PHYS 101 Lab Project Proposal

Conservation of Energy in the Conversion of Elastic Potential to Kinetic and Kinetic to Gravitational Potential Energies and in Elastic collisions

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Part A Conversion of Elastic Potential Energy to Kinetic Energy:

Objective:

This part of the experiment aims to inspect whether the elastic potential energy of the spring can be fully converted to kinetic energy. Kinetic energies will be determined with different starting elastic potential energies. Finally, the error will be found by comparing the experimental result and theoretical result. Observing that elastic potential energy is conserved as a result of this part will be accomplished.

Theory:

1) $U_{el} = 1/2*k*x^2$ [2]

2) $U_{el} \sim x^2$

3) $K = 1/2*m*v^2$ [2]

4) $1/2*k*x^2 = 1/2*m*v^2$ [2]

(k, x = force constant and the compression amount of spring respectively; v, m = velocity, and mass of the object respectively)

The elastic potential energy stored in a string depends on the force constant and the spring compression (formula 1). The formula shows that the energy stored in the spring is directly proportional to the square of the compression amount of the spring (formula 2). Therefore, by changing the compression amount of the spring, even if the force coefficient is not known, one can infer that the elastic potential energy will change proportionally.

Kinetic energy depends on the mass and speed of the object (formula 3). If the object's mass is known, finding its velocity after the spring was released is sufficient to find its kinetic energy. The velocity can be calculated by periodically measuring the object's positions after being launched on a friction-reduced surface.

The ratio of kinetic and elastic potential energies can be examined by changing the elastic potential energy using different compression amounts of spring. Suppose the ratio is directly proportional with the 4th formula. In that case, the energy is conserved while the elastic potential energy is transformed into kinetic energy.

Setup of Experiment:

Equipment List:

1) Air Table
2) Puck
3) Spark Timer
4) Spring
5) Carbon Paper
6) 30 Cm Ruler
7) Scientific Calculator
8) Balance

Procedure and Data:

1) First, measure the weight of the puck.
2) Then fix the spring on one side of the air table.
3) Compress the spring at certain intervals and mark them on carbon paper by writing the amount of compressions in centimeters.
4) Using all the marked points in order, throw the puck on carbon paper with the power of the spring.
5) Measure the displacements of the puck by using traces marked at certain time intervals on carbon paper and save the values in the row which intersects the column of corresponding compression amount in table 1.1.
6) Plot x vs. t graph at plot 1.1 using table 1.1 and find all average velocities. Record them to table 1.2.

7) Using formulas 2 and 3, find the kinetic energies (using found velocities) and elastic potential energies (using compression lengths) for all compression amounts. Record these data to corresponding columns of table 1.2. (If the elastic potential energy due to compression by 1 cm is called 1E, the energy gaining by 2 cm compression can be called 4E and so on.)

8) Plot K vs. U_{el} graph at plot 1.2 using table 1.2 and draw the best possible line.

9) Determine the best possible line of graph 1.2 indicates formula 4 (Linear equation) and calculate the error percentage of the experimental and theoretical result.

Table 1.1

$\Delta \boldsymbol{x}_d$ = displacement of thrown object by compression d at time interval Δt

Δt = time intervals

d_n = the compression amount of the spring in cm

Δt(ms)	$\Delta \boldsymbol{x}_1(d_1)$ (cm)	$\Delta \boldsymbol{x}_2(d_2)$ (cm)	$\Delta \boldsymbol{x}_3(d_3)$ (cm)	$\Delta \boldsymbol{x}_4(d_4)$ (cm)
0-a				
0-b				
0-c				
0-d				
0-e				
0-f				
0-g				
0-h				
0-i				

Plot 1.1

Table 1.2

U_{el} = elastic potential energy of spring by compression d (Unitless since using formula 2)

K = kinetic energy of the object after release from the spring.

