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| **Computer Engineering Department - ITU** |
| **CE200L: Data Structures & Algorithms Lab** |

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| **Course Instructor: Usama Bin Shakeel** | **Dated: 01/09/2022** |
| **Teaching Assistant: Muhammad Sufyan Ashraf** | **Semester: Fall 2022** |
| **Lab Engineer: Nadir Abbas** | **Batch: BSCE2021** |

# **Lab 1B. Using Array List with Templates**

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| **Name** | **Roll number** | **Report**  **(out of 100)** | **Scaled to 10** | **Total**  **(out of 10)** |
| NIMRA MAQBOOL | BSCE21012 |  |  |  |

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## **Objective**

The objective of this lab is to practice problems related to pointers and dynamic memory allocation.

## **Equipment and Component**

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| **Component Description** | **Value** | **Quantity** |
| Computer | Available in lab | 1 |

## **Conduct of Lab**

1. Students are required to perform this experiment individually.
2. In case the lab experiment is not understood, the students are advised to seek help from the course instructor, lab engineers, assigned teaching assistants (TA) and lab attendants.

## **Theory and Background**

The variable that is used to hold the memory address of another variable is called a **pointer** variable or simply a pointer. The data type of the variable (whose address a pointer is to hold) and the pointer variable must be the same. A pointer variable is declared by placing a asterisk (\*) after data type or before variable name in data type statement. E.g. if pointer variable “p” is to hold memory address of an integer variable it is declared as:

**int \*p;**

or to hold address of a float type variable we can declare as:

**float \*rep;**

A **dynamic array** is quite similar to a regular array, but its size is modifiable during program runtime. Dynamic Array elements occupy a contiguous block of memory. Once an array has been created, its size cannot be changed. However, a dynamic array is different. A dynamic array can expand its size even after it has been filled. During the creation of an array, it is allocated a predetermined amount of memory. This is not the case with a dynamic array as it grows its memory size by a certain factor when there is a need.

**Templates** are a feature of the C++ programming language that allows functions and classes to operate with generic types. This allows a function or class to work on many different data types without being rewritten for each one.

**Lab Task**

**Task A**

Design a class to keep a list of similar data in the form of an array, the data type of array will be taken from templates.

**Data Members:**

// Add variable for array, no of elements in the list, and capacity

**Member Functions:**

**//Add function to expand an array by increasing size by 10**

void expand(int)

{

}

**// Add function to contract an array by deleting value from last index**

void deleteFromLast()

{

}

**// Add function to contract an array by deleting value from any index**

void deleteFromIndex(int)

{

}

**// Add function to add element at start index of the array**

void prepend(T)

{

}

**// Add function to add element at last index of the array**

void append(T)

{

}

**// Add function to add element at specific index in array**

void addAtIndex(T)

{

}

**// Add function to sort elements of the array**

void sortArray()

