Ref No:

SRI KRISHNA INSTITUTE OF TECHNOLOGY
BANGALORE

COURSE PLAN

Academic Year FEB 2019

Program:	B E – Computer Science Engineering
Semester :	4
Course Code:	18CS42
Course Title:	Design And Analysis of Algorithm
Credit / L-T-P:	4 / 4-0-0
Total Contact Hours:	50
Course Plan Author:	SHILPA

Academic Evaluation and Monitoring Cell

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Note : Remove “Table of Content” before including in CP Book
Each Course Plan shall be printed and made into a book with cover page
Blooms Level in all sections match with A.2, only if you plan to teach / learn at higher levels

A. COURSE INFORMATION

1. Course Overview

Degree:	BE	Program:	CS
Year / Semester :	2/4	Academic Year:	2019-20
Course Title:	Design and Analysis of Algorthim	Course Code:	17cs43
Credit / L-T-P:	4/L	SEE Duration:	180 Minutes
Total Contact Hours:	50	SEE Marks:	60 Marks
CIA Marks:	30	Assignment	5/ 5
Course Plan Author:	Shilpa	Sign	Dt:
Checked By:		Sign	Dt:
CO Targets	CIA Target : ...... %	SEE Target:	...... %

Note: Define CIA and SEE % targets based on previous performance.

2. Course Content

Content / Syllabus of the course as prescribed by University or designed by institute. Identify 2 concepts per module as in G.

Module	Content	Teaching Hours	Identified Module Concepts	Blooms Learning Levels
1	Introduction: What is an Algorithm?(T2:1.1),Algorithm Specification (T2:1.2), Analysis Framework (T1:2.1), Performance Analysis: Space complexity, Time complexity (T2:1.3). Asymptotic Notations:Big-Oh notation (O), Omega notation (Ω),Theta notation (Θ), and Little-oh notation (o), Mathematical analysis of Non-Recursive and recursive Algorithms with Examples (T1:2.2, 2.3, 2.4).Important Problem Types:Sorting, Searching, String processing, Graph Problems, Combinatorial Problems. Fundamental Data Structures: Stacks, Queues, Graphs, Trees, Sets and Dictionaries . (T1:1.3,1.4)	10 (4, 6)	- Specification -Framework -Recurrence Notation -Mathematical Analysis	
2	Divide and Conquer: General method, Binary search, Recurrence equation for divide and conquer, Finding the maximum and minimum (T2:3.1, 3.3, 3.4), Merge sort, Quick sort (T1:4.1, 4.2) , Strassen's matrix multiplication (T2:3.8) , Advantages and Disadvantages of divide and conquer. Decrease and Conquer Approach: Topological Sort. (T1:5.3)	10 (9, 1)	-Sorting -Matrix Operation -Travesal method -Source Removal Methodology	
3	Greedy Method: General method, Coin Change Problem, Knapsack Probl em, Job sequencing with deadlines (T2:4.1, 4.3, 4.5). Minimum cost spanning trees: Prim's Algorithm, Kruskal's Algorithm (T1:9.1, 9.2) . Single source shortest paths: Dijkstra's Algorithm (T1:9.3) . Optimal Tree problem: Huffman Trees and Codes (T1:9.4) .)Transform and Conquer Approach: Heaps and Heap Sort (T1:6.4	10 (9, 1)	-Knapsack Problem -Sequencing -Spanning Tree -Shortest Path -Code Generation -Representation change -Sorting	
4	Dynamic Programming: General method with Examples, Multistage Graphs (T2:5.1, 5.2) . Transitive Closure: Warshall's Algorithm, All Pairs Shortest Paths: Floyd's Algorithm, Optimal Binary Search Trees, Knapsack problem ((T1:8.2, 8.3, 8.4), Bellman-Ford Algorithm (T2:5.4) , Travelling Sales Person problem (T2:5.9) , Reliability design (T2:5.8).	10	-Multistage graph -Transitive Closure -Shortest path -Negetive Edge Weight	

			-TSP Problem	
5	Backtracking: General method (T2:7.1) , N-Queens problem (T1:12.1) , Sum of subsets problem (T1:12.1) , Graph coloring (T2:7.4) , Hamiltonian cycles (T2:7.5) . Branch and Bound: Assignment Problem, Travelling Sales Person problem (T1:12.2)0/1 Knapsack problem (T2:8.2, T1:12.2): LC Branch and Bound solution (T2:8.2) , FIFO Branch and Bound solution (T2:8.2) . classes (T2:11.1) . NP-Complete and NP Hard problems: Basic concepts, non deterministic algorithms, P, NP, NP-Complete, and NP-Hard	10 (5, 3,2)	-State Space Tree -Subsets Generation -Coloring of Graphical -Cycle Identification -Lower count -assignment -TSP Deteministic -NP,P Complete Problem	
-	**Total**	**50**	-	-

3. Course Material

Books & other material as recommended by university (A, B) and additional resources used by course teacher (C).

1. Understanding: Concept simulation / video ; one per concept ; to understand the concepts ; 15 – 30 minutes
2. Design: Simulation and design tools used – software tools used ; Free / open source
3. Research: Recent developments on the concepts – publications in journals; conferences etc.

Modules	Details	Chapters in book	Availability
A	**Text books (Title, Authors, Edition, Publisher, Year.)**	-	-
1, 2, 3, 4, 5	T1.Introduction to the Design and Analysis of Algorithms, Anany Levitin:, 2rd Edition, 2009. Pearson.	1,2,3,4,8, 9	In Lib / In Dept
1, 2, 3, 4, 5	T2.Computer Algorithms/C++, Ellis Horowitz, Satraj Sahni and Rajasekaran, 2nd Edition, 2014, Universities Press	2,3,5,8,9	In Lib/ In dept
B	**Reference books (Title, Authors, Edition, Publisher, Year.)**	-	-
1, 2	1.Introduction to Algorithms, Thomas H. Cormen, Charles E. Leiserson, Ronal L. Rivest, Clifford Stein, 3rd Edition, PHI	?	In Lib
1, 2,3, 4, 5	2.Design and Analysis of Algorithms , S. Sridhar, Oxford (Higher education)	?	Not Available
		?	In lib
C	**Concept Videos or Simulation for Understanding**	-	-
C1	www.tutorialspoint.com/design_and_analysis_of_algorithms		
C2	https://www.javatpoint.com/daa-tutorial		
C3	http://openclassroom.stanford.edu/MainFolder/CoursePage.php?course=IntroToAlgorithms		
C4	https://onlinecourses.nptel.ac.in/noc17_cs27/preview		
C5	https://www.khanacademy.org/computing/computer-science/algorithms		
C6			
C7			
C8			
C9			
C10			
D	**Software Tools for Design**	-	-
	http://www.sciencehq.com/computing-technology/programming-tools.html		
	http://www.sciencehq.com/computing-technology/programming-tools.html		

E	**Recent Developments for Research**	-	-
	http://www.niser.ac.in/~aritra/AWorkshop		
F	**Others (Web, Video, Simulation, Notes etc.)**	-	-
1	https://www.tutorialspoint.com/design_and_analysis_of_algorithms/design_and_analysis_of_algorithms_p_np_class.htm		
?			

4. Course Prerequisites

Refer to GL01. If prerequisites are not taught earlier, GAP in curriculum needs to be addressed. Include in Remarks and implement in B.5.

Students must have learnt the following Courses / Topics with described Content . . .

Modules	Course Code	Course Name	Topic / Description	Sem	Remarks	Blooms Level
1	17pcd13/23	C Programing	1. Knowledge on Data Structures	2		Understand L2
2	17cs33	Data Structure and Application	Knowledge of Algorithm	3		Understand L2
3						
4						
-						
-						

5. Content for Placement, Profession, HE and GATE

The content is not included in this course, but required to meet industry & profession requirements and help students for Placement, GATE, Higher Education, Entrepreneurship, etc. Identifying Area / Content requires experts consultation in the area.

