Topics:

1. Matrix multiplication
   (a) Lower bound
   (b) Analysis of the usual matrix multiplication algorithm
   (c) Strassen's Matrix Multiplication algorithm
   (d) Recurrence relation for Strassen's Algorithm
2. Graph representation
   (a) Definition of a graph
   (b) Properties: degree, size of a graph
   (c) Undirected and directed graphs
   (d) Representation using Adjacency list and Adjacency matrix
   (e) Types of graphs: sparse, complete, K_i, etc.
3. Undirected graphs
   (a) DFS using explore
   (b) postvisit and previsit numbers
   (c) Types of edges: Tree and back
   (d) Connected components
   (e) Using DFS to find connected components
   (f) Using DFS to determine if a graph is acyclic
4. Directed graphs
   (a) DFS pre and post visit number computation
   (b) Types of edges: back, tree, cross, and forward
   (c) Properties of pre and post visit numbers
5. Directed Acyclic Graphs (DAG)
   (a) Definition
   (b) Topological sorting (linearization)
   (c) Proof of correctness of linearization using type of edges and the properties of post visit numbers
   (d) Finding Source and sink vertices in a DAG
6. Strongly Connected components (SCC)
   (a) Definition of the "connected" relation
   (b) Definition of SCC as equivalence classes
   (c) Decomposing a digraph into a DAG of SCC
   (d) Proof using properties of post visit numbers, that explore can find a vertex in a sink SCC
   (e) Algorithm to find SCC on a digraph

7. Shortest paths on undirected graphs
    (a) The breadth first search algorithm (BFS)
    (b) Using BFS to find all shortest paths from one node
    (c) Proof that BFS correctly finds all shortest paths from a given node
    (d) Analysis of the BFS and DFS algorithms
8. Priority Queues
    (a) Min/Max binary Heap definition and properties
    (b) Operations on Heaps and analysis
    (c) Heapsort and analysis
9. Shortest paths
    (a) Weighted graph representation
    (b) Dijkstra's shortest paths algorithm
    (c) Correctness of Dijkstra's algorithm
    (d) Binary heap (min-heap) implementation
    (e) Worst case analysis of Dijkstra's algorithm
    (f) Dijkstra's in the case of negative weight edges
    (g) All pairs shortest paths (Bellman-Ford)
    (h) Negative cycle detection
10. Disjoint sets
    (a) Union-find problem
    (b) Union by rank
    (c) Find using path compression
    (d) Analysis of union-find (without path compression)
    (e) Complexity of union-find with path compression
11. Greedy algorithms
    (a) Definition of the greedy approach
    (b) Definition of a MST
    (c) Definition and properties of a cut
    (d) Kruskal's MST algorithm
    (e) Prim's MST algorithm and its difference with respect to Kruskal's algorithm
    (f) Correctness of Prim's and Dijkstra's algorithms
    (g) Analysis of both MST algorithms