Errata, Clarifications, & Additional Material

December 12, 2024

For *Applied Numerical Methods for Partial Differential Equations* by Carl L. Gardner, Springer, 2024

Errata

Clarifications

p 130, 2nd paragraph: Requiring $\Delta t \leq h/c$ for stability is an example of the CFL condition: . . .

p 132, 2nd paragraph: *FTCS for* $u_t + cu_x = 0$ satisfies the CFL condition for $r \leq 1$ but is unconditionally unstable: . . .

Add after sentence with (8.149) on p 160: In (8.149), the forward-in-time $\Delta w/\Delta t$ is a shorthand for any consistent and stable (explicit) timestepping scheme like RK3.

p 169, 3rd paragraph: . . . two copies of the 1D code (see (8.149)), one for the x sweep for evaluating $f(w)_x$ and one for the y sweep for evaluating $g(w)_y$.

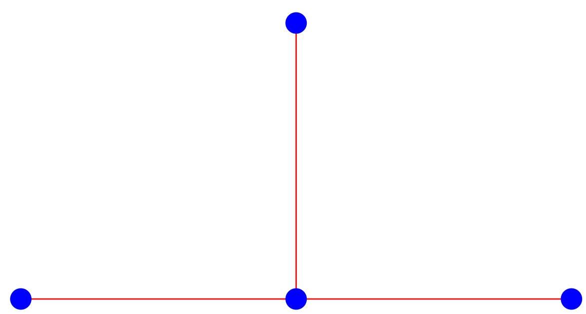
p 172, 3rd paragraph: . . . two copies of the 1D WENO3 method (see (8.149)): an x sweep for calculating $f(w)_x$ and a y sweep for calculating $g(w)_y$.

p 192 after (9.40): . . . $\Delta \mathbf{u}/\Delta t$ is a shorthand for any consistent and stable (explicit) timestepping scheme . . .

Additional Material

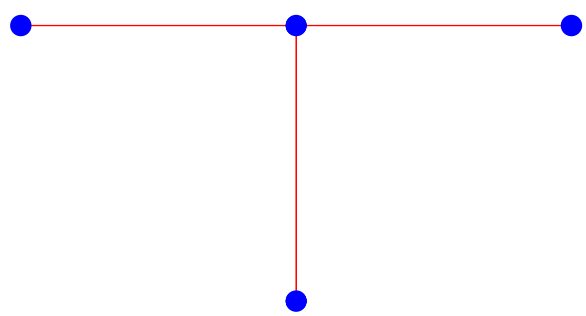
Space-time Stencils for Classical Parabolic Methods

The stencils for classical methods for time-dependent PDEs are shown in Figs. 1–7. In these diagrams, space is horizontal and time is vertical. Figure 3 is annotated to indicate spatial grid points $i-1$, i, and $i+1$ and time levels n and $n+1$. To compute the new solution u_i^{n+1} with the trapezoidal rule method, the old solution values u_i^n and $u_{i\pm1}^n$ are coupled with the new solution values u_i^{n+1} and $u_{i\pm1}^{n+1}$.



forward Euler

Figure 1: Space-time stencil for the forward Euler parabolic method.



backward Euler

Figure 2: Space-time stencil for the backward Euler parabolic method.

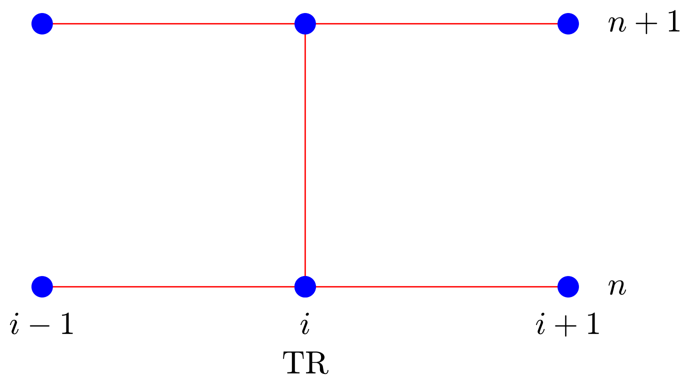


Figure 3: Annotated space-time stencil for the trapezoidal rule parabolic method.

Space-time Stencils for Classical Hyperbolic Methods

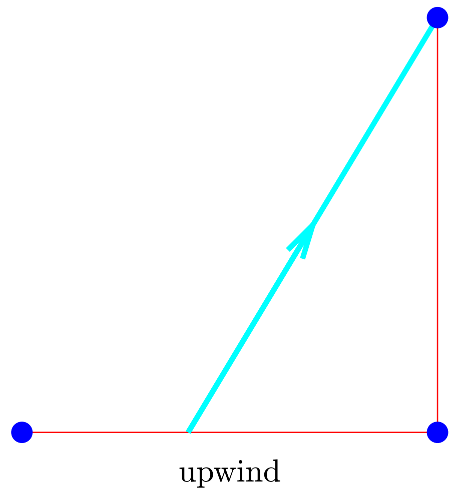


Figure 4: Space-time stencil for the upwind hyperbolic method for $u_t + cu_x = 0$ with $c\Delta t < \Delta x$.

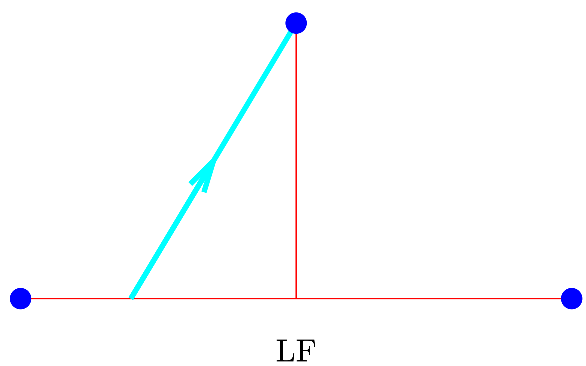


Figure 5: Space-time stencil for the Lax-Friedrichs hyperbolic method for $u_t + cu_x = 0$ with $c\Delta t < \Delta x$.

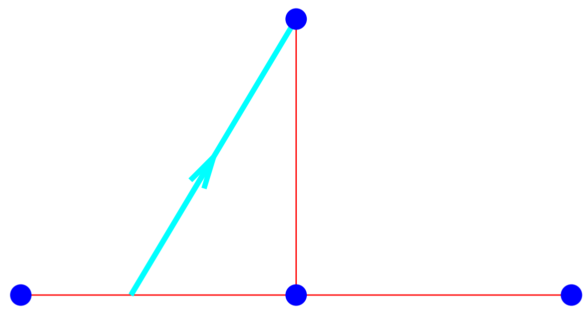


Figure 6: Space-time stencil for the *always unstable* forward time central space method when applied to hyperbolic PDEs.

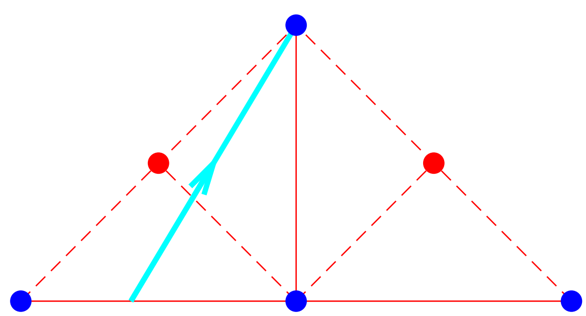


Figure 7: Space-time stencil for the Lax-Wendroff hyperbolic method for $u_t + cu_x = 0$ with $c\Delta t < \Delta x$.