

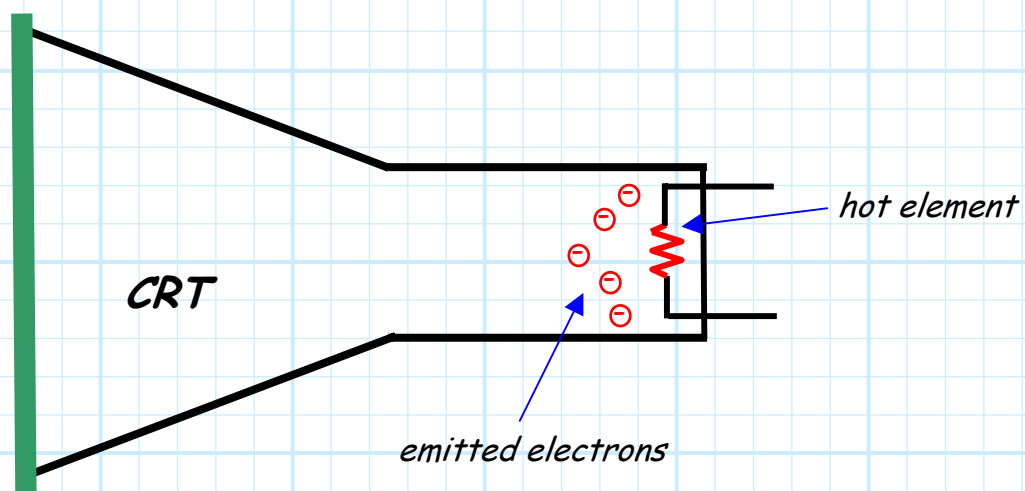
Example: The Lorentz Force Law

You are all very aware of the practical importance of the Lorentz force law! In fact, you likely **observe** its effects several times each day.

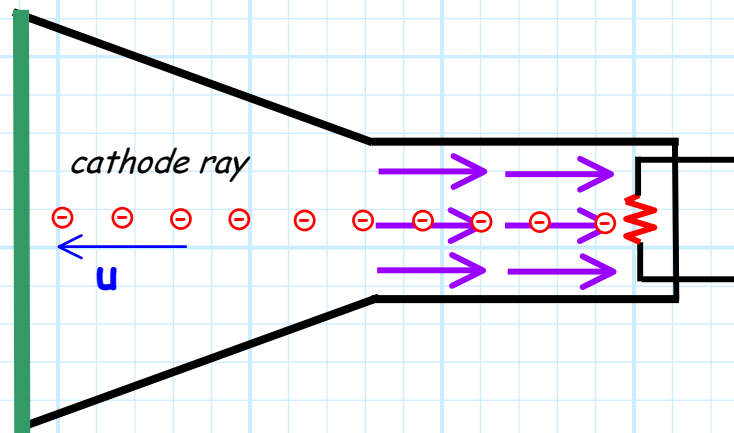


An almost perfect application of the Lorentz Force Law is the **Cathode Ray Tube (CRT)**—the device at the heart of every **television** and computer **monitor** (or, at least, the non-plasma/LED kind!).

At the very back of a CRT is an element that is heated to very high temperatures. This hot element begins to “**emit**” **electrons** into the vacuum of the CRT.

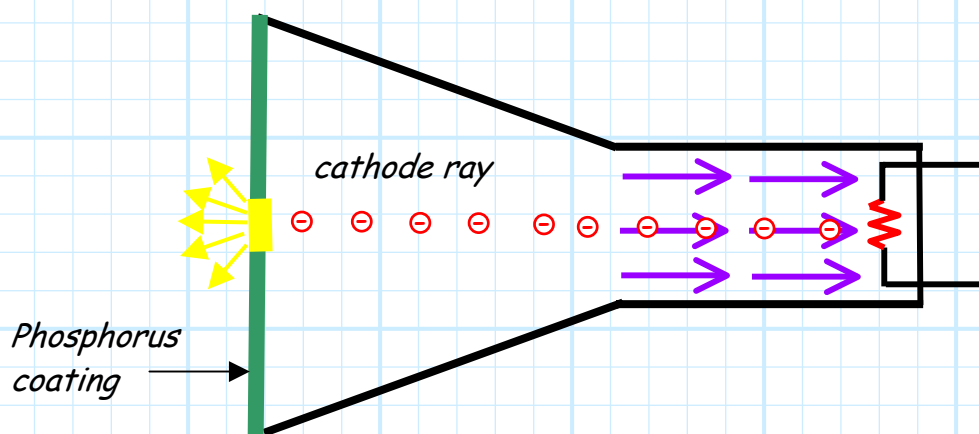


Then, an **electric field** $\mathbf{E}(\vec{r})$ with **large** magnitude is created within the tube. The resulting force ($\mathbf{F} = Q_e \mathbf{E}(\vec{r})$) accelerates the electrons toward the front, creating a stream of electrons—a “**cathode ray**”.



Since the electric field strength (i.e., the **force** on the electrons) is large, the electrons have great velocity (i.e., **kinetic energy**) when they reach the front of the CRT.

