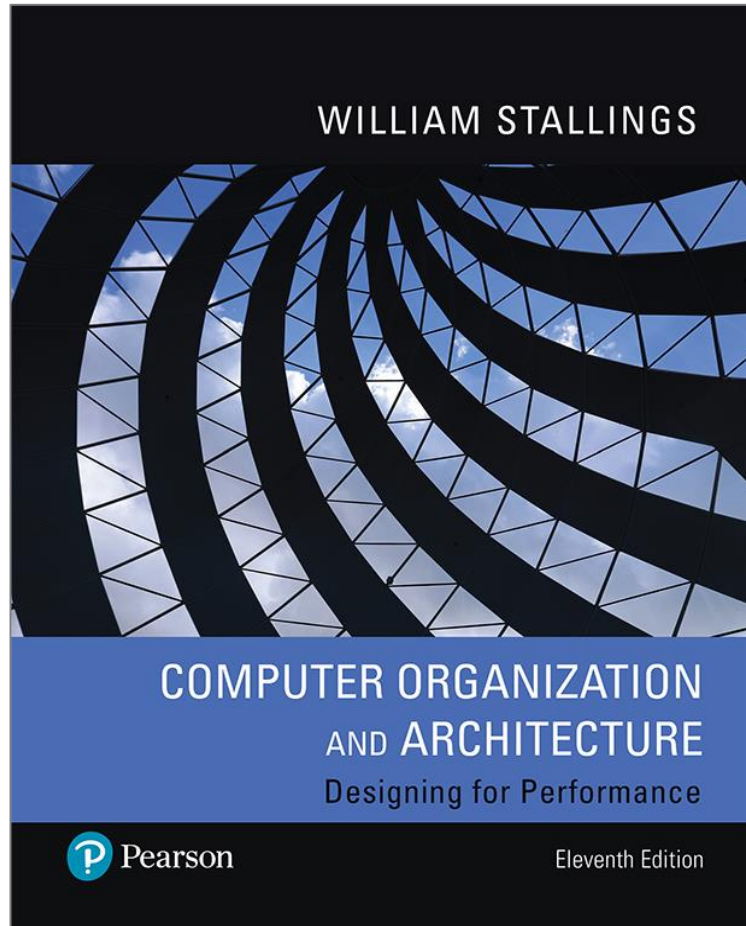


Computer Organization and Architecture

Designing for Performance

11th Edition



Chapter 7

External Memory

Magnetic Disk

- A disk is a circular *platter* constructed of nonmagnetic material, called the *substrate*, coated with a magnetizable material
 - Traditionally the substrate has been an aluminium or aluminium alloy material
 - Recently glass substrates have been introduced
- Benefits of the glass substrate:
 - Improvement in the uniformity of the magnetic film surface to increase disk reliability
 - A significant reduction in overall surface defects to help reduce read-write errors
 - Ability to support lower fly heights
 - Better stiffness to reduce disk dynamics
 - Greater ability to withstand shock and damage

Data are recorded on and later retrieved from the disk via a conducting coil named the *head*

- In many systems there are two heads, a read head and a write head
- During a read or write operation the head is stationary while the platter rotates beneath it

The write mechanism exploits the fact that electricity flowing through a coil produces a magnetic field

Electric pulses are sent to the write head and the resulting magnetic patterns are recorded on the surface below, with different patterns for positive and negative currents

The write head itself is made of easily magnetizable material and is in the shape of a rectangular doughnut with a gap along one side and a few turns of conducting wire along the opposite side

An electric current in the wire induces a magnetic field across the gap, which in turn magnetizes a small area of the recording medium

