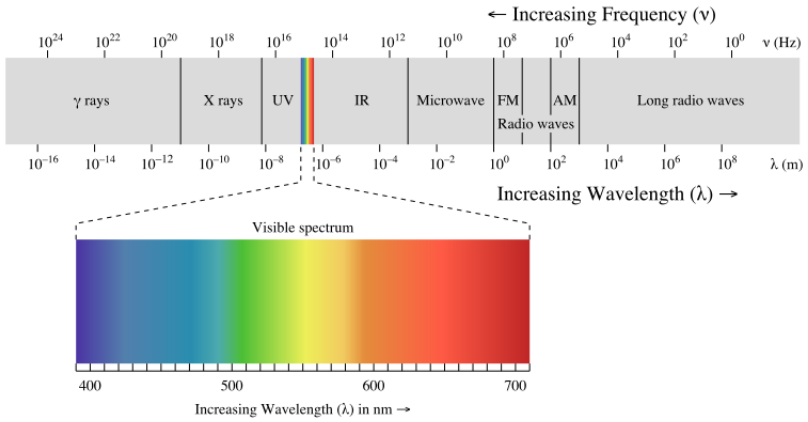
Heat Transfer
Radiation

Introduction

In this activity you will explore infrared radiation, which you can't see but can feel as heat.

Do objects at room temperature give off radiation?

Radiation is the common name for electromagnetic energy traveling through space. It goes very fast (ten times around the earth in one second) and can pass through a vacuum. It doesn't need material to travel in. It has many forms, including visible light, infrared (IR), ultraviolet (UV), X-rays, microwaves, and radio waves. These are all the same form of energy, just with different frequencies and amounts of energy. Different frequencies of radiation interact with matter differently, which makes them seem more different to us than they really are.



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Radiation is not heat. Radiation and heat are two different forms of energy. But one is often transformed into the other in everyday situations. Thermal energy is often transferred by radiation, mostly in the infrared (IR) and visible range. All materials that are warmer than absolute zero (-273 °C) give off radiation due to the fact that their atoms are vibrating. The amount of radiation is proportional to the fourth power of the temperature (T^4), measured from absolute zero. So, the hotter an object, the more radiation it emits.

Note: This is one section of the "Science of Heat Transfer" chapter of the Engineering Energy Efficiency Project. See: http://concord.org/engineering

To download Energy2D software, go to http://energy.concord.org/energy2d/

To run the models in this chapter, go to http://energy.concord.org/htb

Note the video tutorial.

Also most surfaces absorb radiation and transform it into heat. White surfaces reflect visible light, but absorb infrared. Black surfaces absorb both visible light and infrared.Shiny surfaces reflect both of them.

The fact that all objects give off radiation energy is a little surprising. We usually imagine that only "red hot" materials radiate, because we can't see other wavelengths that aren't visible light. This experiment will explore radiation from objects at ordinary temperatures. This radiation is mostly in the infrared range, which is right next to visible light but with longer wavelengths. Note the infrared range on the chart above.

5A: Radiation energy depends on temperature

Energy2D

This model shows two objects at different temperatures that are giving off electromagnetic radiation. Open Model 5A and follow the instructions, then answer the following questions.

Describe the effect of temperature on the intensity of radiation, and hence its heating effect on objects that absorb it.

Think of a real-world situation where you have felt radiation from something hot and something cold even though they were not visibly hot or cold.

Does the cold jar "radiate cold," or does it "radiate less heat"? Why?

Explain why it is uncomfortable to sit near windows on a cold night even if they are tightly sealed and don't let cold air in.

Connection to buildings

Application

Passive solar heating consists of letting in sunlight energy (mostly visible light) and stopping heat loss, some of which is IR radiation outward from the warm building. There's a trade-off between the two processes. Larger windows gain more sunlight, but they also lose much more heat than walls. There have been considerable technical advances over the years to make windows that are transparent (let light in), but also have a high insulating value (keep heat in).

For example:

- two layers of glass (three layers in northern climates), with an air space between
- argon gas in the air space, which is less conducting than regular air
- "low-emissivity" coatings on the glass surfaces, which reduces the emission of radiation from the glass itself. If you coated the jar of hot water in this way, the radiation meter would not show a temperature rise when it faced the jar.

Picture a room with large windows on one wall and a steam radiator on the opposite wall. Steam radiators are large cast-iron objects that get very hot — almost too hot to touch. On a cold night, or when the sun is not shining, sketch on the drawing below all of the ways that the heat from the steam radiator and the loss of heat from the windows become distributed throughout the room.