CS235101 Data Structure Midterm Exam

1. **(10%) Performance Analysis**
   a. **(3%)** Please define three asymptotic notations, Θ, O and Ω.
   b. **(2%)** Prove that if $f_1(n) = O(g_1(n))$ and $f_2(n) = O(g_2(n))$, then $f_1(n)f_2(n) = O(g_1(n)g_2(n))$.
   c. **(5%)** Please determine the big-O complexity of following functions:
   $f(n) = n^2 + 3n + 4$
   $f(n) = n + \log n$
   $f(n) = 2^n + n^{10000}$
   $f(n) = 6n^3/(\log n + 1)$
   $f(n) = n!$

2. **(15%) Expression Evaluation**
   a. **(6%)**Please evaluate the value of the following postfix and prefix expression
      1. Postfix :
         3 6 − 2 5 * +
      2. Prefix :
         − + − * 2 3 5 / * 4 3 6 5

   b. **(9%)**Given the infix expression
   $$A - (C + D)* E - F * C$$
   Please show the sequence of stacking operations of infix to postfix
   (Please refer the following example of converting infix to postfix)

Infix Expr : A + B			
	Next Token	Stack	Output String
1	A	EMPTY	EMPTY
2	+	EMPTY	A
3	B	+	A
4	END OF STRING	+	AB
5		EMPTY	AB+

3. **(15%) Circular Lists**

   a. **(10%) Linked Stack and Queue:**

   Given the follow class definition of linked stack and queue, please write down the implementation of two member functions:
   void LinkedStack::pop(void) and void LinkedQueque::push(int data).

```
class LinkedStack{
	LinkedStack(void);

	void pop(void);

	int capacity;
	ChainNode *top;
}
```

```
class LinkedQueque{
	LinkedQueque(void);

	void push(int data);

	ChainNode *front;
	ChainNode *rear;
}
```

```
class ChainNode{
	ChainNode( int data, ChainNode* link);

	int data;
	ChainNode* link;
}
```

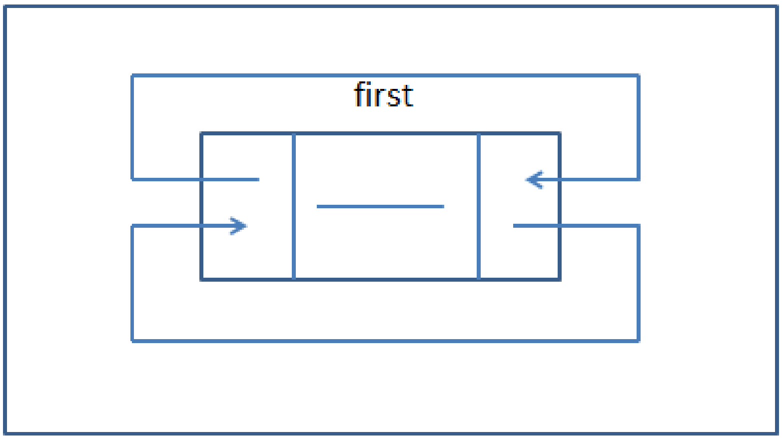
   b. **(5%) Double Circular List**

   Given the class definition of DcList and DclistNode, please write down the implementation of void DcList::insert(DclistNode *p, DclistNode *x).
   (Note that initially DcList ->first points to a dummy node as shown in the following figure).

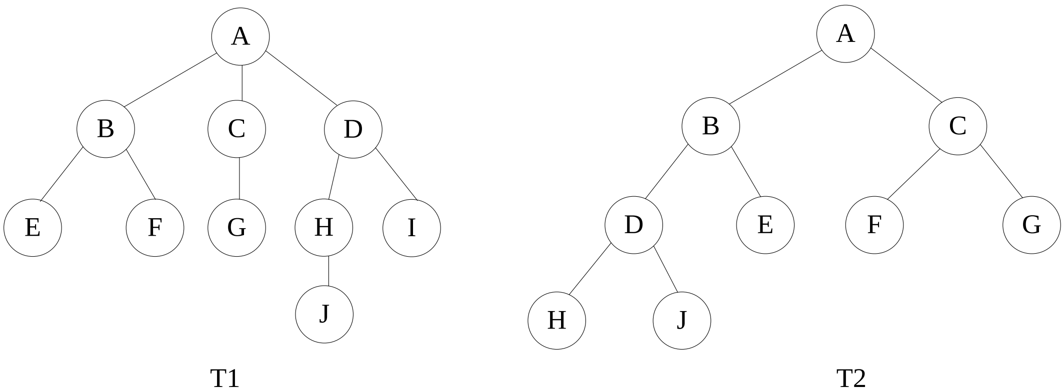
```
class DcList {
	DcList (void);

	//insert node p to the right of node x
	void insert(DclistNode *p, DclistNode *x);

	DclistNode *first;
}
```

```
class DclistNode{
        friend class DcList;
        DclistNode (int, DclistNode*, DclistNode*);

        int data;
        DclistNode *left;
        DclistNode *right;
}
```

