☐PHYS115 ☐PHYS121 ☐PHYS123
☐PHYS116 ☐PHYS122 ☐PHYS124

Lab Cover Letter

Author (*You*) Trevor N. Signature: Trevor N.

I declare that this assignment is original and has not been submitted for assessment elsewhere, and acknowledge that the assessor of this assignment may, for the purpose of assessing this assignment: (1) reproduce this assignment and provide a copy to another member of faculty; and/or (2) communicate a copy of this assignment to a plagiarism checking service (which may then retain a copy of this assignment on its database for the purpose of future plagiarism checking).

Lab Partner(s) Katherine

Date Performed 24/01/24 Date Submitted 25/01/24

Lab (*such as #1: UNC*) #1: UNC

TA: Phillip

GRADE (*to be filled in by your TA*) See your TA for detailed feedback.
An '*x*' next to a subcategory means you need to improve this aspect of your work.

Paper Subtotals (points)

( ) ***General*** **(6)**
_____ Sig. figs.
_____ Units
_____ Clarity of Presentation
_____ Format

( ) ***Abstract*** **(4)**
_____ Quantity or principle
_____ How measurement was made
_____ Numerical Results
_____ Conclusion

( ) ***Intro & Theory*** **(9)**
_____ Basic principle
_____ Main equations to be used
_____ Apparatus
_____ What will be plotted
_____ Fitting parameters related

( ) ***Exp. Procedures*** **(15)**
_____ Description
_____ Stating and justifying uncertainties
_____ Data Record
_____ Quality of Lab Work

( ) ***Analysis & Error Analysis*** **(20)**
_____ Discussion
_____ Equations & Calculations
_____ Presentation inc. Graphs, Tables
_____ Results Reported & Reasonable
_____ Underlined items addressed

( ) ***Discussion & Conclusions*** **(6)**
_____ Numerical comparison of results
_____ Logical conclusions
_____ Discussion of pos. errors
_____ Suggestions to reduce errors

( ) **Paper Total (60 points)**
(30 points for CME or EPF)

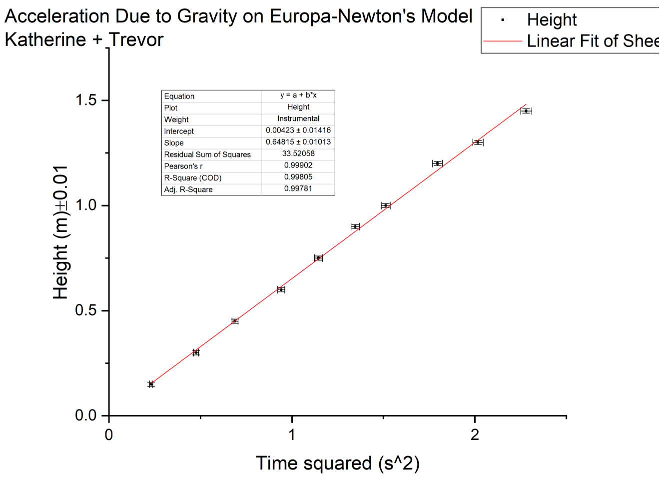
( ) **Notebook (10 points)**
_____ Format (*proper style, following directions*)
_____ Apparatus (*brief description of equipment, including sketches*)
_____ Data (*including computer file names and manually recorded data*)
_____ Experimental Technique (*describing your procedures; stating & justifying uncerts.*)
_____ Analysis (*results and errors*)

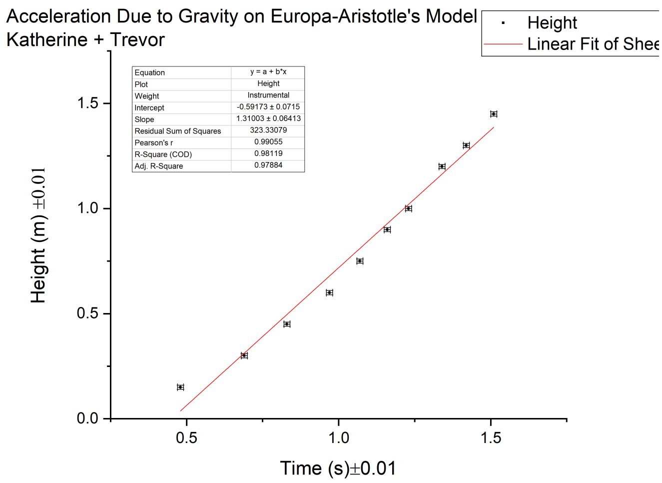
( ) **Worksheet(s)/Fill-in-the-Blank-Report (30 points)** *if applicable*

( ) **Adjustments** – late submissions, improper procedures, etc. – or bonus points for exceptional work.

