**Name:**

**Date:**

**School:**

**Facilitator:**

7.02 Roller Coaster Energy Lab

**Open the virtual lab “Kinetic and Potential Energy” linked on the Task page. Complete the lab to answer the overall focus question: Over the course of a roller coaster ride, why do the hills get smaller and smaller?**

# Part 1: Potential Energy

## Section A

**In this section, you will examine how the force needed to life an object and the gravitational potential energy the object possesses are affected by mass.**

1. Run Trials 1-3, and after each trial:
   1. Use the Transfer Data button to transfer the force and energy data from the Data Panel to the table.
   2. Press the “Equals” button to calculate the object’s potential energy.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Table 1: Effects of Mass** | | | | | | |
| **Trial** | **Mass (kg)** | **Acceleration due to gravity (m/s2)** | **height (m)** | **force (N)** | **energy to lift object (J)** | **potential energy (J)** |
| **1** | **1.0 (kg)** | **9.8 m/s2** | **100 m** |  |  |  |
| **2** | **5.0 (kg)** | **9.8 m/s2** | **100 m** |  |  |  |
| **3** | **0.1 (kg)** | **9.8 m/s2** | **100 m** |  |  |  |

1. Compare the forces needed to lift objects of different masses to the same height. How does mass affect the amount of force needed?

1. Compare the energies needed to lift objects of different masses to the same height. How does mass affect the amount of energy needed?

## Section B

**In this section, you will examine how the force needed to life an object and the gravitational potential energy the object possesses are affected by height.**

1. Run Trials 1, 4, and 5, and after each trial:
   1. Use the Transfer Data button to transfer the force and energy data from the Data Panel to the table.
   2. Press the “Equals” button to calculate the object’s potential energy.

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| **Table 2: Effects of Height** | | | | | | |
| **Trial** | **Mass (kg)** | **Acceleration due to gravity (m/s2)** | **height (m)** | **force (N)** | **energy to lift object (J)** | **potential energy (J)** |
| **1** | **1.0 (kg)** | **9.8 m/s2** | **100 m** |  |  |  |
| **4** | **1.0 (kg)** | **9.8 m/s2** | **50 m** |  |  |  |
| **5** | **1.0 (kg)** | **9.8 m/s2** | **10 m** |  |  |  |

1. Compare the forces needed to lift objects of the same mass to different heights. How are the forces needed to lift the objects affected by the distances the objects move?

1. Compare the energies needed to lift objects of the same mass to different heights. How are the energies needed to lift the objects affected by the distances the objects move?

## Section C

**In this section, you will examine how the force needed to life an object and the gravitational potential energy the object possesses are affected by acceleration due to gravity (g). The g-values in Table 3 represent the gravitational acceleration on earth (9.80 m/s2), Mars (3.80 m/s2), and the moon (1.60 m/s2).**

1. Run Trials 1, 6, and 7, and after each trial:
2. Use the Transfer Data button to transfer the force and energy data from the Data Panel to the table.
3. Press the “Equals” button to calculate the object’s potential energy.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Table 3: Effects of Gravitational Acceleration** | | | | | | |
| **Trial** | **Mass (kg)** | **Acceleration due to gravity (m/s2)** | **height (m)** | **force (N)** | **energy to lift object (J)** | **potential energy (J)** |
| **1** | **1.0 (kg)** | **9.8 m/s2** | **100 m** |  |  |  |
| **6** | **1.0 (kg)** | **3.8 m/s2** | **100 m** |  |  |  |
| **7** | **1.0 (kg)** | **1.6 m/s2** | **100 m** |  |  |  |

1. Compare the forces needed to lift objects of the same mass to the same height on earth (Trial 1), Mars (Trial 6), and the moon (Trial 7). Are there differences in the forces needed to lift the objects? Explain.

1. Compare the energies needed to lift objects of the same mass to the same height on earth (Trial 1), Mars (Trial 6), and the moon (Trial 7). Are there differences in the energies needed to lift the objects? Explain.

1. Examine the energy needed to lift an object to a given height. Compare that energy to the gravitational potential energy the object possesses at that height. Are they similar? Explain.

