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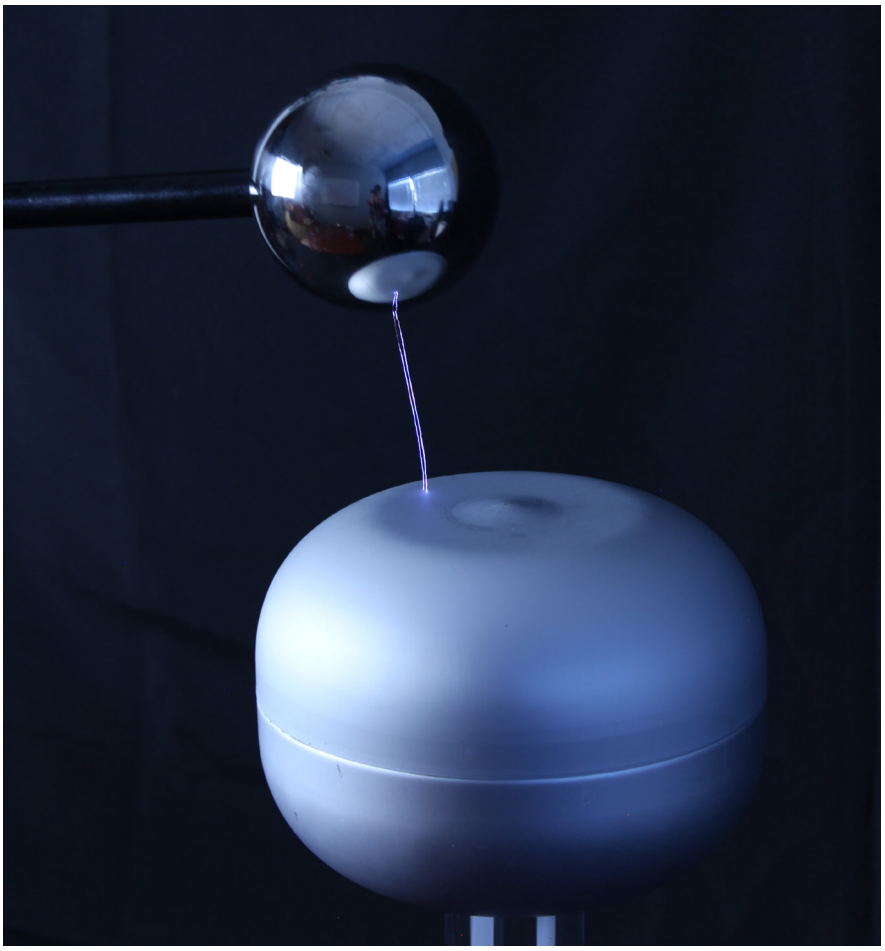

VAN DE GRAAFF GENERATOR

Spinner Package Demonstration Guide

Demonstrations for the Science First Van de Graaff generator and its included accessories.

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TEACHING WITH VAN DE GRAAFF

The Van de Graaff generator can be used to teach many concepts, including:

- Frictional charge generation
- Electrostatic repulsion
- Charging and discharging
- Lightning
- Electrostatic fields
- Electric potential

NGSS Standards

3-PS2-3 Motion and Stability: Forces and Interactions
Make observations and/or measurements of an object's motion to provide evidence that a pattern can be used to predict future motion.

MS-PS2-3 Motion and Stability: Forces and Interactions
Ask questions about data to determine the factors that affect the strength of electric and magnetic forces.

HS-PS3-5 Energy
Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction .

Visit www.ScienceFirst.com for additional accessories and demonstrations

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SAFETY

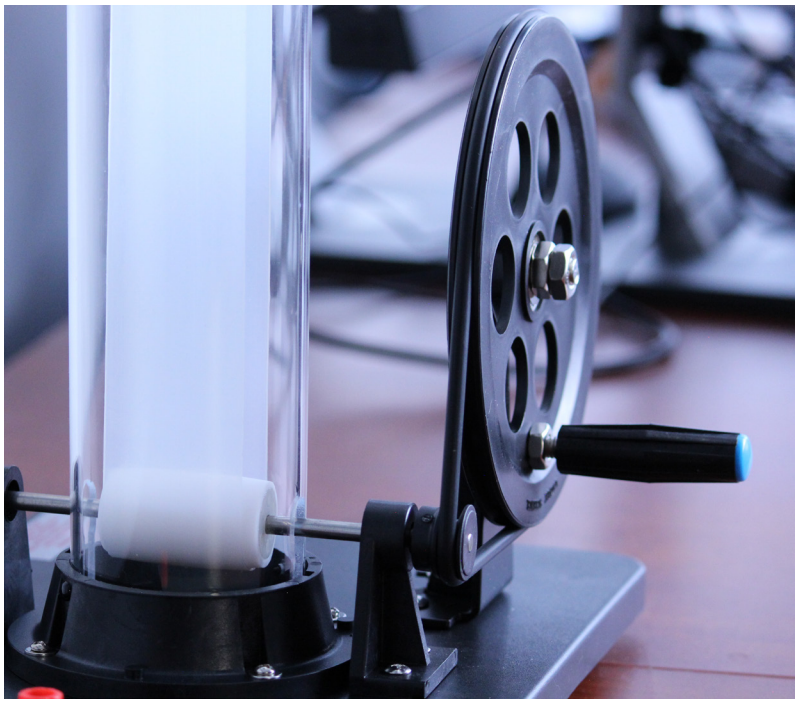
Warning:

