Question 1: Buffer Management...........................[390 points]

(i) **[10 points] Buffer Management:**
Distinguish between disk management and buffer management.

(ii) **[10 points] Locality of Reference:**
Define locality of reference: (1) spatial and (2) temporal.

(iii) **[10 points] Buffer Manager:**
Define the input and output of a page table.

(iv) **[10 points] Buffer Manager:**
List the purpose of these meta-data: (1) dirty flage, and (2) reference counter.

(v) **[30 points] Locks vs Latches:**
List three differences between locks and latches.

(vi) **[10 points] Locks vs Latches:**
With latches, we do not need to be able to rollback changes. Why?

(vii) **[10 points] Page Table vs. Page Directory:**
Distinguish between page table and page directory.

(viii) **[10 points] Page Table vs. Page Directory:**
Distinguish between page table and page directory.

(ix) **[10 points] Buffer Manager Interface:**
List the two key functions supported by the buffer manager.

(x) **[10 points] Buffer Manager:**
What data structure is used to implement a page table inside the buffer manager?

(xi) **[10 points] Buffer Manager:**
What is the purpose of page-level latch?

(xii) **[10 points] Logging:**
What is the log sequence number (LSN) of a page?

(xiii) **[10 points] Logging:**
What is write-ahead logging (WAL)? Justify its name.

(xiv) **[30 points] Logging:**
To update a tuple in a table, list the three operations done in a DBMS that uses write-ahead logging. Why are these operations needed?

(xv) **[10 points] Multiple Buffer Pools:**
List a benefit and a limitation of maintaining multiple buffer pools.

(xvi) **[10 points] Pre-fetching:**
Explain pre-fetching in the context of sequential heap scan with an example.

(xvii) **[10 points] Pre-fetching:**
Explain pre-fetching in the context of index scan with an example.

(xviii) **[10 points] Scan Sharing:**
Define scan sharing. Does it require spatial locality or temporal locality or both?

(xix) **[10 points]　Buffer Pool Bypass:**
Define buffer pool bypass optimization. How is it related to scan-resistant buffer replacement policies?

(xx) **[10 points]　Direct I/O:**
Define direct I/O.

(xxi) **[10 points]　OS Page Cache:**
List two limitations of relying on the OS for moving data between memory and disk.

(xxii) **[10 points]　Background Writing:**
Define background writing optimization. How does the DBMS ensure the atomicity property?

(xxiii) **[10 points]　ACID:**
Define the ACID properties. Which two properties are guaranteed by the WAL protocol?

(xxiv) **[10 points]　Other Memory Pools:**
What is anonymous mapping? Distinguish it from file-backed mapping. What are the flags passed to mmap for these two types of memory mapping?

(xxv) **[10 points]　Buffer Replacement Policies:**
Define the buffer replacement problem. What is the optimal policy?

(xxvi) **[10 points]　Buffer Replacement Policies:**
What is a page fault? How does it vary with buffer size?

(xxvii) **[10 points]　Policy vs Mechanism:**
Distinguish between policy and mechanism with an example.

(xxviii) **[10 points]　FIFO:**
List a limitation of the FIFO policy.

(xxix) **[10 points]　LRU vs LFU:**
When does LRU outperform LFU? When does LFU outperform LRU?

(xxx) **[10 points]　CLOCK:**
Why does the CLOCK policy approximate LRU?

(xxxi) **[10 points]　Sequential Flooding:**
Define the sequential flooding problem.

(xxxii) **[10 points]　Sequential Flooding:**
Why is LRU-K resistant to the sequential flooding problem?

(xxxiii) **[10 points]　Sequential Flooding:**
Why is 2Q resistant to the sequential flooding problem?

(xxxiv) **[10 points]　2Q vs LRU-K:**
How is 2Q related to LRU-K?

(xxxv) **[10 points]　Priority Hints:**
Define priority hints. Illustrate with an example.