KATHMANDU UNIVERSITY
End Semester Examination
June/July, 2023

Marks Scored:

Level : B.E./B.Sc.
Year : III
Course : COMP 314
Semester : II
Exam Roll No. :
Time: 30 mins.
F. M. : 10
Registration No.:
Date : 29 JUN 2023

SECTION "A"
[20 Q. × 0.5 = 10 marks]

Encircle the most appropriate option among the given choices.

1. The recurrence relation $T(n) = 4T(\frac{n}{2}) + 1$, T(0) = 0 solves to _____.
   a. $T(n) = \theta(1)$
   b. $T(n) = \theta(log_2 n)$
   c. $T(n) = \theta(n^2)$
   d. $T(n) = \theta(nlog_4 n)$

2. If the following data are sorted using Radix sort, what will be the order of the data after sorting them by the second digit?
   725, 211, 323, 151, 813, 535
   a. 211, 151, 323, 813, 725, 535
   b. 211, 813, 725, 323, 535, 151
   c. 151, 211, 323, 535, 725, 813
   d. 211, 813, 323, 725, 535, 151

3. Which of the following algorithm runs in O(log n) in the best case?
   a. Selection sort b. Insertion sort c. Heap sort d. Merge sort

4. Which of the following statements is **TRUE** about Fibonacci heap and binomial heap?
   a. Both Fibonacci heap and binomial heap are binary trees.
   b. Inserting a node takes O(log n) in both Fibonacci heap and binomial heap.
   c. Extraction of minimum key takes O(log n) in both Fibonacci heap and binomial heap.
   d. Finding the minimum key takes O(log n) in both Fibonacci heap and binomial heap.

5. What is the time complexity of searching an element in a B-tree with n nodes?
   a. $\theta(1)$ b. $\theta(logn)$ c. $\theta(nlogn)$ d. $\theta(n)$

6. Which of the following statements is not true in a red-black tree constructed by inserting the following sequence of data: 7, 2, 9, 5, 10?
   a. There are 2 red nodes and 3 black nodes.
   b. 5 is the right child of 2.
   c. Inserting an 8 or a 1 will not affect the black height of the tree.
   d. One rotation was needed while constructing the tree from the given sequence of data.

7. To sort a list with n elements, the insertion sort begins with the _____ element.
   a. first b. second c. third d. fourth

8. Which of the following is **TRUE** about heap sort?
   a. Heap sort is an in-place sorting algorithm
   b. Heap sort has O(log n) average case time complexity
   c. Heap sort is a stable sorting algorithm
   d. Heap sort uses divide-and-conquer strategy

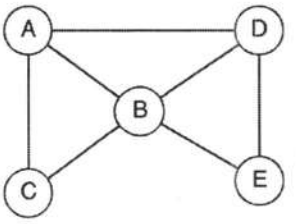
9. Using backtracking, N-Queen problem can be solved in
   a. $O(N^N)$ b. $O(N!)$ c. $O(2^N)$ d. $O(N \times N)$

10. What is a randomized Quick Sort?
    a. The leftmost element is chosen as the pivot
    b. The rightmost element is chosen as the pivot
    c. Any element in the array is chosen as the pivot
    d. A random number in the array is chosen as the pivot

11. Which of the following is **NOT** a solution for 5-Queen problem?
    a. (4, 2, 5, 3, 1) b. (3, 5, 2, 4, 1) c. (1, 4, 3, 5, 3) d. (3, 5, 2, 1, 4)

12. Which of the following tasks takes the most time while solving the fractional knapsack problem using greedy approach?
    a. Breaking items into fraction b. Adding items into knapsack
    c. Sorting d. Looping through sorted items

13. Which of the following is **NOT** a spanning tree of the given graph?



    a. G = ({A, B, C, D, E}, {(A, B), (B, D), (D, E), (A, C)})
    b. G = ({A, B, C, D, E}, {(A, C), (B, C), (D, E), (A, C)})
    c. G = ({A, B, C, D, E}, {(A, D), (B, E), (D, E), (A, C)})
    d. G = ({A, B, C, D, E}, {(A, B), (B, D), (B, C), (A, C)})

14. Which of the following is a requirement for Dynamic Programming?
    a. Any problem can be solved using Dynamic Programming.
    b. While solving the problem, some subproblems must be encountered more than once.
    c. The problem must be NP.
    d. The problem must be solvable using greedy methods.

