DESIGN AND ANALYSIS OF ALGORITHMS

Subject Code: CS501PC
Regulations: R16 - JNTUH
Class: III Year B.Tech CSE I Semester

Department of Computer Science and Engineering
BHARAT INSTITUTE OF ENGINEERING AND TECHNOLOGY
Ibrahimpatnam - 501 510, Hyderabad
DESIGN AND ANALYSIS OF ALGORITHMS (CS501PC)

COURSE PLANNER

I. COURSE OVERVIEW:
Introduction to fundamental techniques for designing and analyzing algorithms, including asymptotic analysis; divide-and-conquer algorithms and disjoint set operations; graph algorithms; backtracking algorithms; greedy algorithms; dynamic programming; and branch and bound algorithms; NP-Hard and NP-Complete problems.

II. PREREQUISITE(S):
1. Problem Solving Skills
2. Basic Programming
3. Data Structures
4. Formal Languages and Automata Theory

III. COURSE OBJECTIVES:
1. To analyze performance of algorithms.
2. To choose the appropriate data structure and algorithm design method for a specified application.
3. To understand how the choice of data structures and algorithm design methods impacts the performance of programs.
4. To solve problems using algorithm design methods such as the greedy method, divide and conquer, dynamic programming, backtracking and branch and bound.
5. To understand the differences between tractable and intractable problems.
6. To introduce P and NP classes.

IV. COURSE OUTCOMES:

<table>
<thead>
<tr>
<th>S.No</th>
<th>Description</th>
<th>Bloom’s Taxonomy Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ability to analyze the performance of algorithms.</td>
<td>Analyze (level 4)</td>
</tr>
<tr>
<td>2</td>
<td>Ability to choose appropriate algorithm design techniques for solving problems.</td>
<td>Knowledge, Application (level 1, level 3)</td>
</tr>
<tr>
<td>3</td>
<td>Ability to understand how the choice of data structures and algorithm design methods impact the performance of programs.</td>
<td>Understanding, Synthesis (Level 2, level 5)</td>
</tr>
</tbody>
</table>

V. HOW PROGRAM OUTCOMES ARE ASSESSED:

<table>
<thead>
<tr>
<th>Program Outcomes (PO)</th>
<th>Level</th>
<th>Proficiency assessed by</th>
</tr>
</thead>
<tbody>
<tr>
<td>PO1 Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems related to Computer Science and Engineering.</td>
<td>3</td>
<td>Assignments</td>
</tr>
<tr>
<td>PO2 Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems related to Computer Science and Engineering and reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.</td>
<td>3</td>
<td>Assignments</td>
</tr>
<tr>
<td>PO3 Design/development of solutions: Design solutions for complex engineering problems related to Computer Science and Engineering and design system components or processes that meet the specified needs with appropriate consideration for the public health and</td>
<td>2</td>
<td>Assignments</td>
</tr>
</tbody>
</table>
safety, and the cultural, societal, and environmental considerations.

<table>
<thead>
<tr>
<th>PO4</th>
<th><strong>Conduct investigations of complex problems:</strong> Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.</th>
<th>2</th>
<th>Assignments</th>
</tr>
</thead>
<tbody>
<tr>
<td>PO5</td>
<td><strong>Modern tool usage:</strong> Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.</td>
<td>--</td>
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</tr>
<tr>
<td>PO6</td>
<td><strong>The engineer and society:</strong> Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the Computer Science and Engineering professional engineering practice.</td>
<td>1</td>
<td>Assignments</td>
</tr>
<tr>
<td>PO7</td>
<td><strong>Environment and sustainability:</strong> Understand the impact of the Computer Science and Engineering professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.</td>
<td>-</td>
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</tr>
<tr>
<td>PO8</td>
<td><strong>Ethics:</strong> Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.</td>
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</tr>
<tr>
<td>PO9</td>
<td><strong>Individual and team work:</strong> Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.</td>
<td>-</td>
<td>--</td>
</tr>
<tr>
<td>PO10</td>
<td><strong>Communication:</strong> Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.</td>
<td>-</td>
<td>--</td>
</tr>
<tr>
<td>PO11</td>
<td><strong>Project management and finance:</strong> Demonstrate knowledge and understanding of the engineering and management principles and apply these to one’s own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.</td>
<td>-</td>
<td>--</td>
</tr>
<tr>
<td>PO12</td>
<td><strong>Life-long learning:</strong> Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.</td>
<td>2</td>
<td>Research</td>
</tr>
</tbody>
</table>

1: Slight (Low)  
2: Moderate (Medium)  
3: Substantial (High)  
- : None

**VI. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:**
Program Specific Outcomes (PSO) | Level | Proficiency assessed by
--- | --- | ---
PSO1 Foundation of mathematical concepts: To use mathematical methodologies to crack problem using suitable mathematical analysis, data structure and suitable algorithm. | 3 | Lectures, Assignments
PSO2 Foundation of Computer System: The ability to interpret the fundamental concepts and methodology of computer systems. Students can understand the functionality of hardware and software aspects of computer systems. | 2 | Lectures, Assignments
PSO3 Foundations of Software development: The ability to grasp the software development lifecycle and methodologies of software systems. Possess competent skills and knowledge of software design process. Familiarity and practical proficiency with a broad area of programming concepts and provide new ideas and innovations towards research. | -- | --

VII. SYLLABUS:

UNIT- I

UNIT- II
Disjoint set operations, union and find algorithms, AND/OR graphs, Connected Components and Spanning trees, Bi-connected components Backtracking-General method, applications- The 8-queen problem, sum of subsets problem, graph coloring, Hamiltonian cycles.

