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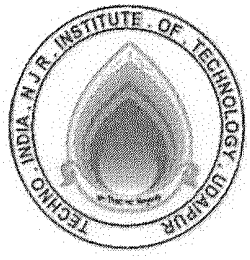

Course File

Analysis of Algorithms (5CS4- 05)

Kirti Dashora
(Assistant Professor)
Department of CSE

For Techno India NJR Institute of Technology
पंकज पोरवाल
Dr. Pankaj Kumar Porwal
(Principal)

RAJASTHAN TECHNICAL UNIVERSITY, KOTA

Syllabus

III Year-V Semester: B.Tech. Computer Science and Engineering

5CS4-05: Analysis of Algorithms

Credit: 3 **Max. Marks: 150(IA:30, ETE:120)**

3L+0T+0P **End Term Exam: 3 Hours**

SN	Contents	Hours
1	**Introduction:** Objective, scope and outcome of the course.	01
2	**Background**: Review of Algorithm, Complexity Order Notations: definitions and calculating complexity. **Divide And Conquer Method**: Binary Search, Merge Sort, Quick sort and Strassen's matrix multiplication algorithms.	06
3	**Greedy Method**: Knapsack Problem, Job Sequencing, Optimal Merge Patterns and Minimal Spanning Trees. **Dynamic Programming**: Matrix Chain Multiplication. Longest CommonSubsequence and 0/1 Knapsack Problem.	10
4	**Branch And Bound**: Traveling Salesman Problem and Lower Bound Theory. Backtracking Algorithms and queens problem. **Pattern Matching Algorithms**: Naïve and Rabin Karp string matching algorithms, KMP Matcher and Boyer Moore Algorithms.	08
5	**Assignment Problems**: Formulation of Assignment and Quadratic Assignment Problem. **Randomized Algorithms**- Las Vegas algorithms, Monte Carlo algorithms, randomized algorithm for Min-Cut, randomized algorithm for 2- SAT. Problem definition of Multicommodity flow, Flow shop scheduling and Network capacity assignment problems.	08
6	**Problem Classes Np, Np-Hard And Np-Complete**: Definitions of P, NP-Hard and NP-Complete Problems. Decision Problems.Cook's Theorem. Proving NP-Complete Problems - Satisfiability problem and Vertex Cover Problem. Approximation Algorithms for Vertex Cover andSet Cover Problem.	08
	Total	41

Course Overview:

Algorithm design and analysis provide the theoretical backbone of computer science and are a must in the daily work of the successful programmer. The goal of this course is to provide a solid background in the design and analysis of the major classes of algorithms. At the end of the course students will be able to develop their own versions for a given computational task and to compare and contrast their performance

Algorithm design and analysis provide the theoretical backbone of computer science and are a must in the daily work of the successful programmer. The goal of this course is to provide a solid background in the design and analysis of the major classes of algorithms. At the end of the course students will be able to develop their own versions for a given computational task and to compare and contrast their performance

Course Outcomes:

CO. NO.	Cognitive Level	Course Outcome
1	Synthesis	Student will be able to design algorithms and to analyze the performance of algorithms by identify different aspects of time and space complexity of recursive and non recursive codes
2	Synthesis	Students will able to apply various algorithms for different computing problems using dynamic programming and branch and bound techniques and try to solve different more real time complex problems
3	Design	Students will be able to design and evaluate algorithms using various algorithm design techniques for pattern matching algorithms.
4	Analyze	Students will be able to analyze randomized algorithms, Recite algorithms that employ randomization.
5	Design	Relate the concepts of NP Completeness for analyze and solving the complexity of real life problems.

Prerequisites:

1. Fundamentals of C programming.
2. Students should have proper knowledge of Data structures.
3. Students should be able to find efficiency of different type of codes.

