VIQC Elementary School - Reverse Engineering Online Challenge

Deconstruction of Evelots Hand Crank Flashlight

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Summary Report

As our society progresses with increasingly advanced technological innovations, a major problem that newer generations will have to face is climate change. While we didn't quite find the solution to climate change, we learned about something just as important in this challenge: sustainability. Introducing the device that we chose to reverse engineer: the Evelots Hand Crank Flashlight, a flashlight that keeps on lighting even long after the battery has died.

For the VIQC Elementary School - Reverse Engineering Challenge, we chose to dismantle this hand powered flashlight for many reasons. First, we were intrigued by how the handle actually generates electricity. In addition, the flashlight looks easy to disassemble and is fairly small in size. Furthermore, flashlights are not dangerous to take apart after the batteries are taken out, and it was also quite cheap to buy, which meant that everyone on our team would be able to have their own individual flashlight to disassemble. Since all kinds of lights surround us in our day-to-day lives, we felt it would be insightful to understand how something as important as lights work.

On the outside, the flashlight looks very simple, but the mechanism for the hand crank to operate is actually made of complex and delicate components that fit together intricately in order to work.

First, there are only two screws that need to be loosened for the top case plate to come off, revealing all the components. Immediately, we see the hand crank and a gear that spins along with it. With no case securing the crank, it swings outward, ready to be pressed. Directly underneath the hand crank is the magnet mechanism that converts the rotational energy of the hand crank to electrical energy. This is what keeps the flashlight operable after the battery dies.

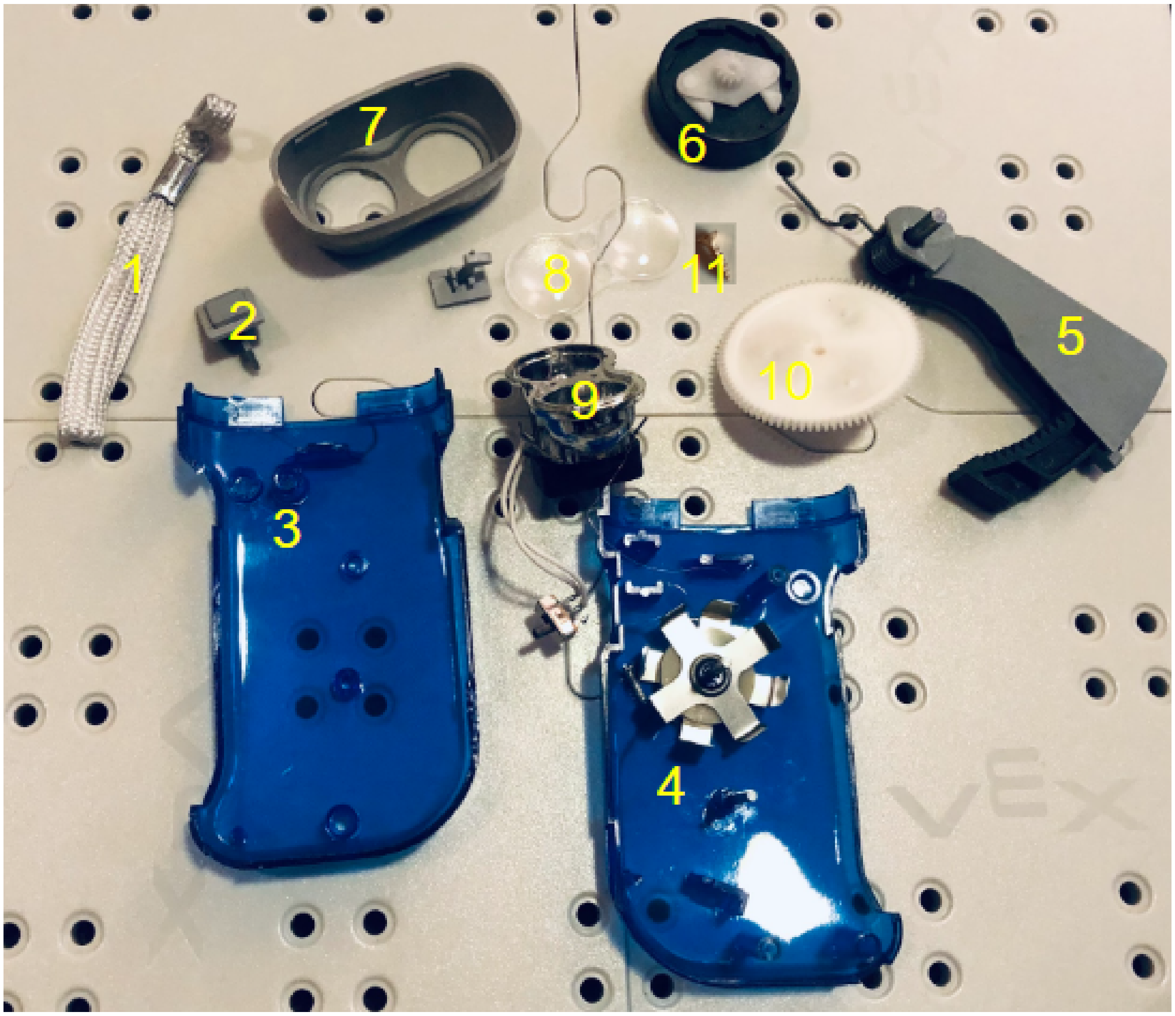
Next to the hand crank is where the actual flashlight and batteries are located. There is a concave lens on the outside that diffuses the beam of the flashlight, and a wire runs all the way from the flashlight to the hand crank on the bottom half.

After deconstructing the entire flashlight, we learned two main scientific concepts, that of Faraday's law and batteries. The key takeaway from everything we learned is sustainability. Currently, we rely on fossil fuels and other nonrenewable resources to generate electricity, and so exploring how to create clean energy through renewable methods such as solar panels, wind turbines, hydroelectricity, and nuclear energy will be very important to reducing our carbon footprint on our environment. Another priority will be figuring out ways to better store electrical power in batteries.

Overall, we were very happy that we chose to take apart this flashlight, as it helped us understand something that is everywhere in our day-to-day lives. Through dismantling this small handheld flashlight, we gained a large amount of scientific knowledge that can help us convert to using sustainable energy in the future. We were amazed by all the circuitry and technologies that go into simply making our world a brighter place.