The front of the CRT is coated with **phosphorous**, and so the cathode ray “slams” into this phosphorous coating. The kinetic energy of each electron must be **dissipated** in some way. Typically, energy is dissipated as **heat** (the coating heats up), but for phosphorous, this energy is likewise dissipated in the form of **light**—the phosphorous begins to **glow!**

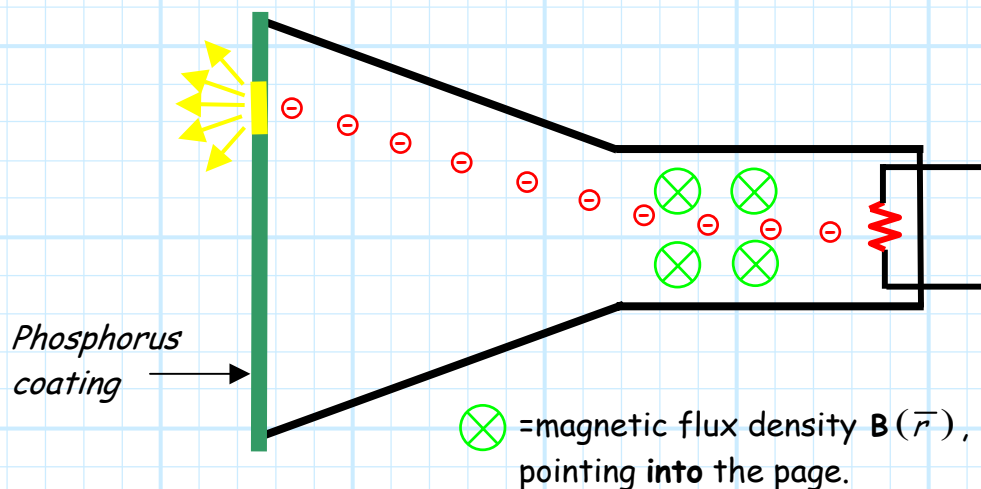


More specifically, the **spot** on the coating where the cathode ray strikes begins to glow (i.e., **fluoresces**). The **larger** the electric field, the higher the energy and thus the **brighter** the glow. Thus, we can **modulate** the light intensity by **changing** the electric field magnitude as a function of **time**.

Q: *But this electron beam would cause only **one** "pixel" to glow. How do we get the **other** pixels to emit light?*

A: This is where the **other** component of the Lorentz force Law is used!

We additionally can place a **magnetic flux density** $\mathbf{B}(\vec{r})$ within the CRT—this will cause the cathode ray to **deflect**!

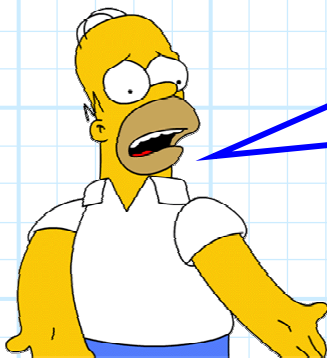


Q: *So, now we've caused a **different** pixel to glow—but how do we get all the pixels to **simultaneously** (but independently) glow? Does it require **multiple** cathode rays within the CRT?*

A: Nope! We simply **change** the magnitude and direction of $\mathbf{B}(\vec{r})$ within the CRT, and the magnitude and direction of the cathode ray **deflection** will change.

In other words, we “**scan**” the cathode ray across the screen, starting at the left end of the first “line” of pixels, and ending up at the right end of the last. As we scan, we simultaneously modulate the **electric** field, so that each pixel is the proper brightness.

The whole process is similar to how an **ink-jet printer** works (scans left to right, one line at a time)!



Q: *Wait a second! I've watched a lot of TV, and I've **never** noticed anything like that happening on my screen!*

A: There are **two** reasons that we do not **perceive** this scanning on a CRT screen. The first is that this scanning happens much too **fast** for our **feeble** minds to comprehend—**30 times every second** for standard TV.

The second reason is something called “persistence”. When a cathode ray is removed from a spot on the phosphorous coating, it does **not** immediately turn off! It “**persists**” for a little bit, staying bright just long enough for the next cathode ray “scan” to come along.

Because of these two effects, a TV picture scan seems to **meld** into one continuous, uninterrupted 2-dimensional image!

Philo T Farnsworth (1906-1971)

On September 7th, 1927, the first successful demonstration of television occurred. A mostly self-taught genius named Philo T. Farnsworth transmitted an image of a horizontal line to a receiver in the next room. Farnsworth was born on August 19th, 1906, at Indian Creek in Beaver County, Utah. At age six he told his Dad that he'd been born an inventor. An amazing young boy, he built an electric motor at age 12 and won his first national contest at age 13. In the contest sponsored by *Science and Invention Magazine*, Farnsworth created a thief proof lock. He didn't stop there.

During the summer of 1921 (**he was 15!**), Farnsworth was leading a horsedrawn plowing machine when he stopped to look over his work. He suddenly realized that just as he was plowing the field into parallel rows, he could scan an image row by row. He figured that by doing this one line at a time, with a beam of electrons inside a cathode ray tube, he might successfully transmit an image to a receiver. He went on to demonstrate the first operational, all electronic television system in 1927.

With an extension on his funding, it was May 1928 when Farnsworth transmitted a two-dimensional image of his wife and assistant Pem, to a receiver for viewing by an audience. Using a sketch kept by his high school chemistry teacher, Justin Tolman, he went on to win a legal suit against RCA. They claimed, to no avail, that their man, Vladimir Zworykin, had documented this concept first.

The monumental contribution made by Philo T. Farnsworth was not recognized before he died of emphysema on March 11, 1971, in Salt Lake City, Utah.

By Sarah Lane, from:

www.classbrain.com/artholiday/publish/article_168.shtml

