Physics 2BL Homework Set 01

Taylor Problems: 3.10, 3.28, 3.36, 3.41

3.10: 1 Deck = 52 Cards

Thickness of one deck is measured to be: T = 0.590 ± 0.005 inches

(A) Thickness of one card = t = (1/52) T → **t = 0.01135 ± 0.00010 inches**

(B) N = Number of cards measured to obtain desired uncertainty

T = N t

$\delta T = N\,\delta t \rightarrow N = \delta T/\,\delta t = \dfrac{0.005 inches}{0.00002 inches}$ = **N = 250 Cards**

This is 4 decks and 42 cards or about 5 decks.

3.28: $T = 2\pi\sqrt{L/g}$

L = 1.40 ± 0.01m , g = 9.81m·sec^{-2}

(A) $T = 2\pi\sqrt{(1.40m)/(9.81m\cdot s^{-2})} = 2.37\text{sec}$

$$\delta T = \left|\frac{dT}{dL}\right|\delta L = 2\pi\cdot\frac{1}{2}(L/g)^{-1/2}\cdot(1/g)\cdot\delta L$$

$$= (\pi/g)\cdot\sqrt{g/L}\cdot\delta L$$

$$= (\pi/9.80\,m\cdot s^{-2})\cdot\sqrt{9.80\,m\cdot s^{-2})/(1.40m)}\cdot(0.01m)$$

δT = 0.008 sec

T = 2.375 ± 0.008 sec

(B) $T_{Measured}$ = 2.39 ± 0.01 sec

so, **2.367 sec ≤ $T_{Predicted}$ ≤ 2.383 sec**

and 2.38 sec ≤ $T_{Measured}$ ≤ 2.40 sec

These ranges just barely overlap since both share the endpoint at 2.38 seconds. Thus, the predicted and measured values of the pendulum are consistent with one another.

3.36: (A) $(12\pm1)\times[(25\pm3)-(10\pm1)]$

$$= (12\pm1)\times\left(15\pm\sqrt{3^2+1^2}\right) = (12\pm1)\times(15\pm3)$$

$$= 180\pm180\sqrt{(3/15)^2+(1/12)^2}$$

= 180 ± 40

≤

(B) $\sqrt{16 \pm 4} + (3.0 \pm 0.1)^3 (2.0 \pm 0.1)$

$$q_1 = \sqrt{16 \pm 4}\,,\ \frac{\delta q_1}{4} = \left|\frac{1}{2}\right| \frac{4}{|16|} = \frac{1}{2}\left(\frac{1}{4}\right) = \frac{1}{8} \Rightarrow \delta q_1 = \frac{1}{2}$$

$$q_2 = (3.0 \pm 0.1)^3,\ \frac{\delta q_2}{27} = 3\frac{0.1}{3.0} \Rightarrow \delta q_2 = 2.7\text{, round to 3}$$

$$q_3 = (27 \pm 3)(2.0 \pm 0.1),\ \frac{\delta q_3}{54} = \sqrt{\left(\tfrac{3}{27}\right)^2 + \left(\tfrac{0.1}{2.0}\right)^2} \Rightarrow \delta q_3 = 6.6\text{, round to 7}$$

$$q_4 = (4.0 \pm 0.5) + (54 \pm 7) = 58 \pm \sqrt{(0.5)^2 + (7)^2}$$

$\rightarrow$ = **58 ± 7**

(C) $(20 \pm 2)\exp[-(1.0 \pm 0.1)]$

$$q_1 = \exp[-(1.0 \pm 0.1)],\ \delta q_1 = |-\exp[-(1.0)]| \cdot (0.1) \Rightarrow \delta q_1 = 0.37 \pm 0.04$$

$$q_2 = (20 \pm 2)(0.37 \pm 0.04) = 7.4$$

$$\left(\tfrac{1}{7.4}\right)\delta q_2 = \sqrt{\left(\tfrac{2}{20}\right)^2 + \left(\tfrac{0.04}{0.37}\right)^2} = 0.15 \Rightarrow \delta q_2 = 1.1$$

$\rightarrow$ = **7.4 ± 1.1**

3.41:

i (deg) All ± 1	r (deg) All ± 1	sin(i)	sin(r)	n= $\frac{\sin i}{\sin r}$	$\frac{\delta \sin i}{\lvert\sin i\rvert}$	$\frac{\delta \sin r}{\lvert\sin r\rvert}$	$\frac{\delta n}{n}$	δn
10	7	0.174	0.122	1.42	10%	14%	17%	0.2
20	13	0.342	0.225	1.52	5%	8%	9%	0.14
30	20	0.5	0.342	1.46	3%	5%	6%	0.09
50	29	0.766	0.485	1.58	1%	3%	3%	0.05
70	38	0.940	0.616	1.53	1%	2%	2%	0.03

If we are told by the manufacturer that n = 1.50, we may check this against our measured data. We check that n-δn ≤ 1.50 ≤ n+δn. This is true for each case except i = 50°. Still, the lower bound is close to 1.50 (differing by 0.03). The results are fairly consistent with the manufacturer's reported value. As the angles increase, the uncertainties in the angles are constant so their fractional uncertainties decrease. Thus, the fractional uncertainties in n also decrease as i increases.