The Motion of a Freely Falling Object

In this laboratory, we will study the motion of a freely falling object. We would like to know the position of the object (with respect to some coordinate system) at each point in time. This is very difficult to measure directly, since the time that an object spends in the air before hitting the ground is very short. If we tried to use a stopwatch to measure the time it took for the object to fall from one place to another, we would not be likely to get accurate results.

Because an object falls to the ground so quickly, we use a spark tape apparatus to record the position of the falling object. The apparatus generates a spark every 1/60 s, which produces a dot on the paper. So, after using the apparatus, you have a strip of paper with dots representing the position of the object at 1/60 s increments.

Step 1

Use the spark tape apparatus to make a record of the position of the falling object at 1/60 s time intervals.

Step 2

Lay your tape out across the table. Choose a dot near the beginning of the fall to be "$t = 0$". Note that $t = 0$ is *not* the time at which the object began to fall. It is just a starting point for our analysis of the motion. Let us choose our coordinate system to be such that $x = 0$ is the location of the object at $t = 0$ and x increases as the object moves down toward the ground. So, in our coordinate system, "down is positive". If this offends you, you may feel free to develop your own coordinate system, but in that case you must *clearly write down* how you are setting up your coordinate system, so that the rest of your results can be interpreted in that light.

Measure the position of each dot with respect to the $t = 0$ dot, and record your results in the table. Try to be very precise with your measurement. Measure the number of millimeters, and estimate the number of tenths of a millimeter. You may use centimeters or millimeters when you make the measurements, but use meters when you write the results in the table provided. For example, an entry of 0.9456 m has the level of precision that I'd like to see.

Analysis using tables

Calculate the average velocity for each 1/60 s time interval and enter this on the table provided. For the interval between 0 s and 1/60 s, enter the average velocity in the row between the "0 s" row and the "1/60 s" row. We will interpret this average velocity to be the velocity of the particle at the midpoint of the time interval (1/120 s for this first time interval).

After you have calculated all of the velocities, calculate accelerations for each interval and put them in the table.

Analysis using graphs

Make graphs of the position you measured as a function of time and of the velocity you measured as a function of time. Properly label the axes with the appropriate quantity and units. Draw the best line you can through the points on the velocity graph and find the slope of that line.

Questions

1. Would you characterize this motion as having constant velocity? If so, what is that constant value? If not, why not?
2. Would you characterize this motion as having constant acceleration? If so, what is that constant value? If not, why not?
3. Find the average of the acceleration values you calculated in your table.
4. What are the highest and lowest values of acceleration you calculated in your table? This gives some indication of the precision of your result.
5. What is the slope of the best line on your velocity graph?
6. What is the accepted value for the acceleration of gravity? (from your book, say)

Time (s)	Position (m)	Velocity (m/s)	Acceleration (m/s^2)
0		XXXXXXXX	XXXXXXXX
1/120	XXXXXXXX		XXXXXXXX
1/60		XXXXXXXX	
3/120	XXXXXXXX		XXXXXXXX
2/60		XXXXXXXX	
5/120	XXXXXXXX		XXXXXXXX
3/60		XXXXXXXX	
7/120	XXXXXXXX		XXXXXXXX
4/60		XXXXXXXX	
9/120	XXXXXXXX		XXXXXXXX
5/60		XXXXXXXX	
11/120	XXXXXXXX		XXXXXXXX
6/60		XXXXXXXX	
13/120	XXXXXXXX		XXXXXXXX
7/60		XXXXXXXX	
15/120	XXXXXXXX		XXXXXXXX
8/60		XXXXXXXX	
17/120	XXXXXXXX		XXXXXXXX
9/60		XXXXXXXX	
19/120	XXXXXXXX		XXXXXXXX
10/60		XXXXXXXX	
21/120	XXXXXXXX		XXXXXXXX
11/60		XXXXXXXX	
23/120	XXXXXXXX		XXXXXXXX
12/60		XXXXXXXX	
25/120	XXXXXXXX		XXXXXXXX
13/60		XXXXXXXX	
27/120	XXXXXXXX		XXXXXXXX
14/60		XXXXXXXX	
29/120	XXXXXXXX		XXXXXXXX
15/60		XXXXXXXX	
31/120	XXXXXXXX		XXXXXXXX
16/60		XXXXXXXX	
33/120	XXXXXXXX		XXXXXXXX
17/60		XXXXXXXX	
35/120	XXXXXXXX		XXXXXXXX
18/60		XXXXXXXX	
37/120	XXXXXXXX		XXXXXXXX
19/60		XXXXXXXX	
39/120	XXXXXXXX		XXXXXXXX
20/60		XXXXXXXX	XXXXXXXX