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※ 考生請注意：本試題不可使用計算機。　請於答案卷(卡)作答，於本試題紙上作答者，不予計分。

一、選擇題: (30 分, 每題 2 分)

1. Which of the following is very useful in scenarios where data have to be stored and then retrieved in reverse order:

   (a) Queue; (b) Stack; (c) Deque; (d) None of the above.

2. Which of the following is more general than the others:

   (a) Queue; (b) Stack; (c) Deque; (d) None of the above.

3. When inorder traversing a tree results in **DBEAC**, the postorder traversal would return:

   (a) **CAEBD**; (b) **DEBCA**; (c) **ABDEC**; (d) None of the above.

4. There is an algorithm which inserts an item to an ordered SeqList of $n$ elements and still keeps the SeqList ordered. The computational efficiency of this inserting algorithm is:

   (a) $O(\log n)$; (b) $O(1)$; (c) $O(n)$; (d) None of the above.

5. How many non-empty pointers are there in a full binary tree of $n$ nodes?

   (a) $n - 1$; (b) $n + 1$; (c) $n$; (d) None of the above.

6. Which of the following is an unstable sorting algorithm?

   (a) Insertion sort; (b) Bubble sort; (c) Quick sort; (d) None of the above.

7. Which of the following is the best sorting algorithm in terms of time and space complexities?

   (a) Insertion sort; (b) Heap sort; (c) Quick sort; (d) Merge sort.

8. Let $f(n) = 2n^4 + 3n^3 - 100n + 1$. Which of the following statements is false?

   (a) $f(n) = \Theta(n^4)$; (b) $f(n) = \Omega(n^3)$; (c) $f(n) = O(n^5)$; (d) None of the above.

9. What is the depth of a complete binary tree of $n$ nodes?

   (a) $\text{floor}(\log_2 n)$; (b) $\text{ceiling}(\log_2 n)$; (c) $n$; (d) None of the above.

10. Which of the following trees is identical to a binary search tree, except that for every node in the tree, the height of the left and right subtrees can differ by at most 1?

    (a) Red-black tree; (b) Splay tree; (c) AVL tree; (d) B$^+$ tree.

11. What is the maximum difference in the number of edges between any two undirected connected graphs with $n$ vertices?

    (a) $O(1)$; (b) $O(n)$; (c) $O(n^2)$; (d) None of the above.

12. The output from scanning a minimum heap with a level-order traversal algorithm:

    (a) must be an descending sequence; (b) must be ascending sequence; (c) must have a minimum item at the rear position; (d) must have a minimum item at head the position.

13. A self-balancing binary search tree is often implemented by the following data structure except

    (a) R-tree; (b) Red-black tree; (c) AVL tree; (d) 2-3 tree.

14. Which of the following cannot be used to handle collisions in hashing?

    (a) Separate chaining; (b) Linear probing; (c) Quadratic probing; (d) None of the above.

15. Which of the following sequence of keys is a heap?

    (a) 94, 31, 52, 23, 15, 72; (b) 94, 52, 31, 72, 15, 23; (c) 04, 15, 31, 23, 52, 72; (d) None of the above.

二、問答題: (70 分)

1. The Lucas numbers are defined as: $L_0=2$, $L_1=1$, and $L_i = L_{i-1}+L_{i-2}$ for $i>1$. Write both a recursive and an iterative pseudo code to compute $L_i$. (16 分)

2. Consider the following circular queue with `front=3` and `rear=1`.

| Q[0] | Q[1] | Q[2] | Q[3] | Q[4] | Q[5] |
|------|------|------|------|------|------|
| 1,000 | 1,0000 | | | 10 | 100 |

   After executing the following five instructions: "Insert 11", "Delete", "Insert 111", "Delete", "Insert 1".

   (a) What is the value of the variable `front`? (3 分)

   (b) What is the value of the variable `rear`? (3 分)

   (c) Draw the status of the circular queue after the five instructions above are executed. (10 分)

3. Let $\mathbf{a} = (a_1, a_2, \ldots, a_m)$ and $\mathbf{b} = (b_1, b_2, \ldots, b_n)$ be two linked lists. Assume that in each list, the nodes are in non-decreasing order of their field values. Write a (pseudo) code to merge the two lists together to obtain a new linked list $\mathbf{c}$ in which the nodes are also in this order. (10 分)

```
struct node {
    int item;
    struct node *link;
};
typedef struct node list_node;
typedef struct node *list_pointer;

list_pointer merge(list_pointer a, list_pointer b) {
    list_pointer temp;
    /* Please fill in your code here. */
}
```

4. Answer the following two questions regarding binary tree and explain how you obtain your answers:

   (a) What is the maximum number of nodes on level $i$ of a binary tree? (3 分)

   (b) What is the maximum number of nodes in a binary tree of depth $k$? (3 分)

5. Suppose that a hash table contains `hash_size=17` entries indexed from 0 through 16 and that the following sequence of keys are to be mapped into the table:

   22, 55, 26, 29, 400, 0

   (a) Determine the hash addresses and find how many collisions occur when these keys are reduced by applying the operation % `hash_size`. (7 分)

   (b) Find a hash function that will produce no collisions for these keys. (3 分)

6. Please insert the keys 41, 38, 31, 12, 19, 8 into an initially empty red-black tree. (12 分)