PRE-LAB WORKSHEET

Name: ____________________________________

Lab 3: Motion with Constant Acceleration

This Worksheet is designed to help you prepare for the lab. Place your Worksheet on the instructor's desk on the day of your lab **before** the lab starts. Write your letter answers on the lines provided. Please use capital letters.

I) Read the *Purpose* and *Theory* sections. Answer the following.

1. Acceleration is defined as:

____ A) meters per second^2 B) velocity/time C) (velocity)·(time)

2. When an object moves with constant velocity, its acceleration is

____ A) constant B) zero C) decreasing D) m/s^2

II) Read the *Procedure* section. Answer the following.

3. What piece of equipment determines the final position of the cart that is relevant to your measurements?

____
A) the distance between the main and the secondary photogate
B) the main photogate
C) the secondary photogate
D) the cart-stopper at the end of the track

4. Step 2 instructs you to set the photogate to "1 ms scale". This means that:

___
A) the maximum time interval the photogate will measure is 1 ms.
B) the average time interval the photogate will measure is 1 ms.
C) the display on the photogate can be 1.073.
D) the display on the photogate can be 0.0385.

5. How much is the initial velocity of the cart?

___ A) 9.8 m/s^2 B) 9.8 m/s C) between 20 and 110 cm/s D) 0

6. What causes the cart to accelerate down the track?

___ A) your hand B) motion sensor C) the cart wheels D) gravity

3. MOTION WITH CONSTANT ACCELERATION

Purpose: To observe and make measurements on an object moving with a constant acceleration.

Equipment: linear low-friction track
photogate timers
cart
level

Theory:

A cart is put on a tilted linear frictionless track so that the cart moves down the track slowly. The equations for an object moving with constant acceleration are given by:

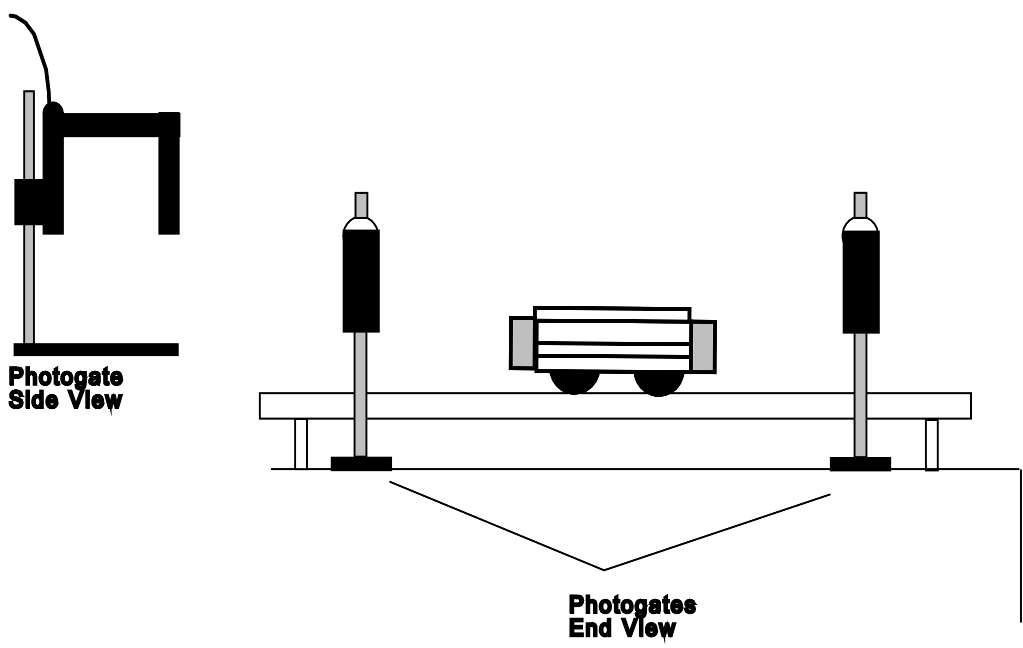
$$d = v_o t + \frac{1}{2} a t^2$$

$$v = v_o + a t$$

where t is the time required for the object to travel a distance (d), with an initial velocity (v_o), and an acceleration (a).

