Period of a Pendulum (Part 1)

Lab Notebook

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Date:	2025/10/17
Course:	PHYS 13100 2
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A reminder: when completing your lab notebook, it's preferable to answer in short sentences and bullet points rather than long paragraphs. You don't need to use full sentences or any formal format… this record is *for you*, and the TA is just looking for it to be complete.

A note on symbols and equations: Inserting symbols and equations into your notebook is possible, but not always quick and easy (especially if you've never had to do it before). We don't want you to spend a lot of time figuring out formatting when you could be spending that time on physics. So consider the following shortcuts as you fill out your notebook.

-You can insert an equation by selecting "Insert: Equation" from the menu bar
-If you can't find a symbol in the "Insert: Special Characters" menu, then spell then spell the symbol out (for example... pi, delta_x, B_exp, +/-)
-If you need to do a long block of math, it may be quicker to write it out on a piece of paper and take a picture.

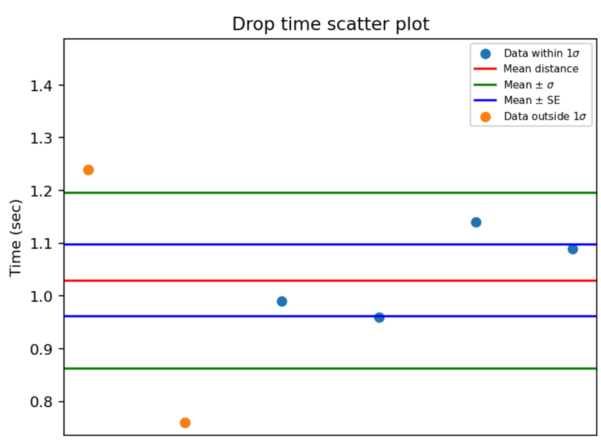
Dropping paper: a quick statistics lesson

Give a short description (1 or 2 sentences) of how you dropped your paper and determined the fall time. Record your data here. What is your answer to "How long does it take for a piece of paper to fall 1 m?"

Table 1.1: Data for Dropping Paper Experiment

Trials#	*Measurement (s)*
1	*1.24*
2	*0.76*
3	*0.99*
4	*0.96*
5	*1.14*
6	*1.09*
Mean	*1.03 ± 0.24*

We set up the meter stick on a roughly perpendicular surface on top of the table, dropping the paper from the top of the meter stick and then recording the time it takes for the paper to fall onto the table below. We used six trials to determine the mean of the trials to factor in random uncertainties arising from air resistance or the path of the paper.



After the group discussion and after talking to a neighboring group, feel free to revise or add to your answer here. Are you in agreement with the neighboring group? Do you have any ideas for why or why not?

The data we have is not in agreement with neighboring groups. While we got 1.03 s, some groups got 1.32s and 0.63s. This is in a reasonable range since the uncertainty is considerably *big (± 0.24), so as that of the other groups, and the big uncertainty explains the fluctuation of the result.*

The period of a pendulum

Record your data, observations, and thoughts here. Include information about your procedure (including pictures), your predicted period, and your values (with uncertainties) for angles *θ* < 10°.

(Predicted period: 1.23 seconds)

```
# L is the length of your pendulum (in meters)
L = 0.377

# T_predicted is the value of the period predicted from the formula (in seconds)
T_predicted = 2*np.pi*np.sqrt(L/9.81)

print("Predicted Period: T = ", T_predicted, "seconds")
```

```
Predicted Period: T =  1.2317314763581602 seconds
```

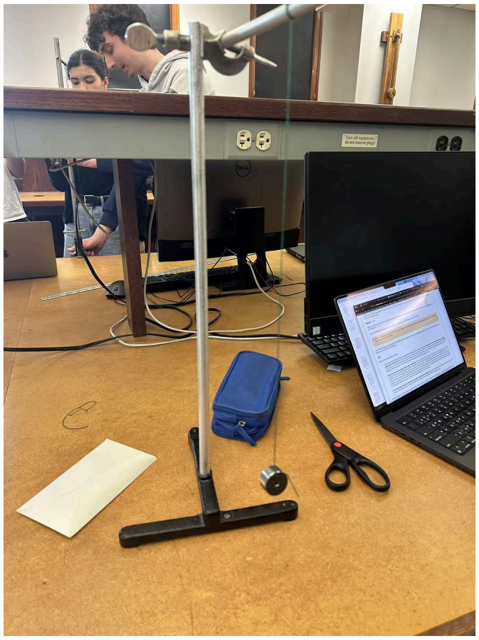
$T_{predicted} = 2\pi\sqrt{\frac{L}{g}} = 2\pi\sqrt{\frac{0.377}{9.81}} = 1.23\ seconds$