{

}

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| **Function.h:**  #include <iostream>  using namespace std;  template<typename T> class customizedArray { //making class private:  int sizeOfArray; //declaring  int NoOfElement; //declaring  T \*array; public:  customizedArray(int s) {  sizeOfArray = s; //copying  NoOfElement = 0; //placing it to zero  array = new T[sizeOfArray];  for (int i = 0; i < sizeOfArray; i++) {  array[i] = 0; //setting values to zero  }  }   void add() {  for (int i = NoOfElement; i < sizeOfArray; i++) {  cout << "ENTER DATA = ";  cin >> array[i]; //taking input  NoOfElement++;  }  }   void display() {  for (int i = 0; i < sizeOfArray; i++) {  cout << array[i] << " "; //displaying array elements  }  cout << endl;  }   void expand() {  sizeOfArray = sizeOfArray + 10; //increasing size  T \*array1 = new T[sizeOfArray]; //making a new dynamic array  for (int i = 0; i < sizeOfArray; i++) {  array1[i] = array[i];  }  delete[]array; //deleting  array = array1; //pointing at  array1 = NULL; //null it  }    void deleteAnElementFromLast() {  sizeOfArray = NoOfElement - 1;  T \*array2 = new T[sizeOfArray]; //making a new dynamic array  for (int i = 0; i < sizeOfArray; i++) {  array2[i] = array[i]; //copying  }  delete[]array; //deleting  array = array2; //copying  array2 = NULL; //null it   }   void deleteAnElementFromSpecificIndex() {  int index;  T \*array2 = new T[sizeOfArray]; //making a new dynamic array  for (int i = 0; i < sizeOfArray; i++) {  array2[i] = array[i]; //copying  }  delete[]array; //deleting  array = array2; //copying  array2 = NULL; //null it  cout << "ENTER INDEX = ";  cin >> index;  sizeOfArray = sizeOfArray - 1;  for (int i = index; i < sizeOfArray; i++) {  array[i] = array[i + 1];  }  for (int i = 0; i < sizeOfArray; i++) {  cout << array[i] << " "; //displaying array elements  }  cout << endl;  }   void addAtElementAtTheStartOfArray() {  int element;  sizeOfArray = sizeOfArray + 1;  T \*array2 = new T[sizeOfArray]; //making a new dynamic array  for (int i = 0; i < sizeOfArray; i++) {  array2[i] = array[i]; //copying  }  delete[]array; //deleting  array = array2; //copying  array2 = NULL; //null it  cout << "enter element.." << endl;  cin >> element;  for (int i = sizeOfArray - 1; i > 0; i--) {  array[i] = array[i - 1];  }  array[0] = element;  }   void addElementAtLastIndexOfArray() {  int element;  cout << "enter element.." << endl;  cin >> element;  sizeOfArray = sizeOfArray + 1; //increasing size  T \*array2 = new T[sizeOfArray]; //making a new dynamic array  for (int i = 0; i < sizeOfArray; i++) {  if(i==sizeOfArray-1){  array2[i] = element;  }//copying  else{  array2[i] = array[i];  }  }  delete[]array; //deleting  array = array2; //copying  array2 = NULL; //null it  }   void addToIndex() {  int element;  int index;  sizeOfArray = sizeOfArray + 1;  T \*array2 = new T[sizeOfArray]; //making a new dynamic array  for (int i = 0; i < sizeOfArray; i++) {  array2[i] = array[i]; //copying  }  delete[]array; //deleting  array = array2; //copying  array2 = NULL; //null it  cout << "enter the position where you want to put the element.." << endl;  cin >> index;  cout << "enter element.." << endl;  cin >> element;  if (index <= sizeOfArray && index >= 0) {  for (int i = sizeOfArray - 1; i >= index - 1; i--) {  array[i + 1] = array[i];  }  array[index] = element;  } else {  cout << "the index you have written is greater than the size of array.." << endl;  exit(3);  }  }   void sortArray() {  int size;  int temp;  cout << "ENTER SIZE = ";  cin >> size;  cout << "ENTER NUMBERS IN ARRAY TO BE SORTED = ";  for (int i = 0; i < size; i++) {  cin >> array[i];  }  for (int i = 0; i < size - 1; i++) {  for (int j = i + 1; j < size; j++) {  if (array[j] < array[i]) {  temp = array[j];  array[j] = array[i];  array[i] = temp;  }  }  }  for (int i = 0; i < size; i++) {  cout << array[i];  }  }   };  **Main.cpp:**  #include "Functions.h" #include <iostream>  using namespace std;  int main() {  int opt;  cout << "CHOOSE OPTIONS..." << endl;  cout << "1.EXPAND AN ARRAY." << endl;  cout << "2.DELETE AN ELEMENT FROM LAST INDEX." << endl;  cout << "3.DELETE AN ELEMENT FROM SPECIFIC INDEX." << endl;  cout << "4.ADD AN ELEMENT AT THE START OF ARRAY." << endl;  cout << "5.ADD ELEMENT AT THE LAST INDEX OF ARRAY." << endl;  cout << "6.ADD TO SPECIFIC INDEX." << endl;  cout << "7.SORT THE ARRAY." << endl;  cout << "8.EXIT." << endl;  cin >> opt;  if (opt == 1) {  customizedArray<int> c(5); //calling object  c.add();  c.display();  c.expand();  c.display();   }  if (opt == 2) {  customizedArray<int> c(5); //calling object  //calling  c.add();  c.display();  c.deleteAnElementFromLast();  c.display();   }  if (opt == 3) {  customizedArray<int> c(5); //calling object  c.add();  c.display();  c.deleteAnElementFromSpecificIndex(); // c.display();   }  if (opt == 4) {  customizedArray<int> c(5); //calling object  c.add();  c.display();  c.addAtElementAtTheStartOfArray();  c.display();   }  if (opt == 5) {  customizedArray<int> c(5); //calling object  c.add();  c.display();  c.addElementAtLastIndexOfArray();  c.display();   }  if (opt == 6) {  customizedArray<int> c(5); //calling object  c.add();  c.display();  c.addToIndex();  c.display();  }  if (opt == 7) {  customizedArray<int> c(5); //calling object  c.sortArray();  }  if (opt == 8) {  cout << "YOU CHOOSE TO EXIT..." << endl;  exit(4);  }   } |

