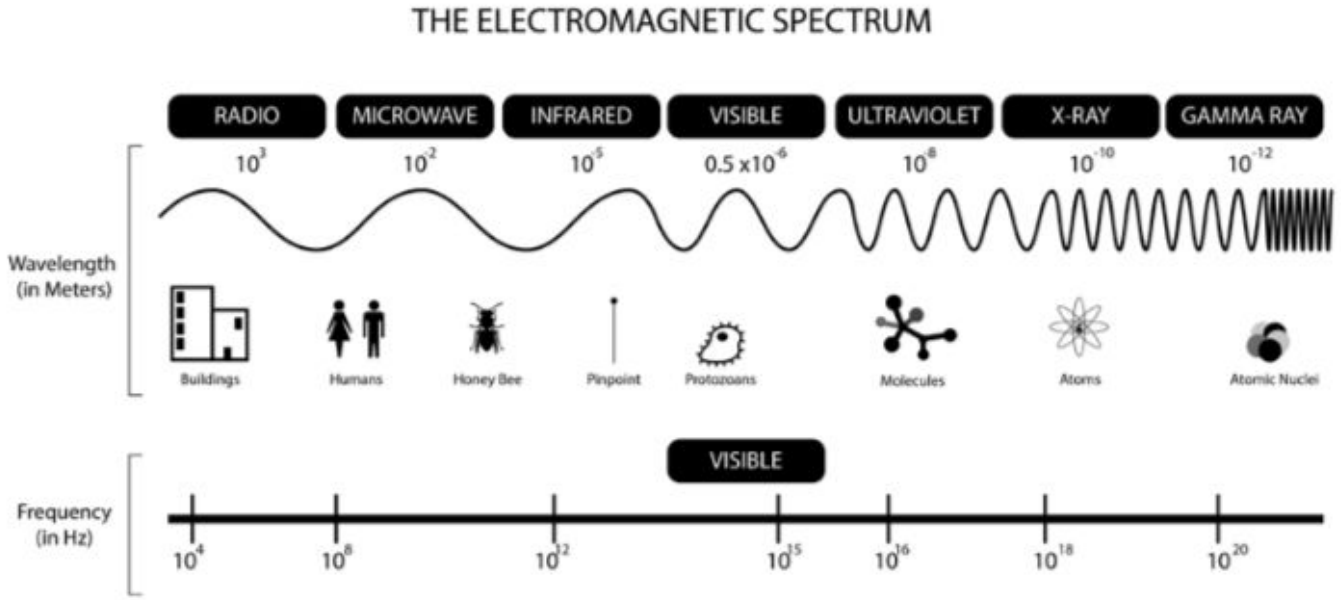
Radiation and Energy Transfer: What Color Should We Paint a Building to Reduce Cooling Costs?

Introduction

Radiant energy is the energy transported by electromagnetic waves. Electromagnetic waves transport many different types of energy (see figure below). 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.



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 will use the following link for the *Heat Absorption* Gizmo during your investigation:
https://www.explorelearning.com/index.cfm?method=cResource.dspView&ResourceID=655
You can only use this Gizmo for five minutes a day without signing up for a free account.

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 temperature. To accomplish this task, you will visit the *Heat Absorption* Gizmo. First, just play around with the interactive to understand how it works and what variables can be changed. Then decide which variables you will use to determine which color a building should be painted in order to reduce the cooling costs. Remember, you only want to be changing one variable at a time.

Before you can begin collecting data, you must first determine what type of data you need to collect, how you will collect it, and how you will analyze it.

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:
- 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?

Report
Once you have completed your research, you will need to prepare an investigation report that consists of four sections (be sure to have section headings):
1. Introduction: Give some background information on the topic. Explain what question you were trying to answer and include a hypothesis. (Background info, research question and hypothesis)
2. Procedure: What did you do during your investigation and why did you conduct your investigation in this way? (How you collected and analyzed data)
3. Data: Include a data table and/or graph to show your results. Be sure to include a title for your table or graph with labels for the variables.
4. Conclusion: What is your argument? (Claim - Evidence - Reasoning)

Your report should answer these questions in two pages or less. The report must be typed, and any diagrams, figures, or tables should be embedded into the document. Type your report on Google Docs (12 point font, double-spaced) and share it with your teacher. Your report will be graded based on the rubric in the class syllabus.