PHYS 310 -- Solutions for Homework #1

1. Hughes and Hase, 2.2

(i) Calculate the mean

```
data = {5.33, 4.95, 4.93, 5.08, 4.95, 4.96, 5.02, 4.99, 5.24, 5.25, 5.23, 5.01}
{5.33, 4.95, 4.93, 5.08, 4.95, 4.96, 5.02, 4.99, 5.24, 5.25, 5.23, 5.01}
```

Find mean using the "Mean" function, then the old - fashioned way of adding everything and dividing by N using Total or using Sum

```
Mean[data]
5.07833
```

```
Total[data] / Length[data]
5.07833
```

```
Sum[data[[i]], {i, 1, Length[data]}] / Length[data]
5.07833
```

Gives the same answer, as would be expected.
So answer is 5.07833 Amps/Watt.

(ii) standard deviation using eq. (2.3)

```
deviations = data - Mean[data]
{0.251667, -0.128333, -0.148333, 0.00166667, -0.128333, -0.118333,
 -0.0583333, -0.0883333, 0.161667, 0.171667, 0.151667, -0.0683333}
```

```
stdev = Sqrt[Total[deviations^2] / (Length[data] - 1)]
0.14358
```

```
StandardDeviation[data]
0.14358
```

Agrees with the Mathematica formula for Standard Deviation.

So answer is 0.14358 Amps/Watt.

(iii) standard error (i.e., standard deviation of the mean)

```
stderr = stdev / Sqrt[12]
0.0414479
```

So answer is 0.04 Amps/Watt.

2. Hughes and Hase, 2.3

For 1 min α=1 pT. Use that $\alpha = \sigma_{N-1}/\sqrt{N}$.
We are asked about factor c necessary to get α_{new}=0.1 α_{old} so
α_{new}=0.1 α_{old}=0.1 $\sigma/\sqrt{N_{\text{old}}}$
$= \sigma\Big/\sqrt{N_{\text{new}}} = \sigma\Big/\sqrt{c\,N_{\text{old}}}$
and therefore c=100 which means that **you should take 100 minutes of data.**

3. Hughes and Hase, 2.6

The fractional error of an error is $\frac{1}{\sqrt{2N-1}}$.

(i) δ=3.27346, α_δ=0.01913, N=5
$1\Big/\sqrt{8}$ =0.35 → 35% fractional error → report 1 sigfig → **3.27±0.02**

(i) δ=3.26513, α_δ=0.002506, N=50
$1\Big/\sqrt{48}$ =0.14 → 14% fractional error → report 1or 2 sigfig →
3.265±0.003 or 3.2651±0.0025 .

(i) δ=3.26681, α_δ=0.000270, N=100
$1\Big/\sqrt{98}$ =0.10 → 10% fractional error → report 2 sigfig → **3.26681±0.00027**

4. Pendulum measurements

Data for pendulum swings. Standard deviation is 0.04 s.
Experiment A : 12 sets of 10 swings, average time for 10 swings = 28.39 s;
Experiment B : 1 set of 120 swings, time for 120 swings = 340.61 s.

Period for A -- Average period T = 28.39s/10 = 2.839 s. Standard error for 10 swings is 0.04s/$\sqrt{12}$ or 0.0126491 s. So uncertainty for a single swing is a tenth of this, or 0.00126491.

So, **for Experiment A, T = (2.839±0.001) s**

Period for B is 340.61s/120 or 2.83842. Error is simply standard deviation divided by 120: 0.04/120 or 0.000333

So, **for Experiment B, T = (2.8384±0.0003) s**.

5. Estimating data

One method is to look for the median. There are 15 data points. The middle value is 4.19365, meaning 7 values are larger than this and 7 are smaller. The median can be a poor estimate for the mean if the distribution is very assymetric, but these numbers go up to 4.5 and down to 3.9, so it looks like they are fairly well centered on **4.2**.

Using H & H's "rough estimate" for the standard deviation, we find that the max value minus the mean is about 0.3. Taking × 2/3 of that gives a standard deviation of **0.2**.