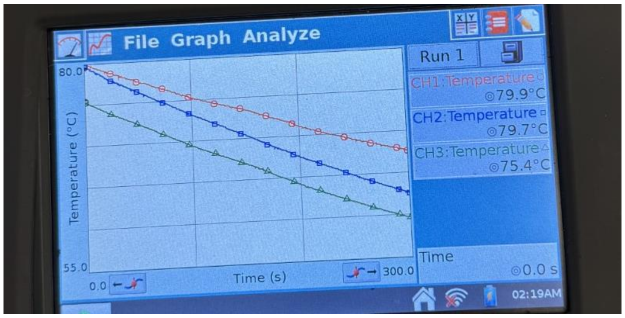
Introduction

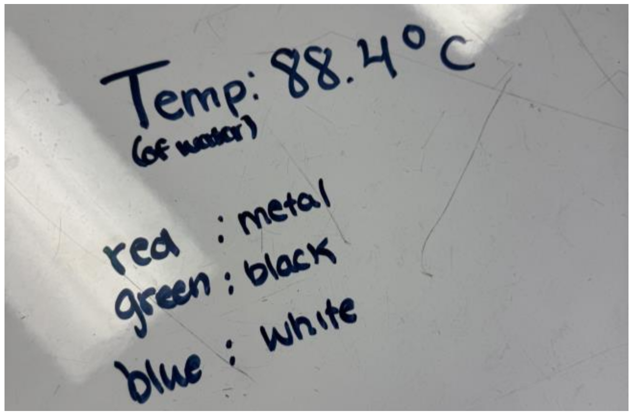
Thermal properties in physics describe how materials react to temperature changes and are essential for understanding the behavior of matter in different environments. These properties are governed by thermodynamics and heat transfer principles, which determine how energy moves and changes within systems. This lab explores the intriguing thermal characteristics of materials, focusing on how they absorb, emit, and transfer heat. Through experiments, we will gain practical insights into concepts such as thermal radiation, heat transfer, energy efficiency, and phase transitions.

Problem 1: Radiative Cooling

Emissivity is a property of an object that determines the rate of radiative heat transfer, from windows to radiators objects with high emissivity are unsung but important components of the mechanisms that we interact with every day. The material properties of an object typically determine the emissivity alongside its shape and size. This experiment will analyze the difference between 3 aluminum cylinders cooling radiatively, two of the cylinders are treated with white and black paints respectively.

Problem 1 Data:





Problem 1 Analysis:

We notice that the data shows two lines (blue and green) with the same rate of energy loss, while red decreases significantly slower, green and blue are the treated cylinders, where despite the color differences the data shows that only the material properties of the parts which are exposed to and able to radiate the heat away, impact the heat transfer of the object. A possible explanation for the metal cylinder (red) decreasing significantly slower is because it is shiny, making it have a lower emissivity as it reflects more infrared radiation. It can be noted that as radiative cooling solely is determined by the outmost layer, this is the same concept at play with wrapping food in foil while cooking it, allowing for higher conservation of heat internally, which keeps the center at a more stable temperature.

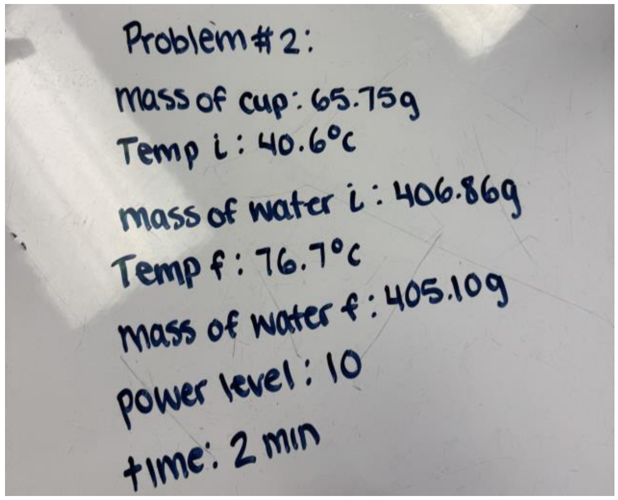
Problem 2: Measuring Efficiency of a Microwave Oven

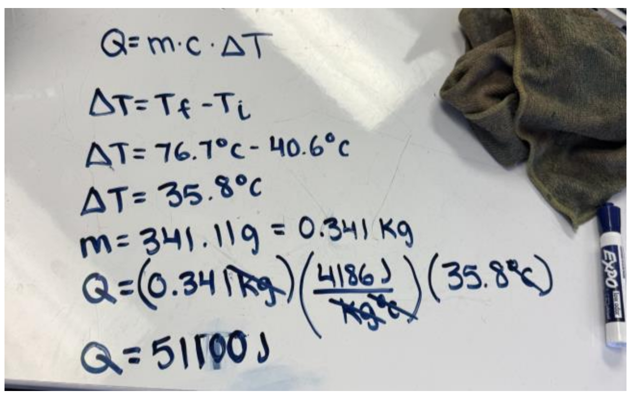
Efficiency is the ratio of useful energy output (what you get) to the energy input (what you pay). For a microwave, the useful energy output is the amount of energy transferred to the food, which in this experiment will be measured by the temperature increase in water. The energy input is the power the microwave consumes, which is indicated on the appliance's label. For this experiment, an empty plastic cup was weighed in grams and then water was added to the cup and also weighed. The cup of water was then placed into the microwave at its highest power level for 2 minutes (ensuring that the vent of the cup lid was open). The initial and final temperatures were taken, and calculations were performed to find the efficiency of the microwave oven.