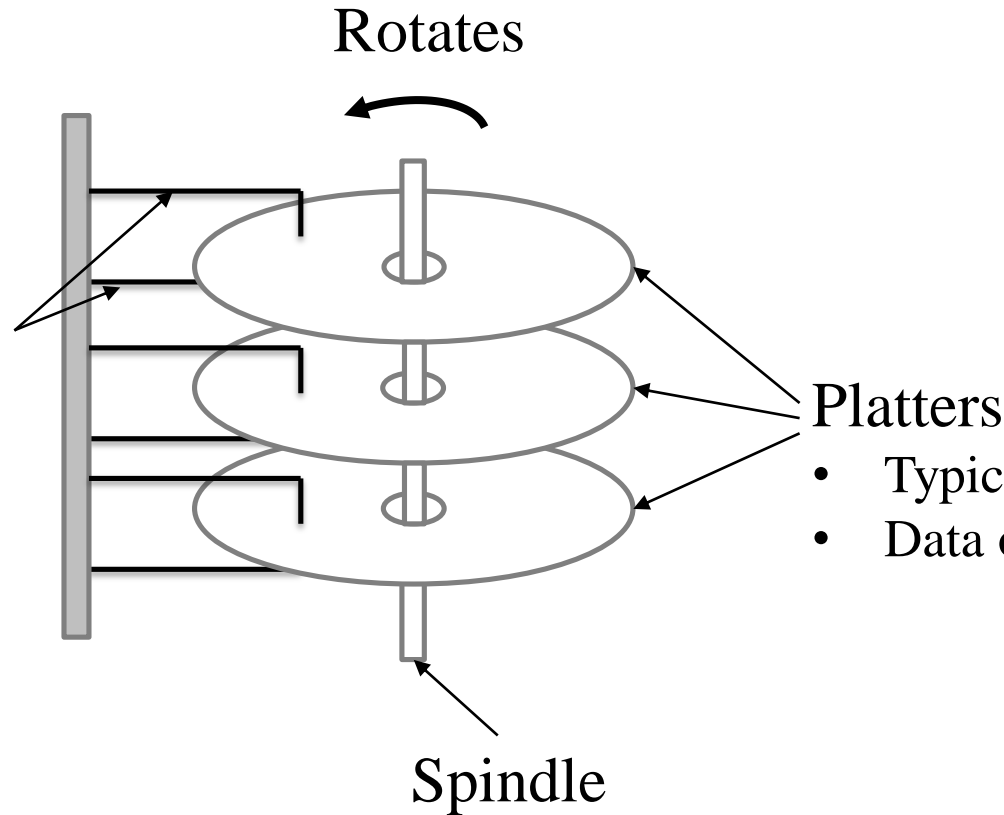
Reversing the direction of the current reverses the direction of the magnetization on the recording medium

Magnetic Read and Write Mechanisms

Magnetic Disk (aka Hard Disk/Drive)

Read/Write Head

- One head per surface.
- Doesn't rotate.



Platters

- Typically small number
- Data on two surfaces

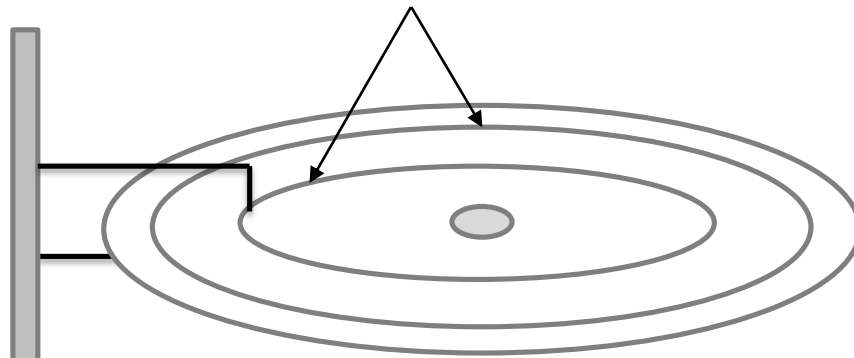
Spindle

- Rotates the platters

Magnetic Disk (aka Hard Disk/Drive)

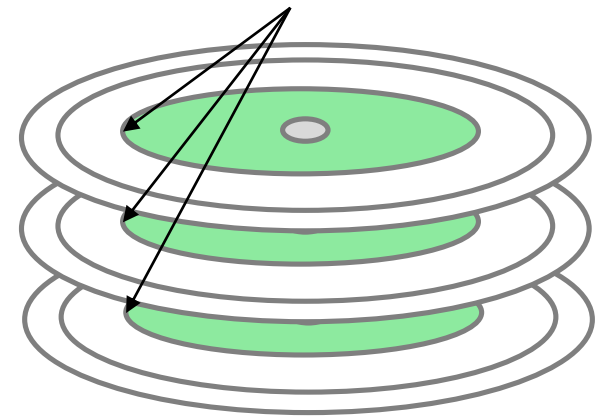
Track

- Thousands of tracks per surface
- Same width as the head



Cylinder

- Multiple tracks of different platters



Sectors

- A head doesn't read/write an entire track.
- Instead, a track is divided into sectors and a head read/write a sector at a time
- Hundreds of sectors per track

