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Educational Innovations, Inc.®

Radiometer

RAD-105

What is a radiometer?

The radiometer is a light bulb-shaped device containing an object that looks like a weather vane (wings arranged in a circle like spokes of a wheel). Developed to measure the intensity of radiant energy, or heat, the radiometer will:

1. Help you understand the principles of energy conversion.
2. Show how heat and mechanical energy are products of energy conversion.

Most of us don't realize how important energy is in our lives. In actuality, every facet of our life involves energy. One of the reasons we tend to take energy for granted is that it is constantly changing from one form to another. We call this change **conversion**.

During this conversion, energy is changing to and from potential and kinetic forms of energy. **Potential energy** is the energy stored in matter; **kinetic energy** is the energy of motion. In all energy conversions, the useful energy output is less than the energy input. This is because some energy is used to do work, and some energy is converted to heat.

Sir William Crookes invented the original radiometer in the mid-nineteenth century. The device was developed to measure the intensity of radiant energy, or heat.

What causes the vanes of the radiometer to spin?

The atmosphere inside a radiometer is a nearly perfect vacuum. More than 99% of the air has been removed, leaving only thousands of air molecules inside the radiometer compared to the trillions of air molecules in the outside atmosphere. The "lighter air" inside the radiometer means that the air molecules are able to move about more freely.

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About Your Radiometer

The opposing sides of each vane within the radiometer are alternately dark and light in color. As light (infrared radiation) hits the vanes, the lighter side reflects the light while the dark side absorbs it. As the dark side absorbs the radiant energy, a difference in temperature develops between the vanes. The freely moving air molecules bounce off the dark side with a great deal of energy. As the air molecules "kick" away from the dark side of the vane, they form convection currents and momentum transfer, causing the vanes to spin away from the side from which they kicked (that is, away from the dark side of the vane).

Stronger light means that more energy will be absorbed on the dark side, and the air molecules will "kick off" faster and with greater force. Therefore, as the light gets brighter, the vane begins to spin faster and faster.

Fun Activities to Try with Your Radiometer

Sunlight is responsible for many things, including the production of our food. Plants use energy from the sun to drive the chemical change in the leaves of plants. Plants act as an energy converter, and they can change the light energy into chemical energy that plants use to grow.

The following experiments also demonstrate an energy conversation. This conversion begins with light energy that is changed into mechanical energy and heat. In all energy conversions, the form of energy changes from a more useful type to a less useful type of energy. Eventually all of the energy that we use will end up as heat, which is the least useful form of energy.

Always remember to be careful while using your radiometer. Because it is made of glass, it may break if handled roughly or dropped. If the radiometer does break, contact an adult immediately to clean the broken pieces.

Experiment 1:

What light source works best?

Materials: Flashlight, lamp with an incandescent bulb, mirror

Put your radiometer under different light sources, including sunlight. Which light source makes the radiometer spin the fastest?

Experiment 2:

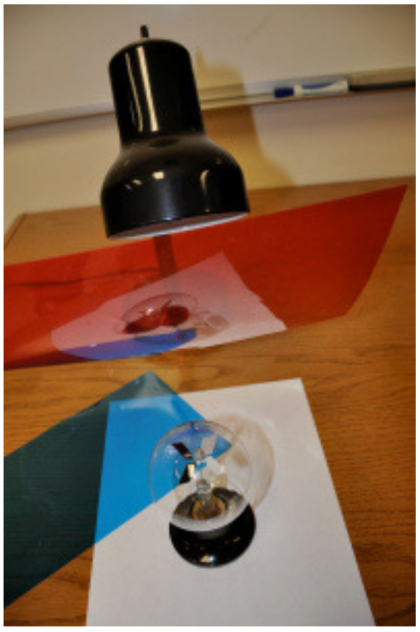
What angle works best?

Hold the radiometer in different positions so light strikes it from different angles. What angle gives the greatest motion to the vanes?

Experiment 3:

Does a mirror increase the intensity?

Hold the radiometer in different positions so light strikes it from different angles. What angle gives the greatest motion to the vanes?



Experiment 4:

Does the radiometer need direct sunlight?