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Course Outcome Mapping with Program Outcome:

Course Outcome	Program Outcomes (PO's)											
CO. NO.	Domain Specific (PSO)					Domain Independent (PO)						
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	3	2	2	1	-	-	1	-	-	1
CO2	2	2	3	2	2	1	-	-	1	-	-	1
CO3	2	2	3	2	2	1	-	-	1	-	-	1
CO4	3	2	3	2	2	1	-	-	1	-	-	1
CO5	3	2	3	2	2	1	-	-	1	-	-	1
1: Slight (Low) , 2: Moderate (Medium), 3: Substantial (High)												

Course Coverage Module Wise:

Lecture No.	Unit	Topic
1	1	**Introduction:** Objective, scope and outcome of the course
2	2	**Background**: Review of Algorithm
3	2	Complexity Order Notations: definitions and calculating complexity
4	2	**Divide And Conquer Method**
5	2	Binary Search, Merge Sort
6	2	Quick sort
7	2	Strassen's matrix multiplication algorithms
8	3	**Greedy Method**:
9	3	Knapsack Problem
10	3	Job Sequencing
11	3	Optimal Merge Patterns
12	3	Minimal Spanning Trees
13	3	**Dynamic Programming**
14	3	Matrix Chain Multiplication
15	3	Matrix Chain Multiplication
16	3	Longest Common Subsequence
17	3	0/1 Knapsack Problem.
18	4	**Branch And Bound**
19	4	Traveling Salesman Problem
20	4	Lower Bound Theory
21	4	Backtracking Algorithms and queens problem
22	4	**Pattern Matching Algorithms**Naïve

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23	4	Rabin Karp string matching algorithms
24	4	KMP Matcher
25	4	Boyer Moore Algorithms
26	**5**	**Assignment Problems**
27	5	Formulation of Assignment
28	5	Quadratic Assignment Problem.
29	5	**Randomized Algorithms**
30	5	Las Vegas algorithms, Monte Carlo algorithms
31	5	Randomized algorithm for Min-Cut, randomized algorithm for 2- SAT
32	5	Problem definition of Multicommodity flow
33	5	Flow shop scheduling
34	5	Network capacity assignment problems
35	**6**	**Problem Classes Np, Np-Hard And Np-Complete**
36	6	Definitions of P, NP-Hard and NP-Complete Problems
37	6	Decision Problems. Cook's Theorem
38	6	Proving NP Complete Problems
39	6	Satisfiability problem
40	6	Vertex Cover Problem
41	6	Approximation Algorithms for Vertex Cover andSet Cover Problem

TEXT/REFERENCE BOOKS

1. **"Introduction to Algorithms (Eastern Economy Edition)" by Thomas H Cormen and Charles E Leiserson**
2. **"Design and Analysis of Computer Algorithms" by AHO**
3. **"Fundamentals of Computer Algorithms(second edition)" by Sahni Horowitz**
4. **"Introduction to the Design and Analysis of Algorithms" by Anany Levitin.**

Course Level Problems (Test Items):

SN	List of Experiments
1	Sort a given set of elements using the Quicksort method and determine the time required to sort the elements. Repeat the experiment for different values of n, the number of elements in the list to be sorted and plot a graph of the time taken versus n. The elements can be read from a file or can be generated using the random number generator.
2	Implement a parallelized Merge Sort algorithm to sort a given set of elements and determine the time required to sort the elements. Repeat the experiment for different values of n, the number of elements in the list to be sorted and plot a graph of the time taken versus n. The elements can be read from a file or can be generated using the random number generator.
3	a. Obtain the Topological ordering of vertices in a given digraph. b. Compute the transitive closure of a given directed graph using Warshall's algorithm.
4	Implement 0/1 Knapsack problem using Dynamic Programming.
5	From a given vertex in a weighted connected graph, find shortest paths to other vertices using Dijkstra's algorithm.
6	Find Minimum Cost Spanning Tree of a given undirected graph using Kruskal's algorithm.
7	a. Print all the nodes reachable from a given starting node in a digraph using BFS method. b. Check whether a given graph is connected or not using DFS method.
8.	Find Minimum Cost Spanning Tree of a given undirected graph using Prim's algorithm.
9.	Implement All-Pairs Shortest Paths Problem using Floyd's algorithm.
10	Implement N Queen's problem using Back Tracking.

Assessment Methodology:

1. MCQ after every module completion.
2. Practical exam in lab where they have to write code on C compiler for the given problem statement. (Once in a week)
3. Assignments one from each unit.
4. Midterm subjective paper where they have to write algorithms to perform different operations on different data structures as mentioned in the modules. (Twice during the semester)
5. Final paper at the end of the semester subjective.

