Introduction to Physics 105

Name _____Conf_____

Partner's Name _____

Equipment

~250 g cart +~250 g mass, track, photogate, card, meter stick, lab jack.

Purpose: Investigate energy relationships through experiments and graphing.

Data: Show your work in the Data and Calculations space. Attach additional work and graphs to lab. Include all steps, labels and remember your units.

Definitions

Work=Force x (distance moved parallel to F) W=F x D‖	**W work (in Joules, J)** **F Force in N** **D‖ distance moved parallel to F (meters, m)**
Gravitational Potential Energy = mgh	**m** mass (kg) **g** acceleration due to gravity (m/s/s) **h** height above reference level (m)
Kinetic Energy = $\frac{1}{2}mv^2$	**m** mass (kg) **v** speed (m/s)
Total Mechanical Energy, E E = PE + KE	**PE = Potential Energy (J)** **KE = Kinetic Energy (J)**

Part 1 Potential and Kinetic Energy

Purpose

In this experiment you will compare the gravitational potential energy stored in the cart to the kinetic energy that the cart receives by changing heights.

Procedure

1. Set up the equipment as shown in Figure 2, on an inclined track. Measure the height of the cart above the table at positions 1, 2, 3, and 4. Be consistent by always measuring the vertical distance from the table to the same point on the cart for each position. Also, when the cart is in position 2 for the height measurement the photogate must be placed at the center of the card to ensure that the speed estimated by the photogate will be close to the speed the cart had at position 2. Use a piece of tape or erasable marker to keep track of each position

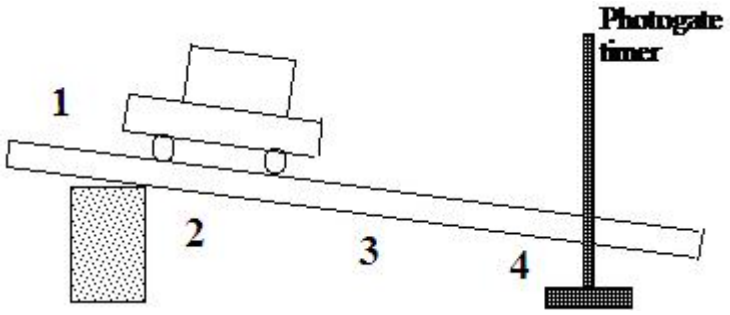


Figure 2

Measure the mass of the cart and compute the potential energy (PE) of the cart at each position. Use a red or blue plastic cart with a 250 g mass inside for all experiments/measurements here. This will give you a total cart mass of about 500 g or 0.50 kg. For calculations in this lab always use units of kg, meters, and m/s, and use g=10 m/s^2.

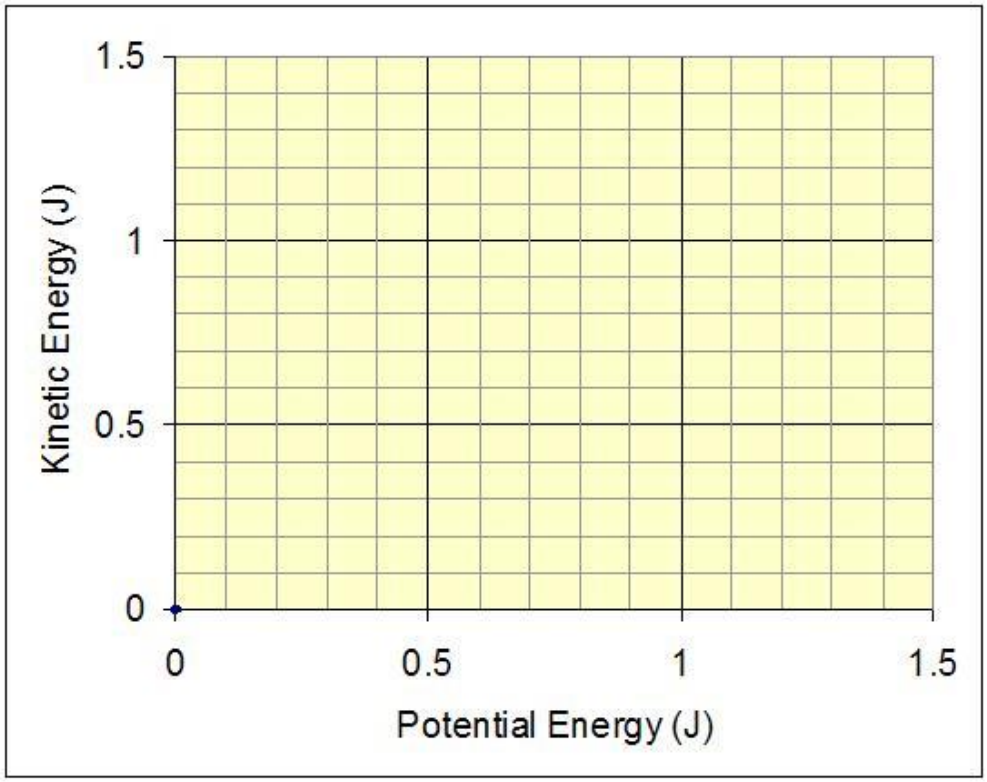
2. Clearly label data and show calculations here. Note a height of 20.0 cm= 0.20 m.

