Home School Series

Homeschool Teacher's Guide for:

Electrophorus

Note: All activities in this document should be performed with adult supervision. Likewise, common sense and care are essential to the conduct of any and all activities, whether described in this document or otherwise. Parents or guardians should supervise children. Rock-it Science assumes no responsibility for any injuries or damages arising from any activities.

Contents:

Title Page of Video

(Numbers in the text are **time codes,** so you can refer back to the video.)

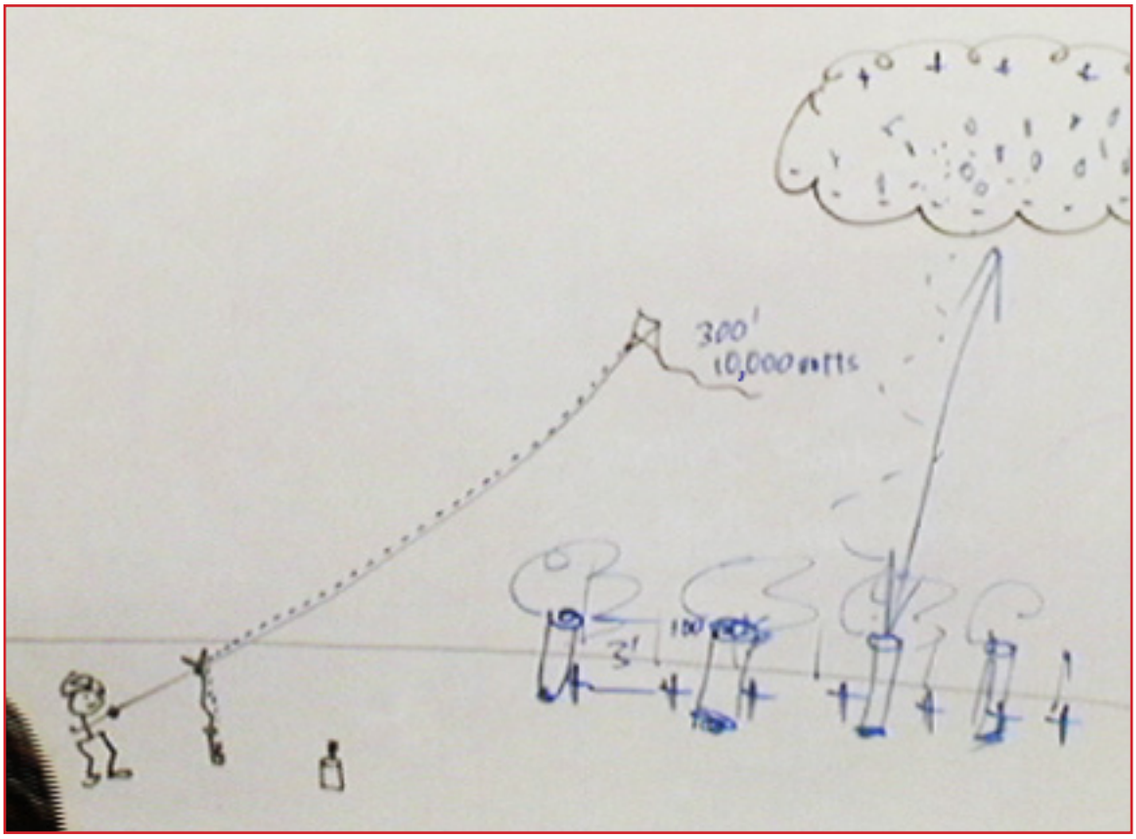
[00:03;09]

Electrophorus
filmed November, 2009

For Rock-it Science Internal Use Only

Students' images in this video should not be used publicly unless their nametags are rendered unreadable and their names are bleeped from the audio track.

Intro Quick Recap:



[IMPORTANT: In the video, the Instructor says if you put a kite up 300 feet, there's 1,000 volts. This is an error. It should be "10,000 volts". And if there's a cloud, the correct amount is "millions" of volts, not "thousands." These numerical errors appear on the white board drawings in the video, but both the drawings and the transcript have been corrected in this Teacher Guide.]

- Draw picture of Benjamin Franklin flying his kite near a cloud. There's a key hanging from the end of the kitestring. A separate silk string is tied near the bottom of the kitestring, and Franklin holds the other end of the silk string. A leyden jar is on the ground nearby.
- Franklin was a practical joker. He learned that you could fly a kite on a clear day and get electricity from it.
- He soaked the kite string in salt water so it would conduct electricity better. The kitestring went from the kite down to a key. There was a silk string about twenty feet long between himself and the key, to keep him from getting shocked.
- As you move up every three feet, there's about a hundred volts of electricity. If your kite is up three hundred feet, there's ten thousand volts, which is a reasonable amount.
- But if there's a cloud overhead, it could be millions of volts.
- So Franklin flew his kite in a clear sky so there'd be thousands of volts on it.
- He'd bring the key near the jar *[show leyden jar]*.

Intro Quick Recap (cont.):

- The jar has aluminum foil on the outside. Franklin probably would have used lead foil. He also put foil on the inside, but the two foils didn't touch each other anywhere.
- He put a steel rod inside with a gold chain that would touch the inside foil.
- While flying his kite, he'd walk around until the key touched the top of the leyden jar. This would store up charge in the jar.
- Then he'd hand the jar to someone. If they happened to touch the top and sides together, they'd get a shock and throw the jar across the room. If they happened to hold it with one hand and touch the top with the other hand, the current would go through their heart, and they'd fall down.
- After experimenting with this, Franklin discovered that clouds almost always have negative charge on the bottom (not sure if he knew about the positive charge on top). But he knew that if you flew a kite at a cloud like that, you could die.
- When he wrote papers about his discoveries, European scientists wouldn't publish them because Franklin was a colonial. They thought he didn't know anything.
- Franklin apparently wrote a letter (which was lost) describing flying a kite under a cloud. Someone in France took it seriously and decided to show him how to do it right. He flew a kite in a lightning storm, was struck by lightning, and died. But Franklin only meant it to be a joke.
- Franklin discovered that when a cloud passes over, positive charge shows up on the ground below the cloud, and the charge moves when the cloud moves.
- The positive charge creates some pull on the cloud -- they're mutually attracted to each other.
- A cloud with really warm, moist air wants to rise up, but the charge on the ground keeps the cloud where it is.
- If you make the charge go away by putting spikes on the ground, the cloud will rise. This makes it cool off, so the little droplets get bigger and bigger, and you get rain.
- In the old days, rainmakers would charge money to fire their cannons at the clouds to make it rain. They thought it was the shock from the loud noise that shook the rain out of the clouds.
- Actually, it was smoke from the cannons. It would rise into the air, and if the smoke particles made it up to the cloud, the tiny raindrops would condense on the particles, and it might rain.
- In the experiment, we're going to be dealing with an induced charge -- the fact that the charge on the cloud can make a charge on the ground.