Teaching and Learning resources unit-wise:

Unit-1

Review of Algorithm

Video Tutorials : https://youtu.be/PVrbRrI0jG4

Theory concepts: https://www.javatpoint.com/daa-asymptotic-analysis-of-algorithms

Sample Quiz: https://www.geeksforgeeks.org/algorithms-gq/analysis-of-algorithms-gq/

Divide And Conquer Method

Video Tutorials : https://youtu.be/i2xhlKLJ5FI

Theory concepts: https://www.javatpoint.com/divide-and-conquer-introduction

Sample Quiz: https://www.geeksforgeeks.org/algorithms-gq/divide-and-conquer-gq/

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Unit-2

A. Greedy Method

Video Tutorials: https://youtu.be/EcT-Jt5WStw

Theory concepts: https://www.javatpoint.com/greedy-algorithms

Sample Quiz: https://www.geeksforgeeks.org/algorithms-gq/greedy-algorithms-gq/

B. Dynamic Programming

Video Tutorials: https://youtu.be/6h6Fi6AQiRM

Theory concepts: https://www.javatpoint.com/dynamic-programming-introduction

Sample Quiz: https://www.geeksforgeeks.org/algorithms-gq/dynamic-programming-gq/

Unit-3

A. Branch And Bound

Video Tutorials: https://www.youtube.com/watch?v=-cBkrzNdQn4

Theory concepts: https://www.geeksforgeeks.org/branch-and-bound-algorithm/

Sample Quiz: https://www.sanfoundry.com/branch-bound-multiple-choice-questions-answers-mcqs/

B. Pattern Matching Algorithms

Video Tutorials: https://youtu.be/EEjNb9yUv1k

Theory concepts: https://www.javatpoint.com/daa-string-matching-introduction

Sample Quiz: https://www.geeksforgeeks.org/algorithms-gq/pattern-searching/

Unit-4

A. Assignment Problems

Video Tutorials: https://www.youtube.com/watch?v=BV2MIZna6PI

Theory concepts: https://www.geeksforgeeks.org/job-assignment-problem-using-branch-and-bound/

Sample Quiz: https://www.geeksforgeeks.org/data-structure-gq/binary-trees-gq/

B. Randomized Algorithms

Video Tutorials: https://youtu.be/Dd0XNsAkkqE

Theory concepts: https://www.geeksforgeeks.org/randomized-algorithms/

Unit-5

Problem Classes Np, Np-Hard And Np-Complete

Video Tutorials: https://youtu.be/id7k6gUkZ8Y

Theory concepts: https://www.javatpoint.com/daa-complexity-classes

Sample Quiz: https://www.geeksforgeeks.org/algorithms-gq/np-complete-gq/

Previous Year Question Papers

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TECHNO INDIA NJR INSTITUTE OF TECHNOLOGY

UDAIPUR 313003 RAJ.

Date: 21/11/2020

NOTICE

This is to inform all the students of fifth semester (2020-21 academic sessions) that the remedial classes will commence from 24/11/2020 (online mode). It is compulsory for the students securing less than 50% marks in second midterm. Attendance will be monitored closely.

Please contact the concerned subject teacher for time slot.

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TECHNO INDIA NJR INSTITUTE OF TECHNOLOGY

UDAIPUR 313003 RAJ.

Date: 26/09/2018

NOTICE

This is to inform all the students of fifth semester (2020-21 academic sessions) that the remedial classes will commence from 29/09/2020(online mode). It is compulsory for the students securing less than 50% marks in first midterm. Attendance will be monitored closely.

Please contact the concerned subject teacher for time slot.

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TECHNO INDIA NJR INSTITUTE OF TECHNOLOGY, UDAIPUR

B. TECH 3rd – YEAR (V SEM.)

Analysis of algorithm (**5CS4-05**)

ASSIGNMENT 1

Answer all questions. Each question carries 5 marks

1. Perform best ,average and worst case run time analysis of insertion sort algorithm? [CO-1]
2. Explain O,Ω,θ,notations for a given function $f(n)=5n^2+3n-7$ [CO-1]
3. Write an algorithm for merge sort and sort given list using merge sort method

   20,35,18,8,14,41,3,33 [CO-2]
4. Differentiate between Greedy algorithm and Dynamic programming [CO-2]
5. Write a program for 0/1 knapsack problem using backtracking strategy. [CO-2]

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TECHNO INDIA NJR INSTITUTE OF TECHNOLOGY, UDAIPUR

B. TECH 3rd – YEAR (V SEM.)

Analysis of algorithm (**5CS4-05**)

ASSIGNMENT 2

Answer all questions. Each question carries 5 marks

1. List the various string matching algorithms along with worst case complexity.[CO-3]
2. Explain Quadratic and Biquadratic assignment Problem. [CO-3]
3. Explain flow shop scheduling problem with the help of example. [CO-4]
4. What is difference between Quick sort and randomized Quick sort? [CO-4]
5. State and prove Cook's theorem. [CO-5]

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B. TECH 3rd – YEAR (V SEM.)

