Physics 427 – Introduction to Computational Physics

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Homework 5 – due March 4, 2021

Problem 1: Review the *ODE Initial Value Problems* notebook from class, which will be of relevance for the Jupyter notebook portion of this assignment, and the lab this week. You should also review the *Numerical Derivatives and Richardson Extrapolation* notebook, which will be of additional relevance for next week.

Problem 2: We might think that all this work to make sophisticated algorithms is not necessary, why not just make step sizes Δx extremely small? Here we will see that this approach does not work. As an example, we will consider $f(x) = \exp^{-x/3}$ and evaluate the derivative at $x = 0.7$ using a finite difference formula.

Calculate the fractional error in the numerical derivative for $\Delta x = 10^{-4}$, 10^{-5}, 10^{-6}, and 10^{-7}. You should find that the error starts growing at some point as Δx gets smaller! How can the error grow as Δx gets smaller?

[Note: Since it is not hard, you may want to calculate the error for a large number of Δx values and make a log-log plot. You will see that the error is not a smooth function but does (eventually) have a general trend of growing as Δx gets smaller.]

Problem 3: Complete the Jupyter notebook part of the assignment.

Optional exam review, Due next Monday, March 8th: Review your exam, and correct any incorrect or missing work. For a fully corrected exam, you can collect up to half of the grade you missed (eg. $C \to B$).