SHEET Number 4

Answer the following Questions.

17. The protocol for a certain data bus is shown in the table below. Draw the corresponding timing diagram. You may refer to Figure 7.11.

Time	Salient Bus Signal	Meaning
t_0	Assert Read	Bus is needed for reading (not writing)
t_1	Assert Address	Indicates where bytes will be written
t_2	Assert Request	Request read to address on address lines
t_3 - t_7	Data lines	Read data (requires several cycles)
t_4	Assert Ready	Acknowledges read request, bytes placed on data lines.
t_4	Lower Request	Request signal no longer needed.
t_8	Lower Ready	Release bus

18. About Figure 7.11 and Problem 17 above, we have not provided for any type of error handling, such as if the address on the address lines were invalid, or the memory couldn't be read owing to a hardware error. What could we do with our bus model to provide for such events?

19. We pointed out that I/O buses do not need separate address lines. Construct a timing diagram like Figure 7.11 that describes the handshake between an I/O controller and a disk controller for a write operation. (Hint: You will need to add a control signal.)

* 20. If each interval shown in Figure 7.11 is 50 nanoseconds, how long would it take to transfer 10 bytes of data? Devise a bus protocol, using as many control lines as you need, that would reduce the time required for this transfer to take place? What happens if the address lines are eliminated, and the data bus is used for addressing instead? (An additional control line may be needed.)

21. Define the terms seek time, rotational delay, and transfer time. Explain their relationship.

♦22. Why do you think the term random access device is something of a misnomer for disk drives?

23. Why do differing systems place disk directories in different track locations on the disk? What are the advantages of using each location that you cited?

♦24. Verify the average latency rate cited in the disk specification of Figure 7.15. Why is the calculation divided by 2?

25. By inspection of the disk specification in Figure 7.15, what can you say about whether the disk drive uses zoned-bit recording?

26. The disk specification in Figure 7.15 gives a data transfer rate of 60MB per second when reading from the disk, and 320MB per second when writing to the disk. Why are these numbers different? (Hint: Think about buffering.)

27. Do you trust disk drive MTTF figures? Explain.

♦28. Suppose a disk drive has the following characteristics:

- 4 surfaces
- 1024 tracks per surface
- 128 sectors per track
- 512 bytes/sector
- Track-to-track seek time of 5 milliseconds
- Rotational speed of 5000 RPM.

♦a) What is the capacity of the drive?
♦b) What is the access time?

29. Suppose a disk drive has the following characteristics:

- 5 surfaces
- 1024 tracks per surface
- 256 sectors per track
- 512 bytes/sector
- Track-to-track seek time of 8 milliseconds
- Rotational speed of 7500 RPM.

a) What is the capacity of the drive?
b) What is the access time?
c) Is this disk faster than the one described in question 17? Explain.

30. Suppose a disk drive has the following characteristics:

- 6 surfaces
- 16,383 tracks per surface
- 63 sectors per track
- 512 bytes/sector
- Tract-to-track seek time of 8.5 milliseconds
- Rotational speed of 7,200 RPM.

a) What is the capacity of the drive?
b) What is the access time?

31. Suppose a disk drive has the following characteristics:

- 6 surfaces
- 953 tracks per surface
- 256 sectors per track
- 512 bytes/sector
- Tract-to-track seek time of 6.5 milliseconds
- Rotational speed of 5,400 RPM.

a) What is the capacity of the drive?

b) What is the access time?
c) Is this disk faster than the one described in Question 26? Explain.

♦32. Transfer rate of a disk drive can be no faster than the bit density (bits / track) times the rotational speed of the disk. Figure 7.15 gives a data transfer rate of 112 GB/sec. Assume that the average track length of the disk is 5.5 inches. What is the average bit density of the disk?

33. What are the advantages and disadvantages of having a small number of sectors per disk cluster? (Hint: You may want to think about retrieval time and the required lifetime of the archives.)

34. How does the organization of an optical disk differ from the organization of a magnetic disk?

35. How does the organization of an SSD differ from a magnetic disc? How are they similar to a disk?

36. In Section 7.6.2, we said that magnetic disks are power hungry as compared to main memory. Why do you think this is the case?

37. Explain wear leveling and why it is needed for SSDs. We said that wear-leveling is important for the continual updating of virtual memory pagefiles. What problem does wear-leveling aggravate for pagefiles?

38. Compare the disk specifications for the HDD and SSD in Figures 7.15 and 7.16 respectively. Which items are the same? Why? Which items are different? Why?

