Mass-Storage Systems

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The First Commercial Disk Drive

1956
IBM RAMDAC computer included the IBM Model 350 disk storage system

5M (7 bit) characters
50 x 24 inch platters
Access time = < 1 second

Magnetic Tape

- Was early secondary-storage medium
  - Evolved from open spools to cartridges
- Relatively permanent and holds large quantities of data
- Access time slow
- Random access ~1000 times slower than disk
- Mainly used for backup, storage of infrequently-used data, transfer medium between systems
- Kept in spool and wound or rewound past read-write head
- Once data under head, transfer rates comparable to disk
  - 140MB/sec and greater
- 200GB to 1.5TB typical storage
- Common technologies are LTO-{3,4,5} and T10000

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Modern Disk Drive

3.5 inch SATA HDD

Different Sized Disk Drives

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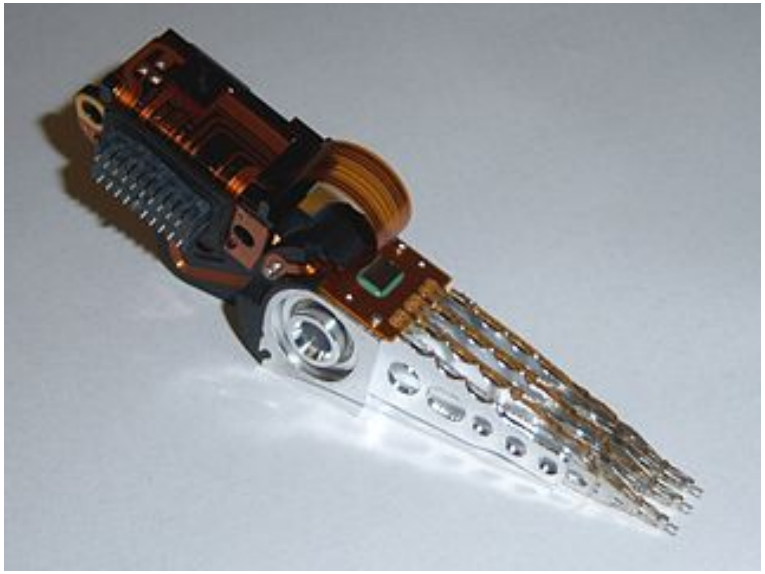
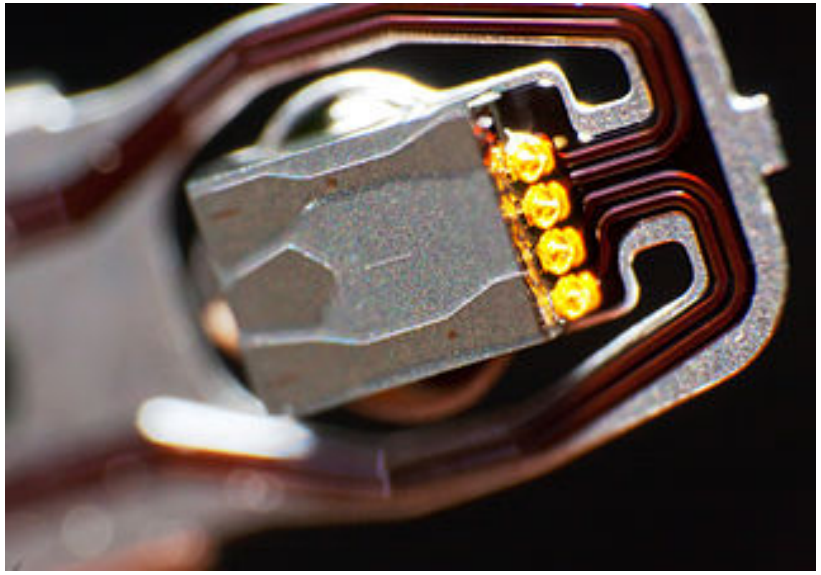
Read-Write Arm and Head



Head stack



Read-write head

Solid-State Drive (SSD)

SSDs use microchips which retain data in non-volatile memory chips and contain no moving parts