Experiment Quick Recap: *"Electrophorus"*


Touch charged pie tin to leyden jar.

- A vinyl record album has flat spots between the songs so you can tell how many songs are on it. The songs that are louder have rougher-looking grooves.
- If you rub the vinyl with wool, it develops static electricity. When you played the record, the needle that picked up the recorded sound would also pick up the static.
- Put the record on the table and rub it with wool to charge it up. Wherever you touch it with your fingertip, you discharge some of the static.
- Someone thought you could make an infinite amount of energy with a charged record. You take a pie plate and glue a piece of foam on it to use as a handle.
- You charge up a record, place the pie tin on it, touch the top, take it off, and touch it to a leyden jar to transfer the charge.
- Then repeat several times (you don't need to rub the record again). The theory is that charge on the record never goes away, and the only work you've done is moving the pie tin from the record to the leyden jar. We're going to see if this is true.
- Students work in groups of two.
- Each group gets a pie tin and glues a piece of foam tubing onto it.
- Each group also gets a record, a piece of wool, and a leyden jar.
- The jar only works if there's salt water in it, so students fill it with water up to 1/2 inch below the top of the foil.
- Instructor comes around and pours salt into each leyden jar. Then students screw the lid on.
- Students put the record on the table, rub it with the wool, place the pie tin on it, touch the inside of the pie tin with a finger, then touch the tin to the nail in the top of the leyden jar.
- Then they touch the leyden jar ***with one hand only*** -- touching their thumb to the side and their forefinger to the nail on top -- to see if they can feel any charge.
- Then they repeat the process five times and check for a charge, then ten times and check it again.
- Instructor blows up a balloon, rubs it on a student's hair to generate static charge, touches the pie tin to the spot on the balloon where it was rubbed, and then touches the pie tin to the leyden jar.
- Students repeat this several times to see if they can build up a detectable charge in the jar.


Safe way to touch the jar, with ONE HAND only.

Experiment Quick Recap (cont.): *"Electrophorus"*

- Instructor passes out small neon lightbulbs so students can touch one of its wires to the top of the leyden jar to check for charge.
- Instructor brings out Van de Graaf generators. Students hold the top of the jar near the Van de Graaf, keeping it level so the salt water doesn't get into the threads. They let the jar get zapped a few times, then use the neon light to check for charge. (Only one student at a time may charge their jar; otherwise the person closest to the ball gets all the charge.)
- For a demo, Instructor has one student (someone with flyaway hair) stand on an insulated stepstool and put their hand on top of a Van de Graaf generator. Their hair should stand up.
- Static electricity acts differently than other electricity. If you put electricity through aluminum, whatever charge you put on it shows up on the front side and the back side.

Spark from Van de Graaf ball to leyden jar.

- But if you have something that's charged up, like someone's head, and suppose their head is positive, it attracts the negative guys to the outside of the pie tin.
- When you touch it, the negative guys drain off and it supposedly leaves positive guys all over the pie tin, and that's what jumps into the leyden jar.
- We don't know why static electricity acts that way, where a conductor can have one side positive and the other side negative, but it does.

Equipment List: *"Electrophorus"*

Items needed for Instructor:

- Insulated stepstool
- Bucket, 5-gal (for water)

Items needed for Students:

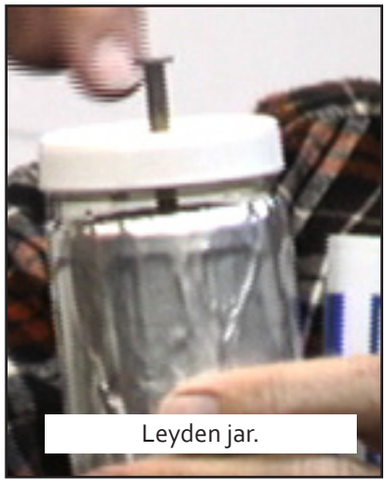
Consumables (per group of 2 students):

- Salt (ordinary table salt), 1 tsp
- Water, approx. 3 oz.

Other (per group of 2 students):

- Record album, vinyl
- Cloth, wool, approx. 4" x 4"
- Pie tin, aluminum, approx. 9"
- Foam tubing, approx. 2" diameter
- Glue gun
- Leyden jar, 4-oz
- Cup, clear plastic, 16-oz.
- Van de Graaf generator (1 per 4 students)
- Balloon, 11"
- Neon bulb, small

Small neon bulb



Leyden jar.

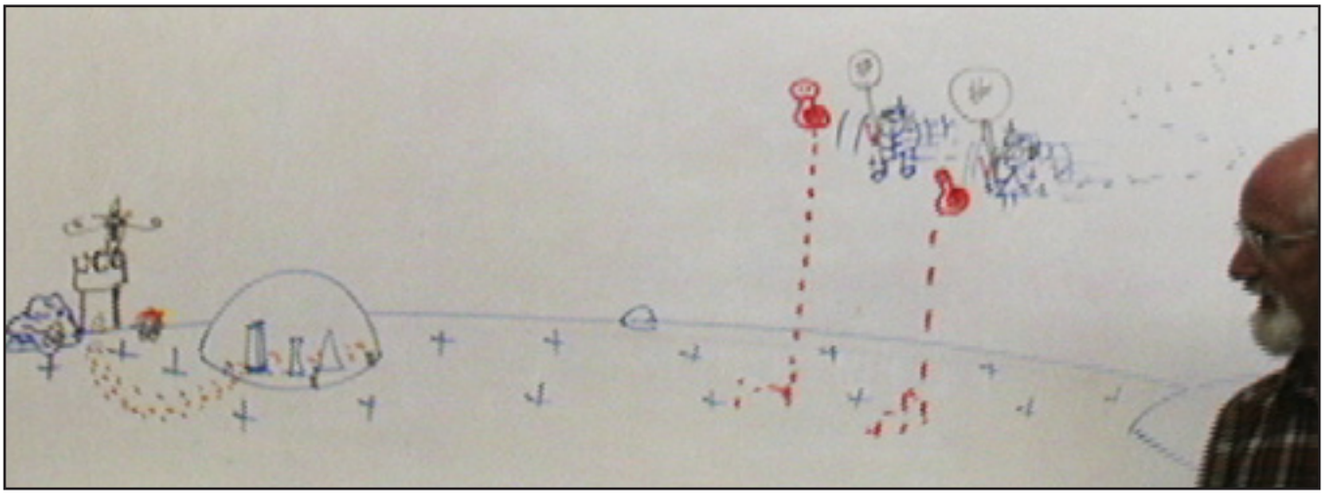
Van de Graaf

Prep Work:

