

Question 1: Memory Management [285 points]

- (i) [20 points] **Virtualization:**
Define virtual memory. List two benefits of memory virtualization.
- (ii) [10 points] **Memory Management Unit:**
List the input and output of a memory management unit.
- (iii) [10 points] **Memory Mapping:**
Define memory mapping. List two benefits of memory mapping.
- (iv) [10 points] **Stack vs Heap:**
Distinguish between stack and heap segments. List a limitation of each segment.
- (v) [10 points] **Memory Error Detection:**
How does valgrind memcheck work? List two types of memory errors that it can detect.
- (vi) [10 points] **Smart Pointer:**
Define a smart pointer in C++. List a benefit of using smart pointers.
- (vii) [10 points] **Dynamic Memory Management:**
Distinguish between `new` and `malloc`. How are they related to each other?
- (viii) [10 points] **Dynamic Memory Management:**
Distinguish between `memcpy` and `memmove`. How are they related to each other?
- (ix) [10 points] **Dynamic Memory Management:**
Distinguish between `unique_ptr` and `shared_ptr` in C++.
- (x) [10 points] **Dynamic Memory Management:**
Distinguish between `copy` and `move` semantics in C++. Which one is faster to execute? Justify your answer.
- (xi) [20 points] **Resource Acquisition Is Initialization:**
Define the Resource Acquisition Is Initialization principle. Illustrate this principle in case of: (1) file management and (2) memory management.
- (xii) [10 points] **Memory Mapping:**
Distinguish between `MAP_SHARED` and `MAP_PRIVATE`.
- (xiii) [20 points] **Malloc:**
How is `malloc` related to `mmap`?
- (xiv) [20 points] **Segment:**
Define a segment. Is it a linear or a non-linear? List two benefits of using segments.
- (xv) [10 points] **Disk Block Mapping:**
Distinguish between: (1) static file-mapping, (2) dynamic block-mapping, and (3) dynamic extent-mapping.
- (xvi) [15 points] **Disk Block Mapping:**
List the three levels of database space allocation. How are they related to each other?

- (xvii) **[10 points] Extent vs Segment:**
Distinguish between extent and segment.
- (xviii) **[10 points] Types of Segments:**
Distinguish between permanent and temporary segments. When are these segments created?
- (xix) **[10 points] Types of Segments:**
List two private segments.
- (xx) **[10 points] Types of Segments:**
What is stored in the free space inventory segment? Is it private or public?
- (xxi) **[10 points] Types of Segments:**
List two public segments.
- (xxii) **[10 points] Types of Segments:**
Each slotted page segment has two member variables: (1) schema segment and (2) free space inventory segment. Why?
- (xxiii) **[10 points] System Catalog:**
Define a system catalog. How is typically managed by a DBMS?
- (xxiv) **[10 points] System Catalog:**
Distinguish between data and meta-data. Illustrate the difference with an example.