Topics included are like, a. Advanced Topics, b. Recent Developments, c. Certificate Courses, d. Course Projects, e. New Software Tools, f. GATE Topics, g. NPTEL Videos, h. Swayam videos etc.

Modules	Topic / Description	Area	Remarks	Blooms Level
1			Gap A seminar on Electron Tubes & amplifiers	Understand L2
3				
3				
5				
-				
-				

B. OBE PARAMETERS

1. Course Outcomes

Expected learning outcomes of the course, which will be mapped to POs. Identify a max of 2 Concepts per Module. Write 1 CO per Concept.

Modules	Course Code.#	Course Outcome **At the end of the course, student should be able to . . .**	Teach. Hours	Concept	Instr Method	Assessment Method	Blooms' Level
1	18CS42.1	understand a given algorithm and	3	Algorithm	Black	Test/	L2

		express its time and space complexities in asymptotic notations.		Properties	board /system	assignments	Understand
1	18CS42.2	Solve recurrence equations using Iteration Method, Recurrence Tree Method and Master's Theorem	7	Recurrence strategy	Black board /system	Test/ assignments	L4 Analyze
2	18CS42.3	Analyze time efficiency of algorithms using Divide and Conquer Strategy.	8	Divide and Conquer	Black board /system	Test/ assignments	L4 Analyze
2	18CS42.4	Analyze algorithms using Decrease and Conquer Strategy.	2	Decrease and Conquer	Black board /system	Test/ assignments	L4 Analyze
3	18CS42.5	solve Optimization problems using Greedy strategy.	9	Optimization	Black board /system	Test/ assignments	L4 Analyze
3	18CS42.6	solve Optimization problems using transform and conquer strategy.	1	Instance Transformation	Black board /system	Test/ assignments	L4 Analyze
4	18CS42.7	Distinguish Dynamic Programming and Greedy Strategies.	10	Dynamic Programming	Black board /system	Test/ assignments	L4 Analyze
4	18CS42.8	Test the efficient algorithms using Back Tracking for solving problems.	3	Back tracking	Black board /system	Test/ assignments	L4 Analyze
5	18CS42.9	Differentiate Branch Bound with Back tracking for solving problems.	3	Branch and Bound	Black board /system	Test/ assignments	L4 Analyze
5	18CS42.10	examine computational problems into P, NP, NP-Hard and NP-complete	4	Computational problem	Black board /system	Test/ assignments	L3 Apply
-	**-**	**Total**	**50**	**-**	**-**	**-**	**L2-L4**

2. Course Applications

Write 1 or 2 applications per CO.
Students should be able to employ / apply the course learnings to . . .

Modules	Application Area Compiled from Module Applications.	CO	Level
1	Database Management	CO1	L2
1	Web Design	CO2	L4
2	Traffic Management	CO3	L4
2	Big data ,	CO4	L4
3	Data Science	CO5	L4
3	Optimized Telecommunications Routing	CO6	L4
4	Biometric Invention	CO7	L4
5	Genetic Algorithms	CO8	L4
5	Data Compression	CO9	L4
5	Resource Allocation	CO10	L3

3. Mapping And Justification

CO – PO Mapping with mapping Level along with justification for each CO-PO pair.
To attain competency required (as defined in POs) in a specified area and the knowledge & ability required to accomplish it.

Modules	Mapping		Mapping Level	Justification for each CO-PO pair	Level
-	**CO**	**PO**	**-**	**'Area': 'Competency' and 'Knowledge' for specified 'Accomplishment'**	**-**
1	17cs 43.1	PO1	3	As the students could just define the knowledge acquired	L2
1	17cs	PO2		Knowledge of algorithm analysis methods helps students in problem	L2

	43.1			analysis	
1	17cs 43.1	PO3	1	Knowledge of algorithm analysis is the first step in developing solutions	L2
	17cs 43.1	PO4		This knowledge is the basis of conducting investigations of complex problems	L2
2	17cs 43.1	PO12		Learning is required as technology changes	L2
2	17cs 43.2	PO3		Complexity analysis of the engineering solutions will help students to design and develop sustainable solutions.	L4
2	17cs 43.2	PO4		A complexity analysis of the engineering solutions provide Information to provide valid conclusions	L4
	17cs 43.2	PO12		Learning is required as technology changes	L4
	17cs 43.3	PO3		Choosing an appropriate problem solving method helps students during the design and development of solutions.	L4
	17cs 43.3	PO5		A knowledge in the problem solving methods will help the students to choose the best method to solve a problem	L4
	17cs 43.3	PO12		Learning is required as technology changes	L4
	17cs 43.4	PO3		Knowledge of algorithm analysis is the first step in developing solutions	L2
	17cs 43.4	PO5		A knowledge in the problem solving methods will help the students to choose the best method to solve a problem	L4
5	17cs 43.4	PO12		Learning is required as technology changes	L4
5	17cs 43.5	PO1		As the students could just define the knowledge acquired	L4
5	17cs 43.5	PO2		Knowledge of algorithm analysis methods helps students in problem analysis	L4
	17cs 43.5	PO3		Knowledge of algorithm analysis is the first step in developing solutions	L4
	17cs 43.5	PO12		Learning is required as technology changes	L4
	17cs 43.6	PO1		As the students could just define the knowledge acquired	L4
	17cs 43.6	PO2		Knowledge of algorithm analysis methods helps students in problem analysis	L4
	17cs 43.6	PO3		Knowledge of algorithm analysis is the first step in developing solutions	L4
	17cs 43.6	PO12		Learning is required as technology changes	L4
	17cs 43.7	PO3		Knowledge of algorithm analysis is the first step in developing solutions	L4
	17cs 43.7	PO4		This knowledge is the basis of conducting investigations of complex problems	L4
	17cs 43.7	P12		Learning is required as technology changes	L4
	17cs 43.8	PO1		As the students could just define the knowledge acquired	L4
	17cs 43.8	PO2		Knowledge of algorithm analysis methods helps students in problem analysis	L4
	17cs 43.8	PO3		Knowledge of algorithm analysis is the first step in developing solutions	L4
	17cs 43.8	PO4		This knowledge is the basis of conducting investigations of complex problems	L4
	17cs 43.8	PO5		A knowledge in the problem solving methods will help the students to choose the best method to solve a problem	L4
	17cs 43.8	PO12		Learning is required as technology changes	L4

	17cs 43.9	PO1		As the students could just define the knowledge acquired	L3
	17cs 43.9	PO2		Knowledge of algorithm analysis methods helps students in problem analysis	L3
	17cs 43.9	PO3		Knowledge of algorithm analysis is the first step in developing solutions	L3
	17cs 43.9	PO4		This knowledge is the basis of conducting investigations of complex problems	L3
	17cs 43.9	PO12		Learning is required as technology changes	L3
	17cs 43.10	PO1		As the students could just define the knowledge acquired	L3

4. Articulation Matrix

CO – PO Mapping with mapping level for each CO-PO pair, with course average attainment.

