Creating Science 2 – Electricity

Fun, safe, and one of the most important things in modern society – just how many ways are there that electricity can hurt you? ***#CreatingScienceElectricity***

DANGERS!

This section cannot explain every possible danger in this activity. Adult care and surveillance is required at all times. Please exercise all appropriate caution at all times.

The actual range for stopping the human heart is quite small. For this reason, house electricity is outside this range, and most damage is done as the muscles are forcibly contracted and physical injury results. Even so, a little knowledge can be a very dangerous thing, so DO NOT mess around with electricity until you are properly and professionally trained in all the dangers. This document WILL NOT prepare you with adequate professional training.

Suggested Outcomes

(NOTE: This is by no means an exhaustive list of possible outcomes, neither is it intended that ONLY these outcomes can or should be met. Science is a deeply interrelated activity, and you may find cross curriculum links you can and should use.)

Science understanding

- Physical sciences 6: Electrical energy can be transferred and transformed in electrical circuits and can be generated from a range of sources (ACSSU097)

Science inquiry skills

- Communicating 6: Communicate ideas, explanations and processes using scientific representations in a variety of ways, including multi-modal texts (ACSIS110)

Science as a human endeavour

- Nature and development of science 6: Science involves testing predictions by gathering data and using evidence to develop explanations of events and phenomena and reflects historical and cultural contributions (ACSHE098)
- Use and influence of science 6: Scientific knowledge is used to solve problems and inform personal and community decisions (ACSHE100)

Cross curricular outcomes

- Design and Technologies Knowledge and Understanding 5-6: Investigate how electrical energy can control movement, sound or light in a designed product or system (ACTDEK020)

For example, investigating the features of electrical devices such as switches, light globes and sensors.

Science vocabulary words

Tier 1 (Everyday words) Danger, light, sound.

Tier 2 (Dual meaning)

- Power – in every day usage simply means 'ability to do', but in science and electrical work has a very specific definition. Power is the rate (energy amount per time period) at which work is done or energy converted. The scientific unit of power is the watt (W), which is equal to one joule (energy amount) per second (time period). The electrical power unit is usually the Kilowatt (kW), which is equal to one thousand watts.
- Electricity – even this definition can get very, very complex. Electricity is measured in Coulombs. Electricity is not the flow of electrons; instead it's the electrons and protons themselves. When electricity flows, it is called Electric Current. Usually we mean 'eletric current' when we're talking about 'electricity', but there's usually no need to get so pedantic at this level.

Tier 3 (Specialised vocabulary)

- Volt, resistance, current – see below

Preparation

- Electric toys, such as a plasma ball, old vacuum tube television, tesla coil, Jacob's ladder, and any other high voltage but reasonably safe electrical device such as a Van De Graff generator.

Learning Intent (student friendly)

'We are learning to' (WALT). See electricity in action and learn to be safe with it.

Success criteria

'What I'm looking for' (WILF) safe behaviour around electricity and a presentation on the topic.

Student learning goals

Help students make a self-monitored learning goal for this lesson.

Evidence of learning

How will you know when the learning goal is achieved? What EVIDENCE do you have that your students have met or exceeded the learning expectations?

They aren't dead… even better, they can explain safety around electricity AND the reason for these rules and how they keep us safe.

Suggestions for other year levels

As always, more material is presented here than can be used by the average class during the average lesson time. However, since the students questions can and should guide student learning, more material is presented for you convenience. Remember, it is not uncommon for students to only remember those points which answered their personal questions.

Younger:

Children at this age can have difficulty with focus. Avoid tangents into interesting side tracts if you're attempting to make a key point.

Middle:

This activity is well suited to this age group. Are they able to accurately measure electric voltage, current and resistance.

Teen:

Have them research the historical development of electricity. Have they heard about the Bagdad battery? Or Benjamin Franklin and his key laden kite?

Engage

- ⇨ Note the Learning Intention of this lesson for students.
- ⇨ Make sure all students write down any questions they may have generated during this phase regarding the topic for today.

Demonstrate the sparks that are generated from a 12V car battery when the leads are shorted out.

Ask if a student would like to touch both leads and conduct the electricity through their body. Usually, someone will offer. MAKE SURE THAT;

1. They do not have any open cuts or wet hands, it can lower the resistance to the point they will get an electric shock.
2. They touch the electrodes with the BACK of their hands – it not only hurts less because there are less sensitive nerves on the front of their hand, it is less likely to cause them to become stuck to the wire like touching it with the front of their hand might[1].

