1. A manufacturer wishes to design a hard disk with a capacity of 30 GB or more (using the standard definition of 1 GB = 2^30 bytes). If the technology used to manufacture the disks allow 1024-byte sectors, 2048 sectors/track, and 4096 tracks/platter, how many platters are required? (Assume a fixed number of sectors per track)

   Sol:

   Multiplying bytes per sectors per tracks per platter gives a capacity of 8GB (8x2^30 bytes) per platter. Therefore, 4 platters will be requires to give a total capacity of >=30GB.

2. A hard disk with one platter rotates at 15,000 r/min and has 1024 tracks, each with 2048 sectors. The disk head starts at track 0 (track are numbered from 0 to 1023). The disk then receives a request to access a random sector on a random track. If the seek time of the disk head is 1 ms for every 100 tracks it must cross;

2 a) What is the average seek time?

2 b) What is the average rotational latency?

2 c) What is the transfer time for a sector?

2 d) What is the total average time to resolve a request?

Sol:

a. **Since the disk head starts at track 0, it will have to travel 0 tracks to handle a request to track 0, 1 track to handle a request to track 1, and so on, up to 1023 tracks to a request to track 1023. On average, the head will have to travel half of the way to the outermost track 511.5 tracks. At 100 tracks/ms, this gives an average seek time of 5.115 ms.**
b. **At 15,000r/min, each rotation takes 4ms. The average rotational latency in half the rotation time, or 2ms.**
c. **Each rotation takes 4ms. There are 2048 sectors per track, so each sector takes 4ms/2048 = 1.95 microseconds to pass under the read /write head. Therefore, the transfer time is 1.95 microseconds.**
d. **The average access time is just the sum of the three components, or 7.117 ms (rounding to four significant digits) As stated in the text, this neglects the time to transmit the data to the processor.**

3. Researchers have been investigating systems in which the operating system deliberately places the most-frequently-used files on the outer tracks of a system's hard disk to improve performance.

3 a) Why would this improve performance?

3 b) Would this approach give better performance on a system that had a variable or a fixed number of tracks per sector?

3 c) In a system that used a fixed number of sectors per track, does it matter whether the operating system places the most-frequently-used files on the inner or outer tracks, or is it just important that they be placed close together?

3 d) How does your answer to **c** change on a system that uses a variable number of sectors per track?

Sol:

a) **If files are randomly assigned to tracks, the most-frequently-used files will tend to be spread evenly across the disk and I/O requests will also tend to be evenly spread across the disk. Placing the most-frequently-used files on the outer tracks means that most I/O requests will be to those tracks. This reduces the average number of tracks that the disk head has to cross to satisfy a memory request, reducing the average seek time.**

b) **In a fixed-sectors-per-track system, all tracks contain the same number of sectors, and that number is determined by the number of sectors that fit on the innermost track of the disk. a variable-sectors-per-track system, the innermost track generally has the same number of sectors as in a fixed-sectors-per-track system, but the outermost tracks contain many more sectors and thus much more data. This means that the most-frequently-used files can be placed on fewer tracks on a disk that has a variable number of sectors per track than on a disk that has a fixed number of sectors per track, since the most-frequently-used files are placed on the outermost tracks. Thus, the average number of tracks that the disk head to cover will be smaller when this approach is used on a disk that has a variable number of tracks per sector, leading to lower seek times and better performance.**

c) **On a disk that has a fixed number of sectors per track, all of the tracks on a disk contain the same amount of storage, making them equivalent. It doesn't matter which set of adjacent tracks are used to hold the most-frequently-used files on such a system, because all tracks are the same. The performance benefit comes from placing the most-frequently-used files close together, reducing average seek time.**

d) **On disks that have a variable number of sectors per track, the outermost tracks contain more data than the innermost tracks. Thus, placing the most-frequently-used files on the outermost tracks allows them to be compacted onto fewer tracks than placing them on the innermost tracks, so placing the most frequently-used files on the outermost tracks will give better performance.**