PHY 122 LAB 8

Conservation of Energy

Introduction

In this lab, we will consider the motion of a pendulum bob from the viewpoint of energy. We'll see that mechanical energy is a constant of the motion, although it may change from kinetic to potential and vice versa.

Theory

For an isolated object (or collection of objects) with only conservative forces acting, the total mechanical energy is conserved. In this lab, we look at the motion of a simple pendulum acting under the influence of gravity. The pendulum is a rigid extended object, but it behaves like a single particle with mass concentrated at the center of mass (CM). Then we have, for kinetic energy,

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

and, for potential energy,

$$U = mgh \tag{2}$$

where v is the velocity of the pendulum bob, measured along a circular arc, and h is height of the bob. We can write the conservation of mechanical energy as

$$\frac{1}{2}mv^2 + mgh = E = constant \tag{3}$$

Procedure

You will use a spark-timer to measure the position along the arc for a pendulum bob as it swings. You will thus create a motion diagram for the swinging bob. A side view of the apparatus is sketched below.

Be careful to get a true reference line for the horizontal.

It is easy to tear the paper, so you must take care to launch the pendulum in the plane of the back plate. To do this, use the fine nylon string pulled over the marked bolt.

Analysis

If you divide equation (3) by m, you obtain $\frac{1}{2}v^2 + gh$ = constant, so that you don't need to measure the mass of the bob to verify the conservation of mechanical energy.

1. Make columns of Δx, h, and t from the motion diagram of the swinging bob.

   You should measure Δx between every other dot, and measure h from the

dot which is "in between". (Why is this the correct procedure?) Time has an arbitrary origin and intervals of exactly 1/60 sec. Estimate an uncertainty for each data point.

2. Show that the total energy per unit mass, *i.e.* $\frac{1}{2}v^2 + gh$, is constant over time. If it is not constant, be prepared to offer a reasonable explanation.
3. Plot v^2 versus h, and from your slope determine g and σ_g. Compare your result with the accepted value of g.

Some Things to Think About

You have to select an origin of coordinates to measure h. How does this selection affect energy conservation?

The bob follows a circular path, which idicates that gravity is not the only force acting upon it. Identify the additional force and discuss how it might affect equation (3).