Analysis of algorithm (**5CS4-05**)

VIVA-YOCE

Unit 1 (CO-1)

1. What are the two main measures for the efficiency of an algorithm?
2. Write an algorithm to insert a node in a sorted linked list.
3. What are the Asymptotic Notations?
4. Find the first or last occurrence of a given number in a sorted array.
5. What is the objective of the knapsack problem?

Unit 2 (CO-2)

1. What are the dynamic programming methods?
2. How dynamic programming is different from the memorization and recursion.
3. Which of the branch and bound strategy leads to depth first search?
4. What is Backtracking?
5. How 0/1 knapsack is different from fractional knapsack problem.

Unit 3 (CO-3)

1. **Which procedure is used as key element in a backward chaining algorithm?**
2. **What is the name of elements present in patterns?**
3. **Which keeps variable binding on an association list?**
4. **Which is used to compare patterns and datums element by element?**

Unit 4 (CO-4)

1. **What is las vegas algorithm.**
2. **What is Monte carlo algorithm.**
3. **What is 2-sat problem?**
4. **What is Min-cut algorithm?**

Unit 5 (CO-5)

1. **What is p class of algorithms?**
2. **Differentiate between NP hard and NP complete problems.**
3. **What is 3-sat problem?**
4. **What is approximate algorithm.**

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B. TECH 3rd – YEAR (V SEM.)

Analysis of algorithm (**5CS4-05**)

Quiz-1

Attempt all questions. Each quiz ***carries 1 mark***
No negative marking. ***Time – 10 mins***

Q. 1. Which Data Structure is used to perform Recursion?

A : Array
B : queue
C : stack
D : linked list

Q. 2. What is the objective of the knapsack problem?

A : To Get Maximum Total Value In The Knapsack
B : To Get Minimum Total Value In The Knapsack
C : To Get Maximum Weight In The Knapsack
D : To Get Minimum Weight In The Knapsack

Q. 3. Which of the following algorithm can be used to solve the Hamiltonian path problem efficiently?
A : branch and bound
B : iterative improvement
C : divide and conquer
D : greedy algorithm

Q. 4. What is the worst case time complexity of merge sort?

A : O(N Log N)
B : O(n*n)
C : O(Log N)
D : O(Log Log N)

Q. 5. What is tail recursion?

A : A recursive function that has two base cases
B : A function where the recursive functions leads to an infinite loop
C : A recursive function where the function doesn't return anything and just prints the values
D : A function where the recursive call is the last thing executed by the function

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Q. 6. Fractional knapsack problem is also known as

A : 0/1 knapsack problem
B : Continuous knapsack problem
C : Divisible knapsack problem
D : Non continuous knapsack problem

Q. 7 What approach is being followed in Floyd Warshall Algorithm?

A : Greedy Technique
B : Dynamic Programming
C : Linear Programming
D : Backtracking

Q. 8. Which of the following algorithms has worst time complexity?

A : insertion sort
B : binary search
C : linear search
D : merge sort

Q. 9. Which data structure is used for implementing a FIFO branch and bound strategy?

A : Stack
B : Queue
C : Array
D : Linked List

Q. 10. What is the average case time complexity of merge sort?

A : O(N Log N)
B : O(n*n)
C : O(Log N)
D : O(Log Log N)

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Answer Quiz1

1. Stack
2. To Get Maximum Total Value In The Knapsack
3. Branch and bound
4. O(N Log N)
5. A function where the recursive call is the last thing executed by the function
6. Continuous knapsack problem
7. Dynamic Programming
8. Insertion sort
9. Queue
10. O(N Log N)

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B. TECH 3rd – YEAR (V SEM.)

Analysis of algorithm (**5CS4-05**)

Quiz-2

Attempt all questions. Each quiz ***carries 1 mark***
No negative marking.