- Construct leyden jars as follows:
  - Baby food jars, 4-oz. (either glass or plastic) with *plastic* lids. **IMPORTANT: *Do not* use jars larger than 4 oz., because they would store too much charge.**
  - Tape, foil, with peel-off backing. Comes in rolls 2" x 50 yds. *Apply to outside of jar only. Leave the top 1/2" of jar uncovered.*
  - Nail, 16-penny size, driven through center of lid. It doesn't matter whether the nail touches the bottom of the jar on the inside.
  - Water, approx. 3 oz. *Keep water level below the level of the foil tape.*
  - Salt (ordinary table salt), 1 tsp. Add to water in jar. *Be sure none of the salt water gets onto the threads or outside of the jar.*
- Note: For this lesson, the Instructor constructed the empty leyden jars ahead of time and the water and salt were added during the experiment.

Pie tin, foam tube, vinyl record, and wool cloth.

Story Quick Recap: "*Jack & Jill, Floating Detectives*"

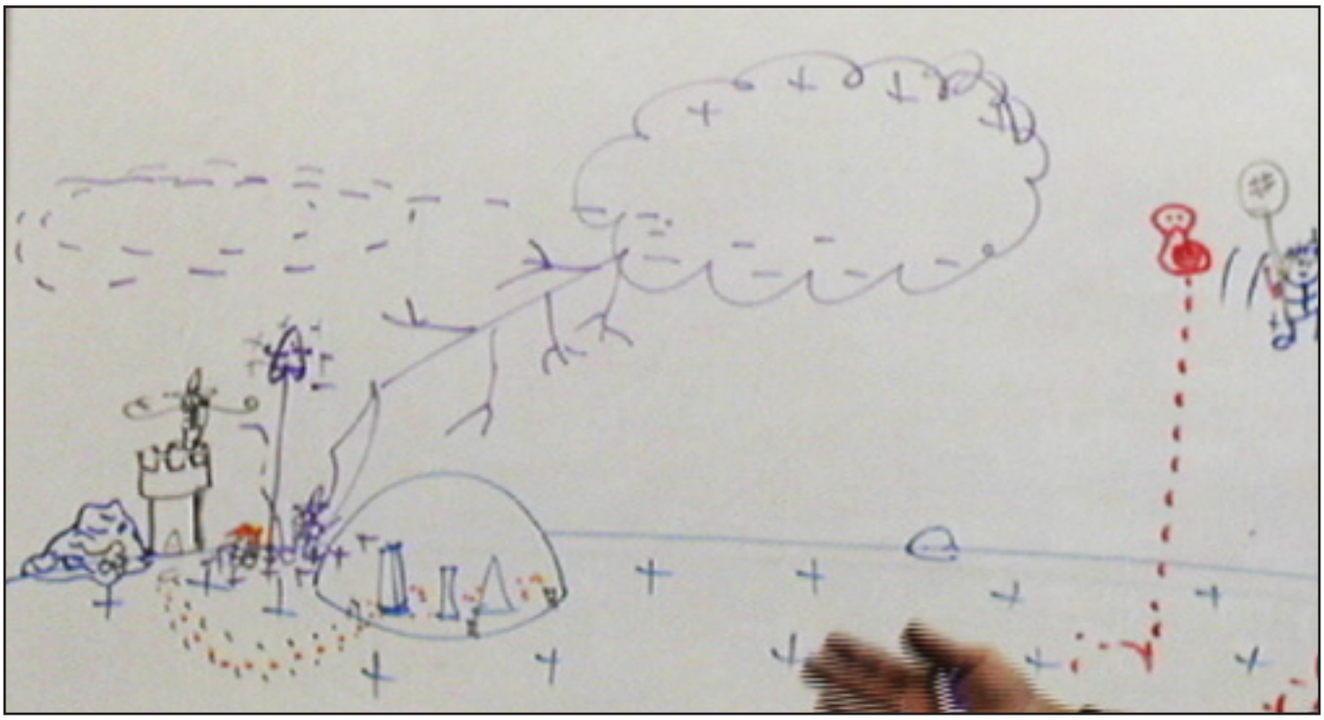


- Jack and Jill were living in the future, where you could float in midair and propel yourself forward.
- The cities were under glass domes because the atmosphere was all messed up.
- People made themselves float by increasing the static charge on the earth. Instead of just 100 volts per three feet, they made it about a hundred thousand volts per three feet. So there was a huge positive charge.
- They had clothing that would get all static-y when they walked around. And the static charge from the person would also be positive.
- Positive charges repel each other, so people could hover. If they wanted to propel themselves forward, they could put on needles pointing backward, so some of the charge would leak off. As you went forward, you would also go down.
- Jack and Jill had a magic wand that they could point at their Kick-Mes to make all of their charge go away. This would make the Kick-Me's fall to the ground and bounce, which made them happy.
- They could also use the wand to reverse the charge on the Kick-Mes, making them negative, so they're attracted to the ground and fall really hard. They like this even better.
- Evil Mister Fred didn't live in a domed city. He had his castle on the outside, in the polluted air. He wore scuba tanks for breathing
- He modified his vacuum cleaner so he could get a charge with it and zoom around really fast. The minions had to live out in the stale air, but they could hold their breath for a long time.
- Evil Mister Fred wanted to steal stuff from the domed cities, but they were protected, so his minions couldn't just walk through.
- So he had them dig tunnels under the city walls, pop up somewhere, and steal stuff, usually M&Ms. But Evil Mister Fred wanted then to steal valuable stuff like gold and diamonds.