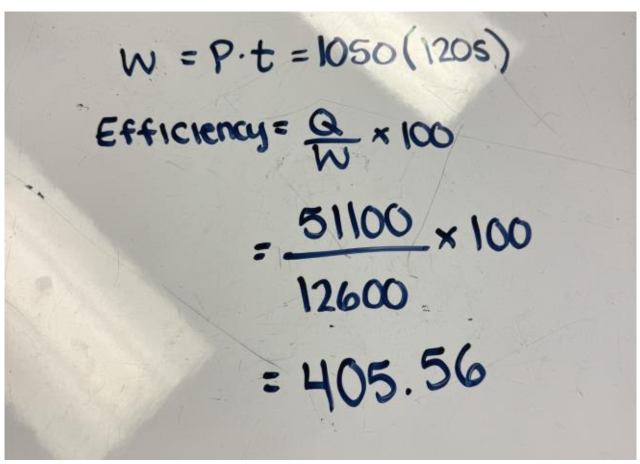
$$W = P \cdot t$$

$$Efficiency + \frac{Q}{W} \cdot 100$$

Problem 2 Data:







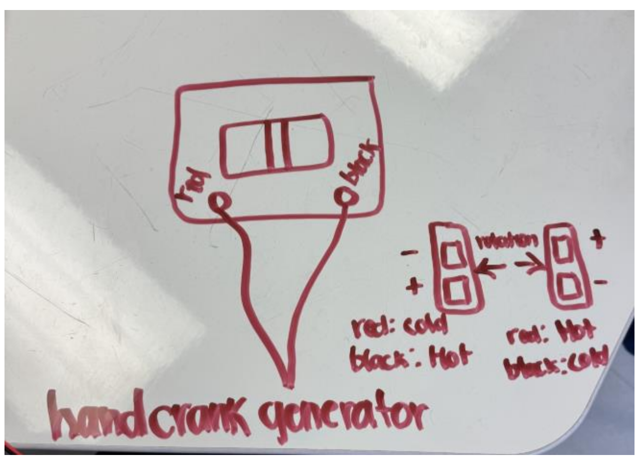
Problem 2 Analysis:

The power level of the microwave was 1050 W. Using the power level and the time (120 s) we found that W is 12600 ws. In order to find efficiency, the mass of the water (0.341 kg), capacity coefficient (4186 J/kg*°c), and the change in temperature (35.8 °c) were all multiplied to get 5100J as Q. Q was then divided by W (51100/12600) and multiplied by 100 to get efficiency (405.56). This value is reasonable given the fact that water takes longer to heat up, especially at larger volumes. Some factors that may play into this value could be the design of the microwave, initial temperature of the water, and heat lost to the surroundings. A better insulated cup would improve efficiency.

Problem 3: The Heat Pump

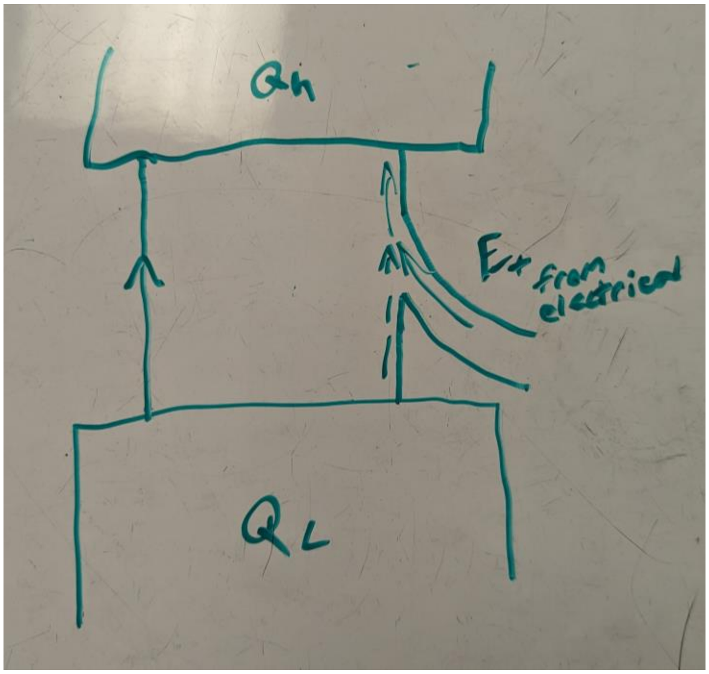
Energy transfer is a common principle between all forms of energy, being able to map the flow of energy as it changes forms can help to determine and predict the future behavior of a system. In this case, we look at Peltier device and determine the flow of energy through the system.

Problem 3 Data:



Problem 3 Analysis:

Thermal energy in this system is transferred from the electrical energy moved through the device, alongside thermal energy already in the metal, these are both moved towards the cold



reservoir. Some energy is returned into your fingertips when touching the cold reservoir, however this energy is lower than the energy it pulls away. While you certainly could use similar systems, being able to move the high heat away from yourself would be essential to cool a room as eventually the heat will radiate back into the environment.

Conclusion

In this lab, we investigated various concepts related to heat transfer, including radiative cooling, microwave oven efficiency, heat pumps, and phase changes. Each experiment provided valuable insights into how energy is transferred and transformed in different systems. By conducting these experiments, we deepened our understanding of heat transfer, material properties, and phase transitions, which are essential for real-world applications ranging from cooking and refrigeration to energy-efficient technologies.

Clarification on Lab 13

In problem 2 when trying to find the unknown "room" temperature, we completely overlooked the very obvious solution. We realize now that the value of was simply the zero of the linear regression line, found with –b/m.