Individuals with cardiac pacemakers or other electronic medical implants or devices should never operate or come in contact with the generator. Discharge of static electricity could cause the device to be damaged or malfunction.

Caution:

This device is designed to emit high-voltage electrical energy. Do not operate this unit near any electrical devices, including, but not limited to, cell phones, stereos, tablets, and computers. Science First is not responsible for damage due to improper usage.

- Adult supervision is required. This generator is safe when used properly.
- Only plug the generator into a grounded (3-prong) 110 volt 60 Hz outlet (motor-operated models).
- Do not operate outdoors or in wet locations.



INTRODUCTION TO THE VAN DE GRAAFF

Operation

1. Turn the generator on using the switch on the base (or begin turning the handle, if you have the hand-crank model).
2. When finished, turn the generator off (or stop turning the handle).
3. After operation, always discharge the unit.

How to Discharge the Generator

Discharging the generator after use is a critical step to avoid being shocked. The discharge wand works best when plugged into the ground port at the base of the generator, but should be used even if the ground port is in use by another accessory.

1. Turn the generator off (or stop turning the handle).
2. Hold the discharge wand by the handle and bring it near the dome of the Van de Graaff. You should hear and/or see a spark. You may need to do this a few times, depending on how much charge has built on the dome.
3. The dome is now safe to touch.

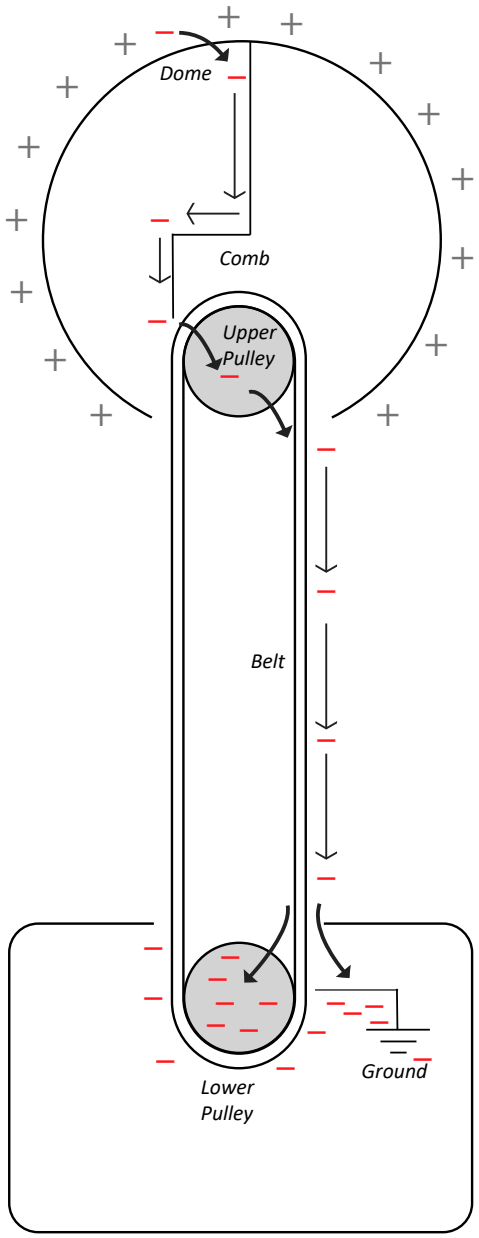
Shock

The Van de Graaff generator is safe to use. Any shocks you may receive while operating are not dangerous, though they may be surprising.