# Part 2: Kinetic Energy

## Section A

**In this section, you will drop an object and calculate its kinetic energy at different points during its fall.**

1. Run Trial 1:
2. Click the drop points (1-6) to display the height and velocity of the object before, during, and after its fall.
3. After each click, use the “Transfer Data” button to transfer the drop-point data from the Data Panel to the table.
4. Press the “Equals” button to calculate the object’s kinetic energy.

|  |  |  |  |
| --- | --- | --- | --- |
| **Table 4: Kinetic Energy** | | | |
| **initial setting: mass = 1.0 kg, g = 9.80 m/s2, height = 100 m** | | | |
| **Drop Point** | **Height (m)** | **Velocity (m/s)** | **Kinetic energy (J)** |
| **1** | **100 m** |  |  |
| **2** |  |  |  |
| **3** |  |  |  |
| **4** |  |  |  |
| **5** |  |  |  |
| **6** |  |  |  |

1. Examine the data table. How much kinetic energy does the object have before it is dropped?

1. Describes the height, velocity, and kinetic energy of the object as it falls.

1. As the object falls, does kinetic energy increase, decrease, or stay the same?

1. After the object hits the ground, how much kinetic energy does it have?

## Section B

**Next, you will investigate how the kinetic energy of a falling object is affected by its mass, the gravitational acceleration it experiences, and the height from which it is dropped.**

1. Run Trials 2-7. For each trial:
2. Click the drop points to display the height and velocity, just before it hits the ground.
3. Use the “Transfer Data” button to transfer the drop-point data from the Data Panel to the table.
4. Press the “Equals” button to calculate the object’s kinetic energy.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Table 5: Factors Affecting Kinetic Energy** | | | | | | |
| **initial settings** | | | | **measured values** | | |
| **trial** | **mass (kg)** | **g (m/s2)** | **height (m)** | **height (m)** | **velocity (m/s)** | **kinetic energy (J)** |
| **2** | **0.5 kg** | **9.8 m/s2** | **100 m** |  |  |  |
| **3** | **0.1 kg** | **9.8 m/s2** | **100 m** |  |  |  |
| **4** | **1.0 kg** | **3.8 m/s2** | **100 m** |  |  |  |
| **5** | **1.0 kg** | **1.6 m/s2** | **100 m** |  |  |  |
| **6** | **1.0 kg** | **9.8 m/s2** | **50 m** |  |  |  |
| **7** | **1.0 kg** | **9.8 m/s2** | **10 m** |  |  |  |

# Part 3: Mechanical Energy

**In this section, you will observe how energy storage methods – potential energy and kinetic energy – change and are related to the mechanical energy an object possesses.**

1. Run Trial 1. For each trial:
   1. Click the drop points to display the height and velocity of the ball before its dropped (drop point 1), during its fall (drop points 2-5), during its “bounce” (drop point 6), during its rise (drop points 7-10), and at the top of its rise (drop point 11).
   2. After each click, use the “Transfer Data” button to transfer the drop-point data from the Data Panel to the table.
   3. Press the “Equals” button to calculate the object’s mechanical energy.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Table 6: Mechanical Energy** | | | | | |
| **initial settings: mass = 1.0 kg, g = 9.80 m/s2, height = 100 m** | | | | | |
| **drop point** | **height (m)** | **velocity (m/s)** | **potential energy (J)** | **kinetic energy (J)** | **mechanical energy (J)** |
| **1** |  |  |  |  |  |
| **2** |  |  |  |  |  |
| **3** |  |  |  |  |  |
| **4** |  |  |  |  |  |
| **5** |  |  |  |  |  |
| **6** |  |  |  |  |  |
| **7** |  |  |  |  |  |
| **8** |  |  |  |  |  |
| **9** |  |  |  |  |  |
| **10** |  |  |  |  |  |
| **11** |  |  |  |  |  |

1. How does potential energy change as the ball moves up and down?

1. How does kinetic energy change as the ball moves up and down?

1. How does mechanical energy change as the ball moves up and down?

1. Trial 1 was done in the absence of friction and air resistance. Run Trial 2 to observe how these forces can affect the behavior of the ball. Describe the similarities and differences between the ball’s motion in the two trials.