UNIT- III

UNIT- IV
Dynamic Programming- General Method, applications- Chained matrix multiplication, All pairs shortest path problem, Optimal binary search trees, 0/1 knapsack problem, Reliability design, Traveling sales person problem.

UNIT- V
Branch and Bound- General Method, applications-0/1 Knapsack problem, LC Branch and Bound solution, FIFO Branch and Bound solution, Traveling sales person problem.

NP-Hard and NP-Complete problems- Basic concepts, Non-deterministic algorithms, NP - Hard and NP- Complete classes, Cook’s theorem.

SUGGESTED BOOKS:

TEXT BOOKS:

REFERENCE BOOKS:
2. Design and Analysis of Algorithms, S. Sridhar, Oxford Univ. Press
3. Design and Analysis of algorithms, Aho, Ullman and Hopcroft, Pearson Education.

NPTEL Web Course:
1.  [http://nptel.ac.in/courses/106101060/](http://nptel.ac.in/courses/106101060/)
2.  [tp://onlinecourses.nptel.ac.in/noc16_cs04/preview](tp://onlinecourses.nptel.ac.in/noc16_cs04/preview)

NPTEL Video Course:

GATE SYLLABUS:
Searching, sorting, hashing. Asymptotic worst case time and space complexity. Algorithm design techniques: greedy, dynamic programming and divide-and-conquer. Graph search, minimum spanning trees, and shortest paths.

IES SYLLABUS:
Not Applicable

### VIII. COURSE PLAN:

<table>
<thead>
<tr>
<th>Sl No</th>
<th>Week</th>
<th>Topic</th>
<th>Course Learning outcomes</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td><strong>Introduction</strong></td>
<td>Understand the fundamentals of Design and Analysis of Algorithms</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>Algorithm definition,</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>Algorithm Specification,</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>Performance Analysis-</td>
<td>Compare the performance of the algorithms</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>Space complexity, Time complexity,</td>
<td></td>
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<tr>
<td>6</td>
<td></td>
<td>Randomized Algorithms.</td>
<td></td>
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<tr>
<td>7</td>
<td>2</td>
<td><strong>Divide and conquer</strong>- General method,</td>
<td>Describe the Significance of Divide and Conquer Design method</td>
<td>1</td>
</tr>
<tr>
<td>8</td>
<td></td>
<td>applications - Binary search,</td>
<td>Apply the Concept of Divide and Conquer method to solve the real world problems.</td>
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<tr>
<td>9</td>
<td></td>
<td>Merge sort,</td>
<td></td>
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<tr>
<td>10</td>
<td></td>
<td>Quick sort,</td>
<td></td>
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<tr>
<td>11</td>
<td>3</td>
<td>Strassen’s Matrix Multiplication</td>
<td></td>
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<tr>
<td>12</td>
<td></td>
<td>BRIDGE CLASS -1</td>
<td>Assess the student skills.</td>
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</table>

**UNIT-II**

<table>
<thead>
<tr>
<th>Sl No</th>
<th>Week</th>
<th>Topic</th>
<th>Course Learning outcomes</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>13</td>
<td>4</td>
<td>Disjoint set operations,</td>
<td>Explain the basics of various mathematical concept of searching and</td>
<td>1</td>
</tr>
<tr>
<td>14</td>
<td></td>
<td>union and find algorithms,</td>
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<tr>
<td>15</td>
<td></td>
<td>AND/OR graphs,</td>
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<tr>
<td>16</td>
<td></td>
<td>Connected Components</td>
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<tr>
<td>17</td>
<td>traversing and Spanning trees,</td>
<td><strong>Understand</strong> the various searching techniques.</td>
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<tr>
<td>18</td>
<td>Bi-connected components</td>
<td><strong>Discuss</strong> the various connected components techniques.</td>
<td></td>
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<tr>
<td>19</td>
<td><strong>Backtracking</strong> - General method,</td>
<td><strong>Define</strong> the concept of Backtracking.</td>
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<tr>
<td>20</td>
<td>Applications - The 8-queen problem,</td>
<td><strong>Compute</strong> the real world problems by using Backtracking.</td>
<td></td>
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<tr>
<td>21</td>
<td>sum of subsets problem,</td>
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<tr>
<td>22</td>
<td>graph coloring.</td>
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<tr>
<td>23</td>
<td>Hamiltonian cycles</td>
<td></td>
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<tr>
<td>24</td>
<td>BRIDGE CLASS -2</td>
<td><strong>Assess</strong> the student skills.</td>
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</tbody>
</table>

**UNIT-III**

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<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>25</td>
<td><strong>Greedy method</strong> - General method,</td>
<td><strong>Describe</strong> the concept of Greedy method.</td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>applications - Knapsack problem,</td>
<td><strong>Apply</strong> the Concept of Greedy method to solve the real world problems.</td>
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<tr>
<td>27</td>
<td>Job sequencing with deadlines,</td>
<td></td>
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<tr>
<td>28</td>
<td>Mock Test-1</td>
<td></td>
<td><strong>1 st MID EXAMS</strong></td>
</tr>
<tr>
<td>29</td>
<td>Minimum cost spanning trees,</td>
<td></td>
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<tr>
<td>30</td>
<td>Single source shortest path problem.</td>
<td></td>
<td><strong>Assess</strong> the student skills.</td>
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<tr>
<td>31</td>
<td>BRIDGE CLASS-3</td>
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**UNIT-IV**

