# Explorations of heat transfer on Earth's surfaces

**Key questions:** What types of light does the Sun emit? Which types of light have the most energy? How does the Sun's energy transfer make the Earth's surface warmer, and how do different surface features (like ice, forests, water, rock) and human actions affect this heating process?

**Station 1: What is light?**

1. Make a list of everything you think you know about light and sunlight.

2. Take a look at this diagram. What do you think it is showing?

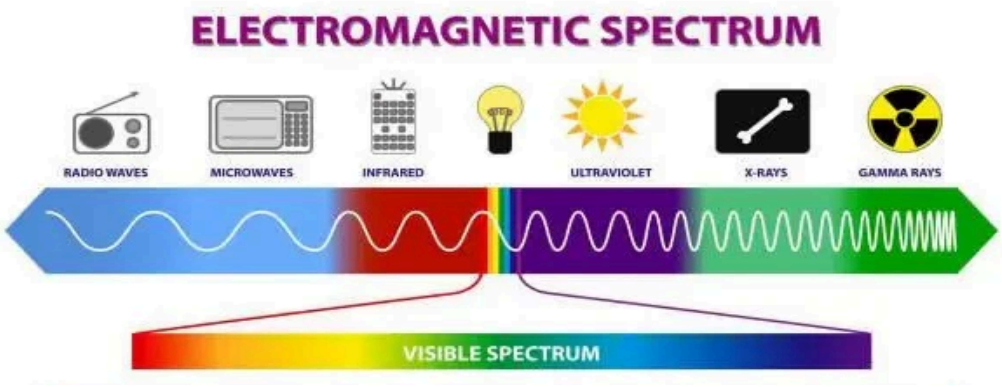



Figure 1: School of PE. (2024, January 5). Waving hello: Exploring electromagnetic radiation [Blog post graphic]. School of PE. https://schoolofpe.com/blogs/news/waving-hello-exploring-electromagnetic-radiation-html.

   a. What do you notice about this electromagnetic (light) spectrum?

   b. What makes one form of light (or electromagnetic radiation) different from another? For example, what makes an X-ray different from a radio wave?

3. The graphic below adds more information to the electromagnetic spectrum:

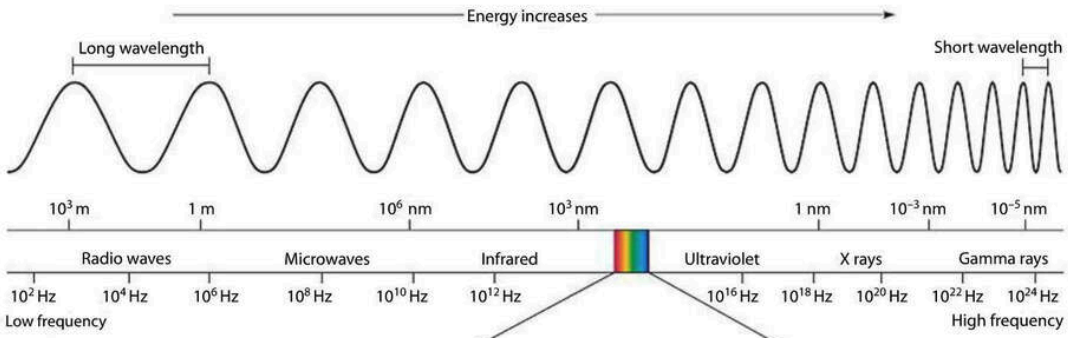



Figure 2. The electromagnetic spectrum. From "The Electromagnetic Spectrum," by NASA, 2026, NASA Science. (https://science.nasa.gov/learn/heat/resource/the-electromagnetic-spectrum/)

Based on the graphics from questions 2 and 3, describe what you think "wavelength" means, and what wavelength tells you about the different types of light (electromagnetic radiation).

4. Can we measure parts of the electromagnetic spectrum?
   a. The rainbow shown in the photo below was made by shining sunlight through a prism onto a piece of paper. Using the photo for a reference, imagine you were holding a thermometer in the places listed in the table. Predict a temperature for each spot in the table below (hint - average room temperature is about 71 degrees F).

**Predict the temperatures here:**

| Position | Temperature (°F) |
|---|---|
| Shade (not close to rainbow) | |
| Within the rainbow | |
| Next to red (Infrared) | |

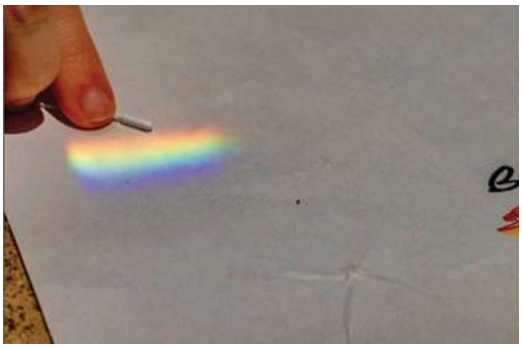


Figure 4: Lopez, R.E., Matsler, K.J. (2025, January 1). The Quantum for All Students and Teachers Project: Sample Activities and the Historical Storyline Linking Them.The Physics Teacher. Phys. Teach. 63, 26–28.

b. Compare your predictions with your classmates. Are they similar or different?

c. Watch these two videos. Your teacher may have them set up on computers, or will provide you with the links.
   i. https://www.youtube.com/shorts/9hMXy2-6FfQ
   ii. https://www.youtube.com/watch?v=aHQVB6qgZAU

d. Were your predications correct?

e. What conclusions can you make based on your observations? How can you connect this to the electromagnetic spectrum graphics above?

