

# How Hard Disks Work

by [Marshall Brain](#)

Nearly every [desktop computer](#) and [server](#) in use today contains one or more hard-disk drives. Every [mainframe](#) and [supercomputer](#) is normally connected to hundreds of them. You can even find VCR-type devices and [camcorders](#) that use hard disks instead of [tape](#). These billions of hard disks do one thing well -- they store changing digital information in a relatively permanent form. They give computers the ability to remember things when the power goes out.

In this edition of [HowStuffWorks](#), we'll take apart a hard disk so that you can see what's inside, and also discuss how they organize the gigabytes of information they hold in files!

## Hard Disk Basics

Hard disks were invented in the 1950s. They started as large disks up to 20 inches in diameter holding just a few [megabytes](#). They were originally called "fixed disks" or "Winchesters" (a code name used for a popular IBM product). They later became known as "hard disks" to distinguish them from "[floppy disks](#)." Hard disks have a **hard platter** that holds the magnetic medium, as opposed to the flexible plastic film found in tapes and floppies.

At the simplest level, a hard disk is not that different from a [cassette tape](#). Both hard disks and cassette tapes use the same **magnetic** recording techniques described in [How Tape Recorders Work](#). Hard disks and cassette tapes also share the major benefits of magnetic storage -- the magnetic medium can be easily erased and rewritten, and it will "remember" the magnetic flux patterns stored onto the medium for many years.

Let's look at the big differences between cassette tapes and hard disks:

- The magnetic recording material on a cassette tape is coated onto a thin plastic strip. In a hard disk, the magnetic recording material is layered onto a high-precision aluminum or glass disk. The hard-disk platter is then polished to mirror-type smoothness.
- With a tape, you have to fast-forward or reverse to get to any particular point on the tape. This can take several minutes with a long tape. On a hard disk, you can move to any point on the surface of the disk almost instantly.
- In a cassette-tape deck, the read/write head touches the tape directly. In a hard disk, the read/write head "flies" over the disk, never actually touching it.
- The tape in a cassette-tape deck moves over the head at about 2 inches (about 5.08 cm) per second. A hard-disk platter can spin underneath its head at speeds up to 3,000 inches per second (about 170 mph or 272 kph)!
- The information on a hard disk is stored in extremely small magnetic domains compared to a cassette tape's. The size of these domains is made possible by the precision of the platter and the speed of the medium.

Because of these differences, a modern hard disk is able to store an amazing amount of information in a small space. A hard disk can also access any of its information in a fraction of a second.

A typical desktop machine will have a hard disk with a capacity of between 10 and 40 [gigabytes](#). Data is stored onto the disk in the form of **files**. A file is simply a named collection of [bytes](#). The bytes might be the [ASCII codes](#) for the characters of a text file, or they could be the instructions of a software application for the computer to execute, or they could be the records of a data base, or they could be the pixel colors for a GIF image. No matter what it contains, however, a file is simply a string of bytes. When a program running on the computer requests a file, the hard disk retrieves its bytes and sends them to the [CPU](#) one at a time.

There are two ways to measure the performance of a hard disk:

- **Data rate** - The data rate is the number of bytes per second that the drive can deliver to the CPU. Rates between 5 and 40 megabytes per second are common.
- **Seek time** - The seek time is the amount of time between when the CPU requests a file and when the first byte of the file is sent to the CPU. Times between 10 and 20 milliseconds are common.

The other important parameter is the **capacity** of the drive, which is the number of bytes it can hold.

## Inside a Hard Disk

The best way to understand how a hard disk works is to take a look inside. (Note that **OPENING A HARD DISK RUINS IT**, so this is not something to try at home unless you have a defunct drive.)

