B. P. PODDAR INSTITUTE OF MANAGEMENT AND TECHNOLOGY
DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING
ACADEMIC YEAR: 2021-22

COURSE OUTCOMES

Course:Design and Analysis of Algorithms
Code: PCC-CS404
Branch & Sec: CSE (Sec-B)

COURSE OUTCOMES:

Sl No	Course Outcomes	Cognitive Level	PO mapping	PSO mapping
CS404.1	Able to Argue the correctness of algorithms using inductive proofs and Analyze worst-case running times of algorithms using asymptotic analysis.	Analyze	PO1, PO2, PO3, PO4, PO8, PO9, PO10	PSO1,PSO2
CS404.2	Able to explain important algorithmic design paradigms (divide-and-conquer, greedy method, dynamic-programming and Backtracking) and apply when an algorithmic design situation calls for it.	Create	PO1, PO2, PO3, PO4, PO8, PO9, PO10, PO12	PSO1,PSO2
CS404.3	Able to Explain the major graph algorithms and Employ graphs to model engineering problems, when appropriate.	Create	PO1, PO2, PO3, PO4, PO8, PO9, PO10,, PO12	PSO1,PSO2
CS404.4	Able to Compare between different data structures and pick an appropriate data structure for a design situation	Analyze	PO1, PO2, PO3, PO4, PO8, PO9, PO10, PO12	PSO1,PSO2
CS404.5	Able to Describe the classes P, NP, and NP-Complete and be able to prove that a certain problem is NP-Complete.	Evaluate	PO1, PO2, PO3, PO4, PO8, PO9, PO10	PSO1,PSO2
CS404.6	Able to perform Amortized analysis for data structures like Hash Tables, Disjoint Sets and Splay Trees.	Analyze	PO1, PO2, PO3, PO4, PO8, PO9, PO10	PSO1,PSO2

CO MAPPING WITH PO/PSO

Course: Design and Analysis of Algorithms
Code: PCC-CS404
Branch & Sec: Computer Science & Engineering (Sec-B)

COURSE OUTCOMES VS PO and PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
PCCCS 404.1	2	3	2	2	-	-	-	1	1	2	-	-	2	2
PCCCS 404.2	3	3	3	2	-	-	-	1	1	2	-	3	2	2
PCCCS 404.3	2	3	3	3	-	-	-	1	1	2	-	3	2	2
PCCCS 404.4	2	3	2	2	-	-	-	1	1	2	-	3	2	2
PCCCS 404.5	2	3	2	3	-	-	-	1	1	2	-	-	2	2
PCCCS 404.6	2	3	2	3	-	-	-	1	1	2	-	-	2	2
PCCCS404	**2.2**	**3**	**2.3**	**2.5**	**-**	**-**	**-**	**1**	**1**	**2**	**-**	**3**	2	2

For Entire Course, PO/PSO Mapping; 1 (Low); 2 (Medium); 3 (High) Contribution to PO/PSO

PO REFERENCE:

PO1†	Engineering†Knowledge†	PO7†	Environment†&†Sustainability†	PSO1†	Domain†Skills 1†
PO2†	Problem†Analysis†	PO8†	Ethics†	PSO2†	Domain†Skills 2†
PO3†	Design†&†Development†	PO9†	Individual†&†Team†Work†	†	†
PO4†	Investigations†	PO10†	Communication†Skills†	†	†
PO5†	Modern†Tools†	PO11†	Project†Mgt.†&†Finance†	†	†
PO6†	Enginerr†&†Society†	PO12†	Life†Long†Learning†	†	†

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PSO REFERENCE:

PSO1	Students will have proficiency in emerging domains like artificial intelligence, data science and distributed computing to develop solutions through innovative projects and research.
PSO2	Students will have capabilities to work in synergized teams to cater to the dynamic needs of the industry and society.