( ) Total Grade

Graded by ___________ (TA's initial)





a_N and δ_{aN} are shown on the graph

Newton's model is significantly closer to modeling the data than Aristotle's model. As you can see in the variance in the slope, Newton's has around 6x less variance and roughly one order of magnitude higher correlation (r). The data points on Newton's graph stay significantly closer to the fit line whilst Aristotle's model has a consistent and predictable deviation from the line of best fit. I would report a value of $0.65 \pm 0.001 \frac{m}{s^2}$ to my supervisor.

Trevor N. tln32 Lab1 PHYS121 Sec: 118-B Stanton 11

	Weight (g) Tennis Ball	Length (cm) String	Diameter (cm) Tennis Ball	Length (m) Total	Period (s) 10 swings	Period (s) 1 swing	g (m/s^2)	Weight (N)
1	58	65.5	6.31	0.68655	16.18	1.618	10.35321	0.55
2	58	65.7	6.35	0.68875	16.33	1.633	10.19645	0.53
3	58	65.8	6.40	0.69000	16.10	1.610	10.50890	0.54
4	58	65.9	6.41	0.69105	16.24	1.624	10.34421	0.54
5	58	65.7	6.21	0.68805	16.29	1.629	10.23617	0.55
6	58	66.1	6.30	0.6925	15.88	1.588	10.84123	0.55
7	57	66.0	6.21	0.69105	16.07	1.607	10.56422	0.53
8	57	66.3	6.26	0.69430	16.02	1.602	10.66026	0.52
9	57	66.2	6.18	0.69290	15.94	1.594	10.76598	0.51
10	58	66.2	6.28	0.69340	16.02	1.602	10.66642	0.52
mean	57.7	65.94	6.291	0.69085	16.107	1.6107		0.534
SD	0.48305	0.26331	0.07923	0.00251	0.14979	0.01499		0.0143
SE	0.15275	0.08327	0.02505	7.9413×10^{-4}	0.0474	0.00474		0.00452

$$g = 4\pi^2 \frac{l}{T^2}$$ $g \approx 10.51277\ m/s^2 \approx \boxed{g = 10.5\ m/s^2}$

$$\delta_g = \sqrt{\delta_{gl}^2 + \delta_{gT}^2}$$ $\delta_g \approx 0.06304531 \approx \boxed{\delta_g = 0.1\ m/s^2}$

$$\delta_{gl} = \frac{4\pi^2}{T^2}\delta_l$$ $\delta_{gl} \approx 0.01209649$

$$\delta_{gT} = -8\pi^2 \frac{l}{T^3}\delta_T$$ $\delta_{gT} \approx$ ~~[illegible]~~ 0.06187395

Result: $g = \boxed{10.5 \pm 0.1\ m/s^2}$

Procedure:

- Measure
  - Mass of Tennis Ball
  - Weight of Tennis Ball w/ scale
  - Length of string from Ball to end w/ meter stick
  - Diameter of Ball w/ calipers
  - Period of 10 swings w/ stopwatch

Our measurement only had one decimal place as we had to estimate that due to the stick being obstructed by the ball

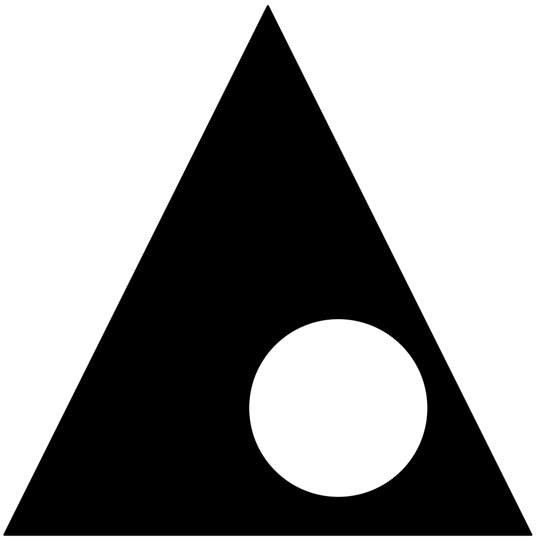
- Analysis
  - Derive the length from the tip of the string to the center of the ball from the length & diameter measurements
  - Derive the time of one period from the measurement of 10.
  - Find the mean, SE, SD of all measurements

- Setup
  - Attach a string to a tennis Ball w/ a loop on the other end.
  - Suspend the tennis ball by the string such that the tennis ball is only touching the string
- Measure Period by deviating the tennis ball from equilibrium by less than 5° off the vertical.
- Calculate g from the formula of $g = 4\pi^2 \frac{l}{T^2}$ & the means of measurements
- Derive δ_g from δ_T and δ_l

<u>UNC LAB:</u> <u>Error Analysis and Propagation Exercise</u>

Revised April 06, 2006

Your Name: Trevor



This exercise is designed to help you understand error analysis and error propagation. You need to determine the area of the shaded region in the figure above; that is, the area of a triangle minus the area of a circle. If the triangle has a height, *h*, and width, *w*, and the circle has diameter *d*, then the shaded area is given by the formula $A = hw/2 - \pi d^2/4$.

