VAN DE GRAAFF GENERATOR

CAT NO. PH 0918A

Experiment Guide

GENERAL BACKGROUND:

The van de Graaff generator is a simple device designed to create large voltages with low current. It can be used to dynamically demonstrate several physical concepts, including: electrostatics, conservation of charge, conduction, and ionization.

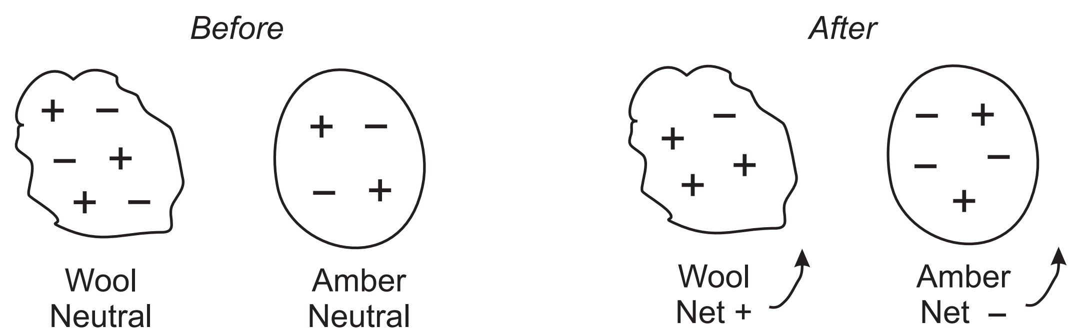
Static electricity is a familiar concept we encounter on a daily basis. It explains: why static cling affects our clothes, the shock we sometimes experience when touching a doorknob on a dry winter day, and why we can cause a friend's hair to stand on end by “charging up” a balloon.

Charge Conservation and Transfer

Charge is an intrinsic (natural) property of particles. Charges can be positive, negative, or neutral. When two charges have opposite signs (positive and negative), they are attracted to one another. When two charges have the same sign (both negative or both positive), they are repelled. Within any material there are both positive and negative charges, and how the material behaves depends on whether there are more positive charges, more negative charges, or an equal number of both (neutral object). The total charge in the universe is always conserved-- we cannot create new charges or destroy existing ones. Charge can, however, be transferred between objects. Conduction is one process by which a charged object transfers charge to another object through contact.

Triboelectric Effect (“Charging by Friction”)

Most static electric phenomena are due to the triboelectric effect, which affects both conductors and insulators. In this effect, two neutral objects touch or are rubbed together so that electrons can pass between them. Some objects give up electrons easily and others hold on to them tightly. The triboelectric scale is used to rate the natural tendency of materials to give up electrons: objects that lose electrons easily are “positive,” those that hold on to them tightly are “negative.” Notice that this property is not the same as conductivity, which measures how easily electrons move within a given object. When amber (negative on the triboelectric scale) is rubbed with a piece of wool (positive on the triboelectric scale), the wool gives some of its electrons to the amber and both emerge with a net charge.



Notice that charge is merely exchanged between the amber and wool and that the total charge stays the same. When objects acquire charge in this way, they can then "cling" to other objects (attracting them with their charge), or discharge onto another object (like after you acquire a net charge from the carpet and discharge it on a nearby doorknob or an unsuspecting friend).

Conductors and Insulators

Atoms are made of a nucleus formed from protons (positive charge) and neutrons (neutral charge) surrounded by orbiting electrons (negative charge). Most materials have an equal number of protons and electrons and are electrically neutral. When electrons are not tied to the nucleus (or are loosely bound), they may move through the material. How easily they can move from one end to the other depends on whether the material is an insulator or conductor. In conductors, electrons can move freely, whereas in insulators they cannot.

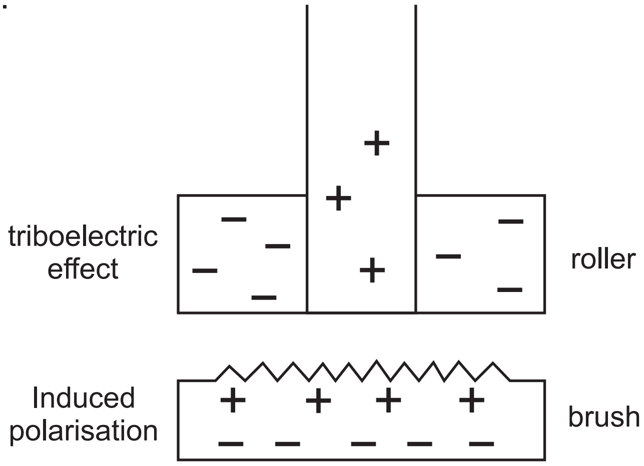
Ionization

The van de Graaff generator also demonstrates ionization of air. Ionization occurs when the electric field strength becomes strong enough to strip electrons from atoms in the surrounding air. When the electrons recombine with the positive ions in new combinations, visible light is released.

How the van de Graaff Generator Accumulates Charge

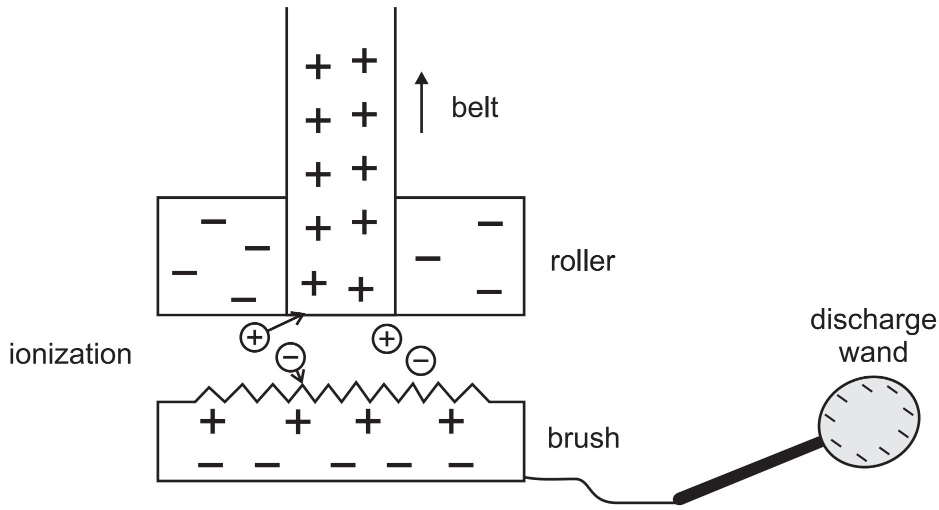
The van de Graaff generator uses an insulating belt turning on two rollers to carry charges from the bottom of the apparatus to the top and deposit them on the collecting dome.