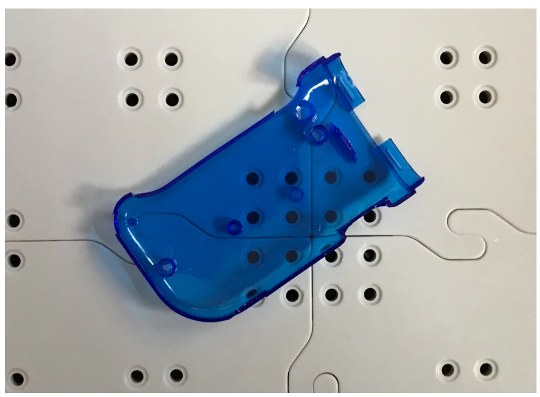
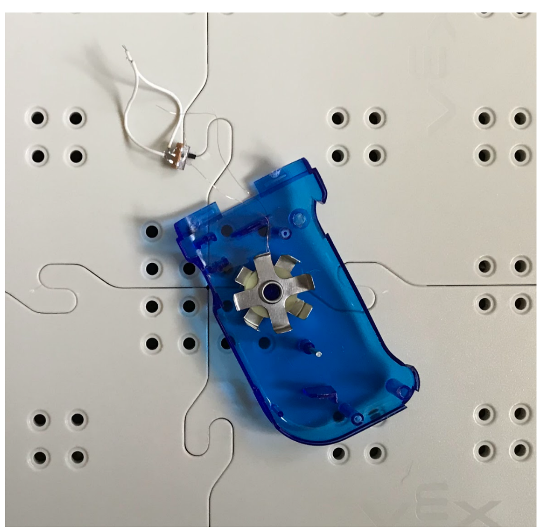
(Words: 499)

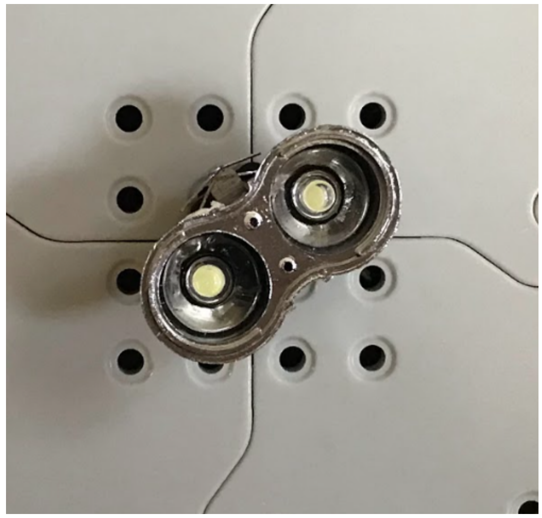
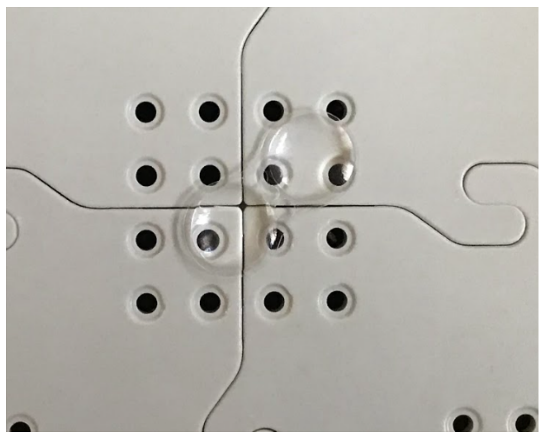
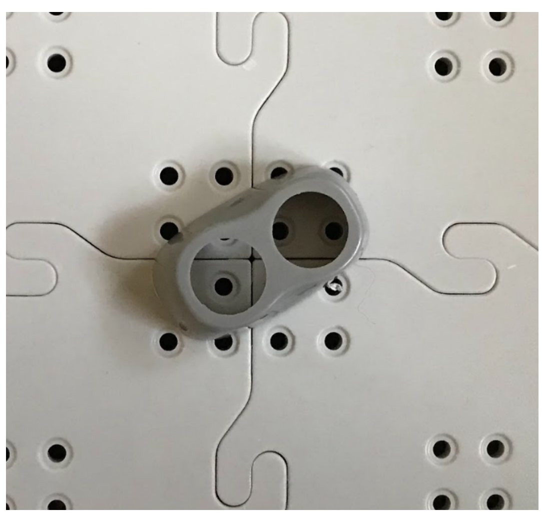
Appendix: Parts Picture

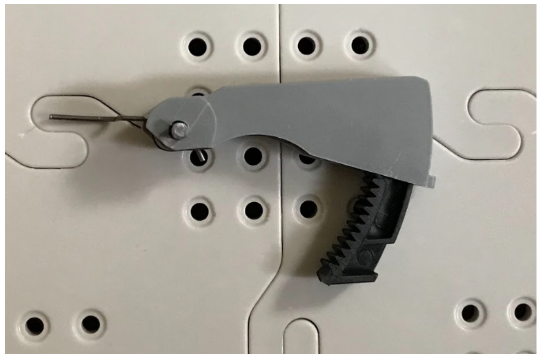
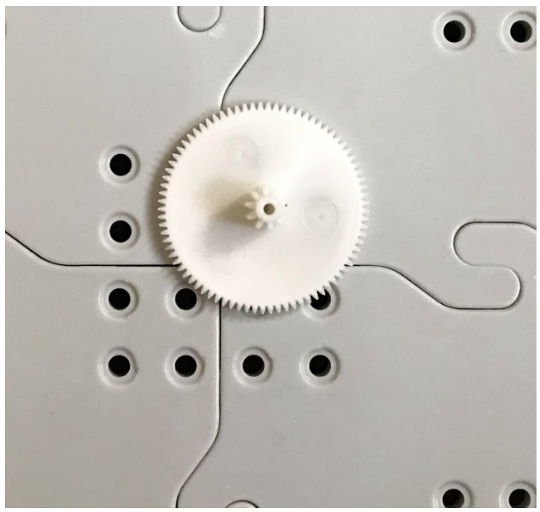
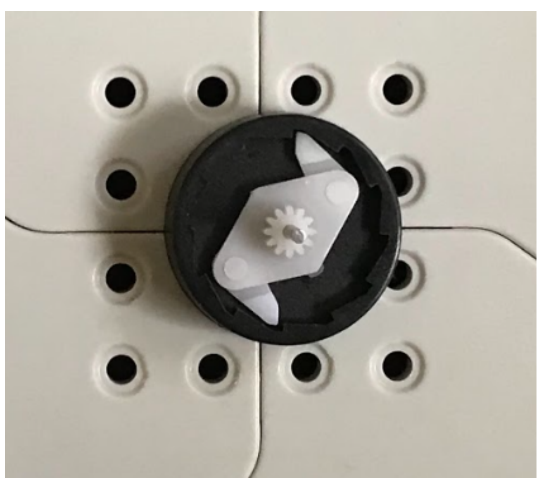


