

NEWTON'S SECOND LAW

Purpose:

1. To study and measure the effect that forces have on the motion of a cart on a horizontal track.
2. To become familiar with the use of the computer and motion detector as a tool for taking and analyzing experimental data.

Equipment:

Computer with Logger Pro software, lab pro interface, motion detector, horizontal track, cart, low friction pulley, string, paper-clip weight hanger, regular weight hanger, slotted weights, triple beam balance, carpenter level, two mass bars

Introduction:

This experiment uses the cart + pulley + hanging-mass setup shown in Figure 1. When a mass is hung from the string, the cart accelerates as the mass falls. The net force acting on the cart-mass system is the weight of the hanging mass minus a small friction force, f . Thus, we can find the acceleration of the cart by using Newton's second law along with the free body diagram shown in Figure 2:

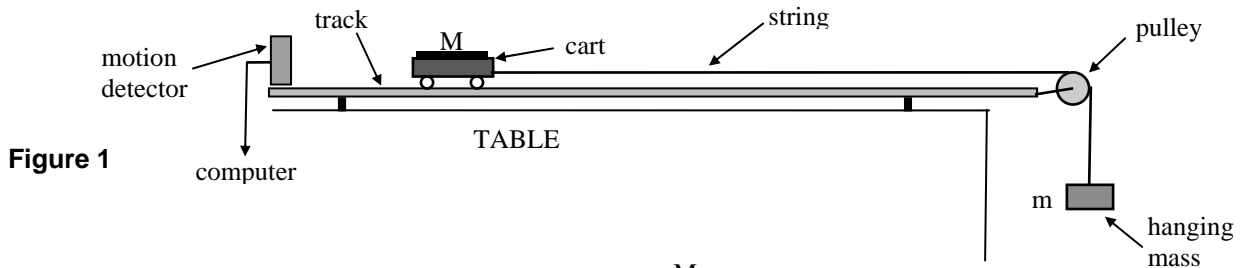


Figure 1



Figure 2 (free body diagram)

$$\Sigma F = ma$$

$$mg - f = (m + M)a$$

$$(1) \quad a = \frac{mg - f}{m + M}$$

Procedure:

1. Set up the apparatus as shown in Figure 1. Use the carpenter level to verify that the track is level. Adjust the height of the pulley such that the string appears to be level (by eye). Place the cart and two mass bars separately on the balance scale and make a record of their total mass. Connect the lab pro interface to the computer and the motion detector to the DIG/SONIC2 port on lab pro interface. On the computer, open the **Physics Apps** folder and start the **Logger Pro** software, open the **Mechanics** folder and then the **graphlab** file. You should see a blank position vs time graph.
2. First, the friction acting on the system must be determined. To do this the cart will be made to move with constant speed ($a = 0$). Attach a small mass (one or two grams) to the paperclip weight hanger at the end of the string and give the cart (with the two mass bars) a gentle push away from the motion detector. Adjust the hanging mass until the cart can be made to move with constant speed. When this appears to be the case, collect some position vs time data with the computer and motion detector to verify that the velocity is constant. What should the graph look like in this case? Calculate the friction force, f , by using equation 1 above with $a = 0$. Verify

your calculations for f with your instructor. You will use this friction force in all of your subsequent calculations.

3. **Note: In what follows, be sure to catch the rolling cart before it crashes into the end of the track!** Remove the paper clip weight hanger and attach a 50 g weight hanger and an additional 50 g mass to the end of the string. Release the cart from rest (at an initial position of 50 cm from the detector) and, using the computer, record the distance versus time data as the cart accelerates down the track and verify that the data are consistent. Use a quadratic fit for these data to determine the **acceleration** of the cart plus hanging mass system. (Be sure to select a range of data which ends before the hanging mass hit the ground.) Repeat this measurement at least four more times, and calculate the average acceleration for this mass. Weigh the weight hanger to get a precise measure of the total hanging mass. Record all data in a neat data table.
4. Using equation (1), calculate the predicted acceleration of the system. Compare this predicted value with the experimental value found in part 3 and calculate the percent difference.
5. Repeat steps 3 and 4 using total hanging masses of 150g, 200 g, and 250 g.
6. Print out a single plot of position versus time data with the appropriate quadratic fit. In your lab book, make qualitative sketches of the corresponding velocity versus time, and acceleration versus time graphs below this graph. Record your final results in a table like the one shown below.

FINAL RESULTS TABLE

TRIAL	$m(\text{kg})$	$M(\text{kg})$	$a_{\text{pred}}(\text{m/s}^2)$	$a_{\text{exp}}(\text{m/s}^2)$	% diff