Turning the hand crank causes the lower roller to turn. Charges between the roller and the belt begin to be transferred through the triboelectric effect. The roller steals electrons from the belt and so the roller acquires a net negative charge while the belt acquires a net positive charge. The concentrated negative charges on the stationary roller repel negatively charged electrons on the brush (mesh metal square), leaving positive charges near the brush tips. It is important to note that the concentration of charge on the roller is greater than that on the belt so the roller and belt together have a negative net charge.



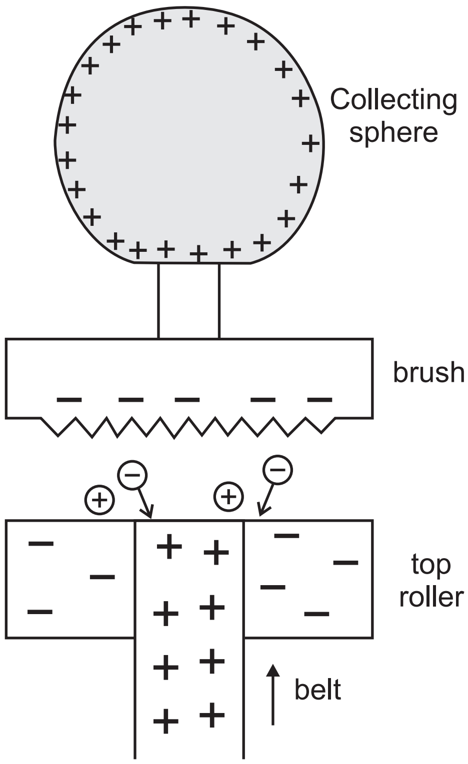
Bottom Roller

The electric field created from the negative charges on the stationary (but rotating) roller ionizes the air between the brush and roller, creating positive ions and free electrons. The positively charged ions are drawn toward the negatively charged roller, but run into the insulating belt on their way towards it. The belt therefore now has a supply of positive charges that it carries to the top of the apparatus. When the discharge wand is connected to the bottom of the apparatus, negative charges from the ionized air are collected by the discharge sphere.



Top Roller

At the top of the apparatus there is another roller and brush and a similar process occurs. The positive charges carried up the belt attract electrons in the top brush. The electric field ionizes the air between the brush and the roller/belt. The positively charged ions are repelled by the positive charges on the belt and attracted to the electrons near the tip of the brush. The conducting collecting sphere is connected to the top metal brush and collects the accumulating positive charge.



Charges are also transferred between the top roller and brush due to the triboelectric effect. Whether the roller gains a positive or negative charge depends on the material properties of the top roller. The free electrons in the ionized air are attracted to the positive charges on the belt and, depending on whether the roller has a positive or negative net charge, this effect can be enhanced. As the belt returns to the bottom it carries either no charge or a net negative charge, depending on the material properties of the roller.

Charge Accumulation and Discharge

As the hand crank is turned, the apparatus continues accumulating charges onto the collecting sphere until a surface maximum is reached. When this occurs, the high voltage from the charged conductor breaks down the air surrounding the top of the device. The conductor will discharges through any nearby object. When the discharge wand is brought near the collecting sphere, the conductor discharges and a small “lightning” strike can be observed. As the device discharges, it ionizes the surrounding air, stripping air atoms of their free electrons. Unlike at the bottom and top of the van de Graaff generator, though, here we do not transport the separated charges away and the electric field is much stronger. They can therefore recombine and, when they do, emit the light we observe.

Standards: (Taken from the May 2012 draft of the Next Generation Science Standards)

3.IF Interaction of Forces

E) Investigate the push-and-pull forces between objects not in contact with one another.

4. E Energy

B) Carry out investigations to provide evidence that energy is transferred from place to place by sound, light, heat, electric currents, interacting magnets and moving or colliding objects.

MS.PS-IF Interactions of Forces

a) Plan and carry out investigations to illustrate the factors that affect the strength of electric and magnetic forces. [Clarification Statement : Investigations can include observing the electric force produced between two charged objects at different distances and measuring the magnetic force produced by an electromagnet with a varying number of wire turns, number or size of dry cells, or size of iron core.] [Assessment Boundary : Qualitative, not quantitative; no assessment of Coulomb's law]

b) Plan and carry out investigations to demonstrate that some forces act at a distance through fields. [Assessment Boundary : Fields included are limited to gravitational, electric and magnetic. Determination of fields are qualitative, not quantitative (e.g. forces between two human-scale objects are too small to measure without sensitive instrumentation.)]

REQUIRED COMPONENT (INCLUDED)

Name of Part	***Quantity***
Assembled base (rollers, belt, brushes)	1
Large metal dome	1
Discharge wand	1
Grounding wire	1

RECOMMENDED COMPONENTS (NOT INCLUDED)

Name of Part	***Quantity***
Puffed cereal or styrofoam peanuts	1 cup
Plastic bowl	1
Metal bowl/can/ladle	1
Balloon	1
Paper, tape, cheerleading pom-pom	
Bubbles	1
Fluorescent bulb	1

SAFE HANDLING OF APPARATUS:

Warning: Persons with cardiac pacemakers should never operate the van de Graaff generator.

