Ring Pendulum Lab

June 22, 2015

Equipment set up as described in manual
- 7 rings: 5 sizes w/ one size having 3 masses
- Timer in pendulum mode: pendulum breaks beam 3 times to get one period

Physical properties of ~~pendula~~ rings

Ring	inner diameter (mm) (calipers)	outer diameter (mm)	mass (g) ± 1%
1	32.42 ± 0.02	38.52 ± 0.02	30.7
2	64.06	73.10	11.3
3	63.48	72.70	33.2
4	63.40	72.42	106.4
5	139.10	152.06	101.9
6	284 ± 2	302 ± 2	311.1
7	428 ± 2	455 ± 2	640.4

(meter stick)

A Mass dependence

(All times ± 0.0001 s) ← least count of timer

Ring	Time 1 (s)	2 (s)	3 (s)	4 (s)	5 (s)
2	0.5303	0.5289	0.5278	0.5271	0.5277
3	0.5253	0.5250	0.5268	0.5250	0.5257
4	0.5305	0.5289	0.5284	0.5269	0.5276

~~B~~ C Amplitude dependence

(all ring 6)

Amplitude (°)	Time 1 (s)	2 (s)	3 (s)	4 (s)	5 (s)
5 ± 2	1.0961	1.1128	1.0928	1.0991	1.0930
10	1.1014	1.0937	1.0974	1.1020	1.0968
15	1.1067	1.1070	1.1042	1.1033	1.1077
20	1.3441	1.1092	1.1109	1.1137	1.1080

greater than least count of protractor

Ring Pendulum, cont.

B Diameter dependence

Ring	Time 1 (s)	2 (s)	3 (s)	4 (s)	5 (s)
1	0.3791	0.3788	~~0.3791~~	0.3780	0.3775
5	0.7707	0.7707	0.7686	0.7701	0.7708
7	1.3441	1.3440	~~1.4397~~ 1.3437	1.3431	1.3436

ring almost fell off

+ reuse data for rings 2, 3, 4, and 6 (5° amplitude)

TA discussion on logs at end of class

$\ln ab = \ln a + \ln b$

$\ln a^n = n \ln a$

$T = Ad^n$ ← empirical equation

$\ln T = \ln(Ad^n) = \ln A + \ln d^n = \ln A + n \ln d$

$\ln T = n \ln d + \ln A$

$y = m x + b$

$\ln T$ on vertical axis
$\ln d$ on horizontal axis
$\Rightarrow$ slope = n
y-intercept = $\ln A$

$A = e^{\text{y-intercept}}$

Ring Pendulum, cont.

Calculations

Ring 1: mean diameter $\frac{d_o + d_i}{2} = \frac{(32.42 + 38.52)\,mm}{2} = 35.47\,mm$

uncertainty diameter $\frac{1}{2}\sqrt{\sigma_{d_o}^2 + \sigma_{d_i}^2} = \frac{1}{2}\sqrt{(0.02^2 + 0.02^2)\,mm^2} = 0.0141\,mm$

mean time — average in Excel $= 0.3785\,s$

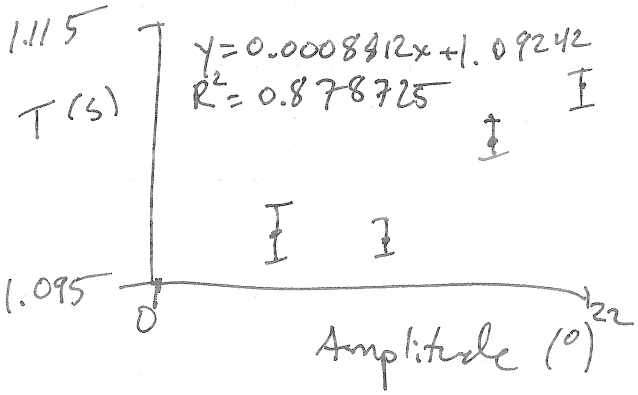
uncertainty time — standard deviation in Excel $= 0.00022\,s$

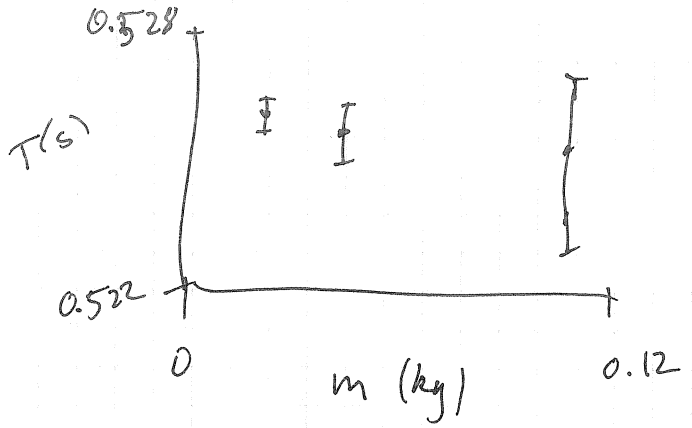
standard error $= \frac{0.00067\,s}{\sqrt{5}} = 0.00032\,s$

