

1. [Unit 13] Given the following parameters of a hard drive:

- 6000 rpm
- Full-stroke seek time: 10 ms
- Interface transfer rate: 200 MB/s

Calculate the maximum IO latency of reading all data from a 100 MB file, whose DoF (Degree of Fragmentation) is 5. Notice that DoF of a file is the ratio of the current number of extents of the file to the ideal number of extents of the file. The largest extent size supported by the file system is 128 MB.

2. [Unit 14] In practice, I/O schedulers favor synchronous requests over asynchronous requests. Explain the rationale of this design.
3. [Unit 15] Modern flash memory has very large block size. For example, in Micron 3D TLC NAND flash, a block consists of 1535 pages. Discuss how large blocks would affect the following:
- a) Garbage collection performance
  - b) Degree of read disturbance
4. [I/O1] The effect of anticipatory scheduling is neutralized if prefetching is enabled and processes are doing sequential access. Explain why.
5. [I/O2] The mClock algorithm may be at odds with seek-optimized disk scheduling. Explain why there is such a conflict and propose a solution.
6. [I/O3] What are Shingle-Magnetic Recording (SMR) drives? Why it is difficult to handle random writes in SMR drives?
7. [FL1] Modern SSDs support a new feature called Multi-Stream Writing. Demonstrate how this feature benefits garbage collection using an example.
8. [FL2] What will happen if we write data to flash memory without wear leveling and replace worn-out blocks with reserved blocks?
9. [FL3] The threshold voltage ( $V_{th}$ ) of flash cells is disturbed by various kinds of noises. What kind(s) of noises could cause the following results? Why?
- a) Unexpected increase in  $V_{th}$ .
  - b) Unexpected loss in  $V_{th}$ .

Q1~Q3: 14 pts each, Q4~Q9: 10 pts each. Total: 102 pts.

**\*\*You must provide sufficient details to your answer. Fail to do so will cause a significant score penalty.**

**\*\*Write down your answers in English.**

**\*\*You can consult to any available resources.**

**\*\*Discussion is prohibited. Cheating will be punished seriously.**