# Pre-Lab Information

Purpose Explore the conversion of energy in a system.

Time Approximately 45 minutes

Question How is potential energy converted to thermal energy in a system?

Hypothesis #1 If the height of the cylinder increases, the temperature of the water increases, because a greater height means the cylinder has more potential energy that can be converted to thermal energy, increasing the temperature of the water.

Hypothesis #2 If the mass of the cylinder increases, the temperature of the water increases, because a greater mass means the cylinder has more potential energy that can be converted to thermal energy, increasing the temperature of the water.

Variables for H1 *Independent Variable:* height of the cylinder

 *Dependent Variable:* temperature of the water

 *Constant:* mass of the cylinder

Variables for H2 *Independent Variable:* mass of the cylinder

 *Dependent Variable:* temperature of the water

 *Constant:* height of the cylinder

Summary This experiment is divided into two parts. For each part, you will use a simulation to examine energy conversion in a system. In the simulation, potential energy of a cylinder is converted to kinetic energy as the cylinder drops from a pulley. This movement turns a propeller within an enclosed water bath, which changes the temperature of the water as kinetic energy is converted to thermal energy. For the first part of the experiment, you will vary the height of the cylinder. For the second part of the experiment, you will vary the mass of the cylinder.

# Lab Procedure

1. **Open the simulation.**
	1. Be sure to follow all the directions provided in the lab guide as well as on screen during the virtual lab.
	2. Open the “Energy Conversion in a System” Gizmo.
	3. Briefly review the functionality of the Gizmo, identifying sliders and buttons that you will use to complete the experiment. Ask your teacher about using the Gizmo if you have any questions.



***Part I: Changing the Height of the Cylinder***

1. **Run the simulation using a cylinder height of 100 m.**
	1. Use the figure above to help set up the experiment. Move the first slider to set the mass of the water at 1.0 kg.
	2. Move the second slider to set the initial temperature of the water at 25°C.
	3. Move the third slider to set the mass of the cylinder at 5 kg.
	4. Move the fourth slider to set the height of the cylinder at 100 m.
	5. Click the Play button. Let the cylinder fall to the floor.
	6. Once the cylinder has stopped moving, record the water’s final temperature in Table A. Be sure to use the temperature reading found in the top-left corner of the simulation.
2. **Run the simulation using a cylinder height of 200 m.**
	1. Click the Reset button to return the system to the starting conditions.
	2. Move the fourth slider to set the height of the cylinder at 200 m. Be sure to keep the first, second, and third sliders the same as in Step 2.
	3. Click the Play button. Let the cylinder fall to the floor.
	4. Once the cylinder has stopped moving, record the water’s final temperature in Table A. Be sure to use the temperature reading found in the top-left corner of the simulation.
3. **Run the simulation using a cylinder height of 500 m.**
	1. Click the Reset button to return the system to the starting conditions.
	2. Move the fourth slider to set the height of the cylinder at 500 m. Be sure to keep the first, second, and third sliders the same as in Step 2.
	3. Click the Play button. Let the cylinder fall to the floor.
	4. Once the cylinder has stopped moving, record the water’s final temperature in Table A. Be sure to use the temperature reading found in the top-left corner of the simulation.
4. **Run the simulation using a cylinder height of 1,000 m.**
	1. Click the Reset button to return the system to the starting conditions.
	2. Move the fourth slider to set the height of the cylinder at 1,000 m. Be sure to keep the first, second, and third sliders the same as in Step 2.
	3. Click the Play button. Let the cylinder fall to the floor.
	4. Once the cylinder has stopped moving, record the water’s final temperature in Table A. Be sure to use the temperature reading found in the top-left corner of the simulation.
5. **Calculate the change in water temperature for each run.**
	1. Calculate the change in water temperature (∆*T*) for each cylinder height using the initial water temperature (25°C) and the final water temperature you recorded. Record your answers to the nearest hundredth in Table A.
6. **Calculate the gravitational potential energy of the cylinder for each run.**
	1. Calculate the gravitational potential energy (*PEg*) of the cylinder for each height. Remember that the gravitational potential energy (*PEg*) of an object can be calculated using the formula

*PEg* = *mgh*,

where the cylinder’s mass (*m*) is multiplied by acceleration due to gravity (*g*) and the cylinder’s height (*h*).

* 1. Convert the gravitational potential energy from joules (J) to kilojoules (kJ). Record your answers to the nearest tenth in Table A.
1. **Calculate the heat generated in the system.**
	1. Calculate the amount of heat generated (∆*H*) for each cylinder height. Remember the amount of heat generated can be calculated using the formula

∆*H* = *mwcw*∆*T*,

where *mw* is the mass of the water, *cw*,is thespecific heat capacity of water (use *cw* = 4.186 kJ/kg°C), and ∆*T* is the change in water temperature. Record your answers to the nearest tenth in Table A.

