Notice: The SoE Honor’s Code applies to this examination. You are allowed a printed copy of all course website material as well as 2 pages of handwritten notes. Show all your reasoning and calculations. Additional paper is available.

1. What is the fundamental factor limiting the data density of optical storage.

Wavelength of light. Features much smaller than the wavelength of the laser cannot be discerned.

2. The Seagate Cheetah 10K.6 has a capacity of 146.8 GB with an Ultra 320 SCSI interface. Its spindle speed (rotations per minute) is 10K. Its average seek time is 4.7 msec for reads and 5.2 msec for writes. (The head needs to be better positioned for writes, therefore this dual seek time rate.) Assume that we have a workload of 60% reads and 40% writes, all to single sectors.

a. What is the average time that a request takes?

b. What is the maximum number of requests that the drive can handle per second?

(a) A single rotation takes 1/10K min = 60/10000 sec = 6 sec. A latency is therefore 3 sec.

If we only read / write single sectors, we can neglect transfer times. A read then takes 4.7 msec for the seek and 3 sec for the rotational delay or 7.7 msec. Similarly, a write takes 5.2 msec + 3 msec = 8.2 msec. On average, a request takes 0.4 · 8.2 msec + 0.6 · 7.7 msec = 7.9 msec.

(b) If $x$ is the maximum number of requests per second, then $x$ · 7.9 msec = 1 sec, therefore $x = 126.58$.

3. The Western Digital Caviar IDE drive has a capacity of 250 GB and a rotational speed of 7200 rotations per minute. Its read seek time is 8.9 msec and its write seek time is 10.0 msec. Assume that you deploy 5 of these drives in a RAID Level 5 configuration. Assume that the RAID has to sustain a workload of 250 requests, out of which 50 are write requests. What is the average utilization of one of the five disks?

A single rotation takes 1/7200 min = 60 / 7200 sec = 8.333 msec, so that the latency is 4.167 msec. A single sector read takes 8.9 msec + 4.167 msec = 13.067 msec. With 200 read requests, each disk is reading for 200 · 13.067 / 5 = 522.667 msec. A write takes place at two different disks. Each write is done via a read – modify – write operation. We therefore have one read seek, one latency, and one full rotation to do at each of the two disks written. At a disk, this takes 21.4 msec. Thus, a disk in the array is busy 2 · 21.4 msec · 50 / 5 = 428 msec. Therefore, each disk is busy 950.667 msec for every second. This is a load of 95.067 %, unacceptable for fast response times.