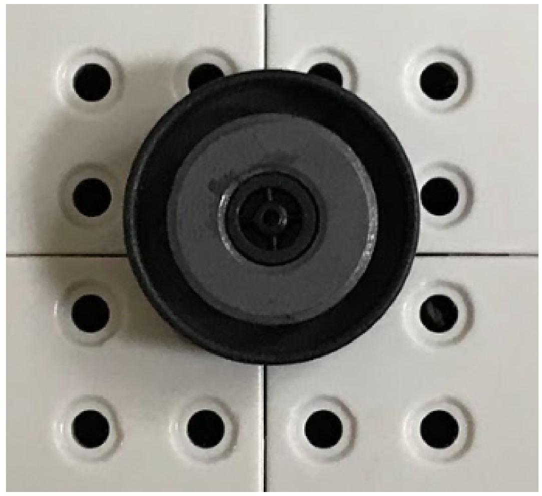
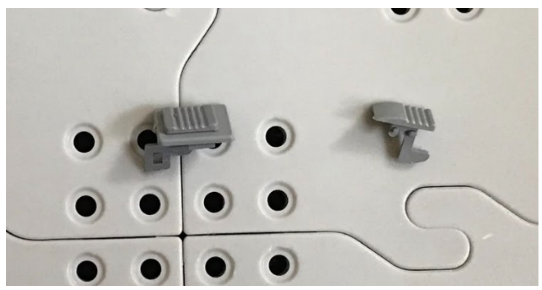
1. Lanyard
2. Buttons
3. Top Case Plate
4. Bottom Case Plate
5. Hand Crank
6. Magnet Mechanism
7. Flashlight Lens Case
8. Flashlight Lens
9. LED Light
10. Gear for Hand Crank
11. Screws

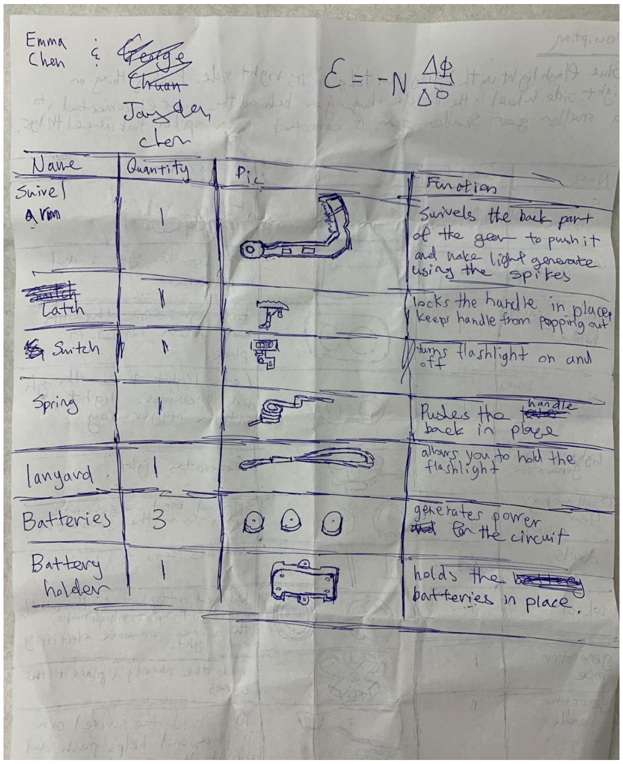
Table of Parts and their Functions

Name	**Quantity**	**Image**	**Function**
Screws	2		Holds the two shells of the flashlight together
Top Case Plate	1		Protects inside components from wear; anchors to the bottom case
Bottom Case Plate	1		Has case outlines for housing inside components; holds on wires that supply flashlight with electricity

LED Light	1		Projects the flashlight beam; also houses the un-detachable button batteries
Flashlight Lens	1		Concave glass lens that disperse the light rays so the flashlight beam covers a bigger area
Flashlight Lens Case	1		Covers and protects the glass of the flashlight

Hand Crank	1		Converts the chemical energy of our hand pressing the crank into rotational energy; there is a spring within the gray triangle part that resets the position of the crank
Gear for Hand Crank	1		Magnifies the rotational energy converted by the hand crank with a speed ratio, so that more energy can be harvested by the magnet magnetism
Magnet Mechanism	1	Front View:  Back View:	Converts rotational energy into electrical energy through the use of magnets

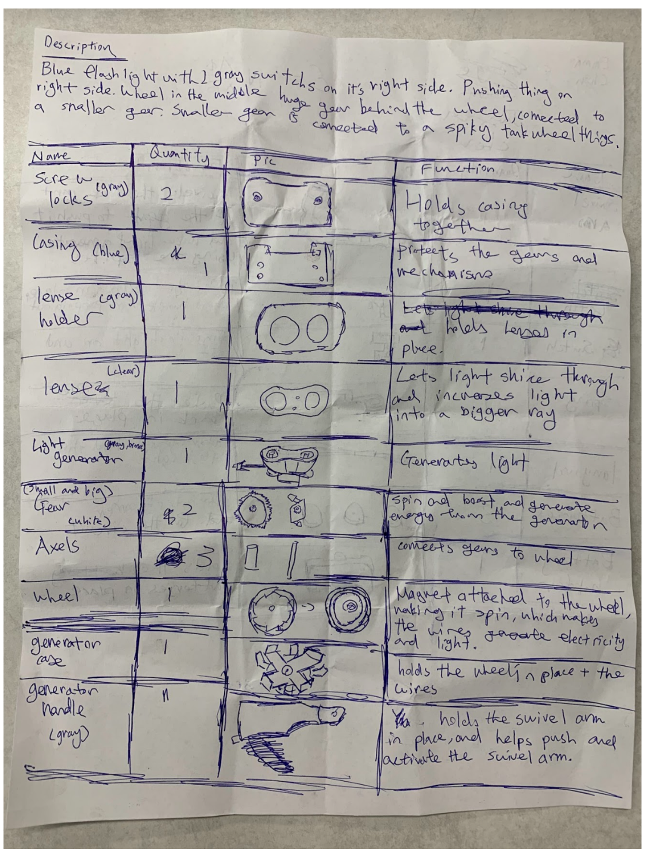
			
Buttons	2		Top button turns the flashlight on and off, bottom button unclasps the hand crank
Lanyard	1		Attaches to the flashlight and allows you to hold onto it more securely



