2023

COMPUTER SCIENCE

Paper : CSMC-102

(Data Structures and Algorithms)

Full Marks : 70

The figures in the margin indicate full marks.

Candidates are required to give their answers in their own words as far as practicable.

Answer ***Question No.* 1, *Question No.* 2,** and ***any four*** from the rest.

1. Answer ***any five*** questions : 2×5

(a) Differentiate little-oh from Big-Oh.

(b) State two similarities and two differences between BFS and DFS.

(c) How can a three-dimensional sparse matrix be defined? Give reasons to support your answer.

(d) Define the vertex cover problem of a graph and explain it with the help of a suitable example.

(e) Highlight two strengths and two weaknesses of *GraphSort*.

(f) Consider a graph $G = (V, E)$, where $|V|$ is at least 6 and $|E|$ is at least 7, and show how disjoint set data structure may work on it in identifying pendant and isolated vertices.

(g) State *travelling salesman problem* in its decision version and optimization version.

2. Answer ***any five*** questions :

(a) Define tree. What do you mean by tree structure? Provide different ways of viewing the following tree: (A(B(E, F), C(G), D(H(K), I(L, M), J))). 1+1+2

(b) Define a graph theoretic problem whose implementation could be performed with the help of *queue* as a data structure. Clearly explain the steps of an underlying algorithm and show how queue may play its role to solve the problem. 1+3

(c) State the purpose of *Karatsuba algorithm*. Use this algorithm to compute the value of (1234 × 4321), and also mention its complexity issues. 1+(2+1)

(d) Define and exemplify binomial heap. Prove that there is at most one binomial tree in a binomial heap whose root has a given degree. 1+3

(e) State the associated problem and satisfy the following query with necessary proof: "Given an undirected graph G, can G be painted with three colours?" 4

(f) What do you mean by *heuristic*? When do we usually devise a heuristic algorithm? How is it different from approximation algorithm? 1+1+2

Please Turn Over

(g) Highlight the important things that helped to develop the foundations for the theory of NP-completeness following the published article entitled "The complexity of theorem proving procedure" authored by Stephen Cook. 4

3. (a) Given two strings S_1 = "BDCABA" and S_2 = "ABCBDAB", devise an algorithm that uses tabulation to find the longest common subsequence between the two strings. Also, calculate the time and space complexities of the devised algorithm.

(b) Define a *matroid* and state its structural properties.

(c) If a graph can be modelled as a matroid, then prove that the proposed structure satisfies all the structural properties of a classical matroid. (3+2)+2+3

4. (a) What do you mean by a *height-balanced tree*? State reasons to realize such trees in practice.

(b) Consider the following sequence of elements and insert them, in the order given, to build a height-balanced tree after each insertion. Then, delete n from the final height-balanced tree obtained.

$b,\ v,\ w,\ f,\ z,\ n,\ h,\ p,\ k,\ s$

(c) Compute the smallest number of keys that when inserted in an appropriate order, will force a B-tree of order m to have three levels (assuming the root is at level one). (1+1)+(3+1)+4

5. (a) Suppose that L_1 and L_2 are two lists containing n_1 and n_2 integers, respectively, and both lists are already sorted in their numerical values in non-descending order,

(i) Use the idea of binary search to describe how to find the median of the $n_1 + n_2$ integers in total without combining the lists.

(ii) How the same search technique could help in computing the median of the combined lists?

(b) Devise a simple, easy-to-calculate hash function for mapping three-letter words to integers between 0 and n-1, both inclusive. Find the values of your function on the words: LPA, MAP, BPU, SET, TET, SAT, CTS, LAP, PAM, SIT, PUB, JEE, BTA and TCS for $n = 7$. Try for as few collisions as possible. (4+1)+5

6. (a) Define a biconnected graph and a biconnected component (BCC) of a graph. Devise an algorithm to compute the BCCs of graph $G = (V, E)$, where $V = \{a, b, c, d, e, f, g\}$ and $E = \{\{a, b\}, \{b, c\}, \{a, c\}, \{c, d\}, \{b, e\}, \{b, f\}, \{e, f\}, \{f, g\}\}$. Also, mention the data structure you like to utilize and state the time complexity of the algorithm.

(b) Briefly state the underlying principle of *ShellSort*, and using this principle, sort the following numbers with diminishing increments 5, 3, and 1.

104, 27, 32, 96, 109, 63, 41, 10, 59, 18, 53, 60, 91, 46 (1+3+1)+(1+4)

7. (a) State the steps of proving a new problem NP-complete, and briefly explain with the help of an appropriate example.

(b) How are the problems in NP and the problems in NP-hard differentiated? How are they similar?

(c) Relatively compare the proofs of NP-completeness by *restriction* and *local replacement*, and explain with necessary examples. 3+3+4

8. (a) Critically comment on the following statement and justify the same with the help of proper example(s)— "The underlying principle of *SieveSort* is nothing but a *multi-way Quick Sort* algorithm." Also, give an example to show that *SieveSort* is not a stable sorting algorithm.

(b) What do you mean by *amortized analysis* of algorithms? How is it differentiated from worst-case analysis and average-case analysis? State the role of *credit balance function* in computing the amortized cost of some algorithm. (3+2)+(1+2+2)
