

**Question 1: Introduction ..... [120 points]**

- (a) [15 points] **Properties of a DBMS:**  
Provide brief definitions of these terms.
- Scalability
  - Reliability
  - Concurrency
- (b) [20 points] **Derived Data Structures:**  
Distinguish between a hash table and a tree derived data structure based on their:
- Ordering of keys
  - Average- and Worst-Case Time Complexity of Key Insertion operation
  - Average- and Worst-Case Time Complexity of Key Search operation
  - Average- and Worst-Case Space Complexity
  - Support for Range Scans
- (c) [10 points] **Merging Two Lists:**  
Given two lists L1 and L2, give an algorithm to find all entries that occur on both lists with  $O(n \lg n)$  complexity.
- (d) [10 points] **Merging Two Lists:**  
Given two sorted lists L1 and L2, what is the time complexity of the optimal algorithm to find all entries that occur on both lists.
- (e) [10 points] **Merging Two Lists:**  
Given two lists L1 and L2, give an algorithm to find all entries that occur on both lists when only one of the lists fits in memory.
- (f) [10 points] **Merging Two Lists:**  
Given two lists L1 and L2, give a partitioning-based algorithm to find all entries that occur on both lists when both lists do not fit in memory.
- (g) [15 points] **Big O notation:**  
List three limitations of time complexity analysis based on Big O notation in practice.
- (h) [10 points] **Hard Disk Drive:**  
Why is a hard disk drive (HDD) unable to support fast random I/O operations?
- (i) [10 points] **Solid State Disk:**  
Why is a solid state disk (SSD) able to support fast random I/O operations?
- (j) [10 points] **Disk- vs Memory-Centric DBMSs:**  
Why is the classical architecture suboptimal on modern hardware?