Do not run the device near operating computer or electronic equipment.

The van de Graaff generator is designed to produce high voltages using currents too low to cause serious injury. However, always exercise caution when using the generator to avoid painful or surprising sparks.

Always discharge the device between demonstrations using the included discharge wand.

DO NOT USE with Leyden jars to avoid injury.

MAINTENANCE AND CARE:

Store the generator in a dry, dust-free environment under a polythene cover. Keep the device dry even on wet, humid days.

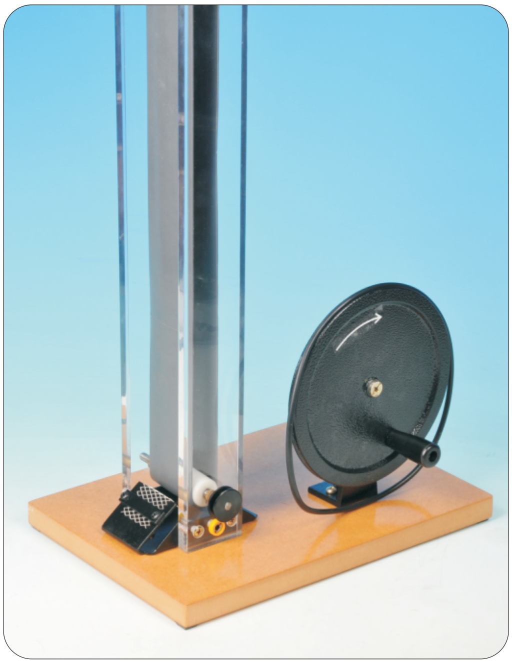
To prolong the life of the belt, run the generator for only short periods of time and ensure that the brushes are not in direct contact with the belt.

Brush Adjustments:

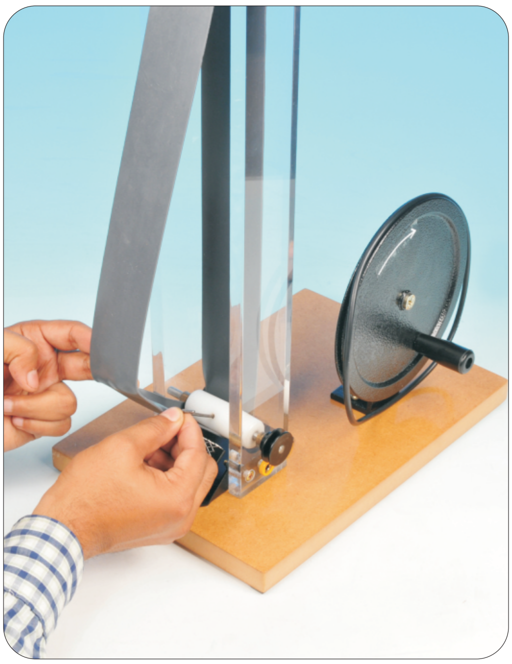
If needed, the top and bottom aluminum mesh brushes can be adjusted. Simply loosen the two screws on the bracket, slide the brush to adjust, and retighten the screws. Always leave some space between the brush and the belt.

Belt Replacement:

Replacement belts can be ordered from the dealer and should be installed by qualified persons. When replacing the belt, take care not to bend the bottom brush. The brush can be easily removed to prevent damaging it by following the instructions above.

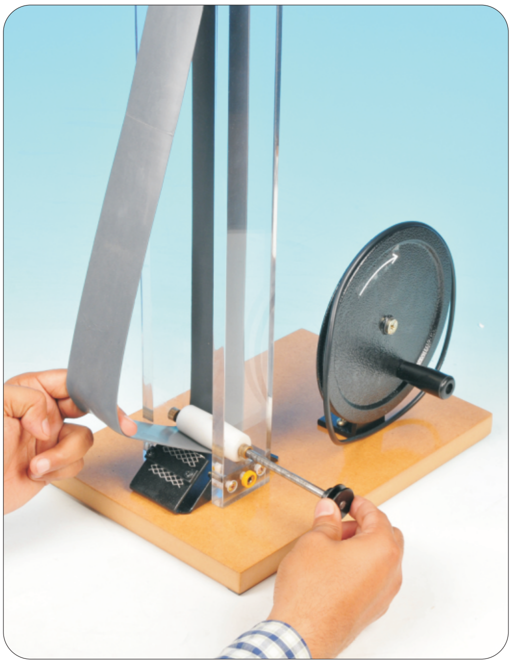


1. Remove the collecting sphere from the top of the apparatus and set aside. Unplug the discharge wand and remove the rubber cord connecting the large and small pulleys (around the hand-crank wheel). Recommended: remove lower brush.



2. Use an allen wrench to loosen the set screw in the middle of the lower roller (see photo)

3. Pull the black knob (small pulley) to slide the axle partially out of the lower pulley.
4. Slide the belt out from the lower roller.
5. Lift the upper roller out from the side bearings and remove belt and roller.
6. Wrap the new belt around the top roller. Place top roller back into side bearings.
7. Slide bottom of new belt around lower pulley.
8. Turn small pulley to try to align flat rectangle of metal axle with set screw hole in lower roller. Push the pulley to slide axle back into place



9. Tighten set screw with allen wrench. To ensure set screw aligns with flat rectangle of axle, it may help to turn pulley with one hand while tightening set screw with the other.

Cleaning:

The van de Graaff generator should be lightly dusted regularly with a clean, dry cloth. Occasionally, it may be necessary to use a small amount of a methylated spirit to clean the collector dome and brass top brush. For the dome, remove it from the apparatus before wiping with a clean cloth and small amount of solvent. Be sure that the solvent evaporates before replacing the dome onto the apparatus. To clean the top brush, remove it by unscrewing the self tapping screws and be sure the solvent evaporates before reinstalling. As always when replacing the brush, position it so that there is a small air gap between the brush and the belt.