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<tbody>
<tr>
<td>37</td>
<td><strong>Dynamic Programming</strong> - General Method, applications - Chained matrix multiplication,</td>
<td><strong>Understand</strong> the Dynamic Programming techniques.</td>
<td></td>
</tr>
<tr>
<td>38</td>
<td>All pairs shortest path problem,</td>
<td><strong>Demonstrate</strong> the Dynamic programming techniques.</td>
<td></td>
</tr>
<tr>
<td>39</td>
<td>Optimal binary search trees,</td>
<td></td>
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<tr>
<td>40</td>
<td>0/1 knapsack problem,</td>
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<tr>
<td>41</td>
<td>Reliability design,</td>
<td></td>
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<tr>
<td>42</td>
<td>Traveling sales person problem.</td>
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<td>43</td>
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<td>44</td>
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</tbody>
</table>
## UNIT-V

| 45 | 12 | Branch and Bound- General Method, applications-0/1 Knapsack problem, LC Branch and Bound solution, FIFO Branch and Bound solution, Traveling sales person problem. | State the purpose of Branch and Bound |
| 46 | 13 | NP-Hard and NP-Complete problems- Basic concepts, Non-deterministic algorithms, NP - Hard and NP- Complete classes, Cook’s theorem | Solve the real world problems by using Branch and Bound. Distinguish the concept of NP-Hard and NP-Complete Problems. Discuss the concept of Non-deterministic algorithms Distinguish the concept of NP-Hard and NP-Complete Problems. |
| 48 | 14 | BRIDGE CLASS-4 | Assess the student skills. |
| 53 | 14 | REVISION | Revise the concepts of all units |
| 55 | 14 | PREVIOUS PAPER DISCUSSION | Discuss the questions from previous year question papers |

### IX. MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES:

<table>
<thead>
<tr>
<th>COs / POs</th>
<th>Program Outcomes</th>
<th>Program Specific Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO1</td>
<td>PO1 PO2 PO3 PO4 PO5 PO6 PO7 PO8 PO9 PO10 PO11 PO12</td>
<td>PSO1 PSO2 PSO3</td>
</tr>
<tr>
<td>3 3 3 3 3</td>
<td>- - - - - - - - - -</td>
<td>3 3 3</td>
</tr>
<tr>
<td>CO2</td>
<td>PO1 PO2 PO3 PO4 PO5 PO6 PO7 PO8 PO9 PO10 PO11 PO12</td>
<td>PSO1 PSO2 PSO3</td>
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<td>3 3 2 3 3</td>
<td>- - - - - - - - - -</td>
<td>2 3 3</td>
</tr>
<tr>
<td>CO3</td>
<td>PO1 PO2 PO3 PO4 PO5 PO6 PO7 PO8 PO9 PO10 PO11 PO12</td>
<td>PSO1 PSO2 PSO3</td>
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<td>3 3 2 2 2</td>
<td>- - - - - - - - - -</td>
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### X. QUESTION BANK: (JNTUH)

<table>
<thead>
<tr>
<th>No</th>
<th>Question</th>
<th>Blooms Taxon</th>
<th>Program Outc</th>
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</thead>
</table>

| | | | |
UNIT – I

PART – A (SHORT ANSWER QUESTIONS)
1. Define the term algorithm and state the criteria the algorithm should satisfy.
   Knowledge
2. Compute the average case time complexity of quick sort.
   Apply
3. Describe the role of space complexity and time complexity of a program.
   Knowledge
4. If \( f(n) = 5n^2 + 6n + 4 \), then prove that \( f(n) \) is \( O(n^2) \).
   Apply
5. What is meant by divide and conquer? Give the recurrence relation for divide and conquer.
   Understand

PART – B (LONG ANSWER QUESTIONS)
1. Write binary search algorithm and analyze its time complexity.
   Understand
2. Explain quick sort algorithm and simulate it for the following data 20, 5, 10, 16, 54, 21.
   Apply
3. Illustrate merge sort algorithm and discuss time complexity.
   Understand
4. Describe strassen’s matrix multiplication.
   Understand
5. Sort the list of numbers using merge sort: 78, 32, 42, 62, 98, 12, 34, 83.
   Apply

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<table>
<thead>
<tr>
<th>S. No</th>
<th>Question</th>
<th>Blooms Taxonomy Level</th>
<th>Program Outcome</th>
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</table>

UNIT – II

PART – A (SHORT ANSWER QUESTIONS)
1. Discuss about union operation on sets.
   Knowledge
2. Describe AND/OR graph.
   Understand
3. Explain game tree.
   Understand
4. Define a connected and bi-connected component.
   Knowledge
5. Define an articulation point?
   Knowledge

PART – B (LONGANSWER QUESTIONS)
1. Discuss various tree traversal techniques with examples.
   Understand
2. Discuss about weighting rule for finding UNION of sets and collapsing rule.
   Understand
3. Differentiate divide and conquer and greedy method.
   Understand
4. Discuss game trees.
   Understand
5. Compare and contrast BFS and DFS.
   Analyze