Emma Chen & ~~George Chuan~~ Jayden Chen

$\mathcal{E} = -N \frac{\Delta \Phi}{\Delta t}$

Name	Quantity	Pic	Function
Swivel arm	1		Swivels the back part of the gear to push it and make light generate using the spikes
~~Switch~~ Latch	1		locks the handle in place, keeps handle from popping out
Switch	1		turns flashlight on and off
Spring	1		Pushes the ~~lever~~ handle back in place
lanyard	1		allows you to hold the flashlight
Batteries	3		generates power ~~and~~ for the circuit
Battery holder	1		holds the ~~battery~~ batteries in place.



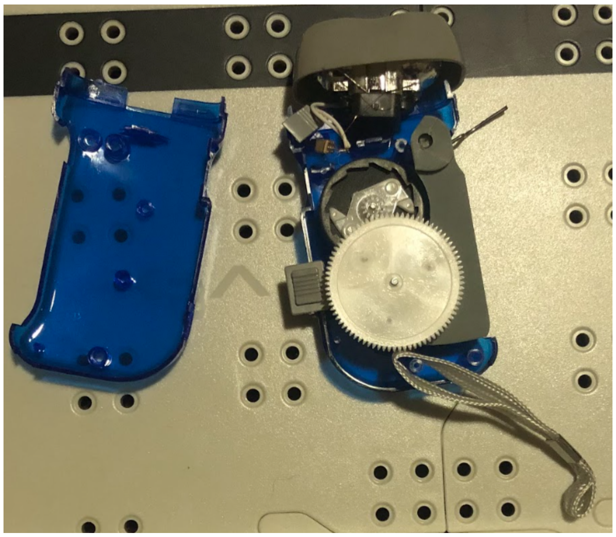
Description

Blue flashlight with 2 gray switchs on it's right side. Pushing thing on right side. Wheel in the middle huge gear behind the wheel, connected to a smaller gear. Smaller gear is connected to a spiky tank wheel things.

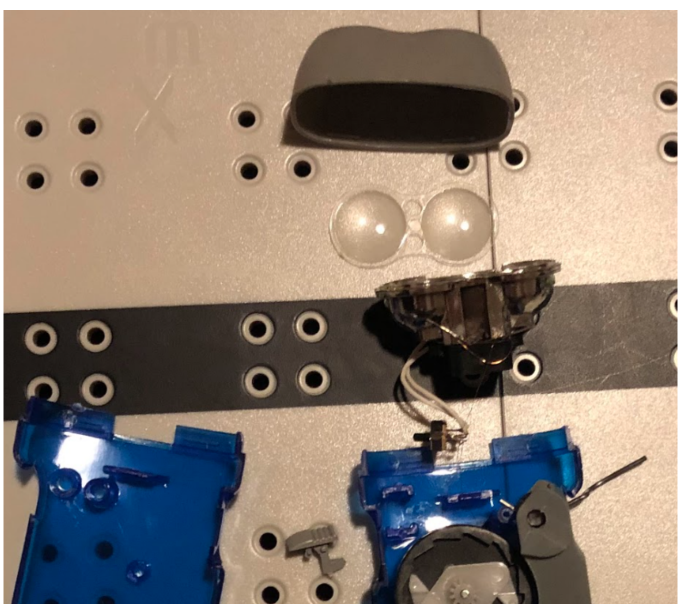
Name	Quantity	Pic	Function
Screw locks (gray)	2		Holds casing together
Casing (blue)	~~4~~ 1		protects the gears and mechanisms
lense (gray) holder	1		~~Lets light shine through~~ ~~and~~ holds lenses in place.
lenses (clear)	1		Lets light shine through and increases light into a bigger ray
Light (gray, bronze) generator	1		Generates light
(Small and big) Gear (white)	~~4~~ 2		spin and boost and generate energy from the generator
Axels	~~2~~ 3		connects gears to wheel
wheel	1		Magnet attached to the wheel, making it spin, which makes the wires ~~generate~~ electricity and light.
generator case	1		holds the wheel in place + the wires
generator handle (gray)	1		holds the swivel arm in place, and helps push and activate the swivel arm.

(Written version of the table above)