#### **Assessment Rubric for Lab**

**Method for assessment:**

Lab reports and instructor observation during lab sessions. Outcome assessed:

a. Ability to conduct experiments, as well as to analyze and interpret data (P) b. Ability to function on multi-disciplinary teams (A)

c. Ability to use the techniques, skills, and modern engineering tools necessary for engineering practice (P)

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| **Performance metric** | **Task** | **CLO** | **Description** | **Max marks** | **Exceeds expectation** | **Meets expectation** | **Does not meet expectation** | **Obtained marks** |
| 1. Realization of experiment (a) | 1 | 1 | Functionality | 40 | Executes without errors excellent user prompts, good use of symbols, spacing in output. Through testing has been completed (35-40) | Executes without errors, user prompts are understandable, minimum use of symbols or spacing in output. Some testing has been completed (20-34) | Does not execute due to syntax errors, runtime errors, user prompts are misleading or non-existent. No testing has been completed (0-19) |  |
| 2. Teamwork (b) | 1 | 3 | Group Performance | 5 | Actively engages and cooperates with other group member(s) in effective manner (4-5) | Cooperates with other group member(s) in a reasonable manner but conduct can be improved (2-3) | Distracts or discourages other group members from conducting the experiment (0-1) |  |
| 3. Conducting experiment (a, c) | 1 | 1 | On Spot Changes | 10 | Able to make changes (8-10) | Partially able to make changes (5-7) | Unable to make changes (0-4) |  |
| 1 | 1 | Viva | 10 | Answered all questions (8-10) | Few incorrect answers (5-7) | Unable to answer all questions (0-4) |  |
| 4. Laboratory safety and disciplinary rules (a) | 1 | 3 | Code commenting | 5 | Comments are added and does help the reader to understand the code (4-5) | Comments are added and does not help the reader to understand the code (2-3) | Comments are not added (0-1) |  |
| 5. Data collection (c) | 1 | 3 | Code Structure | 5 | Excellent use of white space, creatively organized work, excellent use of variables and constants, correct identifiers for constants, No line-wrap (4-5) | Includes name, and assignment, white space makes the program fairly easy to read. Title, organized work, good use of variables (2-3) | Poor use of white space (indentation, blank lines) making code hard to read, disorganized and messy (0-1) |  |
| 6. Data analysis (a, c) | 1 | 4 | Algorithm | 20 | Solution is efficient, easy to understand, and maintain (15-20) | A logical solution that is easy to follow but it is not the most efficient (6-14) | A difficult and inefficient solution (0-5) |  |
| 7. Computer use (c) | 1 | 2 | Documentation & Github Submissions | 5 | Timely (4-5) | Late (2-3) | Not done (0-1) |  |
|  | Max Marks (total): | | | 100 | Obtained Marks (total): | | |  |

Lab Engineer Signature: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_