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<table>
<thead>
<tr>
<th>S. No</th>
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<th>Program Outcome</th>
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UNIT – III

PART – A (SHORT ANSWER QUESTIONS)
1. Define greedy method.
   Knowledge
2. State Prim’s algorithm.
   Knowledge
### UNIT – IV

<table>
<thead>
<tr>
<th>No</th>
<th>Question</th>
<th>Blooms Taxonomy Level</th>
<th>Program Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Write an algorithm for optimal binary search tree Give example</td>
<td>Apply</td>
<td>8</td>
</tr>
<tr>
<td>2</td>
<td>Explain 0/1 knapsack problem with example</td>
<td>Understand</td>
<td>8</td>
</tr>
<tr>
<td>3</td>
<td>Discuss all pairs shortest path problem with an example</td>
<td>Understand</td>
<td>8</td>
</tr>
<tr>
<td>4</td>
<td>Explain 8 – Queens problem</td>
<td>Understand</td>
<td>10</td>
</tr>
<tr>
<td>5</td>
<td>Define Sum of Subsets problem</td>
<td>Understand</td>
<td>10</td>
</tr>
</tbody>
</table>

### PART – B (LONGANSWER QUESTIONS)

<table>
<thead>
<tr>
<th>No</th>
<th>Question</th>
<th>Blooms Taxonomy Level</th>
<th>Program Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Describe the travelling salesman problem and discuss how to solve it using dynamic programming?</td>
<td>Understand</td>
<td>9</td>
</tr>
<tr>
<td>2</td>
<td>Explain the concept Chained matrix multiplication.</td>
<td>Apply</td>
<td>8</td>
</tr>
<tr>
<td>3</td>
<td>Solve the solution for 0/1 knapsack problem using dynamic programming(p1,p2,p3, p4) = (11, 21, 31, 33), (w1, w2, w3, w4) = (2, 11, 22, 15), M=40, n=4</td>
<td>Apply</td>
<td>8</td>
</tr>
<tr>
<td>4</td>
<td>Use optimal binary search tree algorithm and compute wij, cij, rij, 0&lt;=i&lt;=j&lt;=n, p1=1/10, p2=1/5, p3=1/10, p4=1/120, q0=1/5, q1=1/10, q2=1/5, q3=1/20, q4=1/20.</td>
<td>Apply</td>
<td>8</td>
</tr>
<tr>
<td>5</td>
<td>Discuss all pairs shortest path problem with an example</td>
<td>Understand</td>
<td>8</td>
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### UNIT – V

<table>
<thead>
<tr>
<th>No</th>
<th>Question</th>
<th>Blooms Taxonomy Level</th>
<th>Program Outcome</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Define a dead node</td>
<td>Knowledge</td>
<td>10</td>
</tr>
<tr>
<td>2</td>
<td>Differentiate live node and dead node</td>
<td>Knowledge</td>
<td>10</td>
</tr>
<tr>
<td>3</td>
<td>Compare NP-hard and NP-completeness</td>
<td>Knowledge</td>
<td>10</td>
</tr>
<tr>
<td>4</td>
<td>Define deterministic problem</td>
<td>Understand</td>
<td>12</td>
</tr>
<tr>
<td>5</td>
<td>Define maxclique problem?</td>
<td>Understand</td>
<td>12</td>
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</table>
### PART – B (LONGANSWER QUESTIONS)

<table>
<thead>
<tr>
<th></th>
<th>Explain the principle of FIFO branch and bound</th>
<th>Apply</th>
<th>11</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Explain the method of reduction to solve travelling salesman problem using branch and bound</td>
<td>Apply</td>
<td>11</td>
</tr>
<tr>
<td>3</td>
<td>Write non deterministic algorithm for sorting and searching</td>
<td>Apply</td>
<td>11</td>
</tr>
<tr>
<td>5</td>
<td>What is chromatic number decision problem and clique decision problem</td>
<td>Apply</td>
<td>12</td>
</tr>
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### XI. OBJECTIVE QUESTIONS: JNTUH

**UNIT-I**

1. In analysis of algorithm, approximate relationship between the size of the job and the amount of work required to do is expressed by using ________

   (a) Central tendency (b) Differential equation (c) Order of execution (d) Order of magnitude (e) Order of Storage.

   **Ans:** Order of execution

2. Worst case efficiency of binary search is

   (a) log2 n + 1 (b) n (c) N2 (d) 2n (e) log n.

   **Ans:** log2 n + 1

3. For analyzing an algorithm, which is better computing time?

   (a) O (100 Log N) (b) O (N) (c)O (2N) (d) O (N logN) (e) O (N2).

   **Ans:** O (100 Log N)

4. Consider the usual algorithm for determining whether a sequence of parentheses is balanced. What is the maximum number of parentheses that will appear on the stack AT ANY ONE TIME when the algorithm analyzes: (())(()())

   (a) 1 (b)2 (c)3 (d) 4

   **Ans:** 3

5. Breadth first search

   (a) Scans each incident node along with its children. (b) Scans all incident edges before moving to other node. (c) Issame as backtracking (d) Scans all the nodes in random order.

