Scientific Computation Project 2 class feedback

March 24, 2025

- Part 1 question 1: The class did very well overall on parts (a) and (b). For part (c), it was important to actually show that the numerical result followed an exponential trend (e.g. by using a semilog plot) and then to explain why this exponential behavior occurred. Generally, the maximum perturbation energy won't follow an exponential trend for moderate times even if the leading eigenvalue of the Jacobian has a positive real part. Here, when $\mu = 0$, the Jacobian is circulant, and the eigenvectors of circulant matrices are orthogonal. This orthogonality combined with a positive leading eigenvalue leads to the observed exponential trend.
- Part 1 question 2: The key elements we were looking for here were: 1) recognizing that the dynamics were oscillatory and that Fourier spectra should be examined and carefully discussed, 2) using the correlation dimension to assess the presence of chaos, and 3) investigation of the relative dynamics of the different components for each case. Some submissions presented reasonable conclusions based on well-made figures but the discussion connecting the two was too vague or contained too many inaccuracies for much credit to be given for the conclusions. On the other hand, there were several excellent submissions showing a clear understanding of a good range of relevant methods.
- Part 2 question 1: There were two fundamental issues with the given code 1) using `np.linalg.solve` instead of `solve_banded` and 2) using loops instead of vectorized code. Most recognized one or both of these issues but often didn't fully resolve them (e.g. using `spsolve` instead of `solve_banded`).
- Part 2 question 2: Most recognized the need to assess how the cost and accuracy depend on the grid spacing/number of grid points. However test results then needed to be presented using log-log plots in order to clearly identify the trends, and timing results should have been connected to the time complexities of the methods. Since we were interested in multiscale problems, wavenumber analysis should have been considered (it was fine to use numerical tests rather than theoretical results), and since we were comparing two methods, the cost for a given level of accuracy should have been carefully considered.
