

**THE HONG KONG POLYTECHNIC UNIVERSITY**  
**DEPARTMENT OF COMPUTING**  
**EXAMINATION**

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Course : PG Scheme in COMP-61030, MSc Blockchain Technology-61036,  
MSc Health Informatics-06003, MSc Data Science & Analytics-63027,  
MSc Accounting & Finance Analytics-21052

Subject : COMP5112 Data Structures and Database Systems

Group : 201, 202, 204, 207, 208, 231, 232

Session : 2022 / 2023 Semester II

Date : 3 May 2023

Time : 19:00 - 21:00

Time Allowed: 2 Hours

Subject Lecturer: Dr GUO Jingcai

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This question paper has 6 pages.  
(Some pages may be intentionally omitted.)

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**Instructions to Candidates:**

- This is a closed book examination. Please do not bring any books, scrap papers and other written materials, etc. into the examination room/hall.
- You have 2 hours to complete this examination, independently.
- Make sure you write down your name and student ID on the answer book.
- Unless explicitly stated otherwise: A linked list does not have a tail reference; A double linked list has a tail reference; A queue is implemented by an array circularly; You do not need to consider overflow for any of the data structures.

**Do not turn this page until you are told to do so!**

**Section B: Blank Filling Questions (10 points in total).****[Question 13] - 2 points**

For a given singly linked list, please write the operations that insert a new node 'N' after an existing node 'E' (suppose 'E' is not the tail):

\_\_\_\_\_.

**[Question 14] - 4 points**

For a sorted sequence [1, 2, 3, 4, 5, 6, 7, 8, 9, 10], if we apply the binary search algorithm to search item '4', we need to compare \_\_\_\_\_ times along the running process, and the compared items include \_\_\_\_\_.

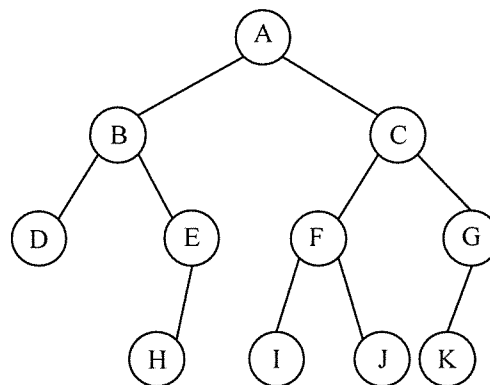
**[Question 15] - 4 points**

Figure 1

To traverse the binary tree demonstrated in Figure 1, the obtained postorder sequence is: \_\_\_\_\_, and the obtained inorder sequence is: \_\_\_\_\_.

**Section C: Short-Answer Questions (12 points in total).****[Question 16] - 4 points**

Please explain and compare *perfect binary tree*, *complete binary tree*, and *full binary tree* in your own words, respectively.

**[Question 17] - 4 points**

Data definition language (*DDL*) and data manipulation language (*DML*) are two types of SQL commands. Please explain their definition and commonly used operations, respectively.

**[Question 18] - 4 points**

The third normal form (3NF) and Boyce-Codd normal form (BCNF) are most widely used in real-world applications. Please explain their definition in detail.

**Section D: Calculation Questions (14 points in total).****[Question 19] - 8 points**

Suppose  $T_1(n), T_2(n), \dots, T_k(n)$  are  $k$  parts of an algorithm, please give the big O time complexity of each part and the algorithm, respectively.

- 1)  $T_1(n) = \log n^2 + \log n^3 + \log n$ ;  $T_2(n) = 6 \log n + n^2 + 2$ ;  $T_3(n) = 2n^2 + 6n$ ;  
ALGORITHM =  $T_1(n) + T_2(n) + T_3(n)$  (4 Points)
- 2)  $T_1(n) = \log n^{1001} - \log n^{60}$ ;  $T_2(n) = 1002n \log n + n + 6$ ;  $T_3(n) = 100n + 3$ ;  
ALGORITHM =  $T_1(n) * T_2(n) * T_3(n)$  (4 Points)

**[Question 20] - 6 points**

Rewrite the arithmetic expression “ $2023 + (5 - 3) * 7 + 9 / 2$ ” to its 1) postfix expression and 2) calculate the result by using a stack (please show the detailed operations in the stack).

**Section E: Comprehensive Questions (40 points in total).****[Question 21] - 6 points**

For an empty binary search tree, we insert 5, 7, 2, 3, 4, 9, 10, 8, 1, and 6 sequentially.

- 1) Please draw the binary search tree (2 points).
- 2) Delete node 1 of the tree obtained in question 1) and draw the obtained new tree (2 points).
- 3) Delete node 7 of the tree obtained in question 1) and draw the obtained new tree (2 points).

**[Question 22] - 8 points**

For a binary tree, we know its preorder sequence is [H, D, A, C, B, G, F, E], and its inorder sequence is [A, D, C, B, H, F, E, G].

- 1) Please draw the binary tree (3 points).

- 2) Write the postorder sequence of this binary tree (2 points).
- 3) Write the list-in-list representation to represent this binary tree (3 points).

**[Question 23] - 6 points**

Given an unsorted list [5, 1, 2, 4, 6, 3], please sort the list in ascending order using selection sort with step-wise results (show the intermediate steps)

**[Question 24] - 10 points**

Consider the bank database as follows, where the primary keys are underlined. Construct the following SQL queries for this relational database.

*branch* (branch name, branch city, assets)

*customer* (ID, customer name, customer street, customer city)

*loan* (loan number, branch name, amount)

*borrower* (ID, loan number)

*account* (account number, branch name, balance)

*depositor* (ID, account number)

- 1) Find the ID of each customer of the bank who has an account but not a loan (3 points).
- 2) Find the ID of each customer who lives on the same street and in the same city as customer “2023” (3 points).
- 3) Find the name of each branch that has at least one customer who has an account in the bank and who lives in “Kowloon” (4 points).

**[Question 25] - 10 points**

For a relation schema  $R(A, B, C, D, E)$  with functional dependencies set  $F: \{A\} \rightarrow \{B\}, \{B, C\} \rightarrow \{D\}, \{C\} \rightarrow \{A\}$ , please answer the following questions.

- 1) Find all candidate keys of  $R$  (3 points).
- 2) Decompose the relation  $R$  into a collection of BCNF relations (4 points).
- 3) Explain whether the above decomposition is dependency preserving or not (3 points).

[This is the end of the examination paper]