How the Generator Works

Van de Graaff generators operate using the following principles:

- When different materials (such as rubber and polyethylene) rub together, one loses electrons to the other. The object that gained electrons will have a *negative* charge and the object that lost electrons will have a *positive* charge. This called the **triboelectric effect.**
- Negative charges repel each other, but are attracted to positive charges. Similarly, positive charges repel each other, but are attracted to negative charges. When charges are repelled, it is called **electrostatic repulsion.**
- When positive and negative charges are separated from one another, a potential difference is created. With a potential difference, **electrostatic discharge** (i.e., sparks) can occur as electrons jump from the negatively charged object to the positively charged object.



Positive generators (like this one) create a positive charge around the dome by pulling electrons from the top of the machine towards the bottom.

At the top of the support column, a silicone rubber belt rotates around a polyethylene pulley. Silicone rubber tends to gain electrons more easily than polyethylene. Because of this, as the belt separates from the pulley to travel down the column, electrons transfer from the pulley to the belt. That loss of electrons creates a net positive charge on the upper pulley.

Drawn towards the positive charge on the upper pulley, electrons move from the dome (leaving a net positive), down the upper comb assembly, and onto the belt, which brings them down to the bottom of the generator. Once at the bottom of the machine, the electron-filled belt travels over a Teflon pulley. The electrons on the belt are repelled from each other **(electrostatic repulsion)**, so at this point, electrons transfer to the Teflon pulley and to the lower comb (ground).

In this way, the negative lower end of the generator continually pulls electrons from the top of the generator. Once the dome can lose no more electrons, it has reached its maximum potential (measured in volts) and the air around the dome begins to ionize (become charged), producing the occasional discharge of electrons from the air to the dome. Since the belt continues to rotate, it brings those electrons into the bottom of the machine, therefore maintaining a net positive charge on the dome.

LIGHTNING

Objective

To demonstrate electrostatic discharge

Required Materials

- Van de Graaff generator and discharge wand

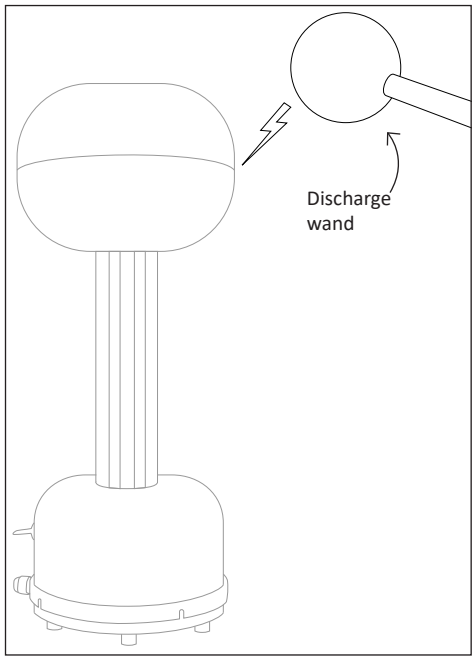
Notes

- This demonstration is best done in a darkened room.

Procedure

1. Plug the discharge wand into the ground plug at the base of the generator.
2. Start the generator.
3. Bring the discharge wand close to the dome.
4. Discharge will occur between the dome and the wand, creating both light and sound.
5. Try bringing the wand closer to and farther away from the dome, observing how distance affects the frequency and brightness of discharges.
6. Turn off and discharge the generator.

Note: You can also observe lightning occurring between the dome and the support column if you simply run the generator for a short period of time without bringing a discharge wand or other object close. This works best on our motor-operated models.



How it Works

The Van de Graaff generator builds positive charge at its dome and negative charge at the ground port. When you plug the discharge wand into that ground port, electrons can easily travel through the ground port to collect on the dome of the discharge wand. When you then bring the negatively-charged discharge wand close to the positively-charged dome of the Van de Graaff, the excess electrons on the wand “jump” towards the strong positive charge of the dome. This results in a visible and audible discharge, which mimics the phenomenon of lightning.

Discharges will continue as long as the generator is running because you have created a complete electrical circuit. In this circuit, electrons are discharged from the wand into the generator, then fed back to the ground port and into the wand once again.

HAIR RAISING

Objective

To demonstrate the principle of electrostatic repulsion

Notes

- **Read the entire procedure before attempting this demonstration.**
- Two people are required to perform this demonstration safely.
- A volunteer with fine, light-colored hair will work best.

Required Materials

- Van de Graaff generator and discharge wand
- Plastic stool (not included)

Procedure

1. Plug the discharge wand into the ground port at the base of the generator.
2. With the generator off, ask the volunteer to remove his or her shoes, then stand on the plastic stool with one hand palm-down on the dome.
3. Start the generator. **Note: Make sure the volunteer does not step down from the stool while the generator is running.**
4. Observe as the volunteer's hair begins to lift. It may take a couple of minutes to reach full effect.
5. When you are done, turn off but **do not discharge the Van de Graaff generator.**
6. Ask the volunteer to remove his or her hand from the dome, then step off the stool.
7. Discharge the generator.

