Assignment 1: Take-Home "Production & Optimization" Sprint

Format: Digital/Coding | **Submission:** GitHub Repository |

These problems are curated from real technical assessments at top global tech firms. They require not just solving the logic but ensuring high performance.

Create your own GitHub repository and check in your code. Explore not only the actual solutions but the approach to solving these problems and the underlying concepts.

1. **The "Global Autocomplete" System (Tries)**
   - **Problem:** Build a Trie-based system that stores 1 million strings. Implement a function that returns the top 5 most frequent suggestions for a given prefix.
   - **Complexity Requirement:** The prefix search must be $O(L)$, where L is the length of the prefix, regardless of the dictionary size.
2. **The "Streaming Max" Analytics (Deques/Monotonic Queue)**
   - **Problem:** You are receiving a stream of server latency data. Given a window size K, calculate the maximum latency in every window.
   - **Complexity Requirement:** You must process each incoming data point in amortized $O(1)$ time.
3. **The "Dynamic Network Vulnerability" (Tarjan's/Graphs)**
   - **Problem:** Given a communication network represented as an undirected graph, identify all "Critical Links" (Bridges). A link is critical if its removal disconnects the network.
   - **Complexity Requirement:** Solve in $O(V + E)$ using a single DFS pass.
4. **The "Range Performance Monitor" (Segment Trees)**
   - **Problem:** Design a system for a stock exchange that handles two operations: update(index, value) for a stock price and queryMax(L, R) to find the highest price in a time range.
   - **Complexity Requirement:** Both operations must be $O(\log N)$.
5. **The "Optimal Resource Allocation" (Bitmask DP)**
   - **Problem:** You have N tasks and N workers (where N < 20). Each worker has a specific cost for each task. Assign exactly one worker to each task such that the total cost is minimized.
   - **Complexity Requirement:** Improve upon the $O(N!)$ brute force to $O(2^N \cdot N^2)$ using state compression.