Lab Connections

YOUR CONNECTION FOR QUALITY SCIENTIFIC EDUCATIONAL LABORATORY EQUIPMENT

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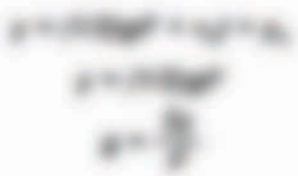
WARNING: ADULT SUPERVISION REQUIRED. PRODUCT IS NOT A TOY. THEY ARE FOR EDUCATIONAL / LABORATORY USE ONLY. THEY ARE NOT FOR USE BY CHILDREN 12 & UNDER.

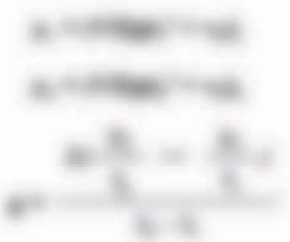
#638-21 The Deluxe Free Fall Apparatus

Method 1:



Method 2:

Method 3:



Calculating Gravitational Acceleration and Initial Velocity

Objectives:

1. Calculate the gravitational acceleration of Earth and compare to the accepted value using multiple methods.
2. Create a displacement vs. time graph to show how the amount of displacement of a free falling object varies with time.
3. Develop and perform a procedure to calculate the velocity of the steel ball as it travels through each of the photogates.
4. Create a velocity vs. time graph to show how the velocity of a free falling object changes through time.

Materials:

1. Deluxe Free Fall apparatus and all included parts
2. Calculator
3. Additional writing paper and graph paper (if needed)

Procedure Part 1: Calculating the Gravitational Acceleration using v_0 and $y_0 = 0$

1. Assemble the Deluxe Free Fall apparatus according to the assembly instructions.
2. Place the electromagnet so that the steel ball is positioned on 0 cm.
3. Place the photogates at positions of your choice. Do not place the photogates very close to each other or very close to the electromagnet. Record these positions in table 1 for trial 1. Proceed through steps 4 – 7 for trial 1.
4. Turn on the Smart Timer and electromagnet. Put a steel ball on the electromagnet. Make sure that the Smart Timer is in "Falling" mode.
5. When you are ready to perform a trial, turn the switch on the Smart Timer to the "Release" position. The timer will start immediately. Record the time taken for the steel ball to reach each of the photogates in table 1. (Remember to include the units: s or ms)
6. Calculate the gravitational acceleration using the times for each photogate and record in table 1.
7. Calculate the percent error of gravitational acceleration from the accepted value, 9.81 m/s^2. Record in table 1.
8. Move all three photogates to different positions on the stand. Repeat steps 4 – 7 for trial 2. Fill in table 1.
9. Create a displacement vs. time graph for a free falling object using all the data from both trials. You should have a total of 6 data points. Describe the graph's trend.

Procedure Part 2: Calculating the Gravitational Acceleration using intervals

1. Place the electromagnet so that the steel ball is positioned on 0 cm.

2. Place the photogates at positions of your choice. Do not place the photogates very close to each other or very close to the electromagnet. Record these positions in table 2 under trial 1. Proceed through steps 3 - 6 for trial 1.

3. Turn on the Smart Timer and electromagnet. Put a steel ball on the electromagnet. Make sure that the Smart Timer is in "Interval" mode.

4. When you are ready to perform a trial, turn the switch on the Smart Timer to the "Released" position. The timer will start immediately. Record the time taken for the steel ball to pass through the interval between the 1st and 2nd photogates and 1st and 3rd photogates in table 2 for the appropriate trial. (Remember to include the units. s or ms.)

5. Calculate the gravitational acceleration and record in table 2.

6. Calculate the percent error of gravitational acceleration from the accepted value, 9.81 m/s^2. Record in table 2.

7. Move all three photogates to different positions on the stand. Record these new positions in table 2 under trial 2. Repeat steps 3 - 6 for trial 2.

Procedure Part 3: Calculating Velocity and Gravitational Acceleration using blocking time

Create a procedure that...

1. Calculates the velocity and gravitational acceleration using the "Blocking-time" mode on the Smart Timer.

2. Gathers data needed to create a velocity vs. time graph.

Perform the procedure and create a velocity vs. time graph. Describe the graph's trend. What does the slope of the graph represent? Calculate the percent error of gravitational acceleration from the accepted value. Create data tables and use additional paper if needed.

Procedure Part 1: Calculating the Gravitational Acceleration using v_0 and $y_0 = 0$

Table 1

Trial	Photogate	Photogate Position (cm)	Free Fall Time	Calculated g (m/s^2)	Percent Error
1	1				
	2				
	3				
2	1				
	2				
	3				

Teacher Notes: Calculating Gravitational Acceleration and Initial Velocity

Procedure Part 1: Calculating the Gravitational Acceleration using v_0 and $y_0 = 0$

