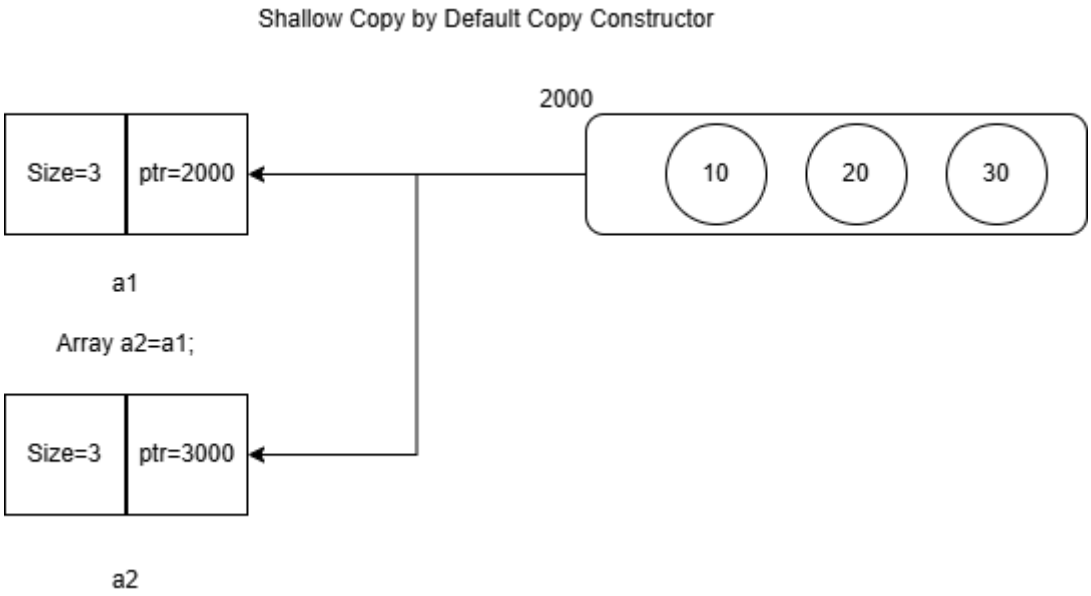
- If we do not provide destructor for the class then compiler provide one destructor for the class by deafult. It is called default destructor.
- Destructor calling sequence is exactly opposite of constructor calling sequence.
- We can not declare destructor static/const/volatile. We can declare constructor as inline and virtual.
- We can overload constructor but we can not overload destructor.
- Note: Even though destructor is designed to call implicitly, we can call it explicitly too.

```
//Array *const this = &a1
 ~Array( void ){ //Destructor
 if( this->arr != nullptr ){
 delete[] this->arr;
 this->arr = nullptr;
 } }
```

- Why we can not overload destructor?
    - To overload function, either number parameters / type parameters or order of type of parameters must be different.
    - But destructor do not take any parameter. Hence we can not overload destructor.

Shallow Copy

- Proecss of copying contents from source object into destination object as it is, is called as shallow copy.
- Shallow copy is also called as bitwise copy / bit-by-bit copy.



- Example 1:

```
int Num1=100;
int Num2=Num1;
```

- Example 2:

```
Student s1;
Student s2=s1;
```

- Copy constructor
    - If we try to intialize newly created object from exisiting object of same class then on newly created object copy constructor gets called.

- Example:

```
int main( void ){
Test t1( 10, 20 ); //On t1, Parameterized ctor will call
Test t2; //On t2, parameterless constructor will call
Test t3 = t1; //On t3, copy constructor will call
return 0;
}
```

- If we do not define copy constructor inside class, then compiler generate one copy constructor for the class by default. It is called as default copy constructor.
- Default copy constructor, by default creates shallow copy.
- Copy constructor is a parameterized constructor of the class which take single parameter of same type as a reference.
- Copy constructor is not a new type of constructor. It is parameterized constructor.
- Syntax:

```
class ClassName{
public:
//const ClassName &other = reference of existing object
//ClassName *const this = Address of newly created object
ClassName( const ClassName &other ){
//TODO: Shallow Copy or Deep Copy
}
};
```

- Example:

```
class Test{
private:
int Num1;
int Num2;
public:
Test( void ){
this->Num1 = 0;
this->Num2 = 0;
}
//const Test &other = t1;
//Test *const this = &t3
Test( const Test &other ){ //Copy Constructor
this->Num1 = other.Num1; //Shallow Copy
this->Num2 = other.Num2; //Shallow Copy
}
Test( int Num1, int Num2 ){
this->Num1 = Num1;
this->Num2 = Num2;
}
```

