Friday, April 15, 2022.

Data Structures and Algorithms LAB – Spring 2022
(BS-IT-F20 Morning & Afternoon)

Lab # 4 (Online Lab)

Submission Deadline: ***Friday, April 15, 2022 (till 6:00 PM)***

Instructions:

- Attempt the following tasks exactly **in the given order**.
- You must complete all tasks individually. Absolutely NO collaboration is allowed. Any traces of plagiarism/cheating would result in an **"F"** grade in this course and lab.
- **Indent** your code properly.
- Use meaningful variable and function names. Use the **camelCase** notation.
- Use meaningful prompt lines/labels for all input/output.
- Do NOT use any **global** or **static** variable(s). However, global named constants may be used.
- Make sure that there are **NO** ***dangling pointers*** or ***memory leaks*** in your programs.
- Late submissions will NOT be accepted, whatever your excuse may be.

Submission Procedure:

i. There are 3 tasks in this lab. You are required to submit C++ program for **Task # 1**. The last 2 tasks are for your practice and you are not required to submit them. But I will assume in quizzes and exams that you have solved all of these questions/tasks ☺

ii. Create an empty folder. Put all of the ***.CPP*** and ***.H*** files (and **input files**) of Task # 1 into this folder. Do NOT include any other files in your submission, otherwise your submission will NOT be graded. Don't forget to mention your Name, Roll Number and Section in comments at the top of each CPP file.

iii. Now, compress the folder (that you created in previous step) in **.RAR** or **.ZIP** format. Then rename the RAR or ZIP file ***exactly*** according to the following format:

`Mor-Lab4-BITF20M123` (for Morning section) OR

`Aft-Lab4-BITF20A456` (for Afternoon section),

where the text shown in **BLUE** should be your **complete Roll Number**.

iv. Finally, submit the *single* **.RAR** or **.ZIP** file through **Google Classroom**.

__Note:__ If you do not follow the above submission procedure, your Lab will NOT be graded and you will be awarded ZERO marks.

Task # 1 50 Marks

When a communications site transmits a message through a packet-switching network, it does not send the message as a continuous stream of data. Instead, it divides the message into pieces called *packets*. These packets are sent through the network to a receiving site, which reassembles the message. Packets may be transmitted to the receiving site along different paths. As a result, they are likely to arrive out of sequence. In order for the receiving site to reassemble the message correctly, each packet must include the relative position of the packet within the message. For example, if we break the message "**COMPUTER PROGRAM**" into packets which are five characters long and preface each packet with a number indicating the packet's position in the message, the result is the following set of packets:

```
1 COMPU
2 TER P
3 ROGRA
4 M
```

No matter in what order these packets arrive, a receiving site can correctly reassemble the message by placing the packets in ascending order based on their position numbers.

You are required to write a C++ program that reassembles the packets contained in a **text file** and extracts the message stored in these packets. Assume that each packet in the message file contains a **position number** and **five characters** from the message. Your program should be based upon the following declarations:

```
const int PACKET_SIZE = 5;  // Number of characters in a packet

struct Packet {
   int position;                // Packet's position within the message
   char body[PACKET_SIZE+1];    // Characters contained in the packet including NULL terminator
};
```

The format of the input file is as follows. The first line indicates the number of packets present in the file. After that those many packets are present in the file (one on each line), in a random order:

```
8
4 ear W
1 Eleme
2 ntary
7 menta
8 ry.
5 atson
3  my d
6 ! ele
```

Your class declaration would look like as follows:

```
class PacketManager {
  private:
      Packet* packets;      // Array which will be used to store the packets read from the file
      int numPackets;       // Number of packets in the above array
      char* message;        // The message that was extracted from the packets
      int msgLength;        // Length of the message
};
```

In the main function, your program should take the name of the input file from the user. If the input file is not found/opened, your program should display an appropriate error message, and ask the user to re-enter the file name. This process should be repeated until the user enters a valid file name. After that, your program should create a **`PacketManager`** object by passing the input file handle into it.

The **`PacketManager`** class should have the following member functions:

1.1 `PacketManager (ifstream& fin);`

Overloaded constructor which receives the file handle (**`fin`**) of the input file which was opened in the **main** function. It will read the number of packets from the input file, and use it to initialize the member variable **`numPackets`** and dynamically allocate an array through the pointer **`packets`**. After that, it will read the packets from the file and store them in the array **`packets`**. The constructor should initialize the pointer **`message`** to NULL, and the member variable **`msgLength`** to 0.