15. What is the length of the longest common subsequence between "digital" and "design"?
    a. 0 b. 2 c. 3 d. 4

16. If the serial application executes in 5645 seconds and a corresponding parallel algorithm runs in 117.6 seconds on 64 cores, what will be the speedup of the parallel algorithm?
    a. 64x b. 31x c. 88x d. 48x

17. Which of the following statements is **TRUE** about Fermat's Primality Test?
    a. Prime numbers are never reported as composite.
    b. Composite numbers are never reported as prime.
    c. Prime numbers are always reported as prime and composite numbers are always reported as composite.
    d. Composite numbers are always reported as composite.

18. Consider the following code:

```
for (j = 0; j < log2(n); j++)
  for (i = 2^j; i < n; i++)
    x[i] = x[i] + x[i - 2^j];
```

    Which of the following statement is **TRUE** about this code?
    a. Running this code in parallel will generate an error.
    b. This code cannot be run in parallel.
    c. This code can be run in parallel.
    d. Results from this code are unpredictable.

19. Which of the following statements is **FALSE**?
    a. Randomized algorithms are usually faster than deterministic algorithms.
    b. Results from probabilistic algorithms are always unreliable.
    c. Randomized algorithms may return different results on different runs.
    d. Reliability of randomized algorithms can be increased by running them multiple times.

20. To which of the following class does CNF-satisfiability problem belong?
    a. P b. NP c. NP-complete d. NP-hard

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SECTION "B"
[6Q × 4 = 24 marks]

Attempt *ANY SIX* questions.

1. Explain why proving correctness of algorithms is important. Identify and use the loop invariant to prove the correctness of the following algorithm, where A is an array containing numbers. [2 + 2]

```
sum = 0
for i from 0 to n-1
  sum = sum + A[i]
```

2. Explain how radix sort works. Why does radix sort require a stable sort? [3 + 1]

3. In a graph with n vertices and m edges, represented by an adjacency matrix, how would you find the edges terminating at a particular vertex? Discuss your problem-solving strategy, write an algorithm and compute its time complexity. [1 + 2 + 1]

4. Why is dynamic programming appropriate for solving the matrix chain multiplication problem? Consider three matrices A, B, C with the dimensions 5 x 7, 7 x 4, 4 x 3 respectively. Using dynamic programming, find the optimal parenthesization for multiplying these matrices. [2 + 2]

5. How is data parallelism different from task parallelism? Write about the things we should consider while designing parallel algorithms. [2 + 2]

6. Give an example of brute force method of problem solving. What are its advantages and disadvantages? [2 + 2]

7. Write short notes on *ANY TWO* of the following topics: [2 + 2]
   a. Self-balancing binary search trees
   b. Relationship between P, NP and NP-complete problems
   c. Flow networks

SECTION "C"
[2 Q. × 8 = 16 marks]

Attempt *ANY TWO* questions.

8. Compare and contrast binomial heap and Fibonacci heap. Construct a binomial heap from the given sequence of data: 5, 3, 9, 1, 7, 8, 2, 4 [3 + 5]

9. What are the benefits of non-deterministic algorithms over deterministic algorithms? State Fermat s Little Theorem. Explain, with examples, why Fermat s Primality test never reports prime numbers as composite but composite numbers may be reported as prime. [3 + 2 + 3]

10. State the knapsack problem. What is the difference between 0/1 knapsack problem and fractional knapsack problem? Solve the following 0/1 knapsack problem using any algorithm design strategy. Justify your choice. [2 + 1 + 4 + 1]

Capacity of the knapsack = 10
Number of items = 4
Weight of the items = {5, 4, 3, 6}
Profit of the items = {15, 12, 15, 12}