Educational Innovations INC

RAD-100

Radiometer

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.

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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.

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 you 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

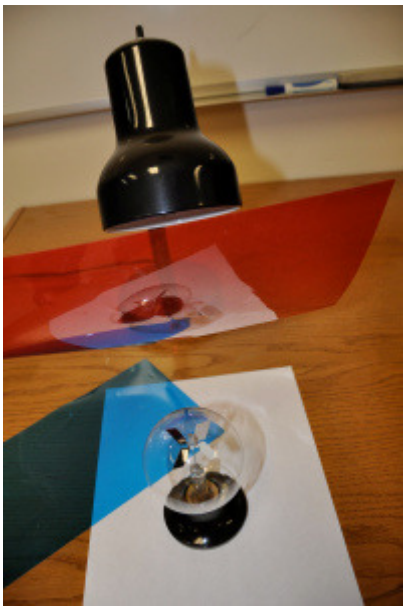
Does a mirror increase the intensity?

Use a mirror to add additional light to the radiometer. Does the mirror make the vanes spin faster or slower? Why do you think that is? Try holding the mirror at different angles to add light from different directions. How does that change the rate of motion?

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 than 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 is 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!

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