1.2 `~PacketManager ();`

Destructor will deallocate all the dynamically allocated memory (if any).

1.3 `void displayPackets () const;`

This function should display all the packets present in the array **`packets`** on screen.

1.4 `void sortPacketsBubbleSort ();`

This **private** member function should **sort** the array **`packets`** in increasing order (according to their **`position`**) using **Bubble Sort**. This function should NOT display anything on screen.

1.5 `void sortPacketsSelectionSort ()`

This **private** member function should **sort** the array **`packets`** in increasing order (according to their **`position`**) using **Selection Sort**. This function should NOT display anything on screen.

1.6 `void extractMessage ();`

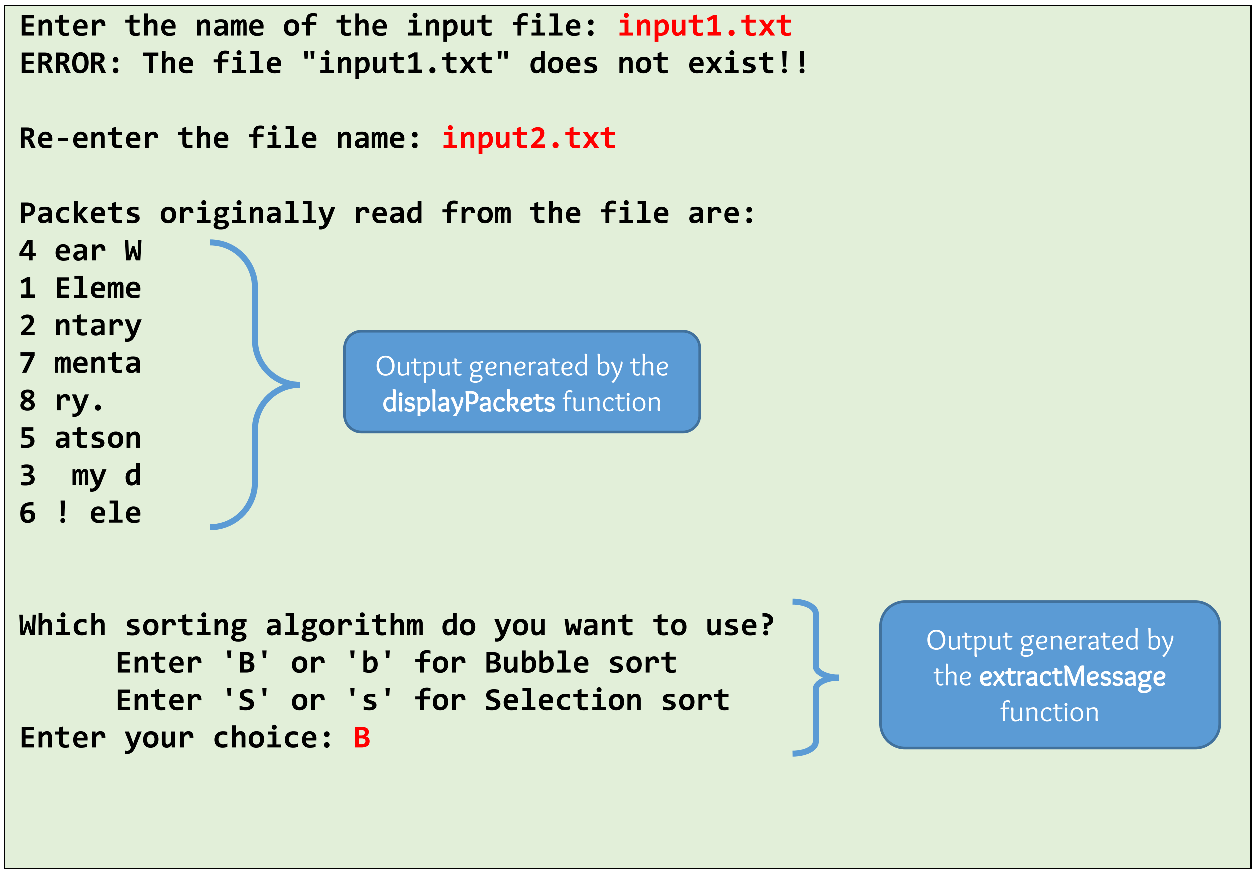
This function extracts the message from the packets and stores the message in the char array **`message`** (see the data members of class **`PacketManager`**). This function will work as follows:

- First of all, this function will ask the user to for the choice of Sorting algorithm to be used. The user should be asked to enter **`'B'`** or **`'b'`** for **Bubble sort**, and **`'S'`** or **`'s'`** for **Selection sort** (see the Sample run shown below). Then, this function should call the appropriate function to sort the array of packets.
- Then, this function should determine the exact message length (**`msgLength`**) and dynamically allocate the array **`message`** accordingly.
- After that, this function should store the extracted message in the array **`message`**.