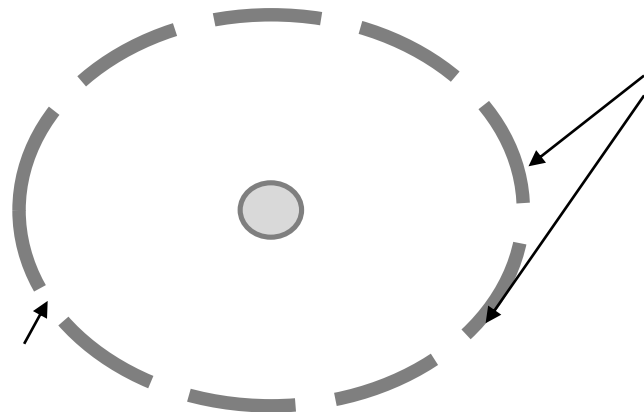


Figure 7.2

Disk Data Layout

- Adjacent tracks are separated by **intertrack gaps** to minimize errors due to misalignment of the head.
- Note that the size data that can be stored in a single sector is the same.

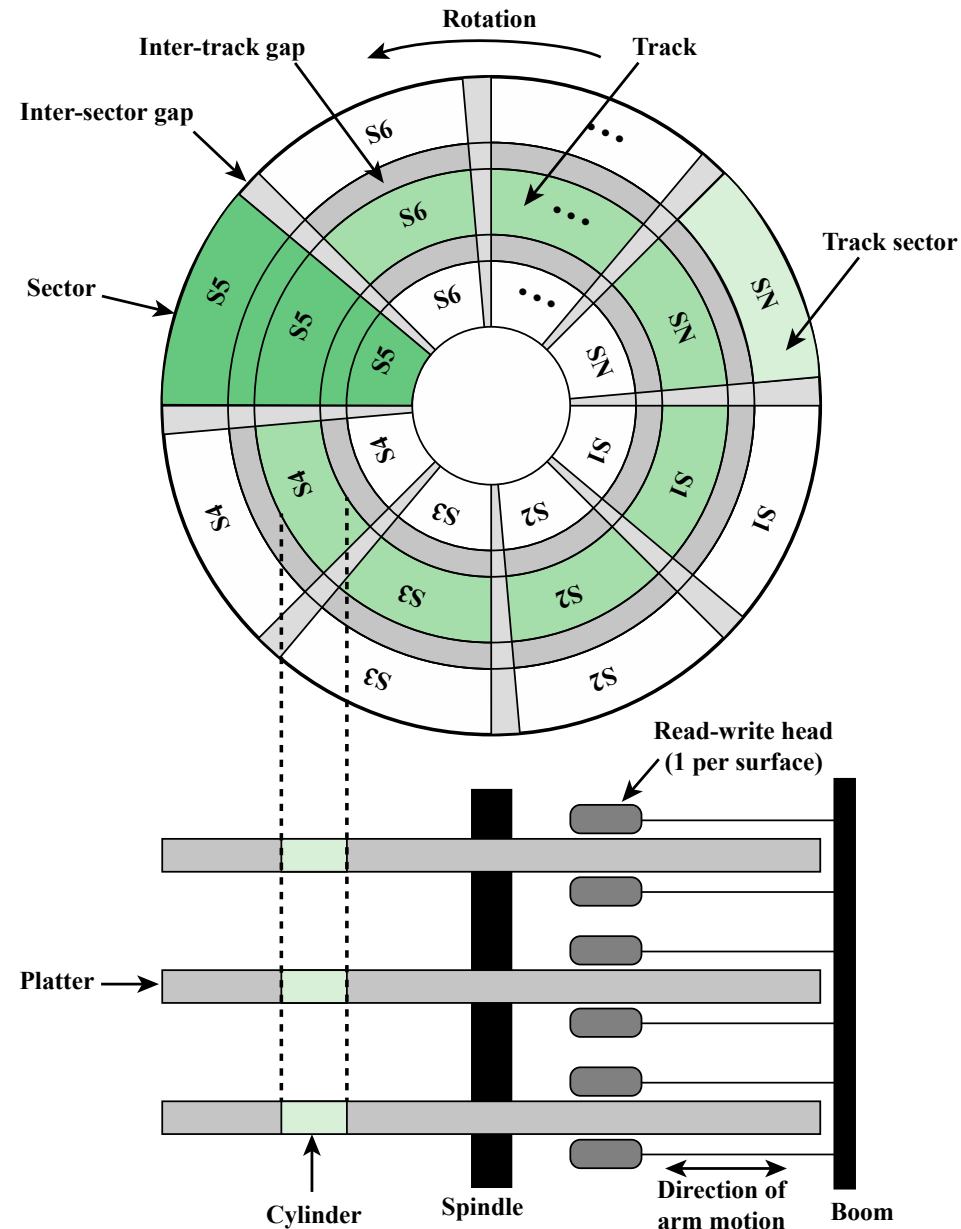
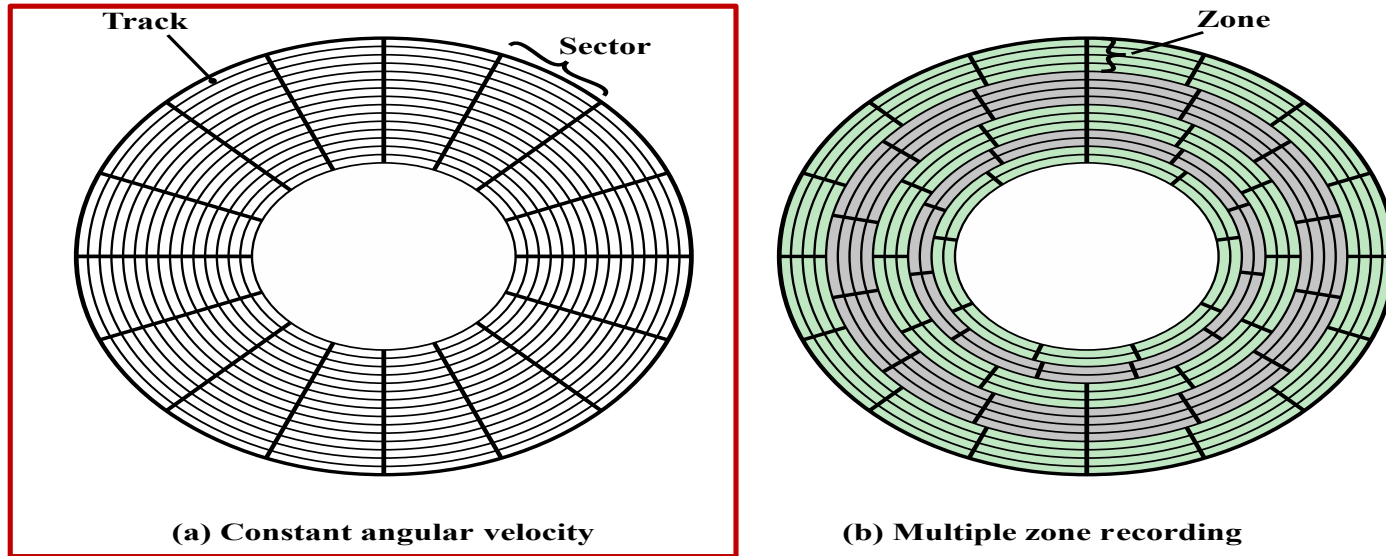