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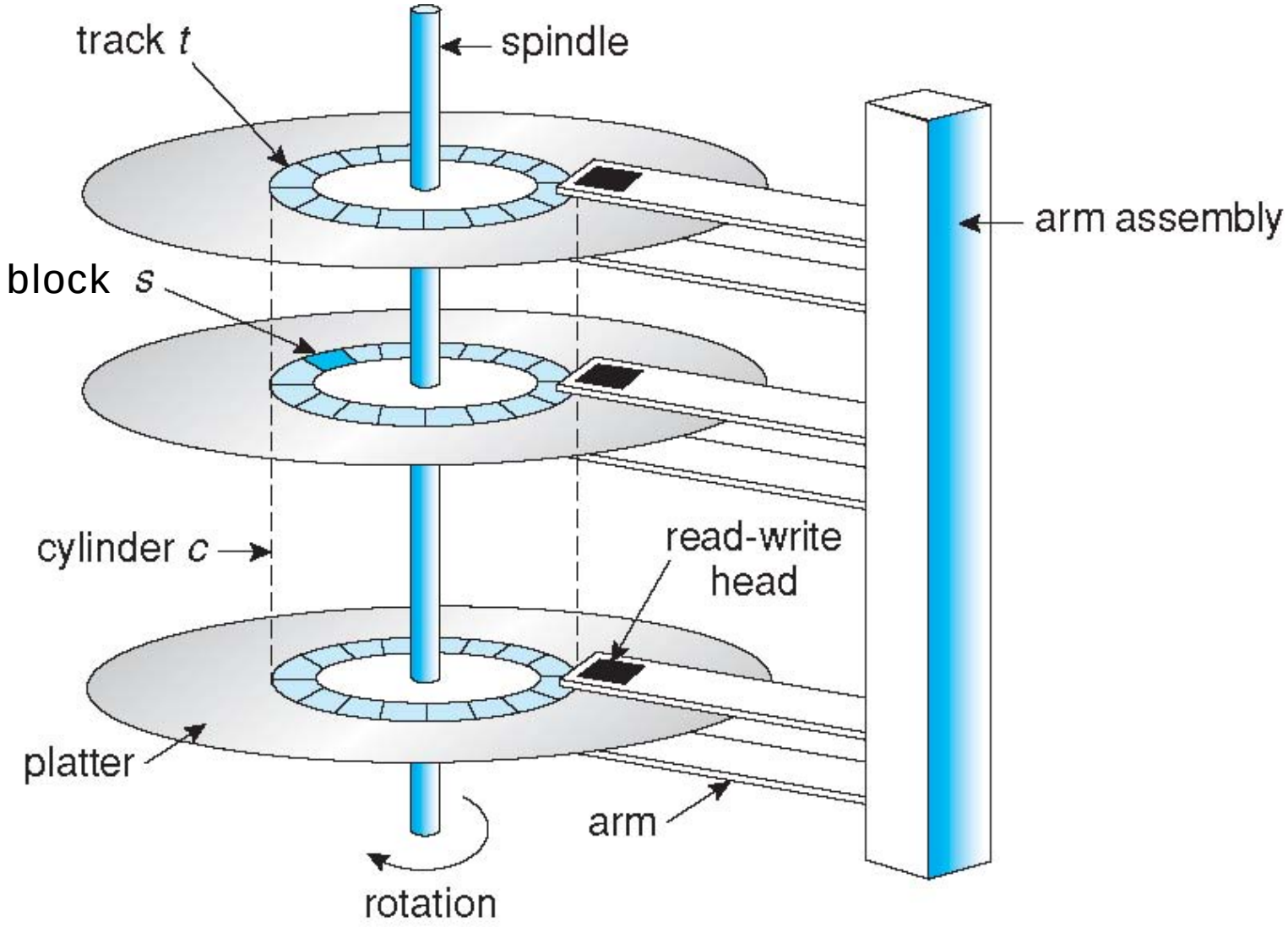
