University of Colombo School of Computing
SCS 1304 - Problem Solving Strategies and Computation Approaches
Lab Sheet 12

A. Find possible Hamiltonian circuits from the given graphs A, B, and C using the backtracking technique. Explore the state-space tree, show all step-by-step solutions.

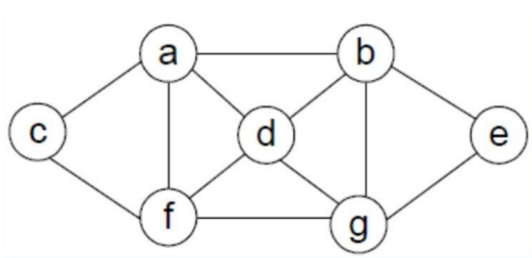


Figure A

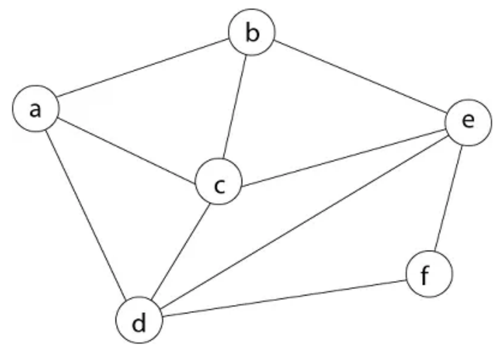


Figure B

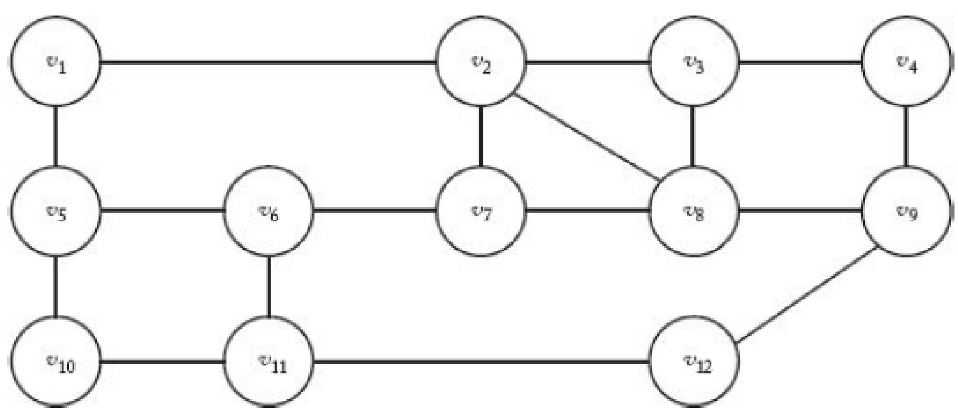
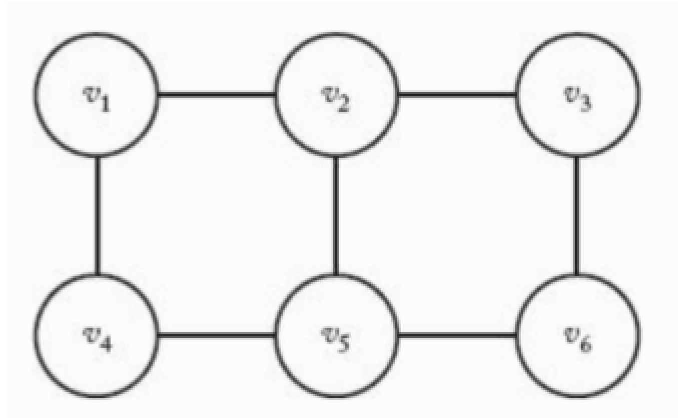


Figure C

B. Use the Backtracking algorithm for the m-Coloring problem to find possible colorings of the graph below using the three colors red, green, and blue. Show the actions (by using state space trees) step by step.

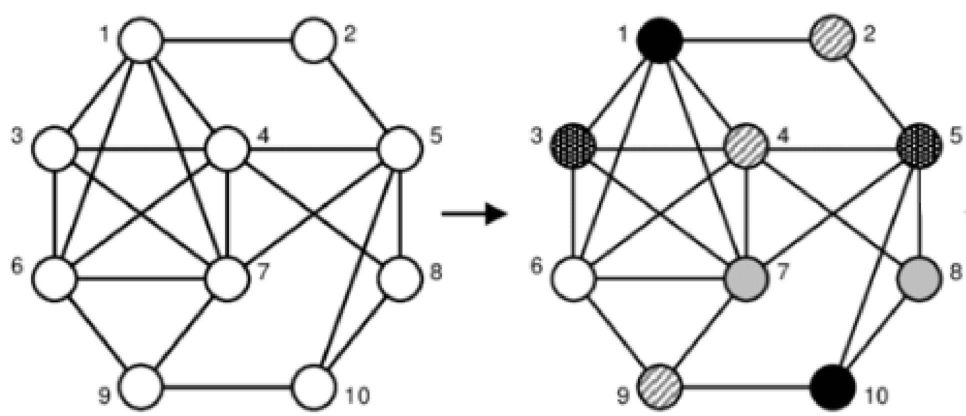


C. **An event management team** needs to schedule 10 different events such that no two events with overlapping participants occur at the same time. This problem can be represented as a **graph coloring problem**, where each event is represented by a vertex, and an edge exists between two vertices if the corresponding events cannot occur in the same timeslot.