$\Delta L = 0.0005$

$\Delta T = 2\pi\sqrt{\frac{0.005}{9.81}} = 0.14$ seconds

Table 1.2: Preparation Data for Pendulum Experiment

Quantity	Measurement
Mass	50.3 ± *0.1 g*
Length	*37.75 ± 0.05 cm*



Procedure:

1. Measure the angle (10, 9, 7, and 5 degrees) from the start of the string using the protractor held against the rod of the pendulum
2. Let go of the weight from the prescribed angle, letting the pendulum oscillate as it is being recorded
3. Using the video, measure the period of the pendulum by using a timestamp to time the recording for one period.

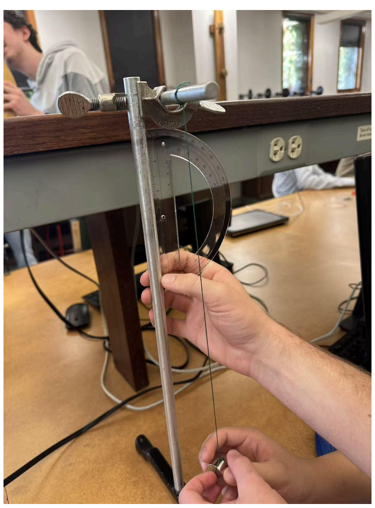


Table 1.3: Experimental Data for Pendulum Experiment

Angle (° ± 0.5 °)	*Measurements（s ± 0.01s）*	*Means (s ± 0.01s)*
5.0	*1.03*	*1.04*
	1.02	

	1.06	
7.0	*1.09*	*1.03*
	1.01	
	1.00	
9.0	*1.04*	*1.04*
	1.03	
	1.06	
10.0	*1.05*	*1.06*
	1.10	
	1.02	
Mean	*1.04 s ± 0.02s*	

Compare your measured values to the predicted period. Do your periods agree, do they disagree, or is it inconclusive?

$$\frac{A-B}{\sqrt{A^2+B^2}} = \frac{1.23-1.04}{(0^2+0.14^2)^{0.5}} = \frac{0.19}{\sqrt{0.020}} = 1.344$$

It's inconclusive; the difference is probably because there's a force exerted on the pendulum while releasing, causing the period to be shorter than expected.

Period of a Pendulum (Part 2)

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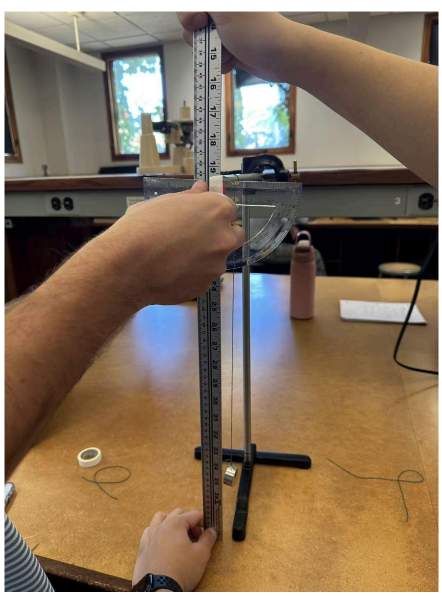
Course:	PHYS 13100 2
Lab Section / TA Name:	2L07/Audrey Scott