***Part II:* *Changing the Mass of the Cylinder***

1. **Run the simulation using a cylinder mass of 1.0 kg.**
	1. Click the Reset button to get ready for the second part of the experiment.
	2. Move the first slider to set the mass of the water at 1.0 kg.
	3. Move the second slider to set the initial temperature of the water at 25°C.
	4. Move the third slider to set the mass of the cylinder at 1.0 kg.
	5. Move the fourth slider to set the height of the cylinder at 500 m.
	6. Click the Play button. Let the cylinder fall to the floor.
	7. Once the cylinder has stopped moving, record the water’s final temperature in Table B. Be sure to use the temperature reading found in the top-left corner of the simulation.
2. **Run the simulation using a cylinder mass of 3.0 kg.**
	1. Click the Reset button to return the system to the starting conditions.
	2. Move the third slider to set the mass of the cylinder at 3.0 kg. Be sure to keep the first, second, and fourth sliders the same as in Step 9.
	3. Click the Play button. Let the cylinder fall to the floor.
	4. Once the cylinder has stopped moving, record the water’s final temperature in Table B. Be sure to use the temperature reading found in the top-left corner of the simulation.
3. **Run the simulation using a cylinder mass of 6.0 kg.**
	1. Click the Reset button to return the system to the starting conditions.
	2. Move the third slider to set the mass of the cylinder at 6.0 kg. Be sure to keep the first, second, and fourth sliders the same as in Step 10.
	3. Click the Play button. Let the cylinder fall to the floor.
	4. Once the cylinder has stopped moving, record the water’s final temperature in Table B. Be sure to use the temperature reading found in the top-left corner of the simulation.
4. **Run the simulation using a cylinder mass of 9.0 kg.**
	1. Click the Reset button to return the system to the starting conditions.
	2. Move the third slider to set the mass of the cylinder at 9.0 kg. Be sure to keep the first, second, and fourth sliders the same as in Step 10.
	3. Click the Play button. Let the cylinder fall to the floor.
	4. Once the cylinder has stopped moving, record the water’s final temperature in Table B. Be sure to use the temperature reading found in the top-left corner of the simulation.
5. **Calculate the change in water temperature for each run.**
	1. Calculate the change in water temperature (∆*T*) for each cylinder mass using the initial water temperature (25°C) and the final water temperature you recorded. Record your answers to the nearest hundredth in Table B.
6. **Calculate the gravitational potential energy of the cylinder for each run.**
	1. Calculate the gravitational potential energy (*PEg*) of the cylinder for each mass. Remember the gravitational potential energy (*PEg*) of an object can be calculated using the formula

*PEg* = *mgh*,

where the cylinder’s mass (*m*) is multiplied by acceleration due to gravity (*g*) and the cylinder’s height (*h*).

* 1. Convert the gravitational potential energy from joules (J) to kilojoules (kJ). Record your answers to the nearest tenth in Table B.
1. **Calculate the heat generated in the system.**
	1. Calculate the amount of heat generated (∆*H*) for each cylinder mass. Remember the amount of heat generated can be calculated using the formula

∆*H* = *mwcw*∆*T*,

where *mw* is the mass of the water, *cw* is thespecific heat capacity of water (use *cw* = 4.186 kJ/kg°C), and ∆*T* is the change in water temperature. Record your answers to the nearest tenth in Table B.

# Data

Record your data either in your lab notebook or in the tables below.

**Table A**

**(*Ti* = 25°C; *mwater* = 1.0 kg; *mcylinder* = 5.0 kg)**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| ***h*****Cylinder Height****(m)** | ***Tf*****Final Temperature of Water****(°C)** | **∆*T*****Change in Water Temperature****(°C)** | ***PEg*****Gravitational Potential Energy of Cylinder****(kJ)** | **∆*H*****Heat Generated****(kJ)** |
| 100 |  |  |  |  |
| 200 |  |  |  |  |
| 500 |  |  |  |  |
| 1,000  |  |  |  |  |

**Table B**

**(*Ti* = 25°C; *mwater* = 1.0 kg; *h* = 500 m)**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| ***mC*****Cylinder Mass****(kg)** | ***Tf*****Final Temperature of Water****(°C)** | **∆*T*****Change in Water Temperature****(°C)** | ***PEg*****Gravitational Potential Energy of Cylinder****(kJ)** | **∆*H*****Heat Generated** **(kJ)** |
| 1.0  |  |  |  |  |
| 3.0 |  |  |  |  |
| 6.0 |  |  |  |  |
| 9.0 |  |  |  |  |