CONSERVATION OF ENERGY

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OBJECTIVE: To experimentally determine a spring’s constant (k) and to study the conservation of energy in a closed system.

THEORY: The sum of all of the energy in a system remains constant. This law is an extension of the conservation of mass, such that energy cannot be created or destroyed it can only change form. When an object falls, the potential energy (PE) stored in the object is converted into an equal amount of kinetic energy (KE) right before its velocity comes to an abrupt halt as the object contacts a solid surface. With a spring the concept is very similar, because when the spring is compressed potential energy is stored within it and when it is released the spring extends beyond its equilibrium displaying an equal amount of kinetic energy.

PROCEDURE: A spring with an unknown constant was clamped to the top of a stand so that it was positioned perpendicular to the floor. A meter stick was attached to the system so that the stretching of the spring could be measured consistently from the same reference point in the system.

First, the spring’s constant (k) was determined. This was accomplished by establishing an equilibrium point where the spring rests relative to the meter stick with no other forces acting on it except gravity. A 50 gram mass was hung at the end of the spring and the resulting displacement was measured (x) and recorded. The force for the weight was calculated (F), then the springs constant was calculated using the equation:

* k = F/x

This process was repeated using 100 grams, 150 grams, 200 grams, and 250 grams. After all of the constants were calculated an average was obtained and this was recorded as the spring constant to be used in the rest of the experiment. A graph was created of the force versus the displacement of the different trials of the experiment. The slope of the graph exemplified the constant of the spring. The percent difference between the average constant and the calculated slope was determined, and the standard deviation of the average constant (k) was calculated.

An equilibrium position was recorded of the spring without any mass hanging on it. Then a 200 gram mass was placed on the end of the spring and the mass was held 0.04 meters below the equilibrium point, the measured value was recorded as x1. The mass was released and the lowest point in its decent was recorded as x2. This process was repeated three more times adding 0.04 meters to the length of x1 for each trial. For each of the lengths the change in potential energy was calculated in two ways. The first calculation used gravitational potential energy (PEg) and the second utilized the change in the spring’s potential energy using the previously calculated spring constant (PEs). The percent difference between the potential energies was calculated.

In the final stage of the experiment a 200 gram mass was attached to the spring and left to dangle below the original equilibrium position. The mass was then pulled 0.04 meters lower and recorded as x2 then released. The maximum height of the resulting bounce was recorded in reference to the original equilibrium as x1. This process was repeated three more times adding 0.04 meters to the length of x1 for each trial. For each of the lengths the change in potential energy was calculated in two ways. The first calculation used gravitational potential energy (PEg) and the second utilized the change in the spring’s potential energy using the previously calculated spring constant (PEs). The percent difference between the potential energies was calculated.

DATA: Calculating the spring constant.

|  |  |  |  |
| --- | --- | --- | --- |
| Mass (kg) | Distance, x (meters) | Force, F (N) | Constant (k) |
| 0.05 | 0.045 | 0.49 | 10.89 |
| 0.10 | 0.11 | 0.98 | 8.91 |
| 0.15 | 0.17 | 1.47 | 8.65 |
| 0.20 | 0.235 | 1.96 | 8.34 |
| 0.25 | 0.395 | 2.45 | 6.21 |

Sample calculations:

* F = m \* gravity
* k = F/x
* (average) = (t1 + t2 + t3 + t4 + t5)/5
* (standard deviation) = ((1/5)\*((10.89 - 8.91 - 8.65 - 8.34 - 6.21 - 

Conservation of Potential Energy Part 1: Equilibrium Point = 0.28 meters

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| X1 (m) | X2 (m) | PEg (J) | PEs (J) | % Difference |
| 0.04 | 0.43 | 0.7644 | 0.7882 | 3.06 |
| 0.08 | 0.39 | 0.6076 | 0.6265 | 3.06 |
| 0.12 | 0.347 | 0.4449 | 0.4558 | 2.42 |
| 0.16 | 0.305 | 0.2940 | 0.2899 | 1.40 |

Conservation of Potential Energy Part 2:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| X1 (m) | X2 (m) | PEg (J) | PEs (J) | % Difference |
| 0.19 | 0.27 | 0.1568 | 0.1582 | 0.89 |
| 0.15 | 0.31 | 0.3136 | 0.3165 | 0.92 |
| 0.12 | 0.35 | 0.4508 | 0.4648 | 3.05 |
| 0.075 | 0.39 | 0.6174 | 0.6298 | 1.99 |

Sample Calculations:

* PEg = m\*g\*(x2 – x1)
* PEs = (1/2)\*k\*(x22 – x12)
* % Difference = (A - B)/((A + B)/2)\*100

RESULTS: The Average spring constant: 8.6

The standard deviation of the spring constant: = 1.49

The slope of the graph was: 5.8

The % difference: 38.9 %

ERROR ANALYSIS: the sway of the weight as it moves up and down made the process of determining exactly where the highest or lowest point in the bounce was. Also when dropping the weight it might have been at an angle and not directly perpendicular to the floor. Human judgment may have been impaired due to the angle of observation and the measured distance of the falling/rising weight.

CONCLUSION: the mechanical energy of the system was conserved because the calculated PE and the measured PE were so similar. In the system the calculated potential energy and the measured potential energy varied directly with the changing distance from the equilibrium point.