ACTIVITY 1: CHARGING THE VAN DE GRAAFF

(Teacher answers)

Van de Graaff generators use an insulating belt to carry charge from the bottom to the top of the apparatus and disperse charge on a collecting sphere. In this short exercise, students will determine whether the accumulated charge is positive or negative and illustrate the basic method of how the device charges. Students will charge two objects by rubbing them together (using the triboelectric effect) and, given the charge of the objects they have used, determine the charge accumulated on the van de Graaff generator sphere. Silk and glass, amber and wool, or a balloon and a students hair can all be used.

The charges these materials are known to acquire when rubbed together are:

silk (negative) and glass (positive),

amber (negative) and wool (positive),

balloon (negative) and hair (positive).

balloon (negative) and wool sock (positive).

PROCEDURE:

1. Connect the discharge wand to the generator with the included wire.
2. Begin charging the generator by turning the hand-crank. It is not important to turn the crank fast--a slow and steady rate will charge the generator affectively.
3. Have a volunteer rub together two materials with different triboelectric properties from the list above.
4. Hold the silk or wool near the collecting dome (or release the balloon near it). Note whether the object is attracted or repelled by the generator.
5. Stop turning the crank and discharge the apparatus by touching it with the discharge wand.

DATA/OBSERVATIONS:

What were you two test materials? balloon and wool sock.

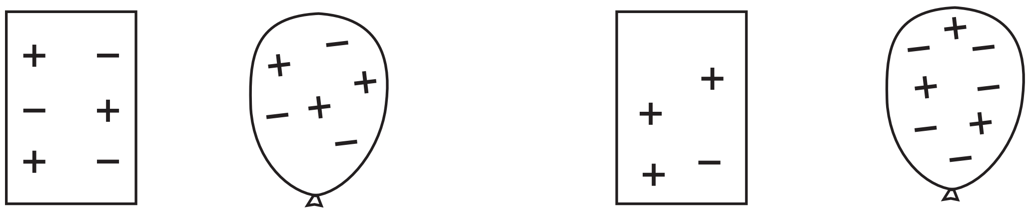
Was your test material attracted to or repelled by the van de Graaff sphere?

The balloon was attracted to the van de Graaff collector sphere and the wool sock was repelled by the Van de Graaff..

DATA ANALYSIS:

Draw a picture of the materials you charged (using the triboelectric effect) before and after you rubbed them together. Indicate the distribution of positive and negative charges in both materials in each case.

Before *After*



Wool sock Neutral | Balloon Neutral | Wool sock Net + | Balloon Net –

Did your test material have a positive or negative charge after rubbing?

<u>The balloon was negatively charged and the wool sock was positively charged.</u>

CONCLUSIONS:

Using your observations above, what can you say about the charge accumulated on the van de Graaff generator? Is it positive, negative, or neutral? How do you know?

<u>The charge must be positive. The balloonhad a negative charge and it was attracted to the globe. Since a neutral object would also attract to a negatively charged object the Van de Graaff must be neutral or positive. Since the wool sock repels and only two like charges repel. I know that the sphere must have had a positive charge.</u>

The van de Graaff generator uses the triboelectric effect and ionization to pump charges up the belt and onto the collecting sphere. With help from your teacher, indicate how the charges are distributed during the process in the space below. Show the final charge accumulated on the sphere (based on your results above), the sign of the charges on the belt, and any other locations your teacher specifies.

Teacher's Note: *For less advanced students, a simple diagram indicating the positive charges on the belt and collecting dome may be appropriate. More advanced students may be able to draw figures similar to those in the General Background section above.*

ACTIVITY 2: LIGHTENING IN THE LABORATORY

(Teacher answers)

PROCEDURE:

1. Connect the discharge wand to the generator with the included wire.
2. Begin charging the generator by turning the hand-crank. It is not important to turn the crank fast--a slow and steady rate will charge the generator effectively.
3. Slowly move the discharge wand closer to the collecting sphere.
4. While turning the crank at a steady rate, try holding the wand close to (but not touching the sphere). Move the wand a few inches back (but still close enough for "lightning" to occur). Note any differences you observe.

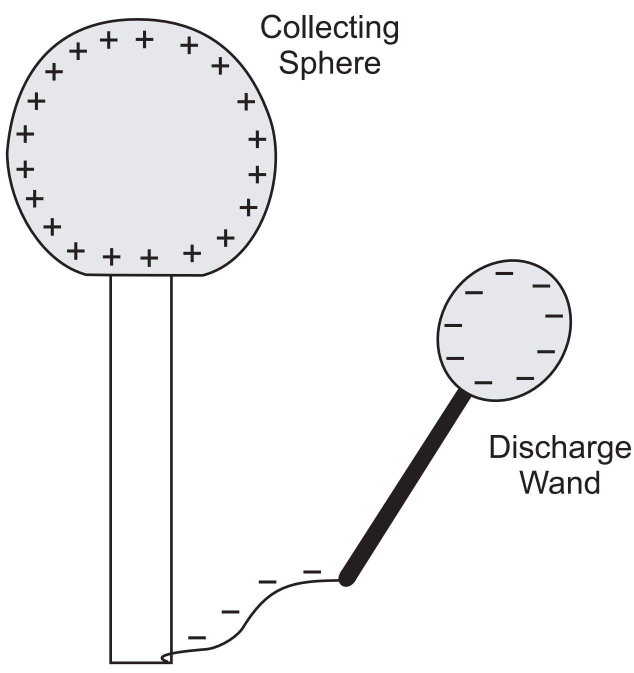
DATA/OBSERVATIONS:

What did you see or hear as the discharge wand approached the collecting sphere?