Story Quick Recap, cont.: "*Jack & Jill, Floating Detectives*"

- He put a hat with a video camera in it on the minions' heads. And he implanted a communication device in their brain so he could hear what they were thinking. But that drove him crazy because minions think really dumb thoughts.
- So he bought them cell phones so he could talk to them and tell them where to go.
- The minions kept digging tunnels into the domed cities and stealing the gold and diamonds.
- So the people called Jack and Jill, famous detectives.
- They told Jack and Jill the thieves were little guys with mustaches and no arms, so Jack and Jill know who was behind it.

Story Quick Recap (cont.):

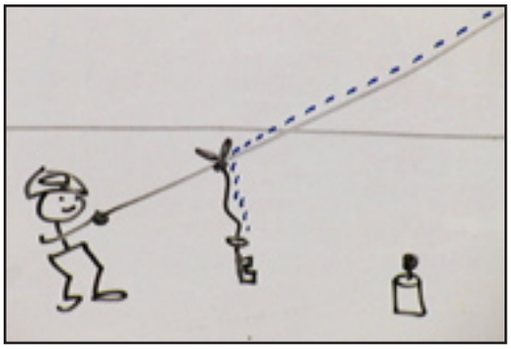


Ending:

- Jack and Jill watched to see if any minions were floating around the domed cities, but they didn't see any. So they knew the minions were tunneling. But they didn't know where.
- Jack and Jill started hovering around Evil Mister Fred's castle, and he didn't want them there.
- So he took some of his minions off the ground, made them positively charged, and held them down with ropes. When he cut the ropes, they'd shoot into the air at Jack and Jill like cannon-balls. And their heads are really hard.
- Jack and Jill called the Acme Store of Everything and ordered a big cloud. As it was hovering in the air, it had positive charge on the top and negative charge on the bottom, and they were balanced.
- The cloud drifted overhead just as Evil Mister Fred took out his pocket knife to cut a minion's rope. The pocket knife has a sharp point on it, so it induces a much bigger positive charge underneath Evil Mister Fred and his minions.
- This made Evil Mister Fred a human lightning rod, and the lightning shot down, and Evil Mister Fred's head exploded. The minions tried to put the pieces back together again, but they messed up the brain part.

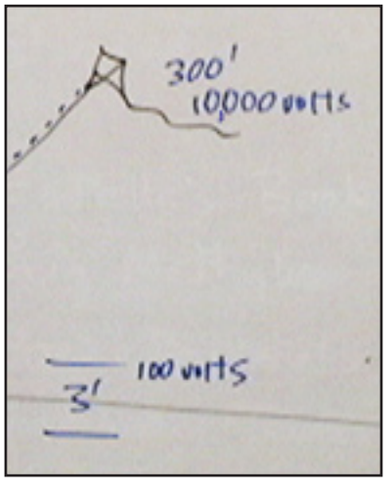
Transcript: Intro

[00:00:11] *[IMPORTANT: In the video, the Instructor says if you put a kite up 300 feet, there's 1,000 volts. This is an error. It should be "10,000 volts." And if there's a cloud, the correct amount is "millions" of volts, not "thousands." These numerical errors also appear on the white board drawings in the video, but both the drawings and the transcript have been corrected in this Teacher Guide.]*



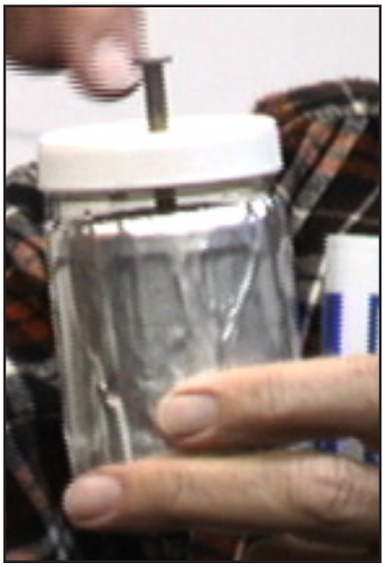
Franklin with kitestring, key and leyden jar.

Know who this guy is? *[Student: Benjamin Franklin?]* Yes. Benjamin Franklin was a practical joker. He liked to goof around. And he discovered that you didn't have to fly a kite on a cloudy day to get electricity. You could fly a kite on a clear day and get electricity from a kite. He took some string -- not sure what kind of string -- and he soaked it in salt water so it would conduct electricity better. And then he let the string go all the way down to a key. Then he had a piece of silk string about twenty feet long between him and the key. This way he could hang onto it, and the electricity wouldn't go into his fingers, and his hair wouldn't go poof, and he wouldn't get all shocked.



100 volts per 3 feet

So as you move up, for every three feet, there's about a hundred volts of electricity. So there's a hundred volts just in that distance. If you put your kite up three hundred feet, then there's ten thousand volts, which is a reasonable amount, not a whole lot. That's in a clear sky. If there's a cloud overhead, all bets are off. It could be millions of volts. And he would fly his kite up there, and there'd be thousands of volts on it. And he could bring it near this jar. This jar has aluminum foil on the outside. He used, I think, lead foil. And on his, he put lead foil on the inside, too. The two foils didn't touch each other anywhere. And he would put a steel rod inside with a gold chain that would touch the inside foil. And he'd set that on the ground, right there, and then he'd walk around until the key would touch the top of the jar. *[Student: Didn't we do this last week?]* Yes. Last week was low voltage, high current. This week is high voltage, low current. *[The student is referring to the lesson on "Capacitors," which the class did the previous week.]*

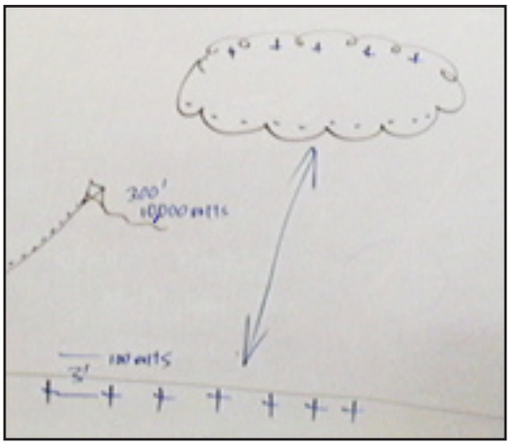


Small leyden jar.