   **Ans:** Scans all incident edges before moving to other node

6. Which method of traversal does not use stack to hold nodes that are waiting to be processed?

   (a) Dept First (b) D-search (c)Breadth first (d) Back-tracking

   **Ans:** Breadth first

7. The Knapsack problem where the objective function is to minimize the profit is______

   (a) Greedy (b) Dynamic 0 / 1 (c) Back tracking (d) Branch & Bound 0/1

   **Ans:** Branch & Bound 0/1

8. Choose the correct answer for the following statements:

   I. The theory of NP–completeness provides a method of obtaining a polynomial time for NP algorithms.

   II. All NP-complete problem are NP-Hard.

   (a) I is FALSE and II is TRUE (b) I is TRUE and II is FALSE (c) Both are TRUE (d) Both are FALSE

   **Ans:** I is FALSE and II is TRUE

9. If all c(i, j )’s and r(i, j )’s are calculated, then OBST algorithm in worst case takes one of the following time.

   (a) O(n log n) (b) O(n3) (c) O(n2) (d) O(log n) (e) O(n4).

   **Ans:** O(n3)

10. The upper bound on the time complexity of the nondeterministic sorting algorithm is

    (a) O(n) (b) O(n log n) (c) O(1) (d) O( log n) (e) O(n2).

    **Ans:** O(n)
11. The worst case time complexity of the nondeterministic dynamic knapsack algorithm is (a) O(n log n) (b) O(log n) (c) O(n^2) (d) O(n) (e) O(1).
   Ans: O(n)

12. Recursive algorithms are based on (a) Divide and conquer approach (b) Top-down approach (c) Bottom-up approach (d) Hierarchical approach
   Ans: Bottom-up approach

13. What do you call the selected keys in the quick sort method? (a) Outer key (b) Inner Key (c) Partition key (d) Pivot key (e) Recombine key.
   Ans: (c) Partition key

14. How do you determine the cost of a spanning tree? (a) By the sum of the costs of the edges of the tree (b) By the sum of the costs of the edges and vertices of the tree (c) By the sum of the costs of the vertices of the tree (d) By the sum of the costs of the edges of the graph (e) By the sum of the costs of the edges and vertices of the graph.
   Ans: By the sum of the costs of the edges of the tree

15. The time complexity of the normal quick sort, randomized quick sort algorithms in the worst case is (a) O(n^2), O(n log n) (b) O(n^2), O(n^2) (c) O(n log n), O(n^2) (d) O(n log n), O(n log n) (e) O(n log n), O(n^2 log n).
   Ans: O(n^2), O(n^2)

16. Let there be an array of length ‘N’, and the selection sort algorithm is used to sort it, how many times a swap function is called to complete the execution? (a) N log N times (b) log N times (c) N^2 times (d) N-1 times (e) N times.
   Ans: N-1 times

17. The sorting method which is used for external sort is (a) Bubble sort (b) Quick sort (c) Merge sort (d) Radix sort (e) Selection sort.
   Ans: Radix sort

18. The graph colouring algorithm’s time can be bounded by _________ (a) O(mnm) (b) O(nm) (c) O(nm, 2n) (d) O(nmn).
   Ans: O(nmn).

19. Sorting is not possible by using which of the following methods? (a) Insertion (b) Selection (c) Deletion (d) Exchange
   Ans: Deletion

20. What is the type of the algorithm used in solving the 8 Queens problem? (a) Backtracking (b) Dynamic (c) Branch and Bound (d) DandC
   Ans: Backtracking

UNIT-II

1. Name the node which has been generated but none of its children nodes have been generated in state space tree of backtracking method.
   (a) Dead node (b) Live node (c) E-Node (d) State Node
   Ans: Live node

2. How many nodes are there in a full state space tree with n = 6?
   (a) 65 (b) 64 (c) 63 (d) 32
   Ans: 63

3. This algorithm scans the list by swapping the entries whenever pair of adjacent keys are out of desired order.
   (a) Insertion sort. (b) Bubble sort. (c) Shell sort. (d) Quick sort.
   Ans: Bubble sort.
5. From the following chose the one which belongs to the algorithm paradigm other than to which others from the following belongs to.
(a) Minimum & Maximum problem. (b) Knapsack problem. (c) Selection problem.(d) Merge sort.
Ans: Knapsack problem.

6. To calculate $c(i, j)$’s, $w(i, j)$’s and $r(i, j)$’s; the OBST algorithm in worst case takes the following time.
(a) $O(\log n)$  (b) $O(n^4)$  (c) $O(n^3)$  (d) $O(n \log n)$
Ans: $O(n^3)$

7. What is the type of the algorithm used in solving the 4 Queens problem?
(a) Greedy  (b) Dynamic  (c) Branch and Bound (d) Backtracking.
Ans: Backtracking.