Time – 10 mins

1. ___ is an optimization technique for particular classes of backtracking algorithms that repeatedly solve sub-problems.

a. Decrease and conquer
b. Dynamic programming
c. Branch and bound
d. Divide and Conquer

2. The binomial coefficient is represented as ___.

a. kCn
b. nCk
c. n+1Ck
d. nCk+1

3. ___ is the technique by which we make a function perform faster by trading space for time.

a. Divide and conquer
b. Greedy
c. Memoization
d. Recursion

4. The root node in the B-Tree technique has ___ limit on the number of children?

a. Lower
b. Upper and Lower
c. Upper
d. No

5. The shift table is to be initialized to ___ to compute the bad character shift.

a. The number of matches of the pattern with the text
b. The number of mismatches occurring
c. Length of the pattern-1
d. Length of the pattern

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6. Each slot of the bucket array in separate chaining stores ___.

a. Records
b. A pointer to a linked list
c. Hash key values
d. Both b & c

7. The best possible value of the problem objective, written as a function of the state, is called the ___.

a. Value function
b. Control variables
c. Policy function
d. Principle of Optimality

8.If we have materials of different values per unit volume and maximum amounts, the ___ Knapsack problem finds the most valuable mix of materials that fit in a knapsack of fixed volume.

a. Bounded
b. Binary
c. 0-1
d. Fractional

9. We use ___ for finding solutions to sub-problems, so as to reduce recalculation.

a. Backtracking
b. Recursion
c. Memoization
d. Branch and bound algorithms

10. ___ means calculating the minimum amount of work required to solve the problem.

a. Upper-bound
b. Lower–bound
c. Adversary
d. Problem reduction

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Answer Quiz2

Ans: c Memoization

Ans: c Upper

Ans: d Length of the pattern

Ans: b A pointer to a linked list

Ans: a Value function

Ans: d Fractional

Ans: c Memoization

Ans: c Find

Ans: b Lower–bound

Ans: d Decision

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5E1355

Roll No. _____ [Total No. of Pages : 2]

5E1355

B.Tech. V- Semester (Main) Examination, Nov. - 2019
PCC/PEC Computer Sc. and Engg.
5CS4-05 Analysis of Algorithms
(Common With CS,IT)

Time : 3 Hours **Maximum Marks : 120**
Min. Passing Marks : 42

Instructions to Candidates:

*Attempt all ten questions from **Part A**, five questions out of Seven from Part B and **Four** questions out of Five from **Part C**.*

Schematic diagrams must be shown wherever necessary. Any data you feel missing suitably be assumed and stated clearly. Units of quantities used/calculated must be stated clearly. Use of following supporting materials is permitted during examination. (No material is required)

PART - A

Attempt **All** questions of Part A (10×2=20)

1. Define complexity with its Notations.
2. Explain what is Greedy Approach to solve the problems.
3. Difference between Greedy Algorithms and Dynamic Programming Approach.
4. What is minimum spanning tree?
5. What is Cut and Min cut?
6. Define cook's theorem.
7. Define Backtracking.
8. What is P, NP and NP hard problems?
9. Define Assignment Problem.
10. Differentiate between Feasible and Optimal solution.

PART - B

Attempt any five questions out of seven (5×8=40)

1. Using Quick sort algorithm sort the following sequence
A = {13,19,9,5,12,8,7,4,21,2,6,11}.

2. Given 10 files with lengths of {28,32,12,5,84,53,91,35,3 and 11} Find the optimal merge pattern. Also calculate the total number of moves.
3. What do you understand Dynamic programing approach also illustrate its elements.
4. Using strassen's matrix multiplication algorithm compute the matrix product

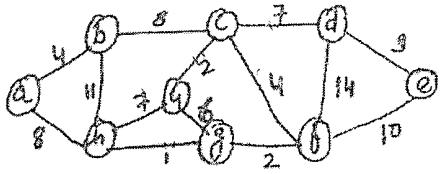
$$A=\begin{bmatrix}1 & 3\\ 7 & 5\end{bmatrix} B=\begin{bmatrix}6 & 8\\ 4 & 2\end{bmatrix}$$

5. Explain the vertex cover and set cover problem.
6. Differentiate between backtracking and branch and bound algorithms.
7. Explain the quadratic assignment problem.

