(Knowledge for Development)

KIBABII UNIVERSITY

(KIBU)

MAIN CAMPUS

UNIVERSITY EXAMINATIONS

END OF SEMESTER EXAMINATION

2021/2022 ACADEMIC YEAR

THIRD YEAR FIRST SEMESTER EXAMINATION

FOR THE DEGREE OF BACHELORS OF SCIENCE IN

(COMPUTER SCIENCE)

COURSE CODE: CSC 312

COURSE TITLE: DESIGN AND ANALYSIS OF ALGORITHMS

DATE: 20/05/2022 **TIME: 9.00 A.M. – 11.00 A.M.** **2HRS**

INSTRUCTIONS TO CANDIDATES:

ANSWER QUESTIONS ONE AND ANY OTHER TWO.

QUESTION ONE (COMPULSORY) [30 MARKS]

a. Why do we require the understanding of complexity theory when handling computational problems? **[3 marks]**

b. Suggest two ways in which sequential search algorithm can be improved. **[2 marks]**

c. Explain the control abstraction of divide and conquer technique **[2 marks]**

d. i. Simulate the running time of a binary search. **[4 marks]**

ii. You are given the following array elements in Table 1 below.

Table 1: Array Elements in Computer Memory

1	4	5	7	8	9	10	23	25	27	30	32	41

Provide an algorithm for searching a value x=100 using binary search. Estimate the best case and the worst case scenarios of the algorithm. **[3 marks]**

a. i. Define the meaning of a spanning Tree and a Minimum Spanning Tree (MST). **[3 marks]**

ii. How will you find MST using prim's algorithm and Kruskal's algorithm? **[3 marks]**

b. The code to compute the matrix product C = A * B is given below.

```
for (i = 1; i<=n; i++)  n
for (j = 1; j<=n; j++) n
C[i, j] = 0; 1 n*n
for (k = 1; k<=n; k++) n
C[i, j] = C[i, j] + A[i, k] * B[k, j]; (n*n*n)
```

Compute the running time of the code. **[4 marks]**

c. Explain the application of the following algorithms:

i. Branch and Bound Algorithm **[2 marks]**

ii. Randomized Algorithm **[2 marks]**

iii. Backtracking Algorithm **[2 marks]**

QUESTION TWO [20 MARKS]

a. Using limits show that $f(n) = 4n^3 + 10n^2 + 5n + 1$ is in $g(n) = n^4$ **[2 marks]**

b. Explain the assignment problem. How will you solve the assignment problem using optimization techniques? Illustrate briefly. **[4 marks]**

c. How will you classify a given problem as P and NP type? Discuss the available methods to solve NP problems. **[4 marks]**

d. Consider a knapsack of capacity, **W=65** and the list of provided items as in the Table 1 below.

Table 1: Items to be added in the Knapsack

Items	A	B	C	D
Profits	180	100	120	120
Weights	40	10	20	24

Compute the optimized solution or maximum profit in the knapsack using:

i. Greedy strategy **[4 marks]**

ii. Dynamic programming approach **[4 marks]**

iii. Which strategy will you prefer? Justify. **[2 marks]**

QUESTION THREE [20 MARKS]

a. Discuss the applicability of design and analysis of an algorithm to a computer science student. **[3 marks]**

b. Discuss branch and bound method with an example. **[3 marks]**

c. Discuss the basic NP-complete problems showing their transformation topology. **[3 marks]**

d. Let **M** be a deterministic Turing Machine **(TM)** that halt on all inputs. Space complexity of **M** is a function **f: N→N**, where **f (n)** is the maximum number of call of tape and M scans any input of length n. if the space complexity of **M** is **f (n),** then M runs in space **f (n).** Estimate the space complexity of **TM** using asymptotic notation. **[3 marks]**

e. Discuss Prism's algorithm and use it to estimate the minimum cost of the network diagram in **Figure 1**. **[3 marks]**

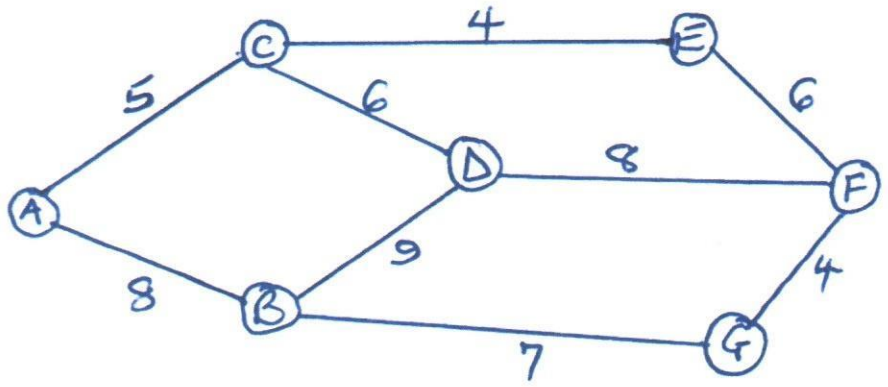

Figure 1: Network Diagram 1.

i. Consider the following recursive algorithm for computing the sum of the first n cubes.

