



南方科技大学  
SOUTHERN UNIVERSITY OF SCIENCE AND TECHNOLOGY

Course Name: CS203 Data Structures and Algorithm Analysis Exam Duration: 2 hours

Dept.: Department of Computer Science and Engineering

Exam Paper Setter(Signature): \_\_\_\_\_ Reviewer(Signature): \_\_\_\_\_

**Note 1:** Write all your solutions in the answer book. You can ask additional answer book if necessary **Note 2:** If a question asks you to design an algorithm, full marks will be given if your algorithm runs with **OPTIMAL** time complexity

**Note 3:** If a question asks you to design an algorithm, you **ONLY** need to describe your ideas in concise and clear English.

Question No.	1	2	3	4	5	6	7	8	9	10
Score	20	20	20	20	20					

This exam paper contains 5 questions and the score is 100 in total. (Please hand in your exam paper, answer sheet, and your scrap paper to the proctor when the exam ends.)

### Part I. Multiple choice[20 pts, 2 pts for each question]

- Given node  $p$  in a double linked list, the statement to delete node  $p$  is ( ).
  - $p \rightarrow next \rightarrow prev = p \rightarrow prev; p \rightarrow prev \rightarrow next = p \rightarrow prev;$
  - $p \rightarrow next \rightarrow prev = p \rightarrow next; p \rightarrow prev \rightarrow next = p \rightarrow next;$
  - $p \rightarrow next \rightarrow prev = p \rightarrow next; p \rightarrow prev \rightarrow next = p \rightarrow prev;$
  - $p \rightarrow next \rightarrow prev = p \rightarrow prev; p \rightarrow prev \rightarrow next = p \rightarrow next;$
- What is the time complexity of function `fact()`? ( )
 

```
int fact(int n) {
    if(n<=1) return 1;
    return n*fact(n-1);
}
```

  - $O(n \log n)$
  - $O(n)$
  - $O(\log n)$
  - $O(n^2)$
- Which option cannot be the result of quick sort (in ascending order) after two iterations? ( )
  - 2,7,5,6,4,3,9
  - 2,3,5,4,6,7,9
  - 4,2,3,5,7,6,9
  - 3,2,5,4,7,6,9
- Let the initial state of stack  $S$  be empty. The push-in sequence of stack  $S$  is 1,2,3,4. Supposed the pop-out sequence of  $S$  is  $P_1, P_2, P_3, P_4$ , which option cannot be the value of  $P_2, P_4$ ? ( )
  - 2,4
  - 2,1
  - 4,3
  - 3,4

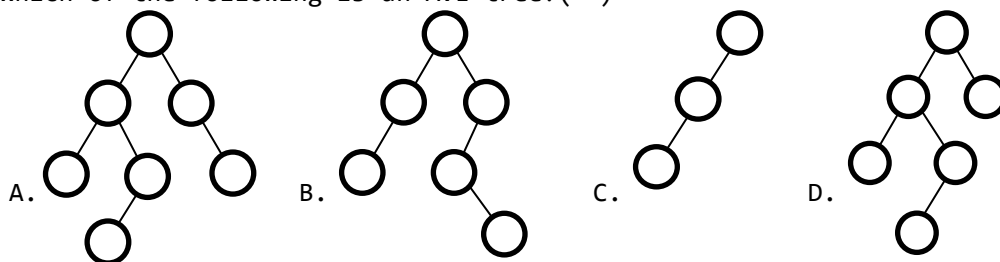
5. Given search text  $T$  with length  $N$  and search pattern  $P$  with length  $M$ , the time complexity of KMP to search  $P$  in  $T$  is \_\_\_\_.

