Behr Free-Fall Lab

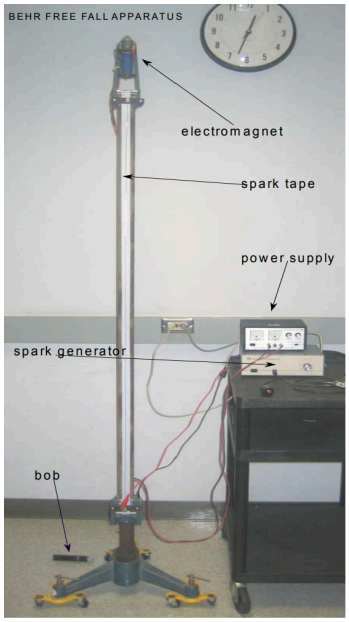
Objective

To determine the gravitational acceleration through utilization of the definition of a derivative and to compare the observed gravitational acceleration to the accepted value.

Theory

The kinematic equations abide by the concept that velocity is the time derivative of displacement and that acceleration is the time derivative of velocity and that we can move freely between the three units by either deriving or integrating. At its core, the derivative is the slope of the tangent line at a given point, and the derivative can be simulated by taking the slope between two points over an increasingly small time interval. The kinematic equations in question are $y_f = v_o t + \frac{1}{2}at^2$, and $v_f = v_o + at$ and will serve as the equations to which our data will be fitted.

Apparatus



- Behr Free-Fall Apparatus
- Spark Timer
- Power Supply
- Tape
- 2 Meter Stick

Procedure

The Behr Free Fall Lab consisted of using the Behr Free-Fall Apparatus to determine an observed value of gravitational acceleration. It consists of three major components: the spark tape, electromagnet, and spark timer. In which the spark timer is used to time the freefall experiment, the spark tape to record the timings and displacement of the bob, and the electromagnet to release the bob at the velocity of 0m/s. To operate the freefall apparatus the shock timer must be primed and then the electromagnet must be deactivated after.

In an ideal situation, the spark tape should have over 15 contact markings, of which the first six should be ignored due to the initial release, resulting in 7 viable data points. Once the spark tape is measured out and the data is entered into Excel two lines of best fit should be calculated. Firstly a polynomial line of best fit for displacement versus time and then a velocity versus time linear line of best fit should be calculated from the slope between data points in increments of one. Thus, allowing the experimenter to familiarize themselves with Excel software.

Calculations

Figure 1.0

Time	0	0.1	0.2	0.3	0.4
Cm $\pm$ 0.05	0	14.65	38.9	72.75	116.42
Time 2	0.05	0.15	0.25	0.35	0.45
V_{avg}	146.5	242.5	228.5	436.7	

Before the calculations are conducted it should be noticed that the timing was meant to hold a total of seven data points for time 1 as the Behr free fall apparatus was not tall enough to create all seven data points. Similarly, the time intervals are taken at a timing of 60Hz with a translation to intervals of 0.1 seconds. Furthermore, the average velocity is calculated by using

an adapted slope equation: $v_{avg} = \frac{(y_1 - y_0)}{(t_1 - t_0)}$, decreasing the total amount of velocity data points to 4. In order to create time data points that match the velocity data points we used the equation $t = (t_0 + t_1)/2$, creating a time that corresponds to each velocity data point on a time versus velocity graph.

Figure 2

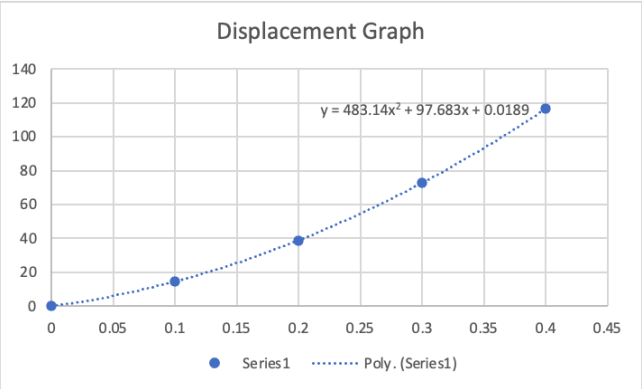
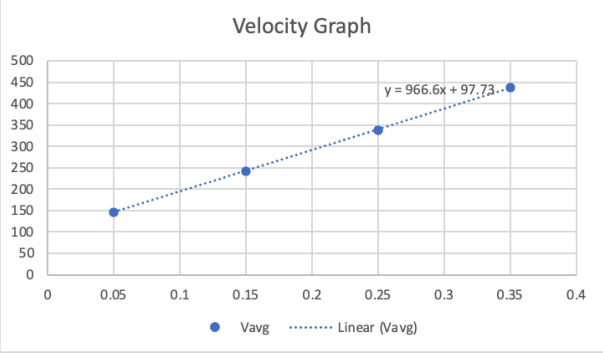


Figure 3



Data Analysis

As seen in figures two and three we are left with two equations of best fit for the datasets $y = 483x^2 + 97.683x + 0.0189$, and $y = 966.6x + 97.73$ for respected velocity and acceleration. Within the provided equations we see multiple discrepancies, beginning with the initial displacement, as the parabolic line of best fit includes an initial displacement of 0.02

centimeters, this could possibly be due to a discrepancy with how the Excel software interprets the data. Furthermore, the displacement equation includes an initial velocity of 98 cm/s whereas the ideal displacement equation would have an initial velocity of 0 cm/s as the Behr freefall apparatus would deactivate the magnet holding the bob in place, meaning that it is not launched but released. Thus these possible discrepancies may have occurred due to a small quantity of data.

Conclusion

In summary, we are left with a percent error of 1.5%, as our observed acceleration $9.66 m/s^2$ is not the same as the accepted value $9.81 m/s^2$. Possible sources of error could have been frictional forces with the bob, the contact points between the bob, paper, and copper wire, and the lack of a complete dataset. Furthermore, for future repetitions of the Behr Free Fall experiment a full 1.85 meter distance should be used to allow for the full six data points.