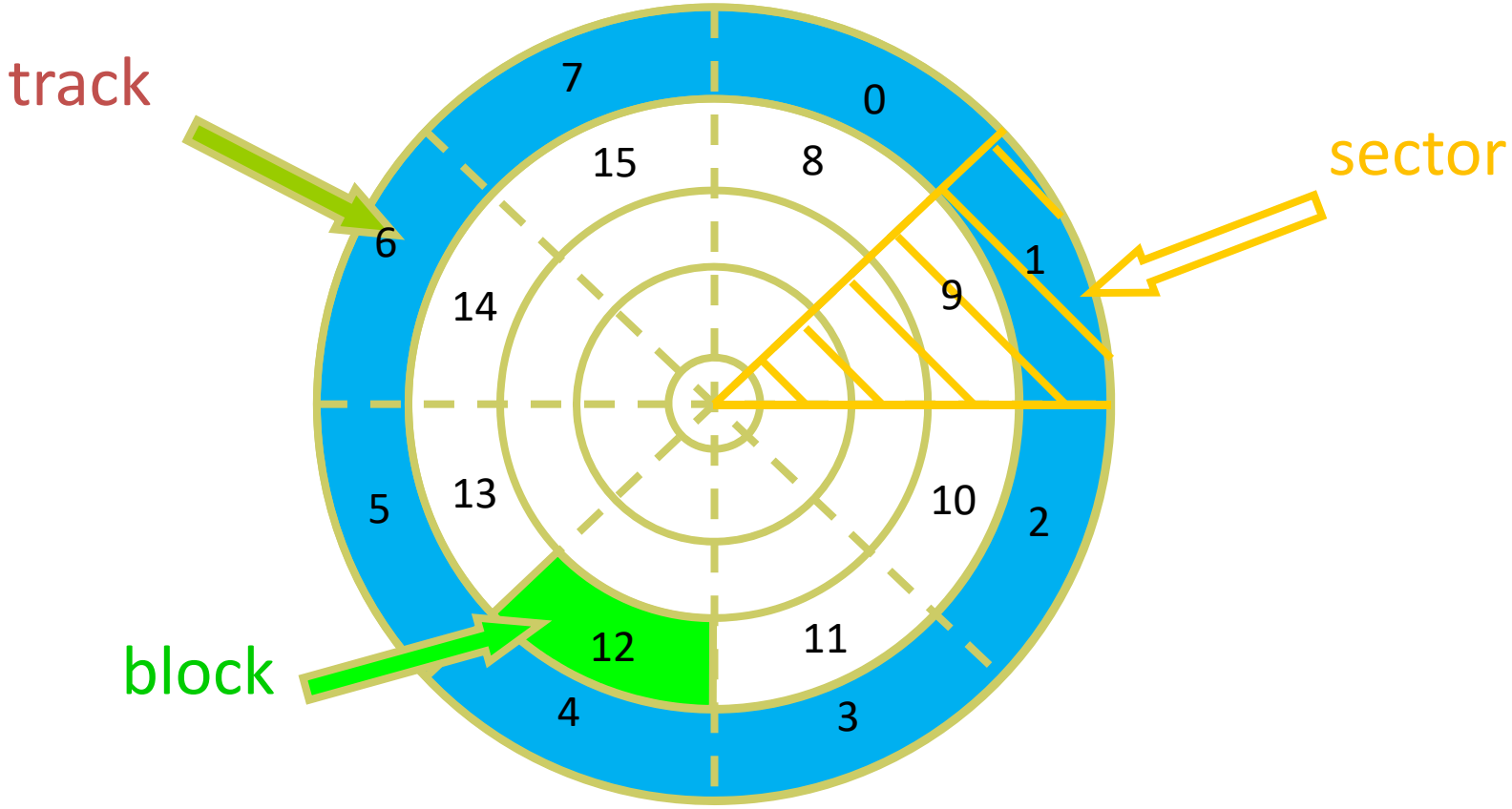
Moving-head Disk Mechanism