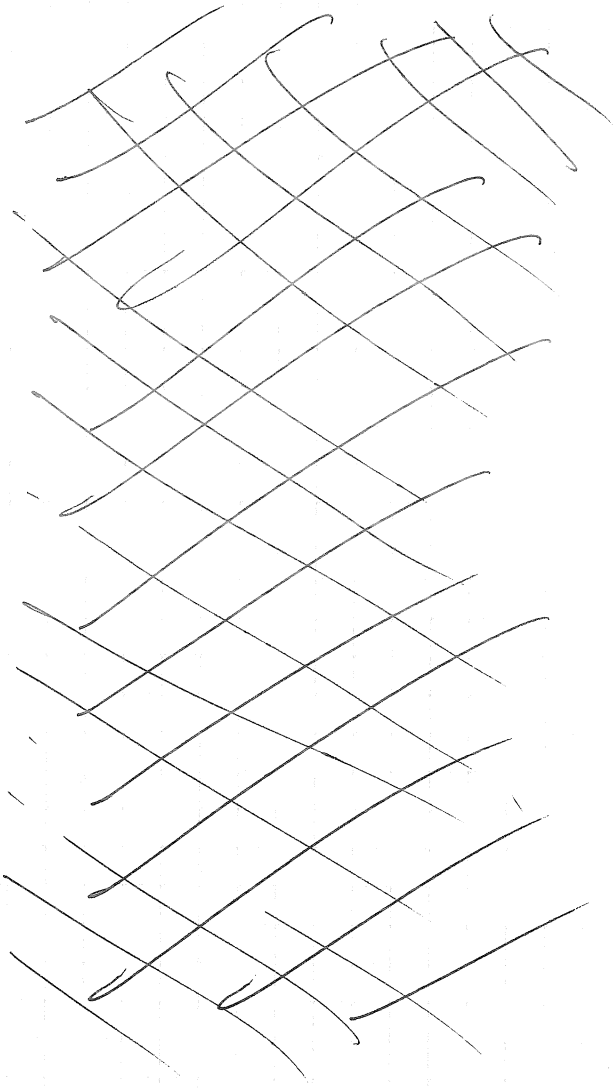
$\ln T = \ln 0.3785\,s = -0.9715$ (unitless)

$\sigma_{\ln T} = \frac{\sigma_T}{T} = \frac{0.0003\,s}{0.3785\,s} = 0.00079$ (unitless)

→ Plots done in Excel (sketches)

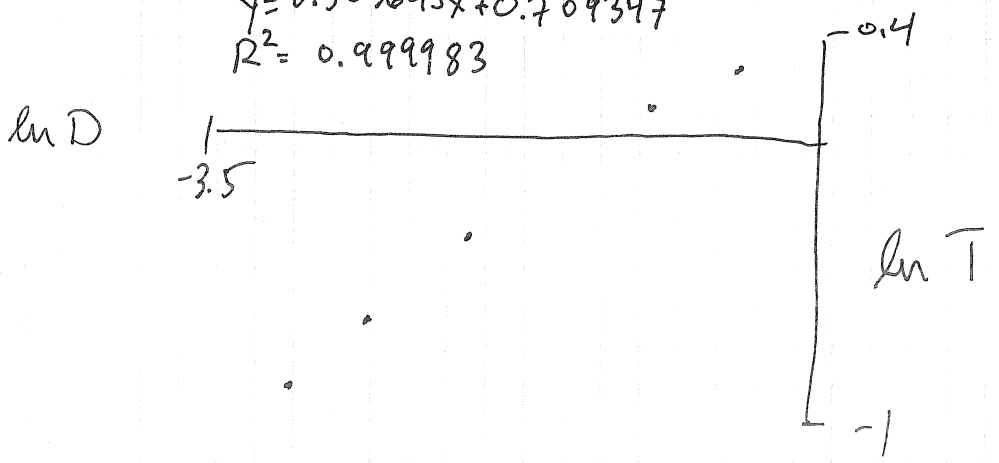






Ring pendulum, cont.

$y = 0.503643x + 0.709347$
$R^2 = 0.999983$



from LINEST: $\sigma_{slope} = 0.0012$
$\sigma_{y\text{-intercept}} = 0.0026$

$n = 0.5036 \pm 0.0012 \rightarrow \boxed{0.504 \pm 0.001}$

$A = e^{0.709347} = 2.0327 \ s/\sqrt{m}$

$\sigma_A = \sigma_{y\text{-intercept}} e^{y\text{-intercept}} = (0.0026) e^{0.709347 \ s/\sqrt{m}} = 0.00528 \ s/\sqrt{m}$

$A = (2.0327 \pm 0.00528) s/\sqrt{m} \rightarrow \boxed{(2.033 \pm 0.005) s/\sqrt{m}}$