-	-	Course Outcomes	Program Outcomes															-
Modules	CO.#	**At the end of the course student should be able to . . .**	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	Level
1	18CS42.1	Analyze a given algorithm and express its time and space complexities in asymptotic notations.	2.4	1.8	2.6	2.5	-	-	-	-	-	-	-	2.8	-	-	-	L2
1	18CS42.2	Solve recurrence equations using Iteration Method, Recurrence Tree Method and Master's Theorem	-	-	2.6	2.5	-	-	-	-	-	-	-	2.8	-	-	-	L4
2	18CS42.3	Classify the Problem using Divide and Conquer Strategy.	-	-	2.6	-	2.25	-	-	-	-	-	-	2.8	-	-	-	L4
2	18CS42.4	Analyze algorithms using Decrease and Conquer Strategy.	-	-	2.6		2.25						-	2.8	-	-	-	L4
3	18CS42.5	Compare Optimization problems using Greedy strategy.	2.4	1.8	2.6	-	-	-	-	-	-	-	-	2.8	-	-	-	L4
3	18CS42.6	Analyze Optimization problems using transform and conquer strategy.	2.4	2.4	2.6								-	2.8	-	-	-	L4
4	18CS42.7	Differentiate Dynamic Programming and Divide and Conquer Strategies.	-	-	2.6	2.5	-	-	-	-	-	-	-	2.8	-	-	-	L4
4	18CS42.8	Analyze efficient algorithms using Back Tracking and Branch Bound Techniques for solving problems.	2.4	1.8	2.6	2.5	2.25	-	-	-	-	-	-	-	-	-	-	L4
5	18CS42.9	Analyze efficient algorithms using Branch Bound Techniques for solving problems.	2.4	1.8	2.6	2.5							-	-	-	-	-	L3
5	18CS42.10	classify computational problems into P, NP, NP-Hard and NP-complete	2.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	L3
-	**CS501PC**	**Average attainment (1, 2, or 3)**																**-**
-	*PO, PSO*	*1.Engineering Knowledge; 2.Problem Analysis; 3.Design / Development of Solutions; 4.Conduct Investigations of Complex Problems; 5.Modern Tool Usage; 6.The Engineer and Society; 7.Environment and Sustainability; 8.Ethics; 9.Individual and Teamwork; 10.Communication; 11.Project Management and Finance; 12.Life-long Learning; S1.Software Engineering; S2.Data Base Management; S3.Web Design*																

5. Curricular Gap and Content

Topics & contents not covered (from A.4), but essential for the course to address POs and PSOs.

Mod	Gap Topic	Actions Planned	Schedule Planned	Resources Person	PO Mapping

ules					
1	Substitution method	Assignment	Given	–	3,4
2	Stress en's Matrix	Assignment	Given	–	3,4
3					
4					
5					

6. Content Beyond Syllabus

Topics & contents required (from A.5) not addressed, but help students for Placement, GATE, Higher Education, Entrepreneurship, etc.

Modules	Gap Topic	Area	Actions Planned	Schedule Planned	Resources Person	PO Mapping
1	Examples of NP Hard, NP Complete problems.	Extra Classes		Concern Faculty		List from B4 above
1						
2						
2						
3						
3						
4						
4						
5						
5						

C. COURSE ASSESSMENT

1. Course Coverage

Assessment of learning outcomes for Internal and end semester evaluation. Distinct assignment for each student. 1 Assignment per chapter per student. 1 seminar per test per student.

Modules	Title	Teach. Hours	No. of question in Exam						CO	Levels
			CIA-1	CIA-2	CIA-3	Asg	Extra Asg	SEE		
1	Definition,specification,framework, Asymptotic notation,problem types	10	2	-	-	1	1	4	CO1,CO2	L2,L4
2	Divide and Conquer,Decrease and conquer	10	2	-	-	1	1	4	CO3,CO4	L4
3	Greedy method ,Transform and conquer approach	10	-	2	-	1	1	4	CO5,CO6	L4
4	Dynamic Programming	10	-	2	-	1	1	4	CO7	L4
5	Backtracking,Branch and Bound,Knapsack problem,NP-Complete and NP-Hard Problem	10	-	-	4	1	1	3	CO8,CO9,CO10	L4,L3,L3
-	**Total**	**50**	**4**	**4**	**4**	**5**	**5**	**19**	-	-

2. Continuous Internal Assessment (CIA)

Assessment of learning outcomes for Internal exams. Blooms Level in last column shall match with A.2.

Evaluation	Weightage in Marks	CO	Levels

CIA Exam – 1	30	CO1, CO2, CO3, CO4	L2, L3, L4
CIA Exam – 2	30	CO5, CO6, CO7	L3, L4
CIA Exam – 3	30	CO8,CO9,CO10	L3, L4
Assignment - 1	10	CO1, CO2, CO3, CO4	L2, L3, L4
Assignment - 2	10	CO5, CO6, CO7	L3, L4
Assignment - 3	10	CO8,CO9,CO10	L3, L4
Final CIA Marks	**40**	**-**	**-**

D1. TEACHING PLAN - 1

Module – 1

Title:	Introduction to Algorithm and recurrence Method	Appr Time:	10 Hrs
a	***Course Outcomes***	-	**Blooms**
-	Students will be able	-	**Level**
1	To Analyze a given algorithm and express its time and space complexities in asymptotic notations.	-	L2
2	To Solve recurrence equations using Iteration Method, Recurrence Tree Method and Master's Theorem	-	L4
b	***Course Schedule***	-	-
Class No	**Module Content Covered**	**CO**	**Level**
1	What is an Algorithm?Algorithm Specification	CO1	L2
2	,Analysis Framework	CO1	L2
3	Performance Analysis: Space complexity,	CO1	L2
4	Time complexity	CO1	L2
5	Asymptotic Notations:Big-Oh notation (O), Omega notation (Ω), Theta notation (Θ), and Little-oh notation (o),	CO2	L3
6	Mathematical analysis of Non-Recursive with Examples	CO2	L4
7	recursive Algorithms with Examples .	CO2	L4
8	Important Problem Types:Sorting, Searching, String processing, Graph Problems, Combinatorial Problems.	CO1	L3
9	Fundamental Data Structures: Stacks, Queues,	CO1	L3
10	Graphs, Trees, Sets and Dictionaries.	CO1	L3
c	**Application Areas**	**CO**	**Level**
1	Able to Analyze a given algorithm and express its time and space complexities	CO1	L2
2	Able to Solve recurrence equations	CO2	L4
d	**Review Questions**	-	-
1	Define best case, worst case and average case efficiency. Give these efficiencies for sequential search.	CO1	L2
2	Briefly explain important fundamental data structures used in algorithm design.	CO1	L2
3	Describe basic efficiency classes. (9 points)	CO1	L2
4	Briefly explain the important problem types coming under design and analysis of algorithms.	CO2	L4
5	Explain three asymptotic notations with a neat diagram. Prove $n^2 + 5n + 7 = \Theta(n^2)$	CO2	L3
e	**Experiences**		
1			
2			
3			

Module – 2

Title:	Divide and Conquer Technique	Appr Time:	10 Hrs
a	***Course Outcomes***	-	**Blooms**
-	The student should be able to:	-	**Level**
1	Design algorithms using Divide and Conquer Strategy.		L4
2			
b	***Course Schedule***	-	-
Class No	**Module Content Covered**	**CO**	**Level**
11	Divide and Conquer: General method,	CO3	L4
12	Binary search,	CO3	L4
13	Recurrence equation for divide and conquer,	CO3	L4
14	Finding the maximum and minimum	CO3	L4
15	Merge sort,	CO3	L4
16	Quick sort ,	CO3	L4
17	Strassen's matrix multiplication	CO3	L4
18	Advantages and Disadvantages of divide and conquer	CO3	L4
19	Decrease and Conquer Approach:	CO3	L4
20	Topological Sort.	CO3	L4
c	**Application Areas**	**CO**	**Level**
1	Able to design algorithms using Divide and Conquer Strategy.	CO3	L4
d	**Review Questions**	-	-
6	Find the upper bound of recurrences given below by substitution method. i) T(n) = 2 T(n/2)+n ii) T(n) = T(n/2) + 1	CO3	L4
7	Briefly explain binary search algorithm along with efficiency analysis	CO3	L4
8	Write the algorithm for Merge Sort. Derive the time efficiency of the algorithm.	CO3	L4
9	State and apply Master theorem application	CO3	L3
10	Sort the following elements using merge sort. Write the recursion tree. 70, 20, 30, 40, 10, 50, 60 Twisted : Use D & C method which divides problem size by considering position	CO3	L4
e	**Experiences**	-	-
1			
2			
3			
4			
5			