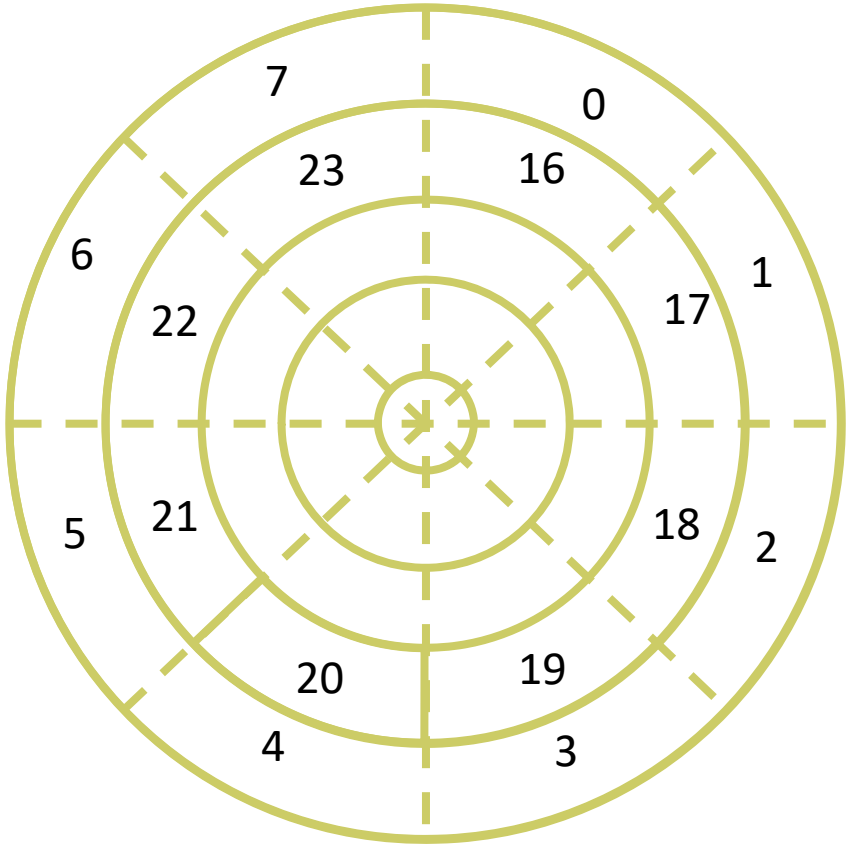


Disk Structure

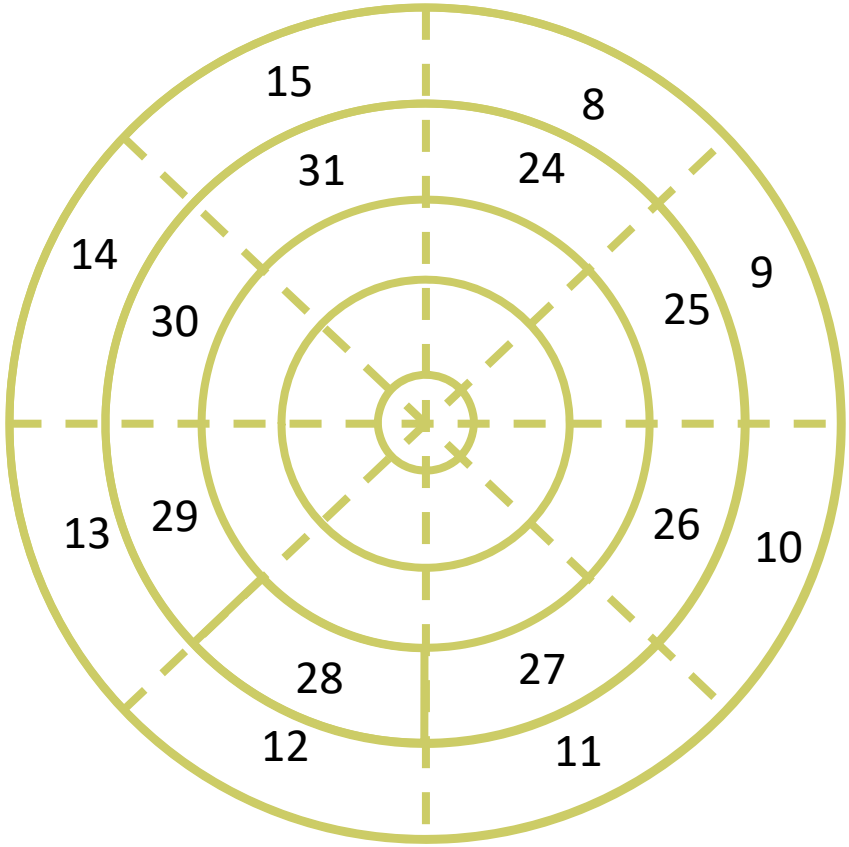


0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	.....

Disk Structure



Platter 0



Platter 1

Overview of Mass Storage Structure

- **Magnetic disks** provide bulk of secondary storage of modern computers
  - Drives rotate at 60 to 250 times per second
  - **Transfer rate** is rate at which data flows between drive and computer
  - **Positioning time** (**random-access time**) is time to move disk arm to desired cylinder (**seek time**) and time for desired sector to rotate under the disk head (**rotational latency**)

Disk Scheduling

- There are many sources of disk I/O request
  - OS, System processes, Users processes
- OS maintains queue of requests, per disk or device
- Idle disk can immediately work on I/O request, busy disk means work must be queued
  - Optimization algorithms only make sense when a queue exists
- The operating system is responsible for using hardware efficiently — for the disk drives, this means having a fast access time and disk bandwidth
  - Minimize seek time ≈ seek distance
  - What about rotational latency?
    - Difficult for OS to calculate
- Several algorithms exist to schedule the servicing of disk I/O requests
- We illustrate scheduling algorithms with a request queue (0-199)

  98, 183, 37, 122, 14, 124, 65, 67 Head pointer 53

Disk-Scheduling Algorithms

- First-Come, First-Served (FCFS) Scheduling
- Shortest Seek Time First (SSTF) Scheduling
- SCAN Scheduling
- C-SCAN Scheduling
- LOOK/C-LOOK Scheduling