They will more than likely NOT get electrocuted. Ask everyone WHY?

- ⇨ Encourage and validate student explanations of this phenomenon. You may like to ask students to write or draw their explanation personally to avoid embarrassment to students

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[1] Our muscles use electricity to contract. The gripping muscles that help us close our fingers are almost always stronger than the ones we use to open our fingers. If you touch an electric wire with enough voltage to electrocute you, and the current is stuck on, your muscles will contract and possible make you hold on to the wire and not let you let go! With respect to this electric fences now pulse on and off, to allow animals and humans to let that painful wire go!

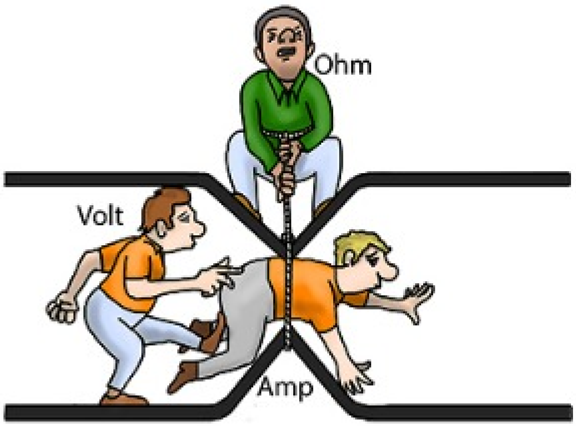
unfamiliar with this material. Remember, 'I don't know' is a valid explanation in science – it is the beginning of learning new things!

Explore

What else can make that spark? Water? Salty water? Metal? A graphite pencil? Try a few different things.

Explain

Electricity is usually explained in at least three parts;



Quantity	Symbol	Unit of Measurement	Unit Abbreviation
Current	I	Ampere (Amp)	A
Voltage	V or E	Volt	V
Resistance	R	Ohm	Ω

Taken 27 Apr 19 from https://c.mi.com/thread-845722-1-0.html

- **Voltage** is how much pressure the electricity has. High voltages can shoot a long way from their point of origin. A really good example is lightning.
- **Resistance** is how much the object or material the electricity is passing through is able to stop, or 'resist' that flow of electricity – and it will turn that electrical energy into heat instead. Air has a very high resistance, possibly the highest apart from the vacuum of space; almost no electricity can travel through it. Metals and salty water have a much lower resistance, to the point that they offer almost none at all and are called conductors. But everything except superconductors have some resistance, so as metals conduct electricity they will heat up a little, and if there's a lot of electricity they heat up a lot and can melt or burn away!
- **Current** is very confusing, and it's *sort of* how much electricity is passing by a point. Current is a lot more dangerous than voltage. Our body can withstand millions of volts as long as

there is a teeny, tiny current flowing with it. There's actually only a narrow range of dangerous current, as beyond a certain point (and assuming the electricity is very brief, as with lightning) we might be paralysed momentarily, our heart stops and then starts again, our skin may burn and we'll be in incredible pain, but humans tend to live from brief electric shocks of even very high current. Even so, DON'T test this!!!!

In the current example, 12 volts is not enough to break through the resistance of human skin, and the current cannot flow. That's why cars use only 12 volts, otherwise they'd be zapping us all the time! It actually takes a very

Elaborate

⇨ Ask students if they can design new ways to test this explanation, is it really sufficient? Can they think of further or better explanations, and the experiments needed to test them?

Explore other electrical equipment. What safety rules are necessary for staying safe?

- DO NOT test without using approved devices, the current can be so high no amount of resistance in your skin can protect you.

Evaluate

⇨ Review with students what they felt they learnt from this lesson. Did they have any questions at the start that they feel were answered?

Success criteria

⇨ Review the Learning Intentions of this lesson with students. Was it met?

At the end of each class, review the learning objective and see how we did. Ask:

⇨ Did you achieve your learning goal?
⇨ What worked to help you achieve it?

Assessment

Prior learning:

Quiz; what do you know about electricity, and electrical safety?

Formative:

As students are learning, help them self-monitor their own learning and achievements.

Summative:

Help students consider ways they can communicate their new understanding to others, just as scientists need to do.

So what?

How do I stay safe around electricity?