Figure 7.3

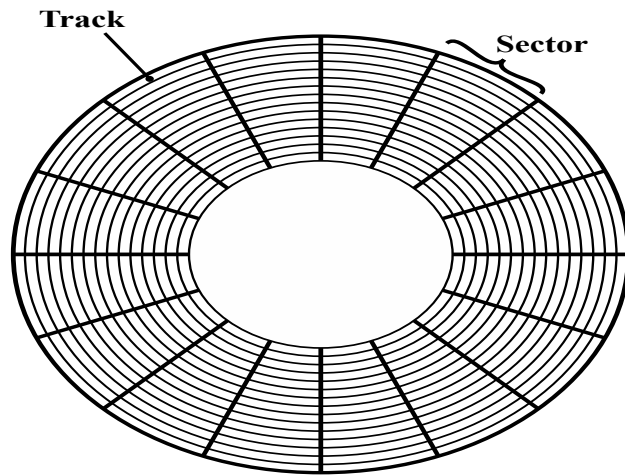
Comparison of Disk Layout Methods



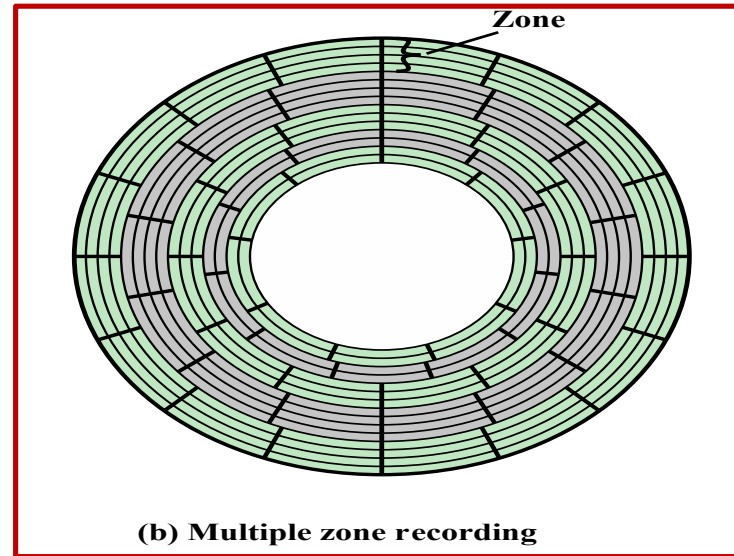
- The information can then be scanned at the same rate by rotating the disk at a fixed speed, known as the constant angular velocity (CAV)
- The disadvantage of CAV is that the amount of data that can be stored on the long outer tracks is the same as what can be stored on the short inner tracks.

Figure 7.3

Comparison of Disk Layout Methods



(a) Constant angular velocity



(b) Multiple zone recording

- In multiple zone recording (MZR), the surface is divided into a number of concentric zones (16 is typical).
- Each zone contains a number of contiguous tracks, typically in the thousands. Within a zone, the number of bits per track is constant.
- Zones farther from the center contain more sectors than zones closer to the center.

Figure 7.4

Legacy and Advanced Sector Formats

Gap: Separates sectors.

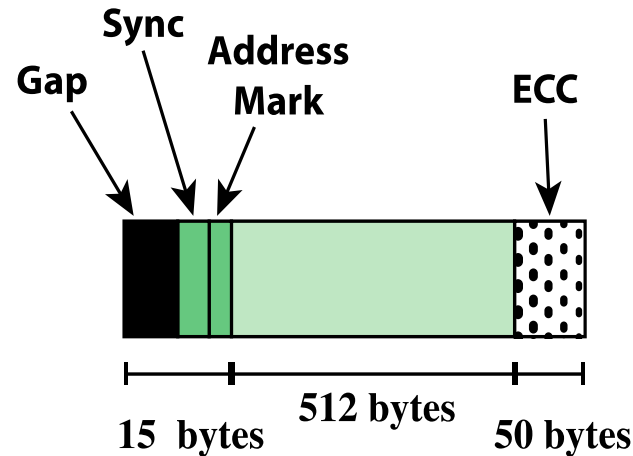
Sync: Indicates the beginning of the sector and provides timing alignment.

Address mark: Contains data to identify the sector's number and location. It also provides status about the sector itself.