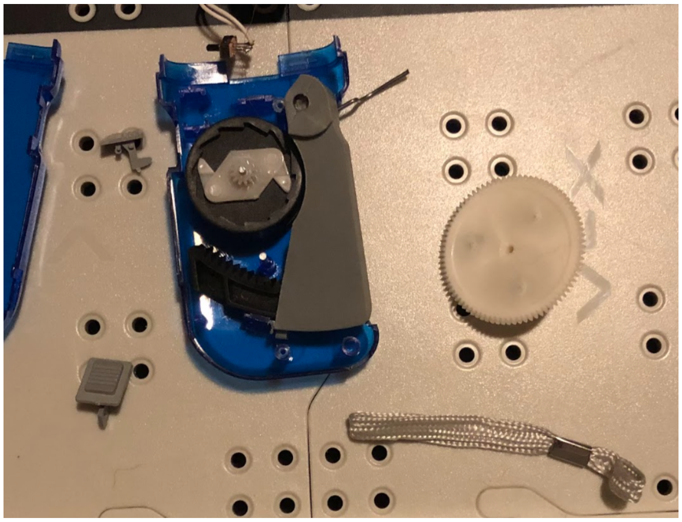
Disassembly Procedure



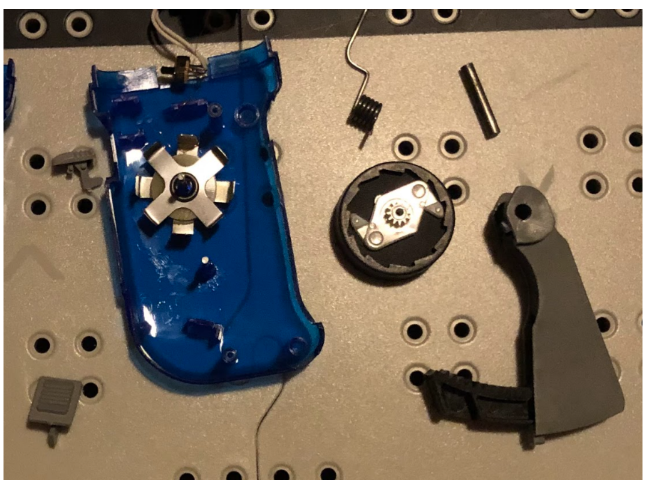
1. The disassembly procedure for the flashlight was not extremely complicated. On the outside there are two screws holding the two cases together. Unscrewing both allowed us to pop the top case plate (the case on the left in the picture) off, revealing all the components inside.



2. The first system we took out was the flashlight itself. As shown in the picture, the flashlight lens case is the first to come off, and immediately next is the flashlight lens, which functions to diffuse the flashlight beam. Next is the LED light itself, stuck inside are the two button batteries. Connecting these three components to the rest of the flashlight is a singular set of white wires, on which is a switch that turns the flashlight on and off.

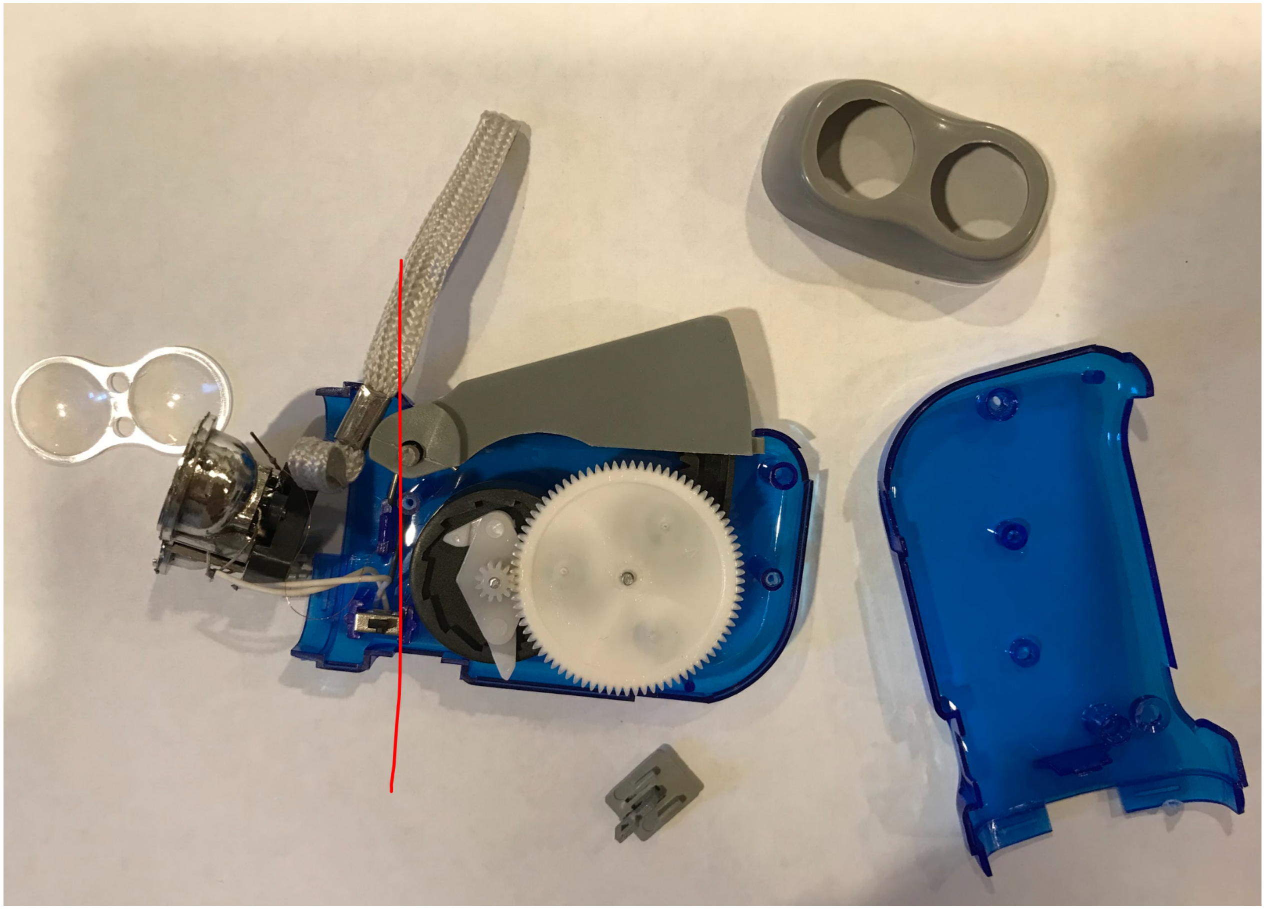


3. Moving onto the hand crank system, the buttons, lanyard, and gear for the hand crank all come off easily. Looking inside, we saw that the part of the hand crank that makes contact with the gear is quite small, meaning that it is on a speed ratio. In other words, for every one crank of the hand crank, the gear spins around 3 times, which greatly increases the amount of electricity manually generated.



4. The last things to come off are the actual hand crank itself and the magnet mechanism, and also a rod (top right) that holds the crank in place and the spring (top middle) that resets the hand crank after each push. There is an 8-sided metal star left on the case plate, but that is glued on tightly and serves to help hold everything in place.