JUSTIFICATION FOR MAPPING:

CO	PO MAPPED	LEVEL	JUSTIFICATION
PCCCS404.1	PO1, PO2, PO3, PO4, PO8, PO9, PO10	2, 3, 2, 2, 1, 1, 2	This is highly correlated with engineering knowledge and problem analysis since it deals with correctness and running time of algorithms.
PCCCS404.2	PO1, PO2, PO3, PO4, PO8, PO9, PO10, PO12	3, 3, 3, 2, 1, 1, 2, 3	Most importantly this is the main CO in Design and Analysis of Algorithm course by providing the different design techniques to develop an efficient algorithms
PCCCS404.3	PO1, PO2, PO3, PO4, PO8, PO9, PO10, PO12	2, 3, 3, 3, 1, 1, 2, 3	Essentially this CO relates to different graph traversal algorithms which are used for social network analysis and our day to day problem.
PCCCS404.4	PO1, PO2, PO3, PO4, PO8, PO9, PO10, PO12	2, 3, 2, 2, 1, 1, 2, 3	This is related to different types of data structure which are playing important role for designing algorithm.
PCCCS404.5	PO1, PO2, PO3, PO4, PO8, PO9, PO10	2, 3, 2, 3, 1, 1, 2	This CO relates to understand, analysis, design and application of the notion of Polynomial and Non-polynomial time algorithms and categorized by P, NP – Complete and NP – Hard.
PCCCS404.6	PO1, PO2, PO3, PO4, PO8, PO9, PO10	2, 3, 2, 3, 1, 1, 2	This CO relates to analysis of few data structures like Hash Tables, Disjoint Sets and Splay Trees where occasional operation is very slow, but most of the operations which are executing very frequently are faster.

CO	PSO MAPPED	LEVEL	JUSTIFICATION
PCCCS404.1	PSO1, PSO2	2, 2	This CO is about problem analysis since it deals with correctness and running time of algorithms.
PCCCS404.2	PSO1, PSO2	2, 2	This CO talks about state of the art algorithm design to develop efficient algorithm.
PCCCS404.3	PSO1, PSO2	2, 2	This CO talks about state of the art Graph algorithm is required for computer vision and embedded system development.
PCCCS404.4	PSO1, PSO2	2, 2	This CO talks about state of the art Data Structure is required to design algorithms.
PCCCS404.5	PSO1, PSO2	2, 2	This CO talks about different categories of problems P, NP – Complete and NP – Hard which is required for advance algorithms.

PCCCS404.6	PSO1, PSO2	2,2	This CO talks about Amortized analysis which is required for few data structures like Hash Tables, Disjoint Sets and Splay Trees where occasional operation is very slow, but most of the operations which are executing very frequently are faster.

Design & Analysis of Algorithm MAKAUT Syllabus

Code: PCC-CS404
Contact: 3L + 1T
Credits: 4

Complexity Analysis:[2L]
Time and Space Complexity, Different Asymptotic notations – their mathematical significance
Algortihm Design Techniques:
Divide and Conquer: [3L]
Basic method, use, Examples – Binary Search, Merge Sort, Quick Sort and their complexity.
Heap Sort and its complexity [1L]
Dynamic Programming: [3L]
Basic method, use, Examples – Matrix Chain Manipulation, All pair shortest paths, single source shortest path.
Backtracking: [2L]
Basic method, use, Examples – 8 queens problem, Graph coloring problem.
Greedy Method: [3L]
Basic method, use, Examples – Knapsack problem, Job sequencing with deadlines, Minimum cost spanning ree by Prim's and Kruskal's algorithm.
Lower Bound Theory: [1L]
O(nlgn) bound for comparison sort
Disjoint set manipulation: [2L]
Set manipulation algorithm like UNION-FIND, union by rank.
Graph traversal algorithm: Recapitulation [1L]
Breadth First Search(BFS) and Depth First Search(DFS) – Classification of edges - tree, forward, back and cross edges – complexity and comparison
String matching problem: [3L]
Different techniques – Naive algorithm, string matching using finite automata, and Knuth, Morris, Pratt their complexities.
Amortized Analysis: [3L]
Aggregate, Accounting, and Potential Method.
Network Flow: [3L]
Ford Fulkerson algorithm, Max-Flow Min-Cut theorem (Statement and Illustration)
Matrix Manipulation Algorithm: [3L]
Strassen's matrix manipulation algorithm; application of matrix multiplication to solution of simultaneous linear equations using LUP decomposition, Inversion of matrix and Boolean matrix multiplication.
Notion of NP-completeness: [3L]
P class, NP class, NP hard class, NP complete class – their interrelationship, Satisfiability problem, Cook's theorem (Statement only), Clique decision problem
Approximation Algorithms: [3L]
Necessity of approximation scheme, performance guarantee, polynomial time approximation schemes, vertex cover problem, travelling salesman problem.

Text Book:
1. T. H. Cormen, C. E. Leiserson, R. L. Rivest and C. Stein, "Introduction to Algorithms"
2. A. Aho, J.Hopcroft and J.Ullman "The Design and Analysis of Algorithms"
3. D.E.Knuth "The Art of Computer Programming", Vol. 3
4. Jon Kleiberg and Eva Tardos, "Algorithm Design"

Reference:
K.Mehlhorn , "Data Structures and Algorithms" - Vol. I & Vol. 2.
S.Baase "Computer Algorithms"
E.Horowitz and Shani "Fundamentals of Computer Algorithms"

E.M.Reingold, J.Nievergelt and N.Deo- “Combinational Algorithms- Theory and Practice”, Prentice Hall, 1997

LESSON PLAN

Course: *Design and Analysis of Algorithms*
Code: PCC-CS404
Contact: 3L
Credits: 3

Required Text Books:

1. T. H. Cormen, C. E. Leiserson, R. L. Rivest and C. Stein, "Introduction to Algorithms" 2nd Edition
2. E.Horowitz and Shani "Fundamentals of Computer Algorithms" 2nd Edition.
3. A. Aho, J.Hopcroft and J.Ullman "The Design and Analysis of Algorithms"
4. Klenberg, Trados , "Algorithm Design"
5. Goodrich "Design of Algorithms"
6. E.M.Reingold, J.Nievergelt and N.Deo- "Combinational Algorithms- Theory and Practice", Prentice Hall, 1997

Web resources

W1: https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-006-introduction-to-algorithms-spring-2008/lecture-notes/

W2: https://www2.cs.duke.edu/courses/fall10/cps130/lectures.html

W3: https://www.isical.ac.in/~arijit/courses/spring2017/daa-mtech.html

W4: http://www.cs.umd.edu/class/fall2015/cmsc451/

W5: http://www.cse.iitd.ernet.in/~ssen/csl356/admin356.html

W6: https://www.cs.virginia.edu/~luebke/cs332/

W7: https://www.cs.umd.edu/users/samir/

Lecture No.	Topics to be covered	Ref	Teaching Aids	Teaching Method
1	Course Outcome for the course CS-501; Algorithm: Definition, Time and Space complexity of an Algorithm, Tower of Hanoi problem.	1	White Board	Discussion
2	Different Asymptotic notations: Big-O, Big-Ω (Big-Omega),Big-θ (Big-Theta) notation their mathematical significance	1	White Board	Illustration by example, Discussion
3	Introduction to divide and conquer; Binary Search Algorithm: complexity analysis	1	White Board	Illustration by example, Discussion
T1	Analysis of Asymptotic running time of Binary Search	W1	White Board	
34	Merge Sort: Algorithm, Example, complexity analysis	1	White Board	Illustration by example, Discussion
5	Quick Sort: Algorithm, example,complexity analysis for best case & worst case	1, 2	White Board	Problem Solving, Surprise Test
6	Heap: definition, Max Heap, Min Heap; Heap sort technique and complexity	1, 2, 4	White Board	Assignments

