Phy 200/210 Lab — Acceleration in free fall

Name_______________________________ **Date**__________

Lab Partner_______________________________________ **Section**___________

As you will see demonstrated, a falling weight will leave a recording of its position as it falls by passing electrical sparks through a waxed paper tape 60 times per second. The space between any two neighboring spark-dots represents how far the weight fell during a time interval of 1/60 s. 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. The caliper dial is graduated in increments of 0.1 mm (0.0001 m). Measurements of this precision will be needed for meaningful data, so the dial should be carefully zeroed before beginning the experiment.

1. Find the first clear, sharp dot at the low-speed end ("top") of the tape and 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 zero. This zero-point will be a reference point for later measurements, so examine the spacing of the next few dots to make sure it's really a spark dot and not a stray mark. If you're not sure, ask the instructor to check the tape. Please note that the weight 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.... If you notice any gaps where a spark-dot seems to be missing, use another tape. The very last dot on the tape should be ignored since it is usually made after the falling weight hits bottom.

2. First measure the distance from the zero-point to dot #2 and record the value in the table below. Between dot zero and dot #2, the weight fell for 2/60 s (0.03333 s in decimal form.) Make sure you record the distance to within 0.1 mm. *If you get a distance that is an exact integer number of millimeters, write it with a place holder zero after the decimal point to show the full resolution of the measurement.*

To fill in the other columns on the table, measure the distances for the spark-dots indicated. At the high-speed end of the tape, the calipers may not be large enough to measure the distance in one step. You can instead measure from the first dot in the interval to the dot in the middle of the interval, and add it to the distance from the middle dot to the next one.

Then for each interval, convert the distance in millimeters to meters and compute the average velocity over that interval in meters per second. Since the distances are known to three or four significant figures, and the time interval is typically regulated by the electrical grid operator to three or more significant figures, the speeds should be recorded to four significant figures to avoid errors from premature round off. For a speed between 1 and 10 m/s, this means recording the speed in m/s to three decimal places.

Table 1. Distance of fall during specified intervals on spark-timer tape.

Spark-dot interval	Midpoint dot #	distance / mm	distance / m	average velocity / (m/s)
0 – 2	1			
3 – 5	4			
6 – 8	7			
9 – 11	10			
12 – 14	13			
15 – 17	16			
18 – 20	19			
21 – 23	22			

Think for a minute about the average speed for an interval. For example, take the first interval from spark dot zero to spark dot #2. It's only an *average* speed because the speed was changing as the weight went from the zero-point to dot #2. This average must be *higher* than the instantaneous speed at the zero-point, but *lower* than the speed at dot #2. From the pattern of dots, we might hypothesize that the speed increases smoothly at a uniform rate, at least over any one brief interval. That implies that this average speed you just calculated must be equal to the instantaneous speed at the *mid-point* of the interval. (Here we mean the midpoint in *time*. Since the speed is not constant, this is different from the midpoint measured in distance units along the tape.) For the interval between dot zero and dot #2, the midpoint in time is simply dot #1 and the average speed over that interval must be the instantaneous speed at dot #1. So our table is also a table of instantaneous speeds – the speeds the falling weight had at the midpoints of each of the measured intervals.

To find the acceleration, we first take the difference between two instantaneous velocities. Then we divide this difference by the time elapsed between the points corresponding to those velocities. For example, 12/60 s is the time elapsed between point #1 and point #13 since there are 12 "spaces" between those two dots on the tape.

3. Calculate the average acceleration in m/s/s for the time period from dot #1 to dot #13 and enter it in the space below, showing the calculation, not just the result. The result should be given to three decimal places.

4. Now calculate the average acceleration for the time period from dot #4 to dot #16.

5. Now calculate it for the time period from dot #7 to dot #19.

6. Finally, calculate it for the time period from dot # 10 to dot #22.

7. Is there any trend in your acceleration values? Do the accelerations appear to be increasing or decreasing systematically as you go down the tape or do they appear to be basically steady with only random fluctuations from one to another?

8. Find the average of your four acceleration values. Again, show your calculations as well as your result.

9. What is the percentage discrepancy between your average value and the standard value for the New Haven area of 9.803 m/s/s? As always, show the calculation.