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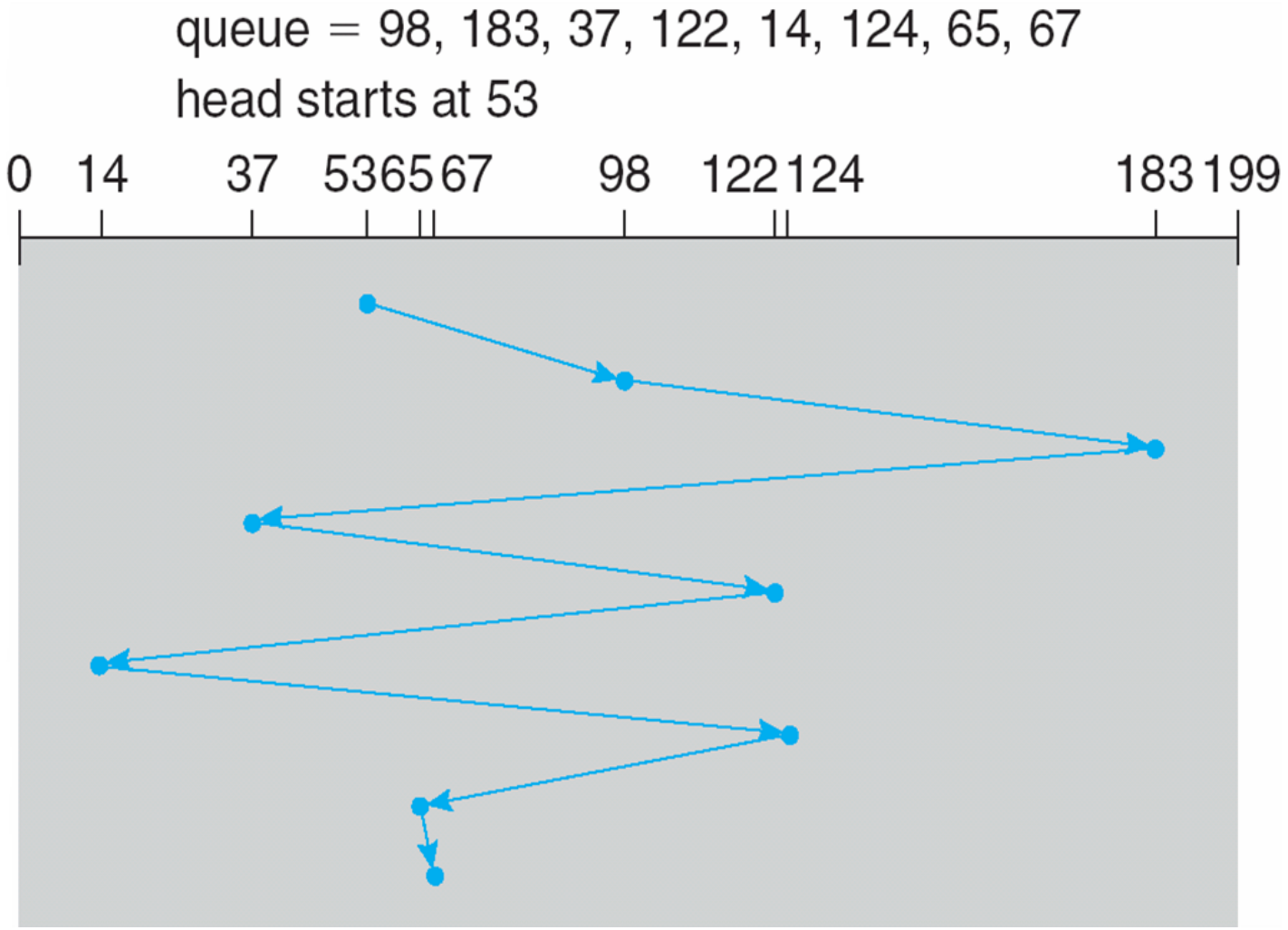
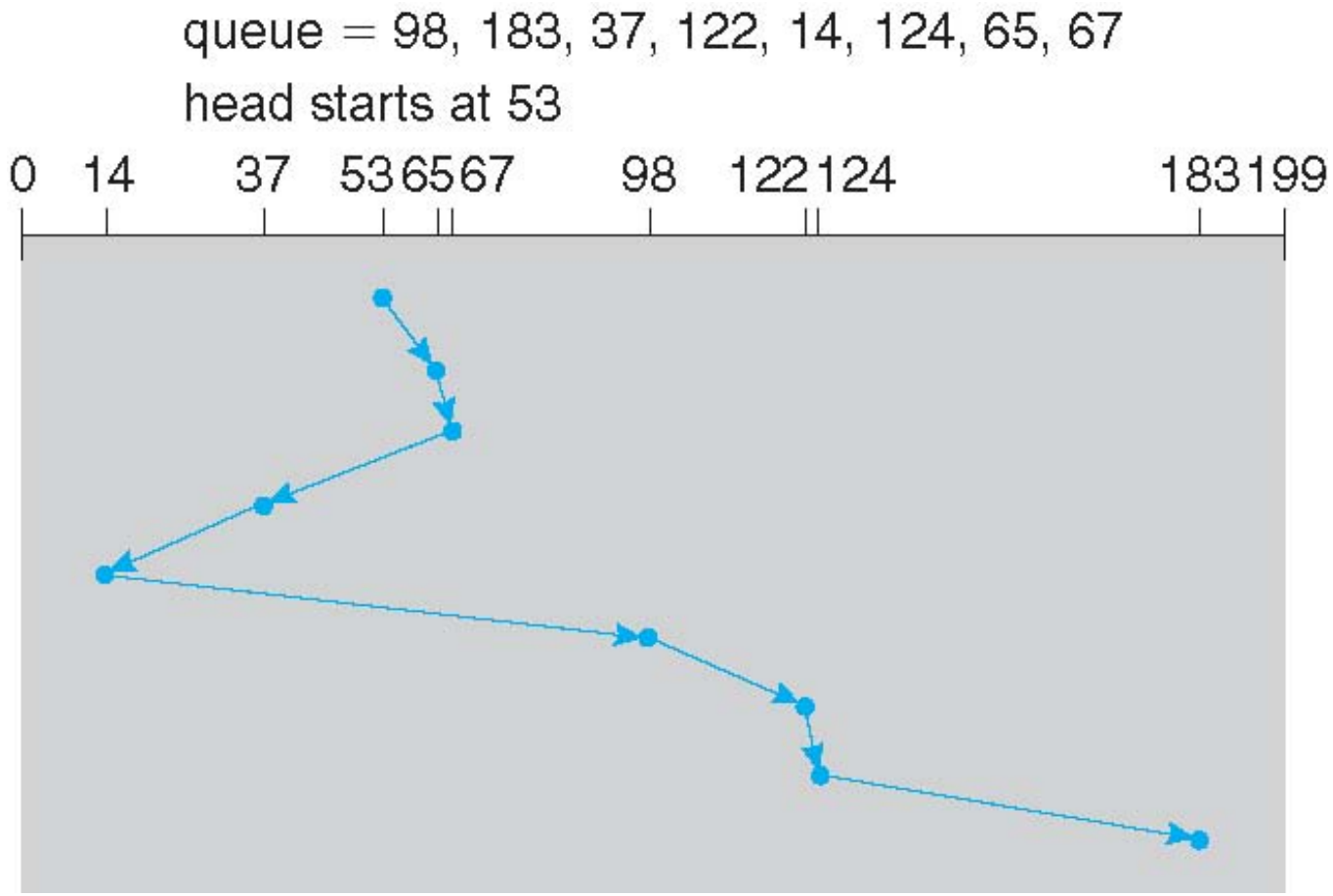
FCFS Scheduling