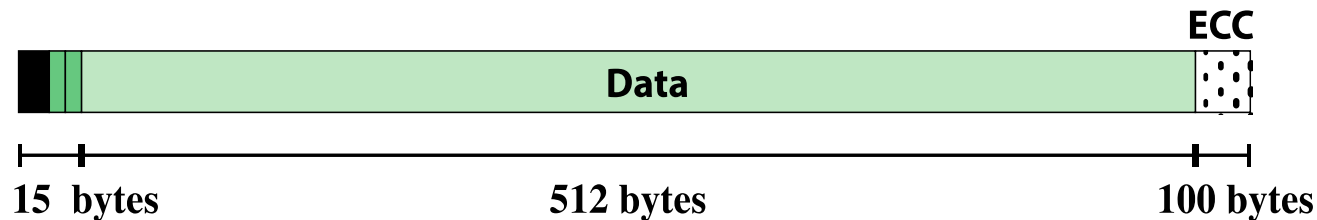
Data: The 512 bytes of user data.

Error correction code

(ECC): Used to correct data that might be damaged in the reading and writing process.



(a) Legacy 512-byte sector



(b) Advanced Format 4k-byte sector

Table 7.1

Physical Characteristics of Disk Systems

Head Motion Fixed head (one per track) – rare today Movable head (one per surface) Disk Portability Nonremovable disk - HDD Removable disk – Floppy Disk Sides Single sided – one surface / platter Double sided – two surfaces / platter	Platters Single platter Multiple platter Head Mechanism Contact (floppy) Fixed gap Aerodynamic gap (Winchester)
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Characteristics

- Fixed-head disk
 - One read-write head per track
 - Heads are mounted on a fixed ridged arm that extends across all tracks
- Movable-head disk
 - One read-write head
 - Head is mounted on an arm
 - The arm can be extended or retracted
- Non-removable disk
 - Permanently mounted in the disk drive
 - The hard disk in a personal computer is a non-removable disk
- Removable disk
 - Can be removed and replaced with another disk
 - Advantages:
 - Unlimited amounts of data are available with a limited number of disk systems
 - A disk may be moved from one computer system to another
 - Floppy disks and ZIP cartridge disks are examples of removable disks
- Double sided disk
 - Magnetizable coating is applied to both sides of the platter

Disk Classification

The head mechanism provides a classification of disks into three types

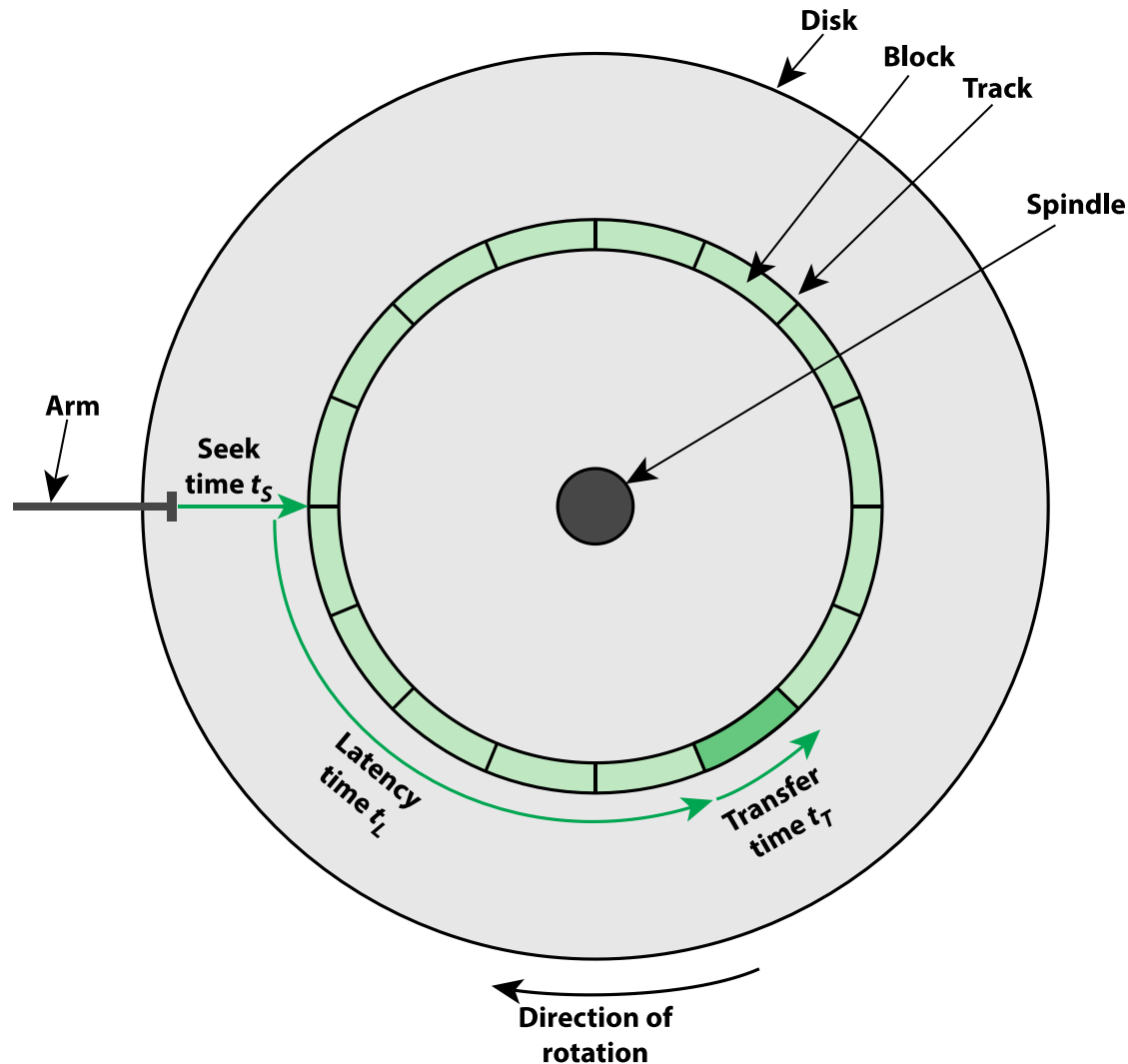
- The head must generate or sense an electromagnetic field of sufficient magnitude to write and read properly
- The narrower the head, the closer it must be to the platter surface to function
 - A narrower head means narrower tracks and therefore greater data density
- The closer the head is to the disk the greater the risk of error from impurities or imperfections

