Physics 217

Conservation of Energy

Introduction and Goals

In this lab you will use video analysis to investigate how gravitational potential energy converts into kinetic energy for a small cart (or ball) rolling down a smooth incline. By comparing predicted and measured speeds at the bottom of the incline for different incline angles, you will:

- Test the conservation of mechanical energy (neglecting friction and air resistance).
- Examine any systematic deviations from perfect energy conservation as the incline angle varies.
- Quantify relative errors between theoretical predictions and experimental measurements.

We will analyze four videos of the same object released from rest on inclines set to **3°, 5°, 7°, and 10°**.

Theoretical Background

When an object of mass m starts from rest at height h on a frictionless incline, its gravitational potential energy

$$U = mgh$$

is converted into kinetic energy

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

Therefore at the bottom of the incline the final velocity is $v = \sqrt{2gh}$. On an incline of angle θ the h at some distance L along the incline is given by $h = L\sin\theta$.

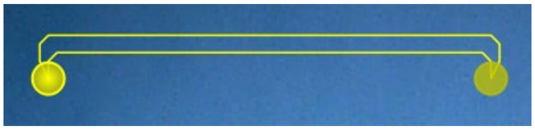
Any difference between v_{theory} and the measured speed $v_{measured}$ indicates non-conservative effects (e.g., rolling friction, air drag).

Instructions

1. Download the videos from Live Photo Physics.
2. Open Pasco Capstone.
3. Open Video Analysis.

4. Open the 3° track video.
5. Move the x-y axis so that it is centered on the bottom of the track, and rotate it so the +x is along the track pointing toward the cart.
6. Hide the x-y axis by pressing this button: 
7. Advance the frames until you see the scale length reference frame on the video.

8. Move the calibration scale to match the 1.00 m scale on the video (this scale is set by where the front of the cart starts to where it ends before it collides with the back stop on the track).



9. Once the calibration is set, hide the calibration scale.
10. Press "create tracked object" 
11. Rename this tracked object to "Cart"
12. Double click on the cart to start tracking then continue to track the object with a single click in this way until the projectile lands back inside the cart.
13. Produce an x position and velocity vs time graph, and use it to determine the following values:
    a. Initial position of the cart(x direction)
    b. Initial velocity of the cart (x direction)
    c. Final position of the cart (x direction)
    d. Final velocity of the cart (x direction)
14. Save this graph as a PDF for your final lab report.
15. Repeat these steps on the other videos ($5°$, $7°$, and $10°$).

Data Analysis & Questions

[Q1] Using $h = L\sin\theta$, where L is the distance along the incline (in our case the x position), and θ is the inclination angle of the track, calculate the expected final velocity of the cart using the initial position of the cart ($v_{theory} = \sqrt{2gh}$).

[Q2] For each angle, and your answers in [Q1], calculate the percent error for each angle

$$\delta v = \frac{|\, v_{measured} - v_{theory} \,|}{v_{theory}} \times 100\%$$

[Q3] Based on your results from the prior questions, does your data justify the assumption of conservation of mechanical energy? Explain, that is defend your answer and if you answer "no" explain what sources of error you believe could occur, either in our assumptions of experimental procedures.