Student Work Sample 1

Kinetic Energy Lab [redacted]

Item	Description	Data Set 1	Data Set 2
Appearance	1. Typed, neatly presented	✓	
	2. Appropriate order	✓	
Overall Objective	1. Purpose clearly stated indicating why you are doing the investigation	✓ ✓	
Purpose	1. A statement of which variables you are going to investigate and which variables you are going to hold fixed	✓ ✓	
Diagram	1. Diagram showing how you set up your experiment.	✓	
	2. Labels indicating parts of the apparatus or where you made measurements.	✓	
	3. Energy Flow Diagram including friction compensation..	✓	
Procedure	1. Description of your procedure	✓	
	2. Procedure is a numbered list of instructions	✓	
Data Table	1. Measurements organized into a neat table	✓	
	2. Other information (like fixed values) are also listed	✓	
Evaluation of Data Set – Interpretation of Graphs	1. Clear explanations of each step of the data evaluation	✓	
	2. Table of Calculated Values (could be in your data table)	✓	
	3. Graphs (including any linearized graphs)		
	a. Appropriate format (graph paper or computer print out)	✓	
	b. Labels, units, etc.	✓	
	c. Quality of results	✓	
	4. Interpretation of graphs		
	a. Written interpretation of general trends	✓	
	b. Meaning of intercept	✓	
	d. Equation	✓	
Combined Analysis	1. Clear explanations of proportionality argument	✓	
	2. Combined proportionality	✓	
	3. Calculation of proportionality constant		
	a. Slope and fixed measurements	✓	
	b. "k" value	✓	
	c. average "k"	✓	
	4. Error Analysis		
	a. % error from expected constant	✓	
	b. Explanation of possible sources of error	✓	
	5. Final Equation	✓	
Conclusion	1. Restatement of and answer to purpose	✓	
	2. Written description (English sentences) of general relationship	✓	
	3. Restatement of final equation	✓	
	4. Meaning of final equations (general trends relating all 3 variables)	-2	
Post Lab	1. Notes on Post Lab	✓	
	2. Relation to other energy quantities.	✓	
	3. Domain of Model	✓	

Maximum Score = 25

Group Score = 21

Lab reports should be written in an impersonal, objective style. All personal pronouns (I, you, we) should be omitted.

[redacted]

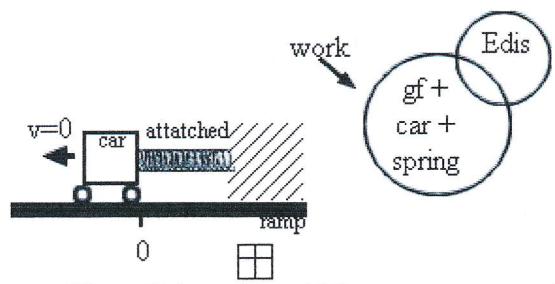
Period 2

Kinetic Energy Lab

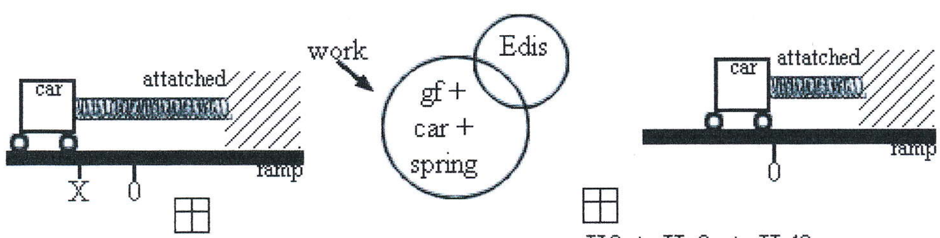
Overall Objective: Develop a quantitative model for kinetic energy

Specific purpose: To determine the relationship between:

- Velocity and kinetic energy by keeping mass constant
- Velocity and mass by keeping kinetic energy constant