Tips from the Masters to make it work:

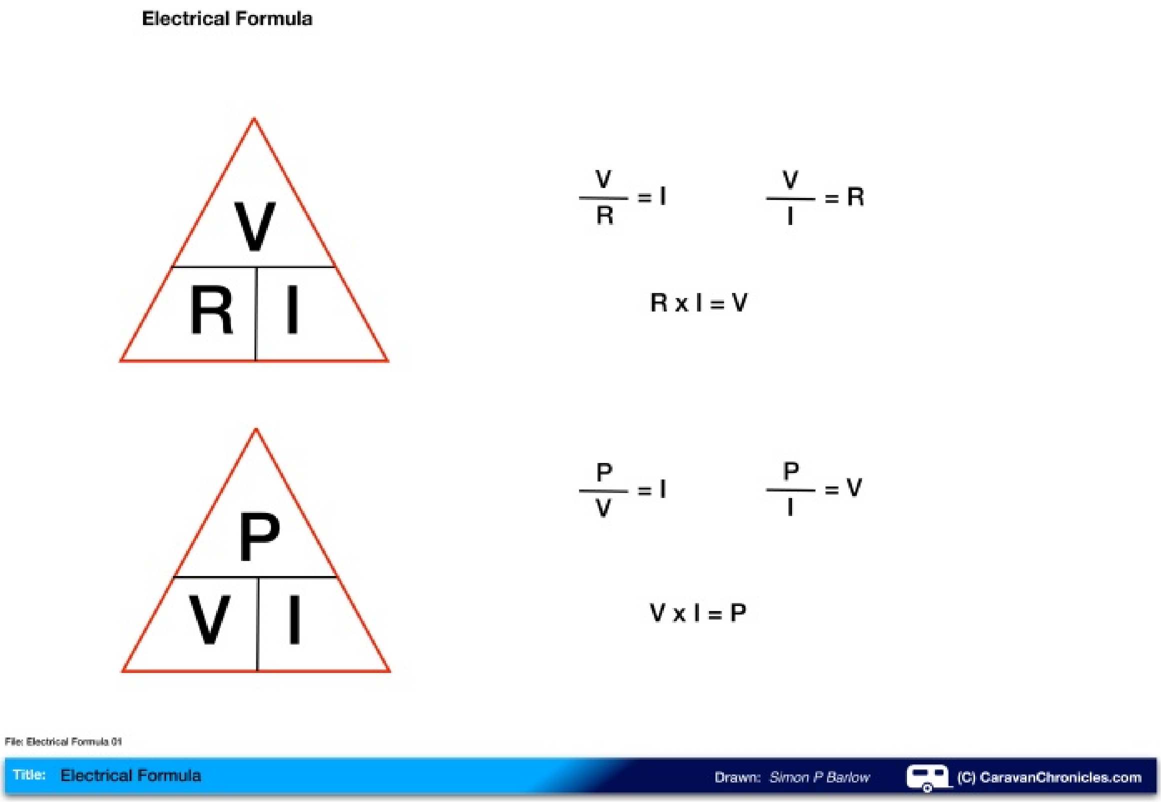
Above: A tesla coil in action. Below: Magnetism can move electricity!

Appendix:

It is not the Voltage that can kill humans, it is the current that kills.

How to get killed by electricity:

- It must go through you, not only into you. (birds on wires)
- Too low and it can't go through, too high and the heart muscle can restart.
- With sweat and no bleeding cuts, electricity would rather go around you than through you.
- It must have enough "electron flow rate" (amps) to harm you. The amount of "push" they have (voltage) can often be negligible (as in van de graff generators and tesla coils). So if only one or two electrons are whizzing away at enormous power and pressure, you might n



Comments patched together 27 Apr. 19 from https://www.quora.com/How-many-volts-will-kill-you

Sensation of mild shock starts at around 1 mA. For currents above 10 milliamps, muscular contractions are so strong that the victim cannot let go of the wire that is shocking him. At values as low as 20 milliamps, breathing becomes laboured, finally ceasing completely even at values below 75 milliamps.

As the current approaches 100 milliamps, ventricular fibrillation of the heart occurs - an uncoordinated twitching of the walls of the heart's ventricles which results in death.

Above 200 milliamps, the muscular contractions are so severe that the heart is forcibly clamped during the shock. This clamping protects the heart from going into ventricular fibrillation, and the victim's chances for survival are good.

