BEHR FREE-FALL LAB

OBJECTIVE

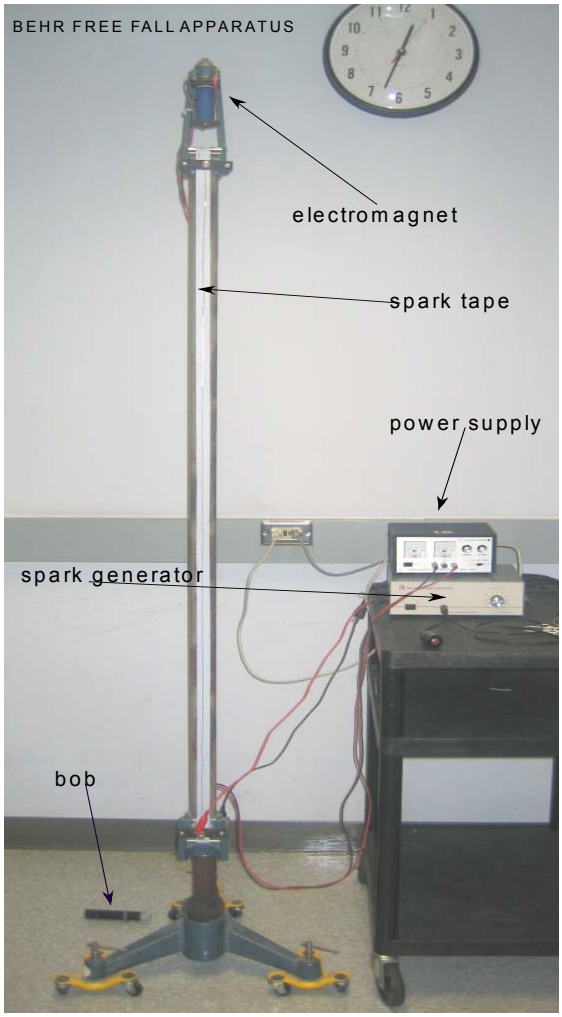
To analyze the motion of an object in Free-Fall by:

1) Analyzing the corresponding equations of motion.
2) Calculating the velocity at different times by using:
   a) the tangent method
   b) the equation of motion x = x(t)
   c) graphical methods ($v = \lim_{\Delta t \to o} \frac{\Delta x}{\Delta t}$)
3) Calculating the acceleration of gravity 'g' and comparing to the expected value of 9.80 m/s^2.

THEORY

Any object moving under the influence of gravity alone, regardless of its initial position, is said to be moving in free-fall. The acceleration of an object in free-fall near the earth's surface is nearly constant and approximately equal to g = 9.80 m/s^2. In this lab you will analyze the motion of an object moving in free-fall by using an apparatus called the Behr Free-Fall. The object moving in free-fall is a 'bob' that will leave a trail of sparks on a wax paper as it falls through some height H. The sparks will be generated by a spark timer set at a frequency of 60Hz (60 sparks per second). Thus, the trail of sparks on the wax paper will be separated by (1/60)s. Using this information one can obtain data for the position as a function of time for this object in free-fall and use the kinematic equations to analyze its motion.

EQUIPMENT



1. Behr Free-Fall Apparatus
2. Spark Timer
3. Power Supply
4. Tape
5. 2-meter stick

PROCEDURE

1. Draw a circle starting with the 2nd or 3rd spark hole. Label this data point X_o. Now draw a circle on every 6th spark hole for a total of 6 data points.
2. Make a graph of x vs. t with EXCEL for the 6 data points.

X (cm)	t(s)
X_o	t_o
X_1	t_1
X_2	t_2
X_3	t_3
X_4	t_4
X_5	t_5

3. Use EXCEL to obtain the equation of the best curve-fit for x vs. t graph.
4. Calculate V_o at t_o, V_2 at t_2, and V_4 at t_4 by drawing tangent lines to the curve x(t).
5. Use the equation x = x(t) obtained in (3) to calculate V_o, V_2, and V_4.
6. Calculate the acceleration of the 'bob' from the equation x = x(t).
7. Prove **algebraically** that the graph of V_{ave} vs t is linear and show how the slope is related to the acceleration of gravity 'g'.
8. Make a graph of V_{ave} vs t using EXCEL and obtain the equation of the best curve fit. Using the above data table, the data points for the graph of V_{ave} vs t correspond to the following:

V_{ave}	t
$V_{01} = (X_1 - X_o)/(t_1 - t_0)$	$(t_1 - t_0)$
$V_{02} = (X_2 - X_o)/(t_2 - t_0)$	$(t_2 - t_0)$
$V_{03} = (X_3 - X_o)/(t_1 - t_0)$	$(t_3 - t_0)$
$V_{04} = (X_4 - X_o)/(t_1 - t_0)$	$(t_4 - t_0)$
$V_{05} = (X_5 - X_o)/(t_1 - t_0)$	$(t_5 - t_0)$
$V_{05} = (X_6 - X_o)/(t_1 - t_0)$	$(t_6 - t_0)$

9. Calculate the acceleration of the 'bob' from the graph of V_{ave} vs t.
10. Calculate the initial velocity V_o of the 'bob' from the graph of V_{ave} vs t.
11. Calculate instantaneous velocity of the 'bob' V_4 at t_4 graphically.
12. Calculate instantaneous velocity of the 'bob' V_2 at t_2 graphically.
13. Compare the two calculated accelerations of the 'bob' to the expected value of $g = 9.80\ m/s^2$.
14. Compare the velocities at t_o, t_2, and t_4 using the 3 different methods.
15. Prove that if the acceleration is constant, then V_{ave} over a time interval is equal to V_{inst} at the midpoint of the time interval.

GRAPHS

1. x vs. t
2. V_{ave} vs. t
3. V_{ave} vs. t for V_2 at X_2
4. V_{ave} vs. t for V_4 at X_4