Lab 1: Waves on a String

Graded

20 Hours, 56 Minutes Late

Student

Fady Youssef

Total Points

89 / 97 pts

Question 1

Data Tables

8 / 8 pts

✔ **– 0 pts** Correct

– 1 pt Missing units

– 1 pt Incorrect units

Nice! Super well organized, which is helpful for me.

Question 2

Regression Plots

10 / 10 pts

✔ **– 0 pts** Correct

– 2 pts missing titles

Question 3

Four-Line Summaries

15 / 15 pts

✔ **– 0 pts** Correct

– 2 pts missing aggrement

– 2 pts unclear titles

– 4 pts missing regressions from LINEST

– 4 pts incorrect units

Question 4

Questions

15 / 15 pts

✔ **– 0 pts** Correct

1 or that since we are applying no tension, that we get no waves. maybe provide some more detail about the "offset", which is the b of y = mx +b you are referring to.

2 good, would be good to see equation 5 here so we can see this result mathematically

3 nice!

Question 5

Error discussion worksheet

14 / 15 pts

– 0 pts Correct

– 1 pt Point adjustment

4 Your slope and y-intercept for the string both disagreed with expect values.

5 You need to propose sources of systematic error that explain the direction in which your results were wrong. In your case, what could have caused the slope to be too large? And what could have caused the y-intercept to be too low? I won't count off this week, but in the future this is the sort of explanation I'm looking for.

6 You need to tell me what the reading error is for each measurement. For example, the reading error in the length of the string was 0.1 cm. -1

Question 6

Sample calculations

9 / 9 pts

✔ **– 0 pts** Correct

– 2 pts missing uncertainty calc

Question 7

Challenge

18 / 25 pts

– 0 pts Correct

– 7 pts Point adjustment

Questions assigned to the following page: 1, 2, and 3

String

L (cm)	176.7

frequency (Hz)
120

N (#)	M (g)
9	52
6	117
8	66
5	169
4	266
3	478

λ (cm)	μ (g/cm)	μ avg (g/cm)	μ STDEV (g/cm)	μ SE (g/cm)	μ AE (g/cm)
39.26666667	0.002297533	0.0023120	1.91079E-05	7.80078E-06	1.52895E-05
58.9	0.002297533				
44.175	0.002304079				
70.68	0.002304624				
88.35	0.002321534				
117.8	0.002346626				

μ (g/cm)
Result: 0.002298 +/- 0.000015
Range: 0.002283 to 0.002313
Expected Range: 0.002278 to 0.002311
Agree? Yes

L_1 (cm)	90
L_2 (cm)	91.3
m (g)	0.208

μ (g/cm)
0.002311111
0.002278204

Yarn

L (cm)	176.7

frequency (Hz)
120

N (#)	M (g)
11	61
7	144
4	435
5	268
3	750
8	102

λ (cm)	μ (g/cm)	μ avg (g/cm)	μ STDEV (g/cm)	μ SE (g/cm)	μ AE (g/cm)
32.12727273	0.004026138	0.003761492	0.000165464	6.75504E-05	0.000132399
50.48571429	0.003848859				
88.35	0.003796494				
70.68	0.00365467				
117.8	0.003681944				
44.175	0.003560849				

μ (g/cm)
Result: 0.00376 +/- 0.00013
Range: 0.00363 to 0.00389
Expected Range: 0.00358 to 0.00377
Agree? Yes

L_1 (cm)	90
L_2 (cm)	94.8
m (g)	0.339

μ (g/cm)
0.003766667
0.003575949

String

linear regression calculations

λ (cm)	$λ^2$ (cm²)	M (g)	expected slope bounds (g/cm²)
39.26666667	1541.871111	52	0.033924567
58.9	3469.21	117	0.033441523
44.175	1951.430625	66	
70.68	4995.6624	169	
88.35	7805.7225	266	
117.8	13876.84	478	

	Slope (g/cm²)	Y-Intercept (g)
Result	0.034537277	-2.309907539
SE	0.000122005	0.857909347
AE	0.00023913	1.681502321

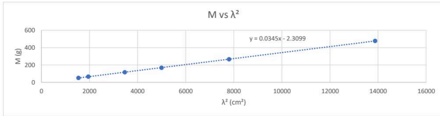
Yarn

linear regression calculations

λ (cm)	$λ^2$ (cm²)	M (g)	expected slope bounds (g/cm²)
32.12727273	1032.161653	61	0.05529052
50.48571429	2548.807347	144	0.052491
88.35	7805.7225	435	
70.68	4995.6624	268	
117.8	13876.84	750	
44.175	1951.430625	102	

	Slope (g/cm²)	Y-Intercept (g)
Result	0.054084236	2.985495836
SE	0.000643155	4.469983057
AE	0.001260583	8.761166791

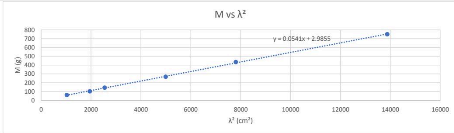
String



Slope (g/cm²)
Result: 0.0345 +/- 0.0002
Range: 0.0343 to 0.0347
Expected Range: 0.0334 to 0.0339
Agree? No