E1. CIA EXAM – 1

a. Model Question Paper – 1

Crs Code:	17CS43	Sem:	IV	Marks:	30	Time:	75 minutes
Course:	Design and Analysis of Algorithms						

-	-	**Note: Answer any 2 questions, each carry equal marks.**	**Marks**	**CO**	**Level**
1	a	Compare the orders of growth of following functions i) (½) n (n-1) and n	5	CO2	L4

		ii) 3n+2 and n			
	b	Explain the mathematical analysis of fibonacci recursive algorithm. Write Bruteforce string matching algorithm.	10	CO2	L4
2	a	Explain the asymptotic notations with examples.	5	CO2	L3
	b	Write an algorithm for selection sort. Analyze its efficiency	10	CO2	L4
3	a	Sort the following elements using merge sort. Write the recursion tree. 70, 20, 30, 40, 10, 50, 60 Twisted : Use D & C method which divides problem size by considering position	9	CO3	L4
	b	what is divide and conquer? Explain the general method of divide and conquer.	6	CO3	L4
4	a	Write a algorithm for Quick sort, and sort the following number's 10, 8, 5, 15, 25, 75, 12. Obtain its time complexity. (10 Marks)	9	CO3	L4
	b	Write the algorithm for sequential search, obtain the time complexity of this algorithm for successful and unsuccessful search in the worst case and best case. (04 Marks)	6	CO3	L4

b. Assignment -1

Note: A distinct assignment to be assigned to each student.

Model Assignment Questions							
Crs Code:	17CS43	Sem:	IV	Marks:	5 / 10	Time:	90 – 120 minutes
Course:	Design and Analysis of Algorithms						
Note: Each student to answer 2-3 assignments. Each assignment carries equal mark.							

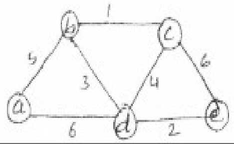
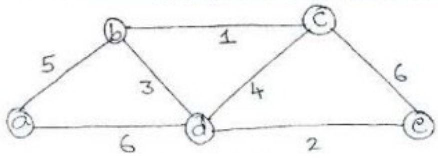
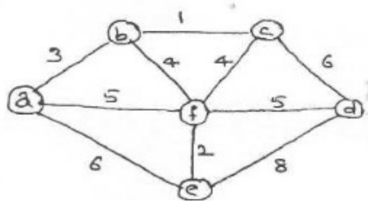
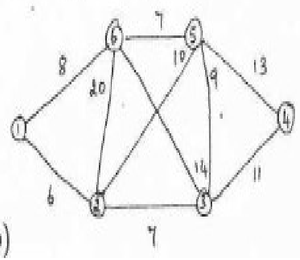
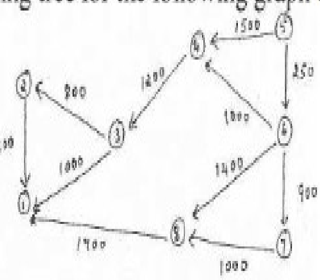
SNo	USN	Assignment Description	Marks	CO	Level
1	1KT17CS001	Describe basic efficiency classes. (9 points)	5	CO1	L2
2	1KT17CS002	Briefly explain the important problem types coming under design and analysis of algorithms.	6	CO2	L4
3	1KT17CS003	Consider Tower of Hanoi puzzle. Derive the recurrence relation for the total movement of disk. Solve the recurrence relation using substitution method	10	CO2	L4
4	1KT17CS004	Write the algorithm for Quick Sort. Derive the best case, worst case, average case time efficiency of the algorithm	10	CO3	L4
5	1KT17CS005	What is an algorithm? Explain the notion of algorithm with an example.	10	CO3	L4
6	1KT17CS006	Find gcd(31415, 14142) by applying Euclid's algorithm. Estimate how many times it is faster when compared to the algorithm based on consecutive integer checking. (04 Marks)	4	CO3	L4
7	1KT17CS007	Compare the order of growth of $\frac{1}{2}n(n-1)$ and n^2.	4	CO3	L4

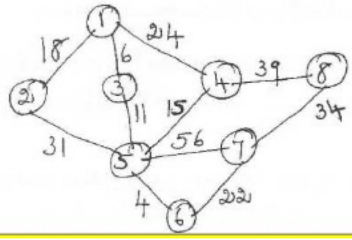
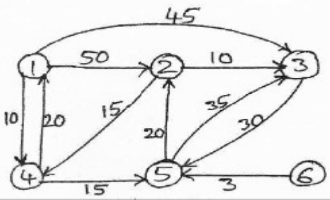
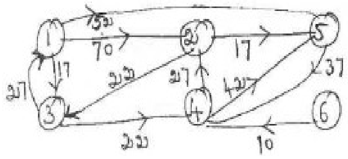
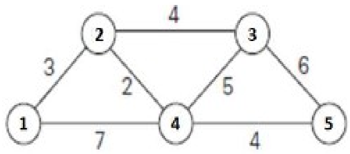
		Find the upper bound of recurrences given below by substitution method. i) $2T\left(\frac{n}{2}\right)+n$ ii) $T\left(\frac{n}{2}\right)+1$			
8	1KT17CS008		4	CO3	L4
9	1KT17CS009	write an algorithm for merge sort. Analyze its efficiency.	7	CO3	L4
10	1KT17CS010	Apply quick sort on following list and draw recursive call tree : 5, 3, 1,9, 8,2, 4,7	10	CO3	L4
11	1KT17CS011	Write the algorithm for quick sort. Derive the worst case time efficiency of the algorithm.	10	CO3	L4

D2. TEACHING PLAN - 2

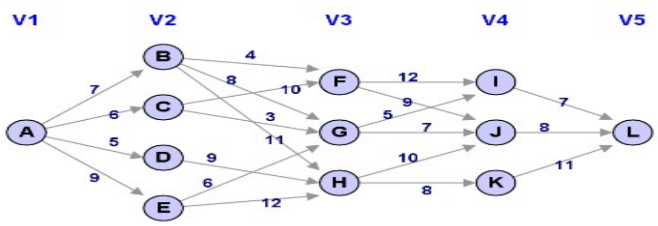
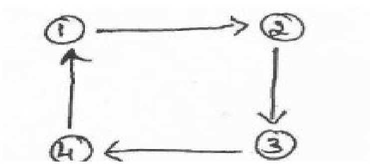
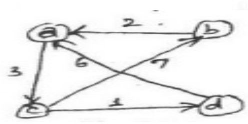
Module – 3

Title:	Greedy Techqunic	Appr Time:	10 Hrs
a	***Course Outcomes***	-	**Blooms**
-	The student should be able to:	-	**Level**
1	Solve Optimization problems using Greedy strategy.	CO4	L4
2			
b	***Course Schedule***	-	-
Class No	**Module Content Covered**	**CO**	**Level**
21	General method, Coin Change Problem,	CO4	L2
22	Knapsack Problem,	CO4	L3
23	Job sequencing with deadlines	CO4	L4
24	Minimum cost spanning trees:Prim's Algorithm,	CO4	L4
25	Kruskal's Algorithm	CO4	L4
26	Single source shortest paths:Dijkstra's Algorithm	CO4	L4
27	Optimal Tree problem:	CO4	L4
28	Huffman Trees and Codes	CO4	L4
29	Transform and Conquer Approach		
30	Heaps and Heap Sort		
c	**Application Area**		
1	Able to solve Optimization problems using Greedy strategy.	CO4	L4
2			
d	**Review Questions**		
	Introduction		
11	Define Optimal solution and feasible solution.	CO4	L2
12	Define Coin Change Problem. State the greedy method to solve the coin change problem. For 49 rupees, find the denominations with least no. of coins. The available denominations in rupees are { 1, 2, 5, 10}	CO4	L4
	Job Sequencing		
14	What is the solution generated by the function job scheduling (JS) when n = 5, $[P_1, P_2, P_3, P_4, P_5] = [20, 15, 10, 5, 1]$ and $[d_1, d_2, d_3, d_4, d_5] = [2, 2, 1, 3, 3]$	CO4	L4

