

## VAN DE GRAAFF GENERATOR FOR THE PHYSICS CLASSROOM

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**Abstract.** Van de Graaff generator is a simple but very useful, electrostatic generator which is able to accumulate electric charge on a hollow metal sphere. It's only made of moving belt, rollers, motor, and copper brushes. The goal is to show that the experiment could be performed by talented elementary student with help from his teacher and meant for the physics classroom in any high school around the world.

**Keywords:** Van de Graaff generator; electrostatics; corona discharge; capacitance; Faraday effect; Triboelectric effect

### Introduction

The inventor of this generator is Robert Jemison Van de Graaff. The Van de Graaff generator was made with a purpose to study the electrostatics and arcs and lightnings, and is also used to accelerate subatomic particles to great speeds.. It's one of the most powerful types of accelerators of the early 1900s. Van de Graaff generators are still used as accelerators to generate energetic particle and x-ray beams in nuclear physics, and in medicine. [1]

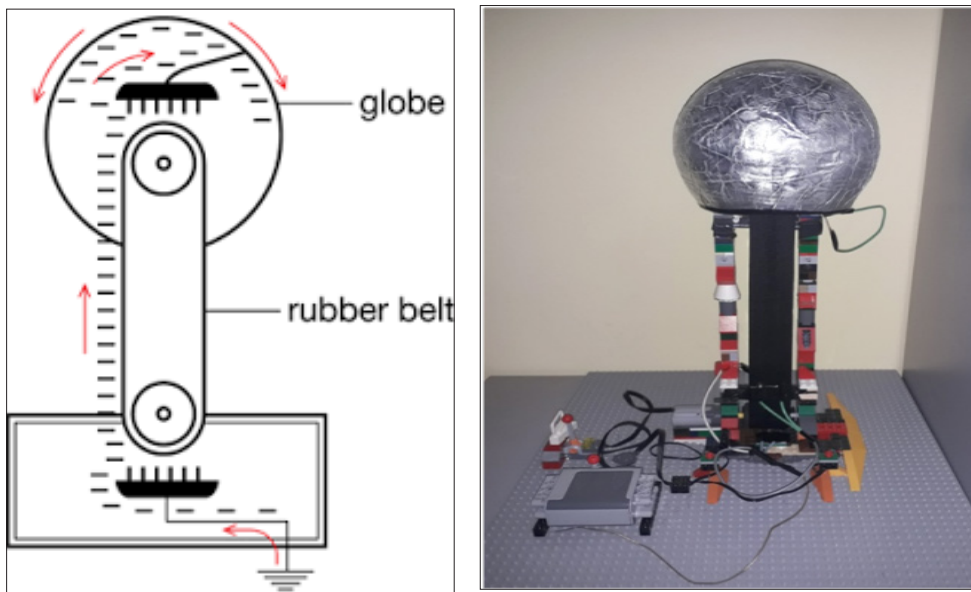
Generators in museums and laboratories can produce up to 25 mega volts and really huge arcs.

Our Van de Graaff generator can produce about 30 kV by the size of the arcs ( 3cm ). It's made of a nylon belt ( pantyhose ), upper roller made of plastic Lego blocks, Lego structure, 9 V dc motor small metal sphere (new year ball) and it is placed in a bigger sphere with a hole on the bottom ( rubber ball cut and wrapped in aluminum tape ) that acts as a Faraday cage.

### Device operation

It's based on triboelectric effect [2], which is basically if two different material rub against each other, they become electrically charged. One of the two materials pulls the electrons from the other one and becomes negative, leaving the other one positive. In our case, the nylon belt leaves its electrons to the top roller and becomes positive, making the plastic lego roller negative, and then the copper brushes take those electrons from the roller and put them in the metal sphere. Also the sphere

covers the sharp edges of the brushes so the charges can't run. The bottom roller is made of rubber wheels to increase friction and prevent the belt from being torn apart. Next to the bottom roller are the other copper brushes, which are very close to the positive belt. The brushes suck electrons from ground (earth) and leave them on the belt so the belt is neutral again. The belt constantly sucks electrons from the ground and puts them in the metal sphere, creating thousands of voltage difference. The metal sphere acts as one side of the capacitor, while the air is dielectric, and the ground is the other side of the capacitor, which means bigger the area – greater the capacitance.[3] In our case around 15 pF.



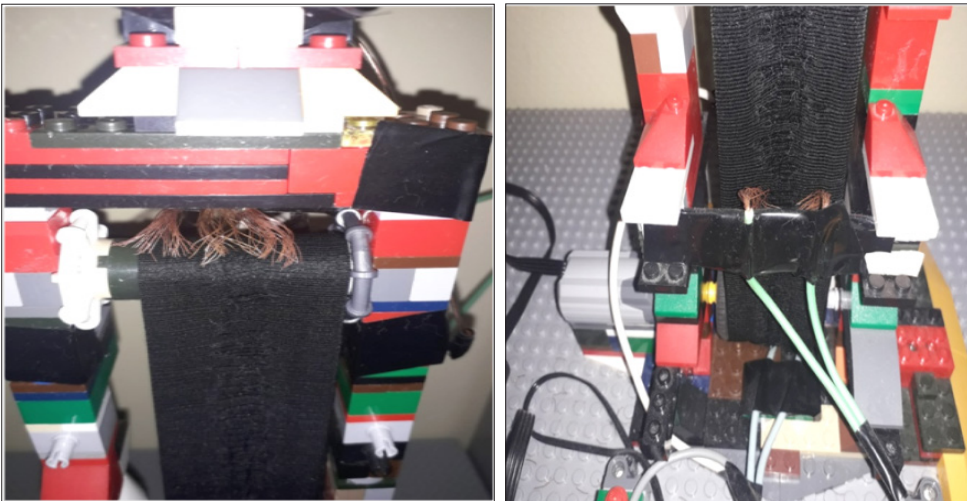
**Fig. 1.** A simple schematic of a Van de Graaff generator is shown on the left, and on the right is a picture of the constructed by us generator

The next pictures are the parts of the generator, zoomed.



**Fig. 2.** This is the battery box (6 batteries, each 1.5V, so 9V total ), the controller and the DC motor

Next to it is the hollow sphere that stays on the top. Its job is to cover the sharp brushes and to accumulate the charges that run away, so more charge is built up, and also it acts like one side of a capacitor, so the bigger it is – the greater is the capacitance. It's made of a rubber ball covered entirely in aluminum tape and then sanded.



**Fig. 3.** Finally, these on the left are the upper brushes and the upper roller, and these on the right are the down roller and the down brushes.

For the whole project we spent about 25 dollars, and we made it in a week working about 2 hours a day plus many tests, failures and a lot of fun.

### **Device Operation/Conclusions**

One of the purposes of the competition “Devices for Physics laboratory” is to promote motivated students to develop new experimental set-ups by themselves which are related to the deep understanding of the science. As a rule this work is supervised by teachers but very often this is a common work by father and son. With the global degradation of the physics education, such experimental set-ups will become more and more valuable. Moreover, the participation of the students in the design and building is much more educational than any boring physics textbook and last but not least, it is more fun.

It would work much better if it is taller and far from any other conductor. The material that is used as the belt can be changed to work better. Also if it was in a vacuum the arcs would be huge!

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