How The Flashlight Works in Detail

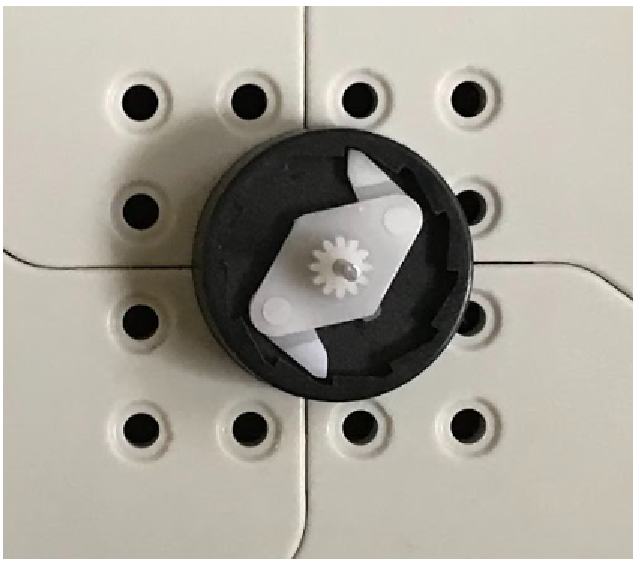


Caption: top view of flashlight after removing the top case plate and flashlight lens case.

We thought of the flashlight as two sections, which is shown by the red line above. The section to the left of the line is the “top section” (when the flashlight is held in our hands), and the section to the right is the “bottom section.” Starting from the bottom section, the gray triangle part is the hand crank. When it pushes inward, it spins a small gear attached underneath the white gear, resulting in a speed ratio. Speed ratios are when the input rotation creates an output rotation that is faster, but it means there is less torque, or how hard the gear can spin. The reason that a speed ratio is used here is because our hands can provide a large amount of gripping force, so the speed ratio is worth the tradeoff. The faster the white gear spins, the faster the magnet mechanism (the black disc with white-transparent lever directly to the left of the white gear) spins. This sends electricity through a wire to the top section of the flashlight, which has the LED light that projects the flashlight beam through the concave glass which disperses the light waves. And there is also a lanyard to hold onto the flashlight better, and also two buttons that turn the flashlight on and off and hold in the hand crank.

Component Scientific Discussion: Electromagnetism and Faraday's Law

A big reason why we chose this flashlight in the first place was how the hand crank can generate electricity. After deconstructing the flashlight, we found the pathway where this happens: the hand crank turns a gear that turns a magnet mechanism that generates electricity. But how exactly does the rotational motion of the magnet mechanism generate electricity?



?

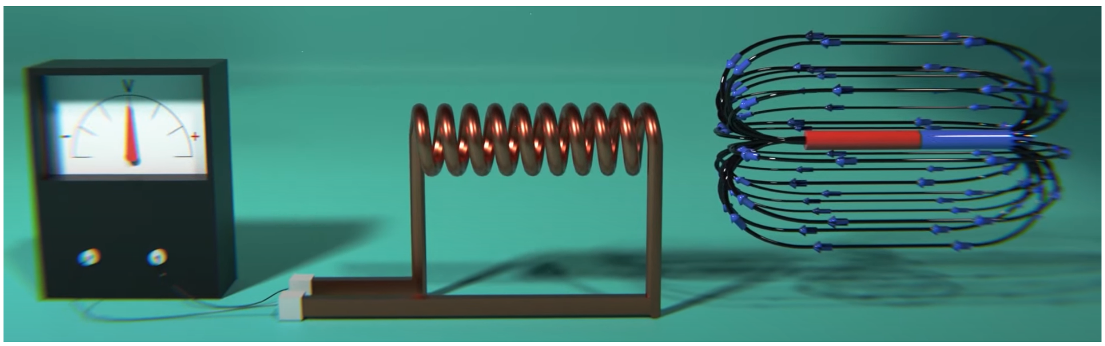
The answer is: Faraday's Law!

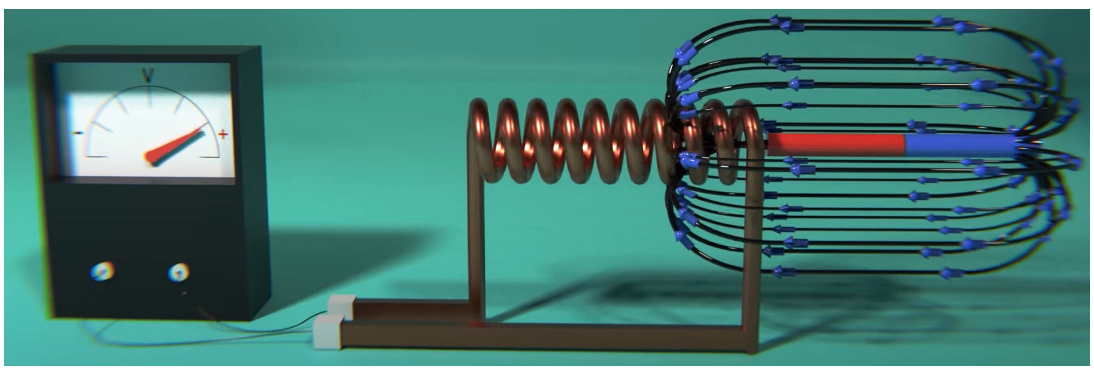
$$\mathcal{E} = -N \frac{\Delta \Phi}{\Delta t}$$

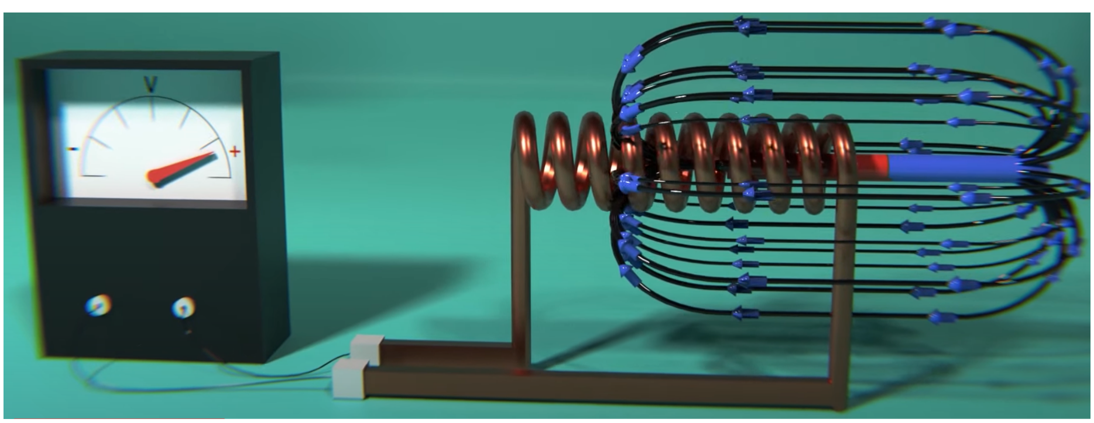
What is Faraday’s law?

