111-1 Data Structure Midterm Exam

1. Please use C program to finish the code (8%)

```
typedef struct node { int value; node *next }
void push (node **top, int new value) {
        node*new_node = (node*) malloc (sizeof (node));
        //your answer (A)
        //add new_node to stack by top
}
int pop (node **top) {
        int value;
        node *deleting_node = *top;
        //your answer (B)
        //remove the deleting node from stack, get the value of deleting node
        free(deleting_node);
        return value;
}
```

2. Let a and b denote positive integers. Suppose a function Q is defined recursively as follows: (9%)

$$\mathrm{Q(a,b)} = \begin{cases} 0 & if\ a < b \\ Q(a-b,b)+1 & if\ b \le a \end{cases}$$

(a) Find the value of Q(14, 3).

(b) Find the value of Q(5861, 7).

(c) What does this function do?

3. Finish the following C programs to implement a doubly linked circular list. (8%)

```
#include <stdio.h>
typedef struct node *nodePointer;
typedef struct node {
        nodePointer llink;
        element data;
        nodePointer rlink;
};
```

```
void dinsert (nodePointer node, nodePointer newnode){
    /* insert newnode to the right of node */
    newnode->llink = node;
    (a) /* your answer */
    (b) /* your answer */
    node->rlink = newnode;
}

void ddelete (nodePointer node, nodePointer deleted){
    /* delete from the doubly linked list */
    if ( node == deleted )
        printf ("Deletion of header node is not permitted.\n");
    else{
        (c) /* your answer */
        (d) /* your answer */
        free (deleted) ;
    }
}
```

4. Consider the following function Fun written in a C-like pseudo-code, which takes an array A of n positive integers and an initially-empty stack S as input parameters:

```
int Fun (A: array, S: stack) {
    int i, t=0;
    for (i=0; n-1; i++) {
        if (A[i]%2==0)
            push (S, A[i]);
        else
            if (S is not empty)
                t = t - pop(S);
    } // end of for-loop
    while (S is not empty)
        t = t + pop(S);
    return t;
}
```

What is the output (returned value) of the function Fun for the array A = {14, 23, 10, 32, 8, 17, 26, 91, 15, 6, 7, 36, 2, 40, 6, 11} (6%)

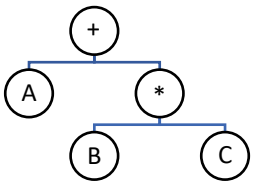
5. Given a singly linked list with n nodes, please show how to use pointers to find the value of the $\frac{n}{2}$ th node after searching the linked list once. (You cannot use an integer to record how many nodes have been visited.) (12%)

6. Consider the following expression:

!A*(B+C)-D=E+F*G

(a) Please draw the expression (binary) tree for the above expression. (3%)

For example: a+b*c



(b) Show how to use the stack to transform the infix order to postfix order. (5%)

7. Consider the following queue of characters, where QUEUE is a circular array which is allocated six memory cells:

FRONT = 2, REAR = 4, QUEUE: __, A, C, D, __, __

(Please use "__" to denote an empty memory cell.) Describe the queue, REAR and FRONT as the following consecutive operations take place: (10%)

(a) F is added to the queue.
(b) Two letters are deleted.
(c) K, L and M are added to the queue.
(d) Two letters are deleted.
(e) R is added to the queue
(f) Two letters are deleted.
(g) S is added to the queue.
(h) Two letters are deleted.
(i) One letter is deleted.
(j) One letter is deleted.

8. Write a program/pseudocode to determine whether two linked lists A and B are identical. Assume you have two pointers, ptrA and ptrB are the pointers to the first node in the linked list A and B respectively. (7%)

9. A linked queue Q and an AVAIL list maintained as a linked stack, are as show in below. Trace the contents of the memory after the execution of the following operations on the linked queue Q.

	Data	Link
23	56	NULL
24	8	29
25	12	34
26	5	NULL
27	76	30
28	123	31
29	9	33
30	45	23
31	23	26
32	56	25
33	78	28
34	123	24

AVAIL: 32 Linked queue Q: FRONT: 27, REAR: 23

(Please draw a table to show the memory after the execution of the operations. And tell me the value of these pointers after these operations) (14%)

(1) Insert 567

(2) Delete

(3) Delete

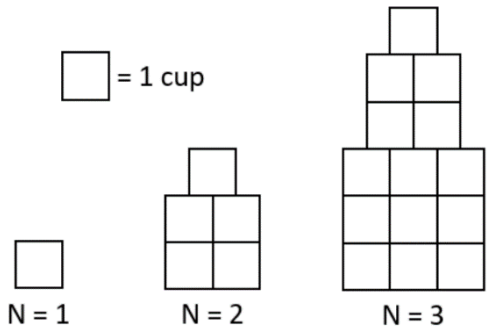
(4) Insert 67

(3% for each pointer, 5% for the table)

10. According to the rules. How many cups she wants to stack?

- **Tower of each layer that is stacked in a square, like the picture.**
- **N : Number of layers**

```
int crystal (int N) {
    if (N==1)
        return 1;
    else
        return (1);
}
```



(1) Finish the program following C programs in this problem. (4%)

(2) What is the result of crystal (6)? (4%)

11. True or False. (6%)

(1) The circular queue can visit all nodes in the queue no matter which node it starts from.

(2) A relation over a set, S, is said to be an equivalence relation over S if and only if it is symmetric, reflexive, transitive over S.

(3) An array is a way of representing a list, which occupies contiguous memory space. The elements in the list use sequential mapping and support random and sequential access.

12. In the data structure queue, elements can be added to one end and removed from the other. Different from queues, a deque allows elements to be added to and removed from both ends.

Given a deque with a permutation of the numbers from 1 to *n* (*n* ≥ 5), we want to remove all of the numbers to form a sequence $< a_1, a_2, a_3, a_4, \dots, a_n >$ that maximizes the alternative sum ($a_1 - a_2 + a_3 - a_4 \dots a_n$), where a_1 is the first number removed, a_2 is the second number, and so on. For example, suppose a deque contains 5 numbers as follow:

(head) 2, 3, 1, 4, 5 (rear)

One possible generated sequence is <5, 2, 4, 1, 3> whose alternative sum is 9.

(1) (5%) Give an example to demonstrate that the problem cannot be solved by a greedy algorithm, which first removes the larger one of the two ends, then removing in the order of the smaller one, the larger one, the smaller one, etc. Show your calculation.

(2) (9%) Design an $O(n^2)$ algorithm to generate the optimal sequence for a given deque. Explain how your algorithm works on the example you give previously in detail.

Hint: You can't just consider those two elements at both ends.

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