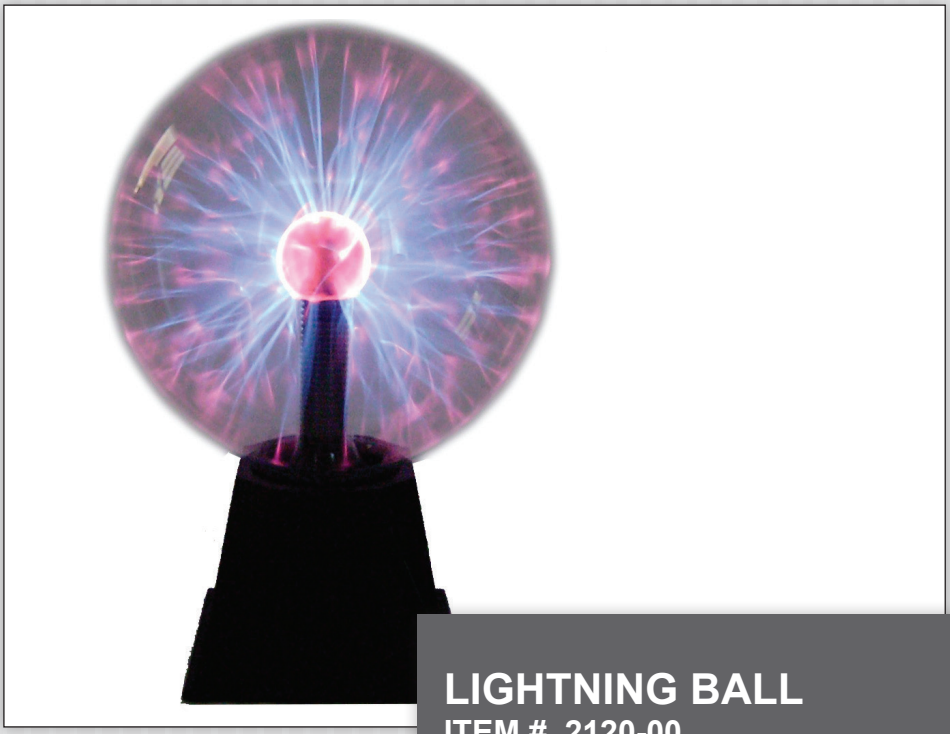
TEACHERS GUIDE



LIGHTNING BALL

ITEM # 2120-00

ENERGY - ELECTRICITY

The Lightning Ball creates plasma using a high voltage electrode in a glass sphere filled with inert gases. It can be used to demonstrate principles of electromagnetism, alternating current, plasma, spectrometry, and energy. Eye-catching and dramatic enough to be used as a demonstration tool in front of the entire class, the Lightning Ball is also safe enough to be an engaging and effective hands-on tool for students of all ages.
So dim the lights, and start exploring!

Materials

- fluorescent lightbulb (any shape)
- incandescent lightbulb
- light emitting diode (LED)
- multimeter
- ruler
- spectrum analyzing equipment

Goals & Objectives

See page 7 for Next Generation Science Standards (NGSS)

BACKGROUND

Plasma, often referred to as the “fourth state of matter”, is created when energy (heat or electromagnetic) is applied to gas causing electrons to break off of atoms and move around freely. In other words, plasma is an electrically charged (ionized) gas and is electrically conductive.

The Lightning Ball, or plasma lamp, was first invented and patented by Nikola Tesla in the 1890s as the “inert gas discharge tube”. Modern designs are credited to Bill Parker, a student at MIT, who accidentally created a plasma lamp by over-pressurizing a test chamber filled with neon and argon in 1971. Later, as a scientist and artist, Parker created plasma lamps for display in museums around the world.

How It Works

When the Lightning Ball is turned on, an electrode at the center of the sphere creates a high alternating voltage current. The current ionizes the noble gasses (mostly neon) inside of the globe, creating plasma. At the same time, the alternating current emitted by the electrode creates an oscillating electromagnetic field, causing the electrons and ions to move around. Collisions between atoms raise atoms and electrons to excited levels. As they return to their ground energy levels they emit a photon of light.

For this reason, plasma filaments can be seen extending from the inner electrode to the outer glass as the electric charge attempt to escape. Touching the glass with a finger provides a direct escape route, and the electric charge travels through the body and to earth.

GLOSSARY

Vocabulary:

- alternating current
- conductor
- current
- electrical potential
- electrode
- filaments
- high-frequency current
- ionize
- noble/inert gasses
- plasma
- pressure
- spectrometry
- voltage

ACTIVITIES

1 Demonstrate plasma:

Turn on the Lightning Ball. Investigate by touching the ball with your hand and varying the number of points of contact (one finger, several fingers, the entire hand). What happens?

Ask students to explain their observations using scientific language.

Use this demonstration to introduce vocabulary terms and concepts.

*Note: Remove rings or other metal jewelry from your hands before touching the Lightning Ball to avoid burns.

2 Hold a fluorescent light bulb close to the Lightning Ball while it is turned on.
What happens? It lights up!

Ask the students to explain their observations and possible explanations.

If you are using a long fluorescent tube, demonstrate different hand placement on the tube. Fluorescent lights work when a high-frequency current excites mercury atoms within the bulb. The excited atoms emit ultraviolet light which is absorbed by a phosphor coating inside the bulb and converted into visible light. If fluorescent bulbs require high-frequency current to work, what does this demonstration indicate about the space around the Lightning Ball?

Have students use a ruler to experiment with different distances between the lightening ball and the fluorescent bulb. How far does sufficient high-frequency current reach?

As a comparison, have the students try the same activity with an LED and an incandescent lightbulb. Which ones light up? Why or why not?

3 Use a multimeter and a ruler to measure and map the electrical potential around the Lightning Ball. Record the electrical potential at various distances around the entire Lightning Ball.

Use the measurements to sketch the electric field around the ball. Compare your findings to your results in Activity 2.

***Note**

It is always wise to DO an experiment ahead of time to be able to best present it to the class.

ACTIVITIES

4 Create lightning!
Place a coin or piece of aluminum foil on top of the plasma ball. The electric current will act to polarize the charges on the coin. Bring a key, finger, or other conductor within a few millimeters of the coin to create a spark.

Use this demonstration to explain how lightning forms due to the ionization and polarization of air in the clouds.

5 Analyze the gasses within the Lightning Ball using spectrum-analyzing equipment (diffraction grating, spectrometer, etc.).

Analyze the point where your finger touches, as well as the light from the filaments.

To create a single, vertical column filament, have a partner place a hand or finger on the top of the ball. Beware that heat can build up as the plasma hits the glass at one point for a longer period of time.

Most plasma globes use a mix of noble gases. Neon is the most common.

DISCUSSION

Additional Discussion and Real Life Applications

1. What effects might the electromagnetic field of the Lightning Ball have on other electronic devices?
2. Where else on earth or in the universe can we find plasma?

Next Generation Science Standards

Students who demonstrate understanding can:

3-PS2-3. Ask questions to determine cause and effect relationships of electric or magnetic interactions between two objects not in contact with each other.

4-PS3-2. Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.

5-PS1-1. Develop a model to describe that matter is made of particles too small to be seen.

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

MS-PS2-5. Conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact.

MS-PS3-2. Develop a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system.

Standards Key

K = Kindergarten
3 = 3rd Grade
(numbered by grade)
MS = Middle School
HS = High School
PS = Physical Science
LS = Life Science
ES = Earth Science

HS-PS2-5. Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current.

HS-PS3-5. 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.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