LAB 4. FORCES ON AN INCLINE

Introduction

This lab comprises two activities, both exploring the forces that act on objects on ramps. In one, you balance a cart free to roll on a ramp against a hanging mass; in the other, you measure the acceleration of a cart rolling down a ramp. Both of these quantify the effect of the inclination angle

Supplies

Both activities: cart with a string, level
Balance: adjustable ramp with pulley, mass hanger and masses,
Kinetics: track, force meter, motion detector apparatus, meter stick

Data Collection

Balance

A string running over the pulley at the end of the ramp connects a mass hanger to a dynamics cart. For a given hanging mass (less than the cart mass), find the inclination angle of the ramp that keeps the cart and hanging weight from accelerating either up or down.

1. Measure and record the mass of the cart.
2. Lower the ramp to the 0° position. Level the ramp.
3. For hanging masses 50 g, 100 g, 150 g, 200 g, 250 g, and 300 g, find the ramp angle at which the hanging weight equilibrates the cart on the ramp:
4. Place the needed mass on the hanger. Run the string over the pullet at the end of the ramp.
5. Adjust the ramp incline angle so that the cart rolls neither up nor down. Tighten the set screws on the ramp to lock it into place.
6. Check the angle by pushing the cart up the ramp and down the ramp. It should coast to a stop on about the same distance and time in both directions. Record the angle.
7. Complete steps 4–6 for each hanging mass.
8. Repeat the measurements (steps 3–7) for all hanging masses three times, by three different experimenters.

Kinetics

Use the motion sensor apparatus to make velocity measurements of the dynamics cart rolling down the ramp. Supplement these measurements with measurements by a spring force meter.

1. Measure the weight (in newtons) of the dynamics cart. Hang the cart by its string from the hook of the spring force meter, and suspend the force meter by its hanger. Read and record the force.
2. Level the track on the table.
3. Elevate the track by placing books or boxes under one end. To know the incline angle of the ramp, measure and record the height of the support and the length of the ramp (hypotenuse) from base to support.

4. Place the cart on the ramp. Hold the cart's string by the hook of the force meter, and read and record the downhill force when the cart is motionless.
5. Place the motion detector at the top of the ramp, facing down.
6. Place the cart at the top of the ramp.
7. Start data collection.
8. Release the cart, allowing it to roll down the ramp.
9. Catch the cart before it reaches the end of the ramp. Do not allow it to collide with the end of the ramp or to crash to the floor.
10 Repeat steps 3–9 for at least three ramp angles.

Data Processing

Balance

1. Average the angle readings for each hanging mass.
2. Make a plot of hanging mass (vertical axis) vs. angle (horizontal axis). On the same axes, plot a smooth curve of $M \sin(\alpha)$, where α is the angle and M is the mass of the cart. Plot the smooth curve for angles 0–45°.

Kinetics

1. Examine the velocity-time graphs from the runs. From the linear regions of the graphs, find the acceleration of the cart.
2. Calculate the sine of the incline angle α of the ramp for each run from the height h and hypotenuse s using the relation $\sin(\alpha) = h/s$.
3. Plot acceleration vs. $\sin(\alpha)$. Draw a straight line to best fit the data. Find the slope of the line.
4. Plot the measured downhill force vs. $\sin(\alpha)$. Draw a straight line to best fit the data. Find the slope of the line.

Lab Report

Present your findings in a brief, lucid report.

Data

Show the raw data table.

Results

Show the graphs that you made: hanging mass vs. angle with $M \sin(\alpha)$; a vs. $\sin(\alpha)$, and tension vs. $\sin(\alpha)$.

Discussion

Do the hanging mass data match the $M \sin(\alpha)$ curve? Should they? Explain.

What is the slope (and units) of the a vs. $\sin(\alpha)$ graph? What is the slope (and units) of the downhill force vs. $\sin(\alpha)$ graph? What is the significance of these slopes?