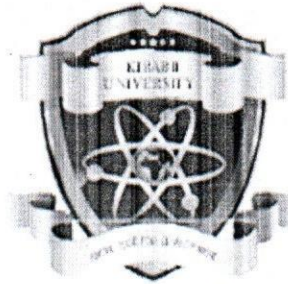


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(KNOWLEDGE FOR DEVELOPMENT)

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**UNIVERSITY EXAMINATIONS
2020/2021 ACADEMIC YEAR**

**END OF SEMESTER EXAMINATIONS
YEAR THREE SEMESTER ONE**

**FOR THE DEGREE IN
(COMPUTER SCIENCE)**

COURSE CODE: CSC 312

**COURSE TITLE: DESIGN AND ANALYSIS OF
ALGORITHMS**

DATE: 13/07/2021 TIME: 9.00 A.M – 11.00 A.M

INSTRUCTIONS

ANSWER QUESTIONS ONE AND ANY OTHER TWO.

QUESTION ONE [COMPULSORY] [20 MARKS]

- a. Define the term algorithm and state the criteria that every algorithm must satisfy. [4 marks]
- b. Explain the three basic design goals that one should strive when design for a program and how the complexity of a program can be measured. [4 marks]
- c. Using an array of 100 elements, define best case, worst case and average case time complexities. [4 marks]
- d. Explain any two factors that the running time of a program depends on factors. [4 marks]
- e. What is the smallest value of n such that an algorithm whose running time is $100n^2$ runs faster than an algorithm whose running time is $2n$ on the same machine? [3 marks]
- f. Explain the characteristic properties associated with a problem that can be solved using dynamic programming. [3 marks]
- g. Briefly explain the concept of P, NP-hard and NP- complete problems. [3 marks]

QUESTION TWO [20 MARKS]

- a. What are the general rules followed when analyzing running time of programs. [3 marks]
- b. Explain the concept of control abstraction in Dynamic Programming. [2 marks]
- c. Explain the differences between Prim's and Kruskal's algorithm. Link this to efficiency analysis. [2 marks]
- d. Define Asymptotic Notations? Explain their significance in analyzing algorithms? [4 Marks]
- e. Explain N-queens problem using Backtracking and draw the state space tree of 4-queens problem [6 Marks]
- f. Describe the travelling salesman problem and discuss how to solve it using dynamic programming? [3 marks]

QUESTION THREE [20 MARKS]

- a. Algorithm analysis is the study of an algorithm's efficiency with respect to resource utilization, discuss these resources [4 marks]
- b. Differentiate between greedy algorithm and dynamic programming and state the nature of problems that can be solved using each approach. [4 marks]
- c. State fractional knapsack problem and give an algorithm for fractional knapsack problem using greedy strategy. [4 marks]
- d. Find an optimal solution to the fractional knapsack problem for an instance with number of items 7, Capacity of the sack $W=15$, profit associated with the items $(p_1, p_2, \dots, p_7) = (10, 5, 15, 7, 6, 18, 3)$ and weight associated with each item $(w_1, w_2, \dots, w_7) = (2, 3, 5, 7, 1, 4, 1)$. [6 marks]
- e. Solve multiplication using Divide and Conquer strategy $12345678 * 21394276$ [4 marks]

QUESTION FOUR [20 MARKS]

- a. Determine the best case and worst-case time complexities of the following two functions **fun1()** and **fun2()**: [4 marks]

```
int fun1(int n)
{
    if (n <= 1) return n;
    return 2*fun1(n-1);
}
int fun2(int n)
{
    if (n <= 1) return n;
    return fun2(n-1) + fun2(n-1);
}
```

- b. Explain Euclid's algorithm for computing $\text{gcd}(m, n)$, hence compute the gcd and the lcm of (31415 and 14142) [4 marks]
- c. If the first program P1 takes $100n^2$ milliseconds and the second program P2 takes $5n^3$ milliseconds. Determine and recommend which program P1 or P2 is better and at what condition? [4 marks]
- d. One of the two software packages, **A** or **B**, should be chosen to process data collections, containing each up to 109 records. Average processing time of the package **A** is $T_A(n) = 0.001n$ milliseconds and the average processing time of the package **B** is $T_B(n) = 500\sqrt{n}$ milliseconds. Which algorithm has better performance in a "Big-Oh" sense? Work out exact conditions when these packages outperform each other. [4 marks]

- e. Let processing time of an algorithm of Big-Oh complexity $O(f(n))$ be directly proportional to $f(n)$. Let three such algorithms A, B, and C have time complexity $O(n^2)$, $O(n^{1.5})$, and $O(n \log n)$, respectively. During a test, each algorithm spends 10 seconds to process 100 data items. Derive the time each algorithm should spend to process 10,000 items. [4 marks]

QUESTION FIVE [20 MARKS]

- a. The aim of designing algorithms is to find an algorithm whose upper bound matches the lower bound of the problem. Write down the procedure used to design an algorithm. [4 marks]
- b. Suppose we use Dijkstra's greedy, single source shortest path algorithm on an undirected graph. What constraint must we have for the algorithm to work and why? [4 marks]
- c. Consider the following recursive algorithm for computing the sum of the first n cubes.

```
S(n) = 13 + 23 + 33 + ... + n3
Algorithm S(n)
  If (n=1) return 1
  Else return (S(n-1) + n*n*n)
end algorithm
```

Set up and solve a recurrence relation for the number of times the basic operation of the algorithm is executed. [6 marks]

- d. Discuss the following briefly:
- i. Parallel algorithms [3 marks]
 - ii. Complexity Theory [3 marks]