Data in Preparation

Table 2.1: Preparation Data

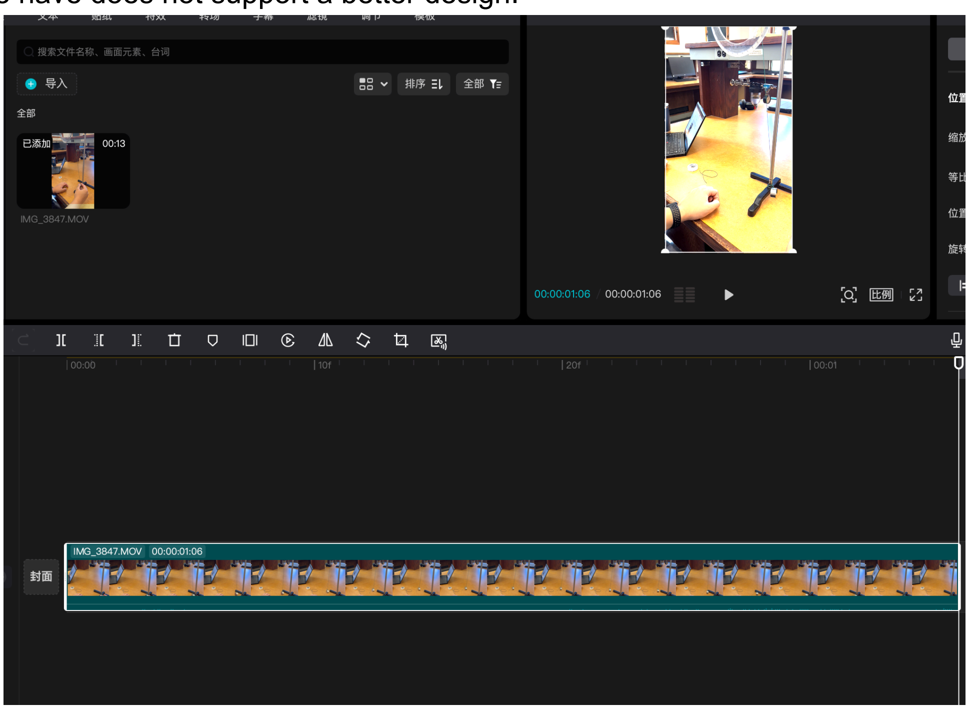
Quantity	Measurement
Mass*	50.1 ± *0.1 g*
Length*	*37.75 ± 0.05 cm*

*: we record the mass since we believe it may impact the result in reality. Since there's air resistance to the pendulum in reality, the mass determines how much acceleration the air resistance can exert onto the pendulum.
*For the length, we try to make it similar to that we have last time so that we can draw a direct comparison.



The image above shows the improvement that we have made to the experiment device this time. We realize the instability of holding the protractor while measuring, so we fixed it on the pendulum using tape with the ruler as a reference of the perpendicular axis.

In this lab we are still using our hands to control the releasing of the pendulum since the material we have does not support a better design.



This image above demonstrates the application we use to measure the time of the pendulum period. We consider the start point as the frame when the mass leaves the hand and we consider the end point as the last point before the frame enters the trace of the second period. We are only measuring the first swing for each trial.

Table 2.2: Checking the Agreement with Lab 1 data

Angle (° ± 0.5 °)	*Measurements (s ± 0.01s)*	*Means (s ± 0.01s)*
10.0	*1.06*	*1.07*
	1.08	
	1.08	

To verify the agreement/disagreement with the experiment conducted the past week, we'll use the 't-test' for one of the past angles, 10 degrees (we are doing 10 degrees for time constraint and we are only comparing the result of 10 degrees from last time so that there won't be implicit impact of angle that we may not be able to consider in reality). In the measurement this time, we still observe the pendulum deviating from the standard choice of a swing (it's also moving in the other axis), but unfortunately we the current equipment we don't have a good way to solve that.

