



Tuesday's Tip

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How Stuff Works

September 16, 2014

Howstuffworks.com is a great Website to visit if you want to understand the basics of almost any technological process. There is much more to the site, but it's a go-to for 'plain English' descriptions of our modern technology.

The staff writers at the site (all entries are signed) make even complicated processes understandable, and all entries contain links to related items at the end, as well as detailed sources. The only down-side to the site, is the many sponsors' ads that support it. If you can tune them out, there is much to gain from a look at this resource!

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How Digital Cameras Work

by Karim Nica, Tracy V. Wilson and Gerald Gurevich

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COOL FACTS

- With a 3-megapixel camera, you can take a higher-resolution picture than most computer monitors can display.
- You can use your Web browser to view digital pictures taken using the JPEG format.
- The first consumer-oriented digital cameras were sold by Kodak and Apple in 1994.
- In 1996, Sony inadvertently sold more than 700,000 camcorders with a limited ability to see through clothes.

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Digital Camera Basics

Let's say you want to take a picture and e-mail it to a friend. To do this, you need the image to be represented in the language that computers recognize -- bits and bytes. Essentially, a digital image is just a long string of 1s and 0s that represent all the tiny colored dots -- or pixels -- that collectively make up the image. (For information on sampling and digital representations of data, see this explanation of the digitization of sound waves. Digitizing light waves works in a similar way.)

If you want to get a picture into this form, you have two options:

- You can take a photograph using a conventional film camera, process the film chemically, print it onto photographic paper and then use a digital scanner to sample the print (record the pattern of light as a series of pixel values).
- You can directly sample the original light that bounces off your subject, immediately breaking that light pattern down into a series of pixel values -- in other words, you can use a digital camera.

At its most basic level, this is all there is to a digital camera. Just like a conventional camera, it has a series of lenses that focus light to create an image of a scene. But instead of focusing this light onto a piece of film, it focuses it onto a semiconductor device that records light electronically. A computer then breaks this electronic information down into digital data. All the fun and interesting features of digital cameras come as a direct result of this process.

In the next few sections, we'll find out exactly how the camera does all this.

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How Digital Cameras Work

Introduction to How Digital Cameras Work

The digital camera is one of the most remarkable inventions of this era because it is so truly different from its predecessor. Conventional cameras depend entirely on chemical and material processes -- you don't even need electricity to operate them. On the other hand, all digital cameras have a built-in computer, and all of them record images electronically.

The new approach has been enormously successful. Even film still provides better picture quality, digital cameras have not completely replaced conventional cameras. But as digital imaging technology has improved, digital cameras have rapidly become more popular.

In this article, we'll find out exactly what's going on inside these amazing digital-image devices.



CCD vs CMOS

- With a digital camera, you can take a high-resolution picture that most computer monitors can display.
- You can use your file browser to view digital pictures taken using the PRC format.
- The first commercial digital cameras were sold by Kodak and Apple in 1991.
- In 1995, Sony introduced what was then the first digital camera with a built-in video camera.

Digital Camera Basics

Let's say you want to take a picture and email it to a friend. To do this, you need the image to be represented in the language that computers recognize -- bits and bytes. Basically, a digital image is just a long string of 1s and 0s that represent all the tiny colored dots -- or pixels -- that collectively make up the image. (For information on sampling and digital representations of data, see the explanation of the digitization of sound waves. Digitizing light waves works in a similar way.)

If you want to get a picture into this form, you have two options:

- You can take a photograph using a conventional film camera, process the film chemically, print it onto photographic paper, and then use a digital scanner to sample the print (send the pattern of light as a series of pixel values).
- You can take a picture into this form, immediately breaking that light pattern down into a series of pixel values -- in other words, you can use a digital camera.

CCD and CMOS: Filmless Cameras

Instead of film, a digital camera has a sensor that converts light into electrical charges.

The image sensor employed by most digital cameras is a charge-coupled device (CCD). Some cameras use complementary metal-oxide semiconductor (CMOS) technology instead. Both CCD and CMOS image sensors convert light into electrons. If you're not too sure about the details, you already understand one of the pieces of technology used to perform the conversion. It's amplified only to think about these sensors in terms of a 2-D array of thousands or millions of tiny color wells.


Once the camera converts the light into electrons, it needs the voltage (accumulated energy) of each well in the image. This is where the differences between the two main sensor types begin:

- A CCD transports the charge across the chip and reads it at one corner of the array. In looking for digital scores for (MCC) then turns each pixel's value into a digital value by measuring the amount of charge at each pixel and converting that measurement to binary form.
- CMOS devices use several transistors at each pixel to amplify and move the charge using more traditional wires.

Differences between the two types of sensors lead to a number of pros and cons:

- CCD sensors create high-quality, low-noise images. CMOS sensors are generally more susceptible to noise.
- Because each pixel on a CMOS sensor has several transistors located next to it, the light sensitivity of a CMOS chip is lower. Many of the photons hit the transistors instead of the photoelements.
- CMOS sensors traditionally consume little power. CCDs, on the other hand, use a process that consumes lots of power. CMOS sensors as much as 10 times more power than an equivalent CMOS sensor.
- CMOS sensors have been mass-produced for a longer period of time, so they are more mature. They tend to have higher quality pixels, and more of them.

Although numerous differences exist between the two sensors, they both play the same role in the camera -- they turn light into electricity. For the purpose of understanding how a digital camera works, you can think of them as nearly identical devices.

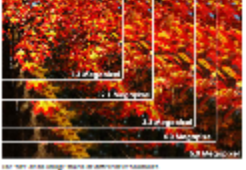


Digital Camera Resolution

The amount of detail that the camera can capture is called the resolution, and it is measured in pixels. The more pixels a camera has, the more detail it can capture and the larger pictures can be without becoming blurry or "grainy."

Some typical resolutions include:

- 2048x1536 - Found on very sharp cameras, this resolution is so low that the picture quality is almost always unrecognizable. This is 32,000 total pixels.
- 1024x768 - This is the low end on most "real" cameras. This resolution is best for emailing pictures or posting pictures on a Web site.
- 1280x800 - This is a "megapixel" image size -- 1,024,000 total pixels -- good for printing pictures.
- 1800x1200 - With almost 2 million total pixels, this is "high resolution." You can print a 6x6 inch print taken at this resolution with the same quality that you could get from a photo lab.
- 3264x1888 - Found on 5-megapixel cameras -- the current standard -- this allows you



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How Telescopes Work
by Craig Freudenrich, Ph.D.

Enlarge the article How Telescopes Work

space exploration picture

Introduction to How Telescopes Work
Maybe you've been out looking at the stars in the night sky, searching for constellations, or maybe you've already learned your way around the constellations, and now you'd like to take a closer look - at objects like the moon, planets or stars - with the aid of a telescope.
A telescope is a device used to magnify distant objects. There are many types to choose from, and many price ranges to consider. How do you know which one is best for you? How can you be sure that you won't be disappointed when you take your new telescope out to see the stars?
In this article, we will examine how a telescope works, discuss the various types of telescopes and take a look at telescope mounts and accessories.

How They Work
A telescope is an amazing device that has the ability to make faraway objects appear much closer. Telescopes come in all shapes and sizes, from a little plastic tube you buy at a toy store for \$2, to the Hubble Space Telescope, which weighs several tons. Amateur telescopes fit somewhere in between, and even though they are not nearly as powerful as the Hubble, they can do some incredible things. For example, a small 6-inch (15 centimeter) scope lets you read the writing on a dime from 150 feet (55 meters) away!
Most of the telescopes you see today come in one of two flavors:
• The refractor telescope, which uses glass lenses.
• The reflector telescope, which uses mirrors instead of the lenses.
Both types accomplish exactly the same thing, but in completely different ways.
To understand how telescopes work, let's ask the following question: Why can't you see an object that is far away? For example, why can't you read the writing on a dime when it is 150 feet (55 meters) away with your naked eyes? The answer to this question is simple: the object does not take up much space on your eye's screen (retina). If you want to think about it in digital camera terms, at 150 feet the writing on the dime does not cover enough pixels on your retina sensor for you to read the writing.

Refractor
Focus
Incoming light is bent into a bright point.
Objective lens
gathers light and bends it into focus.
Pupil of the Eye
Eyepiece
images the bright image from the focus and magnifies it to the size of your eye's pupil.
Incoming light

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This is the simplest telescope design you could have. A big lens gathers the light and directs it to a focal point and a small lens brings the image to your eye.

SCAfterSmallInset
digital camera terms, at 150 feet the writing on the dime does not cover enough pixels on your retina sensor for you to read the writing.

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