	Knapsack Problem		
16	What is a knapsack problem? Obtain solution for the knapsack problem using greedy method for n = 3, capacity m = 20 values 25, 24, 15 and weights 18, 15, 10 respectively.	CO4	L4
	MST		
17	Write a Kruskal algorithm to find minimum cost spanning tree and obtain spanning tree of the graph shown below: (08 Marks) 	CO4	L4
18	Apply PRIMS algorithm for the following graph to find minimum spanning tree. 	CO4	L4
19	Write Krushkal 's algorithm to construct minimum spanning tree and show that the time efficiency isO(|€|log|€|)	CO4	L4
20	Apply Kruskal's algorithm to find the min spanning tree of the graph. 	CO4	L4
21	Using Prim's algorithm, determine minimum cost spanning tree for the following graph 5  Fig. Q3(b)  Fig. Q3(c)	CO4	L4

22	Using Prim's algorithm, determine minimum cost spanning tree for the weighted graph 7 shown below, fig.Q.3(b): (07 Marks) 	CO4	L4
	Dijiktra's Algorithm		
23	Write the dijiktra's algorithm for single source shortest path	CO4	L4
24	Write Dijkstra's shortest path algorithm. Apply Dijkstra's algorithm on Fig. Q3(b) to obtain shortest paths. (10 Marks) 	CO4	L4
25	In the weighted digraph given below, fig.Q.3(c) determine the shortest paths from vertex 1 to all other vertices. (06 Marks) 	CO4	L4
26	Apply Dijikras algorithm to find single source shortest path. Consider source vertes as a) 1 b) 5 	CO4	L4
	Huffman's coding		
27	Construct the Huffman code for the following data. symbol: A, B, C, D, _ frequency: 0.35, 0.1, 0.2, 0.2, 0.15 Also i) encode DAD. ii) Decode 10011011011101	CO4	L4
	Heaps and Heapsort		
28	Construct a heap for the list 1, 8, 6, 5, 3, 7, 4 by the bottom-up algorithm.	CO4	L4
29	Sort the array 2, 9, 7, 6, 5, 8 by heapsort.	CO4	L4
e	**Experiences**	-	-
1			
2			
3			

Module – 4

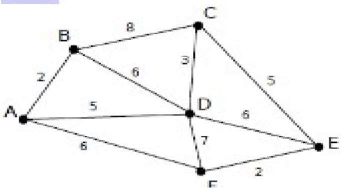
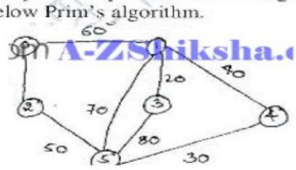
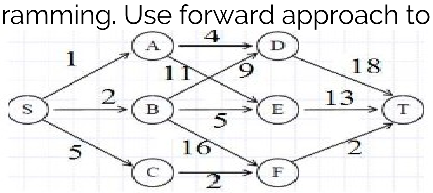
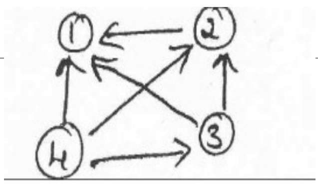
Title:	Dynamic Programming Technique	Appr Time:	10 Hrs
a	***Course Outcomes***	-	**Blooms**
-	The student should be able to:	-	**Level**
1	Compare Dynamic Programming and Divide and Conquer Strategies.	CO5	L4
2			
b	***Course Schedule***	-	-
Class No	**Module Content Covered**	**CO**	**Level**
31	Dynamic Programming: General method with Examples, Multistage Graphs	CO5	L2
32	Transitive Closure:	CO5	L4
33	Warshall's Algorithm,	CO5	L4
34	All Pairs Shortest Paths:	CO5	L4
35	Floyd's Algorithm,	CO5	L4
36	Optimal Binary Search Trees,	CO5	L4
37	Knapsack problem	CO5	L4
38	Bellman-Ford Algorithm	CO5	L3
39	Travelling Sales Person problem		
40	Reliability design		
c	**Application Areas**	**CO**	**Level**
1	Able to compare Dynamic Programming and Divide and Conquer Strategies.	CO5	L4
2			
d	**Review Questions**	-	-
	Introduction		
30	Briefly explain how dynamic programming works.	CO5	L2
	Multistage Graph		
31	Find the shortest path from A to L , in the following multistage graph, using dynamic programming. Use forward approach to solve the prob lem. 	CO5	L5
	Transitive Closure - Warshalls Algorithm		
32	Generate Transitive Closure for the given graph 	CO5	L5
33	Explain Warshall algorithm to find the transitive closure of a directed graph. Apply this algorithm to the graph given below. (08 Marks) 	CO5	L5

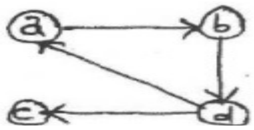
e	**Experiences**		
1			
2			
3			
4			
5			

E2. CIA EXAM – 2

a. Model Question Paper – 2

Crs Code:	17CS43	Sem:	IV	Marks:	30	Time:	75 minutes
Course:	Design and Analysis of Algorithms						

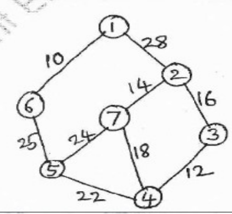
-	-	**Note: Answer any 2 questions, each carry equal marks.**	**Marks**	**CO**	**Level**
1	a	Obtain the optimal solution for the job sequencing problem with deadline, where n = 4 profit $(P_1, P_2, P_3, P_4) = (100, 10, 15, 27)$ and dead lines $(d_1, d_2, d_3, d_4) = (2, 1, 2, 1)$. (04 Marks)	4		
	b	Define MST. Apply PRIMS and KRUSKAL algorithm for the following graph to get MST. Show the intermediate steps. 	11		
2	a	Explain the concepts of greedy technique for prim's algorithm. Obtain minimum cost spanning tree for the graph whose weight matrix is given below $\begin{bmatrix} 0 & 3 & \infty & 7 & \infty \\ 3 & 0 & 4 & 2 & \infty \\ \infty & 4 & 0 & 5 & 6 \\ 7 & 2 & 5 & 0 & 4 \\ \infty & \infty & 6 & 4 & 0 \end{bmatrix}$ (08 Marks)	7		
	b	Explain the concept of greedy technique for Prim's algorithm. Obtain minimum cost spanning tree for the graph below Prim's algorithm. (09 Marks) 	8		
3	a	Find the shortest path from S to T inthe following multistage graph using dynamic programming. Use forward approach to solve the prob lem 	8		
	b	Generate Transitive Closure for the given graph 	7		

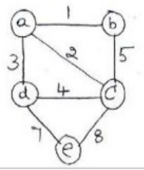
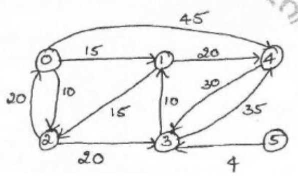
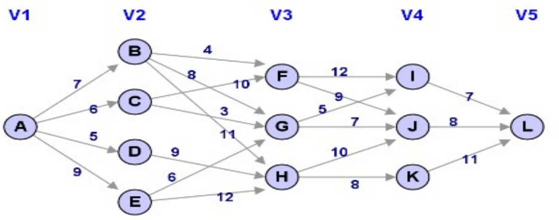
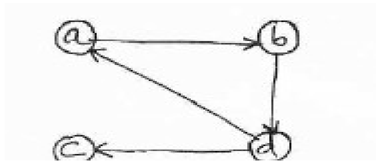
	c				
	d				
4	a	Explain Warshall algorithm to find the transitive closure of a directed graph. Apply this algorithm to the graph given below. (08 Marks) 	8		
	b	Write Warshall's-Floyd Algorithm	7		
	c				
	d				

b. Assignment – 2

Note: A distinct assignment to be assigned to each student.