The figure below shows:

1. The graph representation of the problem (10 vertices).

2. A valid coloring solution using 5 different colors.



Questions

I. Fill the optimised events timetable based on the graph under the suitable slots. The sample format is given.

SLOT 01	SLOT 02	SLOT 03	SLOT 04	SLOT 05

II. Explain how the timetabling problem is mapped to the graph coloring problem.

III. From the provided solution, identify the minimum number of timeslots required and justify why fewer timeslots are not possible.

IV. Explain how the solution guarantees that no conflicting events are scheduled in the same timeslot.

D. A tournament organizer is planning to place cameras on a 4x4 chessboard to monitor the games. Each camera behaves like a **queen** in chess – it can monitor horizontally, vertically, and diagonally. The organizer wants to place exactly 4 cameras so that every camera is safe. Now consider the following **partially completed 4x4 setup**:

- ➔ Queen is already fixed at **(0,1)** (row 0, column 1), (row, column indices 0....3)
- ➔ The organizer claims that this setup **always leads to a valid solution without backtracking**.

I. Draw the state space tree starting with Q1 at (0,1). Show where the algorithm attempts to place Q2, Q3, and Q4.

II. Does fixing Q1 at (0,1) guarantee a valid complete solution? Justify your answer with either a valid final placement or a proof of contradiction.

III. If the placement fails, explain **where backtracking becomes unavoidable**, and propose an alternative position for Q1 that could reduce unnecessary backtracking.

Quiz

1. **Which of the following best describes backtracking?**

   a) A method to optimize minimum or maximum results

   b) A form of exhaustive search using recursion

   c) A greedy algorithm for shortest paths

   d) A divide and conquer method

2. **Backtracking is mainly used when:**

   a) Only one optimal solution exists

   b) We want to find the shortest path only

   c) Multiple solutions exist and we may need all of them

   d) The problem must be solved iteratively

3. **Which data structure approach is commonly used in backtracking?**

   a) Breadth-First Search (BFS)

   b) Depth-First Search (DFS)

   c) Dynamic arrays

   d) Binary heaps

4. **Which of the following is a classic example of backtracking?**

   a) Dijkstra’s shortest path

   b) Rat in a Maze problem

   c) Kruskal’s MST

   d) Binary search

5. **In backtracking, a state space tree represents:**

a) Only the final solutions

b) All possible states including partial and invalid solutions

c) Only the optimal path

d) A queue of choices

6. **What is the key distinguishing feature of backtracking compared to simple recursion?**

a) It avoids recursion completely

b) It uses greedy selection of choices

c) It explicitly undoes choices when paths fail

d) It checks only the optimal solution

7. **Which of these problems is commonly solved using backtracking?**

a) Minimum Spanning Tree

b) N-Queens Problem

c) Binary Search

d) Bellman-Ford Algorithm

8. **What is the time complexity of solving the N-Queens problem using backtracking?**

a) O(N log N)

b) $O(N^2)$

c) O(N!)

d) O(2^N)

9. **In the 4-Queens problem, if a queen cannot be placed safely in the current row, what happens?**

a) The algorithm stops immediately
b) The queen is placed in the same cell again
c) The algorithm backtracks and tries another row/column
d) The board is reset completely

10. **Which of the following is NOT an application of backtracking?**

a) Sudoku solving
b) Crossword puzzle generation
c) Dijkstra's shortest path algorithm
d) Knight's Tour problem

11. **In Sudoku solving using backtracking, what happens when a number violates Sudoku rules?**

a) The algorithm ignores the violation
b) The number is permanently fixed
c) The algorithm backtracks and tries another number
d) The algorithm stops immediately

12. **Which of these is a limitation of backtracking?**

a) Combinatorial explosion in large problems
b) It always guarantees convergence
c) It avoids recursion
d) It is limited to graph problems only

13. **Which optimization technique reduces unnecessary exploration in backtracking?**

a) Divide and conquer
b) Memoization and pruning
c) Dynamic arrays
d) Greedy heuristics

14. **You are designing a timetabling system where no two exams with overlapping students can be scheduled at the same time. Which backtracking problem does this resemble?**

a) Rat in a Maze
b) Graph Coloring Problem
c) Hamiltonian Cycle
d) N-Queens Problem

15. **A knight must visit every square of a chessboard exactly once. Which backtracking problem is this?**

a) N-Queens
b) Knight's Tour
c) Hamiltonian Path
d) Sudoku

16. **Which of the following is a Hamiltonian cycle?**

a) A path that covers all edges exactly once
b) A path that covers all vertices exactly once and returns to start
c) A path that minimizes the cost of traversal
d) A path with only two vertices

17. The Hamiltonian cycle problem is considered:

a) A polynomial-time solvable problem

b) Both a decision and optimization problem

c) Only an optimization problem

d) Only a greedy problem

18. Which of the following is NOT an advantage of backtracking?

a) Completeness

b) Adaptability

c) Always polynomial time complexity

d) Efficiency with strong constraints

19. Which real-world scenario best matches subset sum backtracking?

a) Choosing exam time slots

b) Selecting items from a shopping list to exactly match a budget

c) Routing data packets in a network

d) Finding minimum spanning trees

20. Why is backtracking suitable for solving puzzles like Sudoku or crosswords?

a) Because it can find only one solution efficiently

b) Because it ignores constraints to get fast results

c) Because it incrementally builds solutions and discards invalid ones

d) Because it works only on graphs