Lab 0

Measurements and Uncertainty

You are running an experiment to measure the velocity of a cart rolling down a track.You first measure the mass of the cart 5 different times:

Measurement	Mass
1	251.05 grams
2	249.99 grams
3	251.07 grams
4	251.05 grams
5	251.14 grams

Next, you measure the speed of the cart at the bottom of the track:

Measurement	Speed
1	4.2 m/s
2	3.9 m/s
3	4.1 m/s
4	4.0 m/s
5	4.1 m/s

1. What is your estimate (including uncertainty) of the mass of the cart?
   Answer: I used this Google spreadsheet to find the average and standard deviation of the mass measurements. I found $m = 250.86 \pm 0.49$ g $= 0.25086 \pm 0.00049$ kg

2. What is your estimate (including uncertainty) of the speed of the cart?
   I used the same spreadsheet to calculate the speed. I find $v = 4.1 \pm 0.1$ m/s.

3. Suppose your theoretical prediction for the velocity is 4.12 m/s. Is your measurement consistent with this prediction?
   My measured velocity is $v = 4.1 \pm 0.1$ m/s, which means the true value could be anywhere from 4 to 4.2 m/s. Since 4.12 m/s is within this interval, my measurement and prediction are consistent.

4. Suppose your theoretical prediction for the momentum is 1.15 kg m/s. Is your measured value of the momentum consistent with this prediction?
   First, I must calculate the momentum, $p = mv = 0.25086 \cdot 4.1 = 1.03$ kg m/s. According to my slides from lab:

   $\frac{\sigma_p}{p} = \sqrt{\left(\frac{\sigma_m}{m}\right)^2 + \left(\frac{\sigma_v}{v}\right)^2} = \sqrt{\left(\frac{0.00049}{0.25086}\right)^2 + \left(\frac{0.1}{4.1}\right)^2} = 0.024$
   This leaves me with:
   $\frac{\sigma_p}{p} = 0.024$
   I know $p = mv = 0.25086 \cdot 4.1 = 1.03$ kg m/s; I want σ_p
   $\frac{\sigma_p}{p} = 0.024 \rightarrow \sigma_p = 0.024 \cdot p = 0.024 \cdot 1.03 = 0.025$ kg m/s

   So the estimate for momentum, including uncertainty, is $p = 1.03 \pm 0.025$ kg m/s.
   Is this estimate consistent with the predicted value, 1.15? No it is not, since 1.15 does not fall between 1.03-0.025 and 1.03+0.025.

5. Suppose your lab partner runs 5 more trials and finds a speed of 3.97 ± 0.09 m/s. Is their measurement consistent with your own?
   The two measurements are consistent, since their uncertainty estimates overlap.