PART - C

Attempt any **Four** questions out of five (4×15=60)

1. Using Prim's and Kruskal Algorithm. Find out the minimum cost for a given graph.



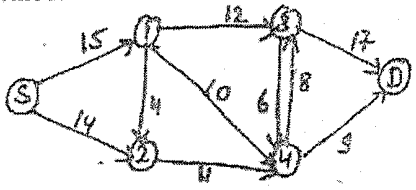
2. Find an optimal paratherization of a matrix chain product whose sequence of dimensions are.
<5,10,3,12,5,50,6>
3. Given the two sequence of characters

$X =< ABCBDAB >$

$Y =< BDCABA >$

Find out longest common subsequence.

4. Define flow M/w and solve the following flow M/w for maximum flow using ford Fulkers on method.



5. For a given text

T = <2,3,5,9,0,2,3,1,4,1; 5,2,6,7,3,9,9,2,1>

P = <3,1,4,1,5> & q = 13. Find the shift s for which pattern P matches the substring of text 7 using Rabin karp algorithm.

5E1355

Roll No. _____ Total No of Pages: 3

5E1355

B. Tech. V - Sem. (Main / Back) Exam., Feb.-March - 2021

Computer Science & Engineering

5CS4 – 05 Analysis of Algorithms

Common for CS, IT

Time: 2 Hours **Maximum Marks: 82**

Min. Passing Marks: 29

Instructions to Candidates:

Attempt all ten questions from Part A, four questions out of seven questions from Part B and two questions out of five from Part C.

Schematic diagrams must be shown wherever necessary. Any data you feel missing may suitably be assumed and stated clearly. Units of quantities used /calculated must be stated clearly.

Use of following supporting material is permitted during examination. (Mentioned in form No. 205)

1. NIL 2. NIL

PART – A

(Answer should be given up to 25 words only) **[10×2=20]**

All questions are compulsory

Q.1 What is Master Method?

Q.2 What is the difference between Dynamic Programming and Divide and Conquer Mechanism?

Q.3 What do you mean by Approximation Algorithms? Give two examples.

Q.4 What do you mean by Lower Bounds?

Q.5 What is Greedy Method?

Q.6 State Cook's theorem.

Q.7 Write down the algorithm of Binary Search.

Q.8 Give a recurrence for merger sort algorithm and solve it.

Q.9 What are the constraints required for a Backtracking method?

Q.10 Order the following time complexities in increasing order.

1, $\log_2 n$, $n \log_2 n$, n, n^3, 2^n, 3^n

PART – B

(Analytical/Problem solving questions) [4×8=32]

Attempt any four questions

Q.1 X = < a, a, b, a, b >, Y = < b, a, b, b >. If Z is an LCS of X and Y, then find Z using dynamic programming.

Q.2 What is the use of prefix function in KMP string matching algorithm? Explain with example.

Q.3 Explain vertex and set cover problem.

Q.4 Write short notes on the following:-

(a) Quadratic assignment problem

(b) Boyer-Moore Algorithm

Q.5 Explain the Las Vegas and Monte Carlo Algorithm with example.

Q.6 Solve the following recurrence relations and find their complexities using master method-

(a) $T(n) = 2T(\sqrt{n}) + \log_2 n$

(b) $T(n) = 4T\left(\frac{n}{2}\right) + n^2$

Q.7 Define the terms P, NP, NP complete and NP-Hard problems.

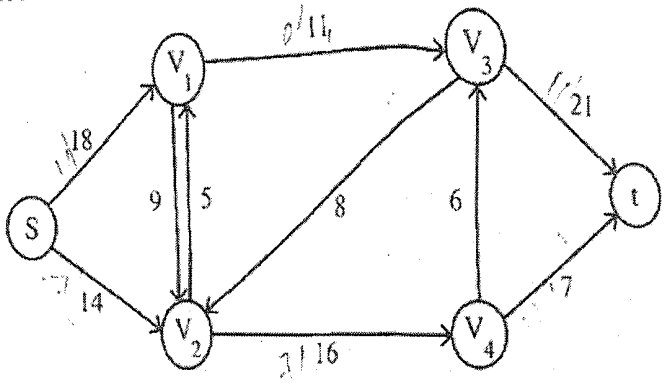
PART – C

(Descriptive/Analytical/Problem Solving/Design Questions)

Attempt any two questions [2×15=30]

Q.1 Find the optimal parenthesization of matrix-chain product whose sequence of dimensions is (4, 10, 6, 40, 5).

Q.2 What do you mean by Multi-commodity flow in the network? Find the max flow path by Ford-Fulkerson method for given network.