DcList



4. (20%) Tree



Given the above two trees, please answer the following questions:

a. (5%) Please convert T1 to a binary tree using left child-right sibling representation.

b. (5%) Degree of T1? Depth of T1? Ancestors of node J? Siblings of node B?

c. **(5%)** Suppose we use array representation for T2, then for any node with index i, $1 \leq i \leq 9$, please define the following terms using i (considering cases of root or having no children): Parent(i) = ? leftChild(i) = ? and rightChild(i) = ?

d. **(5%)** Please give the output of inorder, preorder, postorder and level order traversal of T2.

5. **(20%) Priority Queue (Heap)**

a. **(5%)** Compare the run-time performance (in big-O) of max heaps with that of unsorted and sorted linear lists as a representation of priority queue based on the following operations:

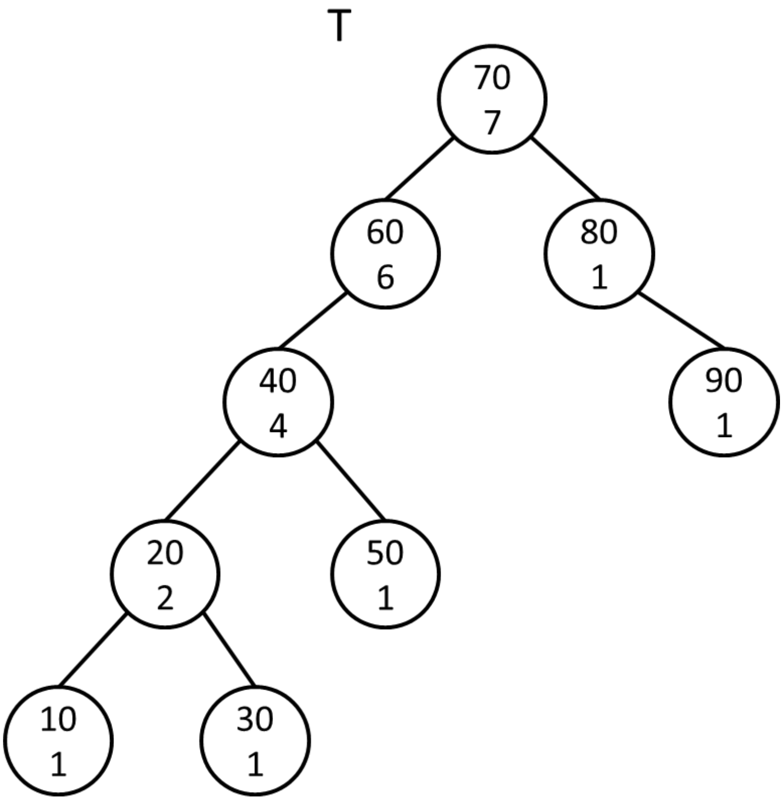
	Top()	Push()	Pop()
Unsorted list			
Sorted list			
Heap			

b. **(5%)** Please reconstruct the max heap from a given output string of inorder traversal of the heap.

16, 62, 5, 95, 1, 88, 2, 99, 3, 14, 78, 10

c. **(10%)** Please illustrate EVERY steps of performing a delete operation on the above max heap.

6. (20%) Binary Search Tree (BST)



Given a binary search tree T with each node contains an additional data field leftSize which is one plus the number of nodes in the left subtree, please answer the following questions:

a. **(15%)** Please write down the codes of "Insert" and "Delete", and "Max" operations of BST (Make sure you maintain the correct number of leftSize!)

b. **(5%)** Please illustrate EVERY steps of deleting a node 40 of the tree T.

```
class Node {
	Node (Key k, Element e) { key = k; element = e; leftSize    =
1;}

	Node* leftChild;
	Node* rightChild;
	Key key;
	Element element;
	int leftSize;
}
```

```
class BST{
	BST (void) { root = NULL; }

	// Insert the node into BST
	void insert (Node& n);

	// Delete the node from BST
	void delete (Node& n);

	// Find the node with largest key in the left subtree
	Node* max (Node* n);

	Node* root;
}
```