



**Task 1.** The clock frequency of the CPU is 100 MHz. A keyboard is connected to the computer. In average, 10 keys are pressed in a second. Theoretically, two key presses can follow each other in 50 ms, key presses closer than this can not be distinguished by the keyboard. 500 clock cycles are necessary to obtain the status of the keyboard. The interrupt processing needs additional 100 clock cycles.

- (a) How many times do we need to poll the keyboard to not to miss any events?
- (b) What is the (relative) load of the CPU devoted to the keyboard when the key press events are handled by polling?
- (c) What is the (relative) load of the CPU devoted to the keyboard when the key press events are handled by interrupts?

**Task 2.** Assume that a hard disk drive has 3 double-sided platters. There are 100000 tracks on each recording surface. The disk uses ZBR with two zones: there are 2000 sectors on tracks 1-50000 (zone 1) and 1000 sectors on tracks 50001-100000 (zone 2). The size of the sectors is 500 byte. The speed of the interface of the HDD is  $250 \cdot 10^6$  byte/s. The command processing time is 1 ms. The average seek time is 5 ms, the rotation speed is 6000 RPM.

- (a) What is the total capacity of the HDD in bytes?
- (b) What is the revolution time of the discs?
- (c) Compute the service time of a read request of a single sector, if the sector falls onto track 25000 (zone 1).
- (d) Compute the service time of a read request of a single sector, if the sector falls onto track 75000 (zone 2).
- (e) On which zone would you put your frequently used data?

**Task 3.** Assume that a hard disk drive has 3 double-sided platters. There are 20000 tracks on each recording surface, with 1000 sectors on each track (there is no ZBR). The sector size is 500 byte. The average seek time is 4 ms. By measurements we have determined that the average service time of read requests aiming a single sector is 10 ms.

- (a) What is the total capacity of the HDD in CHS coordinate system?
- (b) What is the rotation speed (in RPM) if we assume that the data transmission through the interface and command processing are infinitely fast?
- (c) How long does it take to read a sector from the recording surface, once the head and the disc are at the appropriate position?
- (d) Assume that the command processing time is 0.1 ms and the transmission speed of the interface is  $50 \cdot 10^6$  byte/s. What is the (random) throughput measured by 2000 byte long read requests? What is the (sequential) throughput measured by  $50 \cdot 10^6$  byte long read requests?

**Task 4.** The current state of an SSD consisting of 8 blocks is depicted in the following figure.

1 #18 E E E E	2 #2 U 1 I 11 I 9 U 3	3 #17 E E E E	4 #8 U 13 U 7 I 8 I 3	5 #7 I 5 U 6 I 6 U 9	6 #18 U 11 U 8 U 4 E	7 #3 E E E E	8 #9 I 1 U 5 U 10 I 3
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The top left corner of the blocks refer to the number of the block, and the top right corner of the blocks contain the number of programming/erase cycles. Each block consists of 4 pages. For each page the state of the page ("U"=used, "I"=invalid, "E"=erased) and the LBA address of the stored data are provided.

In the initial state blocks 1, 3 and 7 are erased, and the write frontier is block 6.

- (a) How does the state of the SSD change when read requests arrive to LBA address 5, 13 and 2, accordingly. If a new write frontier is needed, select one that ensures the most balanced wearing of the blocks.
- (b) How does the state of the SSD change when the garbage collector is triggered in the initial state? The garbage collector does not stop till the number of erased blocks increases by one. The garbage collector always selects the block containing the most invalid pages. If there are many of such candidate blocks, it picks the least worned one.