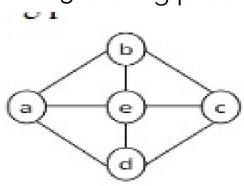
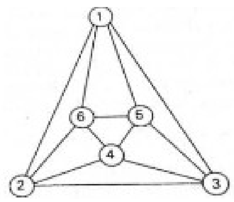
Model Assignment Questions							
Crs Code:	17CS43	Sem:	IV	Marks:	5 / 10	Time:	
Course:	Design and Analysis of Algorithms						
Note: Each student to answer 2-3 assignments. Each assignment carries equal mark.							

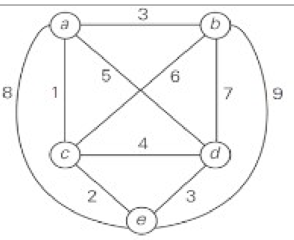
SNo	USN	Assignment Description	Marks	CO	Level
1	1KT17CS001	Define coin change problem. Write the greedy strategy for getting the optimal solution. If coins available are of values { 2, 5, 3, 6 }, find the least denominations for a) 55 b)77	10		
2	1KT17CS002	What is job sequencing with deadline problem? Find solution generated by job sequencing problem with deadlines for 7 jobs given profits 3, 5, 20, 18, 1, 6, 30 and deadlines 1, 3, 4, 3, 2, 1, 2 respectively. (06 Marks)	6		
3	1KT17CS003	What is minimum cost spanning tree? Apply Prim's and Kruskal's algorithm on Fig. Q3(a). (10 Marks) 	10		

<table>
<tr><td>4</td><td>1KT17CS004</td><td>Define minimum cost spanning tree. Give high level description of Prim's algorithm to find minimum spanning tree and find minimum spanning tree for graph shown in Fig.Q3(b) using Prim's algorithm. 8 (08 Marks)

</td><td>8</td><td></td><td></td></tr>
<tr><td>5</td><td>1KT17CS005</td><td>Solve the following single source shortest path problem assuming vertex 5 as the source. (09 Marks)

</td><td>9</td><td></td><td></td></tr>
<tr><td>6</td><td>1KT17CS006</td><td>Construct a Huffman code for the following data:
<table><tr><td>symbol</td><td>A</td><td>B</td><td>C</td><td>D</td><td>_</td></tr><tr><td>frequency</td><td>0.4</td><td>0.1</td><td>0.2</td><td>0.15</td><td>0.15</td></tr></table>Encode ABACABAD using the code. Decode 100010111001010</td><td>10</td><td></td><td></td></tr>
<tr><td>7</td><td>1KT17CS007</td><td>Sort the following lists by heapsort by using the array representation of heaps. 5, 2, 4, 1, 3 (in increasing order)</td><td>8</td><td></td><td></td></tr>
<tr><td>8</td><td>1KT17CS008</td><td>Find the shortest path from A to L , in the following multistage graph, using dynamic programming. Use forward approach to solve the problem

</td><td>10</td><td></td><td></td></tr>
<tr><td>9</td><td>1KT17CS009</td><td>Explain dynamic programming. Find transitive closure using Warshall's algorithm for the digraph Q4(a). (06 Marks)

</td><td>6</td><td></td><td></td></tr>
<tr><td>10</td><td>1KT17CS010</td><td></td><td></td><td></td><td></td></tr>
<tr><td>11</td><td>1KT17CS011</td><td></td><td></td><td></td><td></td></tr>
<tr><td>12</td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

D3. TEACHING PLAN - 3

Module – 5

Title:	Backtracking,Branch and Bound,P,NP-Hard	Appr Time:	10 Hrs
a	***Course Outcomes***	-	**Blooms**
-	The student should be able to:	-	**Level**
1	Design efficient algorithms using Back Tracking and Branch Bound Techniques for solving problems.		L$
2	Classify computational problems into P, NP, NP-Hard and NP-complete		L3
3			
b	***Course Schedule***	-	-
Class No	**Module Content Covered**	**CO**	**Level**
41	Backtracking: General method , N-Queens problem.		
42	Sum of subsets problem , Graph coloring Hamiltonian cycles.		
43	Branch and Bound: Assignment Problem,		
44	Travelling Sales Person problem		
45	0/1 Knapsack problem LC Branch and Bound solution ,		
46	FIFO Branch and Bound solution		
47	NP- Complete and NP-Hard problems: Basic concepts,		
48	non-deterministic algorithms, P, NP,		
49	NP-Complete, and NP-Hard classes		
50			
c	**Application Areas**	**CO**	**Level**
1	Able to design efficient algorithms using Back Tracking and Branch Bound Techniques	CO6	L4
2	Able to classify computational problems into P, NP, NP-Hard and NP-complete	CO7	L3
d	**Review Questions**	-	-
34	What is backtracking. Give the general Procedure.		
35	Apply backtracking to solve the 3-cloring problem for the graph given below. 		
36	Apply the backtracking to the problem of finding Hamiltonian cycle in the following graphs 		
37	What branch and bound method. How it is different from backtracking.		
38	Apply the branch – and -bound algorithm to solve the travelling sales man problem for the following graph. Start city is a. Give the states pace tree		



39	Apply FIFO Branch and Bound method for the following instance of 0/1 Knapsack problem to get the optimal solution. Knapsack Capacity W = 15		

Item No.	1	2	3	4
Weight	2	4	6	9
Value	10	10	12	18

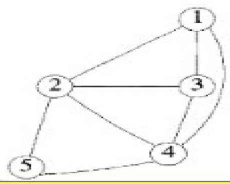
e	**Experiences**	-	-
1			
2			
3			
4			
5			

E3. CIA EXAM – 3

a. Model Question Paper – 3

Crs Code:	17CS43	Sem:	IV	Marks:	30	Time:	75 minutes
Course:	Design and Analysis of Algorithms						

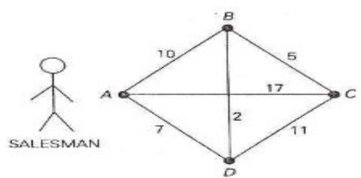
-	-	**Note: Answer any 2 questions, each carry equal marks.**	**Marks**	**CO**	**Level**
1	a	Give the problem statement of n-queens problem. Explain the solution for 4-queens problem using state space tree.	6		
	b	Apply backtracking to solve the following instance of the subset-sum problem : S={1,3,4,5} and d=11. Draw the state space tree.	9		
2	a	Apply backtracking based graph coloring algorithm for the graph given below with m=4. Give state space tree showing first 3 valid assignments.	10		



	b	Give the backtracking based algorithm to the problem of finding Hamiltonian cycle in the graph	5		
3	a	Apply branch and bound method for the following instance of assignment problem to find the optimal solution. Give the complete state space tree	9		

	Job 1	Job 2	Job 3	Job 4
Person a	9	2	7	8
Person b	6	4	3	7
Person c	5	8	1	8
Person d	7	6	9	4

	b	Apply the branch -and- bound algorithm to solve the travelling sales man problem for the	6		



		following graph. Consider start city is A. Give the state space tree.			
	c				
	d				
4	a	With the help of a state space tree, solve the following instance of Knapsack problem by the branch and bound algorithm. Knapsack Capacity W = 15	10		

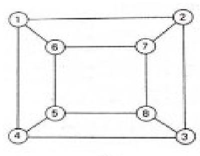
Item No.	1	2	3	4	5	6
Weight	5	7	2	4	5	1
Value	40	35	18	4	10	2

	b	Explain the following with examples a. Class P Problems b. Class NP Problems c. NP complete problem d.NP hard problem.	5		
	c				
	d				

b. Assignment – 3

Note: A distinct assignment to be assigned to each student.

