PHYS 310 — Homework #3

Reading:

- Hughes & Hase Ch 4 has already been assigned, but you might review this (and class notes) for the homework problems below.
- Before the next class, read Hughes and Hase, Chapter 5.

Problems:

1. In Table 4.2 on p. 44, Hughes & Hase claim that for the function

$$Z(A,B) = k\frac{A^n}{B^m}$$

the fractional uncertainty in Z is given by

$$\frac{\alpha_Z}{Z} = \sqrt{\left(n\frac{\alpha_A}{A}\right)^2 + \left(m\frac{\alpha_B}{B}\right)^2}.$$

Use the *calculus approach* to prove this result.

2. In the PHYS 211/212 appendix we discuss the uncertainty in the measurement of g with a pendulum. We say that the uncertainty in the value of g due to our uncertainty in the measurement of the period T is given by

$$\Delta g_T = g(L, T + \Delta T) - g(L, T)$$

(This is H&H's *functional approach.* It's just as reasonable to use

$$\Delta g_T = g(L, T - \Delta T) - g(L, T).$$

Let's assume that $L = 0.96\,\mathrm{m}$ and $T = 1.970 \pm 0.004\,\mathrm{s}$. Does it matter which definition for Δg_T you use? For what values of ΔT will it matter?

3. Section 4.2.2 in Hughes & Hase is a worked example of the determination of pressure and its uncertainty using the van der Waals equation of state and the *functional approach* for determining uncertainties. Repeat these calculations for yourself, determining $P(\bar{V}_{\rm in}, \bar{T})$, α_P^T, α_P^V, and α_P. (Note: there are slight numerical errors for some of the values given in early printings of the text.)

4. Repeat the calculation of the uncertainty α_P in problem #3 using the "calculus approximation" of the uncertainties.

5. Repeat the calculation of the uncertainty α_P in problem #3 using Monte Carlo simulations of the data.

6. Hughes and Hase, Problem 4.8

7. Hughes and Hase, Problem 4.10

8. In homework set #2, problem 8, you simulated the results for a single PHYS 211 lab section doing the M&M experiment. Now simulate the results from 200 lab sections, recording the mean number of brown M&Ms in a bag for each section. Make a histogram of the 200 means, and calculate the standard deviation of those means. Are your results consistent with the predictions of the Central Limit Theorem?