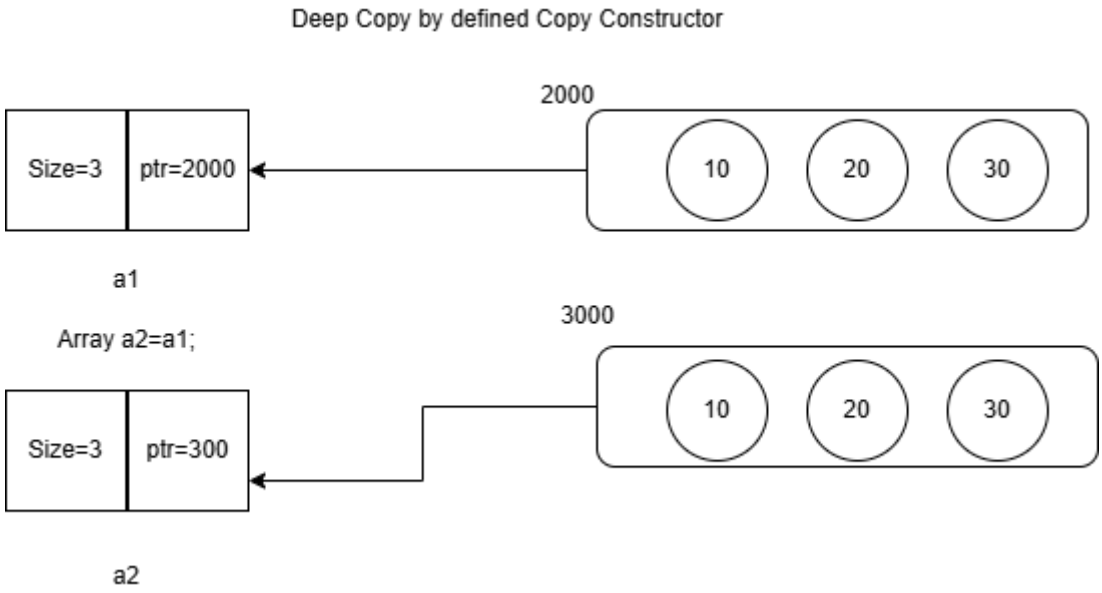
```
void printRecord( void ){
cout << "Num1 Number : " << this->Num1 << endl;
cout << "Num2 Number : " << this->Num2 << endl;
}
};
int main( void ){
Test t1( 10, 20 ); //On t1, Parameterized ctor will call
Test t2; //On t2, parameterless constructor will call
Test t3 = t1; //On t3, copy constructor will call
return 0;
}
```

- Copy constructor gets called in following conditions:
  - If we pass object of a class as a argument to the function then on function parameter copy constructor gets called.
  - If we return object from function by value then compiler implicitly generate anonymous object. On anonymous object compiler implicitly call copy constructor.
  - If we initialize newly created object from exisiting object of same class then on newly created object copy constrcutor gets called.
  - If we throw object then copy of the object gets created on stack frame. On that object copy constructor gets called.
  - If we catch object object by value then on catching object copy constructor gets called.
- use "-fno-elide-constructors" compiler option in project settings
- In below conditions, copy of the object gets created
  - If we pass object to the function by value.
  - If we return object from function by value.
  - If we initialize object from another object.
  - If we assign object from another object.
  - If we throw object
  - If we catch object by value

Deep Copy

- If we make copy of the object with some modifications then such type of copy is called as deep copy.
- Conditions to create deep copy.
  - Class must contain at least one pointer
  - Class must contain user defined destructor with deallocation.
  - We must create copy of the object.
- Steps to create deep copy
  - Copy the required size from source object into destination object.
  - Allocate new resource for the pointer of destincation object.
  - Copy the contents from resource of source object into resource of destination object.
- Where to create deep copy
  - If we pass object to the function by value (Copy Constructor).
  - If we return object from function by value (Copy Constructor).
  - If we initialize object from another object (Copy Constructor).
  - If we assign object from another object (operator=( ))

- If we throw object (Copy Constructor).
- If we catch object by value (Copy Constructor).



