CS525-01/02/03 - Spring 2018
Problem Set 1 Key

---

All submissions must be typed and submitted electronically (handwritten & scanned submissions won't be graded).

## Problem 1

No grade

## Problem 2 [1]

2.a. (1 Point)

10 surfaces $\times$ 10,000 tracks/surface $\times$ 1000 sectors/track $\times 512 = 512,000$ bytes. Thus, the capacity is 51.2 gigabytes.

2.b. (2 Points)

- The average number of sectors per track is 1000, and each sector is 512 bytes. So the average number of bytes per track is 512,000 bytes or 4,096,000 bits.
- The outermost track has length of $3.5\pi \cong 11$ inches. 20% of the track are gaps, so data occupies $3.5\pi \times 80\% \cong 8.80$ inches. The average density of the outermost track is then $\frac{4,096,000}{8.80} \cong 465,455$ bits/inch.
- The innermost track length is $1.5\pi \cong 4.7$ inches. 20% of the track are gaps, so the data occupies about $1.5\pi \times 80\% \cong 3.77$ inches, and the average density is about $\frac{4,096,000}{3.77} \cong 1,086,472$ bits/inch.
- The average density of bits in the sectors of a track is then about $\frac{465,455+1,086,472}{2} = 775,963.5$ bits/inch.

2.c. ( 1 Point)

The maximum seek time occurs when the heads have to move across all the tracks. Thus, the maximum seek time is $1 + .001 \times 9999 \cong 11$ milliseconds.

2.d. (1 Point)

The maximum rotational latency is one full revolution. Since the disk rotates at 10,000 rpm, it takes $\frac{1}{10000}$ of a minute, or 6 milliseconds.

2.e. (2 points)

- We can use the track as an approximation of the circle that the head needs to travel. Thus, there are a total of 1000 sectors and 1000 gaps per circle.
- Since gaps occupy 20% of the circle, they cover $360° \times 20\% = 72°$ of the circle, and so each gap covers $\frac{72°}{1000} = 0.072°$ of the circle arc. Similarly, each sector covers $0.288°$ of the arc ($\frac{80\% \times 360}{1000}$).
- If the block occupies 32 sectors, the head must pass over 32 sectors and 31 gaps between them. Thus, the total degrees that the head needs to cover is $32 \times 0.2888 + 31 \times 0.072 = 11.448°$
- time it takes to make one rotation is $\frac{60 \times 1000}{10000} = 6$ msec. Thus, the disk will cover one degree in $\frac{6}{360} = \frac{1}{60}$ msec.

[1] Credit: Exercise 11.3.1, "Database Systems - The Complete Book", 2nd edition

- Therefore, the transfer time for one block is $\frac{11.448}{60} \cong 0.19$ msec.

2.f. (1 Point)

The average distance traveled by heads is one third of the way across the disk (page 38) $\Rightarrow \cong 3,333$ cylinders. Therefore, the average seek time = $1 + 0.001 \times 3,333 \cong 4.33$ msec.

2.g. (1 Point)

Average rotational latency is the time to rotate the disk half way around, which is $\frac{0.5 \ rotations}{10{,}000 \ rotation/min}$ 3 msec

## Problem 3[2]

3.a. (1 Point)

bytes/track = bytes/sector $\times$ sectors/track = 512 $\times$ 50 = 25K
bytes/surface = bytes/track $\times$ tracks/surface = 25K $\times$ 2000 = 50,000K
bytes/disk = bytes/surface $\times$ surfaces/disk = 50,000K $\times$ 5 $\times$ 2 = 500,000K

3.b. (1 Point)

The number of cylinders is the same as the number of tracks on each platter, which is 2000.

3.c. (3 Points)

The block size should be a multiple of the sector size. We can see that 256 is not a valid block size while 2048 is. 51200 is not a valid block size in this case because block size cannot exceed the size of a track, which is 25600 bytes.

3.d. (2 points)

If the disk platters rotate at 5400 rpm, the time required for one complete rotation, which is the maximum rotational delay, is $\frac{1}{5400} * 60 = 0.011$ seconds. The average rotational delay is half of the rotation time, 0.006 seconds.

3.e. (1 Point)

The capacity of a track is 25 Kbytes. Since one track of data can be transferred per revolution, the data transfer rate is $\frac{25K}{0.011} = 2250$Kbytes/second

[2]Credit: Exercise 9.5. "Database management Systems", 3rd edition