♦ 39. If 800GB server-grade HDDs cost $300, electricity costs $0.10 per kilowatt hour, and facilities cost $0.01 per GB per month, use the disk specification in Figure 7.15 determine how much it costs to store 8TB of data online for 5 years. Assume that the HDD is active 25% of the time. What can be done to reduce this cost? Hint: Use the "Read/Write" and "Idle" power requirements in Figure 7.15.

40. The disk drives connected to the servers in your company's server farm are nearing the end of their useful life. Management is considering replacing 8TB of disk capacity with SSDs. Someone is making the argument that the difference in the cost between the SSDs and traditional magnetic disks will be offset by the cost of electricity saved by the SSDs. The 800GB SSDs cost $900. The 800GB server-grade HDDs cost $300. Use the disk specifications in Figures 7.15 and 7.16 to confirm or refute this claim. Assume that both the HDD and SSD are active 25% of the time and that the cost of electricity is $0.10 per kilowatt hour. Hint: Use the "Read/Write" and "Idle" power requirements in Figure 7.15.

41. A company that has engaged in a business that requires fast response time has just received a bid for a new system that includes much more storage than was specified in the requirements document. When the company questioned the vendor about the increased storage, the vendor said that he was bidding a set of the smallest capacity disk drives that the company makes. Why didn't the vendor just bid fewer disks?

42. Discuss the difference between how DLT and DAT record data. Why would you say that one is better than the other?

43. How would the error-correction requirements of an optical document storage system differ from the error-correction requirements of the same information stored in textual form? What are the advantages offered by having different levels or error correction for optical storage devices?

44. You have a need to archive a large amount of data. You are trying to decide whether to use tape or optical storage methods. What are the characteristics of this data and how it is used that will influence your decision?

45. Discuss the pros and cons of using disk versus tape for backups.

46. Suppose you have a 100GB database housed on a disk array that supports a transfer rate of 60MBps and a tape drive that supports 200GB cartridges with a transfer rate of 80MB per second. How long will it take to back up the database? What is the transfer time if 2:1 compression is possible?

* 47. A particular high-performance computer system has been functioning as an e-business server on the Web. This system supports $10,000 per hour in gross business volume. It has been estimated that the net profit per hour is $1,200. In other words, if the system goes down, the company will lose $1,200 every hour until repairs are made. Furthermore, any data on the damaged disk would be lost. Some of this data could be retrieved from the previous night's backups, but the rest would be gone forever. Conceivably, a poorly-timed disk crash could cost your company hundreds of thousands of dollars in immediate revenue loss, and untold thousands in permanent business loss. The fact that this system is not using any type of RAID is disturbing to you.

Although your chief concern is data integrity and system availability, others in your group are obsessed with system performance. They feel that more revenue would be lost in the long run if the system slows down after RAID is installed. They have stated specifically that a system with RAID performing at half the speed of the current system would result in gross revenue dollars per hour declining to $5,000 per hour.

In total, 80% of the system e-business activity involves a database transaction. The database transactions consist of 60% reads and 40% writes. On average, disk access time is
20ms.

The disks on this system are nearly full and are nearing the end of their expected life, so new ones must be ordered soon. You feel that this is a good time to try to install RAID, even though you'll need to buy extra disks. The disks that are suitable for your system cost $2000 for each 10 gigabyte spindle. The average access time of these new disks is 15ms with a MTTF of 20,000 hours and a MTTR of 4 hours. You have projected that you will need 60 gigabytes of storage to accommodate the existing data as well as the expected data growth over the next 5 years. (All of the disks will be replaced.)

a) Are the people who are against adding RAID to the system correct in their assertion that 50% slower disks will result in revenues declining to $5,000 per hour? Justify your answer.
b) What would be the average disk access time on your system if you decide to use RAID-1?
c) What would be the average disk access time on your system using a RAID-5 array with two sets of 4 disks if 25% of the database transactions must wait behind one transaction for the disk to become free?
d) Which configuration has a better cost-justification, RAID-1 or RAID-5? Explain your answer.

48. a) Which of the RAID systems described in this chapter cannot tolerate a single disk failure?
    b) Which can tolerate more than one simultaneous disk failure?

49. Our discussion of RAID is biased toward consideration of standard rotating magnetic disks. Is RAID necessary for SSD storage? If not, does this make SSD storage slightly more affordable for the enterprise? If it is necessary, do the redundant disks necessarily need to also be SSD?