EXPERIMENT #3 - PHYSICS 30

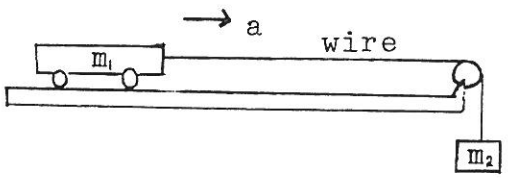
Fletcher-Type Acceleration Apparatus

OBJECT: To study linear acceleration and Newton's second law of motion.

EQUIPMENT: Fletcher-type apparatus & accessories
interval spark timer & paper tape
hanger & slotted weights

THEORY:

The Fletcher-type apparatus is basically a car of mass m_1 which is pulled by a wire along a track by the hanging mass m_2 as indicated below:



a = acceleration of m_1 or m_2

If there is no friction in the system and if the moment of inertia of the car wheels and pulley is ignored, then by applying Newton's second law to m_1 and separately to m_2, one may derive

$$a = \frac{m_2 g}{m_1 + m_2}$$, where g = acceleration due to gravity

If the friction and moment of inertia of the wheels and pulley are considered, then it is more accurate to use the following equation for the theoretical acceleration of the car:

$$a = \frac{(m_2 - m_f)\, g}{m_1 + m_2 + m_i}$$, where $m_i \cong 100$ grams

The mass m_i effectively compensates for the moment of inertia or rotational acceleration of the wheels and pulley. The mass m_f effectively compensates for friction in the system, and m_f is also the amount of hanging mass which is needed to pull m_1 along the track at constant speed.

GENERAL DIRECTIONS:

A. Preliminary adjustments:

1. Place the track on a reasonably stable, level surface which is approximately 100 cm above the floor. During operation the hanging weight should reach the floor (or a cushioned box) before the car reaches the end of the track in order to prevent breaking the wire. Adjust the track's leveling screws until the track is level and straight.

2. Set the car on the track, properly attach the wire to the car and hanging weight, place the special paper tape in the brackets at each end of track so that it passes through the spark gap on top of the car, and properly connect the interval spark timer to the track. The spark timer's electrical ground should be connected to the track properly in order to avoid a possible unpleasant electrical shock.

B. Measurements:

1. Set the spark timer to a reasonable value (usually 0.10 sec is best), load the car with all the cylindrical weights, and adjust m_2 to be about 200 grams. Turn on the spark timer and release the car. This action should produce small spark holes in the paper tape which must be used to determine the experimental value of the car's acceleration. Also, experimentally find the value for m_f , and use a balance scale to determine the car's total mass (m_1).

2. For the next two runs reduce m_2 by approximately 50 grams to 150 grams and later by another 50 grams to 100 grams. In order to keep the mass of the entire system constant, increase the mass of the car by the same amount that you decreased m_2 . Again, determine m_1 , and m_f , and save the paper tape for further analysis.

3. For the last two runs adjust m_2 to be the same original value (approximately 200 grams) as used in part 1 of section B, and reduce the car's mass (m_1) by removing one cylinder and later by removing two cylinders from the car. Again, determine m_1 , and m_f, and save the paper tape for further analysis.

C. Calculations and results:

1. By using only the paper tape, a ruler, and the time interval between sparks determine the experimental value of the car's acceleration for each of the five runs. Do not use the first spark hole on the tapes, and clearly show how you calculate this acceleration.

2. Using the appropriate equation from this lab calculate the theoretical acceleration of the car for each of the five runs. Compare this to the experimental value of the car's acceleration.

3. Summarize your results by making a table for the five runs which includes the total mass of each system ($m_1 + m_2$) , m_1 , m_2 , m_f, experimental acceleration, theoretical acceleration, and percent error for the accelerations.

4. Explain why there is any experimental error for this experiment.

5. By applying Newton's second law to m_1 and separately to m_2, derive: $a = m_2 g/(m_1 + m_2)$. Use a diagram to clearly show all the forces acting on m_1 and m_2 .