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Experiment 1.02: Acceleration Due to Gravity: Vertical Drop

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I. EXPERIMENT 1.02: ACCELERATION DUE TO GRAVITY: VERTICAL DROP

A. Abstract

The acceleration due to gravity is determined using a free falling body.

B. Formulas

$$g = \frac{2}{\Delta t^2}\left(D + d - 2\sqrt{Dd}\right) \tag{1}$$

where d is the distance from the drop point to the first (higher) photogate, D is the distance from the drop point to the second (lower) photogate, and Δt is the time interval for the falling body to move from the higher to the lower gate..

C. Description and Background

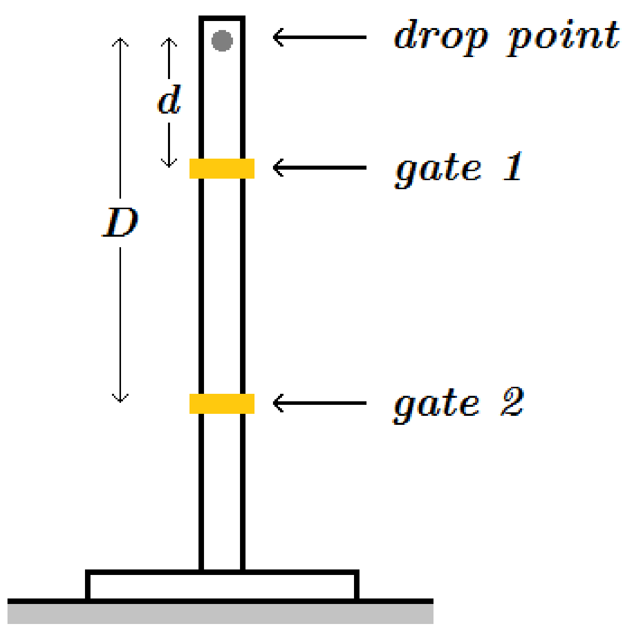

FIG. 1. Drop stand and photogates.

Hisorically, the most well-known gravity experiment is that of Galileo's. He is purported to have dropped items from the top of the leaning tower of Pisa. In fact, he performed *thought* experiments involving free-falling bodies. His (tangible) laboratory experiments involved inclined surfaces in order to prolong the "fall" time. Given the period in history, the ability to make precise measurements, especially of time, was not straightforward, and it took the painstaking work of Giovanni Battista Riccioli and his collaborators to rigoruosly perform the gravity drop experiment. In 1651, he published results from which the acceleration due to gravity could have been inferred to be

$$g = 9.4 \pm 0.2 \; m/s^2$$

in modern SI units [doi: 10.1063/PT.3.1716]. In the current version of the experiment, a small metal sphere is dropped, and its transit time between two arbitrary elevations is measured.

1. Equipment

a. CPO System This system requires manually dropping the ball through the chute at the top of the stand. Use the reset button before each trial drop. The timer will return the interval time from one photogate to the other. When both the A and B console lights are on, the reading is the interval time from the first (higher, A) gate to the second (lower, B) gate.

b. Eisco System The drop stand for this system should be on the floor and the timer on the table. Adjust the base screw so that the stand is perfectly vertical To determine the interval time from the first (higher) gate to the second (lower) gate, switch the timer to *mode* **A**. Reset the timer. This system has a magnetic release. Turn the electromagnet on and attach the metal sphere. When ready, turn the electromagnet off to release the sphere. The console reading will be the interval time from gate one to gate two.

D. Procedure

1. See the Special Instructions on the next page.on how to use the particular timing apparatus in your laboratory.

2. Set the photogates at arbitrary locations along the drop stand. Record the distance from the drop point to the first (higher) photogate, d, and the distance from the drop point to the second (lower) photogate, D.

3. Following the Special Instructions, carefully drop the sphere and record Δt, the time interval for passage from gate one to gate two.

4. Repeat steps 2-3 several times changing the locations of the photogates in each trial.

E. Measurements

trial	d [cm]	D [cm]	Δt [sec]
1			
2			
3			
4			
5			

F. Instructions

1. Make sure the standard error is rounded to one significant figure and that its precision is consistent with that of the average acceleration's.
2. Calculate g in each trial using (1).
3. Take the acccepted value to be $g_{\text{accepted}} = 9.8\ m/s^2$. What is the percent error for your determination of g?
4. How many standard errors is your determination of g away from the accepted value?

G. Calculations

Trial	g [m/s^2]
1	
2	
3	
4	
5	

average acceleration, $\bar{g}$ [m/s^2]	
standard deviation, δg [m/s^2]	
standard error, $\delta \bar{g}$ [m/s^2]	
%-Err ($\bar{g}$)	
$N = \lvert \bar{g} - g_{\text{accepted}} \rvert / \delta \bar{g}$	