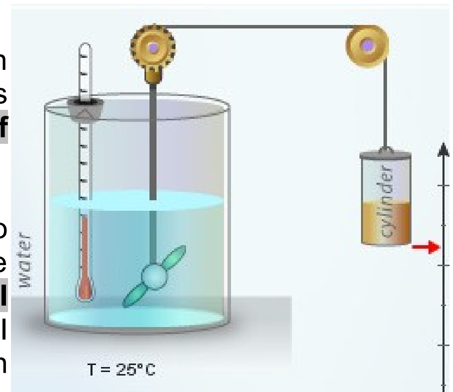
Name: ______________________________________ Date: ________________________

Student Exploration: Energy Conversion in a System



Gizmo Warm-up

Energy constantly changes from one form to another, but in a closed system, the total amount of energy always remains the same. This concept is the **law of conservation of energy**.

The *Energy Conversion in a System* Gizmo™ allows you to observe the law of conservation of energy in action. In the Gizmo, a suspended cylinder has **gravitational potential energy**. When the cylinder is released, the gravitational potential energy is converted into **kinetic energy**, which causes the stirrer in the water to spin.

What is the initial temperature (***T***) of the water? _______________________________________

Click **Play** (▶). What happens as the cylinder drops? _______________________________

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What is the final temperature of the water? ____

Explain why the temperature of the water increased: ___________________________________

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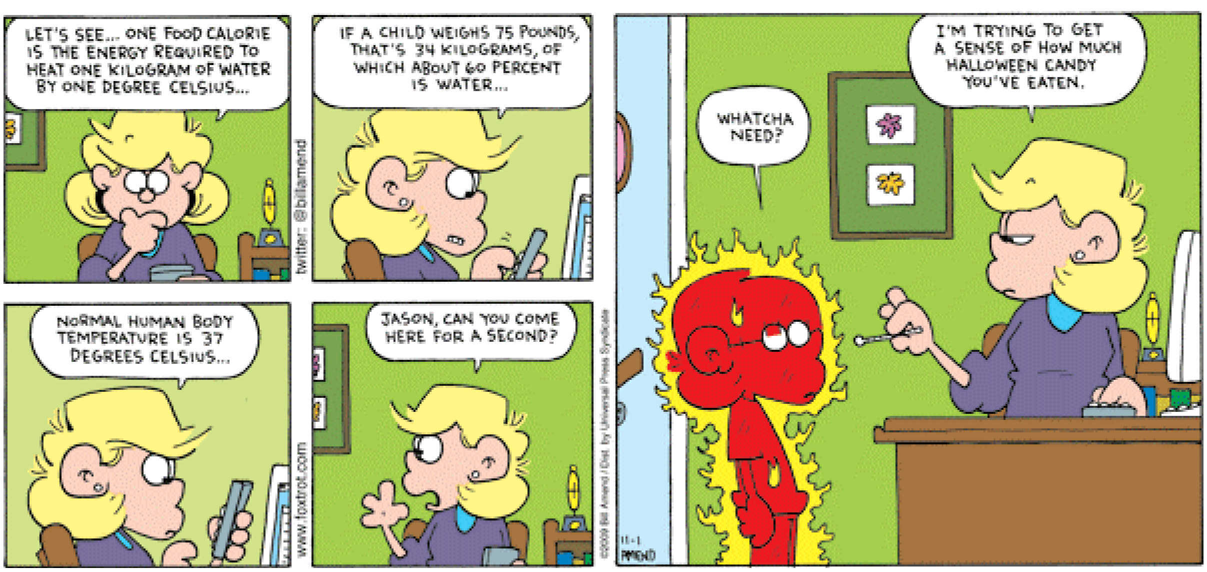
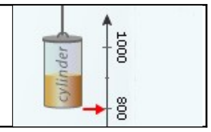


Activity A: **Potential energy and height**	<u>Get the Gizmo ready</u>: • Click **Reset** ( ).	

Introduction: The raised cylinder in the Gizmo has gravitational potential energy (E_g) because gravity can cause the cylinder to drop. When the cylinder drops, its kinetic energy is converted into **heat energy**, which raises the temperature of the water.

Question: How does the cylinder's initial height affect its gravitational potential energy?

Make sure the water's **Mass** is 1.0 kg, its **Temp** is 25 °C, and the cylinder's **Mass** is 5 kg. Set the cylinder's **Height** to 100 m. *(Note: The large height scale used by the Gizmo, while not practical in a real-world experiment, makes it easier to produce observable temperature changes in the water.)*

Click **Play**, and record the water's final temperature in the table below. Repeat the experiment at each cylinder height to complete the second column in the table.

Cylinder height (m)	Final temp. (°C)	Change in temp. (°C)	Cylinder E_g (J)
100 m			
200 m			
500 m			
1,000 m			

Subtract the water's initial temperature from its final temperature to complete the third column of the table.

An object's E_g can be calculated by multiplying its height (h) by its mass (m) and acceleration due to gravity (g): $E_g = mgh$. On Earth, $g = 9.8$ m/s^2. Calculate the cylinder's E_g for each of the trials you completed and fill in the last column of the table.

Study the data you collected:

How does doubling the height of the cylinder affect its E_g? ________________________________

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How does doubling the cylinder's E_g affect the change in temperature experienced by the water?

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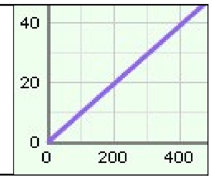
What other variable could you double to double the cylinder's E_g? __________________________

Activity B: Heat energy and temperature	Get the Gizmo ready: • Click **Reset**. • Select the GRAPH tab and choose the **Generated heat** option.	

Question: What factors affect how much the water's temperature changes when a given amount of heat energy is added to the water?

Set the cylinder's **Mass** to 5 kg and its **Height** to 500 m. Use the Gizmo to test each of the scenarios listed in the table and record your results in the last three columns. Use the graph to estimate the generated heat.

Water's mass (kg)	Water's initial temp. (°C)	Water's final temp. (°C)	Change in temp. (°C)	Generated heat (kJ)
1 kg	0 °C			
1 kg	20 °C			
1 kg	40 °C			
0.5 kg	25 °C			
1 kg	25 °C			
1.5 kg	25 °C			

Why was the amount of heat generated the same each time? _________________________

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What was the effect of the initial temperature on the temperature *change* of the water?

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What was the effect of doubling the mass of the water on the temperature change?

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Challenge: Not all substances heat up and cool down at the same rate. A substance's resistance to temperature change is described by its **specific heat capacity** (c):

$$c = \frac{Heat\ Energy}{m \Delta T} \quad \text{where} \quad m = mass \quad \text{and} \quad \Delta T = temperature\ change$$

Use the formula above to calculate the specific heat capacity of water: