Lab Handout

Lab 18. Radiation and Energy Transfer

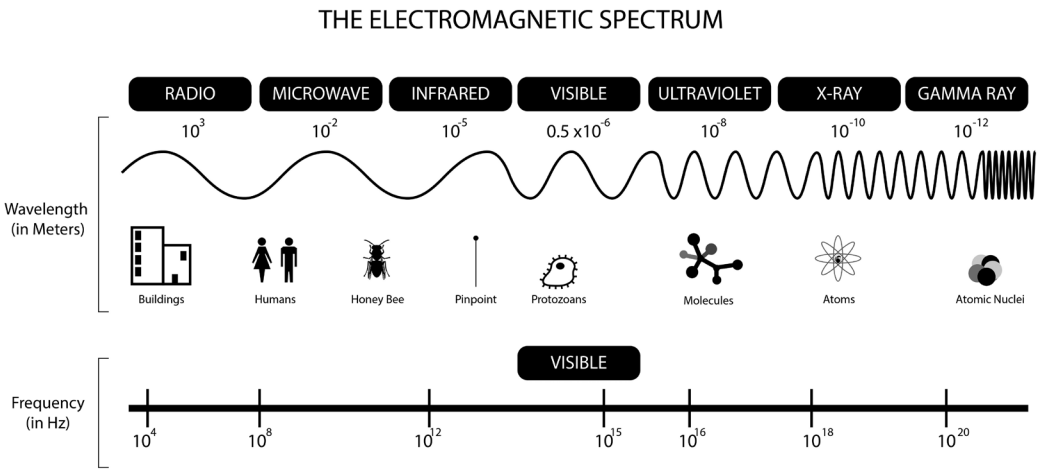
What Color Should We Paint a Building to Reduce Cooling Costs?

Introduction

Radiant energy is the energy transported by electromagnetic waves. Electromagnetic waves transport many different types of energy (see Figure L18.1). The microwaves that warm up your food when you place it into a microwave oven are electromagnetic waves, as are the x-rays that a doctor or dentist uses to take pictures of your bones. In fact, everything you see is also due to electromagnetic waves. Visible light, the light that humans can see, travels in waves. Each color has its own wavelength, which corresponds to a different amount of energy. When those waves reach our eyes, they can then be processed and perceived as color. Certain properties of an object cause it to reflect one wavelength of light and absorb others. For example, the reason an object appears blue is because it absorbs all other wavelengths and reflects a blue wavelength of light, which your eyes receive and, along with your brain, process as the color blue.

FIGURE L18.1

The electromagnetic spectrum



As is true for all energy, radiant energy can be transferred into other forms but cannot be created or destroyed. However, radiant energy is different in that it does not need a medium (matter), such as air or metal, to travel. Radiant energy can travel through a vacuum, such as space. The Sun emits radiant energy that travels through space. Some of that energy reaches Earth. When radiant energy reaches an object, it increases the rate of vibration of the atoms and/or molecules in that object, raising its overall temperature.

Radiant energy from the Sun raises the temperature of nearly everything on Earth, but some things are more affected than others.

When a new building is designed, its architects take into account the future energy costs of the building. Energy-efficient buildings are cheaper and more efficient to own and operate, and are also better for the environment. Some energy-saving or energy-storing measures, such as advanced heating and cooling systems, are expensive, but other measures, such as insulation or paint color, are simpler and less expensive. However, each step taken to increase the energy efficiency of a building is beneficial, not only for those who will own and use the building but for everyone, because we all benefit from the reduced use of energy resources.

Your Task

Use what you know about electromagnetic waves, visible light, and energy transfer to design and conduct an experiment to determine which paint color keeps a building the coolest, reducing its cooling costs.

The guiding question of this investigation is, **What color should we paint a building to reduce cooling costs?**

Materials

You may use any of the following materials during your investigation:

- Canisters with various paint colors
- Heat lamp
- Stopwatch
- Thermometer or temperature probe
- Safety glasses or goggles

Safety Precautions

Follow all normal lab safety rules. In addition, take the following safety precautions:

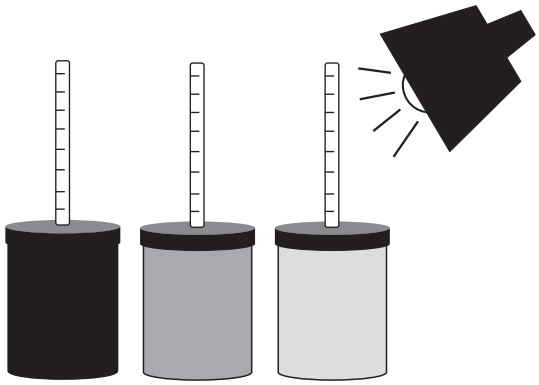
- Wear sanitized safety glasses or goggles during lab setup, hands-on activity, and takedown.
- Use caution when working with heat lamps and metal containers, because they get hot and can burn skin.
- Clamp lamps to a secure structure out of the way of foot traffic, and avoid touching parts of the lamp other than the power switch until it has cooled.
- Only use GFCI-protected electrical receptacles for the heat lamp.
- Handle glass thermometers with care. They are fragile and can break, causing a sharp hazard that can cut or puncture skin.
- Wash hands with soap and water after completing the lab activity.