Q.3 Given the text -

T = < 2, 3, 5, 9, 0, 2, 3, 1, 4, 1, 5, 2, 6, 7, 3, 9, 9, 2, 1 >

P = < 3, 1, 4, 1, 5 >

And modulo q = 13, m = 5

Choose the pattern matching with average case complexity and explain the search process. Justify the answer for choosing such algorithm.

Q.4 Solve the TSP problem having the following cost matrix using branch and bound.

	A	B	C	D
A	X	15	11	7
B	14	X	13	20
C	6	9	X	4
D	8	12	22	X

Q.5 Show all the steps of Strassen's Matrix Multiplication algorithm to multiply the following matrices -

$$X = \begin{bmatrix} 3 & 2 \\ 4 & 8 \end{bmatrix} \text{ and } Y = \begin{bmatrix} 4 & 5 \\ 9 & 6 \end{bmatrix}$$

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Dr. Pankaj Kumar Porwal

(Principal)

Result Analysis

Name	EXT.	INT.	TOT.
	120	30	150
AKMAL HUSSAIN	54	21	75
ANUJ SHARMA	60	28	88
APOORVA JINDAL	82	28	110
ARPITA KOTHARI	75	26	101
BHAVINI MITTAL	86	29	115
BHAVIT KANTHALIA	101	29	130
CHARUL SINGHVI	94	30	124
DEVYANI GUPTA	78	30	108
DHEERAJ DASHORA	66	25	91
DIVYA JAIN	81	27	108
EKANSH JAIN	83	27	110
GARVIT SOLANKI	78	27	105
HARSHIT KAWDIA	31*	24	55*
HIMANSHU JAIN	42	15	57*
HIMANSHU TAK	54	21	75
JAYA GUPTA	84	28	112
JINISHA JAIN	96	25	121
KARTIK BOKADIA	59	24	83
KARTIK KUMAWAT	57	25	82
KARTIK PANCHAL	42	12	54*
KHUSHBOO PADDIYAR	52	25	77
M SAJID MANSOORI	59	26	85
MAHIMA KOTHARI	91	25	116
MAHIMA SHARMA	53	24	77
MILAN PURBIA	42	23	65
MOHAMMED AFZAL RA	70	25	95
MOHIT AMETA	97	21	118
NASEEBA KHAN	54	15	69
NAYAN SHARMA	68	25	93
NIDHI SHUKLA	59	24	83
NIKITA JAIN	68	25	93
NIKITA LILADHAR PAND	83	30	113
NILESH SAHITYA	67	15	82
NIMISHA SHARMA	51	28	79
NISHANT JAIN	69	28	97
PARSHAVI BOLYA	95	29	124
PRACHI PANWAR	81	28	109
PRIYA SUTHAR	48	21	69
RAHUL CHOUDHARY	59	23	82
RAKSHIT JOSHI	64	23	87
RISHIKA JAIN	56	26	82
RONAK ARORA	43	24	67
RUCHIKA PUROHIT	103	30	133

AOA
Mrs. Kirti P.
TOTAL = 59
PASS = 57
FAIL = 2

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SACHIN GARG	22*	13	35*
SIMRAN GERA	84	26	110
SUBHASH MEGHWAL	90	27	117
SWATI DEVPURA	75	24	99
TANISHKA JAIN	81	26	107
VARSHA CHOUDHARY	95	29	124
VEDPRAKASH GUPTA	98	28	126
VIDIT JAIN	56	15	71
VIKAS SONI	55	24	79
VIRENDRA SINGH	42	23	65
YASH MALASIYA	55	29	84
PRERNA PALIWAL	58	29	87
ASHI KOTHARI	74	28	102
SAKSHI MADRECHA	14	28	125
ASHI KOTHARI	75	25	100
SAKSHI MADRECHA	83	24	107

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List of certificates

1. Algorithmic Toolbox
2. Data Structures and Design Patterns for Game Developers
3. Analyze Box Office Data with Plotly and Python
4. Problem Solving Using Programming
5. Programming for Everybody
6. Python Data Structures

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(Principal)

UNIVERSITY OF MICHIGAN

07/01/2020

Kirti Dashora

has successfully completed

Python Data Structures

an online non-credit course authorized by University of Michigan and offered through Coursera

Charles Severance
Clinical Professor, School of Information
University of Michigan

COURSE CERTIFICATE

Verify at coursera.org/verify/RUYPJU4MQSQH

Coursera has confirmed the identity of this individual and their participation in the course.

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