Lab 04: Calculating a Conversion Efficiency

Physics and Mathematics of Sustainable Energy

Friday, October 10, 2025

College of the Atlantic

The **goals** for today are for you to:

- Gain a stronger understanding of conversion efficiencies
- Review/revisit some topics from earlier in the course: energy vs. power and the equation for thermal energy.

Guidelines

- Please work in pairs or trios. When you are done, please scan this worksheet (as a pdf if at all possible), and upload to google classroom.
- Please check with me before you go.
- This assignment is not graded, but I will look these over. I'm asking you to submit this mainly so that I can see how folks are doing in general, what questions people have, etc.

Names: _____

Overview

When you use an electric kettle, electrical energy is converted into thermal energy in the water. But this process is not 100% efficient. Not all of the energy goes into the water; some of the thermal energy goes to heat up the container and some ends up heating up the air. In this lab you'll measure the efficiency of a kettle or a hot plate.

To do so, you will:

1. Heat up a known amount of water. You could determine the mass directly by using the scale. Or you could measure the water with a graduated cylinder[1]. One mL of water has a mass of one gram.

2. Monitor the temperature of the water as it heats up. Let it heat up by at around 40 or 50 degrees.

3. Time how long it takes to heat up.

4. While the water is heating up, keep the temperature probe submerged in the water, but do not let the probe touch the bottom of the kettle. The reason for this is that we want to measure the temperature of the water, not the heating element.

5. While the water is heating up, monitor the power used by the kettle or hot plate. This number will fluctuate a little, but should be fairly constant.

[1] I.e., a nalgene bottle

6. Calculate two quantities (please show your work clearly):

   (a) How much thermal energy went into the water? You can calculate this because you know the water's mass, its specific heat, and the temperature change.

   (b) How much energy did the kettle use? You can calculate this because you know how much power the kettle drew, and how long the kettle was on for.

7. Calculate the efficiency:

$$\text{efficiency} = \frac{\text{Increase in Thermal Energy of Water}}{\text{Energy Used by Kettle or Hot Plate}} . \tag{1}$$

Using the Temperature Probes

1. Grab a temperature probe and connect it to your computer.
2. Go to `https://graphicalanalysis.app`. Click on "sensor data collection". And after a few more clicks you should be ready to collect data.
3. If this doesn't work you could download the the Vernier Graphical Analysis software here: `https://www.vernier.com/products/graphical-analysis/free/`.
4. Start the Graphical Analysis program. In the upper right, click on table and meter. Experiment with the temperature probe and the software to get a feel for how it works.