And he'd touch the key on there and store up charge in the jar. And then he'd take the jar and hand it to somebody. And if the somebody happened to touch the top and the sides together, they would go, "Aaaah!" and throw the jar across the room. If they happened to hold it with one hand and touch the top with the other, the jar would go flying, the current would go through their heart, and they'd fall down.

And we call it a leyden jar, and after experimenting with this, he discovered that clouds almost always have a negative charge on the bottom. I'm not sure if he knew about the positive charge. He knew that if you flew a kite at a cloud like that, you could die.

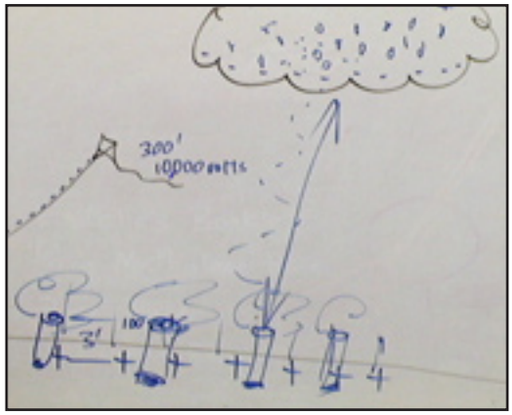
And he had a problem with the people in Europe. He would write these papers about all his discoveries, and they would say, "Oh, that guy. He doesn't know anything. He's just a colonial. He has no brains at all." And he apparently wrote a letter that was lost, describing flying a kite by a cloud. And somebody heard about it -- I think it was a guy in France. He says, "Oh! Those guys! How dumb can you get? He didn't do that right at all. I'll show him how to do that right." So the guy in France went and flew a kite up in storm, lightning hit it, and he died. And Franklin must have felt kind of bad because that was supposed to be a joke, but he took it seriously.



The cloud has a positive charge on the top, a negative charge on the bottom, and creates a positive charge on the earth under the cloud.

Whenever there's a cloud like this flying, he also found out something weird happens. For no reason, positive charge shows up on the ground, under the cloud. And the positive charge moves when the cloud moves. So the positive charge creates some pull on the cloud. They're mutually attracted to each other. So you can have a cloud with really warm, moist air floating in the sky. It wants to rise up, but the charge on the ground is attracted to the charge in the cloud, and the cloud stays where it is. If you somehow make this charge go away by putting spikes on the ground, anything with sharp points, then the cloud will rise. As the cloud rises, it cools off. When it cools off, the little droplets start getting bigger and bigger and bigger, and you get rain.

And there were rainmakers in the old days, and they would come to some town that hasn't had some rain. They'd wait until there were clouds in the sky, and they'd say, "If you pay me a thousand dollars, I'll make it rain." And they had cannons. They'd go out there with old civil war cannons, and they'd shoot the cannons up in the air. They'd say, "We'll shock those clouds. We'll just shake that rain right out of those clouds," because they'd make a loud boom.

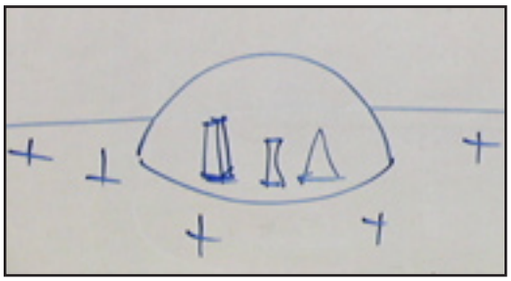


Rainmakers used cannon to send smoke up into the clouds.

Well, that wasn't what happened at all. What happened was, the smoke from the cannons would rise into the air. And if the little particles of smoke happened to make it clear up into the cloud, the tiny raindrops would condense on the little particles, and if they were lucky, it would rain and he'd get his thousand bucks. If the smoke didn't make it up there and it got blown away or whatever, no rain. Too bad, so sad, he got run out of town on a rail.

Well, this charge that's down here is what we're going to be dealing with today. The fact that that *[points to charge on cloud]* makes this stuff *[points to charge on ground]*. It's an induced charge. And we want to see what we can find out about it. But first, we need a crazy story.

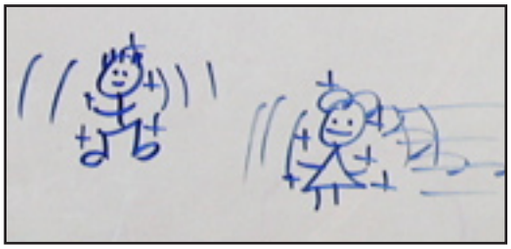
Story: "*Jack and Jill, Floating Detectives*"



Domed city with positive charge on ground.

[00:07:10] Should the story take place in this time period, the old days, or the future? *[Students: Future.]* All right, the future. Once upon a time, Jack and Jill were floating in midair. In those days in the future, they discovered that you could make people float. And you could also make them be propelled forwards while they're floating. And they did it by manipulating the earth. The cities in the future had to be under glass domes because the atmosphere was all messed up. And so there are tall towers and regular buildings inside of the domes. And there's a dome off here, and a dome over there, like that.

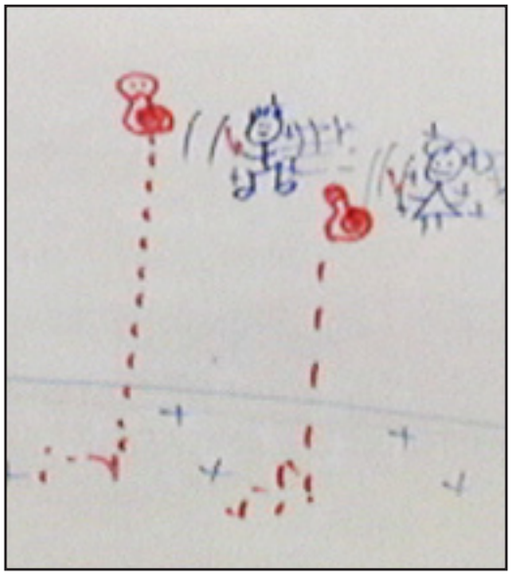
And to make it so people could hover, and kids could ride around on hover skateboards, all they did was increase the static charge on the earth. Instead of making it just a hundred volts per three feet, they made it, oh, about a hundred thousand volts per three feet. So there was this huge positive charge. And they developed clothing that, as you walk around, the clothing would get all static-y. And the static charge from the person would also be positive.