Investigation Proposal Required? ☐ Yes ☐ No

Getting Started

To answer the guiding question, you will need to design an experiment that will allow you to determine which exterior paint color is associated with the lowest average canister temperature. To accomplish this task, you can heat canisters that are painted different colors using a heat lamp (see Figure L18.2). Before you can begin heating different canisters, you must first determine what type of data you need to collect, how you will collect it, and how you will analyze it.

FIGURE L18.2
Heating canisters with a heat lamp



To determine *what type of data you need to collect,* think about the following questions:

- What will serve as your independent variable in the investigation?
- What will serve as your dependent variable in the investigation?
- What types of measurements will you need to make?

To determine *how you will collect your data,* think about the following questions:

- What equipment will you use to take measurements?
- When will you make the measurements that you need?
- What other factors will you need to control during your experiment?
- How will you make sure that your data are of high quality (i.e., how will you reduce error)?
- How will you keep track of the data you collect?
- How will you organize your data?

To determine *how you will analyze your data,* think about the following questions:

- What type of calculations will you need to make?
- What type of table or graph could you create to help make sense of your data?

Connections to Crosscutting Concepts, the Nature of Science, and the Nature of Scientific Inquiry

As you work through your investigation, be sure to think about

- how scientists work to explain the relationships between causes and effects;

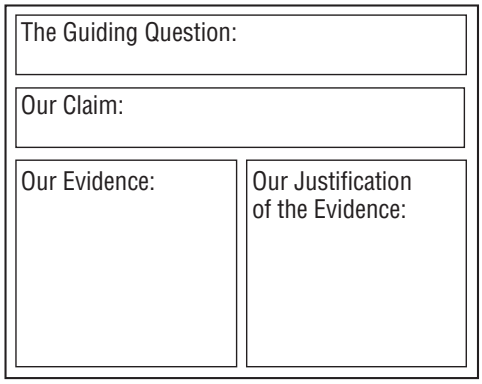
- the importance of tracking how energy moves into, out of, and within systems;
- the difference between scientific laws and scientific theories; and
- the nature and role of experiments in science.

Initial Argument

Once your group has finished collecting and analyzing your data, your group will need to develop an initial argument. Your initial argument needs to include a *claim*, *evidence* to support your claim, and a *justification* of the evidence. The claim is your group's answer to the guiding question. The evidence is an analysis and interpretation of your data. Finally, the justification of the evidence is why your group thinks the evidence matters. The justification of the evidence is important because scientists can use different kinds of evidence to support their claims. Your group will create your initial argument on a whiteboard. Your whiteboard should include all the information shown in Figure L18.3.

FIGURE L18.3

Argument presentation on a whiteboard



Argumentation Session

The argumentation session allows all of the groups to share their arguments. One member of each group will stay at the lab station to share that group's argument, while the other members of the group go to the other lab stations to listen to and critique the arguments developed by their classmates. This is similar to how scientists present their arguments to other scientists at conferences. If you are responsible for critiquing your classmates' arguments, your goal is to look for mistakes so these mistakes can be fixed and they can make their argument better. The argumentation session is also a good time to think about ways you can make your initial argument better. Scientists must share and critique arguments like this to develop new ideas.

To critique an argument, you might need more information than what is included on the whiteboard. You will therefore need to ask the presenter lots of questions. Here are some good questions to ask:

- How did you collect your data? Why did you use that method? Why did you collect those data?
- What did you do to make sure the data you collected are reliable? What did you do to decrease measurement error?
- How did your group analyze the data? Why did you decide to do it that way? Did you check your calculations?

- Is that the only way to interpret the results of your analysis? How do you know that your interpretation of your analysis is appropriate?
- Why did your group decide to present your evidence in that way?
- What other claims did your group discuss before you decided on that one? Why did your group abandon those alternative ideas?
- How confident are you that your claim is valid? What could you do to increase your confidence?

Once the argumentation session is complete, you will have a chance to meet with your group and revise your initial argument. Your group might need to gather more data or design a way to test one or more alternative claims as part of this process. Remember, your goal at this stage of the investigation is to develop the most acceptable and valid answer to the research question!

Report

Once you have completed your research, you will need to prepare an *investigation report* that consists of three sections. Each section should provide an answer to the following questions:

1. What question were you trying to answer and why?
2. What did you do to answer your question and why?
3. What is your argument?

Your report should answer these questions in two pages or less. This report must be typed, and any diagrams, figures, or tables should be embedded into the document. Be sure to write in a persuasive style; you are trying to convince others that your claim is acceptable and valid!