**Station 2: When sunlight reaches Earth: How surfaces heat and hold energy**

Use the infrared thermometer to take measurements of different surfaces near you - try your hand, your face, desk, floor, lamp, windows, etc. Make sure not to shine the lasers in anyone's eyes. Write down your observations:

**Procedures:**

1. **NOTE**: Each student group should only measure ONE assigned material (5 minutes under heat and 5 minutes with heat off). Data from all the materials will be pooled together from the class after testing is complete.
2. Get a data table from your teacher.
3. Take a look at the material that you were assigned.
4. Write a place in the "real world" where you may find this type of material in column 2 of the data table.
5. Make a prediction about how you think these materials will absorb and hold heat.

6. Test your hypothesis.
    a. Place your material on the marked space on the desk and/or measure the distance to ensure your material is the correct distance from the heat lamp.
    b. Take an initial measurement using the infrared thermometer and write it on the group data collection sheet at time 0.0 seconds.
    c. Turn on the lamp
    d. Set a timer for one minute.
    e. After one minute, take a temperature reading. Write your data in the table provided.
    f. Repeat every minute for five minutes.
    g. After five minutes, remove your material from underneath the lamp.
    h. Turn off the lamp and set a timer for one minute. After one minute, take the temperature and record it in your table.
    i. Repeat every minute for five minutes.
    j. The class will gather data for all materials during the discussion and conclusion section.

**Station 3: Hand boilers**

1. Rub your hands together to warm them up.
2. Gently place your hands around the lower bulb of the hand boiler and observe what happens to the liquid inside. Write your observations and your proposed explanation below.
3. To get the liquid back down to the bottom bulb, repeat the procedure above and hold the top bulb.
4. This hand boiler shows the concept of **thermal expansion**. Do a little research on what thermal expansion is and write it in your own words here. Where else does thermal expansion exist?
5. Go to the Energy Forms and Changes PhET simulation: https://phet.colorado.edu/sims/html/energy-forms-and-changes/latest/energy-forms-and-changes_all.html
    a. Click on Intro
    b. Check the Energy Symbols box in the upper right corner

c. Put the iron block and the brick onto the heaters and turn them on for 30 seconds or so (it may be helpful to check the "Link Heaters" button for this). What similarities and differences do you see between the two surfaces?
d. Heat the iron or brick for about 10 seconds and then place it into the beaker of water. What do you observe?

e. Heat the iron or brick for about 30 seconds and then place it into the beaker of water. What do you observe?

f. Do the same for the oil. Notice and record any similarities and differences.

g. Based on your observations, what do you think is meant by the term "thermal expansion"? How does it differ from evaporation? Use examples from the PhET simulation in your answer.

6. Thermal expansion is part of what is making sea levels rise worldwide as a result of climate change/global warming. Explain how you think thermal expansion can lead to rising sea levels. What else do you think leads to rising sea levels?

**Station 4: What type of light does the Sun emit to Earth?**

1. Without looking ahead to the next page, what type(s) of electromagnetic radiation (light) do you think the Sun emits towards Earth? Provide evidence for each of your predictions.

2. Look at this graphic. Were you correct? Name all the types of light that the Sun emits that you missed.

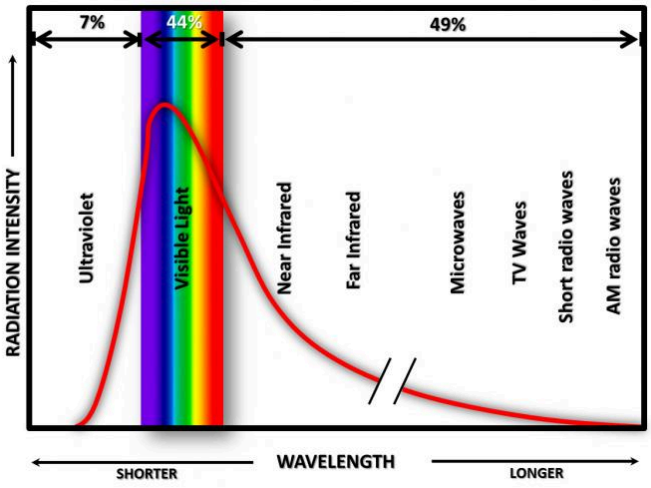



Figure 5. The electromagnetic spectrum. From "Electromagnetic Radiation," by Florida Atlantic University Center for Environmental Studies, 2023, *Climate Science Investigations South Florida*. (https://www.ces.fau.edu/nasa/module-2/radiation-sun.php)