Every measurement has an associated uncertainty. The uncertainties can be labeled with the symbol, δ, which indicates a small change in the associated quantity. The uncertainties of *h*, *w*, and *d* are given by δ_h , δ_w , and δ_d respectively.

Use a metric ruler to measure *h*, *w*, and *d*, estimate the uncertainties δ_h, δ_w, and δ_d in your measurements of each quantity and enter these values below, in cm. For your convenience, copy these values onto the other side of this page.

69.3	±	0.1	cm	69.2	±	0.1	cm	23.3	±	0.1	cm
h	±	δ_h		w	±	δ_w		d	±	δ_d	

(measured w/ calipers)

Now calculate $A = hw/2 - \pi d^2/4$ = 1.97×10³ cm² 1971.395191

To estimate the *uncertainty* in *A*, δ_A, we need to *propagate* each individual contribution to the uncertainty (δ_h, δ_w, and δ_d) through the equation for *A* to find out how much each contributes to the uncertainty in *A* (*these terms are labeled as* δ_{Ah}, δ_{Aw}, *and* δ_{Ad}) and then add these contributions in quadrature $\delta_A = (\delta_{Ah}^2 + \delta_{Aw}^2 + \delta_{Ad}^2)^{1/2}$.

The first step is to determine δ_{Ah}, δ_{Aw}, and δ_{Ad}. This may be done by one of two methods. In the computational method, you calculate the change in *A* caused by substituting for each term, such as *h*, the value plus its estimated uncertainty, such as $h + \delta_h$ (or $h - \delta_h$). The derivative method has you calculate terms such as δ_{Ah} using the idea that any small change in *A* due to a small change in *h* is given by the derivative of *A* with respect to *h*, treating all the other terms such as *w* and *d* as constants. This is properly called a *partial derivative* and uses the symbol ∂ as in $\frac{\partial A}{\partial h}$ rather than $\frac{dA}{dh}$. Once you know how *A* changes as a function of *h*, you can simply multiply this by the estimated uncertainty in *h*, δ_h, to find $\delta_{Ah} = |\partial A/\partial h|\delta_h$.

Now, for some practice in error propagation, fill in each of the blanks on the other side of this page.

h w d

69.3 ± 0.1 69.2 ± 0.1 23.3 ± 0.1

COMPUTATIONAL METHOD

$\delta_{Ah} = |(hw/2 - \pi d^2/4) - ((h+\delta_h)w/2 - \pi d^2/4)| = \{$ *this simplifies to* $\delta_h w/2\} =$ 3.46 cm^2
(units)

$\delta_{Aw} = |(hw/2 - \pi d^2/4) - (h(w+\delta_w)/2 - \pi d^2/4)| =$ 3.465 cm^2

$\delta_{Ad} = |(hw/2 - \pi d^2/4) - (hw/2 - \pi (d+\delta_d)^2/4)| =$ 3.668 cm^2

$\delta_A = (\delta_{Ah}{}^2 + \delta_{Aw}{}^2 + \delta_{Ad}{}^2)^{1/2} =$ 6.216 cm^2

You should quote your value for A in the form $A \pm \delta_A$ (units): 1971 ± 6 cm^2
(δ_A *is normally given with one or at most two significant figures while the most significant figure in the value of* A *should be determined from* δ_A, *as in* A = *3.65 ± 0.03 cm*^{2}. *See Appendix V, Section D.*)

DERIVATIVE METHOD
(*Optional for P115 students*)

$$\delta_{Ah} = \left|\frac{\partial A}{\partial h}\right| \delta_h = \left|\frac{\partial}{\partial h}\left(\frac{hw}{2} - \frac{\pi d^2}{4}\right)\right| \delta_h = \frac{\delta_h w}{2} = 3.46 \ cm^2$$

(units)

$$\delta_{Aw} = \left|\frac{\partial A}{\partial w}\right| \delta_w = \left|\frac{\partial}{\partial w}\left(\frac{hw}{2} - \frac{\pi d^2}{4}\right)\right| \delta_w = \frac{h\delta_w}{2} = 3.465 \ cm^2$$

$$\delta_{Ad} = \left|\frac{\partial A}{\partial d}\right| \delta_d = \left|\frac{\partial}{\partial d}\left(\frac{wh}{2} - \frac{\pi d^2}{4}\right)\right| \delta_d = \frac{\pi d \delta_d}{2} = 3.660 \ cm^2$$

$$\delta_A = \sqrt{\delta_{Ah}^2 + \delta_{Aw}^2 + \delta_{Ad}^2} = 6.113 \ cm^2$$

$A =$ 1971 ± 6 cm^2

You should find that the computational and derivative methods give similar results.

GRADE:_______   **GRADED BY ________**
(out of 10 points)   (TA's initials)