Purpose:

* Determine the acceleration of an object by graphical analysis methods.
* Calculate an experimental value for the acceleration of gravity.

Equipment:

LabQuest Mini with USB cord   Photogate and Photogate cord
Computer with LoggerPro software   Picket fence
                                                                    Ring stand

Introduction:

When an object falls freely, it experiences a constant acceleration due to gravity. If air resistance is neglected, the velocity of the object increases linearly with time. The velocity of such an object after accelerating for a time *t* can be modeled by the equation:

$$v = v_0 + a \cdot t$$

As the object falls, the distance that it falls per unit of time continues to increase, due to its increase in velocity. It can be shown algebraically that the displacement of an accelerating object increases proportionately to the square of the time elapsed. The displacement of such an object after accelerating for a time *t* can be modeled by the equation:

$$d = d_0 + v_o \cdot t + \frac{1}{2} \cdot a \cdot t^2$$

From the above equations, we can predict that an analysis of a Velocity-Time graph will produce a linear relationship, while an analysis of a Distance-Time graph will produce a quadratic relationship.

This experiment will investigate the motion of a "picket fence" as it is accelerated by gravity through a photogate. The picket fence consists of a clear plastic strip with uniformly spaced opaque bands. As the picket fence falls, its opaque bands block the beam of the photogate. The LABQUEST unit measures the time between blockages and uses this information to calculate the average velocity of the picket fence from one band to the next. The change in velocity is then used to calculate the average rate of acceleration.

Procedures:

Securely attach the photogate to a ring stand. Turn the photogate head sideways and extend it over the edge of the lab table so that the picket fence can be dropped through the photogate without striking the lab table below.

Insert the plug of the photogate cord into the DIG I port of the LABQUEST. Use the USB cord to connect the LABQUEST to the computer. Then open the "*Lab #2 Template*" LOGGERPRO file from the class web site or Shared folder.
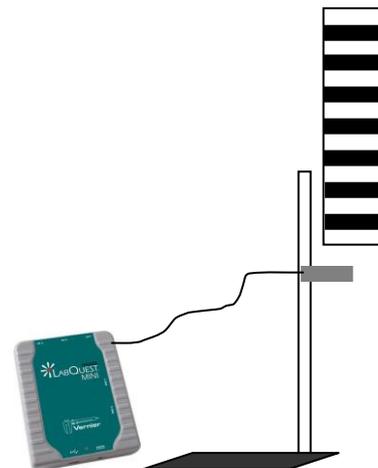
Procedures (cont):

Have one member of your lab group prepare to drop the picket fence by holding it directly above the opening of the photogate. Then click the green COLLECT button on the LOGGERPRO toolbar. Carefully release the picket fence, allowing it to fall through the photogate. Be sure to have a member of your lab group catch the picket fence before it strikes the floor!

Use the ANALYZE → AUTOSCALE commands to view the data collected. If necessary, repeat the experiment until the data collected is acceptable for analysis. Then save the LOGGERPRO file for Trial #1 on your home folder for future analysis. Repeat the experiment until you have obtained two additional data sets that are suitable for analysis. Save the data for these trials as well, being sure not to overwrite the file containing your previous trials.

Calculations:

Calculate the acceleration of the picket fence for Trial #1 using the three graphical analysis methods listed below. Record your results from each method in the Data Table.
  - Use the ANALYZE → CURVEFIT command to perform an appropriate regression on the Distance-Time data
    and use the resulting equation to determine the acceleration of the picket fence.
  - Use the ANALYZE → CURVEFIT command to perform an appropriate regression on the Velocity-Time data
    and use the resulting equation to determine the acceleration of the picket fence.
  - Use the ANALYZE → STATISTICS command to perform a one-variable statistical analysis on the data,
    and use the mean value as the acceleration of the cart.

Repeat the calculations of acceleration for your data files from Trial #2 and Trial #3, recording all results in the Data Table. Print copies of your data, graphs, regression lines, and statistics from each of the three trials to include in your report. *(NOTE: For best printing results, use the FILE → PAGE SETUP command to change the orientation to landscape and the FILE → PRINTING OPTIONS command to add a footer with your Name and Trial #.)*

Calculate an average experimental value for the acceleration of gravity using each of the three types of graphs. Use this average to calculate a percent error for each of the three types of graphs.

Analysis:

To summarize the lab report, answer the application questions below in complete sentences. In addition, include a brief statement of the overall results for the lab.

- Discuss the physical meaning of each coefficient in the curve fitting equation for one of your Distance-Time graphs. Would any of these coefficients change if you held the picket fence at a great distance above the photogate before dropping it? If so, which coefficients would change and how? *(NOTE: You may try this activity during the lab procedures if necessary.)*

- Use the ANALYZE → INTEGRAL command to calculate the area under one of your Velocity-Time graphs. What is the physical quantity represented by this area? Can this quantity be verified? If so, discuss a possible method.

- Which type of graph, (Distance-Time, Velocity-Time, or Acceleration-Time) seemed to yield the most accurate results for the acceleration of gravity? Discuss possible reasons for this.

Lab Report:

Title Page, Objectives, & Overall Report – 5 pts
Procedures – 3 pts
Data Table – 8 pts
Calculations – 8 pts
Analysis – 11 pts

Data Table:

	Graphical Analysis results for Acceleration from . . .		
	Distance-Time graph	Velocity-Time graph	Acceleration-Time graph
Trial #1			
Trial #2			
Trial #3			
Average			
Percent Error			