Q1

Step 1: Calculate the Rotation Time for One Complete Revolution

- The disk rotates at 7200 RPM (revolutions per minute).
- To convert revolutions per minute to revolutions per second (RPS), we divide by 60 (since there are 60 seconds in a minute).

Step 2: Calculate the Transfer Capacity per Revolution

- With the rotation speed in RPS, we can find out how much data can be transferred in one second, and then calculate how much data can be transferred in one revolution by multiplying the transfer rate by the time it takes for one revolution.

Assumptions

- The transfer rate is constant across the whole track.
- The disk's performance characteristics (like its transfer rate) do not vary with its rotational speed or the position on the disk.

Let's do the calculations now.

To calculate the maximum number of bytes that a single outer track can hold:

1. **Rotation Time for One Complete Revolution**: It takes approximately 0.00833 seconds for the disk to make one complete revolution, given its speed of 7200 RPM.
2. **Transfer Capacity per Revolution**: Given the disk's transfer rate of 150 MB/s, during one complete revolution (which takes 0.00833 seconds), the disk can transfer approximately 1,250,000 bytes of data.

Therefore, under the assumption that the disk's transfer rate is constant and applicable uniformly across an entire rotation, a single outer track of the disk can hold a maximum of 1,250,000 bytes of data

Q2

Given Values and Calculations

For the first scenario:

- Average Seek Time = 5ms
- Rotational Speed = 10,000 RPM
- Transfer Rate = 200 MB/s
- Request Size = 65536 bytes (64 KB)

For the second scenario:

- Average Seek Time = 12ms
- Rotational Speed = 5400 RPM

Common Conversion Factors:

- 1 minute = 60 seconds = 60,000 milliseconds
- 1 MB = 106 bytes (using the decimal definition for simplicity)

  106

Calculations for the First Scenario, similar as the Second Scenario

1. **Average Seek Time**: Given as 5ms.
2. **Rotational Latency**:
   - Rotational Speed = 10,000 RPM (Rotations Per Minute)
   - Full Rotation Time = $60{,}000 ms/10{,}000 RPM = 6 ms$
   - Average Rotational Latency = $6 ms/2 = 3 ms$
3. **Transfer Time**:
   - Transfer Rate = 200 MB/s = 200,000 KB/s
   - Time to transfer 64 KB = $64 KB / 200{,}000 KB/s \times 1000$ to convert seconds to milliseconds.

4. **Total Time** = Average Seek Time + Average Rotational Latency + Transfer Time

Results

For the first scenario:

- The total time for a 65536-byte random read request is approximately **8.33 milliseconds**.

For the second scenario:

- With an average seek time of 12ms and a rotational speed of 5400 RPM, the total time for the same read request is approximately **17.88 milliseconds**.

Assumptions

- The calculations assume that the disk is not currently engaged in other operations that would add to the total access time.
- Transfer time calculations assume linear read speed and do not account for potential delays due to disk controller overhead or fragmentation.
- The average rotational latency is calculated as half the time of a full rotation, based on the assumption that the disk needs to rotate halfway on average to reach the desired sector.

Q3

The formula to calculate reliability over a specific period of time, given the MTBF, is:

Reliability as a Probability

Rather than expressing reliability in terms *MTBF* and *MTTR*, it can also be, like availability, expressed as the likelihood that a system is functioning properly during some time period *t*, given some measure of *MTBF* – and, as a corollary, in terms of availability and *MTTR*.

From this perspective, an estimate of the reliability can be calculated as follows:

$$R = e^{-t/MTBF}$$

Where:

- $R(t)$ is the reliability at time t,
- e is the base of the natural logarithm (approximately 2.71828),
- t is the time period for which we want to calculate the reliability, and
- $MTBF$ is the mean time between failures.

For this question:

- $MTBF$=20,000 days
- We want to find the annual reliability, so t=365 days (assuming a non-leap year).

The expected annual reliability of the system, given an estimated mean time between failures of 20,000 days, is approximately **98.19%** expressed as a probability. This means that over the course of a year, the system is expected to be operational and free from failures about 98.19% of the time

Q4

Availability is calculated using the formula:

Availability and MTTR/MTBF

Availability can be defined in terms of reliability when a reliability estimate exists but downtime measure have not been recorded. This is often the case for new systems that are not yet deployed long enough to be able to derive an empirical estimate of availability.

$$A = \frac{MTBF}{MTBF + MTTR}$$

As a corollary we can estimate *MTBF* in terms of availability *A* and *MTTR*, which might sometimes be easier to measure.

$$MTBF = A \times \frac{MTTR}{1 - A}$$

Where:

- *MTBF* = Mean Time Between Failures, and
- *MTTR* = Mean Time to Restore.

In this formula, *MTBF* and *MTTR* need to be in the same units of time. Given that *MTBF* is in years and *MTTR* is in hours, first convert *MTBF* from years to hours for the calculation. Then use the conversion factor that 1 year is approximately equal to 365 days (ignoring leap years for simplicity) and 1 day is 24 hours.

Given Values:

- $MTTR$=1.5 hours,
- $MTBF$=3.1667 years.

First, convert *MTBF* to hours:

$MTBF$=3.1667 years× 365days/year × 24hours/day

Then, calculate the system's availability and compare it to the required availability of 99.995%. proceed with the calculations.

The Mean Time Between Failures (MTBF) for the system is converted to approximately 27,740.292 hours. Based on the calculations, the system's availability is approximately 99.9946%.

This result is slightly below the required availability of 99.995%. Therefore, **the system does not meet the expected availability requirement** as set by the regulations