Name: ____________ Physics 1 - Miguel Rocha Date:____________

Lab 2: Equilibrium on an Inclined Plane

Purpose

To measure the mass of a cart by analyzing the forces in equilibrium in an inclined plane.

Introduction

Newton's first law of motion states that **every object continues in a state of rest or of uniform speed in a straight line unless acted on by a nonzero net force**.

This means that if the sum of the forces acting on an object adds up to zero, then the object will not change its velocity (i.e. there is no acceleration). Thus if an object is not moving or moving with constant velocity, then you know that the law of equilibrium can be applied, which can be expressed mathematically in the following way

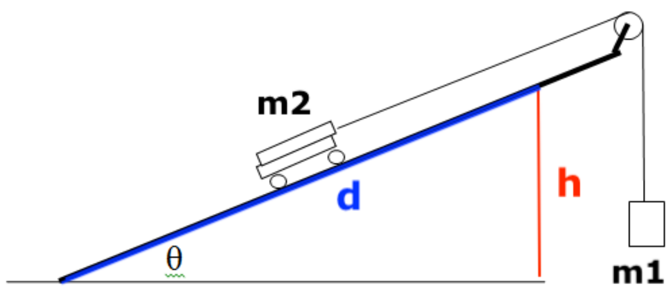
$$\sum F = F_1 + F_2 + \ldots + F_N = 0 \ . \quad \textbf{Eq. 1}$$

In this lab you will use the law of equilibrium in order to find the mass of a cart hanging on inclined plane.

Procedure

1. Setup the inclined plane so that the angle meter reads about 10°. NOTE: You will not use the angle in your calculation so it doesn't have to be exactly 10°.
2. Connect the weight hanger, the force scale, and the cart using a couple pieces of string. Let the string rest on top of the pulley.

3. While holding the cart on the ramp and letting the weight hanger hang from the pulley, add some weight to the weight hanger until you can let go the cart and it wont move (i.e the system stays in equilibrium).
4. Write down in the Data Collection table (next section) the amount of weight needed on the weight hanger in order to keep the system in equilibrium. Also measure the height (***h***) from the table to some point on the plane, and the distance (***d***) from the bottom of the plane to the point on the plane where you are measuring the height (***h***). You're basically measuring the hypotenuse (***d***) and the opposite side (***h***) of the triangle below



5. Repeat steps 1-4 a couple more times changing the inclination of the plane to 20° and 30°.

Data Collection

Inclination	m_1 = mass on hanger (g)	h = height (cm)	d = distance on plane to the point where you measure h (cm)
10°			
20°			
30°			

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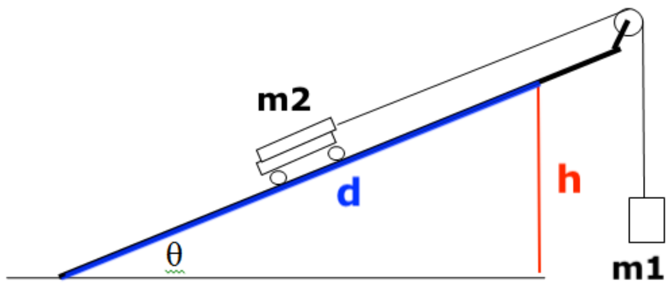
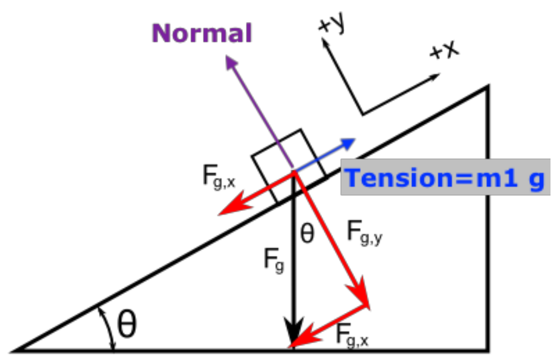
Analysis

1. In the picture below draw and label the vectors associated with every force acting on the system. Remember that the force of gravity on a mass $\boldsymbol{m}$ is given by $\boldsymbol{F_g = mg}$, where **g = 9.8 m/s^2 (~ 10 m/s^2)** is the gravitational acceleration at the surface of the earth. NOTE: Don't do any calculations yet, just label the forces using symbols.



2. If we isolate the cart system and decompose $\boldsymbol{F_g}$ into its components parallel ($\boldsymbol{F_{g,x}}$) and perpendicular ($\boldsymbol{F_{g,y}}$) to the inclined plane, we can apply the law of equilibrium to the forces acting along the x-direction (parallel to the track) and along the y-direction (perpendicular to the track) independently. In that case would have two independent equations, $\sum F_x = 0$ and $\sum F_y = 0$. Use diagram below to write the complete form of thew two equations.



3. From the law of equilibrium along the x-direction we know that $\boldsymbol{F_{g,x} = -m_1 g}$. Also we know that $\boldsymbol{F_g = -m_2 g}$. Finally, using the fact that (from trigonometry) $\frac{F_g}{F_{g,x}} = \frac{m_2 g}{m_1 g} = \frac{d}{h}$, you can use your measurements of $\boldsymbol{d}$ and $\boldsymbol{h}$ in order to find $\boldsymbol{m_2}$ (the mass of the cart). Find the mass of the cart from your 3 different measurements of $\boldsymbol{d}$ and $\boldsymbol{h}$ in your table (one for each inclination).

4. Now find the "actual" mass of the cart by weighting it on the lab scale, and compute the percent error between this actual mass and the average of your indirect measurements.

$$\%\ \text{error} = \frac{|\text{actual} - \text{avg. of your measurements}|}{\text{actual}} \times 100$$

5. There is a source of a minor systematic error in the measurements for this lab, can you tell what it is? HINT: Did you notice if there were any differences between the mass that the force scale was reading and the actual mass on the hanger ($\boldsymbol{m_2}$)?