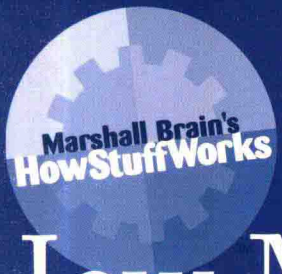
[. . . named **Best of the Web** by *Time Magazine*]



How Much Does the Earth Weigh?

What is Linux?

How do motion sensors work?

Can mood rings really tell my mood?

How does caller ID work?

Why shouldn't dogs eat chocolate?

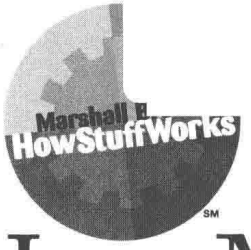
How do trick birthday candles work?

What does it mean to have 20/20 vision?

Why is root beer called root beer?

home appliances use the most power?

Plus dozens of other engaging questions and answers from Marshall Brain and the award-winning team at HowStuffWorks!



How Much Does the Earth Weigh?

Hungry Minds™

Best-Selling Books • Digital Downloads • e-Books • Answer Networks • e-Newsletters • Branded Web Sites • e-Learning

New York, NY • Cleveland, OH • Indianapolis, IN

Hungry Minds™

Published by
Hungry Minds, Inc.
909 Third Avenue
New York, NY 10022
www.hungryminds.com

For general information on Hungry Minds' products and services please contact our Customer Care Department within the U.S. at 800-762-2974, outside the U.S. at 317-572-3993 or fax 317-572-4002.

For sales inquiries and reseller information, including discounts, premium and bulk quantity sales, and foreign-language translations, please contact our Customer Care Department at 800-434-3422, fax 317-572-4002, or write to Hungry Minds, Inc., Attn: Customer Care Department, 10475 Crosspoint Boulevard, Indianapolis, IN 46256.

Library of Congress Cataloging-in-Publication Data available from the publisher.
ISBN: 0-7645-6519-2

How Stuff Works, Inc.
Editor in Chief: Marshall Brain
Editorial Director: Katherine Fordham Neer
Art Director: Rick Barnes
Contributing Writers: Marshall Brain, Kevin Bonsor, Craig Freudenrich, Ph.D., Tom Harris, Karim Nice, and Jeff Tyson
Production Assistant: Sally Guaspari

Hungry Minds, Inc.
Vice President and Publisher: Kathy Nebenhaus
Editorial Director: Cindy Kitchel
Creative Director: Michele Laseau
Special Editorial Assistance: S. Kristi Hart, Brian Hahn

Cover and Layout Design: Michele Laseau, HMI; Rick Barnes, HSW; Cynthia Anderson, Studio Alchemy; and Alex Mabilon
For more cool questions and answers visit www.howstuffworks.com
Manufactured in the United States of America.
10-9-8-7-6-5-4-3-2-1

How Much Does the Earth Weigh?

Hello!

Readers send hundreds of questions to us at How Stuff Works every day. We answer many of them by email and in the forums. But we pick one especially good question to publish as the official "Question of the Day" each morning.

The question of the day is a long tradition at How Stuff Works, and it is one of the most popular features of the site. We have a huge archive containing the hundreds of questions we have answered since the How Stuff Works Web site started, and millions of people visit the archive to find answers to their most burning questions.

In this book, I've collected over 100 of the most popular questions in the archive. These are the best of the best—the questions that readers just HAVE to know the answer to. They are truly fascinating to read through because these are the most intriguing questions on the site.

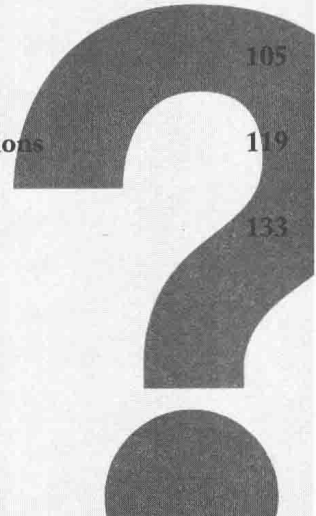
As you look through the book, you will notice two icons.

One is the Top 20 icon. It identifies the 20 most popular questions that How Stuff Works has ever covered.

Then there is the MB icon. These are my personal favorites. I don't know why, but these questions completely fascinated me or blew me away when I discovered the answer.

I'm an extremely curious person. I'm constantly trying to unearth the mysteries behind the things around me. If you, too, find yourself wondering about, well, just about everything, you will love this collection of questions. And if you have other questions, come to How Stuff Works and ask away!

Table of Contents



Now That's Entertainment!

How do the light sabers in the *Star Wars* movies work? • How do fog machines work? • How do light guns work on a video game? • How do they create the special effects in movies like *The Matrix* and in commercials where the camera rotates around a frozen actor? • How is sound recorded on motion picture films? • What does the clapperboard in movie production do? • On television, how does closed captioning work? • Why do all FM radio stations end in an odd number, such as 105.7, 93.3, and 96.9?

How do the light sabers in the *Star Wars* movies work?

Like the *Millennium Falcon*, Yoda, and even *Chitty Chitty Bang Bang* for that matter, a light saber is a special effect that looks so real you actually believe it exists.

The technique used to create the light saber effect in the original *Star Wars* film is straightforward but tedious. On the set, the actors use light sabers made of handles attached to aluminum rods of the correct length. The handles are plastic models and the aluminum rods are painted red or green or blue. The actors use these props as though they were light sabers.

