

Mechanical Equivalent of Heat

Part I: Introduction

In your web browser, navigate to www.gigaphysics.com, then select the **Mechanical Equivalent of Heat** lab. In this simulation, you will explore how gravitational potential energy is converted to kinetic energy as an object falls, and then to heat energy on impact.

The Controls

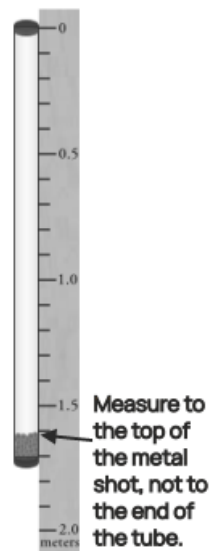
- The **Which metal?** menu lets you select one of three different metals for the experiment.
- The **Flip Tube** button turns the tube over, causing the metal pellets inside to fall from the (new) top to the bottom of the tube. If the pellets are currently at the balance or thermometer instead of inside the tube, this button will be labelled **Close and Flip Tube**.
- The **Metal to Balance** button opens the tube and moves the metal pellets to the balance to display their mass.
- You will use the **Metal to Thermometer** button to move the metal pellets in front of the infrared thermometer so you can measure their temperature.
- You can use the mouse to drag the ruler into position when you are ready to measure the tube.
- The **New Experiment** button changes the random elements of the experiment, such as the mass of the metal pellets and the length of the tube. You probably won't use this button during the experiment; it's really just for when a new student sits down at the same computer and needs to start with random data that doesn't match another student's.

Part II: Proof of Concept

Choose the copper pellets from the **Which metal?** menu. To find the amount of gravitational potential energy that will be converted to heat, you will need the mass of the pellets and the distance they fall. To measure the distance, drag the ruler next to the tube and measure from the top of tube to the top of the copper pellets. Don't include the cap or the pellets themselves in your measurements—only the empty space through which the pellets can actually fall. Record the fall distance in the table below.

You will also need the mass of the pellets. Click the **Metal to Balance** button to remove the shot from the tube and move it to the electronic balance. The balance will record the mass of the pellets in grams. Convert this figure to SI units, then add it to the table below.

You will also need the initial temperature of the pellets in order to calculate the heat produced. Click the **Metal to Thermometer** button to move the pellets to the target in front of the infrared thermometer. Add this value to finish the first data table.



Length of tube	Mass of pellets	Initial temperature

Now it's time to start flipping the tube so the pellets can fall, converting gravitational potential energy to heat on impact. Each impact generates only a small amount of heat, so you will need to flip the tube many times a few dozen times to get useful data. To start, click **Close and Flip Tube**. Continue to flip the tube about 40 times; the on-screen counter will help you keep track. When you have finished, click **Metal to Thermometer** again and read their final temperature. Record the number of times flipped and the final temperature below.

Number of times flipped	Final temperature

Now calculate the amount of gravitational potential energy that was available for conversion to heat, using the formula $E_g = mgh$. For h , be sure to take into account the number of times the tube was flipped. Record your results below.

Total distance fallen	Total gravitational potential energy transformed

Now calculate the amount of heat energy produced using the formula $Q = mc\Delta T$. The specific heat capacity of copper is 385 J/kg-°C.

Change in temperature	Heat energy gained by shot

If you have performed these steps correctly, then the gravitational potential energy lost by the shot should equal the heat energy gained by the shot on impact (at least to within rounding errors).

Part III: Specific Heat Capacity of Lead

Now that you understand the transformation from gravitational potential energy to heat, you can use this relationship to calculate the specific heat capacity of a different metal.

Use the menu to change from **Copper** to **Lead** pellets. As you did before, move the pellets to the balance to get their mass, and to the thermometer to get their initial temperature. Complete the table below with your new data. (As long as you have not clicked **New Experiment**) or refreshed the web page, the length of the tube should not have changed.)

Length of tube	Mass of pellets	Initial temperature

Repeat the tube flipping procedure from before, again recording the number of times you flipped the tube and the final temperature.

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Number of times flipped	Final temperature

Now that you know that the gravitational potential energy of the lead is equivalent to the heat generated, you can use this relationship to calculate the unknown specific heat of lead. Record your results below, showing your work in the space provided.

Specific heat capacity of lead _____

If you have done this procedure and calculation correctly, you should find that the specific heat capacity of lead is about one third of copper's.

Part IV: Specific Heat Capacity of Aluminum

Now change the metal to aluminum and repeat the procedure in part III to find the specific heat capacity of aluminum.

Length of tube	Mass of pellets	Initial temperature

Number of times flipped	Final temperature

Specific heat capacity of aluminum _____

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Part IV: Additional Questions

In parts III and IV, was it truly necessary to measure the mass of the metal pellets in order to calculate the specific heat capacity? Why or why not?

Iron has a specific heat capacity of $450 \text{ J/kg}\cdot\text{C}$. Would an iron nail heat up more or less than an aluminum nail while being pounded into a board with a hammer? Explain your answer.
