2018 Spring (CS2351)
## Data Structure   Midterm Exam

1. Performance analysis (8%)

a. [2%] If $f_1(n) = n$, $f_2(n) = n\log n$, $f_3(n) = 4n^3 + 100000\,n^2$ and $f_4(n) = f_1(n) + f_2(n) + f_3(n)$. What is the tightest big-O of $f_4(n)$.

b. [4%] Write and explain the tightest big-O complexity of these two search algorithms. (The input data is a sorted array.)

```
int linearsearch(int data[], int search){

    int i;

    for (i = 0; i < n; i++){
        if (data[i] == search){
            return i;
        }
    }
    return -1;
}


int binarysearch(int data[], int search, int n){

    int low = 0, high = n - 1;

    while (low <= high){

        int mid = (low + high) / 2;

        if (data[mid] == search){
            return mid;
        }
        else if (data[mid] > search){
            high = mid - 1;
        }
        else if (data[mid] < search){
            low = mid + 1;
        }
    }

    return -1;
}
```

2. Answer the questions based on the following tree. (8%)
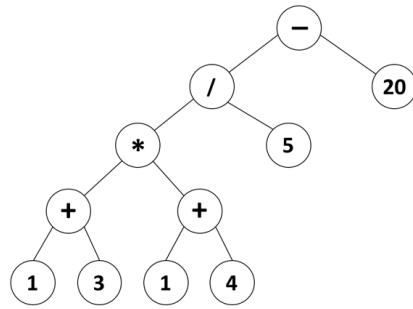
a. [4%] Which binary tree traversal method can derive an **infix** expression? Write down this infix expression *(Hint: Remember to add proper parentheses for clarification.)*

b. [4%] Which binary tree traversal method can derive a **postfix** expression? Write down this postfix expression.

3. Select the most appropriate data structure we discussed in the class for the following scenario. (24%)

a. [8%] Evan usually uses Photoshop(a photo editor) to modify her photo even though she is not good at it. The best functionalities of Photoshop for her are storing the history of actions and undoing the actions in the history. Assume these two functionalities are implemented with a data structure. Which one is it? Reason your choice.

b. [8%] Sharon has too many boyfriend candidates to keep track. Hence, she needs to give every candidate a sequential ID to search. Assume she needs to design a system to store the information and use ID to search. Which data structure you will choose? Reason the choice.

c. [8%] Ray loves to watch video clips and downloads lots of them in his computer. He likes to categorize all the video clips with various genres. The rankings of the genres are: the production company, actors, published year, directors, composers, and visual effect teams, respectively. If you were him, which data structure you may use for such ranking system? Why?

4. A robot named Refu has some failures. It cannot store too many things in its memory. In order to reduce the memory usage, the designer decided to consider its action-and-time history as a sparse matrix. Since you have learned the implementation approaches to store the sparse matrix in linked-list and array. What are the difference between these two implementation approaches? In what case you will suggest to use the array? And in what case you will suggest to use the linked-list? Explain your reasoning. (9%)

5. Suppose a circular queue of capacity (n-1) elements is implemented with an array of n elements. Assume that the insertion and deletion operation are carried out using REAR and FRONT as array index variables, respectively. Initially, REAR = FRONT = 0. (7%)

a. [3%] How is an empty circular queue detected?
b. [4%] How is a full circular queue detected?

6. There is a quiz today. Aida is too nervous so that she spilled her drink on her note. Please help her to rewrite the missing parts. (8%)

a. [2%]
b. [2%]
c. [2%]
d. [2%]

```cpp
class LinkedList;

class Node{
private:
    int data;
    Node* next;

public:
    Node( int data )
    {
        this->data = data;
        this->next = NULL;
    }
    friend class LinkedList;
};


class LinkedList{
private:
    Node* FirstNode;

public:
    LinkedList(){ this->FirstNode = NULL; }
    void Reverse();
};
```

```cpp
void LinkedList::Reverse()
{
    Node *current, *previous, *r;

    current = this->FirstNode;
    previous = NULL;

    while ( current->next            )    (a)
    {
        r        =        previous;

        previous =             ;    (b)

        current  =             ;

        (c)       ->next =        r;
    }

    this->FirstNode =        ;    (d)
}
```
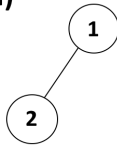
7. Newton is a student in Department of Computer Science at NTHU. After hit by an apple one day, he has a strong interest in tree data structures and wants to learn more about that. (6%)
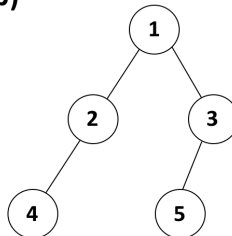
a. [3%] Could you explain to him what is complete binary tree?

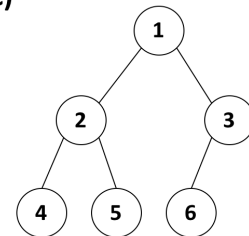b. [3%] Which of the following trees is/are complete binary tree/trees?
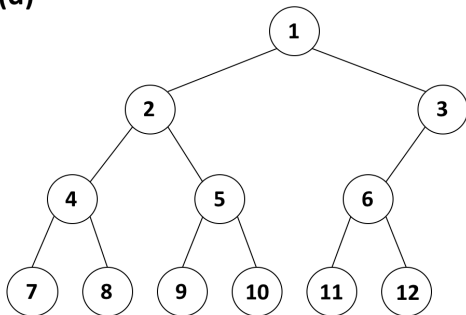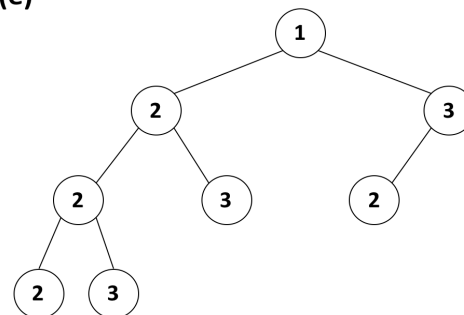

(a)
(b)
(c)
(d)
(e)

8. Binary search tree (12%)

a. [10%] Follow the instructions below one by one to construct a binary search tree.
   (Note: The closest element is the largest element in the left subtree)

   insert 15 → insert 25 → insert 9 → delete 25 → insert 28 → insert22

   → insert 29 → insert 11 → insert 6 → insert 10 → delete 15

b. [2%] What is the rank of "11" and "22"?

9. Quiz Review (15%)
a. [5%] Why cannot we use original Matrix ADT for sparse Matrix?

b. [5%] Why does the textbook have the concepts about "circular queue" but not "circular stack"?

c. [5%] What is the array representation for the following binary tree.