



COMSATS UNIVERSITY ISLAMABAD (CUI)

DEPARTMENT OF COMPUTER SCIENCE
TERMINAL EXAMINATION FALL - 2022
BS (CS)– V SEMESTER
BS (DS/AI/CYS)– IV SEMESTER

Course: CSC301-Design and Analysis of Algorithm
Maximum Marks: 50

Dated: January 26, 2023

Instructor: Tanveer Ahmed
Time Allowed: 180 Minutes

- All questions are self-explanatory and require no further explanations during exam time.
- Make sure that you have signed the attendance sheet before leaving the examination room.
- Return the question paper along with the answer sheet.
- Attempt all questions.

(CLO – 1: Apply inductive proofs techniques to prove the correctness of an algorithm)

Q.# 1. Establish the correctness of following algorithm using *induction*. You should clearly define algorithm's *loop invariant* and prove it by showing all steps i.e., *Initialization*, *Maintenance*, and *Termination*.

[10 Marks:3+2+4+1].

Algorithm *Decimal_to_Binary*(n)

//Input: n, a positive integer

//Output: b, an array of bits, the bin representation. of n, starting with the least significant bits

1. $t \leftarrow n$
2. $k \leftarrow 0$
3. while($t > 0$) do
4. $k \leftarrow k + 1$
5. $b[k] \leftarrow t \bmod 2$
6. $t \leftarrow \lfloor t/2 \rfloor$
7. end

(CLO – 2: Analyze the behavior of an algorithm using asymptomatic analysis.)

[15 Marks:4+6+5].

Q.# 2.

2.1. Find the time complexity of the following code. Use most suitable asymptotic notation among O , Ω , and Θ to specify the time efficiency class of the given code.

```
void fun(int n)
{
    int k = n, j = 1, i = 0;
    while (k > 0)
    {
        // Some O(1) task
        while (i < n)
        {
            // Some O(1) task
            i = i + j;
            j++;
        }
        k = k/3
    }
}
```

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2.2. What are the **running times** of each of following algorithms (in Big-O Notation), and which would you choose?

- a) **Algorithm A** solves problems by dividing them into five subproblems of half the size, recursively solving each subproblem, and then combining the solutions in linear time.
- b) **Algorithm B** solves problems of size n by recursively solving two subproblems of size $n - 1$ and then combining the solutions in constant time.
- c) **Algorithm C** solves problems of size n by dividing them into nine subproblems of size $n/3$, recursively solving each subproblem, and then combining the solutions in $O(n^2)$ time.

2.3. The recurrence $T(n) = 7T(n/2) + n^2$ describes the running time of an algorithm A . A competing algorithm B has a running time of $T'(n) = a T'(n/4) + n^2$. What is the largest integer value for a such that B is asymptotically faster than A ?

(CLO – 3: Design an algorithm for a computational problem by employing an appropriate algorithmic approach.)

[10 Marks:5+5].

Q. # 3.

3.1 Design an algorithm for the following problem using **Divide and Conquer** approach
Problem: Given a list of n distinct positive integers, partition the list into two sublists, each of size $n/2$, such that the difference between the sums of the integers in the two sublists is maximized. You may assume that n is a multiple of 2.

3.2 Design an algorithm for the following problem using **Dynamic Programming**.
Problem: Convert a given string S into palindrome by performing minimum number of edit operations (insertion and deletion).

(CLO – 4: Explain the concept of computability with examples.)

[15 Marks:5+7+3].

Q. # 4.

- 4.1 Explain $3\text{-CNF} \leq_p \text{CLIQUE}$. That is how to reduce 3-CNF Satisfiability problem to an instance of CLIQUE problem in polynomial time.
- 4.2 Transform the 3-CNF formula $\varphi = (x_1 \vee \bar{x}_2 \vee \bar{x}_3) \wedge (\bar{x}_1 \vee x_2 \vee x_3) \wedge (x_1 \vee x_2 \vee x_3)$ into (G, k) such that $\varphi \in 3\text{-CNF} \leftrightarrow (G, k) \in \text{CLIQUE}$.
- 4.3 Identify a CLIQUE from part (4.2) and the corresponding truth assignments.

*****BEST OF LUCK*****