Freely Falling Body

Key Terms: Position, velocity, acceleration

Objective: The purpose of this experiment is to measure the position, velocity and acceleration of an object in free fall to determine the acceleration, *g*, of an object in free fall close to the earth's surface due to gravity.

Equipment: A spark tape, a meter stick.

Physics Theory: Recall the relationship for distance in terms of time and initial velocity for a freely falling body is:

$$y - y_0 = v_0 t + \frac{1}{2} g t^2$$

For an object in free fall starting from rest at height $y_0 = 0$, this relationship may be written:

$$y = \frac{1}{2} g t^2$$

where g = -9.80m/s^2 close to the earth's surface (if one ignores the effects of air friction).

Experimental: In this experiment you will use a tape created by a spark apparatus. This device consists of a metal plummet suspended between two long wires. One of the wires is connected to a high voltage spark generator while the other is connected to ground. When the plummet is released it falls between the two wires to the ground. If a paper tape is placed between the plummet and one of the wires, a spark will travel from the high potential wire, through the tape and plummet, to the low potential wire leaving a small hole in the tape. If the spark generator is set up to produce sparks at regular time intervals, a series of small holes will be produced in the tape at increasing distance intervals.

Without synchronizing the spark generator with the release of the plummet, we do not have enough information make a quantitative statement about exactly when $t = 0$. As it turns out, we do not know exactly where $y = 0$ either. It is possible, however, to determine the velocity and acceleration of the plummet as functions of *position* by measuring the discrete distance between spark holes (Δy) at a fixed time interval (Δt).

You will be provided with a tape that has already had the spark holes burned into it by the plummet apparatus. You are to guess the distance from the first hole (y_1) to the point y_0, and mark this point on the tape. You will then measure, as accurately as possible, the distance from the point y_0 to each successive spark hole in the tape.

Data Analysis: Let's define y_i as the distance to spark hole i from some arbitrary point $y = 0$ (y_0), approximately near where $y = 0$ should be (along the same line as the other spark holes). The time from release of the plummet to the i^{th} spark hole is $t_i = t_0 + i\Delta t$, where we do not know t_0. The average velocity between spark hole i and spark hole $i + 1$ is $v_i = \Delta y_i / \Delta t$ where $\Delta y_i = y_{i+1} - y_i$. The average acceleration is then $a_i = \Delta v_i / \Delta t$ where $\Delta v_i = v_{i+1} - v_i$.