Δd(cm)	v_{av}(cm/ms)	K(N)	U_{el}
d_1			
d_2			
d_3			
d_4			

Plot 1.2

Error Percentage:

Conclusion:

Part B Conversion of Kinetic Energy to Gravitational Potential Energy:

Objective:

The purpose of this part of the experiment is to indicate whether the object's kinetic energy can be fully converted to gravitational potential energy. In part A, the conversion between kinetic and elastic potential energy was examined. Therefore, the conversions between kinetic and gravitational potential energies will be examined using the same elastic potential energies as in part A. In other words, gravitational potential energies will be determined with different starting elastic potential energies and be compared with kinetic energies for the same elastic potential energies from part A. Finally, the error will be found by comparing the experimental result and theoretical result. As a result, observing that the energy is conserved while transforming from kinetic energy to gravitational potential energy will be accomplished.

Theory:

1) $U_{\mathrm{el}} = 1/2{*}k{*}x^2$ [2]

2) $U_{\mathrm{el}} \sim x^2$

3) $K = 1/2{*}m{*}v^2$ [2]

4) $U_{\mathrm{grav}} = m{*}g{*}y$ [2]

4) $1/2{*}k{*}x^2 = m{*}g{*}h$ [2]

5) $1/2{*}k{*}x^2 = 1/2{*}m{*}v^2$ [2]

6) $m{*}g{*}h = 1/2{*}m{*}v^2$

7) $g = 9.8{*}m{*}s^{-2}$ [3]

(k, x = force constant and the compression amount of the spring respectively; g = acceleration due to gravity; v, m, y = velocity, mass, and height of the object, respectively)

Formula 1, 2, 3, and 5 were explained in part A.

Gravitational potential energy depends on the mass, gravitational acceleration, and height of the object (formula 4). Suppose an object's mass is known and assumes that the gravitational acceleration is constant (formula 7). In that case, height is the only unknown to calculate gravitational potential energy. The height can be found by measuring the height of the last position of an object that can reach after it is launched on a friction-reduced surface.

Assuming that formula 4 is correct and formulas 4 and 5 are equalized; theoretically, the kinetic and potential energies must be the same for the same elastic potential energy. After using the identical compression amounts of the string from part A and finding the gravitational potential energies, the ratios between gravitational potential energies and the kinetic energies from part A corresponding to the same elastic potential energies can be examined. If the ratio is directly proportional with the 6th formula, the energy is conserved while the kinetic energy is transformed into gravitational potential energy.

Setup of Experiment:

Equipment List:

1) Air Table
2) Puck
3) Spark Timer
4) Spring
5) Carbon Paper
6) 30 Cm Ruler
7) Scientific Calculator
8) Balance
9) Wooden cube

Procedure and Data:

1) First, measure the weight of the puck.
2) Then fix the spring on one side of the air table.

3) Then compress the spring at certain intervals and mark it on carbon paper by writing the amount of compression in centimeters.
4) Place the wooden cube beneath the middle of the air table to give some inclination to the air table. The cube has a number on it indicating the sine of the angle of inclination.
5) Use the marked points one by one to compress the spring and throw the puck on carbon paper with the power of the spring.

6) Measure the maximum point the puck can reach using traces marked on carbon paper and save the values in the row that intersects the corresponding compression amount column in table 2.1.
7) Using measured maximum points recorded in table 2.1, find each height using sine of the angle and record them in table 2.1.
8) Using formulas 2 and 4, find the potential energies (using found height and g = 9.8 m/s^2) and elastic potential energies (using compression lengths) for all compression amounts. Record these data to corresponding columns of table 2.1. (If the elastic potential energy due to compression by 1 cm is called 1E, the energy gaining by 2 cm compression can be called 4E and so on.)
9) Record the kinetic energies corresponding to the elastic potential energies from part A to corresponding columns of table 2.1.
10) Plot K vs. U_{grav} graph using table 2.1 and draw the best possible line.
11) Determine the best possible plot line 2.1 indicates formula 6. (Linear equation) and calculate the error percentage.

Table 2.1

$\Delta \boldsymbol{x}_d$ = the maximum point of the thrown puck can reach by compression d

h_d = the maximum height of thrown puck can reach by compression d

d_n = the compression amount of the spring in cm

U_{el} = elastic potential energy of spring by compression d (Unitless since using formula 2)

U_{grav} = gravitational potential energy of the object at the maximum height.

K = kinetic energy of the object after release from the spring.