	analysis.			
T2	Analysis of Mergesort, Quicksort and Heapsort	W3	White Board	Illustration by example, Discussion
7	Matrix Chain Multiplication:Algorithm, Overlapping Subproblem, Optimal Substructure	1, 2	White Board	Quiz Group discussion
8	All pair shortest path using Dynamic Programming– Floyd Warshall algorithm	1, 2	White Board	Flip Class
9	Single source shortest path using Dynamic Programming– Bellman Ford Algorithm	1, 2	White Board PPT	Discussion
T3	Discuss Floyd Warshall, Bellman Ford	W5	White Board	Discussion
10	Backtracking: Introduction, N-Queen's problem, Solution Strategy	2	White Board PPT	Discussion, Surprise Test
11	Graph Coloring problem: Solution using Backtracking	1	White Board	Problem Solving
12	Greedy Method: Fractional Knapsack Problem- problem statement, solution	1, 2	White Board	Problem Solving
T4	Dijkstra's Algorithm	2	White Board	Group Discussion
13	Job Sequencing with deadlines- Greedy solution	1, 2	White Board	Assignments
14	Minimal Spanning Tree: Prim's Algorithm & Kruskal's algorithm	1, 2	White Board	Discussion
15	Lower bound of comparison based sorting algorithm Ω(nlog n)	1	White Board	Group Discussion Quiz
T5	Explain MST problem, Job sequencing with deadline	W1	White Board	Quiz
16	Set manipulation algorithm UNION-FIND, Union by Rank	2	White Board	Flip Class
17	Graph Traversal algorithm BFS, finding shortest path and connected components	1	White Board	Illustration by example, Discussion
18	DFS algorithm, Edge classification in DFS Tree, Topological Sorting	1	White Board	Assignments
T6	Explain Set manipulation , BFS and DFS algorithms	W5	White Board	Illustration by example, Discussion
19	String Matching with Naïve algorithm	1	White Board	Group Discussion
20	String Matching using Finite Automata	1	White Board	Assignments
21	Knuth, Morris, Pratt (KMP) Algorithm	1	White Board	Quiz
T7	Discuss String matching Algorithms	W1	White Board	Illustration by example, Discussion
22	Aggregate method	1, 4, 5	White Board	Discussion
23	Accounting method	4, 5	White Board	Discussion
24	Potential method	4, 5	White Board	Discussion
T8	Explain Aggregate, Accounting, Potential	W4	White	
	Methods		Board	

25	Ford – Fulkerson algorithm	1	PPT	Illustration by example, Discussion
26	Max-Flow Min-Cut Theorem	1	White Board	Problem Solving
27	Strassen's matrix multiplication algorithm,	1	White Board	Assignments
T9	Explain Max-Flow Min-cut theorem with Ford Fulkerson algorithm	W3	White Board	Illustration by example, Discussion
28	Solving linear equation using LUP Decomposition	1	White Board	Discussion
29	Inversion of Matrix and Boolean Matrix	1	White Board	Quiz
30	P Class, NP Class, NP Hard and NP Complete – inter relationship	1	PPT	Group Discussion Quiz
T10	Discuss the relation of P, NP, NP-Hard	W5	White Board	Group Discussion
31	Satisfiability problem	1	PPT	Discussion
32	Cook's Theorem, Clique decision problem	1	White Board	Assignments
33	Necessity of approximation scheme, performance guarantee	1	White Board	Group Discussion Quiz
T11	Discuss Satisfiability Problem	W3	White Board	Discussion, Quiz
34	Polynomial time approximation schemes	1	White Board	Group Discussion Quiz
35	Vertex cover problem, Travelling Salesman problem.	1	White Board	Group Discussion
T12	Discuss Travelling Salesman Problem and Vertex Cover Problem	W1	White Board	Illustration by example, Discussion
36	Branch and Bound Method of solving combinatorial optimization problem solving*		White Board	Illustration by example, Discussion

*gap within syllabus

ASSIGNMENT-I

OUTCOME BASED EDUCATION (OBE)

Question No.	Knowledge Domain	Allotted Marks	COs
1,2,3,4,6	Understand, Analyze	10	CO1,CO2
8,9	Understand, Apply		CO2, CO3,CO4
10	Analyze, Evaluate		CO1
5	Evaluate		CO2

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1. Using Recurrence Relation calculate the time complexity of

Merge Sort algorithm, Tower of Hanoi problem. 5+5

2. Write the algorithm of Quick sort. Find the best case, worst case and average case time complexities of this algorithm. 5+5

3. Let A [1.. n] be a sorted array of n distinct integers. Give a divide-and-conquer algorithm that can find an index i such that A [i] = i (if one exists) with running time O (log n).

Find out the number of inversion in an Array A[1.. n] with running time O(nlog n) . If i < j and A[i]>A[j] then
Count_Inversion++ 5+5

4. What is optimal substructure property? Write the algorithm for multiplying a chain of matrices A1 to An where matrix Ai has the dimension mi-1 X mi. Also find the split points. Discuss the time complexity.

3+5+2

5. Find at least three feasible solution for a knapsack having capacity 100 kg for the following list of items having values and weights as shown in table

Item	Value	Weight
I1	10	15
I 2	20	25
I 3	30	35
I 4	40	45
I 5	50	55

Now find the optimal solution of the problem using greedy method. 5+5

6. What do you mean by Dynamic Programming ? What is the difference between dynamic programming and Greedy method?Write the Bellman Ford Algorithm. Analyze its time complexity.