- A.  $O(M+N)$  B.  $O(N)$  C.  $O(M)$  D.  $O(M*N)$

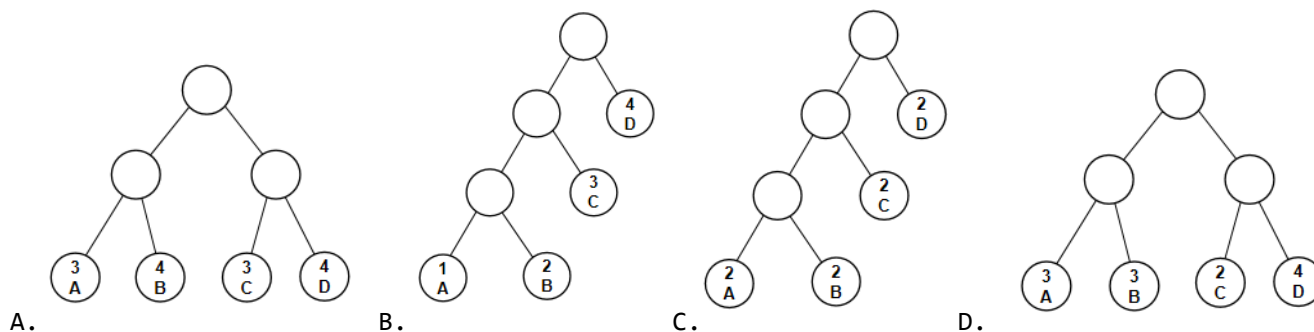
6. Suppose the height of the DFS tree of an undirected graph is  $H_D$  and the height of its BFS tree is  $H_B$ , which option is correct? ( )

- A.  $H_D \geq H_B$  B.  $H_D > H_B$  C.  $H_D \leq H_B$  D.  $H_D < H_B$

7. Which of the following is an AVL tree?( )



8. Which of the following trees is a valid Huffman tree?( )



9. Suppose  $G=(V, E)$  is a directed graph, its vertex set  $V = \{V_1, V_2, V_3, V_4\}$ , and edge set  $E = \{ \langle V_0, V_1 \rangle, \langle V_0, V_2 \rangle, \langle V_0, V_3 \rangle, \langle V_1, V_3 \rangle \}$ . If the depth first traversal of the graph starts from vertex  $V_0$ , the number of different traversal sequences that may be obtained is ( ).

- A. 3 B. 4 C. 5 D. 6

10. Given a complete 3-ary tree with 200 nodes in total, the number of leaf nodes in it is ( ).

- A. 132 B. 133 C. 134 D. none of the above

**Part II. Filling blank questions [20 pts, 5pts for each question]**

1. Suppose that a binary tree's pre-order traversal is ABEDFCGIHJ, and in-order traversal is BDEFAIGCHJ.

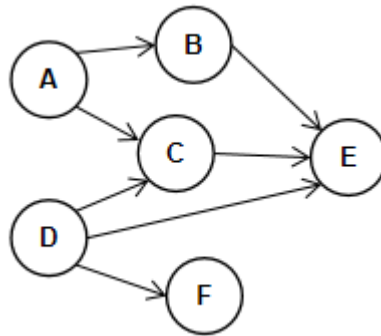
(a) Draw the binary tree.[2 pts]

(b) What is the post-order traversal and the level traversal of the tree.[3 pts]

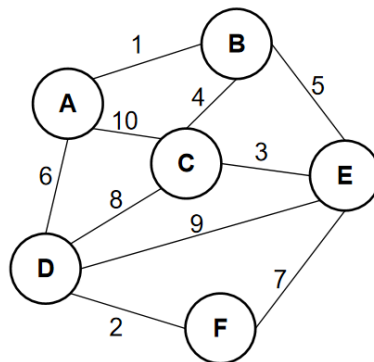
Post-order traversal:\_\_\_\_\_.

Level traversal:\_\_\_\_\_.

2. Please write down all topological orders of the following graph.[5 pts]



3. Use Prim's algorithm to find the minimum spanning tree of the given graph

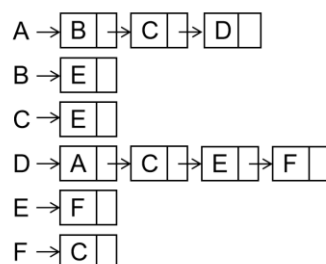


(a) Please write down the edges added to the minimum spanning tree in order. [3 pts]

(A-B)->(\_\_\_\_-\_\_\_\_)->(\_\_\_\_-\_\_\_\_)->(\_\_\_\_-\_\_\_\_)->(\_\_\_\_-\_\_\_\_)

(b) draw the minimum spanning tree. [2 pts]

4. Suppose directed graph G is stored in the form of adjacency list, as shown in the following figure.



(a) draw the graph. [2 pts]

(b) Write down all the Strongly Connected Components of G. [3 pts]