How it works

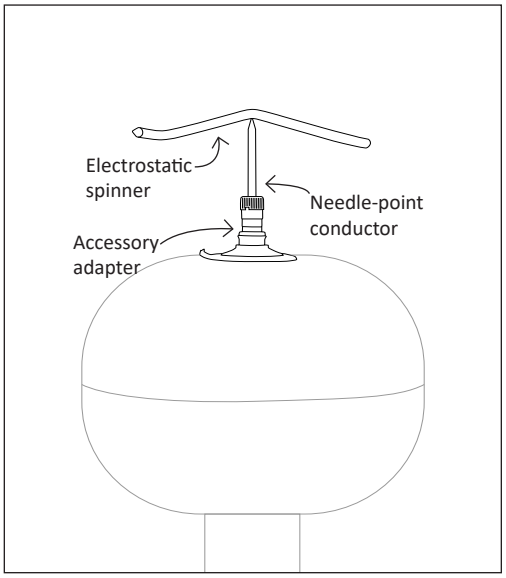
As the Van de Graaff generator runs with the volunteer's hand on it, electrons are pulled from his or her body into the machine, causing the body (including hair) to become positively charged. Because of electrostatic repulsion, each positively-charged strand of hair is repelled from the others and moves away, rising into the air.

The stool is critical in this process because it acts as an insulator and prevents electrons in the ground from moving into the volunteer's body. Therefore, the insulator allows the body to maintain a positive charge. Once the volunteer steps off the stool, electrons are free move from the ground and into the body, neutralizing the charge and causing the hair to fall back down.

ELECTROSTATIC SPINNER

Objective

To demonstrate the principles of electrostatic repulsion and charge density at a point.



Required Materials

- Van de Graaff generator and discharge wand
- Needle-point conductor
- Electrostatic spinner

Notes

- If you have the hand-crank generator (615-3130), you do not need to use the accessory adapter to perform this demonstration. Instead, plug the needle-point conductor directly into the metal bolt on top of the dome.

Procedure

1. Plug the discharge wand into the ground port at the base of the generator.
2. Attach the accessory adapter to the top of the dome.
3. Place the needle-point conductor into the adapter.
4. Place the electrostatic spinner on top of the needle-point conductor.
5. Start the generator.
6. Observe how the speed of the spinner changes as the generator runs.
7. Turn off and then discharge the generator.

How it works

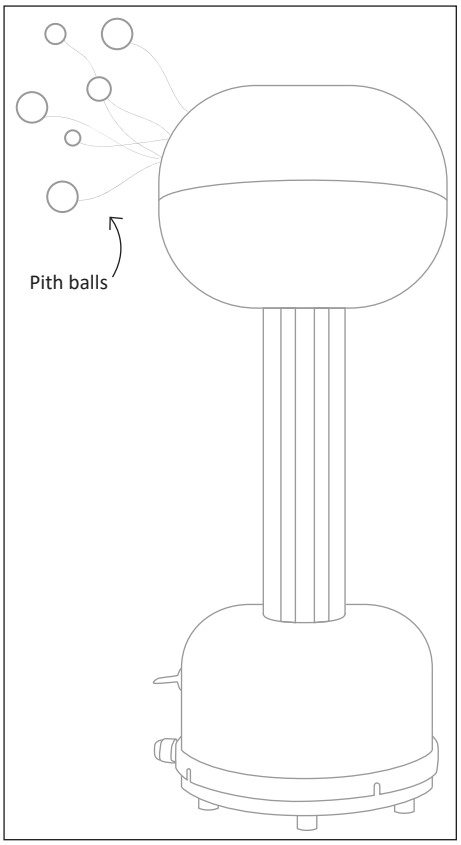
Because it is connected to the dome of the Van de Graaff, the electrostatic spinner gains the same charge as the dome. At the sharp points of the spinner, that charge is densely populated, which creates a strong electric field around each point and ionizes the surrounding air molecules.

Due to electrostatic repulsion, the points of the conductor are repelled away from that ionized air. As it moves, the spinner continuously ionizes the air around it and is continually repelled, moving backwards in a circle. Since the spinner is always receiving charge from the generator, it will spin until the charge tops and it loses momentum.