8. In Knapsack problem, the best strategy to get the optimal solution, where $P_i, W_i$ is the Profit, Weight associated with each of the $X_i$ h object respectively is to
(a) Arrange the values $P_i/W_i$ in ascending order  (b) Arrange the values $P_i/X_i$ in ascending order
(c) Arrange the values $P_i/W_i$ in descending order  (d) Arrange the values $P_i/X_i$ in descending order
Ans: Arrange the values $P_i/X_i$ in descending order

9. Greedy job scheduling with deadlines algorithms’ complexity is defined as
(a) $O(N)$  (b) $\Omega(n \log n)$  (c) $O(n^2 \log n)$  (d) $O(n \log n)$
Ans: $O(N)$

12. From the following choose the one which belongs to the algorithm paradigm other than to which others from the following belongs to.
(a) Minimum & Maximum problem  (b) Knapsack problem (c) Selection problem  (d) Merge sort
Ans: Minimum & Maximum problem

14. Identify the name of the sorting in which time is not proportional to $n^2$.
(a) Selection sort  (b) Bubble sort  (c) Quicksort  (d) Insertion sort.
Ans: Insertion sort

15. The optimal solution to a problem is a combination of optimal solutions to its subproblems. This is known as
(a) Principle of Duality  (b) Principle of Feasibility  (c) Principle of Optimality (d) Principle of Dynamicity.
Ans: Principle of Optimality

16. Which of the following versions of merge sort algorithm does uses space efficiently?
(a) Contiguous version  (b) Array version  (c) Linked version (d) Structure version  (e) Heap version.
Ans: Linked version

17. Identify the correct problem for multistage graph from the list given below.
(a) Resource allocation problem  (b) Traveling salesperson problem
(c) Producer consumer problem  (d) Barber’s problem
Ans: Resource allocation problem

18. How many edges are there in a Hamiltonian cycle if the edge cost is ‘c’ and the cost of cycle is ‘cn’
(a) $c$  (b) $cn$  (c) $n$  (d) $2c$
Ans: $n$

19. A problem $L$ is NP-complete iff $L$ is NP-hard and
(a) $L \cong NP$  (b) $L \alpha NP$  (c) $L \in NP$ (d) $L = NP$
Ans: $L \in NP$
20. What would be the cost value for any answering node of a sub tree with root ‘r’ using branch-bound algorithm?
(a) Maximum (b) Minimum (c) Optimal (d) Average
Ans: Minimum

UNIT-III

1. From the following pick the one which does not belongs to the same paradigm to which others belongs to.
(a) Minimum & Maximum problem (b) Knapsack problem
(c) Selection problem (d) Merge sort
Ans: Knapsack problem

2. Prim’s algorithm is based on ___________ method
a. Divide and conquer method c. Dynamic programming
b. Greedy method d. Branch and bound
Ans. Greedy Method

3. The amount of memory needs to run to completion is known as __________
(a) Space complexity c. Worst case
(b) Time complexity d. Best case
Ans: Space complexity

4. The amount of time needs to run to completion is known as __________
(a) Space complexity c. Worst case
(b) Time complexity d. Best case
Ans: Time complexity

5. __________ is the minimum number of steps that can executed for the given parameters
(a) Average case c. Worst case
(b) Time complexity d. Best case
Ans: Best case

6. __________ is the maximum number of steps that can executed for the given parameters
(a) Average case c. Worst case
(b) Time complexity d. Best case
Ans: Worst case

7. __________ is the average number of steps that can executed for the given parameters
(a) Average case c. Worst case
(b) Time complexity d. Best case
Ans: Average Case

8. Testing of a program consists of 2 phases which are ________________ and ________________
(a) Average case & Worst case b. Time complexity & Space complexity
c. Validation and checking errors d. Debugging and profiling
Ans: Debugging and profiling

9. Worst case time complexity of binary search is ____________
a. O(n) b. O(logn)c. \( \Theta(n\log n) \) d. \( \Theta(\log n) \)
Ans: \( \Theta(\log n) \)

10. Best case time complexity of binary search is ____________
a. O(n) c. \( \Theta(n\log n) \)
b. O(logn) d. \( \Theta(\log n) \)
Ans: \( \Theta(\log n) \)

11. Average case time complexity of binary search is ______________
a. O(n) c. \( \Theta(n\log n) \)
b. O(logn) d. \( \Theta(\log n) \)
Ans: \( \Theta(\log n) \)
12. Merge sort invented by _____________
a. CARHOARE c. HAMILTON
b. JOHN VON NEUMANN d. STRASSEN
Ans : JOHN VON NEUMANN
13. Quick sort invented by _____________
a. CARHOARE c. HAMILTON
b. JOHN VON NEUMANN d. STRASSEN
Ans : CARHOARE
14. Worst case time complexity of Quick sort is _____________
a. O(n2log7) c. O(nlogn)
b. O(n2) d. O(logn)
Ans : O(n2)
15. Best case time complexity of Quick sort is _____________
a. O(n2logn) c. O(nlogn)
b. O(logn) d. O(logn2)
Ans : O(nlogn)
16. Average case time complexity of Quick sort is _____________
a. Θ (nlogn) b. O(logn)c. O(nlogn) d. Θ(logn)
Ans : O(nlogn)
17. Which design strategy stops the execution when it finds the solution otherwise starts the problem from top
a. Back tracking c. Divide and conquer
b. Branch and Bound d. Dynamic programming
Ans: Back Tracking
18. Graphical representation of algorithm is ________________
a. Pseudo-code c. Graph Coloring
b. Flow Chart d. Dynamic programming
Ans: Flow Chart
19. In pseudo-code conventions input express as __________
a. input c. Read
b. Write d. Return
Ans : Write
20. In pseudo-code conventions output express as __________
a. input c. Read
b. Write d. Return
Ans : Read
UNIT-IV
1. Tight bound is denoted as _______
a. Ω c. Θ
b. Ω d. O
Ans : Θ
2. Upper bound is denoted as _______
a. Ω c. Θ
b. ω d. O
Ans : Θ
3. lower bound is denoted as _______
a. Ω c. Θ
b. ω d. O
Ans : Ω
4. The function f(n)=o(g(n)) if and only if Limit f(n)/g(n)=0n->∞
a. Little oh b. Little omega
b. Big oh d. Omega
\textbf{Ans : Little oh}