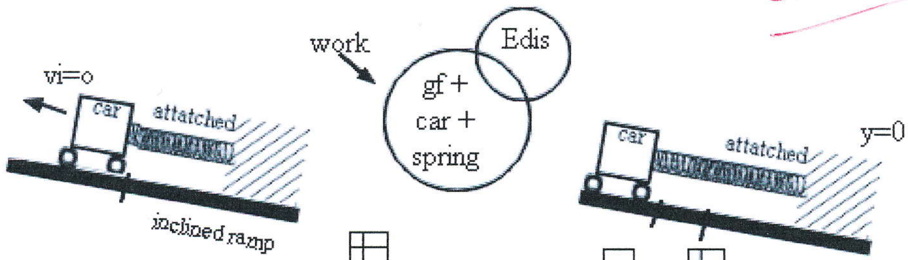


$$K_i + U_{gi} + W + E_{dis} = K_f + U_{gf} + U_{elf}$$

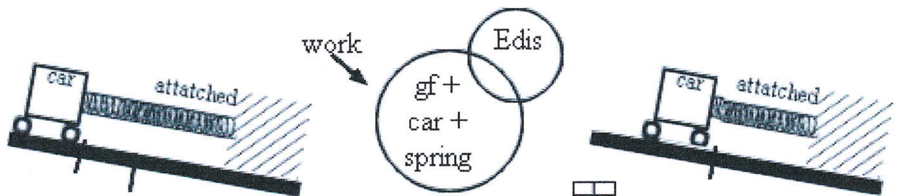


$$K_i + U_{gi} + U_{eli} + W + E_{dis} = K_f + U_{gf} + U_{elf}$$

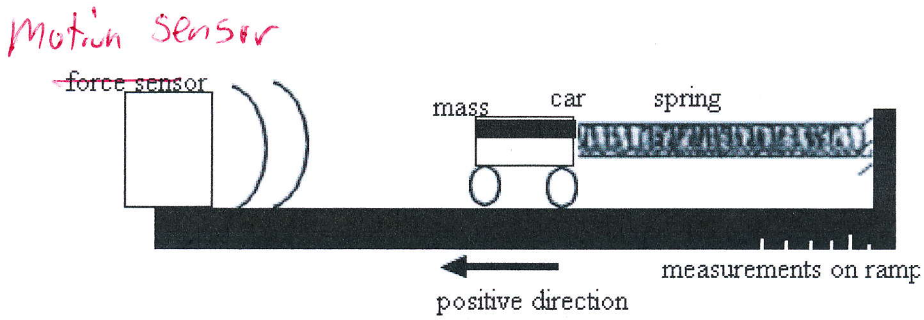
excellent!



$$K_i + U_{gi} + U_{eli} + W + E_{dis} = U_{gf} + U_{elf}$$



$$K_i + U_{gi} + U_{eli} + W + E_{dis} = K_f + U_{gf} + U_{elf}$$



Compensation of friction:

1) Roll the car down the incline, very small acceleration desired, >0.01 m/s/s good
2) If not change the incline to reduce the acceleration,
3) Repeat until $\boxed{a \approx 0\ m/s^2}$

Procedure:

1) Attach a spring onto the cart connecting it to the incline
2) Stretch the spring, still attached to the cart, to a desired length
3) Let go of the cart
4) Find velocity at what point? maximum velocity
5) Repeat for a total of 6 different stretches

Procedure #2:

1) Attach a spring onto the cart connecting it to the incline
2) Stretch the spring to a desired length that will remain constant for all trials.
3) Let go of the cart
4) Find velocity
5) Add mass
6) Repeat for a total of 6 different masses

To find the transfer of elastic to kinetic, the equation w= 1/2kx^2+Fox was used.

Work to stretch the spring = elastic energy stored in spring.

K being the constant of the spring used, x being the stretch, and Fo being the minimum amount of force needed to stretch the spring.