Y-Intercept (g)
Result: -2.3 +/- 1.7
Range: -4 to -.6
Theory: 0
Agree? No

Yarn



Slope (g/cm²)
Result: 0.0541 +/- 0.0013
Range: 0.0528 to 0.0554
Expected Range: 0.0525 to 0.0553
Agree? Yes

Y-Intercept (g)
Result: 3 +/- 9
Range: -6 to 12
Theory: 0
Agree? Yes

Challenge

frequency	length (cm)	λ (cm)	mass (g)
115	176.8	44.2	251.8337597

MD (challenge)

mass string (g)	length string (cm)	mass density string (g/cm)	MD avg (g/cm)
0.862	90	0.009577778	0.009561868
0.862	90.3	0.009545958	

No questions assigned to the following page.

Question assigned to the following page: 5

Error Discussion Worksheet:

1. - Measuring the length of each string.
   - Measuring the stretched length of each string.
   - Possible slight reading error when weighing each string.

2. The most recurring source of of random error is when trying to observe the # of waves and the oscillations in them. While trying to adjust added mass or something gets bumped or moved, the oscillation behavior changes due to change in tension, making it harder to judge and observe sometimes causing the oscillation height increase then after trying it a different time decrease, showing possible random error going in either direction. Another prominent source of random error was sometimes after tying the string to the added mass, we would notice the string would slightly loosen at times and even be completely untied which could have given us varied inaccurate results if it was even slightly loosen from what it should have been. During the lab, another source of random error may have come when marking the stretched length with the used marker as it is wide and may have marked over or under our actual result causing further random error.

3. Based on the experimental results, there is evidence of systematic error in the lab, especially during the string experiment. This is evident from the discrepancy in the y-intercept values, which deviate from the expected theoretical range. The most likely source of this systematic error is the lower mass density of the string and its constant stretching under tension, which may have altered its physical properties and affected the accuracy of the measurements.

4. The most likely source of this systematic error likely comes from the lower mass density of the string and it being constantly stretched by the added mass leading to deformation of the string. This can cause significant variation in our result, and can cause incorrect values when trying to determine the tension or wave properties since the wave isn't in its original form during the entire experiment. Another possible source of systematic error comes from the table or string being unleveled. Despite having the leveling tool, it was hard to determine whether the string was fully leveled since as humans, our hands aren't going to be perfectly steady directly under the line of the string to check if it's leveled which we noticed the table often being unleveled despite us thinking it was before. This can likely lead to minimal inaccuracy though it may have caused larger errors and definitely caused some discrepancies within the data.

Question assigned to the following page: 4

Questions:

1. Thinner strings typically have lower mass density making it easier to vibrate at higher frequencies with less attached mass. Thicker strings have more mass density thus requiring more attached mass to produce the same number of waves because there is more being moved.

2. Given equation 7, the experiment with f = 800 Hz would've required more hanging mass overall to produce the same values for N as with f = 120Hz. As there is a higher frequency, it takes significantly more mass in this case to be able to split up and observe the oscillations with the same results as f = 120 Hz. After calculating with the trial of 61 grams and 11 half wave-lengths, we get the mass of 61 * (800/120)^2 = 2.64 kg which is far larger than any added mass we've added. This shows if we want the same results as 120 Hz and lower half wave-lengths, this will lead to needing even more weight to get the same observable results.

3. The y-intercept should be zero because that is the theoretical value for the relationship between the mass and frequency/wavelength to start at the origin with no offset

Questions assigned to the following page: 6 and 7

Sample calculations — Fady Youssef

1) Wavelength of first standing wave

$2^{L}/N \Rightarrow 2 \cdot \frac{176.7\text{ cm}}{11} \approx 32.13\text{cm} = \lambda$

2) • Minimum expected mass density

$\frac{m}{\lambda_2} \Rightarrow \frac{.339\text{g}}{94.8\text{cm}} \approx .00358\text{ g/cm} = \mu$

• maximum expected mass density

$\frac{m}{\lambda_1} \Rightarrow \frac{.339\text{g}}{90\text{cm}} \approx .00377\text{ g/cm} = \mu$

3) expected slope bounds :(

$$\begin{cases} .037\overline{667}\text{ g/cm}((120\text{ Hz})^2) \cdot \frac{1}{981\text{ cm/s}^2} \approx .05529\text{ g/cm}^2 \\ .035759\text{ g/cm}((120\text{ Hz})^2) \cdot \frac{1}{981\text{ cm/s}^2} \approx .052491\text{ g/cm}^2 \end{cases}$$

4) uncertainties

stdev.s(μ_yarn) = .0001655 g/cm std dev

$\hookrightarrow \frac{.0001655\text{ g/cm}}{\sqrt{6}} = .00006755\text{ g/cm}$ se

$\llcorner .00006755\text{ g/cm} \cdot 1.96$

$\Rightarrow .00013\text{ g/cm} \pm E$

Conditions

frequency: 115 Hz

\# antinodes 8

Predicted mass: ~~242~~ ~~247~~ 252

Actual mass: 242. 4.1%.

Points: 18