1) Consider a disk with the following characteristics (these are not parameters of any particular disk unit): block size B=512 bytes, number of blocks per track=20, number of tracks per surface=400. A disk pack consists of 15 double-sided disks. (This problem assumes a simplified version of the disk model which doesn't take interblock gap size into consideration. In other words, interblock gap size = 0)

(a) What is the total capacity of a track?

Total capacity of a track = Number of blocks per track × Block size

20 blocks × 512 bytes/block = 10,240 bytes = 10.24KB

(b) How many cylinders are there?

Number of surfaces = 15 disks × 2 surfaces/disk = 30 surfaces = 30 surfaces

Each cylinder consists of one track on each of the 30 surfaces, so the number of cylinders is equal to the number of tracks per surface: Number of cylinders=400

(c) What is the total capacity of a cylinder?

Total capacity of a cylinder = Total capacity of a track × Number of tracks in a cylinder

10.24 KB × 30 = 307.2 KB

(d) Suppose the disk drive rotates at a speed of 2400 rpm (revolutions per minute); what is the block transfer time btt in msec? What is the average rotational delay rd in msec?

The disk rotates at 2400 rpm, which means it completes one revolution in 1/2400 minutes or 60,000/2,400 msec.

Time for one revolution = 60,000/2,400 msec = 25 msec

The block transfer time can be calculated as:

Btt = Time for one revolution / Number of blocks per track

25 msec / 20 = 1.25msc

Average Rotational delay (rd) : is half the time for one complete revolution

Rd = 25 msec / 2 = 12.5 msec

(e) Suppose the average seek time is 30 msec. How much time does it take (on the average) in msec to locate and transfer a single block given its block address? (basing on the rd and btt you calculated in problem d)

Time to locate and transfer = Average seek time + Average rotational delay + Block transfer time = 30 msec + 12.5 msec + 1.25 msec = 43.75 msec

(f) Calculate the average time it would take to transfer 20 random blocks and compare it with the time it would take to transfer 20 consecutive blocks. (basing on the assumptions in problem d and e)

For 20 random blocks: Average time = 20 × (Average seek time + Average rotational delay + Block transfer time) = 20 × 43.75 msec = 875 msec

For 20 consecutive blocks: Time = Average seek time + Average rotational delay + 20 × Block transfer time = 30 msec + 12.5 msec + 20 × 1.25 msec = 67.5 msec

2) What are the main goals of the RAID technology? How does it achieve them?

- Main goals of the RAID technology:

- **Cost-Efficiency:** RAID allows the use of cheaper disks in an array to collectively achieve high performance and reliability, often at a lower cost.
- **Performance Improvement:** By splitting data across multiple disks (striping), multiple operations can occur concurrently, improving I/O performance. This can be particularly beneficial in environments that require high data transfer rates or quick data access, such as video editing studios or financial databases.
- **Data protection/Protection:** RAID aims to protect data by storing it across multiple disks. If one disk fails, the data can be recovered from other disks in the array. This adds a layer of fault tolerance

- How does it achieve them?

By combining multiple disks into a single logical unit to achieve various benefits like mirroring, striping, and parity. Some common RAID levels are RAID 0, RAID 1, RAID 5, RAID 6, RAID 10

RAID 0 (Striping):

- Performance: Data is divided into blocks, and each block is written to a different disk drive. This increases the data throughput because multiple disks can be read or written concurrently.
- Reliability: Not improved. In fact, it's worse than a single disk because if any one disk fails, all data is lost.
- Cost-Efficiency: Utilizes full storage capacity of all disks.

RAID 1 (Mirroring):

- Performance: Read performance improves as either disk can be read at the same time. Write performance is the same or slightly worse due to duplicate writes.
- Reliability: Excellent, as data is duplicated. If one disk fails, no data is lost.
- Cost-Efficiency: Requires double the storage capacity, which can be costly.

RAID 5 (Striping with Parity):

- Performance: Good read performance and reasonable write performance. Multiple disks can be read simultaneously.
- Reliability: Parity information is stored across all disks. If one disk fails, data can be reconstructed from the remaining disks.
- Cost-Efficiency: More efficient use of disk space than RAID 1 but requires at least three disks.

RAID 6 (Striping with Double Parity):

- Performance: Similar to RAID 5 but with slightly lower write performance due to additional parity calculations.
- Reliability: Can withstand the failure of two disks.

- Cost-Efficiency: Requires at least four disks but offers better fault tolerance than RAID 5.

RAID 10 (1+0) or (0+1):

- Performance: Excellent read and write performance due to combined striping and mirroring.
- Reliability: Very high, as it combines the advantages of RAID 0 and RAID 1.
- Cost-Efficiency: Requires a minimum of four disks and offers both high performance and data protection, but at a higher cost.

https://phoenixnap.com/kb/raid-levels-and-types
https://www.prepressure.com/library/technology/raid