$w = U_{el}$

Mass (kg)	Stretch (m)	Velocity (m/s)	Uel to K (J)
0.5	0.15	0.4441	0.054
0.5	0.2	0.5469	0.088
0.5	0.25	0.6988	0.131
0.5	0.3	0.7975	0.181
0.5	0.35	0.9316	0.240
0.5	0.4	1.048	0.301

Mass (kg)	Stretch (m)	Velocity (m/s)	Uel to K (j)
0.5	0.4	1.048	0.307
0.75	0.4	0.8622	0.307
1.0	0.4	0.7826	0.307
1.25	0.4	0.6871	0.307
1.5	0.4	0.5304	0.307
1.75	0.4	0.4560	0.307

Manipulated data to linearize v vs. K

Velocity^2 (m^2/s^2)	Kinetic (J)
0.197	0.054
0.299	0.088
0.477	0.131
0.636	0.181
0.868	0.240
1.098	0.301

Manipulated data to linearize v vs. m

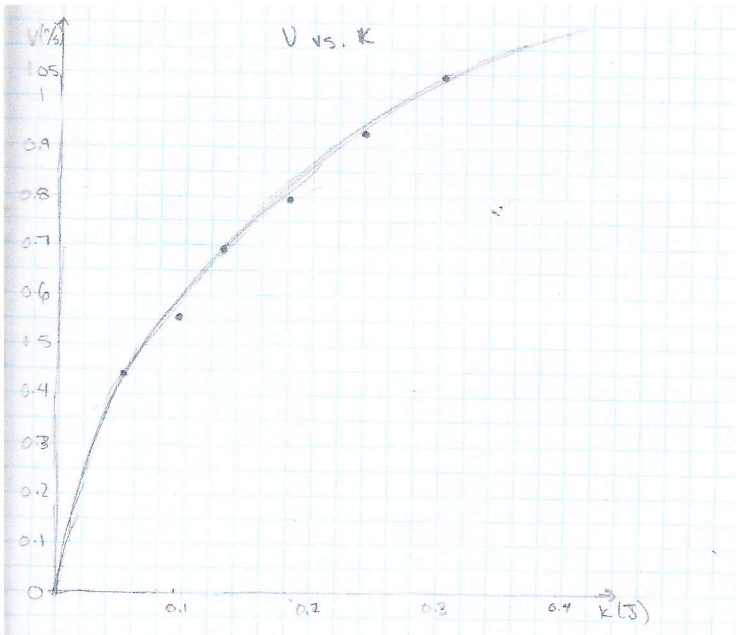
Velocity (m/s)	1/Mass (1/kg)
1.048	2.00
0.8622	1.33
0.7826	1.00
0.6871	0.800
0.5304	0.667
0.4560	0.571

Manipulated data to linearize v vs. 1/m

Velocity^2 (m^2/s^2)	1/Mass (1/kg)
1.098	2.00
0.7433	1.33
0.6177	1.00
0.4721	0.800
0.2813	0.667
0.2079	0.571

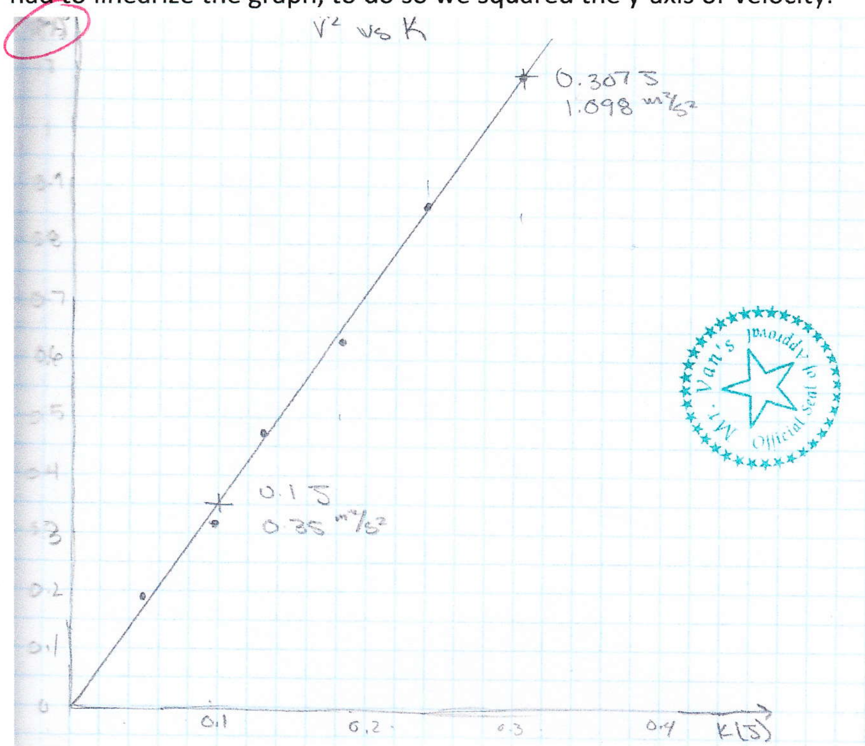
define your variables
(v) (K)

