NEWTON'S 2nd LAW

OBJECTIVE

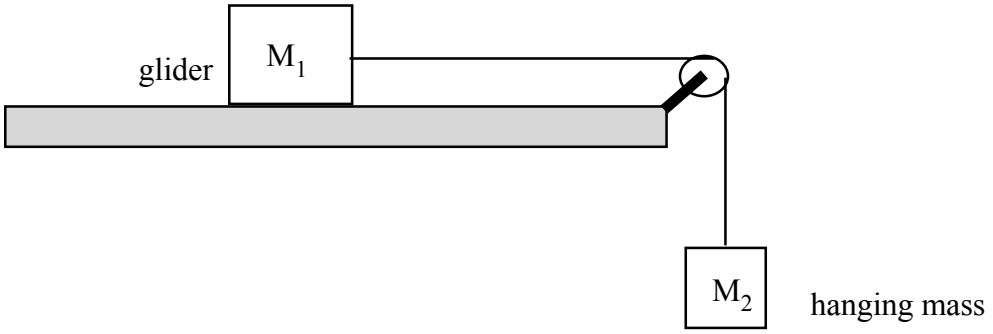
In this experiment you will confirm the validity of Newton's 2nd Law by analyzing the motion of two objects (glider and a hanging mass) on a horizontal air track. First, you will calculate the theoretical acceleration by applying Newton's 2nd Law ($\mathbf{F_{net}} = M\mathbf{A}$), neglecting friction, to the glider and hanging mass. Next, you will calculate the experimental acceleration of the glider by applying the kinematic equations of motion as it moves between two markers (photogates) on the track. We will then compare the experimental acceleration to the theoretical acceleration:

1) Calculate the theoretical acceleration a_{theo} of the system by applying Newton's 2nd Law.
2) Calculate the experimental acceleration a_{exp} of the system by two different methods using the kinematic equations of motion.
3) Compare a_{exp} with a_{theo}.

APPARATUS

1. Air track, blower with hose, and power cord.
2. Two photogates
3. glider
4. accessory box
5. string
6. pan balance

THEORY



1. Apply N2L separately to both M_1 and M_2.
2. Derive the theoretical expression for the acceleration of the blocks (system).

PROCEDURE

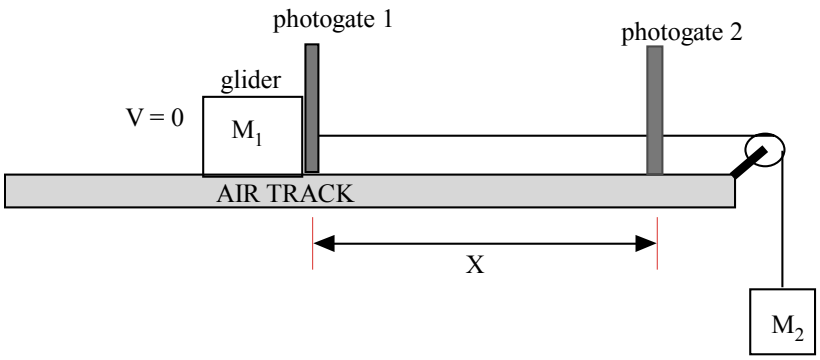


Figure 1 (Method 1)

Method 1 *($x = x_o + v_o t + (1/2)at^2$)*

1. Level air track.
2. Set the distance between the photogates approximately x ≈ 70 cm.
3. Set $M_1 \approx 200$ g and $M_2 \approx 35$ g. M_1 will just be equal to the mass of the glider.
4. Set photogates on PULSE MODE.
5. Release M_1 from rest at photogate 1.
6. Measure time for M_1 to reach photogate 2.
7. Repeat steps (4) and (5) for a total of 5 runs.
8. Calculate a_{exp} for each run and find a_{ave}.

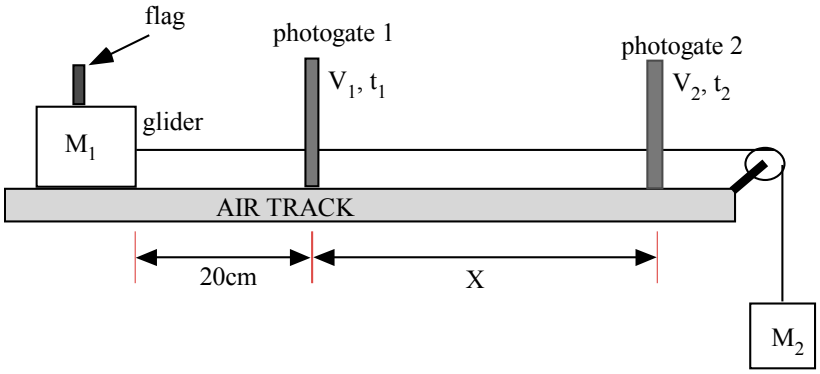


Figure 2 (Method 2)

Method 2 **($V_2^2 = V_1^2 + 2a(X - X_o)$)**

1. Attach the small flag from the accessory box onto M_1.
2. Use x ≈ 70 cm and same M_2 as in Method 1. Measure M_1.
   M_1 = mass of glider + mass of flag.
3. Measure the length of the flag on M_1 using the Vernier calipers.
4. Set the photogates on GATE MODE and MEMORY ON.
5. Release M_1 from rest at 20 cm away from photogate 1.
6. Measure time t_1 through photogate 1 and time t_2 through photogate 2.
7. Calculate V_1 and V_2. These are the speeds of the glider (M_1) as it passes through photogate 1 and photogate 2 respectively.
8. Repeat steps (5) – (7) for a total of 5 runs.
9. Calculate a_{exp} for each run and find a_{ave}.

Using Newton's 2nd Law

1. Using the equation derived in the theory section calculate the theoretical acceleration a_{theo} of the system for Method 1 and Method 2/
2. Compare a_{exp} (average) with a_{theo}.

*Which method gave the smallest % error? Explain in terms of the outcome of the experiment.