Key points:

- Device Basics
    - Status, command, and data registers
    - Polling
    - Interrupts
        - livelock
        - coalescing
    - Programmed I/O
    - DMA
    - Interaction:
        - I/O instructions
        - memory-mapped IO
    - Device drivers
- Hard disk drives
    - Block device (read/write in terms of fixed-size units)
        - Array abstraction
        - Atomic sector writes
    - Internals
        - Rotates at fixed speed (e.g., 7200 RPM)
        - Has r/w head
        - Has > 1 platter
            - comprised of tracks (concentric circles)
            - each platter has 2 surface (top and bottom)
        - Zones
        - Caching
        - Skew
    - Disk operations
        - Seek
        - Rotate
        - Transfer
    - Estimating performance
        - IO time = seek time + rotation time + transfer time
    - Types of IO:
        - Sequential IO
        - Random IO
    - Disk Scheduling
        - shortest job first (SSTF, NBF)
        - Elevator scan
        - SPTF

Homework Questions/Problems:

1. What is a device driver? What does a generic protocol between the system and the device look like?
2. How does the device driver know how to signal an interrupt the OS when a task is done?
3. When are interrupts better than polling?
4. What is the common principle behind DMA and interrupts?
5. What are the three components of I/O delay? Which components dominate the cost of a read/write?
6. Why is a sequential write better than a random write? Would it be true if you could only do one block in a single write operation?
7. Will disk bandwidth be higher than outer zones or inner zones?
8. Assume a disk has bandwidth of 100 MB/s. How long will it take to transfer 1 GB?
9. Assume the disk can do 150 random IOs per second. How long will it taken to transfer 1 GB that is scattered all over the disk?
10. Assume the disk takes 10 ms on average to read/write a random block. How many IO operations can it do per second?
11. Assume the disk takes 6 ms to do any seek, and 2 ms for any rotation. The disk bandwidth is 100 MB/s. The track size is 10 MB. Estimate how long it will take to read 100 tracks in order.
12. The RPM of a drive is 15000. How long does it take to finish one complete rotation?
13. If the disk has a transfer rate of 100 MB/s, how long does it take to transfer 4096 bytes?
14. All the algorithms we discussed are greedy: they simply pick the next best option. Why do you think this is the case?

Chapter 37 includes a disk.py (at the end of the chapter) that allows you to solve many such problems. Check it out and use it for practice!