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Lab 1 - Pendulum

Part 1

Method

In Part 1, we are trying to identify whether or not the period of a simple pendulum is independent of its amplitude. To accomplish this in Part 1, we will measure the period of a simple pendulum of a fixed length and mass, while varying the starting angles the pendulum is swung from. We will be timing these periods with the digital stopwatch from Lab 0.

We estimate that the period is independent of the amplitude, due to the supposed equation:

$$T = 2\pi\sqrt{\frac{l}{g}}$$

We will use a 32.5cm +/- 0.5cm string and a 200g mass. Our method of conducting this experiment was very similar to that of our neighboring group as we both used a 200g mass. However, the neighboring group had a string length of 40.0 +/- 0.5cm long.

Data

The table below shows our four measurements of pendulum angle (amplitude), the period (time in seconds), and the 6 pairwise T score comparisons.

Amplitude Angle (°) +/- 0.5°	Time (s) +/- 0.01s
10°	0.99
30°	1.03
40°	1.08
70°	1.09

Amplitude Angle (°) +/- 0.5°	T SCORES (pairwise)	Results
10 to 30	2.828427125	inconclusive
30 to 40	3.535533906	distinguishable
40 to 70	0.7071067812	indistinguishable
10 to 70	7.071067812	distinguishable
30 to 70	3.535533906	distinguishable
10 to 40	6.363961031	distinguishable

$$\frac{|1.09 - 1.08|}{\sqrt{0.01^2 + 0.01^2}}$$
$$= 0.707107$$

above is an example of how we calculated the T score for each pair

Conclusion

The data we collected for Part 1 does not support the claim that the amplitude of the pendulum swing is independent of the period. Ideally, we would want to see all pairwise T-scores be ~ <=1, meaning all of them are indistinguishable from each other, and thus indicate that regardless of the angle the pendulum swung from, the periods were all very similar. However, we only attained one T-value less than 1.0 for the pairwise between 40° and 70°. Thus, according to our data the amplitude of the pendulum does have some impact on the period (even though we know this in practice to be false).

This can be attributed to outside factors and human error such as pressing the start and stop of the stopwatch at inconsistent times as there are definite inaccuracies in the start and stop times of the digital stopwatch when controlled by people, as opposed to computer software. Another possible factor also attributed to human error could be swinging the pendulum from inexact angles.

Part 2

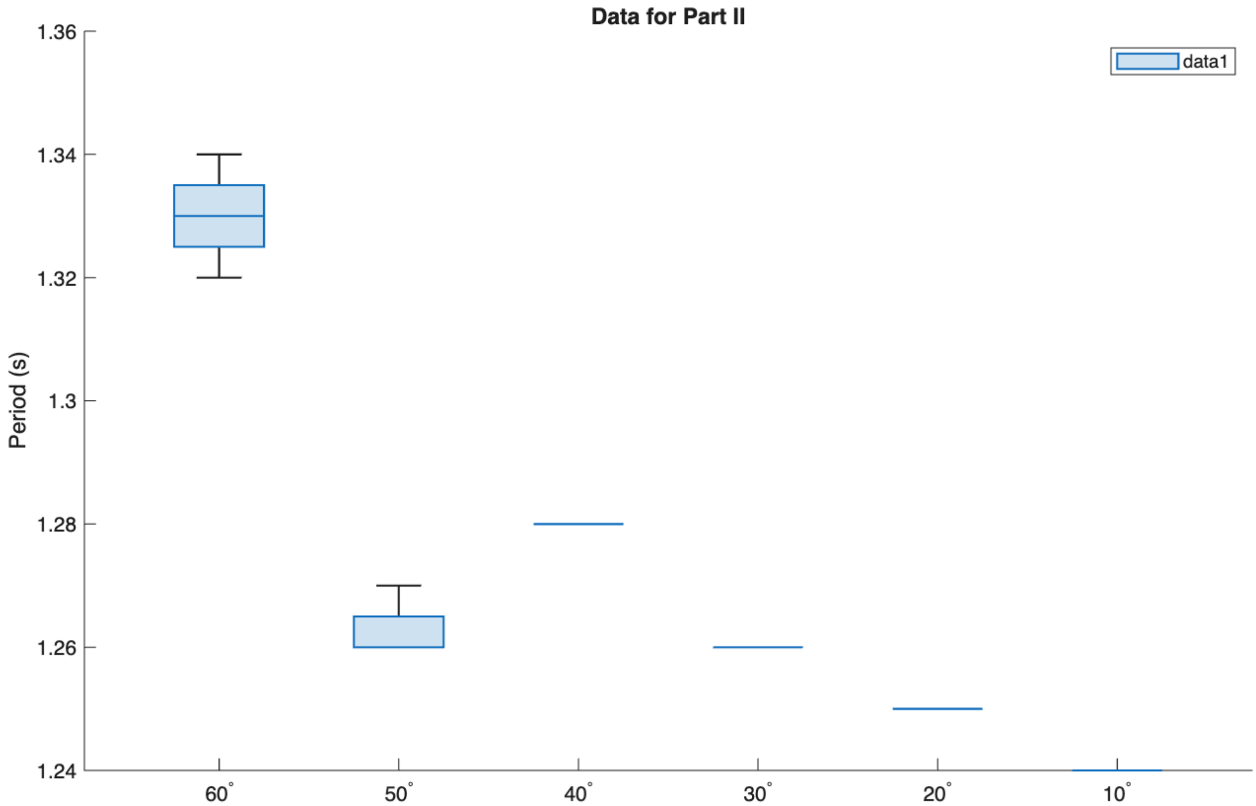
Method:

In Part 1, our systematic error was far larger than our random error. This can be attributed to factors such as human error and the inexact use of the instruments. To improve on the precision of our measurements we will be using computer software PASCO photogate to compute the swing period. This eliminates many error factors such as reaction time and physical button delay.

We will conduct an experiment similar to the one in Part 1. We are using the same pendulum length of approximately 32.5cm and a mass of 200g and will attain 6 total measurements at varying amplitude angles.

Data

Below is a box plot that displays the average period (s), per angle of the swing tested (°).



Just like in Part 1, we hand-computed the T scores (pairwise). Our uncertainty for all measurements is 0.01s.

Amplitude Angle (°) +/- 0.5°	T Scores (pairwise)	Results
10° to 20°	0.707	Indistinguishable
10° to 30°	1.414	Inconclusive
10° to 40°	2.828	Inconclusive
10° to 50°	1.767	Inconclusive
10° to 60°	6.364	Distinguishable
20° to 30°	0.707	Indistinguishable
20° to 40°	2.121	Inconclusive
20° to 50°	0.707	Indistinguishable

20° to 60°	5.656	Distinguishable
30° to 40°	1.414	Inconclusive
30° to 50°	0.354	Indistinguishable
30° to 60°	4.950	Distinguishable
40° to 50°	1.414	Inconclusive
40° to 60°	3.536	Distinguishable
50° to 60°	4.050	Distinguishable

Similarly to Part 1, our experimental design was very similar to our neighboring group's. We both used PASCO photogate to attain a more precise measurement, conducted 6-8 runs, and used a 200g mass. However, our design did differ in that our group noted the average of 4 periods for each run and our neighboring group noted the average of over 10 periods for each run. Additionally, our group stayed consistent with the person who swung the pendulum from each angle, while the members of our neighboring group took turns releasing the pendulum.

Conclusion

For our experiment in Part 2, using PASCO photogate, we obtained inconclusive results of the independence of a pendulum's period on the amplitude of the swing. This aligns with the conclusion that we attained in Part 1. Only 4 out of 15 of our pairwise T scores were <= 1, which indicated that the values were indistinguishable; while 6 out of 16 of our T scores were between 1 and 3, indicating inconclusive results. Thus, we were unable to determine if a pendulum's period is entirely independent or dependent of the amplitude of the swing.

We attribute the differences of measurement to human error in the dropping/swinging of the pendulum (accidental pushes, pulled, etc.)

Our method in Part 2 was more precise than our method in Part 1, as we used the PASCO photogate platform to attain our data and conducted multiple trials per run (varying angle degrees). This helped account for some human error and confounding factors that were present in our method in Part 1. We still experienced some human error in the dropping of the initial pendulum swing, but PASCO photogate eliminated the majority of the time recording errors. We are not entirely confident in our conclusion, and believe that further trials should be conducted.