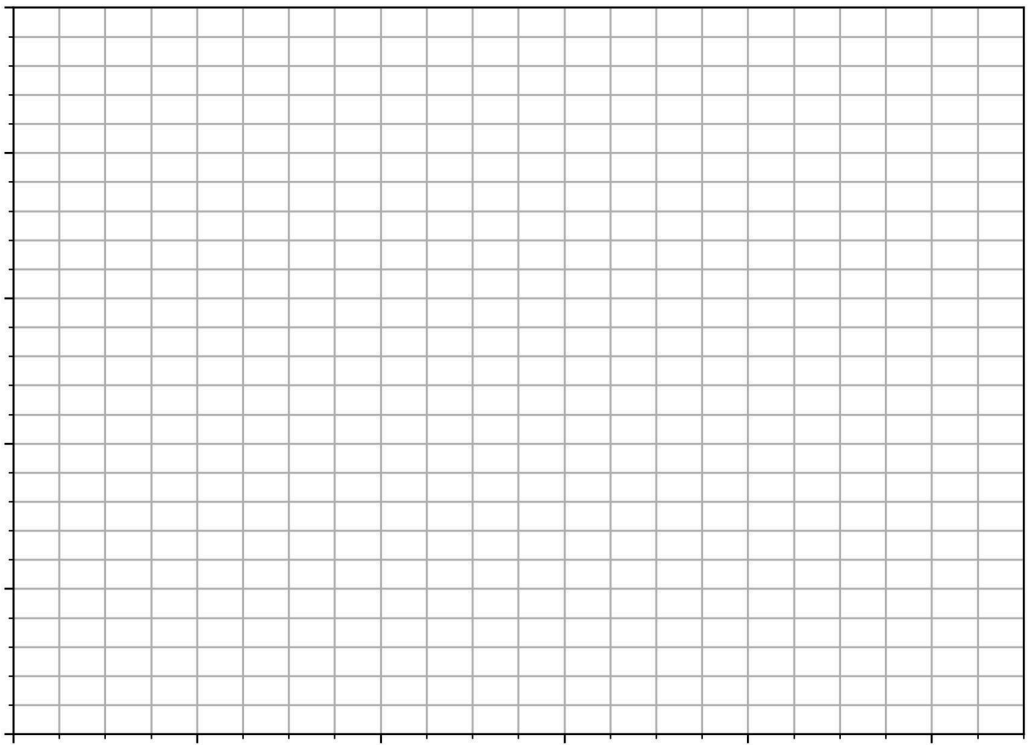
3. Watch this video: Observing the Sun Different Wavelengths of Light! Get Ready for th...

4. Explain why looking at the Sun is dangerous. Do you think it would be dangerous to look at the Sun if it only emitted visible light? What about just visible and infrared? What about just visible and ultraviolet?

**Discussion and Conclusions**

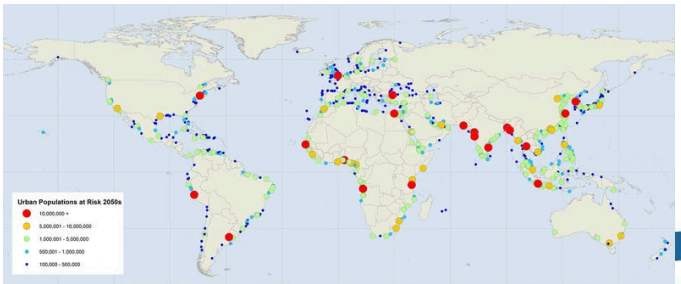
Your teacher will lead you through a discussion and conclusion based on the prompts below:

1. Share your results from Station 2 with the rest of class. Graph your data using the space below or a computer program as your teacher instructs. Discuss how the different materials absorb and store heat. Make analogies to actual surfaces on earth (forests, cities, rivers, oceans, etc.).



2. What are some human activities that drastically change the heat absorption of surfaces on Earth? Be specific and use evidence from the activity to support your claims.

3. Based on what you have learned, describe what you think is meant by the term "urban heat island". Knowing that the following cities are within a mile of



the coastline, what are the implications of urban heat islands on the oceans and the people living nearby?

4. Write a sentence or two linking the ideas of material qualities, heat absorption, and natural and human made surface features on Earth. *Example: "If a material like concrete is near a river, the concrete will absorb lots of the Sun's energy, making it heat up, which could make the water molecules in the river expand and could cause floods."*

5. How might you use these concepts of heat transfer in different jobs like HVAC, architecture and building design, and city planning? What kinds of scientists help understand Earth's heat transfer processes?