Jack & Jill floating in midair, with positive charge on them.

Do positives attract or repel? If you have a positive there *[points to floating person]* and a positive there *[points to the earth],* are they going to go slamming to the earth or be repelled? *[Students: Repelled.]* So, you could have people who were just hovering because of static charge. And this is kind of neat. People could float all around, they could put on some wings and fly, you could propel yourself by putting needles pointing backwards. The charge would leak off and you'd go forward. But if you let the charge leak off, you'd also go down as the charge was going away.

And Jack and Jill were up there. It was kind of neat because they could take their Kick-Mes along. And they have hovering Kick-Mes. And the Kick-Mes are always sad unless you kick them. And Jack and Jill have a magic wand that they could point at the Kick-Mes and make all their charge go away. And the Kick-Mes would start to fall to the ground. And this was kind of neat, because then they'd bounce and they'd laugh and giggle and have a good time bouncing around. They'd try to make them fall onto things like right in front of a passing truck and stuff.

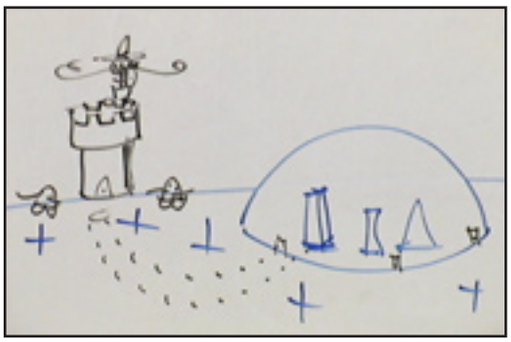


Jack & Jill's magic wands could change the charge on their Kick-Mes.

They also had a button they could push on their wand that would reverse the charge on the Kick-Mes. So instead of just falling by gravity, they'd go accelerating toward the ground, because now they're negative and they're attracted to the

ground, and they really hit with a big old splat -- bwooosshhh! And then they'd put themselves back together and be Kick-Mes again.

Well, that was fun for them, but Evil Mister Fred, he was out there. He was a rogue. He didn't want to build his castle under a dome. He wasn't going to have any of that. He built his castle out in the open in the polluted air. And he wore scuba tanks for breathing. There's a tank on his back. And he modified his vacuum cleaner so that he could get a charge with that. He could zoom around really fast on his vacuum cleaner. His minions, they could just hold their breath a long time. They had to live out there and breathe the stale air.

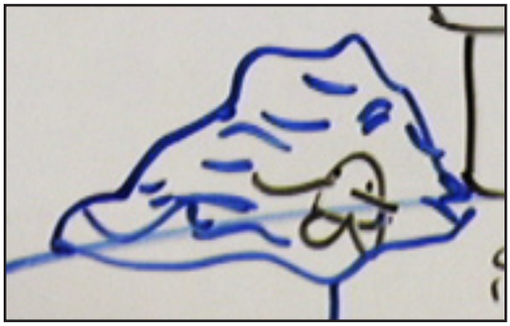


Evil Mister Fred's minions dug tunnels into the domed cities.

And Evil Mister Fred wanted to go into the domed cities and steal stuff. They had these glass walls. They had glass doors with guards on them, and all kinds of protection, so his minions couldn't just wander in there and take stuff. So he said, "Well, we can solve that. Our minions are tough, they're strong, they're smart. We'll just have them dig tunnels under the domes, and they can pop up wherever they happen to pop up, because they never pop up where you expect them. They can steal stuff and bring it back through the tunnels.

Minion with video camera hat.

And they usually would steal things like M&Ms, or doughnuts, because that's what they're attracted to. And Evil Mister Fred wanted them to steal gold and diamonds and rubies. So he put on top of their heads a hat that was really a video camera. And he implanted into their brains a communication box so he could hear what they were thinking. Well, this didn't work, because they think really dumb thoughts and it was driving him crazy. So then he had to go back and buy some really old-fashioned cell phones and plant those on them. And then he could talk to the minions, see what they're doing, and tell them, "No! Leave the M&Ms alone. Go for the gold thing or the diamond stuff."

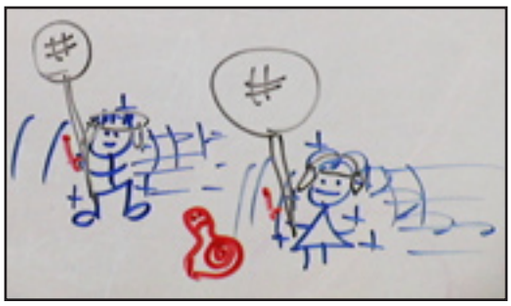


Evil Mister Fred's pile of riches.

And the minions were getting good at this. They'd go in there, and they'd run around and steal stuff and bring it back. And the people in the domed cities didn't like it. Their ancient stuff was being taken away by these minions. Evil Mister Fred now has riches out here, piles of diamonds and stuff. And he uses it to buy anything he wants and create more havoc and mayhem.

The people in the city decided to call Jack and Jill, famous detectives. You can't be a detective unless you have a hat with earmuffs and a magnifying glass. And they called up Jack and Jill and said, "Hey, somebody's stealing all our stuff. Little guys with mustaches. No arms." And Jack and Jill said, "Well, okay, we know who those guys are." And

the people said, "We've got to get all our stuff back and make it so they can never steal anything again." If you were Jack and Jill, and you were solving this problem, what would you do?



Jack and Jill, famous detectives.

Imagination and Brainstorming Time

[00:14:00] *[Students make suggestions]* (THERE ARE NO WRONG ANSWERS! Whatever they say, you should reply: "That's a good idea," "They might do that," etc. After brainstorming, proceed with the experiments, then finish the story.)

Okay, we'll leave this "To be Continued . . ."

Experiment: *"Electrophorus"*

[00:15:25] The first part of the experiment involves antiques. Here we have a record album, "Flamenco Carnival, featuring Pedro de Linares." Your favorite. And suppose you wanted to listen to one of the songs on here that's really loud, but you forgot which one. You know that there are flat spots between the songs, so you can say, "Well, there's one, two, three, four, five, six, seven songs on that side." Well, it turns out that the tiny little grooves that the needle rides in, if the music is loud, the grooves wiggle more. And they look rougher. So if you wanted to spot where the music is soft, you'd look where the grooves seem smooth. If you want a place where it's loud, you look for where it's rougher.