- Example 4:

```
//const Array &other = a1
//Array *const this = &a2
Array( const Array &other ){
cout << "Array( const Array &other )" << endl;
//1. Copy size
this->size = other.size;
//2. Allocate new resource
this->arr = new int[ this->size ];
//3. Copy the contents from source object into destination object.
for( int index = 0; index < this->size; ++ index )
this->arr[ index ] = other.arr[ index ];
}
```

Friend function:

- friend is keyword in C++.
- If we want to access private and protected members of the class inside non member function then we should declare non member function friend.
- We can use friend keyword only inside class.
- Example:

```
#include<iostream>
using namespace std;
class Test{
private:
int num1;
protected:
int num2;
```

```
public:
Test( void ){
this->num1 = 10;
this->num2 = 20;
}
friend int main( void ); //We can declare it in either private/protected/public
section
};
int main( void ){
Test t;
cout << "Num1 : " << t.num1 << endl;
cout << "Num2 : " << t.num2 << endl;
return 0;
}
```

- If we declare function as a friend inside class then it is not considered as a member of a class.
- Example:

```
#include<iostream>
using namespace std;
class Test{
private:
int num1;
protected:
int num2;
public:
Test( void ){
this->num1 = 10;
this->num2 = 20;
}
friend void print( );
};
void print( ){
Test t;
cout << "Num1 : " << t.num1 << endl;
cout << "Num2 : " << t.num2 << endl;
}
int main( void ){
//Test t;
//t.print( ); //Not OK
print( );
return 0;
}
```

- We can declare same function friend into multiple classes:

```
#include<iostream>
using namespace std;
class A{
```

```
private:
int num1;
public:
A( void ){
this->num1 = 10;
}
friend void print( );
};
class B{
private:
int num2;
public:
B( void ){
this->num2 = 20;
}
friend void print( );
};
void print( ){
A a;
cout << "Num1 : " << a.num1 << endl;
B b;
cout << "Num2 : " << b.num2 << endl;
}
int main( void ){
print( );
return 0;
}
```

- We can declare member function of a class as a friend inside another class.
- Example:

```
#include<iostream>
using namespace std;
class A{
public:
void sum( void );
};
class B{
private:
int num1;
int num2;
public:
B( );
friend void A::sum( void );
};
B::B( void ){
this->num1 = 10;
this->num2 = 20;
}
void A::sum( void ){
B obj;
```

```
int result = obj.num1 + obj.num2;
cout << "Result : " << result << endl;
}
int main( void ){
A a;
a.sum( );
return 0;
}
```

- If we want to access private members of the class inside all the member functions of another class then we should declare class as a friend.

```
#include<iostream>
using namespace std;
class A{
public:
void sum( void );
void sub( void );
void multiplication( void );
};
class B{
private:
int num1;
int num2;
public:
B( );
/* friend void A::sum( void );
friend void A::sub( void );
friend void A::multiplication( void ); */
friend class A;
};
B::B( void ){
this->num1 = 10;
this->num2 = 20;
}
void A::sum( void ){
B obj;
int result = obj.num1 + obj.num2;
cout << "Result : " << result << endl;
}
void A::sub( void ){
B obj;
int result = obj.num1 - obj.num2;
cout << "Result : " << result << endl;
}
void A::multiplication( void ){
B obj;
int result = obj.num1 * obj.num2;
cout << "Result : " << result << endl;
}
int main( void ){
```

```
A a;
a.sum( );
a.sub( );
a.multiplication( );
return 0;
}
```

- We can declare mutual friend classes but we can not declare mutual friend functions.
- Example:

```
class A{
private:
int num2;
public:
A( void );
void showRecord( );
friend class B;
};
class B{
private:
int num1;
public:
B( void );
void displayRecord( );
friend class A;
};
A::A( void ){
this->num2 = 200;
}
B::B( void ){
this->num1 = 100;
}
void A::showRecord( void ){
B obj;
cout << "Num1 : " << obj.num1 <<endl;
}
void B::displayRecord( ){
A obj;
cout << "Num2 : " << obj.num2 <<endl;
}
int main( void ){
A a;
a.showRecord( );
B b;
b.displayRecord( );
return 0;
}
```

- Real time example:

```
//Here class Remote is used before definition
class Remote; //Forward declaration
class Television{
 friend class Remote;
}
class Remote{
};
```

To be disscussed tomorrow (13-06-2025)

- Static member and member function
- Anonymous class
- Enum Demo

Operator Overloading

- Tokens
- Classification of operators
- Operator overloading
- Implementation using member function as well as non member function
- Limitations of operator overloading
- Relational Operator overloading
- pre increment and post increment operator overloading
- Insertion and extraction operator overloading
- Assignment operator overloading
- Index operator overloading
- Function call operator overloading

Casting Operators and Storage Classes

- Advanced Type Casting Operators
- Runtime Type Information(RTTI)
- Virtual Pointer and Virtual Table
- Data Security
- Mutable Object