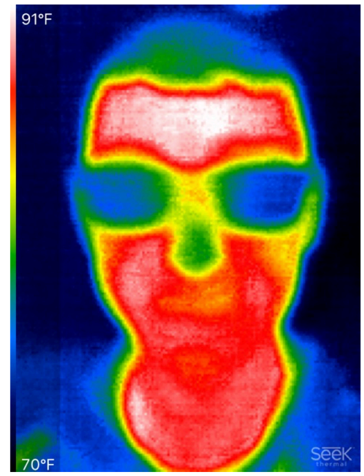
CLIMATE CHANGE TOOLKIT

Infrared Energy



Standards
NGSS ESS3.D Global climate change
NGSS PS4.B Electromagnetic radiation
Grade Level: Middle School

Equipment
Infrared camera
8x10" picture frames (4)
8x10" sheet of black plastic (1), clear plastic (1), glass (1)
Optional: microwave oven and glass or ceramic mug with handle

Overview
Energy is characterized by its wavelength. The electromagnetic spectrum maps out a range of energies from very short wavelength gamma rays (< 10^{-12} meters) to very long wavelength radio waves (1millimeter to 100 kilometers). Near the middle of this spectrum is the visible light that we are most familiar with. Human eyes are energy detectors that are tuned to the wavelengths of the visible spectrum (390 to 750 nanometers). While our eyes do not detect energy of shorter or longer wavelengths we know how to build detectors to do just that. A standard "ear thermometer" that you might use to determine if a child has a fever is a detector of infrared energy.

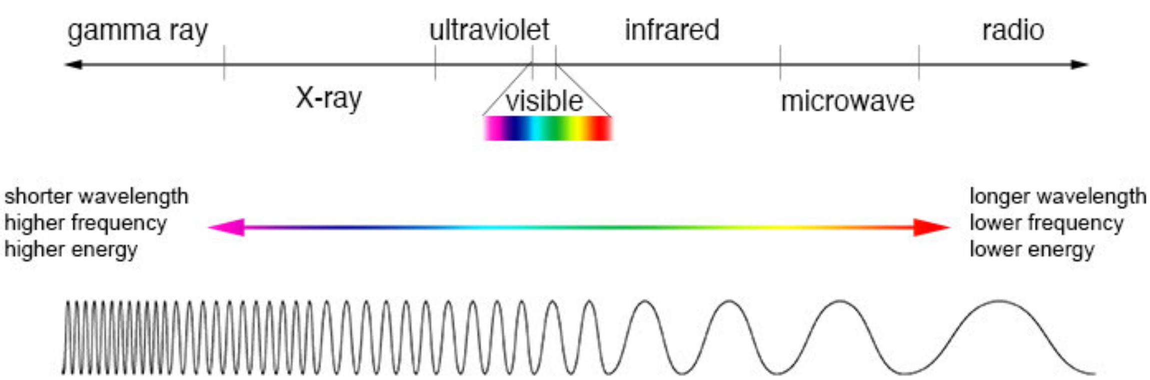
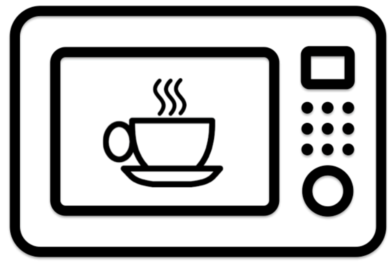


Figure 1: A simplified electromagnetic spectrum.

All objects emit energy. The wavelength of energy that an object emits is determined by the temperature of the object. Hot objects emit short-wavelength energy while cool objects emit at longer wavelengths. An ear thermometer works because human bodies emit energy in the infrared part of the spectrum. A person with a fever has a higher than normal body temperature and emits shorter wavelength infrared energy. The thermometer detects this wavelength difference and displays the elevated body temperature.

When energy is emitted it interacts with any objects that it encounters. We are familiar with a mirrored surface that reflects visible light, or a black road surface that absorbs it. In addition to reflection and absorption energy can also be transmitted (to pass through without interaction), refracted (bent while passing through), or scattered in all directions. Not only does energy interact with different materials in different ways, but energy of different wavelengths will interact differently with different materials. The activities in this handout investigate how infrared energy interacts with common materials. The infrared camera allows us to examine the infrared energy that our eyes would not otherwise be able to see.

Microwaves: A Familiar Example



Microwaves (1m to 1mm) are adjacent to infrared waves (1mm to 0.74µm) on the electromagnetic spectrum, with longer wavelengths. Almost everyone is familiar with the effect of microwave absorption by foods. And if the food is in a container we can examine the way different materials absorb microwaves. For example, when you heat a mug of soup in a microwave oven the soup gets warm but the mug handle does not. **Why?** Because some materials absorb microwave energy and others do not. The water molecules in soup absorb microwaves, while the mug transmits microwaves. When molecules absorb energy they vibrate and heat up.

Visualizing the Invisible with an Infrared Camera

Our bodies emit infrared energy. The Earth also emits infrared. This is because the surface temperatures of the Earth and humans are similar (18ºC for Earth and 37ºC for humans). Examine the infrared photo of a human face on the front page of this handout. Note the color scale on the left-hand side of the image, where each color corresponds to a temperature. A normal photograph captures visible light reflected from the surface of an object. An infrared camera captures the IR energy emitted by objects. In the IR photo you can see that the person's forehead is warm and her nose is cold. She is also wearing glasses.

- Why do the glasses look "cold?"

Glasses are meant to help us see better – but – only at visible wavelengths. Glass is a very good absorber of IR energy. Here the glasses absorb the IR that the woman's face emits, preventing it from reaching the lens of the IR camera, and thus the glasses appear cold.

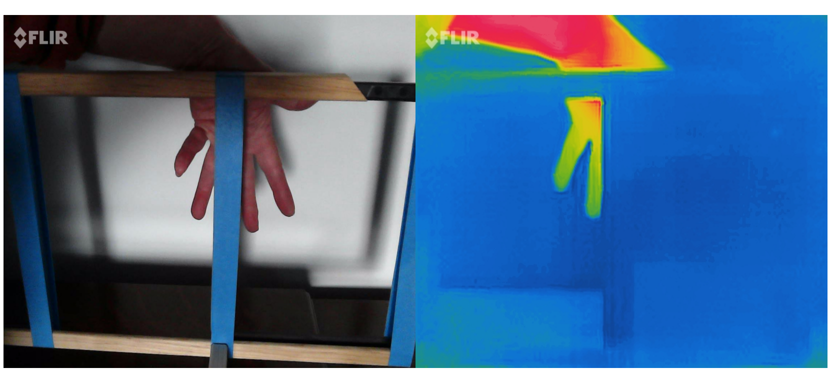
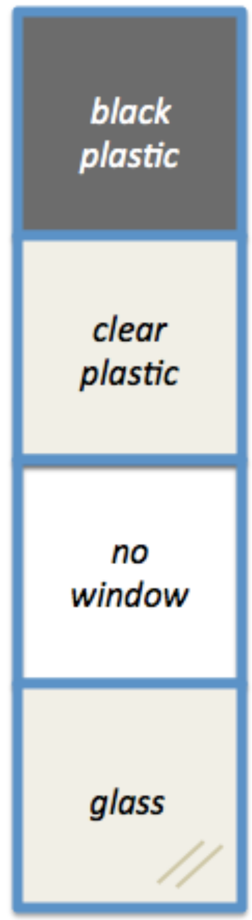


Figure 2: Photo in visible light (L) and infrared light (R). In the visible light image there appears to be no difference between the left side and the right side of the blue divider. However in the infrared it is apparent that there are different materials on one side of the divider and the other, with the right-hand window absorbing the IR energy.

Do This:
Create four different windows with the four picture frames. One frame should hold a pane of glass. One frame should be empty (the “control” frame). Stretch and tape tight a sheet of clear plastic film over one frame and black plastic film over the last frame. Put your hand behind each window in turn and view it with the IR camera. Fill in the table below.

Sketch or describe the IR camera image:	Explain what is happening here:



- Which materials behave the same at both the visible and infrared wavelengths? Which are different?

Resources
Good resource on electromagnetic radiation: https://courses.lumenlearning.com/boundless-physics/chapter/the-electromagnetic-spectrum/

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