**Part III Algorithm Design and Analysis [20 pts]**

- (1) [8 pts] Suppose there are  $n$  students in SUSTech, the weight of each student is an integer, ranges from 30kg to 125kg. There are  $k$  boats which take them to Hong Kong, the capacity of each boat is the same, denote as **cap** (it also is an integer). For safety reasons, each boat only can host at most TWO students and the sum of weights should not be larger than **cap**. The following pseudocode finds the minimum value of **cap** which can take these  $n$  students to Hong Kong safely, please complete the missing lines.

```

[1] int Solver (Array weight, int k) {
[2]     Sort the values in array weight in ascending order
[3]     Initialize the smallest boat capacity scap ← _____
[4]     Initialize the largest boat capacity lcap ← _____
[5]     Initialize the result cap ← -1, variable midcap ← 0
[6]     while( scap <= lcap ) {
[7]         midcap = (scap + lcap) / 2;
[8]         if(available(weight, midcap, k)){
[9]             _____
[10]            _____
[11]        }
[12]        else{
[13]            _____
[14]        }
[15]    }
[16]    return cap;
[17]}

[18] bool available ( Array weight, int capacity, int k) {
[19]     int boatCount ← 0;
[20]     int low ← 0, high ← len(weight) -1;
[21]     while( low < high ){
[22]         while( (weight[low]+weight[high]) > capacity && low<high) {
[23]             boatCount++; high--;
[24]         }
[25]         boatCount++; high--; low++;
[26]     }
[27]     return _____;
[28]}

```

(2) [12 pts] Method A and B are two different sorting algorithms, please answer questions. The start position of array Arr is 0.

**Method A:**

```
[1] void SortA(int Arr[]){
[2]     for(int i = 1; i < len(Arr); i++){
[3]         if(Arr[i] < Arr[i-1]) {
[4]             int tmp = Arr[i], int j;
[5]             for(j = i-1; j >= 0 && tmp < Arr[j] ; j--){
[6]                 Arr[j+1] = Arr[j];
[7]             }
[8]             Arr[j+1] = tmp;
[9]         }
[10]     print Array Arr;
[11] }
[12]}
```

**Method B:**

```
[1]void sortB(int Arr[], int low, int high){
[2] if(low < high){
[3]     int pi = partition (Arr, low, high);
[4]     print array Arr;
[5]     sortB(Arr, ____, ____ );
[6]     sortB(Arr, pi+1, high );
[7] }
[8]}
[9]int partition (int Arr[], int low, int high) {
[10]     pivot = Arr[high];
[11]     i = (low - 1)
[12]     for (j = low; j <= high- 1; j++) {
[13]         if (Arr[j] <= pivot) {
[14]             i++;
[15]             swap (____, ____ )
[16]         }
[17]     }
[18]     swap (Arr[i + 1] , Arr[high])
[19]     return (i+1);
[20]}
```

(a) Method B is quick sort, please complete the method B. [3 pts]

(b) If the original sequence is “25, 40, 3, 55, 30, 26, 18, 45”, after invoking two methods, please write down the outputs ([10] in method A and [4] in method B) step by step. [6 pts]

(c) Consider sorting the following sequences in ascending order by method A and method B, Method A is faster than Method B with input sequences: \_\_\_\_ [3 pts]

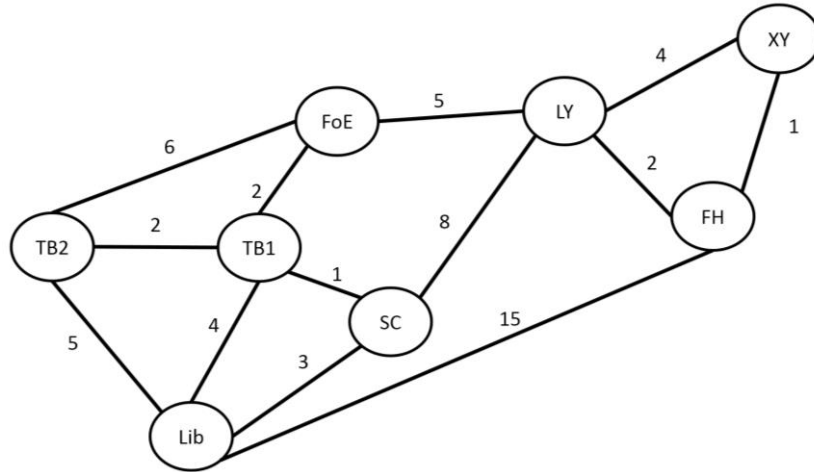
- A. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15
- B. 15, 14, 13, 12, 11, 10, 9, 8, 7, 6, 5, 4, 3, 2, 1
- C. 1, 2, 4, 3, 5, 6, 7, 8, 10, 13, 15, 9, 11, 12, 14
- D. 7, 1, 15, 14, 5, 12, 11, 6, 8, 4, 2, 10, 3, 9, 13