So 100mA can kill you. Between 0.1–0.2 A (100 milliamps) will most likely cause death. Interestingly, above 0.2 A the damage becomes 'only' life threatening again along with severe burns and stopped breathing but usually the victim can be resuscitated & kept alive.

The resistance of dry body is 100,000 ohms so for this body to draw 100mA it requires 10,000 V! But you have seen people dying at lower voltages right? Because wet or broken skin may drop the body's resistance to 1,000 Ohms, adding that high-voltage electrical energy quickly breaks down human skin, reducing the human body's resistance to 500 Ohms." So 100 V is enough to kill under wet condition or when you have broken skin.

A TASER, for example, operates at thousands of volts but cannot generate the current required to kill the average person.

As a rule of thumb, any device that can source more than 0.2 amps at 50 volts is potentially dangerous.

So word to the wise wear non-conductive gloves and shoes always. If you're close to touching hot circuits, grounding your elbow may be a smart idea.

Lightning facts

https://www.energex.com.au/home/power-outages/lightning-tracker

According to Julie Evans, senior meteorologist at the Bureau of Meteorology, if the time between when you see a flash of lightning and hear thunder is less than 30 seconds, your chances of being stuck by lightning are high. One way of determining how close lightning is to you is to count the number of seconds between the flash of lightning and sound of thunder. For every three (3) seconds, the lightning is one kilometre away. Again, if the time is within thirty (30) seconds which means the lightning is as little as ten (10) kilometres away, you should find immediate shelter.

https://www.australiawidefirstaid.com.au/lightning-strikes/

Australia Wide First Aid encourages you to find solid shelter during a storm. This does not include a tree. Try and find shelter within a building, bus shelter or car and avoid water and objects that conduct electricity. This includes:

- Golf Clubs
- Umbrellas
- Metal Fences
- Trees
- Puddles/Pools of Water

If you're unable to find safe shelter, crouch down in the open, feet together with your head tucked down towards your chest. You should aim to make yourself as small as you can. Laying down flat on the ground increases your total body surface area, which also increases your chance of getting struck by lightning.

Evans suggests that you should wait approximately 30 minutes after the last flash of lightning before you leave your shelter. More than half of lightning deaths occur once the storm has passed. i.e.,

- stay dry
- stay in something that conducts electricity, but don't touch it
- wear insulating shoes can help

Lightning Facts:

- Lightning can warm the air by 27,700 degrees Celsius, five times hotter than the surface of the sun
- A strike can contain a hundred million electrical volts
- If your hair stands up on the end of your head, it could indicate positive charges are rising through you. If so, seek immediate shelter
- Thunder is caused by the expansion of rapidly heated air
- Lightning from the top of a thunderstorm cloud carries a large positive charge. This is known as positive lightning
- Positive lightning can strike as far as 16 kilometres from a storm.

Lightning Myths (do not believe):

- Lightning never strikes the same place twice
- A lightning victim shouldn't be touched because you could become electrocuted
- You should shelter under a tree as it is safe
- Structures with metal or jewellery attract lightning.

also

An average bolt of negative lightning carries an electric current of 30,000 amperes (30 kA), and transfers 15 coulombs of electric charge and 500 megajoules of energy. Large bolts of negative lightning can carry up to 120 kA and 350 coulombs.[39] The average positive ground flash has roughly double the peak current of a typical negative flash, and can produce peak currents up to 400,000 amperes (400 kA) and charges of several hundred coulombs.[40][41]

https://www.quora.com/What-is-the-voltage-and-amperage-of-an-average-lightning-bolt answers vary but his is the best answer I found "A typical lightning bolt contains 1 billion volts and contains between 10,000 to 200,000 amperes of current. The average flash would light a 100 watt lightbulb for 3 months." But it generally lightning will only last for microseconds so actual power compared to what we use normally is inconsequential.

How deadly is a lightning bolt?

Taken 27 april 2019 from https://www.quora.com/How-powerful-is-a-lightning-bolt

Perhaps an easier, and more concise answer to your question would be this: "Lightning is the most powerful force you can imagine...and then some. It can cause destruction and pain on levels that you cannot begin to believe." Keep reading for more...

"How powerful is a lightning bolt?" -I recall muttering to the trauma doctor in charge of me at Flagstaff Medical Center just 36 hours after being struck by lightning while backpacking on Arizona's Mogollon Rim.