1.7 `void displayMessage () const;`

If the message had already been extracted from the packets (using the **`extractMessage()`** function), then this function would display the contents of array **`message`** on screen. Otherwise, this function should display an appropriate error message indicating that the message has not yet been extracted.

Also write a driver program which illustrates the usage and working of all the member functions of the **`PacketManager`** class. A sample run of your program might look like this (text shown in red is entered by the user):



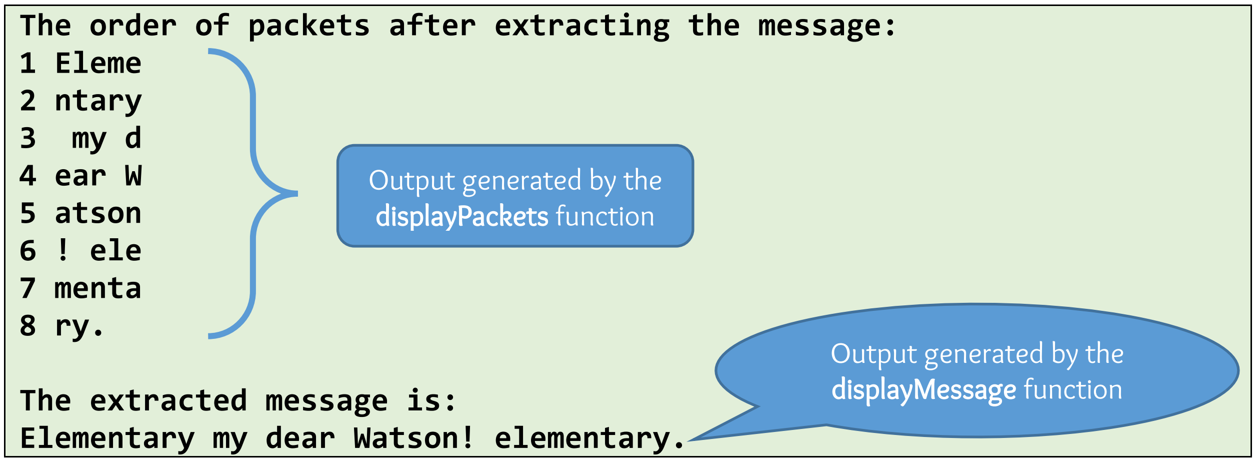
```
Enter the name of the input file: input1.txt
ERROR: The file "input1.txt" does not exist!!

Re-enter the file name: input2.txt

Packets originally read from the file are:
4 ear W
1 Eleme
2 ntary
7 menta
8 ry.
5 atson
3  my d
6 ! ele


Which sorting algorithm do you want to use?
     Enter 'B' or 'b' for Bubble sort
     Enter 'S' or 's' for Selection sort
Enter your choice: B
```

Output generated by the displayPackets function
Output generated by the extractMessage function



```
The order of packets after extracting the message:
1 Eleme
2 ntary
3  my d
4 ear W
5 atson
6 ! ele
7 menta
8 ry.

The extracted message is:
Elementary my dear Watson! elementary.
```

Output generated by the **displayPackets** function
Output generated by the **displayMessage** function

Task # 2

Modify the program, that you implemented above in **Task # 1**, to include the functionality of creating packets from a message entered by the user and store these packets in a text file specified by the user.

Task # 3

Consider the following declaration:

```
struct LetterInfo {
        char letter;        // The letter (alphabet)
        int freq;           // Frequency of the above letter
};
```

Write a C++ program which should read an input text file and determine the frequency of each alphabet in the input file. Note that:

- You are required to count the frequencies of alphabet characters ONLY. Punctuation marks, numbers (digits), and other special characters are NOT to be counted.
- Lower-case and Upper-case alphabets should be counted as same.
- In order to read the contents of the input file, you are only allowed to declare/use a single **`char`** variable. You are NOT allowed to read/store the contents of the input file using **string**(s) or **c-string**(s).

After storing the frequencies of all alphabets in an array of type **`LetterInfo`**, your program should sort this array (using **Insertion sort**) in **decreasing order** of letter **frequency**. At the end, this sorted array of type **`LetterInfo`** should be displayed on screen in a neat and readable way.