**Part IV Tree [20 pts]**

- (1) [10 pts] There are  $n$  students in CS203, each student has a distinct score. The scores are stored in an array  $S$ . we want to find the student whose score is the  $k$ th ( $k \leq n$ ) largest in the class.
- (a) Design an algorithm (describe your idea in clear and concise English) to find the  $k$ th largest students, and then analyze the time complexity of it [4 pts]
- (b) Suppose the score of students in a class is: {50, 80, 90, 75, 88, 95, 76, 71}. Please find top-5 scores by your algorithm in (1) step by step (please draw figures to show your steps). [6 pts]
- (2) [10 pts] Suppose 40, 15, 30, 20, 10, 3, 73, 60, 80 are inserted into an initially empty binary search tree sequentially.
- (a) Draw the tree after this sequence of insertions has been made. [2 pts]
- (b) Give your answer to part (a), draw the corresponding binary search tree of each operation, respectively. [6 pts]
- insert 35,
  - insert 65,
  - remove 40,
- (c) Design an algorithm (describe your idea in clear and concise English) that tests whether a binary tree is a binary search tree. [2 pts]

**Part V Graph [20 pts]**

(1) Given SUSTech campus graph as following, please use Dijkstra Algorithm to find the shortest distances from FoE to other buildings according the following map. Please complete the following table. [8 pts]

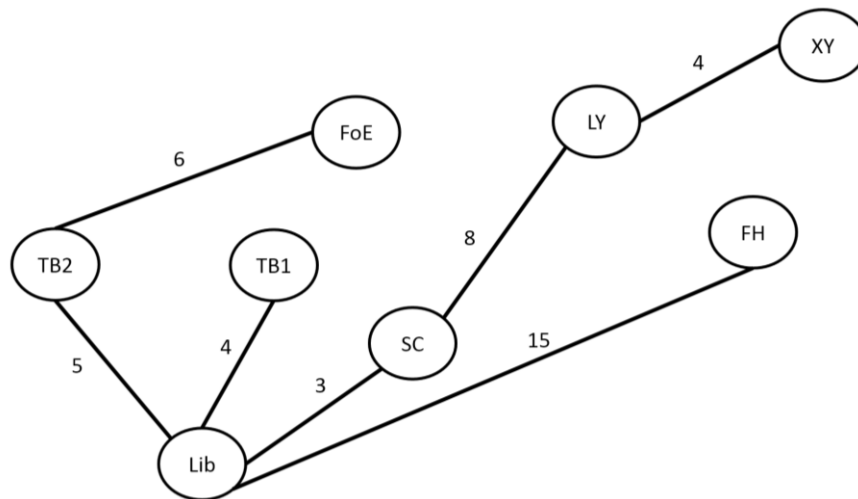


Iteration No.	FoE	Lib	SC	TB1	TB2	LY	FH	XY	Removed node
Iteration 0									
Iteration 1									
Iteration 2									
Iteration 3									
Iteration 4									
Iteration 5									
Iteration 6									
Iteration 7									

(2) Suppose we are building FoE, some roads are removed. The remaining graph is shown as below (The graph does not contain cycle). [6 pts]

(a) What is the maximum distance among all distances of each node pair?

(b) Design an algorithm (describe it by clear, concise English) to find the maximum distance between any two nodes in an undirected acyclic graph and analysis its time complexity.



(3) Finding the maximum distance of any two nodes if the campus graph is directed graph as below

(It is a Directed Acyclic Graph). [8 pts]

(a) What is the maximum distance among all distances of every two nodes in the given campus graph as below?

(b) Design an algorithm (describe it by clear, concise English) to find the maximum distance of any two nodes in a DAG and analysis the time complexity of your algorithm.