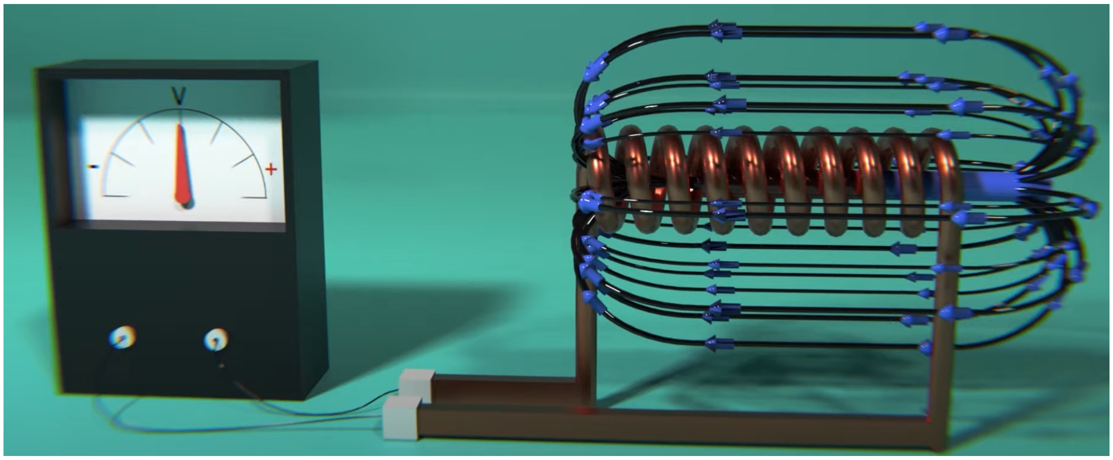
In science terms, the induced voltage of a system is equal to the negative number of loops times the change in the magnetic flux of the system all divided by the change in time.

In our words, a magnetic field can actually generate an electric current. As shown by the pictures below, when you move a magnet through a piece of metal, it creates a voltage difference that can be harnessed into electrical energy. This only happens when the magnet is *in motion*.



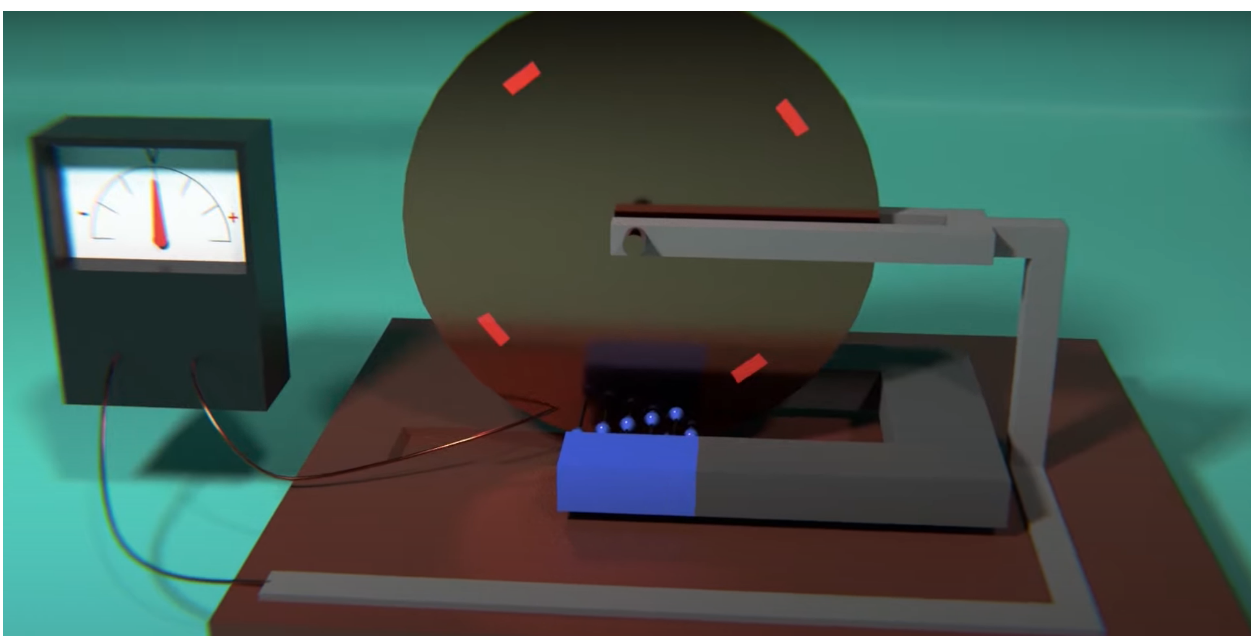






In the first image, the magnet is not moving, so the voltage measure on the left is at 0. In the second and third images, when the magnet is moving, the voltage meter sees that there is an electrical current, and in the fourth image when the magnet is not moving, so the voltage meter is at 0 again.

In our flashlight, the same exact thing happens. The white transparent level spins inside the black circle due to the rotation of the gear and then it generates electricity because of Faraday's Law. Here's a better image that we found that helps us see what is happening easier:



As you can see, the same mechanism is happening in our flashlight and in the image above. In the flashlight, the white level with two joints is actually a ratchet, or a gear that can only spin in one direction. As it spins, it turns the magnet inside around and around, making electricity. Also, the scientific term for the magnet mechanism is a solenoid.

One last thing we also noticed is that the electricity generated from the hand crank does not recharge the button batteries; it directly powers the flashlight. To discover this, we actually turned one flashlight on and set it out overnight to completely drain the battery. The next morning, first we kept the light off and pressed the hand crank many times over and over. Our hypothesis was that if the hand crank recharges the battery, after pressing it over and over, turning the light on should turn the flashlight on. This, however, did not happen, which meant our hypothesis was wrong. We then turned the flashlight on, and then pumped the hand crank, and the flashlight did work, but only as long as we were pressing the hand crank.

