(Approx. 1307)

What is Electricity?
(Hint, the answer is not what you think)
Art Gresham, Editor, Under the Computer Hood User Group

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Several months ago, I read an article on the internet about the First Trans-Atlantic Telegraph Cable.

Significantly, it was a failure. But after laying several more cables and making some important discoveries about Electricity, cables, and technology, we all know it was a world-changing success. But that is another story.

What I want to share in this article is what followed my reading. Some of their discoveries surprised me as a college-trained Electrical Engineer (BE, EECS, Univ of New Mexico). I thought I knew how Electricity works, What it is, What it does, How it moves. However, after much research on technical websites (many of them with mathematical proofs and discussions that are almost over my head, like [https://physics.info/electric-current/,](https://physics.info/electric-current/%2C) and watching some profound videos such as those listed at the end of this article), I found out that I was wrong in almost all of my understanding.

For example, What is Electricity made of? Well, I know the answer. It is electrons.
And how fast do the electrons move? Everyone knows they move at about the speed of light.

Wrong. And Wrong.

Along with ChatGPT, I found a somewhat simplified but accurate set of questions and answers.

A. What caused the failure of the first trans-Atlantic telegraph cable?

*It failed due to a combination of technical problems, environmental factors, and human error.*

*The cable was laid in 1858 and stretched for more than 2,000 miles between Ireland and Newfoundland. At the time, it was the longest cable ever laid and represented a significant technological achievement. However, problems emerged soon after the cable was put into operation.*

*One of the main technical problems was the insulation used on the cable. The insulation was made of gutta-percha, a natural latex material that was supposed to protect the copper wires inside the cable from the seawater. However, it was discovered that the insulation was not strong enough to withstand the high voltages required for long-distance telegraphy. As a result, the cable suffered from frequent breaks and signal
interference.*

*Environmental factors also played a role in the cable's failure. The cable was laid at a depth of approximately 2 miles, which was much deeper than any previous cable. The extreme pressure and cold temperatures at this depth caused the cable to become brittle and break more easily.*

*Human error also contributed to the failure of the cable. During the initial testing of the cable, the technicians in Newfoundland used too much voltage, which caused the insulation to break down and the cable to fail.*

 *There were also problems with the equipment used to transmit and receive the telegraph signals, which led to errors in the transmission and reception of messages.*

*Despite these setbacks, the first transatlantic telegraph cable laid the foundation for future cable communications and demonstrated the potential for global communication through undersea cables.*

*Part of the cause of the failure was the technical team's lack of understanding the impact of the EMF waves when propagated under the ocean. They were working with the basic premise that it was all about the electrons moving in the cable in a linear fashion.*

**BUT...**

B. Is electricity actually an EMF wave or movement of electrons?

*Electricity can refer to both the movement of electrons and electromagnetic waves.*

*When we talk about electricity in the context of a circuit or a wire, we are usually referring to the movement of electrons through the wire. In this case, electrical energy is transmitted through the movement of charged particles, which can be electrons, ions, or other charged particles.*

 *On the other hand, when we talk about electricity in the context of electromagnetic radiation, we are referring to the propagation of electromagnetic waves. These waves consist of oscillating electric and magnetic fields that travel through space at the speed of light.*

*So, in summary, electricity can refer to both the movement of charged particles and the propagation of electromagnetic waves, depending on the context in which the term is used.*

Later research leads me to several YouTube videos trying to demonstrate the speed of electricity. (See References)

The earliest discoveries of electricity until the 1880s (see article on Tesla) dealt with simple Direct Current. So let's ask:

C. Do electrons move through a DC circuit at the speed of light?

*No, electrons do not move through a DC (direct current) circuit at the speed of light. In fact, the speed at which electrons move through a circuit is much slower than the speed of light.*

*In a DC circuit, electrons move from the negative terminal of the voltage source (such as a battery) to the positive terminal. The speed at which they move is called the drift velocity, and it depends on the material the wire is made of and the strength of the electric field in the wire. Typically, the drift velocity of electrons in a wire carrying a current is on the order of millimeters per second, which is much slower than the speed of light (which is approximately 299,792,458 meters per second in a vacuum).*

*It's worth noting that while electrons themselves move relatively slowly through a circuit, electrical energy is transmitted at the speed of light through the electric and magnetic fields surrounding the wires. This means that changes in the electric field at one end of a circuit can be detected at the other end almost instantaneously, even though the electrons themselves are moving much more slowly.*



The Drift Velocity of electrons in a copper wire is about 3 mm per second.
Drawing courtesy of <https://physics.info/electric-current/>

But what about AC (Alternating Current)? If those electrons are that slow-moving, how does the energy from a Generating Station in Arizona get here so fast, or even at all?

D. Do electrons move through an AC circuit at the speed of light?

*No, electrons do not move through an AC (alternating current) circuit at the speed of light. As with a DC circuit, the speed at which electrons move through an AC circuit is much slower than the speed of light.*

*In an AC circuit, the direction of the current periodically reverses, causing the electrons to oscillate back and forth. This oscillation is characterized by a frequency, which is the number of complete cycles of the current per second and is measured in hertz (Hz). In a typical AC circuit used for power distribution in homes and buildings, the frequency is 50 or 60 Hz.*

*The speed at which electrons move in an AC circuit is still determined by the material the wire is made of and the strength of the electric field in the wire, just as in a DC circuit. The average speed of the electrons over time is still much slower than the speed of light, typically on the order of millimeters per second.*

 *As with a DC circuit, changes in the electric field in an AC circuit propagate through the circuit at the speed of light, even though the individual electrons are not moving at anything close to that speed.*

References:

The Big Misconception About Electricity

<https://www.youtube.com/watch?v=bHIhgxav9LY&list=RDCMUCHnyfMqiRRG1u-2MsSQLbXA&index=1>

How Electricity Actually Works
[https://www.youtube.com/watch?v=oI\_X2cMHNe0&list=RDCMUCHnyfMqiRRG1u-
2MsSQLbXA&index=2](https://www.youtube.com/watch?v=oI_X2cMHNe0&list=RDCMUCHnyfMqiRRG1u-)

The Big Misconception About Electricity
<https://www.youtube.com/watch?v=bHIhgxav9LY&t=521s>

So what is surprising about my answer, which I hinted at in the title of this article??

The Answers in *Italics* to the questions above (which I do believe are accurate and true responses) were all generated as my test of ChatGPT, not written by me.

Now do you understand the problem sweeping through high schools, colleges, and elsewhere? If I had tried to pass the above answers as my own, would any of you doubt me? I think not.

Portions of this article co-written by ChatGPT, Feb 13 Version. Free Research Preview.