Winchester Heads

- Used in sealed drive assemblies that are almost free of contaminants
- Designed to operate closer to the disk's surface than conventional rigid disk heads, thus allowing greater data density
- Is actually an aerodynamic foil that rests lightly on the platter's surface when the disk is motionless
 - The air pressure generated by a spinning disk is enough to make the foil rise above the surface

Figure 7.5

Timing of a Disk I/O Transfer



Disk Performance Parameters

- When the disk drive is operating the disk is rotating at constant speed
- To read or write the head must be positioned at the desired track and at the beginning of the desired sector on the track
 - Track selection involves moving the head in a movable-head system or electronically selecting one head on a fixed-head system
 - Once the track is selected, the disk controller waits until the appropriate sector rotates to line up with the head
- Seek time
 - On a movable-head system, the time it takes to position the head at the track
- Rotational delay (*latency time*)
 - The time it takes for the beginning of the sector to reach the head
- Bloc access time (*access time*)
 - The sum of the seek time, the latency time, and the transfer time
- Transfer time
 - Once the head is in position, the read or write operation is then performed as the sector moves under the head
 - This is the data transfer portion of the operation

Table 7.2

Typical Hard Disk Drive Parameters

Characteristics	HGST Ultrastar HE	HGST Ultrastar C15K600	Toshiba L200
Application	Enterprise	Data Center	Laptop
Capacity	12 TB	600 GB	500 GB
Average seek time	8.0 ms read 8.6 ms write	2.9 ms read 3.1 ms write	11 ms
Spindle speed	7200 rpm	15,030 rpm	5400 rpm
Average latency	4.16	< 2 ms	5.6 ms
Maximum sustained transfer rate	255 MB/s	1.2 GB/s	3 GB/s
Bytes per sector	512/4096	512/4096	4096
Tracks per cylinder (number of platter surfaces)	8	6	4
Cache	256 MB	128 MB	16 MB
Diameter	3.5 in (8.89 cm)s	2.5 in (6.35 cm)	2.5 in (6.35 cm)
Maximum areal density (Gb/cm ²)	134	82	66

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