"I, I don't have any idea. You don't need to worry about that. Just be thankful you are alive." -was the doctor's seemingly indifferent response to my actual curiosity and the question at hand.

It would be later that day, at the roughly 48-hour mark when someone who was in my group would bring my phone to me so I could check myself.

Drugged, groggy, and in some of the most intense pain I have ever been in my life *the most intense having just passed, I proceeded to search the Google machine for answers. As I strain my eyes to focus, struggle to hold the phone in my hands, I did everything I could just to be able to read through the information...I wasn't exactly in a state for diligent research.

Then the answer came...the average lightning bolt is somewhere between 100,000,000 - 1,000,000,000 volts of electricity. I was floored...or I would have been, had I not already been drugged out of my mind just to deal with the pain. I sank into the hospital bed and it all made sense. Now it made sense that I felt the way I did -the pain that I was experiencing now made sense.

So there I was, just 48-hours after being struck by lightning, trying to take in the gravity of what had just happened. You see, the thing about lightning is that there is no set protocol to treat a strike...every case is different. Take me for example, nobody could have predicted what transpired.

Without going into too much detail, when I was struck, I went down...immediately. I could hear screams from my group, I could see images of what was going on around me...I was conscious.

Trapped. I could not move, nor did I have any voluntary control of any muscle groups in my body. I had landed in an upright sitting position with my legs stretched out before me. My arms were seizing and convulsing. I could see everything. I could smell everything. I could hear everything.

I took a breath. There was no air to breathe. In an instant I recognized the queer sensation of having my lungs completely full of fluid. I tried to spit. I could not spit -I had no control of any of my muscles in my neck and/or throat...I could not spit.

I tried to rock myself side to side...fighting the direction of the convulsions and seizures, in hopes that I would knock myself over onto my side and the fluids could begin to drain out of my lungs. I could not rock onto my side.

Then it came...the realization that I was sitting upright on a mountain in a pine forest and I was going to drown...and there wasn't a damn thing I could do about it. And then came the first out-of-body experience of the day.

Ultimately, I ended up dying twice up on the mountain that day. From the moment I got struck, it was 2.5 hours before first-responders arrived. They were going to move me via ambulance, but the pain...the screams...they knew I would have gone into shock.

Let me tell you...it's a humbling thing to hear and watch (because they were standing over me while talking) rescue workers say things like "He's not going to make it." and "If we don't get a chopper in here, he will die." I wanted to scream. I wanted to shout "I'M STILL HERE!!!!"...but I couldn't. I was paralysed and completely aware of the entire experience.

It would be a total of 6.5 hours from the moment I got struck to the moment the seizures stopped in the trauma theatre. I quickly fell asleep due to exhaustion.

Then there was that 36-hour mark when I asked the doctor about the lightning intensity. Just after the 48-hour mark and my brief research, I learned just how powerful lightning truly is.

The phone rang. It was my mother in St. Louis whom hadn't yet left to come see me. I was asking her about the others, as I knew I wasn't the only one affected. There was hesitation and pause in her voice. "Som...someone....someone died?" I was able to stammer out as the walls of my world began to collapse inwards. I told my mother that I had to go and immediately called the chaplain into the room. I needed something. I needed meaning.

While the chaplain assured me that this was not my weight to bare, this was not my load...I did not cause the lightning, as the leader of the backpacking group there was an immense sense of survivor's guilt -a very, very hard thing to shake.

To try and wrap this up a little short here, this was a powerful bolt...on the upper end of the scale. It was simply hungry...and out for blood. The ultimate investigation and photos proved the sequence of events. One lightning bolt hit a nearby tree, wrapped around the back of the tree and hit it two more times before entering Christine - a healthy, vibrant 24 year old woman, killing her instantly, before jumping to me.

From Christine the bolt entered my neck and bounced around quite a bit, ultimately leaving at the little metal Gore-Tex emblem on my right boot, just above the ankle. At the metal Gore-Tex emblem, the bolt forked into 3 and hit 3 more members of the group. There were a total of 9 of us on the trip. 1 Fatality, 1 Critical Evacuation, 3 additional people injured...all from one, single bolt of lightning.

Perhaps an easier, and more concise answer to your question would be this: "Lightning is the most powerful force you can imagine...and then some. It can cause destruction and pain on levels that you cannot begin to believe."