Ay190 – Worksheet 11
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1

The moving Gaussian, upwind scheme, and FTCS are implemented in ws11.py. See Figures 2 for upwind errors with $\sigma = \sqrt{15}$ and $\sigma = \sqrt{15}/5$, respectively.

Upwind is stable for all time if $\alpha = v\Delta t/\Delta x \leqslant 1$.

2

For FTCS, we see instability develop at late times as we increases our ntmax and thus our duration. See Fig 4 with durations 200, 400s respectively. FTCS becomes unstable at $t \approx 150s$ unconditionally.

3

The Lax-Friedrich method is an adaption of FTCS which has been made stable for $alpha \leqslant 1$ by adding a damping term to FTCS, resulting in poorer accuracy but stability. See Fig 6. This method is less accurate than Upwind.

4

Code is included for both Leapfrog and Lax-Wendroff. For the Lax-Wendroff method, we see in Fig 8 that error scales as the square of the resolution so the method is indeed 2nd order.

However, this scaling drops off at later t. I couldn't identify why error diverges.

The reader may run all movies by removing hashes.

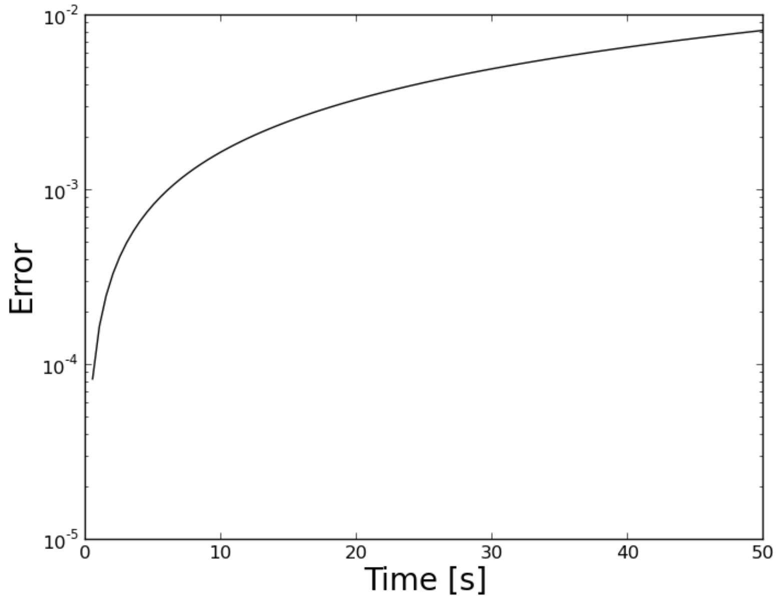

Figure 1: Upwind Error vs Time, $\sigma = \sqrt{15}$

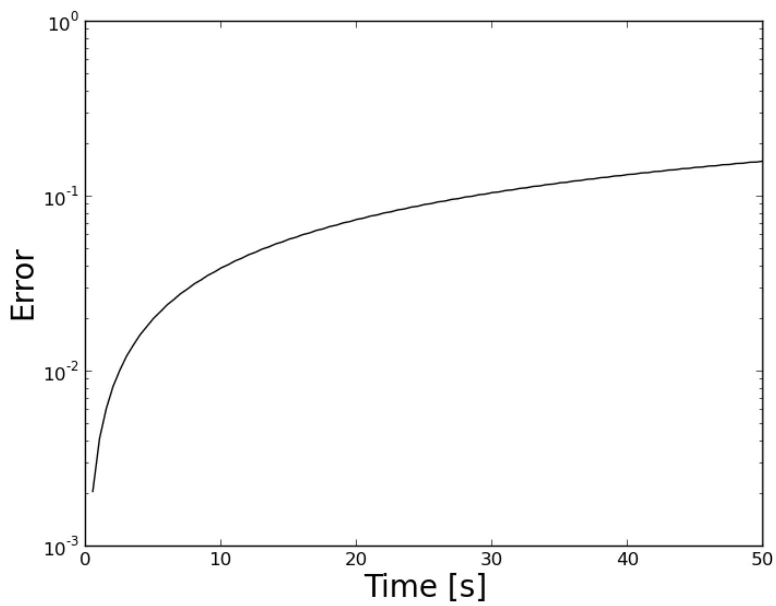