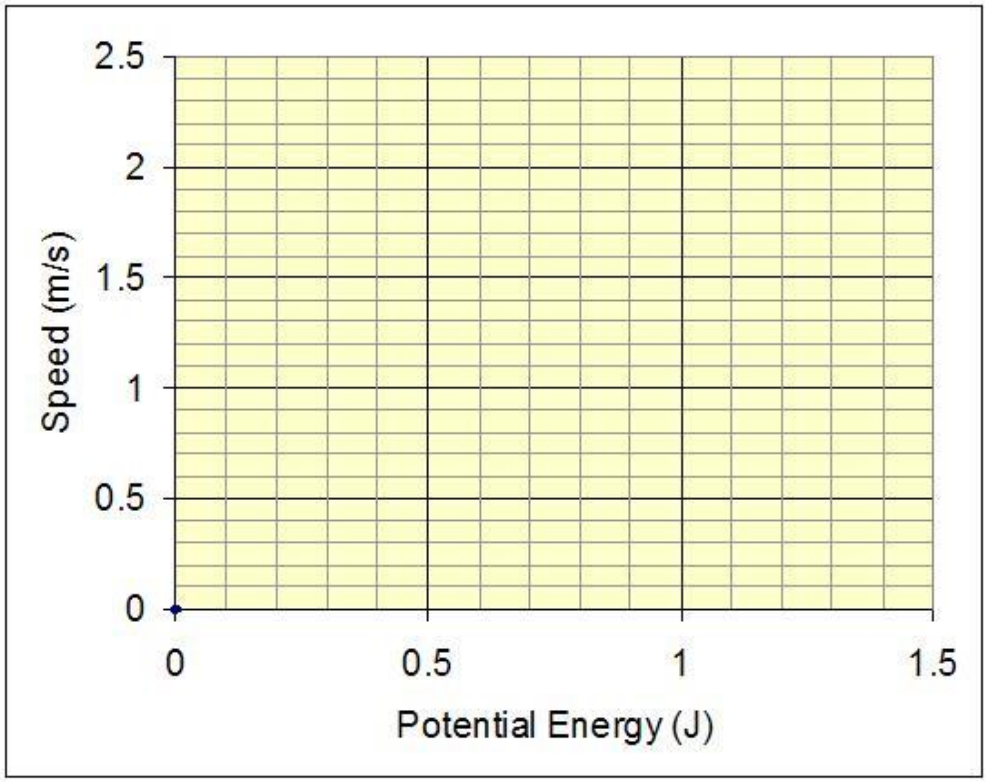
	Position 1	Position 2	Position 3	Position 4
h (m)				
PE=M g h (J)				

3. Place the cart at position 1 and release it <u>from rest</u>. Use the photogate timer to time the cart as it passes through the photogate at each position. Repeat the time measurement 3 times for each position and then average these times to calculate the velocity, v, of the cart at positions 2, 3, and 4. Remember : v = x / t, where x = length of the card and t = time from the photogate. Record the mass of the cart and then calculate the kinetic energy for the cart in positions 2, 3, and 4 (KE=0 for position 1 since v=0).

	Position 1	Position 2	Position 3	Position 4
Card length, x (meters)				
Times , t(sec)	*********			
AvgTime, t(sec)	*********			
Speed,v=x/t (m/s)	0.0			
Mass (kg)		➔ → →	→	→
KE=$= \frac{1}{2} mv^2$ (J)	0.0			

On the axes provided carefully graph kinetic energy KE verses potential energy PE. And on the second set of axes graph speed verses PE.


Kinetic Energy (J)
1.5
1
0.5
0
0
0.5
1
1.5
Potential Energy (J)


Speed (m/s)
2.5
2
1.5
1
0.5
0
0
0.5
1
1.5
Potential Energy (J)

Questions:

1. When the potential energy is large, the kinetic energy is
a. also large b. small c. about the same

2. the relationship between kinetic and potential energy is
a. a straight line sloping down b. a curve that is concaved upward c. a curve that is concaved downward. d. a horizontal straight line e. a straight line sloping upward