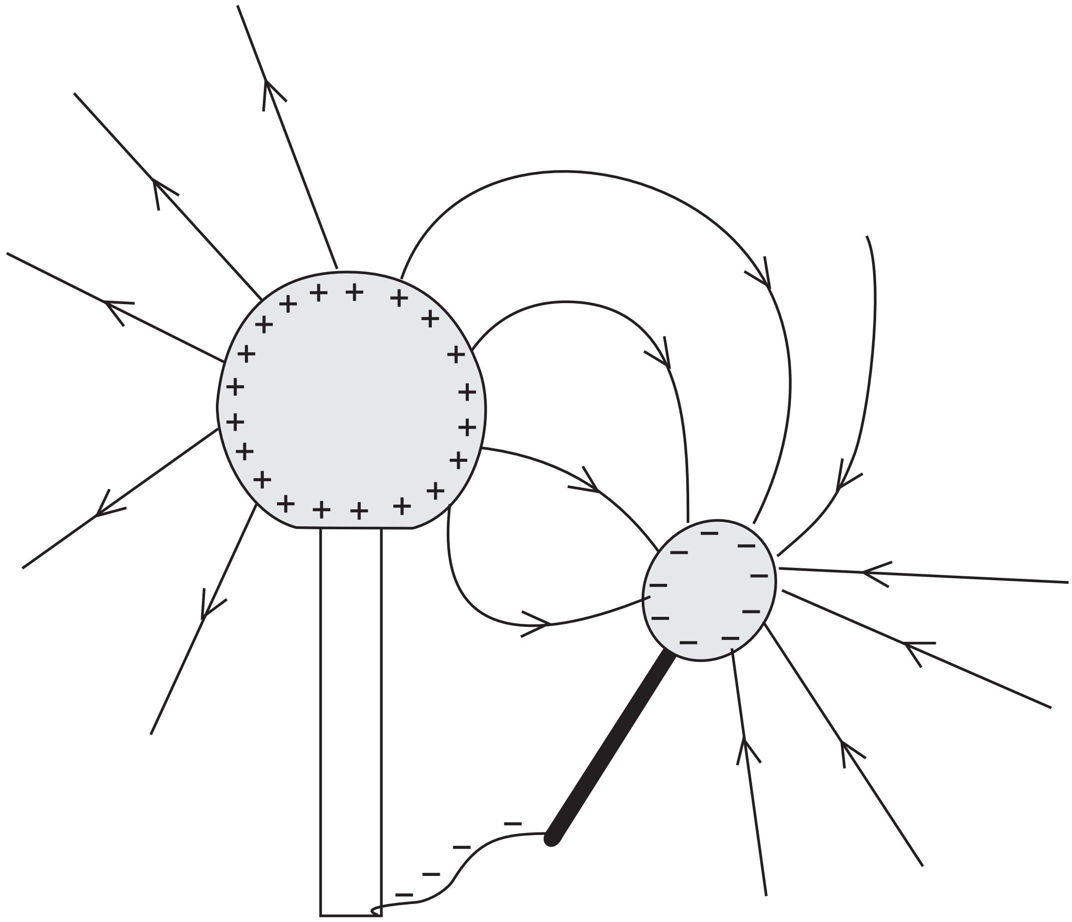
I heard a crackle sound and saw blue light jump between the metal balls. The sphere discharged faster when the wand was closer.

ANALYSIS:

1. Indicate the distribution of positive and negative charges involved in the experiment in a diagram below.



2. Draw a field line diagram of the sphere and wand.



3. Ionizing the air requires some amount of energy. Where did the energy come from? State what types of energy there are and where they come from.

By turning the hand-crank on the generator the experimenter provides mechanical energy to the system. The mechanical energy is converted into electrical energy when the charges are generated.

4. If the charges discharge and the electrical field is gone, where does the energy go?

The total energy is conserved, but it is converted into light, friction, heat, and sound. Some of the mechanical energy is lost to friction in the device, some is lost to heat and sound (like the crackle we hear when the sphere discharges).

ACTIVITY 3: SNAKE CHARMING

(Teacher answers)

Charged objects can attract charge and even neutral materials by exerting a force on the electrons within the material. In the activity below, see if you can control the motion of a strip of uncharged paper without touching it.

PROCEDURE:

1. Place a few small (1” wide) strips of paper on the table near the van de Graaff generator.
2. Connect the discharge wand to the generator with the included wire.
3. Charge the generator by turning the hand crank for 10-20 seconds.
4. Move the discharge wand above the strips of paper. Try wiggling the wand from side to side and up and down. Note your observations below.
5. Stop turning the crank and discharge the collecting globe by touching it with the discharge wand.

DATA/OBSERVATIONS:

What did you observe while the wand moved above the strips of paper?

<u>One end of the paper lifted off the table toward the wand. The strip danced around as the wand moved.</u>

CONCLUSIONS:

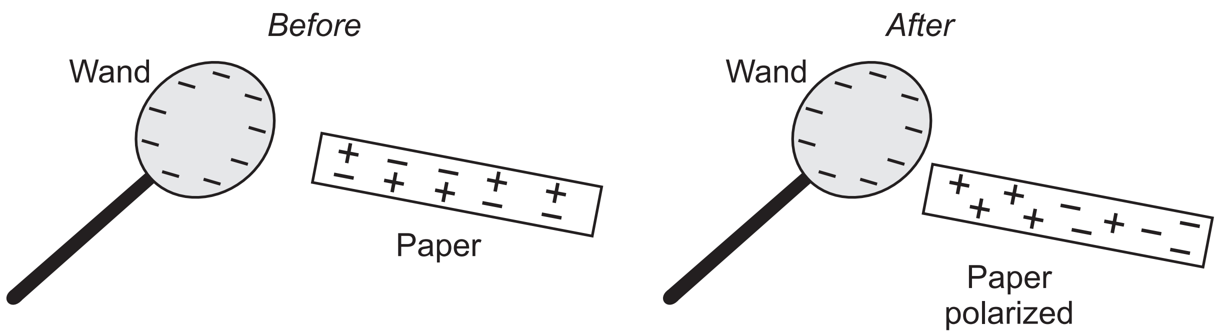
What is the net charge on the paper before the wand is charged?