Total head movement: 640 cylinders

SSTF Scheduling

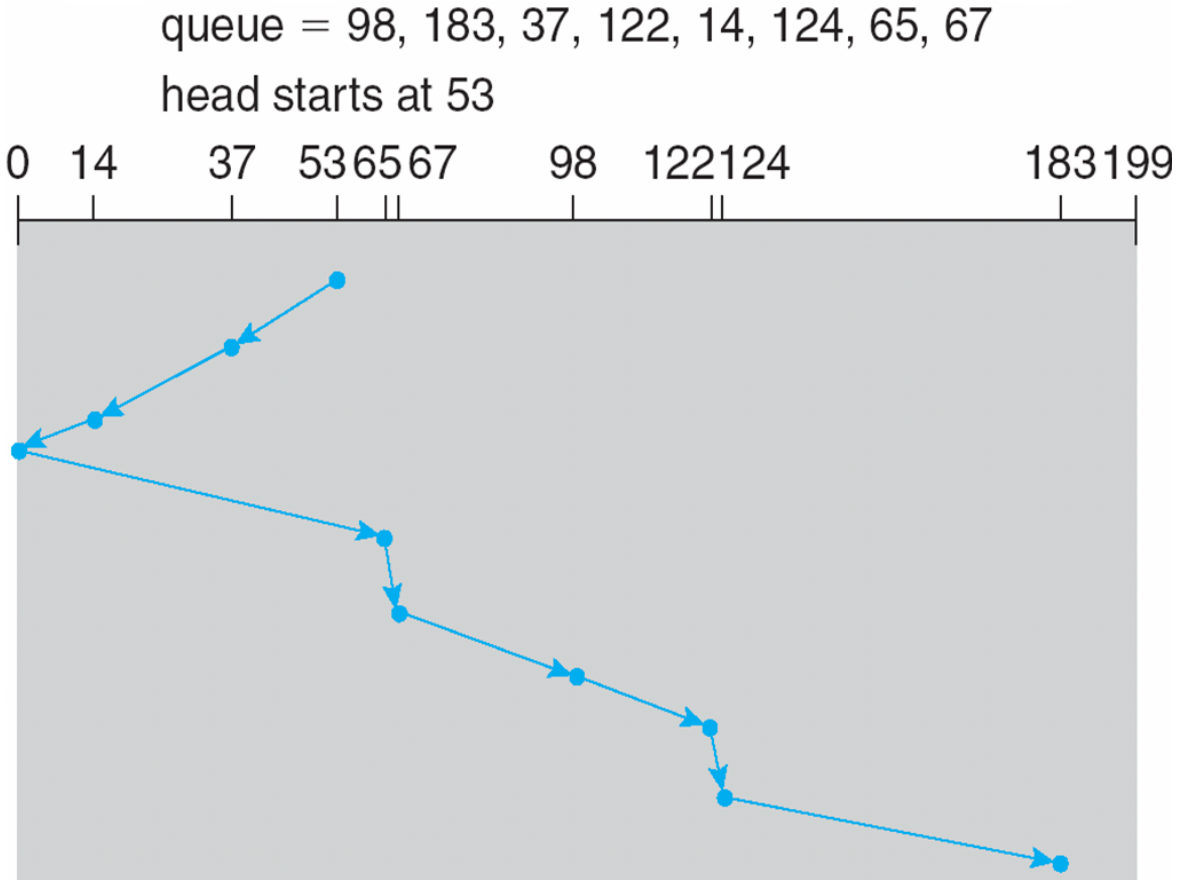
- Shortest Seek Time First selects the request with the minimum seek time from the current head position