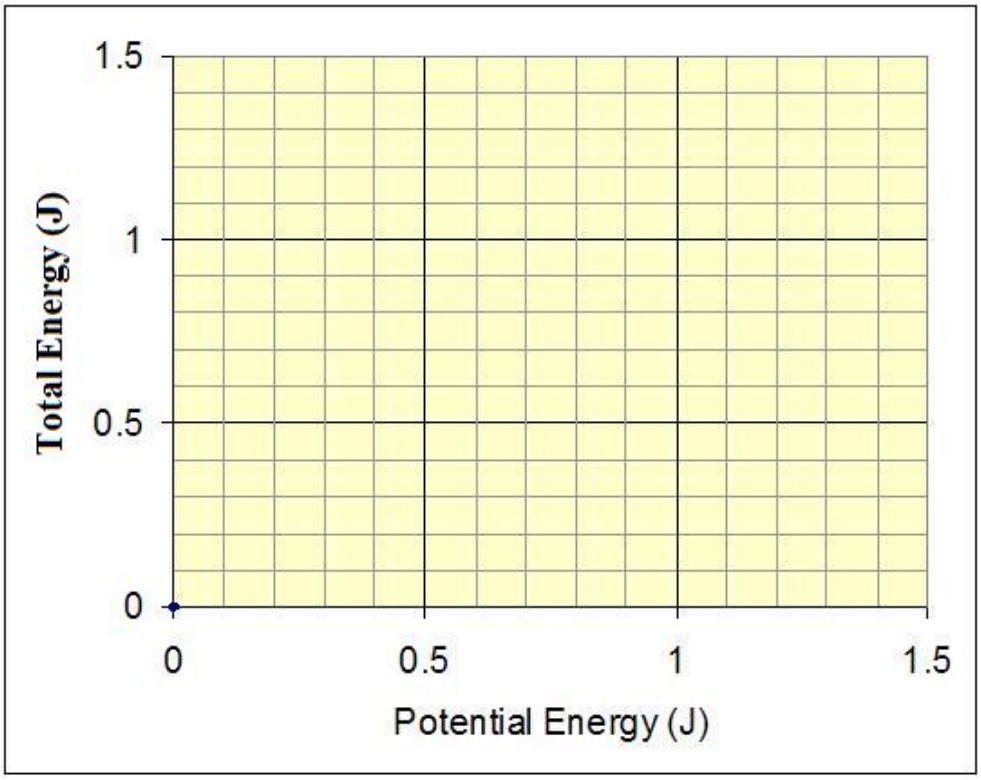
3. When the potential energy is large, the speed is
a. also large b. small c. about the same

4. the relationship between potential and speed is
a. a straight line sloping down b. a curve that is concaved upward c. a curve that is concaved downward. d. a horizontal straight line e. a straight line sloping upward

Calculate the TOTAL mechanical energy, E = KE + PE of the cart at positions 1 through 4, and record in the table below.

	Position 1	Position 2	Position 3	Position 4
PE=M g h (J)				
KE=$= \frac{1}{2} mv^2$ (J)				
Total = KE+PE				

On the axes provided carefully graph the total energy verses potential energy PE



Questions:

5. When the potential energy is large the total energy is
a. also large b. small c. about the same

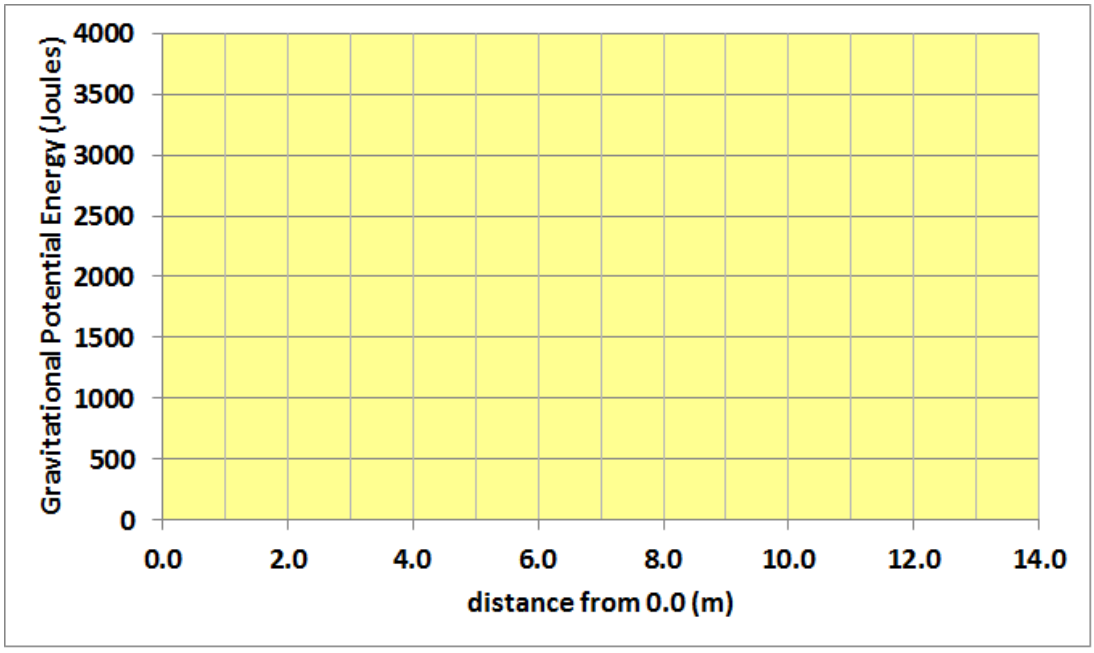
6. the relationship between potential and total energy is
a. a straight line sloping down b. a curve that is concaved upward c. a curve that is concaved downward. d. a horizontal straight line e. a straight line sloping upward