$S(n)=1^3+2^3+3^3+\ldots+n^3$

Algorithm S(n)
If (n=1) return 1

Else return (S (n-)+ 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. **[4 marks]**

QUESTION FOUR [20 MARKS]

a. Explain important fundamental problem type of different categories. **[4 marks]**

b. Explain in brief the basic asymptotic efficiency class **[4 marks]**

c. Explain the method of comparing the order of growth of two functions using limits. **[4 marks]**

d. Consider the graph shown in **Figure 2** below.

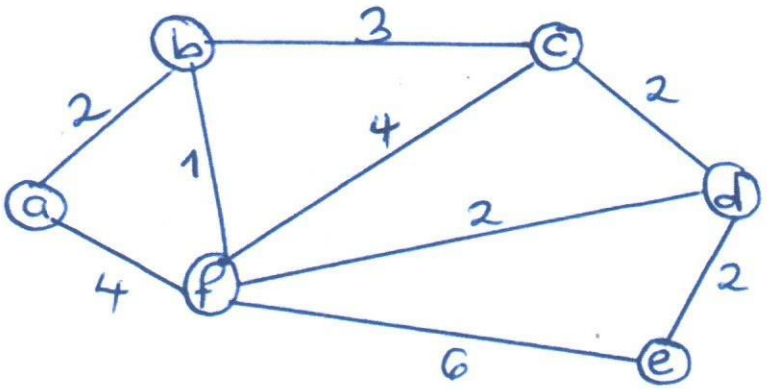

Figure 2: Network Diagram 2.

e. Using appropriate algorithms:

ii. Construct the minimum Spanning Tree (MST). **[4 marks]**

iii. Single source shortest path from node **a** to **e**. **[4 marks]**

QUESTION FIVE [20 MARKS]

a. Discuss various factors that may affect the running time of a computer program. **[3 marks]**

b. Describe how the following algorithms work.

i. Randomized algorithm **[3 marks]**

ii. Approximation algorithm **[3 marks]**

c. Apply Branch and Bound algorithm on the **Figure 3** below to solve the Traveling Salesman problem. **[3 marks]**

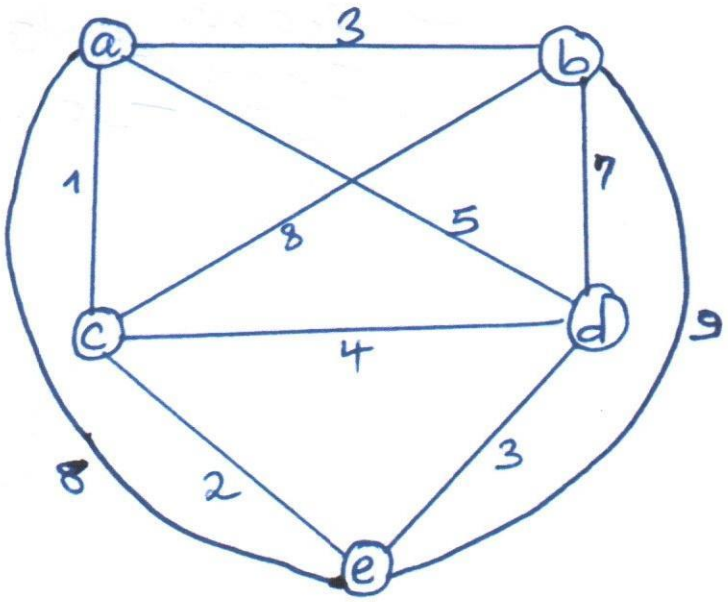

Figure 3: Network Diagram 3.

d. **i.** Software packages A and B of complexity **O (n log n)** and **O(n),** respectively spend exactly TA (n)= CA **n log n** and **TB (n) = CB n** milliseconds to process n data items. During a test, the average time of processing **n = 10000** data items with packages **A** and **B** is **100** milliseconds and **1500** milliseconds, respectively. Derive exact conditions when one package actually outperforms the other and recommend the best choice if up to $\mathbf{n=10^9}$ data items should be processed. **[4 marks]**

ii. Software packages A and B have processing time of exactly $\mathbf{T_A = 3n^{1.5}}$ and $\mathbf{T_B = 0.03n^{1.75}}$, respectively. If you are interested in faster processing of up to $\mathbf{n = 10^8}$ data items, then which package should you recommend? **[4 marks]**