Total head movement: 236 cylinders.

SCAN

- The disk arm starts at one end of the disk, and moves toward the other end, servicing requests until it gets to the other end of the disk, where the head movement is reversed and service continues.



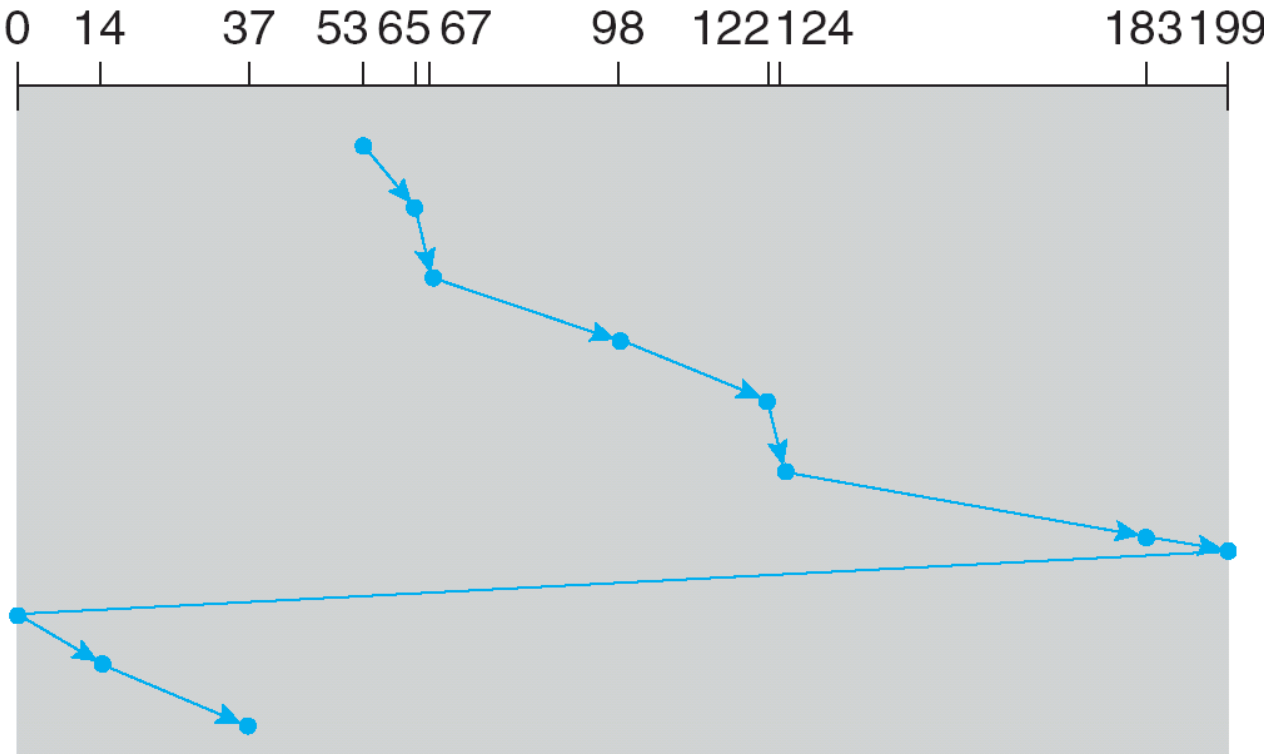
Total head movement: 236 cylinders

C-SCAN

- The head moves from one end of the disk to the other, servicing requests as it goes. When it reaches the other end, it immediately returns to the beginning of the disk, without servicing any requests on the return trip.