5. The function \( f(n) = o(g(n)) \) if and only if \( \text{Limit } g(n)/f(n) = 0 \) \( n \rightarrow \infty \)
a. Little oh b. Little omega
b. Big oh d. Omega
\textbf{Ans : Little omega}

6. The general criteria of algorithm; zero or more quantities are externally supplied is______
a. Output b. Finiteness
b. Effectiveness d. Input
\textbf{Ans : Input}

7. The general criteria of algorithm; at least one quantity is produced ______
a. Output b. Finiteness
b. Effectiveness d. Input
\textbf{Ans : Output}

8. The general criteria of algorithm; Each instruction is clear and unambiguous ______
a. Output b. Definiteness
b. Effectiveness d. Input
\textbf{Ans : Definiteness}

9. The general criteria of algorithm; algorithm must terminates after a finite number of steps ______
a. Output b. Finiteness
b. Effectiveness d. Input
\textbf{Ans : Finiteness}

10. Which is not a criteria of algorithm
a. Input b. Output
b. Time complexity d. Best case
\textbf{Ans : Best case}

11. Which is not in general criteria of algorithm
a. Input b. Output
b. Time complexity d. Effectiveness
\textbf{Ans : Time complexity}

12. Time complexity of given algorithm
Algorithm Display(A)
\{ 
S:=0.0;
For i:=0 to n-1
\{ 
S:=S+A[i];
Return S;
\}
\}
a. 4n+4 c. 4n2+4
b. 2n2+2n+2 d. 4n+4
\textbf{Ans : 4n+4}

13. Time complexity of given algorithm
Algorithm Sum(A, S)
\{ 
for i:=1 to n-1
\{ 
for j:=2 to n-1
\{ 
S := S + i + j;
return S;
\}
a. 6n^2 - 14n + 4  
c. 4n^2 + 6n + 12  
b. 6n^2 + 14n + 10  
d. 6n^2 - 14n + 10 
Ans : 6n^2 - 14n + 10
14. Kruskal algorithm is based on ___________ method
a. Divide and conquer method  
b. Greedy method  
c. Dynamic programming  
d. Branch and bound  
Ans. Greedy method
15. Prims algorithm is based on ___________ method
a. Divide and conquer method  
b. Greedy method  
c. Dynamic programming  
d. Branch and bound  
Ans. Greedy Method
16. The output of Kruskal and Prims algorithm is ______________
   a. Maximum spanning tree  
b. Minimum spanning tree  
c. Spanning tree  
d. None of these  
UNIT-V
1. Job sequencing with deadline is based on __________ method
   a. greedy method  
b. dynamic programming  
c. branch and bound  
d. divide and conquer  
Ans. Greedy method
2. Fractional knapsack is based on __________ method
   a. greedy method  
b. dynamic programming  
c. branch and bound  
d. divide and conquer  
Ans. Greedy method
3. 0/1 knapsack is based on __________ method
   a. greedy method  
b. dynamic programming  
c. branch and bound  
d. divide and conquer  
Ans. Dynamic programming
4. The files x1, x2, x3 are 3 files of length 30, 20, 10 records each. What is the optimal merge pattern value?
   a. 110  
b. 90  
c. 60  
d. 50  
Ans. 90
5. The optimal merge pattern is based on __________ method
   a. Greedy method  
b. Dynamic programming  
c. Knapsack method  
d. Branch and bound  
Ans. Greedy method
6. Who invented the word Algorithm
   a. Abu Ja’far Mohammed ibn Musa  
b. Abu Jafar Mohammed Kasim  
c. Abu Mohammed Khan  
d. Abu Ja’far Mohammed Ali Khan  
Ans. Abu Ja’far Mohammed ibn Musa
7. In Algorithm comments begin with___________
   a. /*  
b. */  
c. /  
d. //  
Ans : //
8. The _________ of an algorithm is the amount of memory it needs to run to completion.
a. Space Complexity c. Best Case  
b. Time Complexity d. Worst Case  
**Ans : Space Complexity**

9. _________ is the process of executing a correct program on data sets and measuring the time and space it takes to compute the results.
a. Debugging c. Combining  
b. Profiling d. Conqure  
**Ans : Profiling**

10. In Algorithm Specification the blocks are indicated with matching _______.
a. Braces c. Square Brackets  
b. Parenthesis d. Slashes  
**Ans : Braces**

11. Huffman codes are the applications of _______ with minimal weighted external path length obtained by an optimal set.
a. BST b. MST  
c. Binary tree d. Weighted Graph  
**Ans : Binary tree**

12. From the following which is not return optimal solution?
a. Dynamic programming c. Backtracking  
b. Branch and bound d. Greedy method  
**Ans : Backtracking**

13. _________ is an algorithm design method that can be used when the solution to a problem can be viewed as the result of a sequence of decisions.
a. Dynamic programming c. Backtracking  
b. Branch and bound d. Greedy method  
**Ans : Dynamic programming**