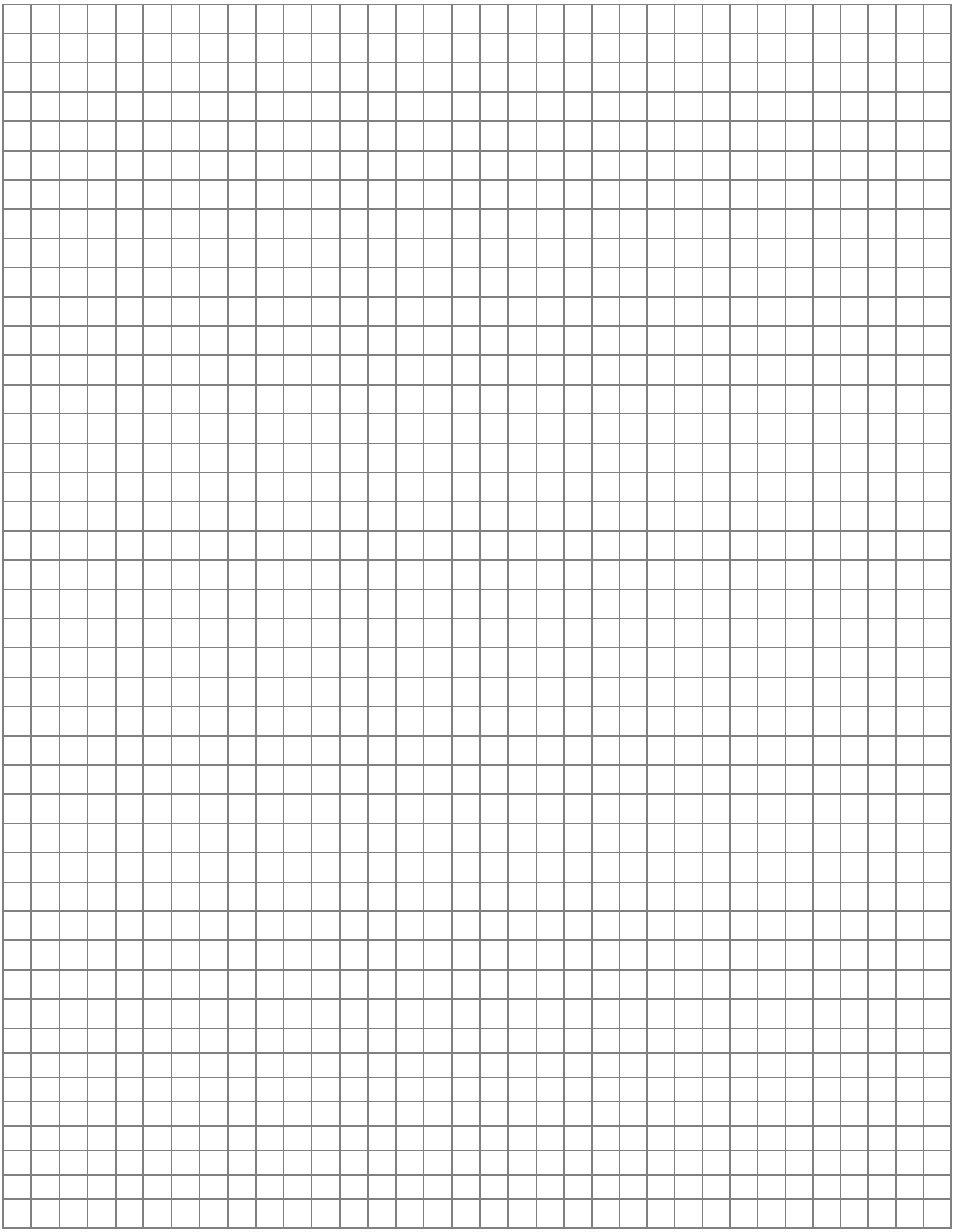
When you examine the data you will notice that the values for y_i increase with each data point, showing the total distance the plummet has moved. You will also notice that the *first difference* Δy_i, which is proportional to the plummet's velocity, increases with each data point due to the increasing distance the plummet falls during each successive fixed interval of Δt (because the plummet is accelerating). The second difference Δv_i increases with each measurement due to the increased velocity. The acceleration of the plummet itself is given last. Since the purpose of this procedure is to determine the acceleration due to gravity of an object in free fall, compute a mean and standard deviation for this column.