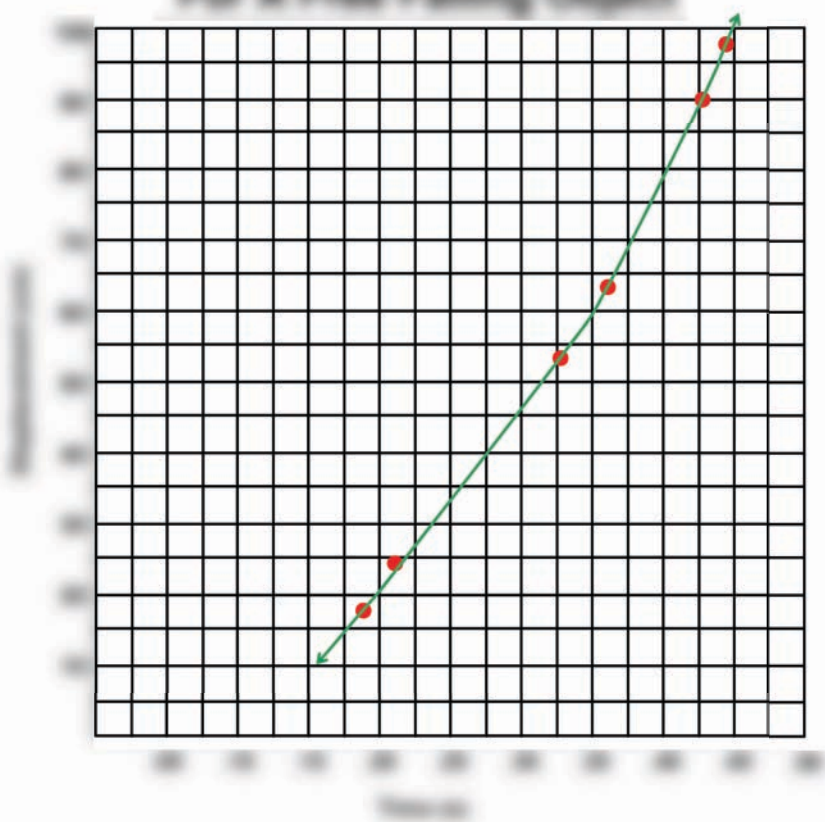
Sample Data

Table 1

Trial	Photogate	Photogate Position (cm)	Free Fall Time (s)	Calculated g (m/s²)	Percent Error
1	1	24	0.2174	10.16	3.57
	2	53	0.3252	9.96	1.63
	3	90	0.4063	9.85	0.41
2	1	17	0.1828	10.17	3.67
	2	43	0.2909	9.89	0.82
	3	80	0.4071	9.87	0.61

Displacement vs. Time

For A Free Falling Object



The graph shows a positive trend in displacement as time increases. There is a slight positive concavity to the trend which means that displacement is increasing at an increasing rate. In other words, the free falling object is accelerating.

Procedure Part 2: Calculating the Gravitational Acceleration using intervals

Table 2

Trial	Photogate	Photogate Position (cm)
1	1	17
	2	63
	3	90
2	1	30
	2	93
	3	77

Table 3

Trial	Photogate Interval	Interval Distance (cm)	Interval Time (s)	Calculated g (m/s²)	Percent Error
1	1 - 2	46	0.1741	9.66	1.5
	1 - 3	73	0.2447		
2	1 - 2	63	0.2013	9.83	0.33
	1 - 3	47	0.1626		

Procedure Part 3: Calculating Velocity and Gravitational Acceleration using blocking time

Sample Procedure and Data:

1. Place the electromagnet so that the steel ball is positioned on 0 cm.
2. Place each photogate at any position on the free fall stand. Record each photogate's position in the table for trial 1.
3. Turn on the Smart Timer and turn the electromagnet to "Attract". Put a steel ball on the electromagnet. Make sure that the Smart Timer is in "Blocking" mode.
4. When you are ready to perform a trial, turn the electromagnet to "Release". Record the blocking time for each photogate in the table.
5. Calculate the velocity of the steel ball as it travels through each photogate given that the diameter of the steel ball is 10mm. Record the velocities in the table below.
6. Do not move the photogates. Switch the mode on the Smart Timer to "Falling" and the electromagnet to "Attract". Place the steel ball on the electromagnet.

7. When you are ready to perform a trial, turn the electromagnet to "Released". Record the time it takes for the steel ball to reach each photogate in the table.

8. Calculate the gravitational acceleration at each photogate from the data. Record in the table.

9. Calculate the percent error of gravitational acceleration from the accepted value ($9.81\ m/s^2$). Record in the table.

10. Move the position of each photogate and record these new positions in the table for trial 2. Repeat steps 1 - 9 for trial 2.

11. Create a velocity vs. time graph using the 6 data points from this procedure.

Trial	Photogate	Photogate Position (cm)	Blocking Time (ms)	Velocity (m/s)	Falling Time (ms)	Gravitational Acceleration (m/s^2)	Percent Error
1	1	10	7.13	2.56	244.3	10.47	6.7
	2	40	5.48	3.30	232.9	9.91	1.0
	3	77	4.91	3.68	364.6	10.11	3.1
2	1	20	6.63	2.65	168.7	10.52	7.2
	2	48	5.65	3.08	210.2	9.83	1.2
	3	85	5.62	4.59	438.7	10.46	6.6

Velocity vs. Time

For A Free Falling Object