<u>The paper is electrically neutral, it has an equal number of electrons and protons.</u>

What is the net charge on the paper after the wand is charged?

<u>The paper stays electrically neutral. The wand never touches the paper and no charge is transferred.</u>

Draw a diagram below to show how the charges in the paper are distributed before and after the wand is charged (assume the wand has a net negative charge).

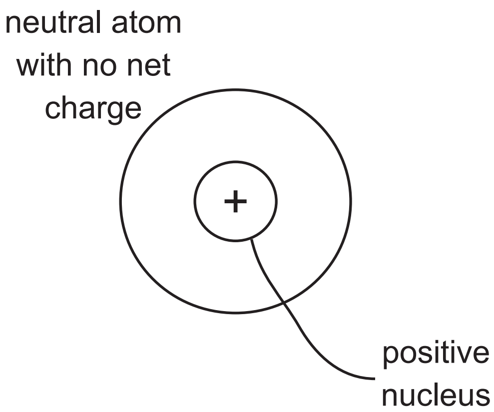


Technically the electrons don't really move from one side of the paper to the other, but shift from one side of the atom to the other creating a positive side of the atom and a negative side of the atom, but for student's conceptual understanding, the diagram above will suffice.

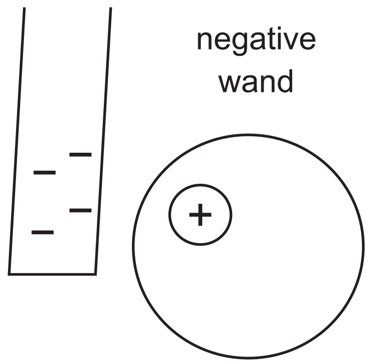
Use your diagram to explain how the wand can “control” (attract/repel) the paper if the paper has no net charge.

The negative charge on the wand repels the electrons in the paper and attracts the positive ions or protons. This induced polarization means that the paper acts as though there is a net positive charge at one end (near the wand) and a net negative charge at the other (near the table). The positive end of the paper attracts the wand and they move toward each other.

Before



After



The electron cloud shifts away from the negatively charged wand forming a slightly positive side of the atom and a slightly negative side of the atom.

ACTIVITY 4: “OBSERVING” ELECTRIC FIELD LINES

(Teacher answers)

A charged object produces an electric field that we can represent with field lines. These lines tell us which direction a test charge will travel when influenced by the electric field. In the following activities, we will “see” the field lines by observing how they cause other materials to behave.

A) Field Lines on the Globe

PROCEDURE:

1. Tear paper into 8-12 thin strips (about 1/2” wide and 6 inches long). Attach the strips to the globe with tape, trying to distribute them evenly. Or, attach a cheerleading pom-pom to the top of the collecting sphere with tape.
2. Charge the van de Graaff generator and note your observations below.

DATA/OBSERVATIONS:

What happened to the paper strips or pom-pom as the globe acquired charge? Draw a picture of what you saw.

The paper strips stood out in all directions on the globe.

CONCLUSIONS:

What was the charge of the paper (or pom-pom) before the van de Graaff was turned on?

The material was electrically neutral. It had an equal number of positive and negative charges.

What was the charge of the paper (or pom-pom) after the van de Graaff was charged? How did it acquire the charge?

It gained a net positive charge from the van de Graaff sphere. The charge was transferred by contact/conduction.

How do you know?

Each strip followed the electric field lines produced by the globe, just like test charges placed in an electric field. Each strip had a net positive charge. I know this because the charge on the sphere is positive and like charges repel. The paper strips repel the sphere and each other, therefore they must all be positive.

B) Hair-Raising Field Lines

In this classic demonstration of the van de Graaff generator, a student volunteer stands on an insulating surface and places one hand on the collecting sphere. Charging the van de Graaff generator produces some hair-raising results.

What was the charge of the volunteer's hair before the van de Graaff was turned on?
The hair was electrically neutral. It had an equal number of positive and negative charges.

What was the net charge of the volunteer after the van de Graaff was charged?
He/she gained a net positive charge from the van de Graaff sphere.

Why is it important for the volunteer to stand on an insulating surface?
The insulating surface prevents the charges from going straight into the ground. If that happens the hair will never acquire a positive charge.

Where does the charge go after the experimentalist stops turning the hand-crank?
Some of it leaks to ground (through the volunteer's feet), some is lost to the air, and some of it stays on the generator (until it is discharged with the wand).

ACTIVITY 5: CONDUCTORS AND INSULATORS
(Teacher Answers)

In this activity, students can compare the behavior of insulators and conductors in the presence of electric fields and charges.

A) Conductors: Flying plates

PROCEDURE:

1. Tape a pie plate to the top of the globe. Place 3-4 more pie plates on top of it. (if pie plates are unavailable, squares of aluminum foil can be used)
2. Charge the van de Graaff generator. Observe the behavior of the pie plates.
3. After the demonstration, discharge the globe.

DATA/OBSERVATIONS:

What did you observe when the generator become charged?

<u>The top pie plate flew up and off, then the next one went, and the next until they were all gone.</u>

CONCLUSIONS:

Was charge transferred to the pie plates? By what physical process?

<u>Yes, each pie plate acquired positive charge through conduction (by touching the plate below it).</u>

What caused the pie plates to "fly away" from the van de Graaff generator?

<u>Each plate has the same charge (positive). Since like charges repel, the top plate flew off one by one.</u>

B) Leaky Insulators: Peanuts, Popcorn !

