## 12.1.3 Example: Application of Forward Euler to Oscillating Combustion

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MO2.4 MO2.7

Now, let's consider the application of Forward Euler to the oscillating combustion IVP. The overall aim of solving this model is to quantify the periodic behavior which is expected to eventually develop with a dominant period given by the injection timescale $T_F$. The solution behavior at the much faster combustion timescale is less likely of interest. Given that, the desired timestep would likely be chosen to ensure that $T_F$ is resolved, but that $\tau$ is not. Mathematically, we might say that the desired $\Delta t$ would be,

$$\tau \ll \Delta t \ll T_F \tag{12.3}$$

So, for the values of $\tau$ and $T_F$ given, this might suggest $\Delta t = 1\text{E-}3\,\mathrm{s}$ which would give 100 timesteps per $T_F$. Unfortunately, when applying Forward Euler, this choice of $\Delta t$ will not work. To illustrate the problem, let's look at the results shown in Figure 12.4. What can be observed is that for $\Delta t$ slightly greater than $1\text{E-}7\,\mathrm{s}$ the Forward Euler solutions start oscillating wildly and with an amplitude that is clearly increasing in time. In fact, beyond $t > 0.2\,\mathrm{s}$, the Forward Euler solutions with $\Delta t > 1\text{E-}7\,\mathrm{s}$ exceed what can be represented with double-precision floating point numbers. Clearly, this unstable behavior is not correct.

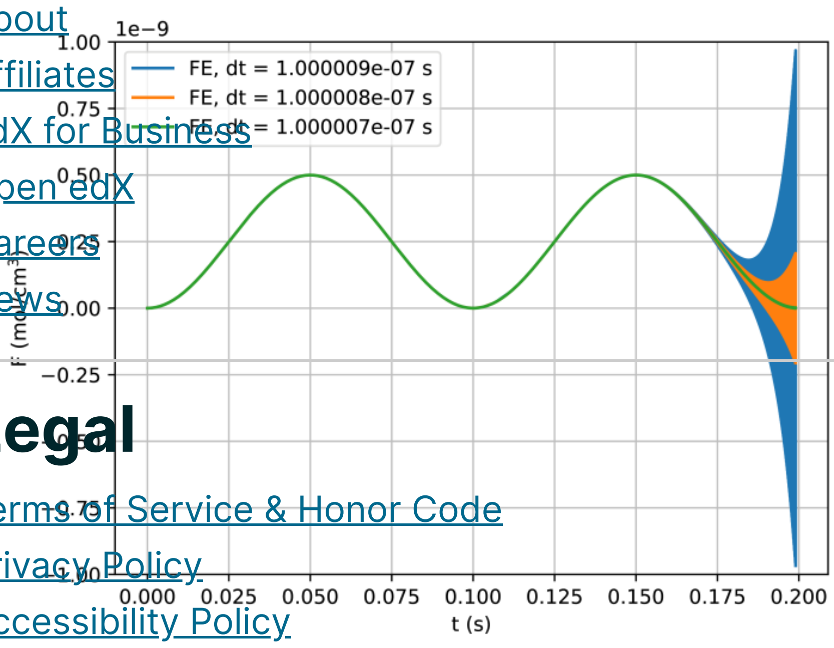


**Figure 12.4:** Impact of $\Delta t$ choice using Forward Euler (FE) method to simulate oscillating combustion with $\tau = 5\text{E-}8\,\mathrm{s}$, $T_F = 0.1\,\mathrm{s}$, and $A_F = 0.01\,\mathrm{mol/cm^3/s}$

The Python code discussed in this video are available in the following zip file.

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