Procedure:

The linear track setup is shown in the figure. Carefully level the track. Tilt the track by inserting the block of wood under one set of legs. Your measurements will be conducted with the cart initially at rest and the cart's flag as close as possible to the first photogate.



1. Locate the main photogate (the one with the display) at the point where your cart will be released. Set the secondary photogate 20 cm down the track. Adjust the heights of the photogates so that the cart's flag activates them when it passes through them.

2. With the photogate set at **"pulse mode" and 1 ms scale** release the cart and record the time it takes to travel the set distance. Write down your data in the "distance measurements" columns (Table 1). Repeat this measurement two more times.

3. Repeat step 2 after increasing the photogates separation by 10 cm.

4. Repeat step 3 until the photogates are separated 110 cm.

5. Average the time measurements and write your values in the appropriat column. ~~Use Excel to make a distance (vertical axis) vs. average time (horizontal axis) graph. Perform a second-order polynomial fit on your data and record the resulting parameters and regression coefficient. Repeat the quadratic fit but this time force the intercept to be zero.~~ Calculate t_avg^2 and place into a new column. By hand, graph distance vs. t_avg^2, forcing the intercept to zero.

6. ~~When possible it is always best to do linear fits on data. In this lab this means plotting the distance vs. the time squared (t^2). Do this and perform a linear regression on this graph setting the intercept (initial velocity) to zero.~~ Plot distance vs. t_avg using Excel. Fit to a quadratic polynomial without forcing intercept to zero.

7. ~~Calculate the uncertainty for the best fit parameters. Follow the procedure on page viii (Computer Regression Method). The equations work although the data was uncertain in the x-axis (time).~~ From the slope of the distance vs. t_avg^2 graph, determine the acceleration, a_2.

8. ~~Use a motion sensor and DataStudio to record the position of the cart as a function of time as it travels down the ramp. Start with the cart at least 0.2 m from the motion sensor.~~ From the formula for the quadratic polynomial fit of distance vs. t_avg graph, determine the acceleration, a_1.

9. ~~Do a quadratic fit on your data and record the resulting parameters in Table 2.~~ Using the angle attachment tool, measure the tilt angle of the track.

10. ~~Repeat steps 8 and 9 two more times.~~ Using this angle, calculate the theoretical acceleration, a_calc

~~11.~~ ~~Average the corresponding acceleration parameters values from your measurements in steps 8 - 9 and write this value in the results section.~~

12. ~~Calculate the percent difference for the accelerations obtained from the graphs.~~ Calculate the percent differences for the accelerations, a_1 and a_2, from a_calc.

Data and Analysis:

Table 1

Distance traveled d (cm)	Time (s)			
	Trial 1	Trial 2	Trial 3	Average time (s)

t_avg^2

Excel graph: d vs. t graph: quadratic equation = ______________________________ ~~R^2 = __________~~

~~d vs. t (intercept forced to 0) quadratic equation = _____________________ R^2 = ________~~

By-hand graph: d vs. t^2 graph: linear equation (intercept forced to zero) = ___________________________

~~R^2 = ______________~~

Uncertainty analysis for d vs. t^2 linear equation parameters:

$$\cancel{\sigma_a = \sqrt{\frac{1}{N-1}\sum_1^N (d_i - mt_i^2)^2}} = \underline{\qquad\qquad} \qquad \cancel{\sigma_m = \frac{\sigma_d}{\sqrt{\sum_1^N t_i^2}}} = \underline{\qquad\qquad}$$

Where *m* is the slope of the linear equation and equal to ½ *a*, *t* are the average times, *N* the number of data points, and σ the standard deviations.

Table 2

Trial	quadratic fit expression
1	
2	
3	

Results:

d vs t graph ~~(intercept forced to zero)~~ acceleration (a_1) = ________________

d vs t^2 graph: acceleration (a_2) = ________________ ~~$\sigma_a = \sigma_m$ =~~ ____________

~~Motion detector:~~ ~~average acceleration (a_{ms}) =~~ ________________

a_calc

% difference of a_1 and $\cancel{a_m}$ = ___________________

% difference of a_2 and $\cancel{a_m}$ = ___________________

a_calc

Conclusions or Summary: