Phy 100's Lab — Acceleration in free fall

Name______________________________ **Course & Section___**

Lab Partner_________________________ **Date______**

As you will see demonstrated, a falling mass will leave a recording of its position as it falls by passing electrical sparks through a paper tape 60 times per second. From measurements of the distances between points on the tape, you can determine the object's acceleration. This is the objective of this experiment. The tapes have been prepared earlier so the only apparatus you will need is a dial caliper. (Note: Some tapes have holes instead of burn marks because they are copies made by pushing a sewing pin through originals.

1. Look at the tape and notice how the spark-dots are farther apart from one another on one end of the tape than the other. State how you can tell which end of the tape was at the top of the free-fall apparatus? If that's readily apparent, you already have a good intuitive understanding of free fall and other motion with constant acceleration; we want to build a precise understanding on that foundation.

2. Find the first clear, sharp dot at the <u>low-speed end</u> of the tape. To make sure it's really a spark dot, and not a stray mark, examine the spacing of the next few dots. If you notice any gaps where a spark-dot seems to be missing, use another tape. If you have any doubts about whether it is really a spark dot, ignore it and find the first one that is definitely a spark dot. Put a little circle around it. (That way, you won't risk confusing it with the stray marks the tape will pick up as you handle it.) Then label it with a <u>zero</u>. This zero-point will be a reference point for later measurements, so If you're not sure, ask the instructor to check the tape. Please note that the mass was already moving at a substantial speed when this initial dot was produced, as is clear once you inspect the free-fall apparatus carefully.

Put circles around the rest of the spark-dots and label them in sequence 1, 2, 3, 4, 5.... You can stop when you get to number 16.

In the steps to follow, you will measure two distances on the tape, one near the low-speed end and one near the other end, from which two velocities can be calculated. From two velocities separated in time, you will be able to figure out the average acceleration the falling mass experienced.

3. First measure the distance from the zero-point to dot #6 using the dial caliper, and record the value in the space below in both millimeters and meters to the proper number of significant figures.

The space between any two neighboring spark-dots represents how far the mass fell during a time interval of 1/60 s (or 0.016667 s). That means that between dot zero and dot #6, the weight fell for 6/60 s, which is the same as 1/10 s or 0.1000 s in decimal form. Now you have the data you need to find the mass's average speed during this interval. Using the time interval 0.1000 s and your measured distance in meters, calculate the average speed and record it below. (Time data comes from the spark generator at a reported precision of 4 significant figures, therefore your average speed below cannot have more than 4 significant figures.)

Think for a minute about this speed; it's an *average* value because after all, the speed was not constant but increasing as the mass fell from dot zero to dot #6. Therefore, this average must be *higher* than the instantaneous speed the mass had at the zero-point, but *lower* than the speed it had when it reached dot #6. You can see from the pattern of dots that the speed increases smoothly at a uniform rate; otherwise we couldn't even talk about a uniform or constant single value for acceleration. Thus, during the first 0.05 seconds, the speed increased by the same amount as it would in the second 0.05 seconds. This implies that the average speed you just calculated must be exactly equal to the instantaneous speed at the *mid-point* in the interval — the speed the mass had at dot #3.

4. Pick another set of dots farther down the tape that shows where the mass fell during a time period 2/60 seconds long. Points #14 to #16 should work, if those dots are sharp and clear. Don't use a pair of adjacent dots (like 13 and 14), since without a dot in-between, we wouldn't know the mass position at mid-interval. Instead, be sure to pick dots that define the beginning and end of an interval that are separated by one other dot that shows where the mass was at exactly half-time (1/60 s) during the total 2/60 s falling interval. (As points 14 and 16 are separated by 15). Specify below which dots you are using.

Measure the distance over this interval using the dial caliper. Again, record the distance in both millimeters and in meters to the appropriate number of significant figures.

What is the duration in seconds of the time interval between these two sparks, expressed both as a fraction and as a decimal? Give the decimal value to at least five decimal places.

From this second set of time-interval and distance data, find the average speed during this interval.

Considering that the change in velocity is uniform over time, steadily increasing just as much in the second 60th of a second as it did in the first, and following the same sort of reasoning as in the discussion for step #3…, at which dot position was the *instantaneous* speed of the falling mass exactly equal to this *average* speed you just calculated?

5.   To get the acceleration, we need to know the change in instantaneous speed as the mass fell from one position to another and divide that by how much time the change took. First, just take the *difference* between the instantaneous speeds calculated in steps 3 and 4 to get the speed change. This is your delta V or Δv:

Next, figure out how much time this speed change actually took, first in 1/60-ths of a second, and then as a decimal. ***You already wrote down at which dots the two different instantaneous speeds occurred, so this is the amount of time that passed as the mass fell from the first to the second of these two dots.*** Think about it carefully and ask your instructor if you are not absolutely certain! This is your delta t or Δt:
.

Computing the acceleration is just one more step: divide the Δv by the Δt it took to occur and record the result to the correct number of significant figures. Use the formula for percent error to compare your answer to 9.803 m/s^2, a more precise documented "book value" for the acceleration due to gravity in the New Haven area.

Is your experimental value greater or less than the documented "g"? Guess more than one reason for the discrepancy and explain what function or malfunction of the apparatus might have caused them.