Buffer Pool Replacement Policies, Data Page Layouts Solution

1. "Numbers everyone should know" by Jeff Dean (Google)
   ● L1 cache reference 0.5 ns
   ● L2 cache reference 7 ns
   ● Main memory reference 100 ns
   ● Read 1 MB sequentially from memory 250,000 ns
   ● Disk seek 10,000,000 ns
   ● Read 1 MB sequentially from disk 30,000,000 ns

2. Why use a buffer pool?
Use a buffer pool to reduce disk IO and to share the same data in memory.

3. Why can't DBMS rely on the memory/file management of the OS?
DBMS can know the page access patterns, can pre-fetch pages, can use different replacement policies, should be able to force pages to disk. DBMS also assumes the buffer pools is ALWAYS in main memory.

4. What is sequential flooding? What are the ways to mitigate the problem?
Sequential flooding occurs when doing a sequential scan on a relation with #pages > #buffers. With LRU, each page read causes a page fault (once the pool is full). In the same situation, MRU has significantly fewer page faults.

5. Buffer Replacement Policies - 4 Buffer pages

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Access Pattern:        A    B    C    D    A    F    A    D    G    D    G    E    D    F
   ● LRU
     ○  1 :   | A |    |    |    |    |    |    |    |    |    |    |    | F |
     ○  2 :   |    | B |    |    | F |    |    |    |    | E |    |    |
     ○  3 :   |    |    | C |    |    |    |    | G |    |    |    |    |
     ○  4 :   |    |    |    | D |    |    |    |    |    |    |    |    |
     ○   hits: 6
     ○ misses: 8
   ● MRU
     ○  1 :   | A |    |    |    | F | A |    |    |    |    |    |    |
     ○  2 :   |    | B |    |    |    |    |    |    |    |    |    |    |
     ○  3 :   |    |    | C |    |    |    |    |    |    |    |    |    |
     ○  4 :   |    |    |    | D |    |    |    | G | D | G | E | D | F |
     ○   hits: 2
     ○ misses: 12
   ● CLOCK
     ○  1 :   | A |    |    |    | F |    |    |    |    |    | D |    |
     ○  2 :   |    | B |    |    |    | A |    |    |    |    |    | F |
     ○  3 :   |    |    | C |    |    |    |    | G |    |    |    |
     ○  4 :   |    |    |    | D |    |    |    |    |    | E |    |
     ○   hits: 4
     ○ misses: 10
   ● (Bonus) CLOCK (with a ref count max of 2)
     ○  1 :   | A |    |    |    |    |    |    |    |    | E |    |
     ○  2 :   |    | B |    |    | F |    |    |    |    |    |    |
     ○  3 :   |    |    | C |    |    |    | G |    |    |    |
     ○  4 :   |    |    |    | D |    |    |    |    |    |    |
     ○   hits: 7
     ○ misses: 7
```

6. Two alternative formats for variable lengths records
Fields delimited by a special symbol (which does not appear in the real data), or array of field offsets.