National University of Computer and Emerging Sciences, Lahore Campus

Course:	Data Structures and Algorithms	Course Code:	CS 2002
Program:	BS (EE)	Semester:	Spring 2022
Duration:	3 hours	Total Marks:	60
Paper Date:	13-Jun-2022	Weight:	50 %
Section:	BEE-4A	Page(s):	10
Exam:	Final		
Name:		Roll Number:	

Instruction/Notes:

- The exam is closed book and notes. No electronic devices including calculators are allowed in the exam.
- Please answer all questions within the spaces provided.
- Use only black or blue pen to solve the paper.
- **No extra sheet shall be provided or attached with the exam. Use page 10 at the end for rough work.**

Question # 1 **[10 marks] [CLO 1]**

(i) [5 marks]

For each function below, give an asymptotic upper bound using "big-Oh" notation. Your answer should be as "tight" and "simple" as possible.

(a)	$f(n) = 4n^3 + 5n^2 \log n$	
(b)	$g(n) = 3n + 4 \log n$	
(c)	$h(n) = 1.6^n + n^5$	
(d)	$k(n) = 2n^2 + 80\log(n)$	

List the Big-oh notations found in (i) in ascending order of complexity (fastest to slowest) in the space below.

(ii) [5 marks]

Calculate the appropriate time complexity expression of the following iterative function with respect to N and express it in terms of Big-O. Show all the working for full credit.

```
void mystery(int n)
{
    for (int i=1; i <= n*4; i=i*2)
    {
        for( j=0;j < i; j++)
            cout<<j;
    }
}
```

Question # 2

[10 marks] [C

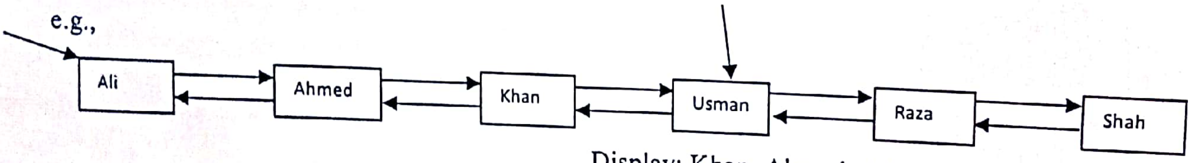
Suppose we have the following class definition of a Doubly linked list and Node class that i

```
class Node
{
  private:
   char *name;
   Node *next ;
   Node *previous ;

public:
   Node(char* pname);
   void setData(char* pVal);
   char* getData();
   Node* getNext();
   void setNext(Node* x);
   Node* getPrevious();
   void setPrevious(Node* x);
};
```

```
class DList
{
private:
  Node *first ;

public:
 DList();
~DList();
//inserts pNew after pBefore
void Insert(Node* pBefore, Node
*pNew);
void Delete(Node* pToBeDeleted);

//function to be implemented
int printNodesinOneDirection(Node
*curr, char LeftOrRight);

};
```

You are required to implement a C++ function that traverses a doubly-linked list consisting of 0 or more from the current node, in the direction indicated by the input parameter (left, or right). For example, if yc at node "Usman" and you're supposed to go left, then, on the screen, print out all the names found in the from the one before "Usman" to the start of the list, in that order (but do not include "Usman" (in the cur node)). The same idea applies when going to the right.

e.g.,



Display: Khan, Ahmed, Ali

Assume that the following declaration is correct:

Finish the following function. Note also that the function returns the number of names that were printed.

int DList::**printNodesinOneDirection**(Node *curr, char LeftOrRight)
{
/* POST-CONDITION: This function starts at Node "curr" and then prints out all the names in the nodes to left ('L') or right ('R') of curr (but excluding the name in curr). The function returns a count of the number names printed on the screen. */

// PRE-CONDITION: curr is either NULL or points to a valid Node
// LeftOrRight is either 'L' or 'R'

Question # 3 [20 marks] [CL

[Marks: 10] Suppose we have the following class definition of a Doubly linked list and Node that it uses. It carries integer data. All member functions are implemented and ready to use.

```
class Node
{
  private:
   in data;
   Node *next ;
   Node *previous ;

public:
   Node(char* pname);
   void setData(int pVal);
   int getData();
   Node* getNext();
   void setNext(Node* x);
   Node* getPrevious();
   void setPrevious(Node* x);
};
```

