Data Structures (CS- 213)
Spring 2018
Assignment #1
Instructor: Mohammad Asad Abbasi
Assigned: 16 February, 2018
Deadline: 1st March, 2018, 4:30pm

Submission Instructions:

- Any information outside the lecture notes and text book should be cited.
- You shall submit written part in hard copy (hand written) to Mr Faaiz in Lab 05 and email programming part to the email address m.asadabbasi@yahoo.com.
- The subject line of email should include Data Structures assignment 1, student name, roll number and section. **Example (Data Structure assignment 1 (Fahad Ahmed, 113, A)).**
- Late submission will be penalized at 10% of total assignment marks per day.

Question # 1

Which data structure/s are most suitable for following scenarios, Justify your selection:

a. You want to store the names of weekdays and access them by the number of a day within the week.
b. You want to store the stations of a public transportation line. New stations can be added to both ends of the line, but not between existing stations. You should be able to traverse the line in both directions.
c. You want to store a phone book, which supports looking up a phone number by name, as well as adding and removing entries.
d. You want to store a sorted list of strings and support the operation of merging two sorted lists into one, in place (without creating a copy of the lists).
e. You are writing software for a call center. When a client calls, his call should be stored until there is a free operator to pick it up. Calls should be processed in the same order they are received.
f. Chess board – an 8 x 8 board used for a game of chess. Each square on the board is either empty or contains a chess piece.
g. The history list recording sites visited by the user of a web browser. As new sites are visited they are added to the list. The list also supports the operation of going back to the web page that was previously visited before the current page and going forward to the next page visited.

Question # 2

A typical array-based list implementation stores references to the list data elements. A typical linked list implementation stores in each link node a reference to the data element and a reference to the next link node. Determine the size of a pointer on your machine. Determine the breakeven point beyond which the array becomes more space efficient than the linked list.

Question # 3

Consider the following code fragment:

```
int count = 0;

int N = a.length;

Arrays.sort(a);

for (int i = 0; i < N; i++) {

for (int j = i+1; j < N; j++) {

if (Arrays.binarySearch(a, a[i] + a[j])) count++;

}

}
```

Suppose that it takes 1 second when N= 3500. Approximately how long will it take when N = 35,000?

Question # 4

Suppose you observe that a program takes x seconds to complete on inputs of size N and y seconds to complete on inputs of size 10 N. Under the hypothesis that the order of growth of the running time is N to a power b, give a formula for b.

Question # 5

Suppose you observe that a program takes 30 seconds to complete on inputs of size 600 and 4.5 minutes to complete on inputs of size 1800. Develop a reasonable hypothesis for the order of growth of the running time.

Question # 6

Design an algorithm that takes an array containing n distinct natural numbers. A number k ≤ n and calculates the sum of the k largest numbers in the array. For example, if the array is {3, 7, 5, 12, 6} and k = 3, then the algorithm should return 25 (12+7+6). You may freely use standard data structure/s and algorithms from the course in your solution, without explaining how they are implemented. Write down your algorithm as pseudo-code, you don't need to write fully detailed code.

Question # 7

What are the steps for inserting a new item at the head of a linked list? Use one short English sentence for each step.

Question # 8

Suppose that p is a reference to an IntNode in a linked list, and it is not the tail node. What are the steps for removing the node after p? Use one short English sentence for each step.

Question # 9

Write a program to create link list of integer type data and insert new element at first, last and any intermediate position of the list.

Question # 10

Write a program to delete element at first, last and any intermediate position of the link list.

Question # 11

Write an algorithm to decide that for a given link list node's data part is even or odd. Also, show total number of even and odd data items in the link list.

Question # 12

Suppose that p, q, and r are all references to nodes in a linked list with 15 nodes. The variable p refers to the first node, q refers to the 8th node, and r refers to the last node. Write a few lines of code that will make a new copy of the list. Your code should set THREE new variables called x, y, and z so that: x refers to the first node of the copy, y refers to the 8th node of the copy, and z refers to the last node of the copy.

Question # 13

Compare the worst-case big-O time analysis of following two methods:

> The addBefore method for the sequence that is implemented using an array, and the addBefore method for the sequence that is implemented using a linked list.

Question # 14

Compare the worst-case big-O time analysis of following two methods:

> The remove method for the sequence that is implemented using an array, and the remove method for the sequence that is implemented using a linked list.

Question # 15

Suppose that a social networking website FRIENDS needs to support two operations: (i) declare A and B to be friends (thus making all of As friends and all of Bs friends friends of each other); and (ii) determine whether A and B are friends. Which data structure/s should FRIENDS use to support these operations. In one or two sentences, justify your answer (describe how FRIENDS should implement the two operations).

Question # 16

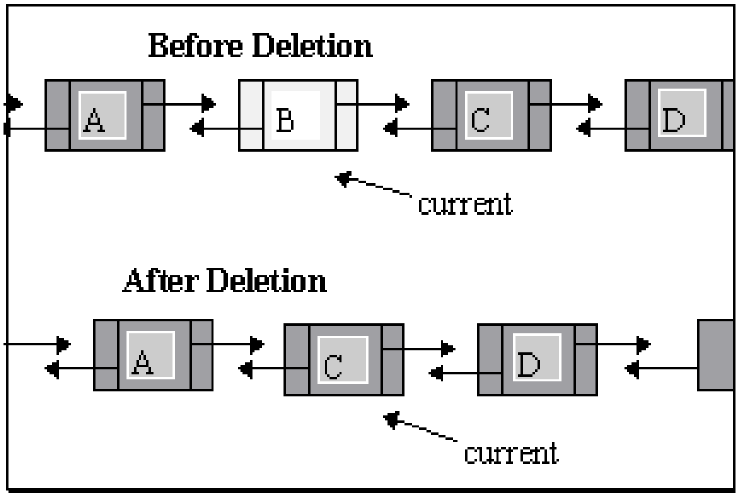
What is the space complexity of a {linked list, circular linked list, doubly linked list} for storing N fixed size items of data?