queue = 98, 183, 37, 122, 14, 124, 65, 67

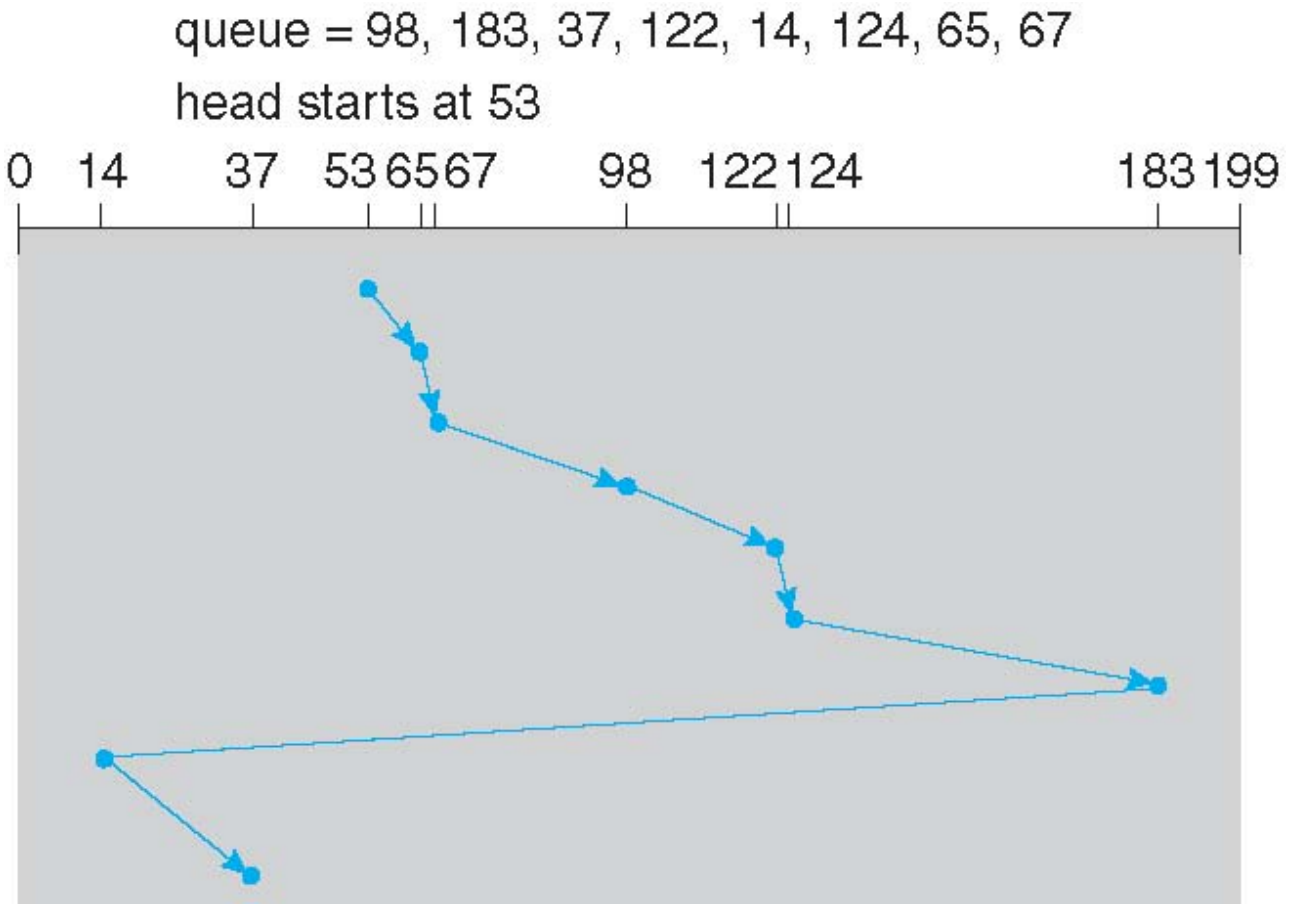
head starts at 53



Total head movement: 382 cylinders

C-LOOK

- Arm only goes as far as the last request in each direction, then reverses direction immediately, without first going all the way to the end of the disk



Total head movement: 322 cylinders

Pop-Quiz

- Suppose that a disk drive has 5,000 cylinders, numbered 0 to 4999. The drive is currently serving a request at cylinder 143, and the previous request was at cylinder 125. The queue of pending requests, in FIFO order, is:
  - 86,1470,913,1774,948,1509,1022,1750,130

- Starting from the current head position, what is the total distance (in cylinders) that the disk arm moves to satisfy all the pending requests for each of the following disk-scheduling algorithms?
  a) SSTF
  b) C-LOOK

Homework

- Reading
  - Chapter 11
- Exercise
  - See course website