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PHYS 211X
Lab 3: Uncertainty and Error, 2/14/2023, Partners: Maite Valentin-Lugo, Seth Waln

Part 1

1. 1-inch: (2.37 ± 0.005)cm

2-inch: (4.96 ± 0.005)cm

3-inch: (7.43 ± 0.005)cm

2. 1-inch: (0.93 ± 0.002)in, expected 1 in.

1-inch: (1.95 ± 0.002)in, expected 2 in.

1-inch: (2.93 ± 0.002)in, expected 3 in.

These values seem to be 0.05-0.07 in off of the expected value, which exceeds the $\pm$ 0.002 in uncertainty. They have decieved us.

	MLE	δ MLE	MRE	δ MRE	W	δ W
Trial 1	26.0 cm	$\pm$ 0.05 cm	45.1 cm	$\pm$ 0.05 cm	19.1 cm	$\pm$ 0.071 cm
Trial 2	44.9 cm	$\pm$ 0.05 cm	54.1 cm	$\pm$ 0.05 cm	19.2 cm	$\pm$ 0.071 cm

3.

$$\begin{aligned} \mathrm{W} &= \mathrm{MRE} - \mathrm{MLE} \\ \frac{\delta W}{\delta MLE} &= 1 \\ \frac{\delta W}{\delta MRE} &= 1 \end{aligned}$$

4.

$$\begin{aligned} \delta W &= \sqrt{\left(\frac{\delta W}{\delta MLE}\delta MLE\right)^2 + \left(\frac{\delta W}{\delta MLE}\delta MLE\right)^2} \\ &= \sqrt{(1(0.05))^2 + (1(0.05))^2} \\ &= \sqrt{0.0025 + 0.0025} \\ &= \sqrt{0.005} = boxed 0.071 \end{aligned}$$

Part 3

Trial	Circumference	δ circ	Diameter	δ diam	π	$\delta\pi$	Is π ?
1	43.7 cm	$\pm$ 0.05 cm	14.1 cm	$\pm$ 0.05 cm	3.09	$\pm$ 0.071 cm	No
2	18.2 cm	$\pm$ 0.05 cm	14.1 cm	$\pm$ 0.05 cm	3.19	$\pm$ 0.029 cm	No
3	36.2 cm	$\pm$ 0.05 cm	11.6 cm	$\pm$ 0.05 cm	3.12	$\pm$ 0.014 cm	No
4	8.6 cm	$\pm$ 0.05 cm	2.6 cm	$\pm$ 0.05 cm	3.31	$\pm$ 0.066 cm	No
5	16.8 cm	$\pm$ 0.05 cm	4.9 cm	$\pm$ 0.05 cm	3.43	$\pm$ 0.036 cm	No

11.

$$\begin{aligned} C &= 2\pi r \\ C &= \pi D \\ \pi &= C/D \end{aligned}$$

12.

$$\begin{aligned}
\pi &= C/D \\
\frac{\delta\pi}{\delta C} &= \frac{1}{D} \\
\frac{\delta\pi}{\delta D} &= -\frac{C}{D^2} \\
\delta\pi &= \sqrt{\left(\frac{1}{D}(0.05)\right)^2 + \left(-\frac{C}{D^2}(0.05)\right)^2} \\
&= \sqrt{0.005 + 0.00012} = \sqrt{0.0051} = \boxed{0.071}
\end{aligned}$$

14.

$$\pi_a vg = 3.228$$

4

Person 1:

Trial	δ TF(s)	Time to fall(s)
1	0.1	0.53
1	0.1	0.50
1	0.1	0.56
1	0.1	0.41
1	0.1	0.47

Person 2:

Trial	δ TF(s)	Time to fall(s)
1	0.1	0.47
1	0.1	0.53
1	0.1	0.41
1	0.1	0.47
1	0.1	0.47

Person 3:

Trial	δ TF(s)	Time to fall(s)
1	0.1	0.50
1	0.1	0.41
1	0.1	0.47
1	0.1	0.56
1	0.1	0.38

16.

$$\text{MTF} = \frac{\sum_{i=1}^{n} TF_n}{n}$$

17.

$$\frac{0.052 + 0.50 + \cdots + 0.56 + 0.38}{n} = \boxed{0.48 \text{ seconds}}$$

18.

$$\begin{aligned}
\delta\text{MTF} &= \frac{\delta TF}{n} \\
&= \frac{0.1}{15} \\
&= \boxed{0.0067}
\end{aligned}$$

19.

$$\text{MTF} = \boxed{(0.48 \pm 0.0067)\text{ seconds}}$$

20. A lot of the values are similar, which brings down the deviation from the average value.

21.

$$\delta TF = \boxed{0.054}$$

22.

$$\text{MTF} = \boxed{(0.48 \pm 0.014)\text{ seconds}}$$

23. The value given in smaller than my calculated mean time to fall and out of bounds of my uncertainty. It's almost certain that this is because we aren't accounting for human error in the δ TF value as well as forces such as air resistence.

24. (a)

$$RU_c = \frac{0.05}{43.7} = 0.0011$$
$$RU_\pi = \frac{0.071}{3.09} = 0.0023$$

It looks like the relative uncertainty for the π being calculated here is almost exactly twice the relative uncertainty of its circumferece.

(b)

$$RU_{TF} = \frac{0.054}{0.53} = 0.010$$
$$RU_{MTF} = \frac{0.0067}{0.48} = 0.0014$$

The relative uncertainty for each time is several times larger than the relative uncertainty of the mean time.

25. The relative uncertainty for the circle trials is larger for π's relative uncertainty than the relative uncertainty for the mean time to fall. This is almost certainly because the ball dropping trails have much more availability for outside variables the influence the outcome, like air resistence, human error, and earthquakes.

Part 5

26.

$$\delta \vec{F_{net}} = \sqrt{\left(\frac{\delta \vec{F_{net}}}{\delta m}\delta m \cdot \vec{a}\right)^2 + \left(\frac{\delta \vec{F_{net}}}{\delta \vec{a}}\delta \vec{a} \cdot m\right)^2}$$

27.

$$\delta \vec{F_G} = \sqrt{\left(\frac{\delta \vec{F_g}}{\delta m}\delta m \cdot \vec{g}\right)^2 + \left(\frac{\delta \vec{F_g}}{\delta \vec{g}}\delta \vec{g} \cdot m\right)^2}$$

28.

$$\delta \vec{p} = \sqrt{\left(\frac{\delta \vec{p}}{\delta m}\delta m \cdot \vec{v}\right)^2 + \left(\frac{\delta \vec{p}}{\delta \vec{v}}\delta \vec{v} \cdot m\right)^2}$$

29.

$$\delta \vec{p_{total}} = \sqrt{\left(\frac{\delta \vec{p_{total}}}{\delta \vec{p}_1}\delta \vec{p}_1\right)^2 + \left(\frac{\delta \vec{p_{total}}}{\delta \vec{p}_2}\delta \vec{p}_2\right)^2}$$

30.

$$\delta U = \sqrt{\left(\frac{\delta U}{\delta k}\delta k \cdot \frac{x^2}{2}\right)^2 + \left(\frac{\delta U}{\delta x}\delta x \cdot k\right)^2}$$

30.

$$\delta K = \sqrt{\left(\frac{\delta K}{\delta m_{total}}\delta m_{total} \cdot \frac{v^2}{2}\right)^2 + \left(\frac{\delta K}{\delta v}\delta v \cdot m_{total}\right)^2}$$