Materials: Flashlight, lamp with an incandescent bulb, mirror, various colors of colored cellophane or colored plastic

Your goal is to find out if the radiometer still spins when the light source has to pass through a colored cellophane or colored plastic. Use the different light sources from Experiment #3, but place the colored cellophane or plastic between the light source and the radiometer so the light has to pass through it. Do certain colors allow more light though to make the vanes spin faster? Do the vanes spin faster or slower with the colored cellophane or the colored plastic?

Experiment 5:

The radiometer and heat energy

Materials: Hair dryer

Use a hair dryer to direct a stream of heat toward the radiometer. Do the vanes turn at all? And if so, what happens after a few seconds? How is this energy source (the hair dryer) different from light energy?

Experiment 6:

Will wind affect the radiometer?

Materials: Fan or drinking straw

Using the drinking straw or fan, blow air at the radiometer. Can you get it to turn? Why or why not?

Experiment 7:

Your turn… Can you devise an experiment?

It's your turn to be the scientist. Now that you know about the radiometer, can you devise an experiment using it? Decide what you're testing for and test your results!

NGSS Correlations

Our Radiometer and these lesson ideas will support your students' understanding of these Next Generation Science Standards (NGSS):

Elementary

4-PS3-1

Students can use Radiometers to make observations and measurements for evidence to construct an explanation relating the speed of an object to the energy of that object.

4-PS3-4

Students can use Radiometers in an investigation to apply scientific ideas to design, test, and refine a device that converts energy from one form to another.

Middle School

MS-PS4-2

Students can use the Radiometer to develop and use a model to describe how waves are reflected, absorbed, or transmitted through various materials.

MS-PS4-2

When light shines on the four diamond-shaped vanes, the paddle wheels spin. The opposite side of the vane is white because the black surface absorbs energy better than the white reflective side. The molecules of air move faster near the black surface. Great for illustrating the conversion of light energy into mechanical energy.

High School

HS-PS4-5

Students can use the Radiometer to conduct investigations about technological devices that use the principles of wave behavior and wave interactions with matter to transmit and capture energy.

Take Your Lesson Further

As science teachers ourselves, we know how much effort goes into preparing lessons. For us, "*Teachers Serving Teachers*" isn't just a slogan—it's our promise to you!

Please visit our website for more lesson ideas:

TeacherSource.com/lessons

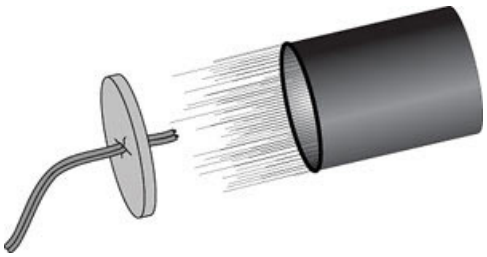
Check our blog for classroom-tested teaching plans on dozens of topics:

http://blog.TeacherSource.com

To extend your lesson, consider these Educational Innovations products:

Handboiler (HB-100)
Great vapor pressure demonstration! When the handboiler is held in your hand, liquid quickly travels from the bottom bulb to the top along with numerous bubbles, giving the appearance of boiling. These new and improved hand-boilers are from a thicker glass and less likely to break.

Drinking Bird (DB-100)
Simply moisten the bird's head with water, place it next to a full glass of water and watch as the bird periodically dunks its head into the glass for a 'drink.' It continues for hours. Great centerpiece for class discussion or laboratory exploration. How does it work? Is it really perpetual motion? Does it work better with hot or cold water? Does it work in an enclosed space, such as an inverted aquarium? Each bird comes complete with an explanation for teachers and suggested experiments. Makes a great addition to the classroom or a great gift!



Piezo Popper Kit (HS-2A)
These amazing piezoelectric devices generate a few thousand volt sparks at the touch of a button. No batteries required. The discharge is created when a small hammer inside the device strikes a quartz crystal. It can be used as a safety lesson to demonstrate the flammability of alcohol or perfume. Igniting two drops of alcohol in a film canister will cause the canister to fly more than 20 feet into the air!