Model Assignment Questions							
Crs Code:	17CS43	Sem:	I	Marks:	30	Time:	
Course:	Design and Analysis of Algorithms						
Note: Each student to answer 2-3 assignments. Each assignment carries equal mark.							

SNo	USN	Assignment Description	Marks	CO	Level
1	1KT17CS001	Explain backtracking concept and apply it solve subset sum problem for S = {6,5,3,7} and d=15. Draw the state space tree.	10		
2	1KT17CS002	Apply the backtracking to the problem of finding Hamiltonian cycle in the following graphs 	6		
3	1KT17CS003	How branch and bound algorithm is different from backtracking	5		
4	1KT17CS004	With the help of a state space tree, solve the following instance of Knapsack problem by the branch and bound algorithm. Knapsack Capacit y W = 10	10		

Item No.	1	2	3	4
Weight	4	7	5	3
Value	40	42	25	12

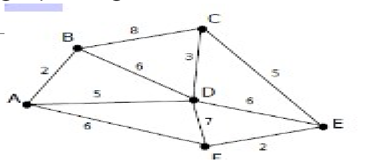
SNo	USN	Assignment Description	Marks	CO	Level
5	1KT17CS005				
6	1KT17CS006				
7	1KT17CS007				

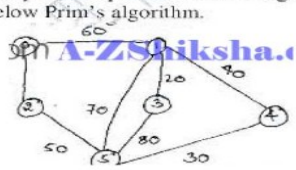
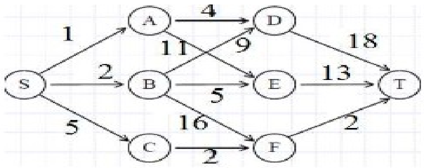
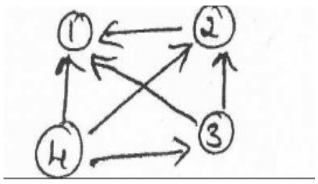
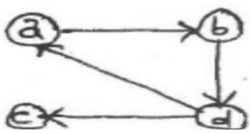
8	1KT17CS008				
9	1KT17CS009				
10	1KT17CS010				
11	1KT17CS011				

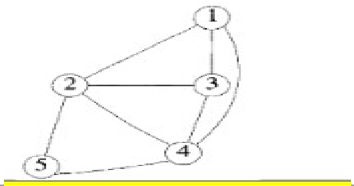
F. EXAM PREPARATION

1. University Model Question Paper

Course:		Design and Analysis of Algorithms	Month / Year		May /2018
Crs Code:		17CS43 Sem: I Marks: 100	Time:		180 minutes
-	**Note**	Answer all FIVE full questions. All questions carry equal marks.	**Marks**	**CO**	**Level**
1	a	Compare the orders of growth of following functions i) (½) n (n-1) and n ii) 3n+2 and n	8		
	b	Explain the mathematical analysis of fibonacci recursive algorithm. Write Bruteforce string matching algorithm.	12		
	c				
	d				
-	a	Explain the asymptotic notations with examples.	10		
	b	Write an algorithm for selection sort. Analyze its efficiency	10		
	c				
	d				
2	a	Sort the following elements using merge sort. Write the recursion tree. 70, 20, 30, 40, 10, 50, 60 Twisted : Use D & C method which divides problem size by considering position	10		
	b	what is divide and conquer? Explain the general method of divide and conquer.	10		
	c				
	d				
-	a	Write the algorithm for sequential search, obtain the time complexity of this algorithm for successful and unsuccessful search in the worst case and best case. (04 Marks)	6		
	b	Write a algorithm for Quick sort, and sort the following number's 10, 8, 5, 15, 25, 75, 12. Obtain its time complexity. (10 Marks)	14		
	c				
	d				
3	a	Obtain the optimal solution for the job sequencing problem with deadline, where n = 4 profit $(P_1, P_2, P_3, P_4) = (100, 10, 15, 27)$ and dead lines $(d_1, d_2, d_3, d_4) = (2, 1, 2, 1)$. (04 Marks)	6		
	b	Define MST. Apply PRIMS and KRUSKAL algorithm for the following graph to get MST. Show the intermediate steps.	14		



-	a	Explain the concepts of greedy technique for prim's algorithm. Obtain minimum cost spanning tree for the graph whose weight matrix is given below $\begin{bmatrix} 0 & 3 & \infty & 7 & \infty \\ 3 & 0 & 4 & 2 & \infty \\ \infty & 4 & 0 & 5 & 6 \\ 7 & 2 & 5 & 0 & 4 \\ \infty & \infty & 6 & 4 & 0 \end{bmatrix}$ (08 Marks)	10		
	b	Explain the concept of greedy technique for Prim's algorithm. Obtain minimum cost spanning tree for the graph below Prim's algorithm. (09 Marks) 	10		
	c				
	d				
4	a	Find the shortest path from S to T inthe following multistage graph using dynamic programming. Use forward approach to solve the problem 	10		
	b	Generate transitive closoure for given graph. 	10		
	c				
	d				
-	a	Explain warshall algorithm to find the transitive closure of a directed graph. Apply this algorithm to the graph given below. (08 Marks) 	12		
	b	Write wharshall's Algorithms.	8		
	c				
	d				
5	a	Give the problem statement of n-queens problem. Explain the solution for 4-queens problem using state space tree.	10		
	b	Apply backtracking to solve the following instance of the subset-sum problem : S={1,3,4,5} and d=11. Draw the state space tree.	10		
6	a	Apply backtracking based graph coloring algorithm for the graph given	10		

		below with m=4. Give state space tree showing first 3 valid assignments. 			
	b	Give the backtracking based algorithm to the problem of finding Hamiltonian cycle in the graph	10		
	c				
	d				

2. SEE Important Questions

Course:		Design and Analysis of Algorithms	Month / Year	May /2018	
Crs Code:		17CS43 Sem: 3 Marks: 100	Time:	180 minutes	
	Note	Answer all FIVE full questions. All questions carry equal marks.	-	-	
Module	Qno.	Important Question	**Marks**	**CO**	**Year**
1	1	Explain all the mathematical notations used for the analysis of an algorithm	06		
	2	Solve the following recurrence relations x(n) =3x(n-1) for n>1,x 1)=4 and x(n)=x(n/2)+n for n>1,x(1)=1,n=2k	06		
	3	Explain the method of comparing the order of the growth of two functions using limits. Compare order of growth of following functions i) log n and sqrt(n) ii) $(\log_2 n)^2$ and $\log_2 n^2$	06		
	4	Explain in brief the basic asymptotic efficiency classes.	02		
	5				
2	1	Determine the efficiency of divide and conquer algorithms.	05		
	2	Explain and Analyze the merge sort algorithm.	10		
	3	How quick sort can be improved?	05		
	4				
	5				
3	1	Explain Kruskal's Algorithm With an example	10		
	2	Construct a Huffman code for the following data: Character : A B C D - Probability: 0.4 0.1 0.2 0.15 0.15	10		
	3				
	4				
	5				
4	1	Write Warshall's algorithm and apply it to compute transitive closure for the directed graph with the adjacency matrix shown below: A B C D A 0 1 0 0 B 0 0 0 1 C 0 0 0 0 D 1 0 1 0	10		
	2	Explain the dynamic programming with Floyd's algorithm in detail. Apply Floyd's all pairs shortest problem. For the digraph given below	10		
	3				
	4				
	5				

5	1	Write an algorithm for sum of subset problem using backtracking. Also solve the following instance of sum of subset problem : S ={1,5,2,7} with d = 8.	10		
	2	Apply Branch and Bound algorithm to solve the travelling salesman problem for the graph with a cost adjacency matrix is as follows. A B C D E A 0 3 1 5 8 B 3 0 6 7 9 C 1 6 0 4 2 D 5 7 4 0 3 E 8 9 2 3 0	10		
	3				
	4				
	5				