PROCEDURE:

1. Place some puffed cereal, packing peanuts, or popcorn inside of a glass or plastic bowl.
2. Balance or tape the partially filled bowl on top of the van de Graaff globe.
3. Charge the van de Graaff generator.
4. After the demonstration, discharge the globe.

DATA/OBSERVATIONS:

What did you observe when the generator become charged?

<u>The popcorn flew off in all directions from out of the bowl.</u>

CONCLUSIONS:

What can you say about the charge of the peanuts/popcorn/cereal pieces before and while the van de Graaff was charged?

The filling was originally electrically neutral. When the van de Graaff became charged, the charge transferred to the filling pieces and they flew away from one another because like charges repel.

If the bowl is made out of "insulating" material (glass or plastic), how was charge transferred to the peanuts/popcorn/cereal?

Through conduction. Even though glass/plastic are insulators, they are not perfect insulators. Some of the electrons move a little and when the charge from the van de Graaff gets strong enough, charge can travel through the glass/plastic and transfer to the filling.

Teacher's note: *If students are unconvinced that charge leaks through the plastic/glass, repeat the demonstration holding the bowl close to (but not touching!) the top of the globe. None of the filling should fly out of the bowl.*

C) Quality Conductors: Peanuts, Popcorn!

PROCEDURE:

1. Repeat the experiment above, but place the filling inside of a metal bowl or container (even a soup ladle also works remarkably well).

DATA/OBSERVATIONS:

What did you observe when the generator become charged?

Nothing happened. The popcorn stayed in the bowl (or only a tiny amount flew out)

CONCLUSIONS:

What can you say about the charge of the peanuts/popcorn/cereal pieces before and while the van de Graaff was charged?

They started and remained neutral. No charge was transferred.

If a conductor transfers charge easily, why don't the peanuts/popcorn/cereal gain charge through conduction and fly off?

Charge moves easily in a conductor and distributes itself on the surface of the container. The charges move away from each other as much as possible and, as a result, the electric field inside of a conductor is zero. Since the electric field inside of the metal bowl must be zero, the filling never acquires charge and remains electrically neutral.

Name:____ Date:_____________

Lab Section:____________

ACTIVITY 1: CHARGING THE VAN DE GRAAFF

Van de Graaff generators use an insulating belt to carry charge from the bottom to the top of the apparatus and disperse charge on a collecting sphere. In this short exercise, students will determine whether the accumulated charge is positive or negative and illustrate the basic method of how the device charges. Students will charge two objects by rubbing them together (using the triboelectric effect) and, given the charge of the objects they have used, determine the charge accumulated on the van de Graaff generator sphere. Silk and glass, amber and wool, or a balloon and a students hair can all be used.

The charges these materials are known to acquire when rubbed together are:

silk (negative) and glass (positive),

amber (negative) and wool (positive),

balloon (negative) and hair (positive).

balloon (negative) and wool sock (positive).

PROCEDURE:

1. Connect the discharge wand to the generator with the included wire.
2. Begin charging the generator by turning the hand-crank. It is not important to turn the crank fast--a slow and steady rate will charge the generator affectively.
3. Have a volunteer rub together two materials with different triboelectric properties from the list above.
4. Hold the silk or wool near the collecting dome (or release the balloon near it). Note whether the object is attracted or repelled by the generator.
5. Stop turning the crank and discharge the apparatus by touching it with the discharge wand.

DATA/OBSERVATIONS:

What were you two test materials? __________ and __________.

Was your test material attracted to or repelled by the van de Graaff sphere?

____

____

DATA ANALYSIS:

Draw a picture of the materials you charged (using the triboelectric effect) before and after you rubbed them together. Indicate the distribution of positive and negative charges in both materials in each case.

Before *After*

Did your test material have a positive or negative charge after rubbing? ____________

____

CONCLUSIONS:

Using your observations above, what can you say about the charge accumulated on the van de Graaff generator? Is it positive, negative, or neutral? How do you know?

____

____

____

____

The van de Graaff generator uses the triboelectric effect and ionization to pump charges up the belt and onto the collecting sphere. With help from your teacher, indicate how the charges are distributed during the process in the space below. Show the final charge accumulated on the sphere (based on your results above), the sign of the charges on the belt, and any other locations your teacher specifies.

Name:____ Date:______________

Lab Section:_____________

ACTIVITY 2: LIGHTNING IN THE LABORATORY

PROCEDURE:

1. Connect the discharge wand to the generator with the included wire.
2. Begin charging the generator by turning the hand-crank. It is not important to turn the crank fast--a slow and steady rate will charge the generator effectively.
3. Slowly move the discharge wand closer to the collecting sphere.
4. While turning the crank at a steady rate, try holding the wand close to (but not touching the sphere). Move the wand a few inches back (but still close enough for “lightning” to occur). Note any differences you observe.

DATA/OBSERVATIONS:

What did you see or hear as the discharge wand approached the collecting sphere?

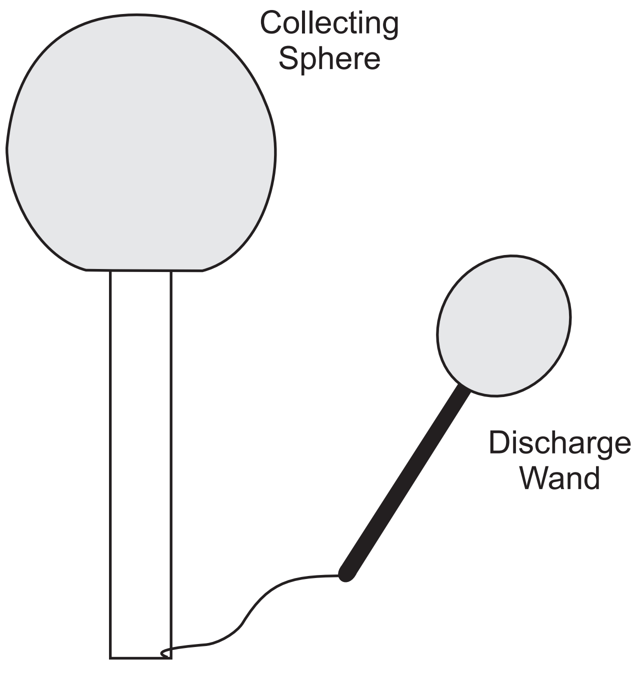
____

____

____

ANALYSIS:

1. Draw the distribution of positive and negative charges on the collecting sphere and discharge wand.



2. Draw atleast five field lines on the diagram you drew in question 1. Indicate the direction the field lines point with an arrow.

