Algorithms-1 - CS21003
(Class Test IV)
Date: 18 – November – 2021

Maximum marks: 30 Duration: 1 hour

File naming convention: e.g., 18CS3004_G3_CT4.pdf (or any other extension for images). In case of multiple files, use _1, _2 etc at the end.

Submission is via Google form only. Email submissions will NOT be accepted. Please manage your time well keeping in mind that Internet and power disruptions are a new normal!

No clarifications from the TAs today. You can make any assumption as long as it is rational and you clearly state the same while solving the problem.

Plagiarism, in any form (including Internet source) will be severely penalized.

Whenever pseudocodes are asked, you can write C/C++ style code/pseudocode

Question 1

Design an algorithm that takes a graph G as input with two specified vertices s and t and a positive integer k and computes the number of paths containing exactly k edges. For this particular problem a path is allowed to have vertex repetitions. The algorithm should have a run time of $O(k(|V| + |E|))$ or better for full credit. Write a C/C++ style pseudocode.

[10 marks]

Question 2

Consider a hash table of size 7 using a hash function $h(x) = x \mod 7$. Draw the hash table if the following elements are inserted in order {19, 26, 13, 48, 17} and the following collision handing techniques are used:

(a) Chaining

(b) Linear probing

(c) Double hashing where the second hash function $h_2(x) = 5 - x \mod 5$

[1+1.5+2.5=5 marks]

Question 3

Answer the following questions with brief justifications.

(a) True or False: There is an algorithm to convert max heap to a BST with $O(n)$ worst-case time complexity.

(b) True of False: Suppose there is a nearly complete binary tree with l levels, and you have an $O(1)$ access to the first (leftmost) element at each level. It is possible to find the second minimum element with $O(1)$ worse-case time complexity.

(c) You are given marks for n students. You have a simple grading scheme with 5 levels, and you want to divide the students into 5 equal sets such that all students in one set can be assigned the same grade. Assuming that the marks for each student are distinct and n is divisible by 5, can you give a worst-case linear time algorithm? Provide a brief pseudocode.

d) You are given marks for n students in the range 0 to k. A popular query that you face is as follows: How many students got marks in the range $[x, y]$? This query may arrive multiple times and you want a worst-case $O(1)$ solution. If you are allowed to pre-process the input in $O(max(n, k))$ time, is there a way you can solve this problem? Briefly explain your solution.

[2+2+3+3=10 marks]

Question 4

You are given a complete binary tree with n nodes. Each node of the tree stores a distinct string. You want to find out if there is a node u in the tree that comes before in the lexicographical ordering, than all its neighbors. A neighbor implies nodes connected to it via a direct edge. Assuming all nodes contain distinct strings, can you solve this problem by looking at (only using the values of) $O(logn)$ nodes? If yes, provide a brief C/C++ style pseudocode. If no, justify why it is not possible.

[5 marks]