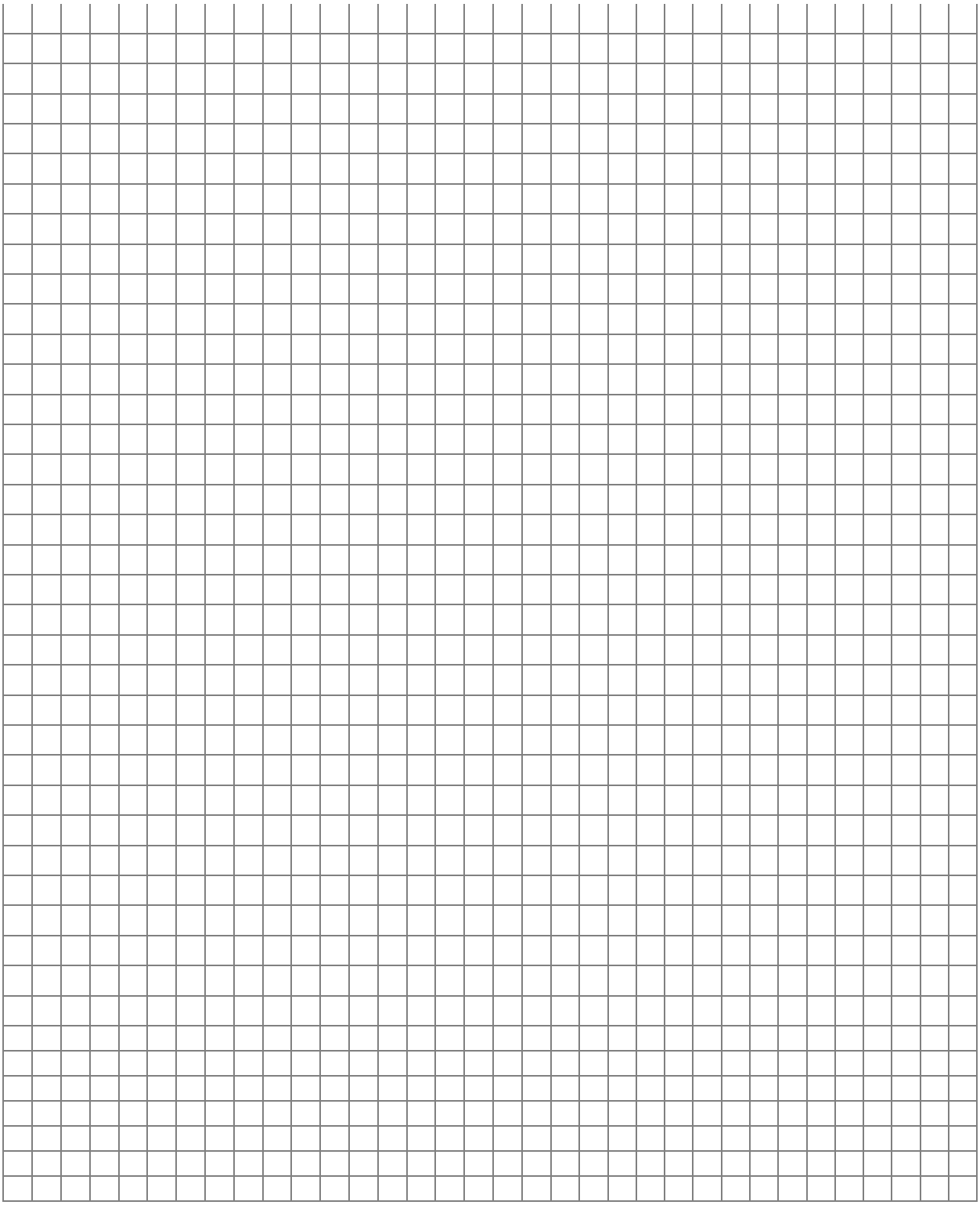
y measurements		Δ y		v=Δy/Δt		Δv		g=Δv/Δt	
y_0=									
y_1=		y_1-y_0=		v_1=					
y_2=		y_2-y_1=		v_2=		v_2-v_1=		g_1=	
y_3=		y_3-y_2=		v_3=		v_3-v_2=		g_2=	
y_4=		y_4-y_3=		v_4=		v_4-v_3=		g_3=	
y_5=		y_5-y_4=		v_5=		v_5-v_4=		g_4=	
y_6=		y_6-y_5=		v_6=		v_6-v_5=		g_5=	
y_7=		y_7-y_6=		v_7=		v_7-v_6=		g_6=	
y_8=		y_8-y_7=		v_8=		v_8-v_7=		g_7=	
y_9=		y_9-y_8=		v_9=		v_9-v_8=		g_8=	
y_{10}=		$y_{10}-y_9$=		v_{10}=		$v_{10}-v_9$=		g_9=	
y_{11}=		$y_{11}-y_{10}$=		v_{11}=		$v_{11}-v_{10}$=		g_{10}=	
y_{12}=		$y_{12}-y_{11}$=		v_{12}=		$v_{12}-v_{11}$=		g_{11}=	
y_{13}=		$y_{13}-y_{12}$=		v_{13}=		$v_{13}-v_{12}$=		g_{12}=	

average of g _____

standard dev. of g _____

percent error _____





Questions for Thought

1. How do you know, from the data, that the velocity is increasing in this experiment?

2. In the data sheet what column indicates that acceleration is uniform? Why?

3. On a separate sheet of paper make a plot of velocity vs. time from your data. What does this plot tell you?

4. On a separate sheet of paper make a plot of acceleration vs. time from your data. What does this plot tell you?