Example 1: Operating Systems – Page Replacement Algorithms

Problem Statement: You are given a reference string of page requests: `7, 0, 1, 2, 0, 3, 0, 4, 2, 3, 0, 3, 2`. Using **FIFO** and **LRU** page replacement algorithms, calculate the number of page faults for each, assuming 3 page frames.

Knowledge Pills:
• What is a page fault?
• FIFO (First-In First-Out) Algorithm
• LRU (Least Recently Used) Algorithm
• How to count page faults
• Difference between FIFO and LRU in behavior

Evaluation Criteria (Max 10 each):
✓ Correct identification and explanation of FIFO and LRU concepts
✓ Accurate simulation of both algorithms for the given reference string
✓ Correct counting and comparison of page faults
✓ Clarity of working steps and tabulation (if any)
✓ Reflection on which algorithm performs better and why

Example 2: Java – Multithreading Synchronization

Problem Statement: Write a Java program that simulates a **Bank** with shared account balance. Two threads represent different ATM machines attempting to withdraw money simultaneously. Ensure that race conditions are avoided.

Knowledge Pills:
• Thread Concept in Java
• Race Condition
• Synchronized Block
• Withdraw Method Logic
• Why synchronization is necessary in shared environments

Evaluation Criteria (Max 10 each):
✓ Correct use of Java threads and syntax
✓ Implementation of synchronized method/block
✓ Accurate handling of shared balance and withdrawal logic
✓ Clear output showing thread-safe behavior
✓ Explanation of the problem solved by synchronization

Example 3: DBMS – Normalization

Problem Statement: Given the following unnormalized relation: `Student(Name, RollNo, Course, Instructor, InstructorEmail)` Assume that each student can enroll in multiple courses with different instructors. Normalize the relation up to **3NF** and explain the process.

Knowledge Pills:
• 1NF – First Normal Form
• 2NF – Second Normal Form
• 3NF – Third Normal Form
• Primary and Foreign Key Concepts
• Why normalization is important

Evaluation Criteria (Max 10 each):
✓ Correct identification of anomalies in unnormalized form
✓ Proper decomposition in 1NF with primary keys
✓ Accurate splitting in 2NF and justification
✓ Transformation into 3NF and schema design
✓ Clarity of explanation and rationale behind each step

Example 4: Data Structures – Binary Search Tree (BST) Traversal

Problem Statement: Given the following list of integers: `[50, 30, 70, 20, 40, 60, 80]`, 1. Construct a Binary Search Tree (BST). 2. Perform **in-order**, **pre-order**, and **post-order** traversals and list the output for each.

Knowledge Pills:
• Binary Search Tree Definition
• BST Insertion Logic
• Tree Traversals
• Why In-order gives sorted output for BST
• Use cases of different traversals

Evaluation Criteria (Max 10 each):
✓ Correct BST structure
✓ Accurate traversal outputs
✓ Clarity of code or approach used
✓ Understanding of traversal logic
✓ Explanation of traversal applications

Example 5: Web Development – RESTful API Design

Problem Statement: Design a REST API for a **Library Management System** with operations to: - Add a book - Borrow a book - Return a book - View all books Specify the **endpoints**, **HTTP methods**, and **response structure**. No need to implement.

Knowledge Pills:
• REST Architecture Basics
• Common HTTP Methods
• Resource Naming Best Practices
• Sample JSON Response Structure
• HTTP Status Codes

Evaluation Criteria (Max 10 each):
✓ Correct mapping of actions to HTTP methods
✓ Clear and RESTful endpoint design
✓ Well-structured sample response formats
✓ Use of standard HTTP status codes
✓ Explanation of stateless design

Example 6: AI/ML – Classification Metrics

Problem Statement: You have trained a binary classification model and obtained: - TP = 70, FP = 10, TN = 50, FN = 20 Calculate: 1. Accuracy 2. Precision 3. Recall 4. F1 Score Interpret each metric in the context of a medical diagnosis system.

Knowledge Pills:
• Confusion Matrix Terminology
• Accuracy Formula
• Precision & Recall
• F1 Score
• Why Accuracy isn’t enough in imbalanced datasets

Evaluation Criteria (Max 10 each):
✓ Correct application of formulas
✓ Interpretation of each metric
✓ Correct handling of FP/FN logic
✓ Relevance of metric for medical context
✓ Overall understanding of classification evaluation

Example 7: Cybersecurity – SQL Injection

Problem Statement: Explain how an attacker can exploit the following insecure login query: ```sql SELECT * FROM users WHERE username = '$username' AND password = '$password'; ``` Suggest and explain how to fix it using prepared statements.

Knowledge Pills:
• What is SQL Injection
• How concatenation-based SQL queries are vulnerable
• Typical payload example
• Prepared Statement (Parameterized Query)
• Best Practices to Prevent SQLi

Evaluation Criteria (Max 10 each):
✓ Identification of vulnerability
✓ Explanation of how injection works
✓ Sample injection payload
✓ Correct use of prepared statements
✓ Broader prevention strategies

Example 8: Compiler Design – First and Follow Sets

Problem Statement: Given the grammar below, compute the **FIRST** and **FOLLOW** sets for each non-terminal. ``` S → A B A → a A | ε B → b B | c ```

Knowledge Pills:
• FIRST Set
• FOLLOW Set
• Epsilon (ε) Handling in FIRST
• Rules for FOLLOW Computation
• Why FIRST and FOLLOW are important

Evaluation Criteria (Max 10 each):
✓ Accurate FIRST set for all non-terminals
✓ Accurate FOLLOW set computation
✓ Handling of epsilon in both sets
✓ Explanation of rules applied
✓ Clear formatting of sets and reasoning

Example 9: Computer Networks – IP Subnetting

Problem Statement: Your organization has been assigned the IP block `192.168.10.0/24`. You need to divide it into **4 equal subnets**. For each subnet, provide: - Subnet Address - Broadcast Address - First and Last Assignable IPs

Knowledge Pills:
• CIDR Notation
• Subnetting Basics
• Formulae for Subnet Calculations
• Subnet Mask Update
• Binary and Decimal Conversion of IPs

Evaluation Criteria (Max 10 each):
✓ Correct identification of subnet mask (/26)
✓ Accurate calculation of 4 subnets
✓ Correct first and last usable IPs
✓ Valid broadcast address derivation
✓ Clear tabular or structured presentation

Example 10: Software Engineering – Use Case Diagram

Problem Statement: Draw a **Use Case Diagram** for an **Online Food Ordering System** involving: - Customer (browse menu, place order, track order) - Admin (manage menu, update prices) - Delivery Agent (accept delivery, mark delivered) Explain the relationships (include actors, use cases, associations, etc.).

Knowledge Pills:
• What is a Use Case Diagram
• Actors
• Use Cases
• Relationships
• Purpose of Use Case Diagram

Evaluation Criteria (Max 10 each):
✓ Proper identification of actors and use cases
✓ Correct associations and relationships
✓ Use of includes/extents where applicable
✓ Visual clarity and correctness of diagram
✓ Explanation of components and choices