PITH BALLS

Objective

To demonstrate the principle of electrostatic repulsion



Required Materials

- Van de Graaff generator and discharge wand
- Pith balls
- Tape (not included)

Procedure

1. Plug the discharge wand into the base of the generator.
2. Tape the ends of the pith ball strings onto the dome of the Van de Graaff generator. You can put all the strings into a bundle or tape them around the dome at intervals.
3. Start the generator and observe how the pith balls behave. Note the difference between the behavior of the conductive pith balls and the standard pith balls.
4. Bring the discharge wand close to the dome while the generator is still running. Observe how the pith balls react to discharge.
5. Turn off the generator and observe the behavior of the balls.
6. Discharge the generator and observe the behavior of the balls.

How it Works

Once the generator is turned on, the charge from the dome extends through the pith ball strings, causing the pith balls to become positively charged. Due to electrostatic repulsion, the balls are repelled from each other and the dome, causing them to rise into the air. This is similar to the hair raising experiment.

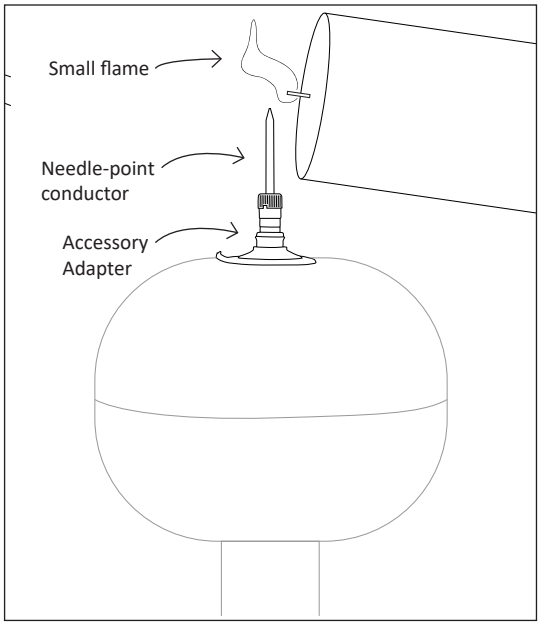
The conductive pith balls behave more erratically than the others because they are coated in graphite, which is a conductive material. The additional conductivity causes the balls to lose charge more easily than standard pith balls. As their charge is lost, the balls fall back towards the generator, regain a positive charge, and are again repelled into the air.

Once you stop the generator, the balls (particularly the non-coated pith balls) will remain in the air until the dome has been discharged or they slowly lose charge to the air. This is because spheres retain their charge well, allowing both the balls and the dome to keep their positive charges for extended periods of time after the generator stops. Once you discharge the dome, the balls will lose their charge and fall back down.

ELECTRIC WIND

Objective

To demonstrate the principle of electric wind



Required Materials

- Van de Graaff generator and discharge wand
- Needle-point conductor
- Accessory adapter
- Small lighter or candle (not included)

Notes

- If you have the hand-crank generator (615-3130), you do not need to use the accessory adapter to perform these experiments. Instead, plug the needle-point conductor directly into the metal bolt on top of the dome.

Procedure

1. Attach the accessory adapter to the dome of the Van de Graaff.
2. Place the needle-point conductor into the accessory adapter.
3. Plug the discharge wand into the ground port at the base of the generator.
4. Start the generator.
5. Bring a small flame (via a candle or lighter) near the tip of needle-point conductor. Observe how the flame behaves once it enters the electric wind.
6. Turn off and then discharge the generator.

How it Works

Narrow objects, like the needle-point conductor, carry a much greater concentration of charges than broad objects like the generator dome. Therefore, the concentration of charges is intense at the tip of the conductor, which causes the air in its vicinity to become ionized. Positive charge in the flame is repelled from the positively ionized air at the tip of the conductor, causing the flame to appear as if it is blowing away from the conductor.

CARRIED WIND

Objective

To demonstrate the principle of carried wind

Required Materials

- Van de Graaff generator and discharge wand
- Needle-point conductor
- Dual-end connector
- Accessory adapter
- Small lighter or candle (not included)

Procedure

1. Plug the discharge wand into the ground port at the base of the generator.
2. Attach the accessory adapter to the dome of the Van de Graaff.
3. Plug the banana-plug end of the dual-end connector into the accessory adapter.
4. Clip the needle-point conductor into the alligator end of the dual-end connector.
5. Start the generator. Be careful not to touch the metal needle-point conductor while the generator is running.
6. Carry the needle-point conductor as far s the connector wire will allow it to go.
7. Bring a small flame (via a candle or lighter) near the tip of needle-point conductor. Observe how the flame behaves once it enters the electric wind.
8. Turn off and then discharge the generator.

How it Works

This experiment works the same as the electric wind experiment on page 10, but the connector wire acts as an extension, allowing you to “carry” the charge from the generator through the wire and into the needle-point conductor.