Well, these things are also made out of vinyl. Vinyl is one of those things that, if you rub it with wool, it develops static electricity. In the old days, when you wanted to play a record, you put the needle on there. And it would go round and round, and it would amplify whatever the needle picked up in vibrations. It would also pick up the static electricity. So your song would be going zzzhhhhh along with the music you're listening to. So people liked to clean them off first. If you rubbed it with wool to clean it, then you got all this static and sound coming out of your stereo system. But that's good for us.

Rubbing vinyl record with wool to charge it up.

If you set a record on the table and rub it with wool, it becomes charged up. It kind of snaps and crackles and stuff. And if you touch it, wherever you touch it you discharge some of the static *[touches various spots on the record with fingertip]*. You probably can't even feel it, but I'm discharging spots all over it.

Now, somebody came up with this idea. He said, "We can make an infinite amount of energy using a charged record. Perpetual energy. All we need is a pie plate and a piece of foam. You charge up your record, throw your pie tin on there, you touch the top *[the inside surface of the pie tin]*. You take it off, and you touch it to a leyden jar." We happen to have a leyden jar here. "You touch it to a leyden jar, and you put it back on there *[on the record]*. You don't need to rub it again. Touch it here *[inside pie tin],* and put it on there *[on leyden jar]*. You do that maybe ten times, and the leyden jar gets charged with charge. And the only work you've done is moving the pan from here to there. And the charge on the record never goes away." That's the theory.

Place pie tin on charged record and touch it with fingertip to discharge a spot.

Then touch the pie tin to the leyden jar.

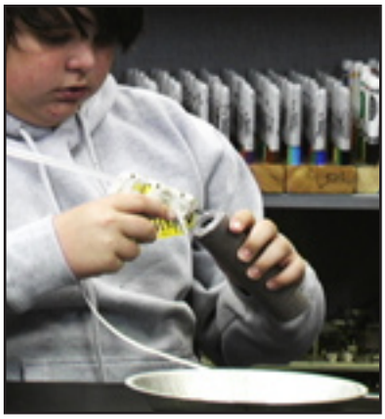
Now, we want to see if this is true. So you're going to have to glue some foamy pieces to some aluminum pans. I found some better ones over at Marie Callender's. They have pans that are better. So we'll give you a piece of foam, a pan, and a record. You're going to have to work with somebody else, because records are hard to come by. We've got eight records. And you'll glue a piece of foam on your pan, and we'll give you a leyden jar. These leyden jars don't work unless you put salt water inside. So when you get your leyden jar, fill it below the level of the aluminum foil a little bit, and we'll dump some salt in there, and then the nail will be your conductor. And you'll be able to store a charge.

After you charge it up, you need some way to test it to see if the charge is there. So, if you want to, you could grab the jar with one hand and touch it with the other. And the charge will go through your arm and through your heart and back into the jar. *[Student: Won't it hurt?]* Yeah, it'll hurt. And you might die. *[Student: Could it cause some kind of condition?]* If you have a weak heart, you'll get little X's where your eyes used to be. *[Student: If you already have a condition, you shouldn't deal with it, right?]* Well, there's a safer way to do it.

Safe way to check for charge.

You don't want electricity to go through your heart. Your heart doesn't like it. So if you're going to touch something to see if it's charged, you can put your finger on the top and touch the side with your thumb ***[of the same hand].*** Then it just goes through your thumb and your finger. It doesn't hurt that at all. So that's the way you're going to test it.

You're going to first just do the touchy thing there *[on pie plate]* and touch on there *[on leyden jar],* one time, and test it and see if you feel anything. And then you're going to do it five times, touch it five times, and touch it to see if anything happens. Then you do it ten times. *[Stu-*



Glue foam tube to pie tin.

dent: So there's no other way besides touching it?] Oh, there is. But I can't tell you that yet. It's a secret.

So we need to plug in some glue guns. Choose a partner, come up here and get one of these older looking *[pans]* that isn't too gooked up, and you can grab a record from over there. Choose one of your favorite artists. There's foam in here. *[Students get supplies and Instructor passes out glue guns and leyden jars. Students use a plastic cup to get some water from a bucket and pour it into their leyden jars. Then the Instructor comes by and pours about a teaspoon of salt into each jar.]*

Add about a teaspoon of salt to the water in the leyden jar.

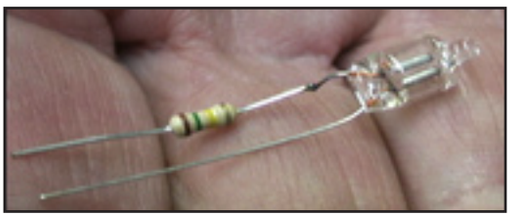
Test yours and see if you can get some charge in the jar. *[Students rub the record with wool, place the pie tin on it, touch the pie tin with their finger, then touch the pie tin to the leyden jar and check it to see if there's a charge.]*

[After a minute or so] Is anybody getting a shock yet? *[Students: No, nothing.] [Students continue charging the jar.]*

[Instructor blows up a balloon and ties a knot in it.] Hang on a second. We want more static. Sometimes these old records just don't do it. *[Student: It works after fifty times!]* Fifty times.

Instructor touches pie tin to balloon while a student discharges a spot.

You have to borrow somebody's head *[starts rubbing the balloon on a student's hair]* and rub a balloon on it. *[Student's hair becomes attracted to the balloon.]* And now there's no question that you have charge. Once you rub the balloon, the spot where you rubbed is where you're going to put your plate *[touches pie tin to balloon]*. And then *[to a different student]*, go ahead and touch the plate, because my hands are full. And then touch it there *[touches pie tin to leyden jar. Instructor repeats the process a few times to charge the jar]*. There's charge there. And somebody needs to touch it and see what they feel *[demonstrates touching the jar with finger and thumb as before]*. And see how many times you have to do it before you can feel it. *[Instructor passes out balloons. Students blow them up, rub them on each other's hair to generate charge, and repeat the experiment.]*



Tiny neon bulb.