Data Analysis 1: To find the relationship between velocity and kinetic energy with a constant mass we first had to graph our data.



We noticed that our points seemed to fall on a curve so we drew a best fit curve to our data. We then had to linearize the graph, to do so we squared the y-axis or velocity.

$(\frac{m}{s})^2 \Rightarrow$



Now, our data seemed to fall on a line, so we drew a best fit line to fit our data. Since it fit so well, we know that velocity squared is linearly proportional to kinetic energy. We then had to write an equation to represent this relationship. It will look like this: $v^2 = (slope) \cdot K + (intercept)$

To find the values for the slope and intercept we took two points off of our graph:

(velocity^2 = 0.35 m^2/s^2, kinetic energy = 0.1 J), (velocity^2 = 1.098 m^2/s^2, kinetic energy = 0.307 J)

$$Slope = \frac{\Delta v^2}{\Delta K} = \frac{1.098\ \mathrm{m^2/s^2} - 0.35\ \mathrm{m^2/s^2}}{0.307\ \mathrm{J} - 0.1\ \mathrm{J}}$$

$$Slope = \frac{0.748\ \mathrm{m^2/s^2}}{0.207\ J}$$

$$Slope = \frac{3.614\ \mathrm{m^2/s^2}}{1\ \mathrm{J}}$$

This slope means that for every Jewel of kinetic energy the object uses its velocity will approach infinity at $3.614\ \mathrm{m^2/s^2}$. We then had to calculate the intercept of our line. To do so we used our initial equation and solved for the intercept, then plugged in one of the points.

$$v^2 = (slope) \cdot K + (intercept)$$

$$v^2 - (slope) \cdot K = (intercept)$$

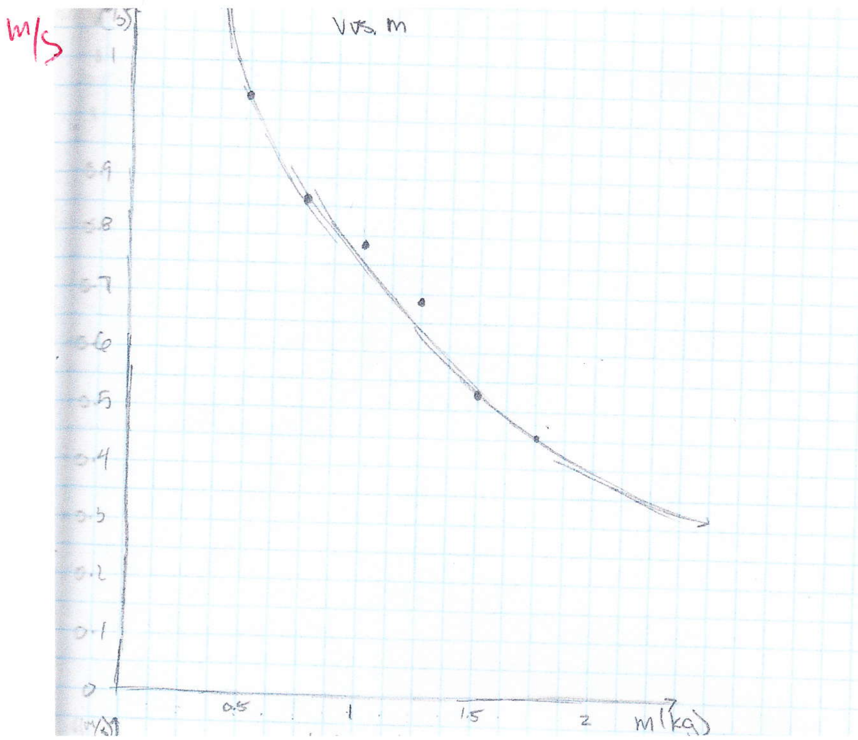
$$(1.098\ \mathrm{m^2/s^2}) - \left(\frac{3.614\ \mathrm{m^2/s^2}}{1\ \mathrm{J}}\right) \cdot (0.307\ \mathrm{J}) = -0.011\ \mathrm{m^2/s^2}$$