3. Ionizing the air requires some amount of energy. Where did the energy come from? State what types of energy there are in the experiment and where they come from.

4. If the charges discharge and the electrical field is gone, where does the energy go?

Name:____ Date:_____________

Lab Section:____________

ACTIVITY 3: SNAKE CHARMING

Charged objects can attract charged and even neutral materials by exerting a force on the electrons within the material. In the activity below, see if you can control the motion of a strip of uncharged paper without touching it.

PROCEDURE:

1. Place a few small (1” wide) strips of paper on the table near the van de Graaff generator.
2. Connect the discharge wand to the generator with the included wire.
3. Charge the generator by turning the hand crank for 10-20 seconds.
4. Move the discharge wand above the strips of paper. Try wiggling the wand from side to side and up and down. Note your observations below.
5. Stop turning the crank and discharge the collecting globe by touching it with the discharge wand.

DATA/OBSERVATIONS:

What did you observe while the wand moved above the strips of paper?

____

____

____

CONCLUSIONS:

What is the net charge on the paper before the wand is charged?

____

____

What is the net charge on the paper after the wand is charged?

____

____

Draw a diagram below to show how the charges in the paper are distributed before and after the wand is charged (assume the wand has a net negative charge).

Before *After*

Use your diagram to explain how the wand can "control" (attract/repel) the paper if the paper has no net charge.

____

____

____

____

Name:____ Date:______________

Lab Section:_____________

ACTIVITY 4: "OBSERVING" ELECTRIC FIELD LINES

A charged object produces an electric field that we can represent with field lines. These lines tell us which direction a test charge will travel when influenced by the electric field. In the following activities, we will "see" the field lines by observing how they cause other materials to behave.

A) Field Lines on the Globe

PROCEDURE:

1. Tear paper into 8-12 thin strips (about 1/2" wide and 6 inches long). Attach the strips to the globe with tape, trying to distribute them evenly. Or, attach a cheerleading pom-pom to the top of the collecting sphere with tape.
2. Charge the van de Graaff generator and note your observations below.

DATA/OBSERVATIONS:

What happened to the paper strips or pom-pom as the globe acquired charge and the voltage grew? Draw a picture of what you saw.

CONCLUSIONS:

What was the charge of the paper (or pom-pom) before the van de Graaff was turned on?

____

What was the charge of the paper (or pom-pom) after the van de Graaff was charged? How did it acquire the charge?

____

How do you know?

____

____

B) Hair-Raising Field Lines

In this classic demonstration of the van de Graaff generator, a student volunteer stands on an insulating surface and places one hand on the collecting sphere. Charging the van de Graaff generator produces some hair-raising results.

What was the charge of the volunteer's hair before the van de Graaff was turned on?

____

What was the net charge of the volunteer after the van de Graaff was charged?

____

Why is it important for the volunteer to stand on an insulating surface?

____

____

Where does the charge go after the experimentalist stops turning the hand-crank?

____

____

Name:____ Date:______________

Lab Section:_____________

ACTIVITY 5: CONDUCTORS AND INSULATORS

In this activity, students can compare the behavior of insulators and conductors in the presence of electric fields and charges.

A) Conductors: Flying plates

PROCEDURE:

1. Tape a pie plate to the top of the globe. Place 3-4 more pie plates on top of it. (if pie plates are unavailable, squares of aluminum foil can be used)
2. Charge the van de Graaff generator. Observe the behavior of the pie plates.
3. After the demonstration, discharge the globe.

DATA/OBSERVATIONS:

What did you observe when the generator become charged and the voltage grew?

____

____

CONCLUSIONS:

Was charge transferred to the pie plates? By what physical process?

____

____

What caused the pie plates to “fly away” from the van de Graaff generator?

____

____

B) Leaky Insulators: Peanuts, Popcorn!

PROCEDURE:

1. Place some puffed cereal, packing peanuts, or popcorn inside of a glass or plastic bowl.
2. Balance or tape the partially filled bowl on top of the van de Graaff globe.
3. Charge the van de Graaff generator.
4. After the demonstration, discharge the globe.

DATA/OBSERVATIONS:

What did you observe when the generator become charged and the voltage grew?

____

____

CONCLUSIONS:

What can you say about the charge of the peanuts/popcorn/cereal pieces before and while the van de Graaff was charged?

____

____

____

If the bowl is made out of "insulating" material (glass or plastic), how was charge transferred to the peanuts/popcorn/cereal?

____

____

____

C) **Quality Conductors: Peanuts, Popcorn!**

PROCEDURE:

1. Repeat the experiment above, but place the filling inside of a metal bowl or container (even a soup ladle also works remarkably well).

DATA/OBSERVATIONS:

What did you observe when the generator become charged and the voltage grew?

____

____

CONCLUSIONS:

What can you say about the charge of the peanuts/popcorn/cereal pieces before and while the van de Graaff was charged?

____

____

If a conductor transfers charge easily, why don't the peanuts/popcorn/cereal gain charge through conduction and fly off?

____

____

____

____

____

____

Manufactured by :
EISCO

U.S. Distributor :
Eisco Scientific
850 St Paul St, Suite 15, Rochester, NY 14605
Email : www.eiscosci.com