Ex/ET/PC/B/T/225/2024

B.E. ELECTRONICS AND TELE-COMMUNICATION ENGINEERING
SECOND YEAR SECOND SEMESTER EXAM - 2024

Data Structures And Algorithms **Time: 3 hours** **Full Marks: 100**

Answer All Questions. Please answer all parts of the same question in the same place.

MODULE 1 (Based on CO 1 and CO 2)

Q.1 (a) Define a queue. Discuss the operational principle of a queue. Explain its two primitive operations. 1+2+2 (CO 1)

(b) Apply the queue in (a) to model customers purchasing tickets from a railway reservation counter. You should show an appropriate implementation. 5 (CO 2)

(c) Define a stack. Compare and contrast a stack and a queue. 1+4 (CO 1)

(d) Apply a stack to evaluate the following postfix expression: 5 (CO 2)

6, 2, 3, +, -, 3, 8, 2, /, +, *, 3, ^, 2, +, $

Here, '$' marks end of input and '^' denotes exponentiation. Show your steps.

Q.2 (a) Define a strictly binary tree. Prove that a strictly binary tree with *n* leaf nodes has *(2n -1)* non-leaf nodes. 1+4 (CO 1)

(b) Explain what is meant by a height balanced tree. Prove that a complete binary tree is always height balanced. 2+3 (CO 1)

(c) Consider the dataset: 8, 6, 10, 4, 7, 9, 11, 3, 5, 2. How can you apply a suitable binary tree representation of this data that can help in sorting and searching? Show a step-by-step construction of such a tree with the first data (*i.e.*, 8) as the root. 2+3 (CO 2)

(d) State if the tree in (c) is height balanced. Illustrate how you will delete the nodes representing the second data (*i.e.*, 6) and the last data (*i.e.*, 2) from this tree. 1+4 (CO 2)

OR

(a) Define a max-heap. Write a pseudocode for building a max-heap and state its complexity. 1+4 (CO 1)

(b) Consider the dataset: 16, 4, 10, 14, 7, 9, 3, 2 to be arranged in a level order binary tree. Construct a max-heap. 5 (CO 2)

(c) Define a planar graph. Draw the graph K_5 and verify that it is non-planar. 1+4 (CO 1)

(d) Apply suitable graphs for modeling the following problems: 5 (CO 2)

i) project allocation among a given set of students and a given set of teachers in a department

ii) a postman visiting a set of streets to deliver mails/packages should start and return to the same post-office visiting each street exactly once

You should show that these problems can be modeled as standard graph problems.

[Turn over

MODULE 2 (Based on CO 3)

Q.3 (a) Prove that for any two functions $f(n)$ and $g(n)$, we have $f(n) = \Theta(g(n))$ iff $f(n) = O(g(n))$ and $f(n) = \Omega(g(n))$. 6

(b) Prove or disprove $f(n) = O(g(n))$ implies $\log(f(n)) = O(\log(g(n)))$, where $\log(g(n)) \geq 1, f(n) \geq 1$ for all sufficiently large n. Assume $f(n)$ and $g(n)$ are asymptotically positive functions. 4

(c) Find the solution to the recurrence relation $T(n) = T\left(\lfloor \frac{n}{2} \rfloor\right) + T\left(\lceil \frac{n}{2} \rceil\right) + 1$ using the substitution method. 10

OR

(a) Prove or disprove $f(n) = O(g(n))$ implies $2^{f(n)} = O(2^{g(n)})$. Assume $f(n)$ and $g(n)$ are asymptotically positive functions. 4

(b) Find the solution to the recurrence relation $T(n) = 2T\left(\frac{n}{2}\right) + n$ using the recursion tree approach. 10

(c) State Master Theorem for solving recurrence relations. 3

(d) Apply Master Theorem to solve the recurrence relation in (b). 3

MODULE 3 (Based on CO 4)

Q.4 (a) Consider the following dataset for ascending order sort: 12, 25, 37, 48, 48, 56, 66, 68, 75, 72, 78. Choose two sorting algorithms – one which will perform well and the other which will not. Justify your choices with proper time-complexity analyses. 6

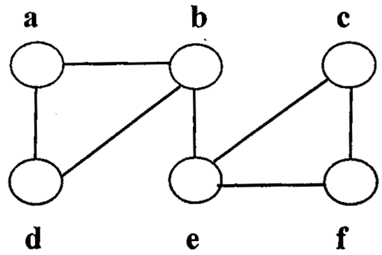
(b) Apply the algorithm which will perform well to sort the data in (a). Show your steps. No pesudocode is necessary. 4

(c) How can you efficiently find the *key* = 75 in the dataset in (a) after sorting has taken place? Trace your solution. Defend your choice with proper time-complexity analyses. 6

(d) Give an example where a *key* should first be converted into an integer within a limited range for further processing of records. What is this conversion called? Compare the roles of a "*modulo*" operator (*i.e.*, x % y, x and y are integers) and a "*floor operator applied on division operator*" (*i.e.*, $\lfloor(x / y)\rfloor$, x and y are integers) in this context. 4

MODULE 4 (Based on CO 5)

Q.5 (a) Consider a set of locations in a GPS navigation system, which can be represented using the following graph:



Suppose the task is to find all neighboring nodes starting from the node **a**. Explain which graph algorithm can achieve this goal. Write a procedure for this algorithm and apply it on the above graph. What is the time-complexity of your solution? 2+(3+4)+1

(b) Finding a Longest Common Subsequence (LCS) is an important problem in the field of computational biology. Explain why a divide-and-conquer type approach is not suitable for solving this problem. Apply a suitable algorithmic strategy to obtain a LCS of the following two protein sequences: 2+8

X = AGGTCA

Y = AAGCT

You should first show the recursive solution.