this is very close to zero

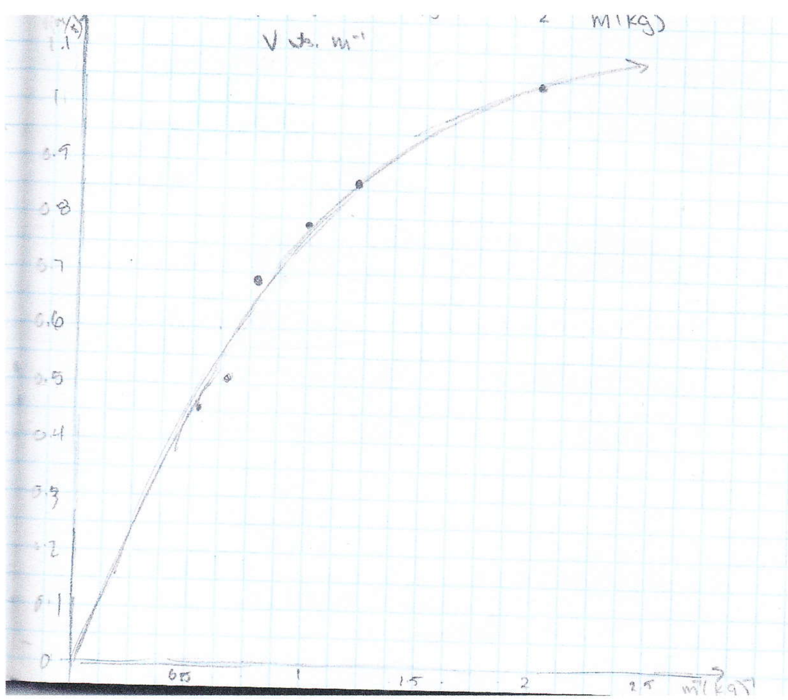
This intercept means that when the object wasn't moving and didn't have kinetic energy it still had a velocity with a value higher than zero. Since you need kinetic energy to move and there should be none, we know that there was some error in our measurements and can reason setting the intercept to zero. Our final equation is:

$$v^2 = \left(\frac{3.614\frac{\mathrm{m^2}}{\mathrm{s^2}}}{1\ \mathrm{J}}\right) \cdot K + (0\ \mathrm{m^2/s^2})$$

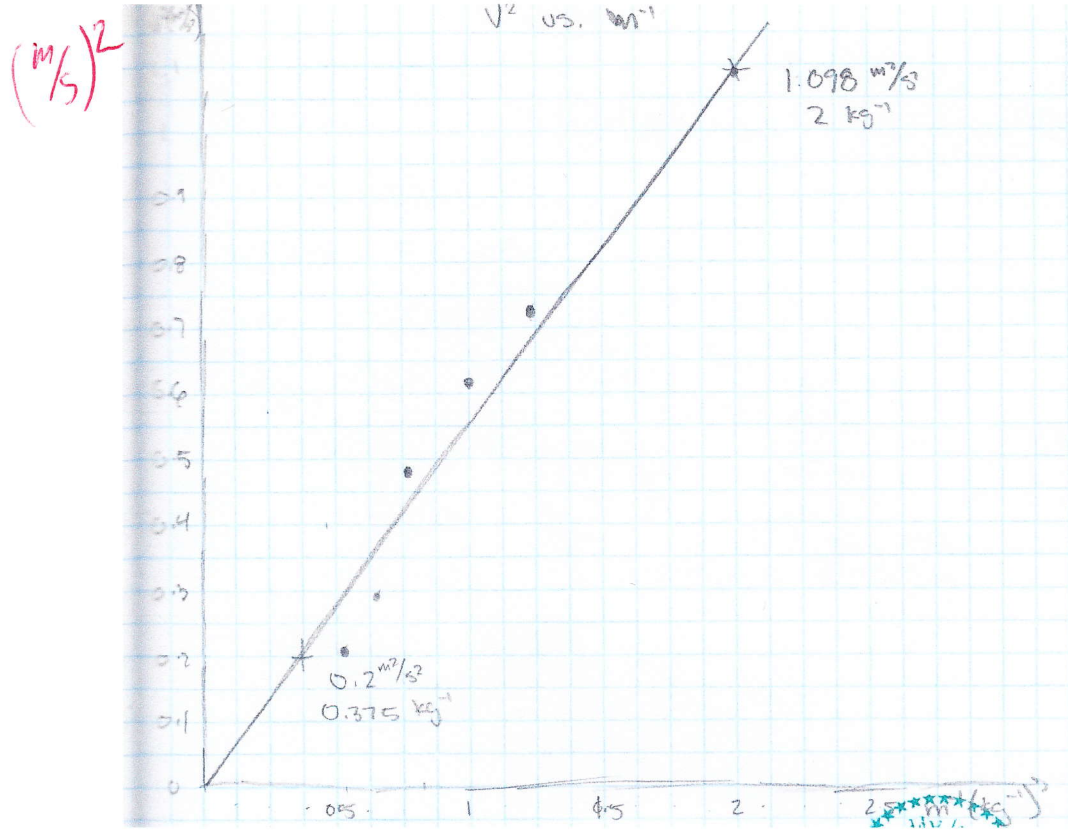
Data Analysis 2: We then had to find the relationship between velocity and mass with constant kinetic energy. To do so we first graphed our data.



We found that our points fell on curve so we drew a best fit curve to match our data. We then tried to linearize the curve by finding the inverse of the x-axis, mass.



Again we found that our points fell on a curve, so we drew another best fit curve to our data. This time when linearizing our data we had to square the y-axis, velocity



Our data seemed to fall in a line so we drew a best fit line to match the graph. The next step was to find an equation to represent this relationship. We know it will look something like this:

$$v^2 = (slope) \cdot 1/m + (intercept)$$

We then had to calculate the values for both the slope and the intercept. To do so we took two points off our linearized graph.

(velocity^2 = 0.2 m^2/s^2, 1/mass =0.375 1/kg), (velocity^2 = 1.098 m^2/s^2, 1/mass = 2 1/kg)

$$Slope = \frac{\Delta v^2}{\Delta 1/m} = \frac{1.098\ \mathrm{m}^2/\mathrm{s}^2 - 0.2\ \mathrm{m}^2/\mathrm{s}^2}{2\ 1/\mathrm{kg} - 0.375\ 1/\mathrm{kg}}$$

$$Slope = \frac{0.898\ \mathrm{m}^2/\mathrm{s}^2}{1.625\ 1/kg}$$

$$Slope = \frac{0.553\ \mathrm{m}^2/\mathrm{s}^2}{1\ 1/\mathrm{kg}}$$

This slope means that as mass approaches zero, velocity will approach infinity. if the kinetic energy remains constant.

The next thing we did was find the value of the intercept. We used t=our initial equation and solved for the intercept by inputting one of our points of the graph.

$$v^2 = (slope) \cdot 1/m + (intercept)$$

$$v^2 - (slope) \cdot 1/m = (intercept)$$

$$(1.098\ \mathrm{m^2/s^2}) - \left(\frac{0.553\ \mathrm{m^2/s^2}}{1\ 1/\mathrm{kg}}\right) \cdot (2\ 1/\mathrm{kg}) = -0.008\mathrm{m^2/s^2}$$

this is very close to zero

This intercept can be interpreted as meaning that when there is no mass or no object it still has velocity. This obviously isn't possible, so it's safe to say that there was some error in our measurements or procedure. Since this is true we can set our intercept to zero, making this our final equation:

Significant figures

$$v^2 = \left(\frac{0.553\,\frac{\mathrm{m^2}}{\mathrm{s^2}}}{1\,\frac{1}{\mathrm{kg}}}\right) \cdot 1/m + (0\ \mathrm{m^2/s^2})$$

good

Combined Analysis: Now that we have the equations for both relationships, we can combine them into one equation. We know that velocity squared is linearly proportional to kinetic energy and the inverse of mass.