Somebody asked, "Isn't there an easier way, rather than touching it with your finger?" So what we have are neon light bulbs like we used in the microwave oven *[Instructor is referring to a lesson called "Unwise Microwave Stuff]*. If you want to test one, you hold one leg of the neon lightbulb, and you touch it

to the nail on top. *[Turns out light.]* If there's any charge, the light will light up. *[Instructor passes out light bulbs and students continue experimenting.]*

[Student: When you touch it, does it drain the charge?] Only on the top side of the plate. The bottom side keeps its charge.

Charging the leyden jar with the Van de Graaf generator.

[Instructor brings out some Van de Graaf generators.] If all else fails, you can put a huge charge in your jar by keeping it level so the salt water doesn't get into the threads, and let it get zapped by the Van de Graaf generator. Don't touch it *[the nail]* with your hands. Use your neon light, and see what it does. Only one person at a time charging the jar. Whoever's charging the closest will get all the charge. *[After a minute or so, Instructor turns off lights so students can see the sparks jumping from the Van de Graaf generator to the jar, and so they can see the neon lights better.]*

Spark from Van de Graaf to leyden jar.

[Lights on.] Does anybody have flyaway hair? *[A student comes forward.]* Would you try standing on this? *[Student stands on insulating stepstool next to Van de Graaf generator.]* Touch the ball and see if your hair flies away. *[Student places one hand on the Van de Graff's ball and his hair starts to stand up. After about thirty seconds, the student steps down.]*

[Instructor picks up one of the pie tins with the foam attached.] If you put electricity through aluminum, whatever charge you put on it shows up on the front side and the back side. But for some reason, if you have something that's charged up, like someone's head, and suppose their head is positive, that attracts negative guys to the outside here. When I touch it, the negative guys drain off and it supposedly leaves positives all over this *[pie tin],* and that's what jumps into the jar when you touch it onto the leyden jar. This is really weird, that static acts differently than other electricity, that on a conductor you can have one side positively charged and one side negatively charged. Don't know how it works, but it does. So now we need an ending for our story.

End of Story

**** DO NOT * present this part of the lesson until after you have done the experiments!***

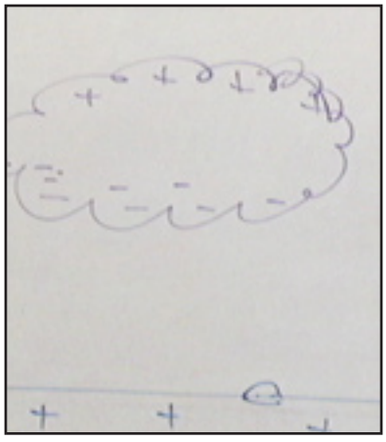
Jack and Jill hovered over the castle.

[00:38:11] Evil Mister Fred and his minions are sneaking into the secure cities with tunnels under the ground. And they were stealing the gold and the M&Ms and the doughnuts and the diamonds. And Jack and Jill were given the task to find out who's doing it and stop them and bring them to justice. Now Jack and Jill were playing around in the air because they had a very high positive charge on themselves and the ground had a very high positive charge. And they thought, "Hmm, I wonder if whoever's doing this is also floating?" And they watched and they watched, and they never saw anybody floating near the cities. And they said, "Ah, there's only one solution. They're tunneling under the ground to get inside." But they didn't know where. They said, "Hmm, we'll just go hover by Evil Mister Fred's place."

Minion on rope and Evil Mister Fred with his pocket knife.

And Jack and Jill would come around at night and just hover up there and watch Evil Mister Fred. And they never saw any minions come out of the castle, but they did see Evil Mister Fred going, "Mwah-ha-ha!" And Evil Mister Fred saw them hovering, and he said, "Would you guys get out of there? You're not supposed to be around here. Just go away!" And Jack and Jill said, "Nope. We're staying here until we find out what's going on."

And Evil Mister Fred said, "Well, I'll show you." And Evil Mister Fred took some of his minions off the ground and made them positively charged, and he held them down with ropes. So now you've got minions tightly held by ropes. And then Evil Mister Fred would cut the ropes, and the minions would shoot up into the air like cannonballs. And their heads are really hard. And he was trying to shoot Jack and Jill down with high-speed minions.



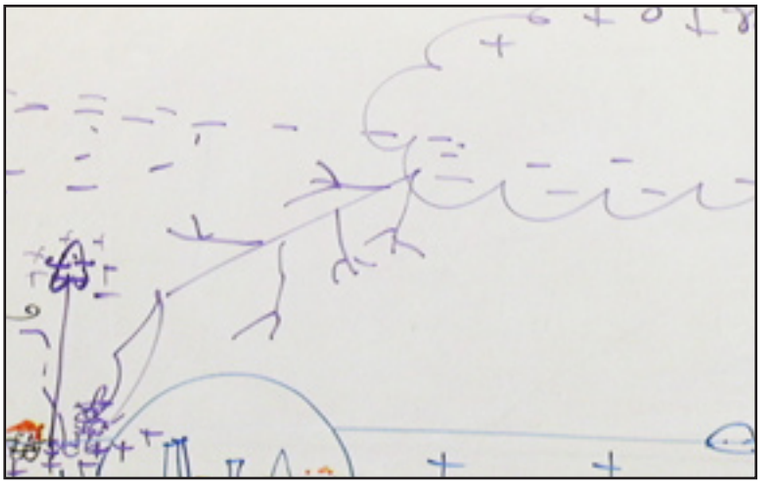
Jack and Jill ordered a big cloud.

Well, Jack and Jill said, "Hmm." So they called the Acme Store of Everything and they ordered a big cloud. The cloud was hovering in the air, but clouds have a negative charge on the bottom and positive on the top. And they're balanced up there. And Evil Mister Fred was down there ready to cut loose one of his minions. He's on the ground and he's got his pocket knife out, and he's ready to let loose and cut the minion free.

The cloud drifted overhead, and a pocket knife has a sharp point on it. And it induces a much bigger positive charge, all under Evil Mister Fred and his minions. Now Evil Mister Fred was standing there. He's

a human lightning rod. And of course, lightning shot down, and Evil Mister Fred's head exploded. And the minions said, "Ohh, Boss!" And they gathered all the pieces of his head and put it back together again. But they kind of messed up the brain part. So after that, Evil Mister Fred -- one eye pointed this way, one eye pointed that way, and he drooled a lot. And they all lived happily ever after, except Evil Mister Fred.

End of Lesson



Lightning from the cloud strikes Evil Mister Fred.