LAB SECTION: ______________________________ NAME: ______________________________

EXPERIMENT 2: FREE FALL

Introduction: In this lab, you will measure the acceleration of an object as it falls toward the earth's surface. Air resistance should not be a factor, so the acceleration of the object should be g, the acceleration due to gravity acting alone. The value of g varies from place to place, being larger at lower elevations, but the average value of g is usually accepted as 9.8 m/s^2 or 980 cm/s^2

For our falling object, we will use a mass of between 0.5 and 1.0 kg. You will create a motion diagram for the falling mass by attaching a paper tape to the top of the mass; the falling mass will then pull the tape past a spark timer making 60 sparks per second. The distance between two successive spark marks will then be a record of the distance fallen by the mass in that particular 1/60th of a second. Let's denote your measured distances as Δd's. The time interval, Δt, for each of these distances is 1/60 s. Since distance equals speed times time, you can then get the **average speed** v_{av} for any time interval from

$$v_{av} = \frac{\Delta d}{\Delta t}.$$

This will give you a sequence of average speeds. To get a change in speed Δv, simply take the difference between two successive average speeds. The time interval for each speed change is Δt; so, the amount of speed-up acceleration a for any particular Δv is given by

$$a = \frac{\Delta v}{\Delta t}.$$

This procedure will give you a sequence of acceleration amounts; you can then take the average of these to get an overall result for your measured acceleration.

You will also determine the acceleration by making a plot of the sequence of average speeds versus time t. The slope of your best-fit line for this speed-versus-time graph will give you an alternative calculation of the overall amount of acceleration.

Procedure

1. Make sure that your spark timer is off, and is set to create 60 sparks per second. Tear off a piece of paper tape just long enough to reach from the bottom of your spark timer to the floor. With the shinier side of the tape facing you (the shinier side is facing outwards in the roll of paper tape), thread the piece of tape through the spark timer from top to bottom; then use masking tape to attach your selected mass to the bottom end of the paper tape. You are now ready to record a motion diagram. Hold the mass so the the top of the mass is just below the bottom of the spark timer. There

is a metal rod positioned above the spark timer; drape the length of paper tape over this rod so that the tape is free to be pulled through the timer by the falling mass. Turn on the spark timer, and then release the mass so that it falls straight down into a box of foam cushions directly beneath the timer. Finally, turn off the spark timer.

2. Repeat the steps in item 1 twice more so that you have three motion-diagram tapes for analysis. To analyze each tape, pick a dot, not too close to the beginning, and label that dot #1; successive dots will be numbered 2, 3, 4, up to 11 (dot #11 must not be close to end-of-tape). This procedure will give you 10 intervals; measure the distance for each of the 10 intervals and record these Δd's in the appropriate Data Table.
3. Divide each Δd by Δt (1/60 s) to get the average speed v_{av} in that interval.
4. Find a sequence of Δv's by taking the differences between successive v_{av}'s. Record the difference between the first v_{av} and the second v_{av} in row #2, etc.
5. Divide each Δv by Δt to get the calculated amount of acceleration for each Δv. Take the average of the nine acceleration values to get the average acceleration for each run. For Data Tables 2.2 and 2.3 write the average value of a in the margin to the right of row #10.

Data Table 2.1 Free Fall Run Number One $\Delta t =$ $\frac{1}{60}$ s ______ mass = ______

Interval	Δd (cm)	v_{av} (cm/s)	Δv (cm/s)	a (cm/s^2)
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

average value of a ______

Data Table 2.2 Free Fall Run Number Two $\Delta t = \frac{1}{60}$ s mass = ________

Interval	Δd (cm)	v_{av} (cm/s)	Δv (cm/s)	a (cm/s^2)
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

Data Table 2.3 Free Fall Run Number Three $\Delta t = \frac{1}{60}$ s mass = ________

Interval	Δd (cm)	v_{av} (cm/s)	Δv (cm/s)	a (cm/s^2)
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

Results

1. Select the Data Table that seems to have the "best run" data. State which table was chosen and explain the basis for your choice.

2. Using your best run data, make a graph of average speed versus time. Select the first value of average speed to have a designated time of $t = 0$. Each successive time will then be larger by an amount Δt. The slope of your best-fit line will then give you an alternative calculation of the average acceleration for this run. Write that slope on your graph, and show the calculation for that slope in the space below.

3. Calculate the percentage error between your slope value and the accepted value of 980 cm/s^2. Show that calculation in the space below.

4. Are you able to conclude that your falling object was falling with the acceleration due to gravity? Why or why not? What other force or forces might have been acting on your falling object other than the force of gravity? Are you able to make any conclusion about other possible forces on your falling object?