After the film is shot, it is taken to the special effects department. In this initial film, the actors look like they are fighting with painted broomsticks instead of light sabers. A special-effects artist now has the job of making those broomsticks look real. The artist looks at the film frame by frame and projects each frame that contains a light saber onto a clear piece of plastic (an animation cel). The special-effects artist draws the outline of each light saber blade in the frame onto the cel. Then, for each frame, the artist paints in the correct color for the blade using a bright cartoon color. Eventually, the artist has a stack of these cels, one for each frame of the movie containing a light saber. The cels are clear everywhere except where the light saber blade is seen in each frame.

Now a new piece of movie film is shot. On this film each animation cel is placed over a black background and shot with a light diffuser over the lens; this diffuser gives the light sabers the glow they have around the edges. If you were to play this film in a projector, all you would see is the light saber blades moving on a black background. Before it is developed, however, the actual footage from the movie is double-exposed onto this same film. The effect is amazing: The light sabers look bright and real!

As movies move more into the digital realm, the job of animating the light sabers gets slightly easier — but not much. In a digital world each frame of the movie is scanned into a computer at extremely high resolution so that each frame can be manipulated on a computer screen. To make the light sabers look real, the special-effects artist looks at each frame on the computer screen,

outlines the broomsticks, colors the areas, and diffuses them (frame by frame by frame...). Instead of being done on a plastic cel, it is all done on separate "cels" in the computer's memory and then merged digitally. The animator must still look at each frame, however, and tediously outline the light saber blades one by one.

Web Links

How Blue Screen Special Effects Work

How do fog machines work?

There are three common ways to produce the fog that you often see in stage productions and at dance clubs:

- Use a fog machine that vaporizes "fog juice"
- Use dry ice
- Invite lots of cigarette smokers

Fog machines and fog juice are the most common methods. The basic mechanism is simple: The juice is heated to create smoke. When you overheat oil on the stove and create a lot of smoke, you are doing approximately the same thing. Cooking oil has a tendency to get gummy and smell bad, however. Fog machines therefore use glycerin or glycol mixed with water, such as propylene glycol and triethylene glycol mixed with 20% water. It is not known whether this fog has any side effects on people's lungs. The fog seems to be problematic for asthmatics, but nothing has been proven conclusively for the general population.

If you would rather make completely safe fog, you can use dry ice. (To find a source for dry ice, look up "ice" in the business directory — and never handle the stuff with bare hands!). When you place dry ice in hot water it creates a dense fog that clings to the floor. This fog contains carbon dioxide (CO_2)and water vapor; you want to be sure the room is ventilated so that CO_2 build-up is not a problem.

How do light guns work on a video game?

Most home video games and many arcade games can use some sort of gun as an input device. You point the gun at the screen and pull the trigger, and if you hit the target on the screen, the target explodes.

To create this effect, the gun contains a photodiode (or a phototransistor) in the barrel. The photodiode is able to sense light coming from the screen. The gun also contains a trigger switch. The output of the photodiode and the switch are fed to the computer controlling the game.

The computer receives signals from the screen driver electronics. The screen driver electronics send pulses to the computer at the start of the horizontal and vertical retrace signals so that the computer knows where the electron beam is on the screen during each frame.The computer normally uses one of two different techniques to determine whether or not the gun is pointed at the target when the user pulls the trigger:

- When the user pulls the trigger, the computer blanks the screen for one frame and then paints just the target object on the screen (as a white object). If the photodiode senses darkness after one vertical retrace signal and light after the next, the computer assumes that the gun is pointed at the target of the screen and scores a hit.
- The computer can blank the screen and then paint the entire screen white. It will take time for the electron beam to trace the entire screen while painting it white. By comparing the signal coming from the photodiode with the horizontal and vertical retrace signals, the computer can detect where the electron beam is on the screen when the photodiode first senses its light. The computer counts the number of microseconds that pass between the time the horizontal and vertical retrace signals start and the photodiode first senses light. The number of microseconds tells the computer exactly where the gun points on the screen. If the calculated position and the position of the target match, the computer scores a hit.

When you pull the trigger, you can normally see the display flash. From the type of flash you see, you can figure out which system is used.

Web Links

How Television Works

How do they create the special effects in movies like *The Matrix* and in commercials where the camera rotates around a frozen actor?

This effect is fascinating to watch! In one commercial a horse stops in mid-air and the camera pans around it. In *The Matrix* the technique is used four times only but is so startling that it leaves an impression over the entire movie.

In the commercials, a simpler technique is used than was used in the film. A collection of perhaps 30 still cameras is set up around the object. At the moment where the action should freeze, all 30 cameras fire at once. The images are played one after another to show the rotation.

In *The Matrix*, the filmmakers used an extremely sophisticated technique to accomplish much more advanced effects. In this technique, not only does the rotation occur, but the actor is also moving in slow motion during the rotation. At least five different special-effect techniques combine to create the final image:

- A large number of still cameras capture the scene, but they fire sequentially around the actor rather than all at once.
- The cameras shoot the actor on a green-screen background.
- The actor is wearing a wire suspended from the ceiling so that he can fall only partway or appear to float in mid-air.
- After the scene is shot, software similar to morphing software interpolates between the images to allow the slow-motion feel. The filmmaker can therefore slow down or speed up the action at will.