NAME: _____ LAB PARTNER: _____

Free Fall

GOAL:

The goal of this experiment is to better understand the concept of free fall, a specific case of 1D motion with constant acceleration, where the acceleration is gravitational.

QUESION:

You are an alien from planet Mars. While on Mars, you were able to estimate the acceleration due to gravity on planet Earth and, more specifically, at Oxford, GA (we will discuss how to make such an estimate when we learn about Newton's Universal law of gravitation in the future.) You have estimated that at Oxford, GA, $g = 9.8$ m/s^2.

You have finally made the trip you have been dreaming of your whole life, and you have just arrived at Oxford, GA. Now that you are here, you would like to see if you can conduct an experiment where you can verify or falsify your theoretical prediction for g. Because you are ambitious, you would also like to know the answer to the following question: Does the time of free fall of an object depend on its mass?

MATERIALS:

You have brought with you in your spaceship the following materials:

1. A metal stand and a steel rod.
2. A right-angle clamp.
3. An electronic scale.
4. Two metal balls of different mass.
5. A meter stick (yes, in Mars you also used the SI system!)
6. A photogate timer.
7. A release mechanism and receptor pad apparatus (i.e., a free fall adapter. Operation instructions are given on the last page.)

• List the physical quantities you can measure with these materials:

_____

1. DOES THE TIME OF AN OBJECT'S FREE FALL DEPEND ON ITS MASS?

In the process of understanding free fall, you would like to know the following: Does the time of an object's free fall depend on its mass? To answer this question, you need to also conduct an experiment with the same materials. Design an experiment which will answer the question of whether the free fall time of a metal ball depends on its mass. To help you with the design process, answer the following while you are thinking about the original question:

- Since you are interested in knowing if an object's fall time depends on its mass, which of the physical quantities you listed above will remain constant during this experiment and which will vary? Why?

  a. Constant _____

  b. Vary _____

  Why?

- In an experiment, the independent variable is the variable that is varied or manipulated by the researcher, and the dependent variable is the response that is measured. Based on your answer to (b) above, which of those quantities will be the independent variable(s) and which the dependent?

  c. Independent: _____

  d. Dependent: _____

  Why?

1. Briefly list the steps of the procedure of the experiment you designed.

2. Conduct the experiment and make a table that records your data (you will have to repeat the experiment several times in order to find the average and standard deviation of the physics quantities of interest. A single data point is not enough for drawing conclusions).
3. What is your conclusion and why?

4. Can you confirm your experimental conclusions by using the free fall equations we learned in class? Explain.

2. WHAT IS THE GRAVITATIONAL ACCELERATION AT OXFORD, GA?

After getting sidetracked, you now want to return to your original question. What is the gravitational acceleration at Oxford, GA?

To help you think about the design of the experiment that will address this question, answer the following questions:

1. What are the equations of free fall?

2. Based on your materials, which of these equations contains parameters that you can measure with your materials?

3. With the answers to the previous questions in mind, which equation will you try to exploit in your experiment so that you can get the value of g? Why?

4. Having that equation and the materials in mind, which physical quantities from the ones you listed on page 1 are constant? Which variables are the independent variables and which are the dependent variables?
   - Constant: _____
   - Independent: _____
   - Dependent: _____

   Why?

5. Describe an experiment that you can conduct that will give you g.

6. If it is not part of your answer in 5 above, think of a way that you can repeat the experiment so that you can change the independent variable.
7. Conduct your experiment and make a table that records all your data.
8. Using Excel construct a graph that has the independent variable on the x axis and the dependent variable on the y axis.
9. Use Excel to fit a trendline to the data points. Make sure you show the equation of the trendline on the graph as well as the R^2 value. (I will give instructions on how to do that in Excel during the lab)
10. What is the form of the equation that best fits your data?

11. Based on your answers to questions 3 and 10 above, as well as the equation of the trendline that Excel calculated, calculate the value of g. Show your work and explain your reasoning.

$$g = \_\_\_\_\_$$

Work/Explanation:

12. Calculate the percent error between your value of g and 9.8 m/s^2:

NOTE: *The % error between two values x_1 and x_2 is*

$$\% \text{ error} = 100 \times \frac{x_1 - x_2}{(x_1 + x_2)/2}$$

EXPERIMENTAL SETUP and DATA COLLECTION:

1. Clamp the ball release mechanism to a lab stand, or any other device that will hold it vertical and at the desired height over the floor or table (see Figure). For best results, the drop height d should be the full two meters allowed by the cable. Shorter heights will work fine, but accuracy is reduced proportionally.
2. Position the ball receptor plate directly under the ball. (You might want to place the receptor plate in a shallow box so the ball doesn't roll away after it falls.)
3. Insert one of the steel balls into the release mechanism, pressing in the dowel pin so the ball is clamped between the contact screw and the hole in the release plate. Lightly tighten the thumbscrew to lock the ball in place.
4. Plug the phone jack into a port on your electronic timing device.
5. Turn the timer ON and set it in the GATE model.
6. Tap the receptor pad to reset the Free Fall Timer electronics.
7. Press the RESET button to reset the timer.
8. Loosen the thumbscrew to release the ball. It should hit the center of the receptor pad. If not, reset the timer, reposition the pad, and try again.
9. Read the time on the digital display of the timer. This is the time it took for the ball to fall a distance d, as shown in the Figure.

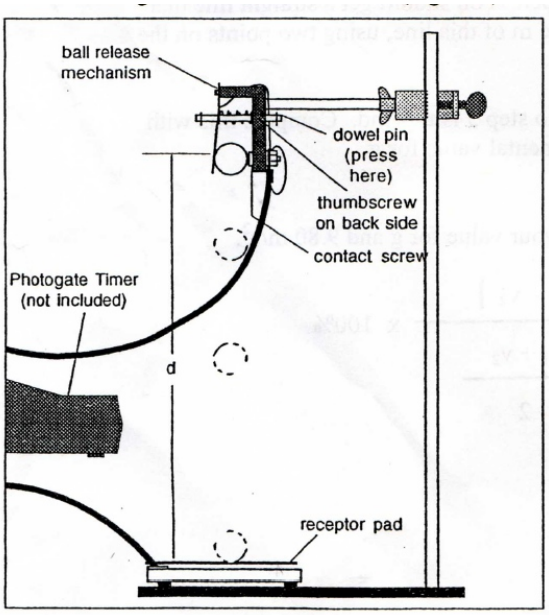

Figure 1: Experimental Setup.

DUE NEXT WEEK...

1. This handout with all questions answered.
2. The tables with the recorded data.
3. Any Excel graphs.

END LAB #2

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