$t` = \frac{A-B}{\sqrt{(\delta A)^2+(\delta B)^2}}$, with last week's value for B = 1.06 and $\Delta B = 0.04$, the experimental uncertainty, which is calculated by dividing the range of values (Max - Min) by 2:

$\frac{Max-Min}{2} = \frac{1.10-1.02}{2} = 0.04$

Based on our measurements for the trial of 10 degrees, we obtained A = 1.07 with the experimental uncertainty $\Delta A = \frac{1.08-1.06}{2} = 0.01$. Substituting the respective values into t`:

$t` = \frac{1.07-1.06}{\sqrt{(.01)^2+(.04)^2}} \approx 0.24$

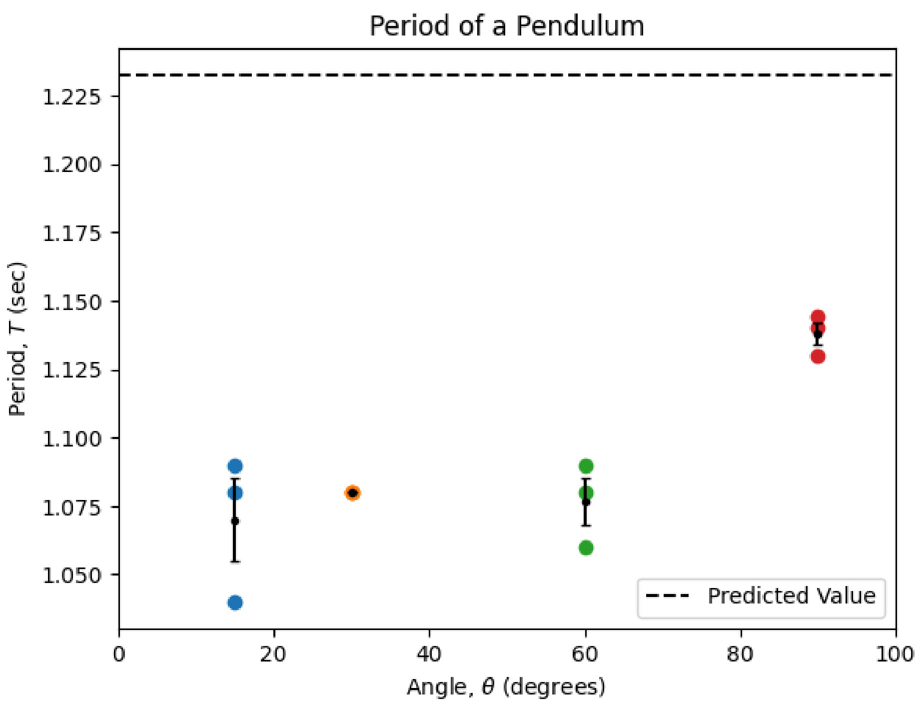
Because our t` angle is within $|t`| \le 1$, this implies that the value we derived with our current setup is in agreement with the values that we derived from last week, suggesting that our values match our values previously

Table 2.3: Lab 2 Measurements of Pendulum Period (θ>10)*

Angle (° ± 0.5 °)	*Measurements (s ± 0.01s)*	*Means (s ± 0.01s)*
15.0	*1:08*	*1.07*
	1:04	
	1:09	

30.0	*1:08*	*1.08*
	1:08	
	1:08	
60.0	*1:09*	*1.08*
	1:08	
	1:06	
90.0	*1:14*	*1.14*
	1:13	
	1:14	
Mean	*1.09 ± 0.04**	