Since we know this we also know that the equation to represent this will look like this:

$$v^2 = k * K * 1/m$$

To find the value for "k" we refer back to the equations we find originally.

$$v^2 = \left(\frac{3.614 \frac{\mathrm{m}^2}{\mathrm{s}^2}}{1\ \mathrm{J}} \right) \cdot K$$

By pure observation we know that "k" multiplied by the inverse of mass will be equal to the above equations slope. We also know that the value inputted as the inverse of mass will be the constant we held of mass during our data collection; 2(1/kg.) $\frac{1}{0.5\ \mathrm{kg}} \leftarrow m = 0.5\ \mathrm{kg}$

$$k * 1/m = \left(\frac{3.614 \frac{\mathrm{m}^2}{\mathrm{s}^2}}{1\ \mathrm{J}} \right)$$

$$k * 2\ 1/kg = \left(\frac{3.614 \frac{\mathrm{m}^2}{\mathrm{s}^2}}{1\ \mathrm{J}} \right)$$

$$k = 1.807$$

We did the same for our other equation.

$$v^2 = \left(\frac{0.553 \frac{\mathrm{m}^2}{\mathrm{s}^2}}{1\ 1/\mathrm{kg}} \right) \cdot 1/m$$

This time we know that the "k" value multiplied by kinetic energy will be equal to the slope of the velocity squared vs. the inverse of mass graph. We know that the value of kinetic energy will be the constant we held during our data collection; 0.307 J.

$$k * K = \left(\frac{0.553 \frac{\mathrm{m}^2}{\mathrm{s}^2}}{1\ 1/\mathrm{kg}} \right)$$

$$k * 0.307\, J = \left(\frac{0.553\, \frac{\mathrm{m}^2}{\mathrm{s}^2}}{1\ 1/\mathrm{kg}} \right)$$

$$k = 1.801$$

We then found the average "k" value which was 1.804.

Our final equation looks like this: $v^2 = (1.804) * K * \frac{1}{m}$ or

$$K = \frac{v^2 * m}{1.804}$$

We know that the actual "k" value should have been 2. Since we know this we can find our percentage of error which was 9.8%. This percentage of error could have been due to some random mistake during our data collection like measuring a length wrong or it could be that we over compensated for friction when adjusting the ramp.

this would give a constant that is too large, not too small

The final equation is supposed to be $v^2 = 2 * K * \frac{1}{m}$ or $K = \frac{1}{2} * v^2 * m$

Conclusion:

In our lab, our overall objective was to develop a quantitative model for kinetic energy and our two specific purposes were:

1. Determine the relationship between Velocity and Kinetic Energy (keeping Mass constant.)
2. Determine the relationship between Velocity and Mass (keeping Kinetic Energy constant.)

While collecting our data for S.P. (1) and graphing it, we came up with a curved line. To create a linear graph we squared velocity. We then got our linear graph and found that as the kinetic energy increased, velocity increased exponentially as well. When we were graphing S.P. (2) data, we had another curved graph. This time we made mass into 1 over mass ~~like the~~ (inverse). And as we graphed this one we came across another curve so we squared velocity. So, as the mass approaches zero, velocity approaches infinity.

(1) An equation relating V and K is:

V^2=3.636m^2/s^2/J(K)-0.018m^2/s^2

(2)An equation relating V and m is:

V^2=.525m^2/s^2/J(K0-0.048m^2/s^2

units.

