Gravitational Potential Energy

Introduction

The motion of a mass due to the gravitational force near the surface of the earth can be described using the constant acceleration equations that result from Newton's Laws. However, because the gravitational force is conservative, we can define the gravitational potential energy. Using the gravitational potential energy and the kinetic energy, we can define the total mechanical energy. The total mechanical energy is a conserved quantity--it remains constant throughout the motion. We can use this to solve for the motion of a mass under the influence of gravity. In this experiment we will compare predictions of v using energy to measured values.

The gravitational potential energy is defined as:

$$U = mgy$$

where m is the mass, g is the gravitational acceleration, and y is the height above zero. The Kinetic Energy is:

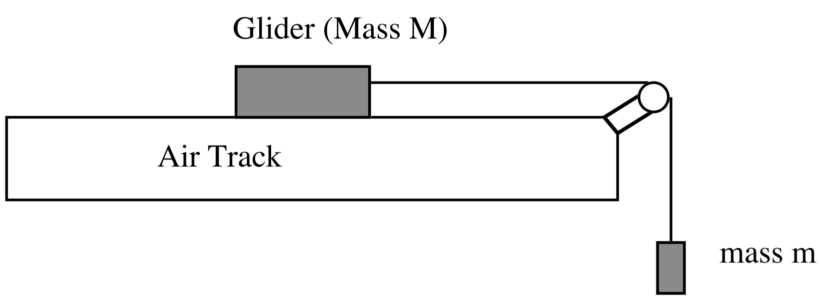
$$K = \frac{1}{2}mv^2$$

We can define the total mechanical energy as

$$E = K + U$$

This energy remains constant throughout the motion.

In this experiment, we will calculate velocity of masses that are being accelerated by falling masses and compare them to measured values. The set up looks like:



Note that m is the mass hanging and M is the total mass of the glider and any masses placed on it.

Prediction of velocity

We will allow the mass m to drop from rest through a fixed distance h. In this case, the initial total energy is

$$E_i = 0 + mgh$$

After the mass falls through the distance h to the ground, the total energy is

$$E_f = \frac{1}{2}(M+m)v^2 + 0$$

Since energy is conserved, we can write

$$E_f = E_i$$

and solve for the velocity

$$v_{pre}{}^2 = \frac{2mgh}{M+m} \qquad (1)$$

Here m is the mass that is hanging from string and M+ m is the total mass of the system.
We will *measure* the velocity by measuring the time that it takes to accelerate through a distance h.

$$x_f = x_i + v_{ix}t + \frac{1}{2}a_x t^2$$

here $h = x_f - x_i$ and $v_{ix} = 0$. We can solve for the acceleration.

$$h = \frac{1}{2}a_x t^2$$

$$a_x = \frac{2h}{t^2}$$

With this acceleration, we can find the final velocity using

$$v_{fx}{}^2 = v_{ix}{}^2 + 2a_x(x_f - x_i)$$

$$v_{fx}{}^2 = \frac{4h^2}{t^2} \qquad (2)$$

We can compare the *predicted* v^2 from equation (1) to the *measured* v^2 from equation (2).

Procedure

Level the air track and make sure that the glider slides smoothly. Check to see that the pulley turns freely.

1. Cut a piece of string that is approximately 1.5 meters long. Attach one end to the glider and tie a weight hanger (2g) to the other end.
2. Hang the string with the hanger over the pulley and set the glider so that the hanger will fall exactly 70 cm until it strikes the ground
3. Place masses on a glider and hanger as indicated in the table below.
4. Set the photogates so that the timer starts immediately when the glider is released and stops immediately when the glider travels exactly 70cm. This is called "Pulse" mode.
5. Release the glider and record the time. You will have timed the acceleration over a distance of 70 cm.
6. Repeat this measurement four additional times and find the average time for the acceleration. Use the average time to determine the v^2 using equation 2.
7. Move the masses from the glider to the hanging position as indicated. Repeat procedure steps 4 and 5.
8. Continue to repeat step 6, moving masses from glider to the hanging position until all of the runs in the table are complete.. Measure the mass m_G of the glider. M is the mass of the glider plus the mass placed on the glider.
9. Plot the measured v^2 vs the mass hanging and determine the slope
10. Compute the predicted v^2 for each hanging mass case using equation 1.
11. Plot the predicted v^2 vs the mass hanging on the same plot as your earlier step

Identification of Pieces:

	A	B
1	Airtrack Piece	Mass(g)
2	Hanger	2
3	Large Metal	10
4	Small Metal	5
5	Large Plastic	2
6	Small Plastic	1

Run Table

	A	B	C
1	Total Hanging Mass	Hanging Pieces	Glider Masses
2			
3	4g	Hanger+Large Plastic	16g
4			
5	7g	Hanger+Small Metal	13g
6			
7	10g	Hanger+Large Plastic+Small Plastic+Small Metal	10g
8			
9	13g	Hanger+Large Metal+Small Plastic	7g
10			
11	15g	Hanger+Large Metal+Large Plastic+Small Plastic	5g
12			
13	18g	Hanger+Large Metal+Small Metal+Small Plastic	2g
14			
15	20g	Hanger+All Masses	0g

Questions.

1. What are the principle sources of error in this experiment?
2. What is the physical significance of the slope of your plot?
3. How does this experiment test the use of conservation of energy to predict velocity?
4. What approximations have we made in this experiment?