7. Is total mechanical energy conserved? That is does the total energy stay about the same? Explain.

Watch the youtube video experiment at
http://www.youtube.com/watch?v=nHEkn7fq8jw.
The skater is released from a height of 1.0, 2.0, 3.0, 4.0, 5.0, and 6.0 meters above the ground. Estimate the horizontal distance, from 0.0, that the skater glides before stopping (his wheel bearings have frozen up). Record these distances in the table below. Calculate the potential energy of the 60.0 kg skater for each height.

Mass (kg)	height (m)	horizontal distance (m)	GPE (J)
60	1		
	2		
	3		
	4		
	5		
	6		
USE g=10 m/s/s			GPE=Mgh

Plot the gravitation al potential energy on the vertical axis and the glide distance on the horizontal axis below.



Let's use the idea of conservation of energy to estimate the friction force acting on the skater.

If the work done by friction to stop the skater equal the decrease in gravitational potential energy then

$$-Fd = -GPE$$

or

$$GPE = Fd$$

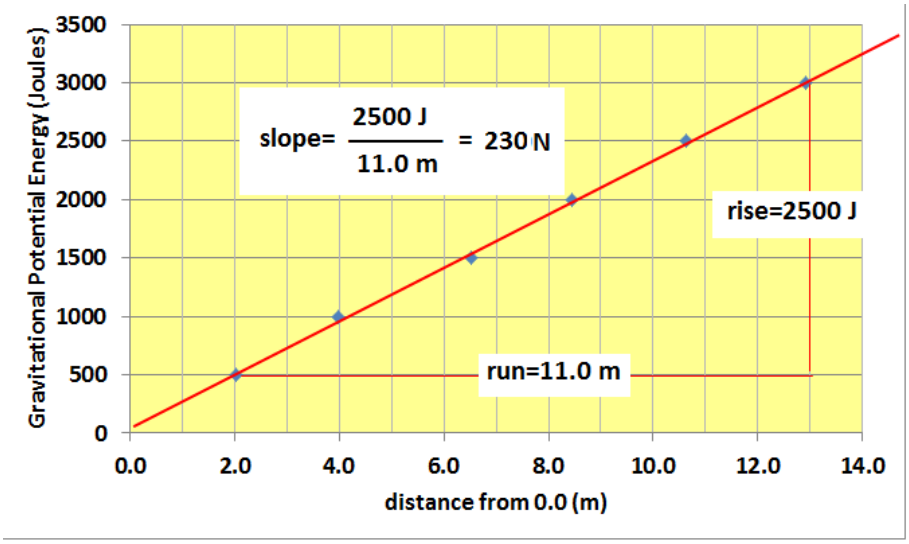
In the top equation the minus sign on the left side is there because the friction force acts opposite to the glide direction and the minus sign on the right means that the potential energy decreased to zero.

We've multiplied both sides of the top equation by -1 and also switched right side with left. The reason we did this is so the bottom equation looks like Y=mX which is stand equation of a straight line from math class. In our case GPE corresponds to y and d corresponds to x and F corresponds to m or the slope of the line.

Does your data suggest a linear relationship between GPE and d? _____

To estimate the friction force, find the slope of the line in your graph above. As a reminder of how to calculate slope (rise /run), an example slope calculation is shown below.

Slope=Friction Force , F=_____



Some additional questions to test your understanding.

1. How much work is done by a 40 N force pushing a cart over a distance of 20.0 m? Assume that the force is always parallel to the surface.

2. Assume that the cart in 1. above has no friction acting on it and it is pushed along the horizontal surface. How much kinetic energy does the cart have after being push the 20.0 m?

3. Assume that the cart in 1. above has no friction acting on it and it is pushed up an inclined surface so that it gains 300 J of gravitational potential energy after being pushed the 20.0 m. How much kinetic energy does the cart have after being push the 20.0 m?

4. Assume that the cart in 1. above has a friction force of 30 N acting on it as it is pushed along the horizontal surface. How much kinetic energy does the cart have after being push the 20.0 m?