2+3+5

7. Write the algorithm for Heap sort. Given a list of numbers 12,8,6,5,13,9,14,15,10,7,11; show how heap sort can be applied to sort. 5+5

8. Define spanning tree. Write Prim’s algorithm to find out minimum cost spanning tree of a graph. Discuss its time complexity. 2+5+3

9. Write Kruskal’s algorithm to find out minimum cost spanning tree of a graph. Discuss implementation techniques, and its time complexity. 5+5

10. Discuss the Different Asymptotic notations: Big-O, Big-Ω (Big-Omega),Big-θ (Big-Theta) – their mathematical significance 4+3+3

MODEL Question Paper (PCC-CS404)

Group A

1. T(n)=T(9n/10)+n , then which one is true…

(a) $O(n^{1/2})$ (b) O(n) (c) $O(n^2)$ (d) O(nlog2n)

2. Choose the correct one: I. $2^{n+10} = O(2^n)$ II. $2^{10n} = O(2^n)$

(a) I Only (b) II Only (c) I and II (d) None

3. T(n)=Running Time of Merge Sort. Choose the correct one…

(a) 6nlog2n+6n (b) (4n+2)(log2n+1) (c) O(nlog2n) (d) All of the above

4. Which of the following algorithm design techniques is used in Quick sort algorithm?

(a) Dynamic Programming (b) Backtracking (c) Divide and conquer(d)Greedy method

5. Time complexity of Heap sort on n items is:

(a) O (n) (b) O (n log n) (c) $O(n^2)$ (d) O (log n)

6.In which sorting technique, an element is placed in its proper position in each step...

A. heap sort B. bubble sort C. quick sort D. merge sort

7. Which of the following can not be performed recursively

(a) DFS (b) quick sort (c) binary search (d)None of these

8. The time complexity of TSP is

(a) $O(n^2 2^n)$ (b)$\Theta(n^2 2^n)$ (c) $\Omega(n^2 2^n)$ (d)None of these

9.Which of the following algorithm solves All pair shortest path problem

(a)Dijkstra (b)Floyd Warshall (c) Prim's (d)D. Kruskal'

10. Which of the following algorithm has tail recursion?

(a)Bubble sort (b)quick sort (c)merge sort (d)none

Group B

1. State Master Theorem and find out the complexity of the following recurrence.

$T(n) = 2T(n^{1/2}) + \log n$ 5

2. Let A[1 … n] be a sorted array of n distinct integers. Give a divide and conquer algorithm which can find an index i such that A[i] = i (if one exist) with running time O(log n). 5

3. Find the minimum number of operations required for the following matrix chain multiplication using Dynamic programming: A (10 x 20) * B (20 x 50) * C (50 x 1) * D (1 x 100) 5

Group C

1.(a) Explain the time complexity of Quick Sort.

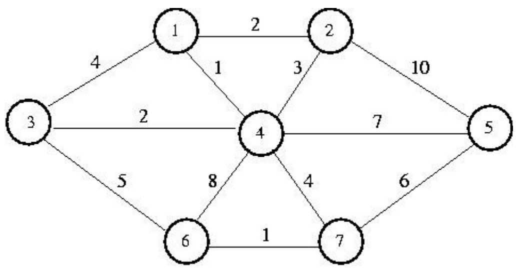
(b) Implement a algorithm in O(nlog n) time which will count the number of inversion in an array of integers A[10]. The inversion will be counted If i<j and A[i]>A[j] Then count++.

(c) How Partition function of Quick Sort used to find kth smallest number in O(log n) time.

5+4+6

2.(a) Write the greedy algorithm for job sequencing with deadline. Using greedy method ,find an optimal solution to the problem of job sequencing with deadline where n=4, (p1,p2,p3,p4)=(100,10,5,27) and (d1,d2,d3,d4)=(2,1,2,1).

(b) Define spanning tree. Using prims algorithm generate the MST from the following graph. (4+5)+(2+4)



3. (a) Define a Graph. How shortest path is computed using BFS(Breath First Search) .

(b) Write DFS algorithm, and explain the edge classification in DFS tree with the following example.

(c) How to find that a particular graph is a DAG (Directed Acyclic Graph)

(1+4)+(2+5)+4