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12.2.4 Stability of Explicit Methods and Implications for Stiff Problems

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MO2.7

While we do not prove this in these notes, *all explicit methods* have a finite maximum possible timestep $\Delta t_{\max}$ above which they will be unstable. The exact value of $\Delta t_{\max}$ depends on the method and the problem being solved. However, roughly $\Delta t_{\max}$ will be proportional to the shortest timescale in the problem. Let's call this shortest timescale for a problem τ (e.g. the combustion timescale in the oscillation combustion example). Then, for an explicit method,

$$\Delta t_{\max} = C\tau \tag{12.30}$$

where C is constant typically around 1. If an explicit method is applied to solve a problem and Δt is chosen to be $\Delta t > \Delta t_{\max}$ then the state $\underline{v}^n$ will increase in magnitude as n increases and eventually (i.e. for large enough n) the numerical approximation $\underline{v}^n$ will no longer be a good approximation to the exact solution.

Now, consider the application of an explicit method to a stiff problem. Let T be the maximum time over which the solution is desired (e.g. in the oscillating combustion problem, this would likely be several periods of $I_F\,(t)$). Then the minimum number of timesteps required to solve this problem will occur when Δt is chosen to be its maximum. Thus,

(12.31)

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