14. The name backtrack was first coined by _______.
a. D.H.Lehmer c. L.Baumert  
b. R.J.Walker d. S. Golomb  
**Ans : D.H.Lehmer**

15. The term ________ refers to all state space search methods in which all children of the –  
nodes are generated before any other live node can become the E-node.
a. Backtracking c. Depth First Search  
b. Branch and Bound d. Breadth First Search  
**Ans : Branch and Bound**

16. A _________ is a round trip path along n edges of G that visits every vertex once and returns to its starting position.
a. MST c. TSP  
b. Multistage Graph d. Hamiltonian Cycle  
**Ans : Hamiltonian Cycle**

17. Graph Coloring is which type of algorithm design strategy?
a. Backtracking c. Greedy  
b. Branch and Bound d. Dynamic programming  
**Ans : Backtracking**

18. Which of the following is not a limitation of binary search algorithm?  
a. must use a sorted array  
b. requirement of sorted array is expensive when a lot of insertion and deletions are needed
c. there must be a mechanism to access middle element directly

19. Binary Search Algorithm cannot be applied to
a. Sorted linked list c. Sorted linear array
b. Sorted binary tree d. Pointer array

Ans: Sorted linked list

20. Two main measures for the efficiency of an algorithm are
a. Processor and memory c. Time and space
b. Complexity and capacity d. Data and space

Ans: Time and Space

XII. GATE QUESTIONS:

1. The order of an internal node in a B+ tree index is the maximum number of children it can have. Suppose that a child pointer takes 6 bytes, the search field value takes 14 bytes, and the block size is 512 bytes. What is the order of the internal node?
   A) 24 B) 25 C) 26 D) 27
   Answer: (C)

2. The best data structure to check whether an arithmetic expression has balanced parentheses is a
   A) queue B) stack C) tree D) list
   Answer: (B)

3. A Priority-Queue is implemented as a Max-Heap. Initially, it has 5 elements. The level-order traversal of the heap is given below: 10, 8, 5, 3, 2 Two new elements 1 and 7 are inserted in the heap in that order. The level-order traversal of the heap after the insertion of the elements is
   A) 10, 8, 7, 5, 3, 2, 1 B) 10, 8, 7, 2, 3, 1, 5 C) 10, 8, 7, 1, 2, 3, 5 D) 10, 8, 7, 3, 2, 1, 5
   Answer: (D)

4. The following numbers are inserted into an empty binary search tree in the given order: 10, 1, 3, 5, 15, 12, 16. What is the height of the binary search tree (the height is the maximum distance of a leaf node from the root)?
   A) 2 B) 3 C) 4 D) 6
   Answer: (B)

5. The goal of structured programming is to
   A) have well indented programs B) be able to infer the flow of control from the compiled code C) be able to infer the flow of control from the program text D) avoid the use of GOTO statements
   Answer: (C)

6. The tightest lower bound on the number of comparisons, in the worst case, for comparison-based sorting is of the order of
   A) n B) n^2 C) n log n D) n log^2 n
   Answer: (B)

7. Let G be a simple graph with 20 vertices and 100 edges. The size of the minimum vertex cover of G is 8. Then, the size of the maximum independent set of G is
   A) 12 B) 8 C) Less than 8 D) More than 12
   Answer: (A)

8. Let A be a sequence of 8 distinct integers sorted in ascending order. How many distinct pairs of sequences, B and C are there such that (i) each is sorted in ascending order, (ii) B has 5 and C has 3 elements, and (iii) the result of merging B and C gives A?
A) 2 B) 30 C) 56 D) 256
Answer : (D)

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A) 10,8,7,5,3,2,1 B) 10,8,7,2,3,1,5 C) 10,8,7,1,2,3,5 D) 10,8,7,3,2,1,5
Answer : (D)

10 The S-N curve for steel becomes asymptotic nearly at
A) 103 cycles B) 104 cycles C) 106 cycles D) 109 cycles
Answer : (C)

XIII. WEBSITES:
- http://www.algorithmist.com/index.php/Main_Page-it contains dynamic programming, greedy, Graph Theory, sorting, Data Structures

XIV. EXPERT DETAILS:
Professor Sartaj Kumar Sahni is an Indian computer scientist, now based in the USA, and is one of the pioneers in the field of data structures. He is a distinguished professor in the Department of Computer and Information Science and Engineering at the University of Florida.
http://www.cise.ufl.edu/~sahni/

XV. JOURNALS:
1. Journal of Graph Algorithms and Applications
url:http://www.emis.de/journals/JGAA/home.html
2. Algorithmica --A journal about the design of algorithms in many applied and fundamental areas http://www.springerlink.com

XVI. LIST OF TOPICS FOR STUDENT SEMINARS:
- Randomized Algorithms, Binary search, Connected components and spanning Trees
- Hamiltonian cycles, Single source shortest path problem, Non-deterministic algorithms

XVII. CASE STUDIES / SMALL PROJECTS:
Six different implementations of a greedy dominating set algorithm are presented and analyzed. The implementations and analysis illustrate many of the important techniques in the design and analysis of algorithms, as well as some interesting graph theory.

2. Scheduling Two Salesmen in a Network.
The two-server problem is concerned with the movement of two servers to request points in a metric space. We consider an offline version of the problem in a graph in which the requests may be served in any order. A family of approximations algorithms is developed for this NP-complete problem.