Component Scientific Discussion: LED Lights

Another thing we researched was the actual light that was on our flashlight, and the first thing we thought of were LED lights. LED stands for light emitting diode, and they are very popular right now.

Before the invention of LED lights, there were two other lights that were used. First, there were incandescent lights:

These lights are very inefficient because the light they emit is generated from heat. Basically, how they work is that a wire is heated until it finally glows, which then gives of heat.

The second light that also came before the LED is the fluorescent light:

These lights work off a chemical reaction. Inside the light is argon gas, a type of element, and also a small amount of mercury vapor, which is another type of element. When electricity is run through the light, ultraviolet light (which cannot be seen) is created, and when that ultraviolet light hits the inside of the light tube, it bounces off and creates light that can actually be seen.

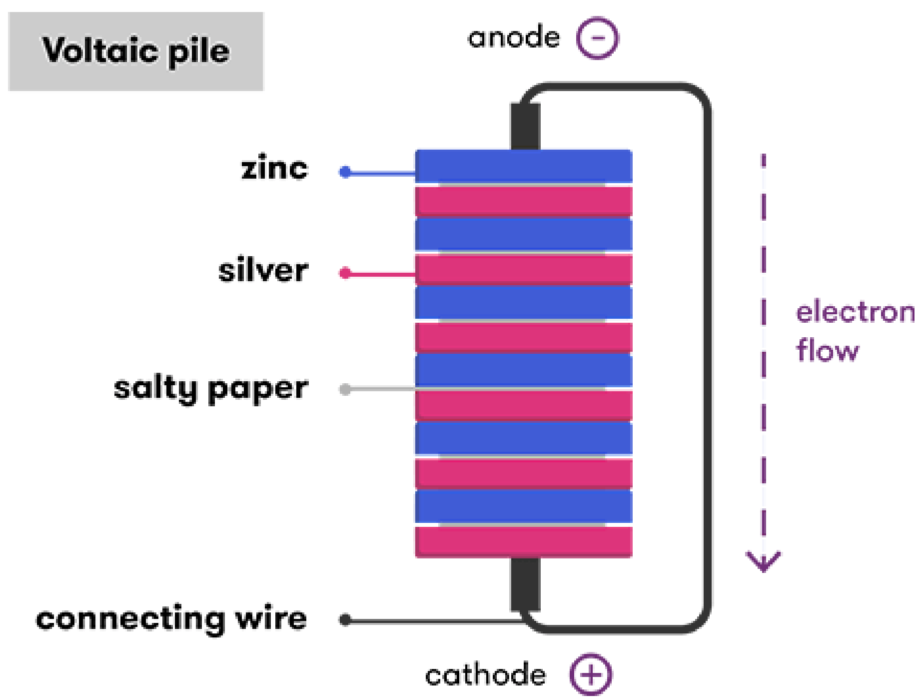
Moving onto LED's, or light emitting diodes, they work when electricity goes through a specific microchip, and then that illuminates the diodes. LED lights are very heat efficient, meaning that they do not give off a lot of heat. Also, there is no argon or mercury used in these lights, which means that it is much less toxic for the environment than fluorescent light bulbs. LED lights also last much longer than the other two lights. The type of light source used in our flashlight is in fact LED.

Component Scientific Discussion: Batteries and Sustainability

As more and more of the things we use such as cars and gas stoves turn electric, storing electricity in batteries becomes more and more important. We predict that in the future, ways to generate electricity such as solar panels, wind turbines, hydroelectricity, and nuclear energy will become much more common, because having rechargeable batteries also becomes more and more important.

Currently, batteries are what power all our electronic things, and different batteries have different impacts on the environment. After taking apart our flashlights, we researched different types of batteries.

First, how batteries work is that they store chemical energy and then convert it to electrical energy. How this happens is when electrons flow from something called the anode to a cathode through circuits:



This creates an electric current that can be used to power things, such as our flashlight.

There are three main types of batteries; Alkaline, Nickel Metal Hydride, and Lithium Ion.

Alkaline batteries were invented first, and they use the element zinc as the anode and the compound manganese dioxide as the cathode. They are one-time use batteries (the electrodes are used up) and so are not rechargeable (so they have low cycling capacities). In addition, alkaline batteries are very hard to recycle, making them very bad for the environment.

Nickel Metal Hydroxide batteries were invented next. Their chemical composition is different, as in that the anode is a compound containing nickel and the cathode is another compound, nickel hydroxide. NMHs are rechargeable (meaning the electrodes are not used up), but are more expensive and lose their storage charge over time. However, they are still better for the environment than alkaline batteries.

Lithium ion batteries are the newest type of batteries, and are the most widely used now. They are used in rechargeable electronics, like in smartphones, tablets, and computers. Lithium ion batteries are easy to be recharged and have no loss in their performance over time. They are also 30% lighter than the other two battery types, making them much more portable.

The batteries used in our flashlights are button batteries, and look like this:

They are alkaline, which means that the batteries themselves are not rechargeable. (The hand crank does not recharge the battery. It creates electricity to directly power the flashlight)

In order to successfully convert to renewable energy, we will need to depend on our ability to store energy in batteries. This is why understanding how batteries work is so important. Currently, batteries are trending to become more efficient and environmentally friendly. New inventions such as new generation lithium ion batteries, lithium-sulfur batteries, and solid state batteries reduce impact on the environment. The last two batteries, lithium-sulfur batteries and solid state batteries are especially important because resources such as lithium are actually running out around the world. In fact, solid state batteries are actually starting to be used in electric vehicles such as Tesla's. Better batteries means being more sustainable through having a lower impact on the environment.

In the end, sustainability is key. With current rates of pollution and resource usages across the world, especially in developed countries, the Earth may run out of resources to support populations in the near future. If we focus on using resources that are sustainable or can be replenished quickly, that will make sure that the world is able to sustain generations of humans to come. We think that clean energy should be a priority of the future. Although the hand-crank flashlight itself is not a source of sustainable energy (it uses an alkaline battery), the applications of the flashlight are very important and can be generalized to many future studies. And that is truly inspirational.

Conclusion

In conclusion, we learned to work really well together as a team, and had tons of fun taking apart the flashlight and learning about its scientific applications. We emerged from the experience as a more close-knit team of friends, excited to learn more, and feeling better about our future on Earth.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Citations:

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