Here is a typical hard-disk drive:



It is a sealed aluminum box with controller electronics attached to one side. The electronics control the read/write mechanism and the [motor](#) that spins the platters. The electronics also assemble the magnetic domains on the drive into bytes (reading) and turn bytes into magnetic domains (writing). The electronics are all contained on a small board that detaches from the rest of the drive:



Underneath the board are the connections for the motor that spins the platters, as well as a highly-filtered vent hole that lets internal and external air pressures equalize:



Removing the cover from the drive reveals an extremely simple but very precise interior:



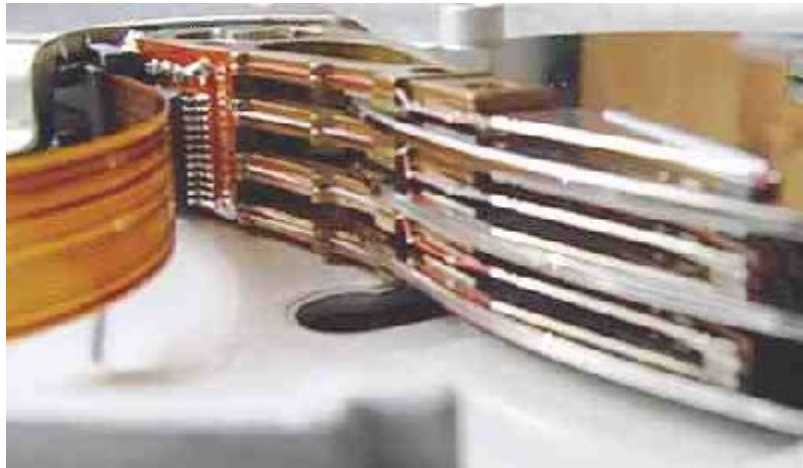
In this picture you can see:

- The **platters**, which typically spin at 3,600 or 7,200 rpm when the drive is operating. These platters are manufactured to amazing tolerances and are mirror-smooth (as you can see in this interesting self-portrait of the author... no easy way to avoid that!).
- The **arm** that holds the read/write heads is controlled by the mechanism in the upper-left corner, and is able to move the heads from the hub to the edge of the drive. The arm and its movement mechanism are extremely light and fast. The arm on a typical hard-disk drive can move from hub to edge and back up to 50 times per second -- it is an amazing thing to watch!

In order to increase the amount of information the drive can store, most hard disks have **multiple platters**. This drive has three platters and six read/write heads:







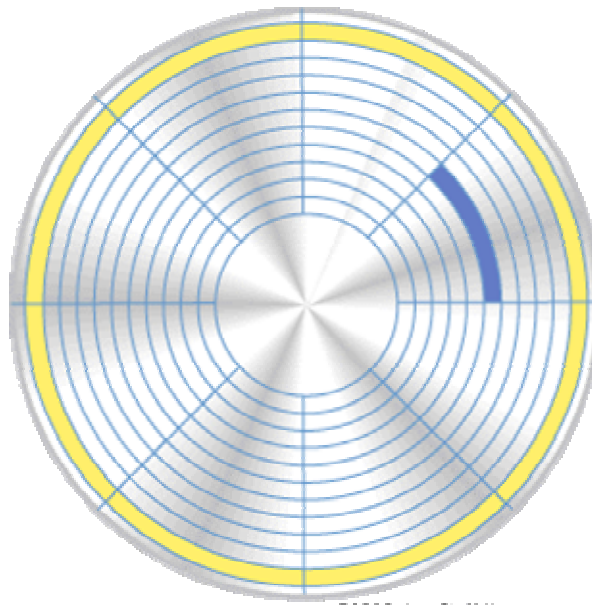
The mechanism that moves the arms on a hard disk has to be incredibly fast and precise. It can be constructed using a high-speed linear motor.



Many drives use a "**voice coil**" approach -- the same technique used to move the cone of a [speaker](#) on your stereo is used to move the arm.

## Storing the Data

Data is stored on the surface of a platter in **sectors** and **tracks**. Tracks are concentric circles, and sectors are pie-shaped wedges on a track, like this:



A typical track is shown in yellow; a typical sector is shown in blue. A sector contains a fixed number of bytes -- for example, 256 or 512. Either at the drive or the [operating system](#) level, sectors are often grouped together into **clusters**.

The process of **low-level formatting** a drive establishes the tracks and sectors on the platter. The starting and ending points of each sector are written onto the platter. This process prepares the drive to hold blocks of bytes. **High-level formatting** then writes the file-storage structures, like the file-allocation table, into the sectors. This process prepares the drive to hold files.