UNIT 1

1. Explain how a host accesses storage using Direct-Attached Storage (DAS). Discuss its benefits and limitations.
2. Compare the Storage Area Network (SAN) architecture with the traditional server-centric architecture. Highlight differences in scalability, performance, and data sharing.
3. Justify the role of Logical Volume Managers (LVMs) in providing dynamic file system expansion and efficient storage management.
4. Explain the concepts of Zone Bit Recording (ZBR) and Native Command Queueing (NCQ) used in disk storage. Describe the advantages of adopting these techniques.
5. A disk drive has the following specifications:

   Cylinders: 800
   Heads per cylinder: 10
   Sectors per track: 200
   Sector size: 512 bytes
   (i) For a given Logical Block Address (LBA) of 120,000, calculate:

   Cylinder number
   Head number
   Sector number
   (ii) Compute the total storage capacity of the disk drive in gigabytes (GB).

   800*10*200*512

6. Explain the process of mapping user files to disk storage with the help of a neat diagram**.** Describe how files are translated from user-level structures to physical disk locations.
7. An application has an average I/O size of **64 KB.**
   The following disk specifications are provided:

- Average seek time = **5 ms**
- Disk rotation speed = **7,200 rpm**
- Data transfer rate = **40 MB/s**

   Determine the **maximum Input/Output Operations Per Second (IOPS)** that the disk can achieve for this application.

8. List and explain the core elements and key characteristics of a data center.
9. Identify and describe the popular interface protocols used for host-to-storage communication.
10. Consider a disk I/O system in which an I/O request arrives at the rate of 80 IOPS. The disk service time is 6 ms.
    - Compute the following: Utilization of I/O controller, Total response time, Average queue size, and Total time spent by a request in a queue.
    - Compute the preceding parameter if the service time is halved.
11. Describe the various components of a Hard Disk Drive (HDD) and explain the function of each component in storing and retrieving data.
12. Examine the factors that affect the Hard disk performance? And also analyze the IOPS requirement of an application, how it affects the average response time?
13. List any 4 DAS Benefits and Limitations.

14. An application requires 1.46 TB of storage capacity and generates 9,000 IOPS at peak workload.
A 146-GB, 15,000-rpm disk drive can deliver a maximum of 180 IOPS at full utilization.

Calculate:

- The number of disks required to meet both capacity and IOPS needs.
- Assume 70% disk utilization for optimal performance.

UNIT 2

An application generates 5,200 IOPS, with 60% read operations. Calculate the disk load for both RAID 1 and RAID 5 configurations.Compare different RAID levels based on their write penalty, disk requirements, read and write performance, and typical applications.

Explain the components of an intelligent storage system with the help of a neat diagram.

What is a **Hot Spare**? Explain how a Hot Spare is utilized in the event of a **disk failure**.Justify

why **Thin LUNs** are suitable for applications that can **tolerate performance variations**.

Differentiate between write-back and write-through cache mechanisms with suitable diagrams.

Describe the different flushing techniques used to clear dirty pages when the cache becomes full to manage space availability.

An application generates 7,200 IOPS, with 60% read operations. Calculate the disk load for RAID 1, RAID 5, and RAID 6. If a hard disk drive (HDD) supports a maximum of 180 IOPS, determine the number of disks required to handle the workload for RAID 1, RAID 5, and RAID 6 configurations.

An application has 1,000 heavy users at a peak of 2 IOPS each and 2,000 typical users at a peak of 1 IOPS each, with a read/write ratio of 2: 1. It is estimated that the application also experiences an overhead of 20 percent for other workloads. Calculate the IOPS requirement for RAID 1, RAID 3, RAID 5, and RAID 6.

Consider an application that generates 5,200 IOPS, with 60 percent of them being reads. i. Calculate the disk load in RAID 5, RAID 1 and RAID 6. ii. Calculate the number of disks required for the application. HDD (hard Disk Drive) with a specification of a maximum 180 IOPS is used.

Compare the common RAID types — RAID 0, RAID 1, RAID 3, RAID 4, RAID 5, RAID 6, and RAID 1+0/0+1 — based on the following parameters:

- Minimum number of disks required
- Storage efficiency
- Read and write performance
- Write penalty
- Data protection

Comparison between Virtual and Traditional Storage Provisioning

Formula for LBA to CHS conversion:

Sector number = (LBA mod SPT) + 1
Head number = (LBA / SPT) mod Heads
Cylinder number = LBA / (SPT × Heads)

Total Capacity = Cylinders × Heads × Sectors per track × Sector size

Ts = T + L + X
IOPS = 1 / Ts

1. Utilization of I/O Controller (U)
U = Arrival rate × Service time

2. Total Response Time (R)
R = Ts / (1 - U)

3. Average Queue Size (Q)
Q = U^2 / (1 - U)

4. Total Time in Queue (W)
W = R - Ts

Part A: Number of Disks for Capacity (Dc)
Dc = Total capacity / Disk capacity

Part B: Number of Disks for IOPS at 100% Utilization
DI = Total IOPS / IOPS per disk

Part C: Number of Disks for IOPS at 70% Utilization
IOPS per disk at 70% utilization:

Number of disks required:
DR = Max(Dc, DI)

Write Penalties:
For RAID 1: 2
For RAID 3: 4
For RAID 4: 4
For RAID 5: 4
For RAID 6: 6

Disk load = (Read IOPS) + (Write penalty × Write IOPS)

Calculate Number of Disks Required: IOPS of that RAID/Given Maximum IOPS