Question # 17

What is the big-O time complexity of {traversing, inserting a node at the front, inserting a node at the end} a {linked list, circular linked list, doubly linked list}? Justify your answer.

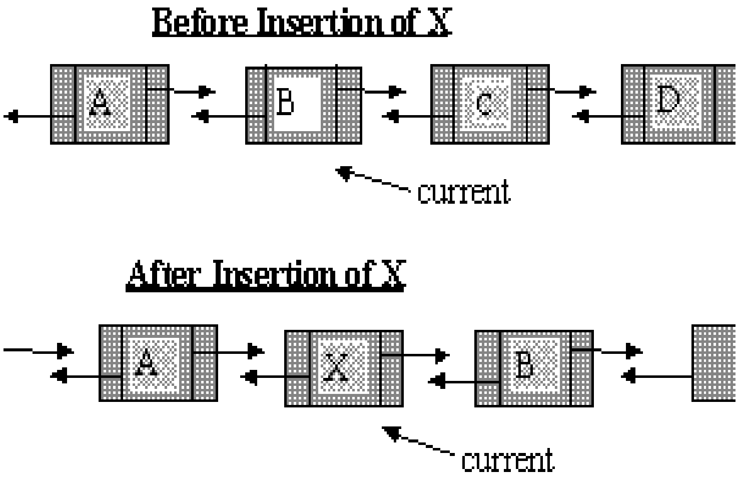
Question # 18

Write algorithm for the following operation on given double link list:



Question # 19

Write algorithm for the following operation on given double link list:



Question # 20

Write a program that implements stack by using array.

Question # 21

Write a program that implements stack by using link list.

Question # 22

Suppose each node of a STACK contains the following information, in addition to required pointer field:

i) Roll number of the student

ii) Age of the student

Give the structure of node for the linked stack in question. TOP is a pointer which points to the topmost node of the STACK. Write the following functions.

i) PUSH() - To push a node to the stack which is allocated dynamically.

ii) POP() - To remove a node from the stack and release the memory.

Question # 23

Consider the usual algorithm to convert an infix expression to a postfix expression. Suppose that you have read 10 input characters during a conversion and that the stack now contains these symbols:

```
                         |     |

                         |  +  |

                         |  (  |

Bottom of stack          |   * |
```

Now, suppose that you read and process the 11th symbol of the input. Draw the stack for the case where the 11th symbol is:

A. A number

B. A left parenthesis

C. A right parenthesis

D. A minus sign

E. A division sign

Question # 24

Given a 5 elements stack S (from top to bottom: 2, 4, 6, 8, 10), and an empty queue Q, remove the elements one-by-one from S and insert them into Q, then remove them one-by-one from Q and re-insert them into S. Now, finally show the elements of S (from top to bottom).

Question # 25

Evaluate the following postfix expression using a stack and show the contents of stack after execution of each operation:

50,40,+,18, 14,-, *,+

Question # 26

Use a stack to evaluate the following postfix expression and show the content of the stack after execution of each operation. Don't write any code. Assume as if you are using push and pop member functions of the stack.

AB-CD+E*+ (where A=5, B=3, C=5, D =4, and E=2)

Question # 27

Write a program that implements queue by using array.

Question # 28

Write a program that implements queue by using link list.

Question # 29

Suppose that Q is an initially empty array-based queue of size 5. Show the values of the data members front and back after each statement has been executed. Indicate any errors that might occur.

```
Queue<Character> Q( 5 );        front = _____ back = _____
Q.enqueue ( ‘A’ );              front = _____ back = _____
Q.enqueue ( ‘B’ );              front = _____ back = _____
Q.enqueue ( ‘C’ );              front = _____ back = _____
char c = Q.dequeue( );          front = _____ back = _____
Q.enqueue ( ‘A’ );              front = _____ back = _____
```

Question # 30

Give the necessary declaration of a linked list implemented queue containing float type values. Also, write a user-defined function to delete a float type number from the queue.

Question # 31

Show how to implement a queue using two stacks. What is the worst-case runtime complexity of the dequeue method?

Question # 32

Write an Insertion Sort algorithm for integer key values. However, the input is a stack (not an array), and the only variables that your algorithm may use are a fixed number of integers and a fixed number of stacks. The algorithm should return a stack containing the records in sorted order (with the least value being at the top of the stack). Your algorithm should be $\Theta(n^2)$ in the worst case.

Question # 33

Write a program that generates 20 random numbers and stores them in an array and sorts them using the Bubblesort algorithm.

Question # 34

Consider the following list of words:

apple, tree, car, dog, yellow, frog, gun, harp

(a) Alphabetize the above list using an insertion sort. Show your work.
(b) Alphabetize the above list using a bubble sort. Show your work. How many complete passes are necessary for the bubble sort to ensure the list is sorted?
(c) Alphabetize the above list using a selection sort. Show your work.

Question # 35

What is the order of each of the following tasks? Choose from O(1), $O(\log_2 n)$, O(n), $O(n\log_2 n)$, $O(n^2)$, $O(2^n)$; each order may appear more than once.)

(a) Popping an item off a stack containing n items.
(b) Performing a Towers of Hanoi algorithm with n disks.
(c) Performing a bubble sort on an array of n integers, in the worst case.
(d) Displaying all n elements in a sorted linked list.
(e) Performing a binary search of a sorted array of n strings, in the worst case.