Conservation of Energy: Relationship between Kinetic and Potential Energy

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Abstract:

The purpose of this experiment was to observe the transfer of kinetic energy to gravitational potential energy, thereby verifying the conservation of energy. This was accomplished by graphing the motion of a ball as it was thrown up and down in the air.

Introduction:

For any force to be able to do work on a system, energy is required. Energy is said to be conserved, meaning energy is neither created nor destroyed but rather is transferred from one form to another or from one object to another (Giancoli). For a closed system, this means the value of the total energy measured at one point of an object's motion is the same as the value of the total energy of that system at any other point.

$$E_i = E_f$$

In the formula above, E stands for the total energy of the system. A system may have multiple types of energy. Kinetic energy (KE) is energy of motion and is represented by the formula: one half times mass times velocity squared (KE = $\frac{1}{2}mv^2$) ("Kinetic Energy"). Gravitational potential energy (GPE) is energy stored by virtue of an object's position and is represented by the formula: mass times the acceleration of gravity times height (GPE = mgh) ("Potential Energy"). According to the theory for energy conservation, as an object gains kinetic energy it should lose gravitational potential energy and vice versa. Overall, the total amount of energy should remain constant.

This theory was tested by throwing a ball into the air and, using a computer program, comparing the ball's maximum KE and GPE. If energy is conserved, these two values should be similar.

Procedure:

The materials used were a large rubber ball, meter stick, computer with Venier data files, and a motion detector. The motion detector was placed flat on the lab bench facing upwards next to the computer with room for the ball to be held above. The mass of the ball was taken using a scale and was recorded on the data sheet, attached. The ball was then raised 30.0 centimeters into the air and positioned directly over the motion detector. The motion detector was activated to begin data collection and the ball was thrown into the air. The ball was caught before hitting the motion detector and data collection was stopped. This created a computer generated energy vs. time graph of the ball's energy during its motion through the air. This process was repeated until five more graphs were obtained with clear energy data for analysis.

Using the ball's mass, the maximum height the ball reached, and the formula for GPE, GPE = mgh, the ball's maximum GPE was obtained. Using the ball's mass and maximum values for velocity, and the ball's maximum KE was calculated using $\frac{1}{2}mv^2$. The maximum values of KE and GPE were then compared and a percent difference calculated.

Data:

Please see data and graphs on attached pages

Error Analysis:

There were several problems collecting data during this lab. Keeping the ball above the motion detector at all times was difficult. Therefore, more than 6 trials had to be done. Also, pings from the motion detector would occasionally miss the ball, while the ball was in motion, causing spikes in the ball's energy graphs. This resulted in more trials. To improve results, more trials could be taken. If the ball were simply dropped toward the motion detector, it should be easier to keep the ball in line with the motion detector, thereby improving data collection.

Analysis:

Energy vs. time graphs from trials 1 through 6 showed that as KE decreased, GPE increased and as GPE decreased, KE increased which was an expected result. Based on the maximum values of KE and GPE, trials that were thrown to a greater height, higher than 1.0 m, tended to produce more accurate results, percent differences of less than 5% between the maximum KE and maximum GPE. The lower the ball was thrown, less than 1.0 m, yielded less accurate results, percent differences between 6% and 13.5%.

Conclusion:

Based on the results seen on Table 1, the maximum values of KE corresponded to the maximum values of GPE with an average percent difference of 7.4%. This confirms that almost all KE is transferred to GPE and vice versa through the movement of the ball in the air. Any differences in the amounts of energy could be due to air resistance and friction between hands and ball as the ball was released and/or caught. Based on the trend of data described in the analysis section, a follow-up lab could be conducted to see if results continued to improve as the maximum height of the ball increases. In conclusion, these results also support the theory of conservation of energy by showing the transfer of one energy form to another within a closed system.

Works Cited:

Giancoli, Douglas C. *Physics: Principles with Applications*. Upper Saddle River: Prentice Hall, 2002. Print.

"Kinetic Energy." *The Physics Classroom.* 2010. Web. 30 October 2010. <http://www.physicsclassroom.com/class/energy/u5l1c.cfm>.

"Potential Energy." *The Physics Classroom.* 2010. Web. 30 October 2010. <http://www.physicsclassroom.com/class/energy/U5L1b.cfm>.