Name:

Partner:

Physics 11
M. Lam

Acceleration due to Gravity Lab

Block:

Objective
Determine the acceleration due to gravity *g* using video analysis

Introduction
In this lab, a mass will be dropped from a height of 2.0 m. A frame-by-frame analysis of the mass in free fall will be used to determine the position of the object at set times.

1. Assuming no air resistance, describe the motion of an object in free fall.

2. Determine the frames per second (fps) of your video recorder (e.g. cell phone). Use the factor label method to determine how many frames would correspond to 0.05 s. *If multiple options are available, a combination of high fps and high resolution is best. Use a minimum of 120 frames per second and a minimum resolution of 720p. You should be able to get these settings using slow motion video which can usually be determined in Settings on your phone (for iPhone: Settings > Camera > Record Slo-mo).*

3. Let x_i represent the initial position of an object, x_f represent the final position of an object, and Δt represent the time interval. Write an expression for the average velocity of an object during that time interval in terms of x_i, x_f, and Δt.

4. Explain how the acceleration of an object can be determined using a velocity vs time graph.

Experimental Method

Part 1: Take a Video of a Mass in Free Fall

1. Position two meter sticks vertically, one on top of the other.

2. One student will shoot a video of the motion. The video recorder should be positioned so the camera can capture the full motion of the object while remaining still. Be sure the video is set to a minimum of 120 frames per second and 720p (usually slow motion video).

3. The other student will drop a small mass from the top of the meter sticks. Position the mass such that the bottom of the mass is aligned with the very top of the meter sticks. The mass should be dropped so it remains as close as possible to the meter sticks without touching them.

4. When both students are positioned accordingly, the video recorder will start shooting the video and signal to their partner to drop the mass.

5. Record video of the mass falling until it hits the ground. Remember not to follow the mass with the camera.

Part 2: Video Analysis

6. Open the video on your phone or computer. The playback tool must have a frame-by-frame option which allows you to move through the frames one-by-one. *On an iPhone, you may use CoachMyVideo (free on the App Store). On a computer, you may use QuickTime Player or VLC.*

7. Move to the frame in which the mass is immediately released. This will be your starting time, $t = 0$ s. *Since the mass will not be moving much initially, it may help to use the movement of the hand or fingers to determine this starting time.*

8. Advance forward by 0.05 s. **Do not use the time displayed on the playback tool. Instead, advance by the number of frames calculated in question 2 of Introduction. You will have to keep track of the frames manually.**

9. Determine the position of the mass by using the meter sticks in the video. The bottom of the mass should be used when measuring the position. Record the position in Table 1.

10. Repeat steps 8 and 9 until the mass hits the floor. Do not include any measurements for the time interval in which the mass hits the floor. *If you notice any duplicate frames in which the object appears frozen, ignore them and skip to the next frame.*

11. Complete Table 1 with the following information:
    - **Position:** the position of the mass at the end of the time interval
    - **Displacement during interval**: the difference between the initial and final positions for the time interval
    - **Velocity during interval**: the displacement during the time interval divided by the length of the time interval.

Table 1: Displacement and Velocity Data for a Mass in Free Fall

Time Interval (s)	**Position *x* (m)**	**Displacement during interval *d* (m)**	**Velocity during interval *v* (m/s)**
0.00 - 0.05			
0.05 - 0.10			
0.10 - 0.15			
0.15 - 0.20			

Analysis and Discussion
Draw a graph of position vs. time. Include a best fit <u>curve</u>.

Draw a graph of velocity vs. time. Include a best fit <u>line</u>.

- Note: Use the mid-point of each time interval to plot velocity values. (e.g. the velocity for 0.05 s - 0.10 s should be plotted at 0.075 s)

Determine the slope of the best fit line. Clearly mark the points on the line used to calculate the slope (e.g. with an ×). Be sure to include units. What quantity does the slope represent?

Compare your experimental result for the acceleration due to gravity to the accepted value. Determine the percent error.

Discuss the sources of error.

Conclusion
Briefly summarize what you did in the lab to achieve the objective.

Restate the your final experimental value of *g* along with a comparison to the theoretical value.

Component	Criterion	Weight	Mark
Introduction	*Objective and introductory questions*	1	
Experimental Method	*Procedure*	1	
Data	*Data quality and presentation*	2	
Analysis and Discussion	*Plot of position vs. time*	1	
	Plot of velocity vs. time	1	
	Calculating and interpreting the slope of the velocity vs. time graph	1	
	Theoretical slope of the velocity vs. time graph and percent error	1	
	At least two significant sources of error	1	
Conclusion	*Summary of the experiment and final results*	1	
TOTAL		10	