The meaning of the (1) equation is that for every J of Kinetic Energy stored in the spring, when the spring is let go, it will have 3.636m^2/s^2. The intercept means that when there is no force in the spring, there is a velocity of -.018 -0.018 m/s in the spring. The meaning of the (2) equation is that for every kg of mass, there is a velocity of .525 0.525 m/s applied to the spring. The intercept means that when the mass is 0 kg there was 0.048 m/s of velocity. The three variables are all related to one another because each affects the other. The more mass an object has, the less velocity ~~and then there is less kinetic energy.~~

This is incorrect. if kinetic energy is fixed and can not change.

Kinetic energy = $\frac{1}{2} m v^2$

Kinetic energy is dependent on mass and velocity. Velocity and mass are independent of each other because kinetic energy is not fixed for objects like it was in procedure #2 of this lab.

POST LAB:

Domain of Model:

1. Particles.
2. speed <<c=speed of light= 3 x 10 ^8 m/s.
3. constant velocity reference frame.

After finding the value of k and doing the combined analysis, we found an equation the would best fit our progress. The equation for K is:

$K=1/2mv^2$

$U_{el} + U_g + U_{chem} + K_{tran} + K_{rot} + K_{tran} + W + E_{dis}$

$=$

$U_{el} = \frac{1}{2} k x^2$

$U_g = mgh$

$W = \vec{F}\vec{d} = Fd(\cos\theta) = \int F\,dx$

P: momentum is vector   kinetic energy is scalar

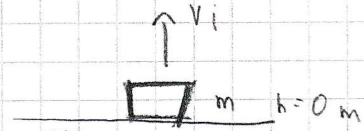
$\vec{P} = m\vec{v}$ $K = \frac{1}{2} m v^2$

Relation to other energy quantities.

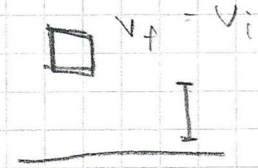
POST Lab.

$v^2 = \frac{2k}{m}$

$\boxed{K = \frac{1}{2} m v^2}$



m + gf



$K_i + \cancel{U_g} + W + \cancel{E_{dis}} = K_f + U_g$

F

$\Sigma F = 0$

$w = mg$

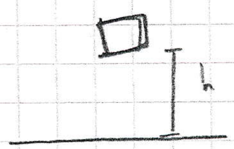
$f = w = 0$

$f = w$

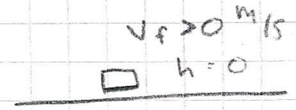
$F = mg$

$$\boxed{\begin{array}{c} W = U_g \\ F \Delta x = U_g \\ \hline mgh = U_g \end{array}}$$

$v_i = 0 m/s$



object + g.f



$U_{gi} = K_f$

$v_f^2 = \cancel{v_i^2} + 2ad$

$mgh = K_f$

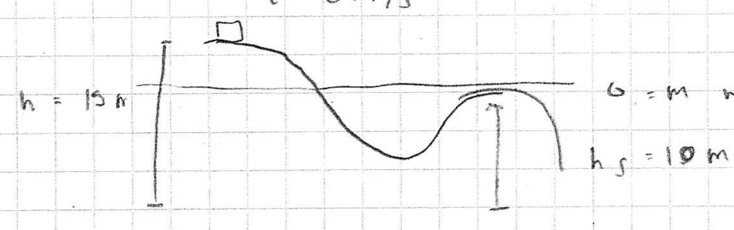
$v^2 = 2(g)h$

$h = \frac{v_f^2}{2g}$

$m \cancel{g} \frac{v_f^2}{2 \cancel{g}} = K_f$

$\frac{1}{2} m v^2 = K_f$

$v_i = 0 m/s$

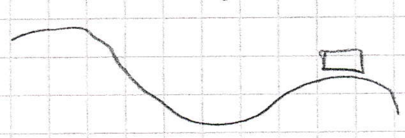


W_i

car + U_g

Edis

$\cancel{K_i} + U_g + \cancel{U_{el i}} + \cancel{W} + \cancel{E_{dis}} = K_f + U_g$



$mgh = K_f$

$\cancel{m} g h = \frac{1}{2} \cancel{m} v^2$

$\sqrt{2gh} = v_f$

$U_{g i} = U_{g f}$