Figure 2: Upwind Error vs Time, $\sigma = \sqrt{15}/5$

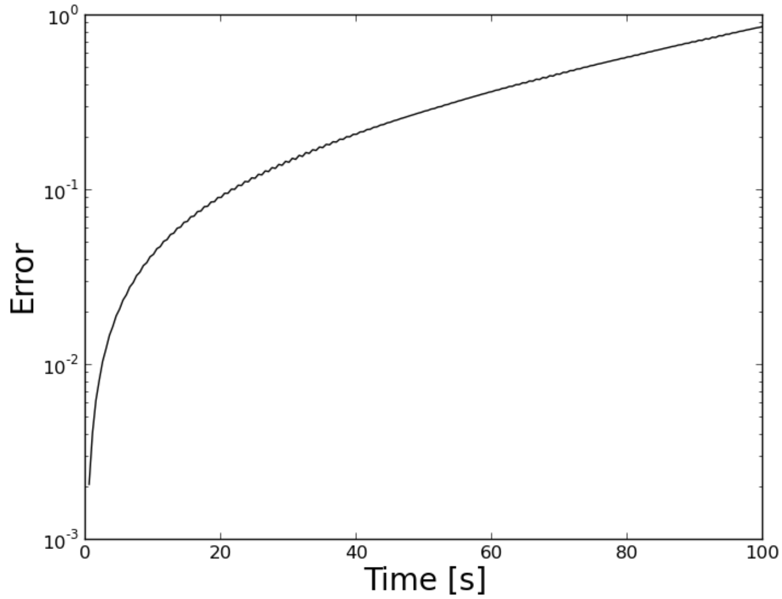

Figure 3: Upwind Error vs Time, $ntmax = 200$

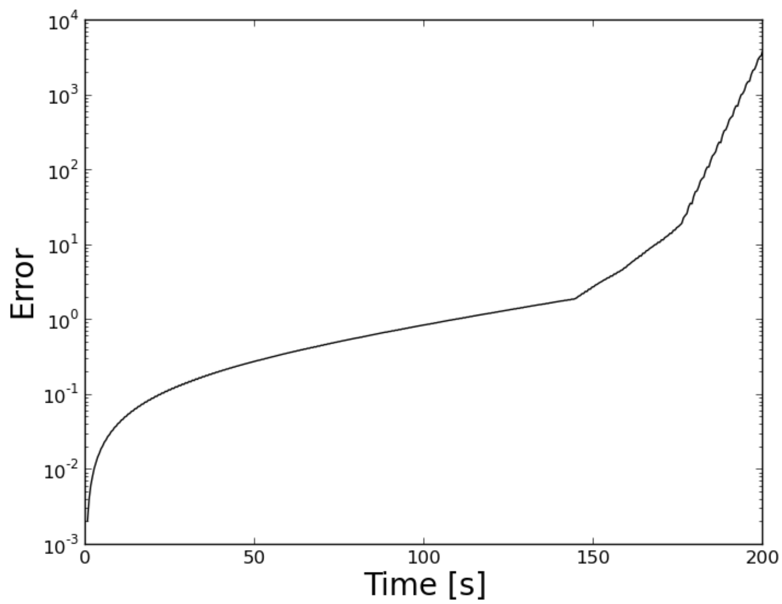

Figure 4: FTCS Error vs Time, $ntmax = 400$

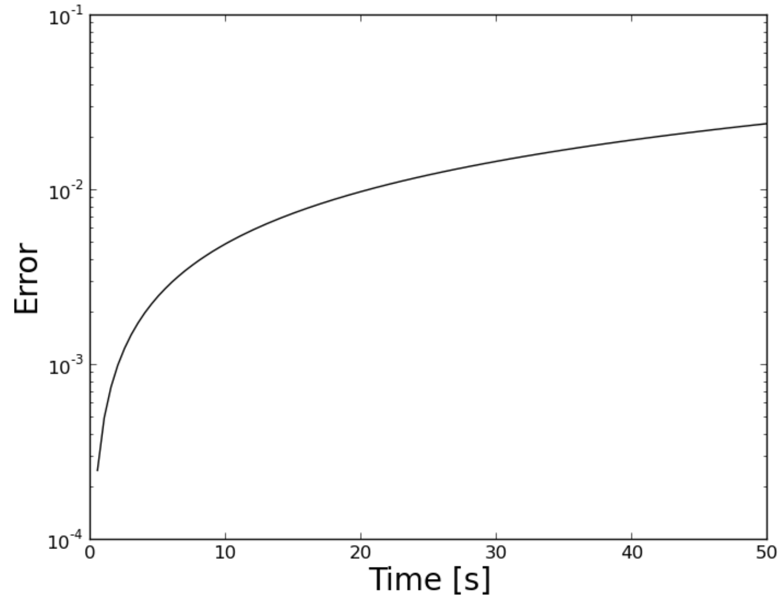

Figure 5: LaxFried Error vs Time, $ntmax = 100$, $\sigma = \sqrt{15}$

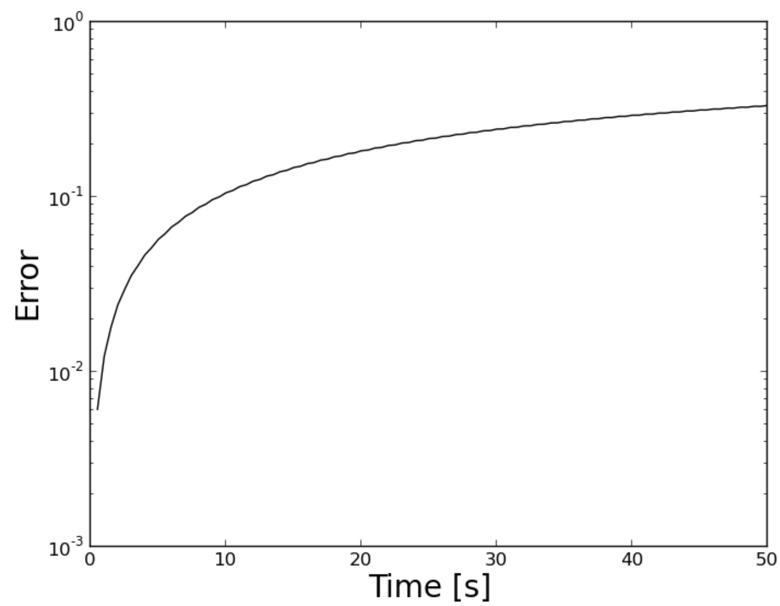

Figure 6: Laxfried Error vs Time, $ntmax = 100$, $\sigma = \sqrt{15}/5$

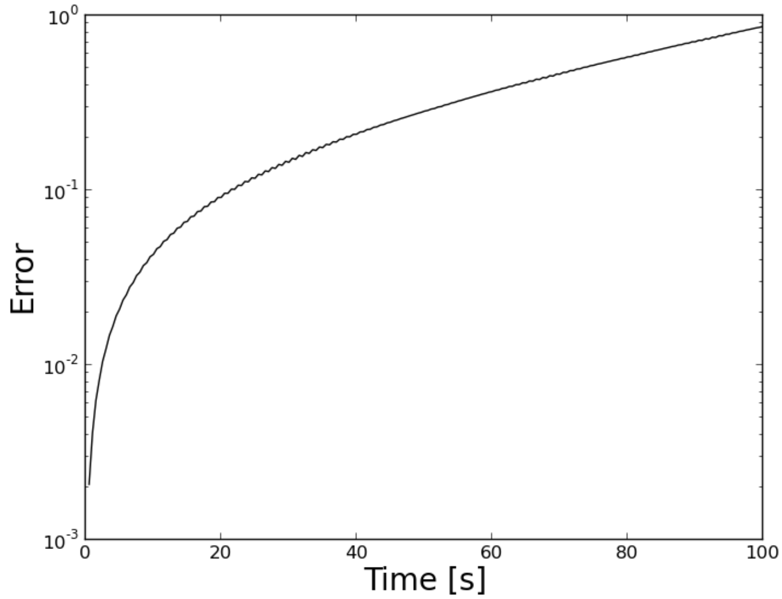

Figure 7: Laxwend Error vs Time, $cfl = .5$

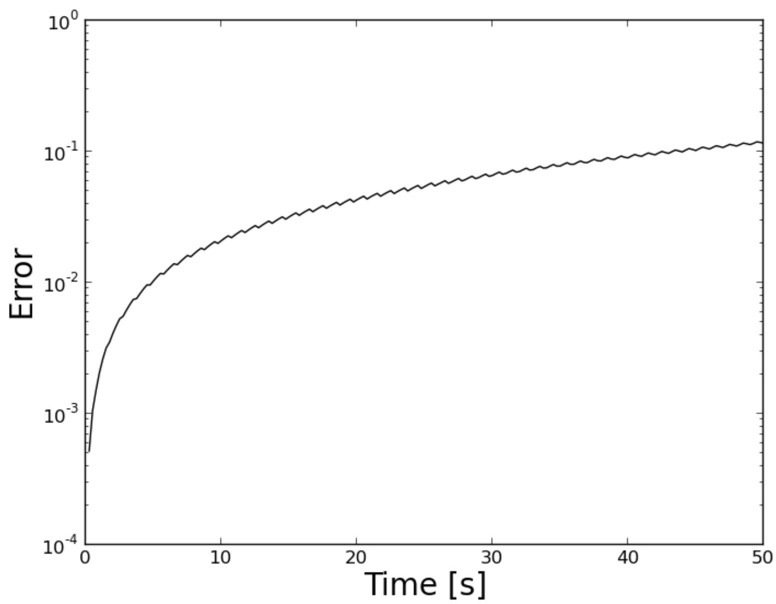

Figure 8: Laxwend Error vs Time, $cfl = .25$