

## COSC 420: Computer Architecture

### Assignment 5

**Due date: April 5, 2024**

Answer the following questions. The questions are numbered as they appear in the textbook.

Please review all the formulas in Section 7.1.

7.1 (12 points) Justify Equation 7.1 . That is, explain how each of the three terms on the right-hand side of the equation contributes to the value on the left-hand side.

7.3 (12 points) Define the following for a disk system:

$t_s$  = seek time; average time to position head over track

$r$  = rotation speed of the disk, in revolutions per second

$n$  = number of bits per sector

$N$  = capacity of a track, in bits

$t_{sector}$  = time to access (read or write) a sector

Develop a formula for  $t_{sector}$  as a function of the other parameters.

7.4 (22 points) Consider a magnetic disk drive with 8 surfaces, 512 tracks per surface, and 64 sectors per track. Sector size is 1 kB. The average seek time is 8 ms, the track-to-track access time is 1.5 ms, and the drive rotates at 3600 rpm. Successive tracks in a cylinder can be read without head movement.

- What is the disk capacity?
- What is the average access time? Assume this file is stored in successive sectors and tracks of successive cylinders, starting at sector 0, track 0, of cylinder  $i$ .
- Estimate the time required to transfer a 5-MB file.
- What is the burst transfer rate?

$$\text{Burst rate} = (\text{revolutions / second}) \times (\text{sectors / revolution}) \times (\text{bytes / sector})$$

7.5 (22 points) Consider a single-platter disk with the following parameters: rotation speed: 7200 rpm; number of tracks on one side of platter: 30,000; number of sectors per track: 600; seek time:

one ms for every hundred tracks traversed. Let the disk receive a request to access a random sector on a random track and assume the disk head starts at track 0.

- a. What is the average seek time?
- b. What is the average rotational latency?
- c. What is the transfer time for a sector?
- d. What is the total average time to satisfy a request?

7.9 (12 points) Consider a 4-drive, 200 GB-per-drive RAID array. What is the available data storage capacity for each of the RAID levels 0, 1, 3, 4, 5, and 6?

7.11 (20 points) Design a backup strategy for a computer system. One option is to use plug-in external disks, which cost \$150 for each 500 GB drive. Another option is to buy a tape drive for \$2500, and 400 GB tapes for \$50 apiece. (These were realistic prices in 2008.) A typical backup strategy is to have two sets of backup media onsite, with backups alternately written on them so in case the system fails while making a backup, the previous version is still intact. There's also a third set kept offsite, with the offsite set periodically swapped with an on-site set.

- a. Assume you have 1 TB (1000 GB) of data to back up. How much would a disk backup system cost?
- b. How much would a tape backup system cost for 1 TB?
- c. How large would each backup have to be in order for a tape strategy to be less expensive?
- d. What kind of backup strategy favors tapes?