G. Content to Course Outcomes

1. TLPA Parameters

Table 1: TLPA – Example Course

Module-#	Course Content or Syllabus (Split module content into 2 parts which have similar concepts)	Content Teaching Hours	Blooms' Learning Levels for Content	Final Blooms' Level	Identified Action Verbs for Learning	Instruction Methods for Learning	Assessment Methods to Measure Learning
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*
1	Introduction: What is an Algorithm? (T2:1.1),Algorithm Specification (T2:1.2), Analysis Framework (T1:2.1), Performance Analysis: Space complexity, Time complexity (T2:1.3).	4	- L1 - L2	L2	Understanding	-Black board -system	-Test -assignments
1	Asymptotic Notations:Big-Oh notation (O), Omega notation (Ω),Theta notation (Θ), and Little-oh notation (o), Mathematical analysis of Non-Recursive and recursive Algorithms with Examples (T1:2.2, 2.3, 2.4).Important Problem Types:Sorting, Searching, String processing, Graph Problems, Combinatorial Problems. Fundamental Data Structures: Stacks, Queues, Graphs, Trees, Sets and Dictionaries . (T1:1.3,1.4)	6	- L3 - L4	L4 e	Evaluation	-Black board -system	-Test -assignments
2	Divide and Conquer: General method, Binary search, Recurrence equation for divide and conquer, Finding the maximum and minimum (T2:3.1, 3.3, 3.4), Merge sort, Quick sort (T1:4.1, 4.2) , Strassen's matrix multiplication (T2:3.8) , Advantages and Disadvantages of divide and conquer.	9	- L2 - L3 -L4	L4	Evaluation	-Black board -system	-Test -assignments
2	Decrease and Conquer Approach: Topological Sort. (T1:5.3)	1	- L3 - L4	L4	Evaluation	-Black board -system	-Test -assignments
3	Greedy Method: General method, Coin Change Problem, Knapsack Probl em, Job sequencing with deadlines (T2:4.1, 4.3, 4.5). Minimum cost spanning trees: Prim's Algorithm, Kruskal's Algorithm (T1:9.1, 9.2) . Single source shortest paths: Dijkstra's	9	- L1 -L2 -L3 - L4	L4	Analyze	-Black board -system	-Test -assignments

	Algorithm (T1:9.3) . Optimal Tree problem: Huffman Trees and Codes (T1:9.4) .)						
3	Transform and Conquer Approach: Heaps and Heap Sort (T1:6.4	1	- L2 - L3 -L4	L4	Evaluation	-Black board -system	-Test -assignments
4	Dynamic Programming: General method with Examples, Multistage Graphs (T2:5.1, 5.2) . Transitive Closure: Warshall's Algorithm, All Pairs Shortest Paths: Floyd's Algorithm, Optimal Binary Search Trees, Knapsack problem ((T1:8.2, 8.3, 8.4), Bellman-Ford Algorithm (T2:5.4) , Travelling Sales Person problem (T2:5.9) , Reliability design (T2:5.8).	10	- L2 -L3 - L4	L4	Evaluation	-Black board -system	-Test -assignments
4	Backtracking: General method (T2:7.1) , N-Queens problem (T1:12.1) , Sum of subsets problem (T1:12.1) , Graph coloring (T2:7.4) , Hamiltonian cycles (T2:7.5) . Branch and Bound: Assignment Problem, Travelling Sales Person problem (T1:12.2) ,	5	- L2 - L4	L4	Analyze	-Black board -system	-Test -assignments
5	0/1 Knapsack problem (T2:8.2, T1:12.2): LC Branch and Bound solution (T2:8.2) , FIFO Branch and Bound solution (T2:8.2) . classes (T2:11.1) .	3	- L3 -L4	L4	Analyze	-Black board -system	-Test -assignments
5	NP-Complete and NP Hard problems: Basic concepts, non deterministic algorithms, P, NP, NP-Complete, and NP-Hard	2	- L2 - L3	L3	Apply	-Black board -system	-Test -assignments

2. Concepts and Outcomes:

Table 2: Concept to Outcome – Example Course

Module-#	Learning or Outcome from study of the Content or Syllabus	Identified Concepts from Content	Final Concept	Concept Justification (What all Learning Happened from the study of Content / Syllabus. A short word for learning or outcome)	CO Components (1.Action Verb, 2.Knowledge, 3.Condition / Methodology, 4.Benchmark)	Course Outcome **Student Should be able to ...**
A	*I*	*J*	*K*	*L*	*M*	*N*
1	-What is an Algorithm? -Algorithm Specification -Analysis Framework - -Performance Analysis:	-Specification -Framework	Algorithm Properties	Understanding	-Analyze -Time and space complexities -Asymptotic notations.	understand a given algorithm and express its time and space complexities in asymptotic notations.
1	-Asymptotic Notations: -Mathematical analysis of Non-Recursive and recursive Algorithms with	-Recurrence Notation -Mathematical Analysis	Recurrence strategy	Evaluation	-Solve -Recurrence equations -Master's Theorem	Solve recurrence equations using Iteration Method, Recurrence Tree Method and Master's Theorem

	Examples -Important Problem Types - Fundamental Data Structures:					
2	-Finding the maximum and - minimum -MergeSort -Quick sort , -Strassen's matrix multiplication	-Sorting -Matrix Operation	Divide-conquer	Evaluation	-Design -Algorithms -Divide and Conquer Strategy.	Analyze time efficiency of algorithms using Divide and Conquer Strategy.
2	-Topological Sort.	-Travesal method -Source Removal Methodology	Decrease and conquer		-Design -Algorithms -Decrease and conque	Analyze algorithms using Decrease and Conquer Strategy.
3	-Coin Change Problem, - Knapsack Problem -Job sequencing with deadlines -Prim's Algorithm, -Kruskal's Algorithm - Dijkstra's Algorithm . - Optimal Tree problem: Huffman Trees and Codes	-Knapsack Problem -Sequencing -Spanning Tree -Shortest Path -Code Generation	Greedy Technique	Analyze	-Solve -Optimization problems -Greedy strategy.	solve Optimization problems using Greedy strategy.
3	-Heaps and Heap Sort	-Representation change -Sorting	Transform and conquer	Evaluation	-Solve -Optimization problems -Representation Change	solve Optimization problems using transform and conquer strategy.
4	-Multistage Graphs . - Warshall's Algorithm, -Floyd's Algorithm, Optimal - Binary Search Trees, - Knapsack problem - Bellman-Ford Algorithm - Travelling Sales Person	-Multistage graph -Transitive Closure -Shortest path -Negetive Edge Weight -TSP Problem	Dynamic Programming		-Solve -Optimization problems -Dynamic Programming	Distinguish Dynamic Programming and Greedy Strategies.

	problem					
5	-N-Queens problem -Sum of subsets problem - Graph coloring - Hamiltonian cycles .	-State Space Tree -Subsets Generation -Coloring of Graphical -Cycle Identification	Backtracking	Analyze	Design Algorithms using Back Tracking	Test the efficient algorithms using Back Tracking for solving problems.
5	-Assignment Problem, - Traveling Sales Person problem -LC Branch and Bound solution -FIFO Branch and Bound solution	-Lower count -assignment -TSP	Branch and Bound	Analyze	Design Algorithms using Branch Bound	Differentiate Branch Bound with Back tracking for solving problems.
5	-Basic concepts, -non deterministic algorithms, -P, NP, NP-Complete, and NP-Hard	Deteministic -NP,P Complete Problem	Computational problem	Apply	Classify computational problems I P, NP, NP-Hard and NP-complete	examine computational problems into P, NP, NP-Hard and NP-complete