*All of the measurements here are done same as how they are done for Table 2.2



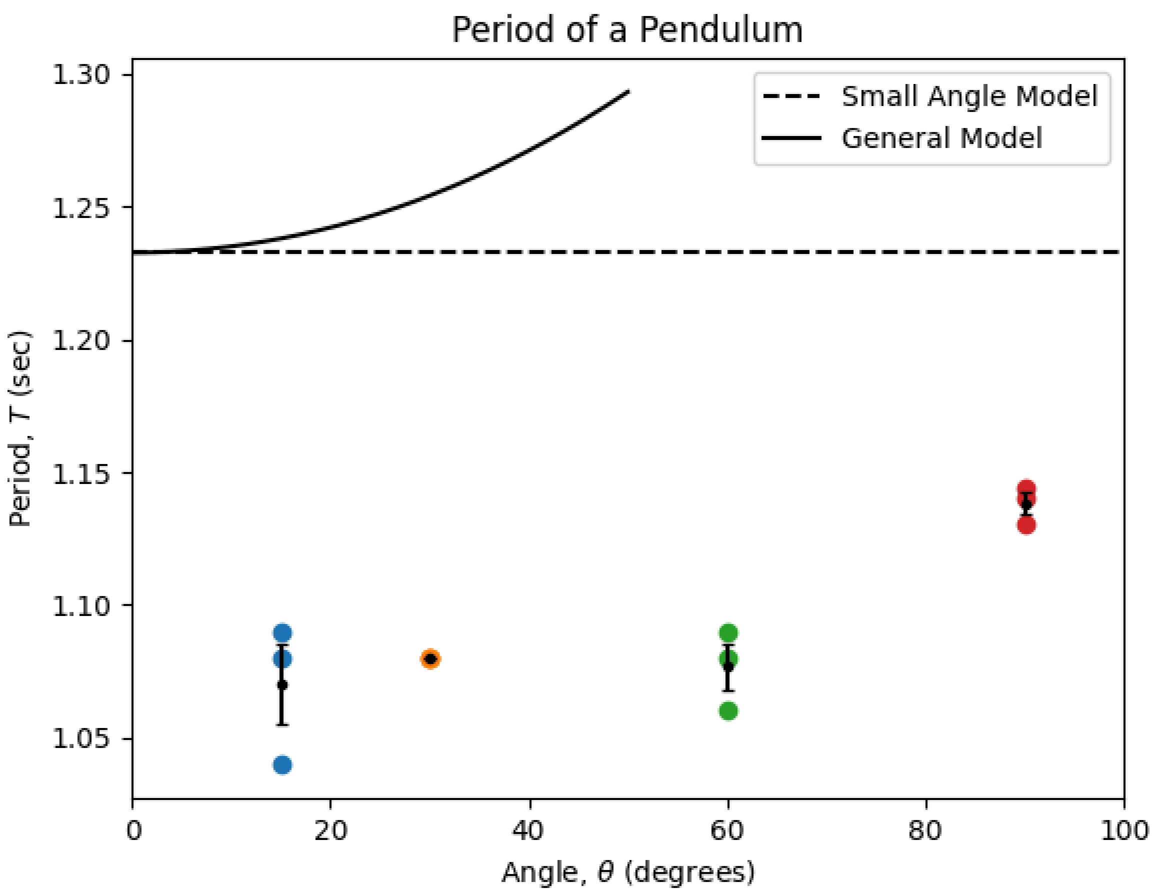
Based on the plotted data for the experiment,

*The uncertainty for the final mean is calculated by half of the max of the individual means for each angle minus the min because it is bigger than the uncertainty of the device (0.01).

To test the agreement of the larger values (from 15 degrees to 90 degrees), we will do a t-test with the mean from all the trials of the previous experiment, where A = 1.04 and $\delta A = 0.02$, the mean and uncertainty obtained from our experiment last week.

The B values, the mean and uncertainty from this experiment, are B = 1.09 and $\delta B = 0.04$.

$$t` = \frac{A-B}{\sqrt{(\delta A)^2+(\delta B)^2}} = \frac{1.04-1.09}{\sqrt{0.02^2+0.04^2}} =- 1.11$$



The image above demonstrate the plot drawn from the code provided. The curve for the general model is calculated by the new model we have and the dash line is the prediction of the previous model we use.
The t-test for the new general model, as computationally calculated in the google collab notebook are as follows:

```python
for n, theta in enumerate(angles):
    print("For", theta, "degrees, t' =", t_prime(avg[n], davg[n],
          T_predicted_expanded(L,theta)))
```

```
For 15 degrees, t' = -10.988235576381971
For 30 degrees, t' = -inf
For 60 degrees, t' = -27.638485268819878
For 90 degrees, t' = -70.12370622425146
/tmp/ipython-input-4162965860.py:23: RuntimeWarning: divide by zero encountered in scalar divide
  return((A-B)/np.sqrt(dA**2 + dB**2))   # If only 3 arguments are given, assumes dB = 0 (e.g. a literature value)
```

The t’ for 30 degrees is negative infinity because the statistical uncertainty is zero.