Δd(cm)	$\Delta \boldsymbol{x}_d$(cm)	h_d(cm)	U_{el}	U_{grav}(N)	K(N)
d_1					
d_2					
d_3					
d_4					

Plot 2.1

Error Percentage:

Conclusion:

Part C Conservation of Kinetic Energy in Elastic Collision:

Objective:

This part of the experiment aims to indicate whether the total kinetic energy of collided objects is conserved after elastic collision. Initial kinetic energies will be used from part A. The kinetic energies of objects after the collision will be determined with different starting kinetic energies. Finally, the error will be found by comparing the experimental result and theoretical result. As a result, observing that the total kinetic energy is conserved after the collision will be accomplished.

Theory:

1) $K = 1/2 * m * v^2$ [2]

2) $1/2 * m * v_{\mathrm{A1}}^2 + 1/2 * k * v_{\mathrm{B1}}^2 = 1/2 * m * v_{\mathrm{A2}}^2 + 1/2 * m * v_{\mathrm{B2}}^2$ [1]

(V_d, m = speed, the mass of the object, respectively)

Kinetic Energy was discussed in part A. If the masses of the objects are known, finding their velocities after the collision is sufficient to find their total kinetic energy. The velocities after the collision can be calculated by periodically measuring the positions of objects after they have collided on a friction-reduced surface. Suppose the final and initial total kinetic energies are equal (formula 2). In that case, the kinetic energy is conserved while the elastic collision of two identical objects.

Setup of Experiment:

Equipment List:

1) Air Table
2) Two Identical Puck
3) Spark Timer
4) Two Identical Spring

5) Carbon Paper
6) 30 Cm Ruler
7) Scientific Calculator
8) Balance

Procedure and Data:

1) First, measure the weight of one of the pucks.
2) Then fix two springs on adjacent sides of the air table.
3) Then compress the springs at certain intervals and mark them on carbon paper by writing the amount of compression in centimeters.
4) Use the marked points one by one to compress the spring and throw the puck with the power of the spring on carbon paper.
5) Measure the displacements of two objects after the elastic collision using traces marked at certain time intervals on carbon paper. Then, save the values in the row that intersects the corresponding compression amount column in tables 3.1 and 3.2 (2 tables for 2 objects).
6) Plot x vs. t graphs at plots 3.1 and 3.2 using table 3.1 and 3.2. From that, find all average velocities. Record them in table 3.3.
7) Using formula 1 and found speeds, find the kinetic energies of the objects after the collision for all compression amounts. Record these data as well as initial total kinetic energies to corresponding columns of table 3.3.
8) Divide final kinetic energies by initial kinetic energies and record them at the corresponding column of table 3.3 (formula 2).
9) Find the error percentage of elastic collision by taking the average of the final and initial kinetic energies divisions.

Table 3.1

Δx_d = displacement of thrown object 1 by compression d at time interval Δt, starting from collision.

Δt = time intervals

d_n = the compression amount of the spring in cm

Δt(ms)	$\Delta x_1(d_1)$ (cm)	$\Delta x_2(d_2)$ (cm)	$\Delta x_3(d_3)$ (cm)	$\Delta x_4(d_4)$ (cm)
0-a				
0-b				
0-c				
0-d				
0-e				
0-f				
0-g				
0-h				
0-i				

Plot 3.1

Table 3.2

Δx_d = displacement of thrown object 2 by compression d at time interval Δt , starting from collision.

Δt = time intervals

d_n = the compression amount of the spring in cm

Δt(ms)	$\Delta x_1(d_1)$ (cm)	$\Delta x_2(d_2)$ (cm)	$\Delta x_3(d_3)$ (cm)	$\Delta x_4(d_4)$ (cm)
0-a				
0-b				

0-c				
0-d				
0-e				
0-f				
0-g				
0-h				
0-i				

Plot 3.2

Table 3.3

$K_{initial}$ = total kinetic energy of the objects after release from the spring.

K_{final} = total kinetic energy of the objects after collision.

Δd(cm)	$v_{\mathrm{av},1}$ (cm/ms)	$v_{\mathrm{av},2}$ (cm/ms)	$K_{1,2}$(N)	$K_{2,2}$(N)	$K_{initial}$ (N)	K_{final} (N)	K_{final}/ $K_{initial}$
d_1							
d_2							
d_3							
d_4							

Error Percentage:

Conclusion:

References:

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