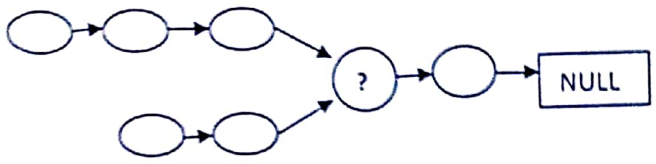
```
class DList
{
private:
  Node *first ;

public:
 DList();
~DList();
//inserts pNew after pBefore
void Insert(Node* pBefore, Node
*pNew);
void Delete(Node* pToBeDeleted);

};
```

Please use the above linked list to implement in C++ the push and pop methods of a Stack carrying integer data. The performance of these methods should not be worse than O(1).

```
void Stack:: push(int pval)
{










}
```

```
int Stack:: pop()
{










}
```

Marks: 10] Suppose there are two singly linked lists both of which intersect at some node (as shown below) and become the same list. The number of nodes in each list before they intersect is not known and both may have it different. List1 may have m nodes before it reaches intersection node and list2 may have n nodes where m and n may be m=n, m<n or m>n.



An algorithm to find the merging node is as given below but its time complexity is O(mn).

```
Node temp=first node of list1
While(temp)
{
        Node temp2= first node of list2
        While(temp2)
        {
                If(temp=temp2)
                        Break and return temp
                Else
                        Temp2= temp2->getNext();
        }
        temp=temp->getNext();
}
```

Please give an algorithm (using Stack/Queue) that improves the performance of the above problem to O(m+n).

[20 marks] [CL

Question # 4

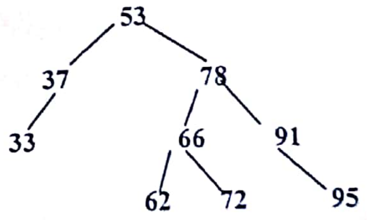
i. [Marks: 3] Illustrate the execution of the first pass of the basic Quicksort algorithm on array A = 43, 13, 89, 34, 21, 44, 99, 56, 9

ii. [Marks: 3] Illustrate the execution of the first pass of the basic Mergesort algorithm on the array A = 43, 13, 89, 34, 21, 44, 99, 56, 9

iii. [Marks: 4] Compare quicksort and mergesort on the basis of worst case performance, stability and memory usage

iv. [Marks: 5] Add the numbers 13,16, 24, 12, 17, 5,10 to a Hash table of Bucket Size 7 using the hash function of NUM%BUCKETSIZE. Show the table if Chaining is chosen for the hash table for overflow handling. Please also state the total number of collisions that happen.

v. [Marks: 5] Insert 75 in the following AVL tree naming the rotation used to balance the tree (show all working for full credit).



a) [Marks: 4] Specify appropriate data structures for the following situations :

i. An online sales store needs to process sale requests in the order they are received.

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ii. A word processor to have ↑ key that causes the preceding command to be redisplayed. Every time the user presses ↑ key, the program shows the command that preceded the one currently displayed ______________________________

iii. A covid19 vaccination authority needs to administer vaccine doses on the basis of priority (senior citizens, frontline healthcare providers having higher priority than others e.g.)

____

iv. An online English to urdu translation service needs to lookup english words and their meaning in urdu ______________________________

b) [Marks: 8] An online delivery app needs to be developed for a local groceries store in Lahore. The idea is to store data about clients who place an order using their mobile phone. The store hires drivers who are handed the grocery items to deliver to the client's address. The priority of the delivery is based on time of order, the oldest order gets delivered first. Also if the client address is within 5km from the store then there are no delivery charges otherwise a delivery charge of Rs 20/km is charged.

i. Which data structure(s) and algorithm(s) are most suitable to develop this app and why?

ii. Please give the overall steps in the form of pseudocode needed to implement the order delivery system, using the data structure(s) and algorithm(s) decided in part(i) above.

c) [Marks: 8] WhatsApp is a mobile app that allow its users to send and receive text, audio and video messages. The WhatsApp team wish to find whether a messages reach back to its sender or not? For example, a person P sends a message to his friends and they forward the message to their friends and so on. Given the users of WhatsApp and the information of all the messages sent by its users to other users, we need to determine that a message is sent back to its user or not for a particular user.

i. Which data structures and algorithms would you like to use in your app so that it functions efficiently?

ii. Give an algorithm (in terms of pseudo-code) that should run on your data structures specified above to find whether a messages reach back to its sender.