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9.2.2 Example: Accuracy of Forward Euler simulation of coffee cooling

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Let's consider the error for the Forward Euler simulation of coffee cooling. Figure 9.1 shows that the error decreases by about a factor of 10 for a factor of 10 decrease in Δt from 50 to 5 minutes. This would seem to indicate a first order ($p = 1$) method since the error seems proportional to Δt.

To see more certainly that Forward Euler is $p = 1$, we plot the maximum error ($e_{\max}$) versus a range of Δt in Figure 9.2. This plot is done using a log-log scale because the slope then is directly the observed order of accuracy. To see that this is true, recall that the definition of the order of accuracy says that,
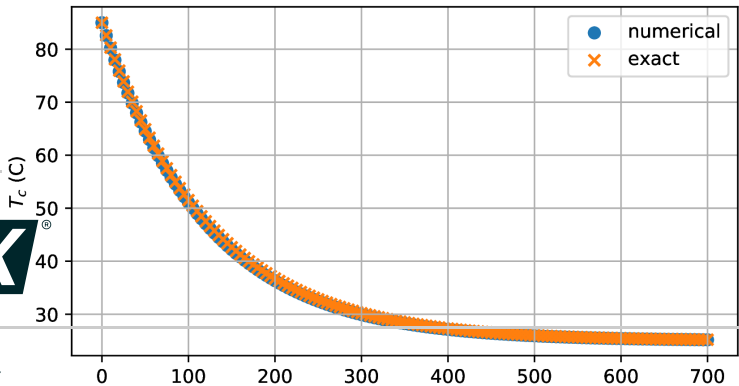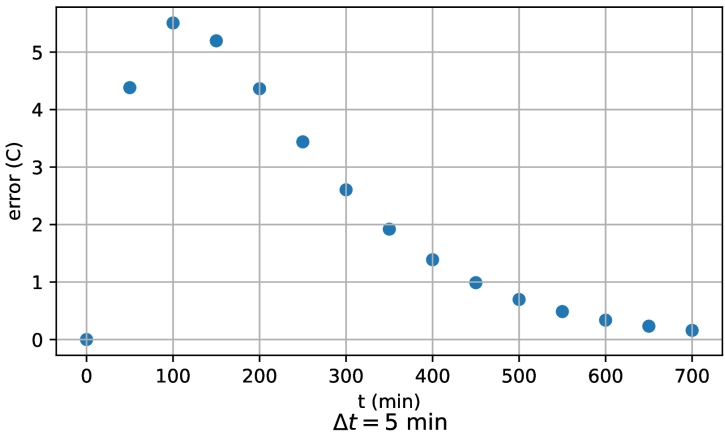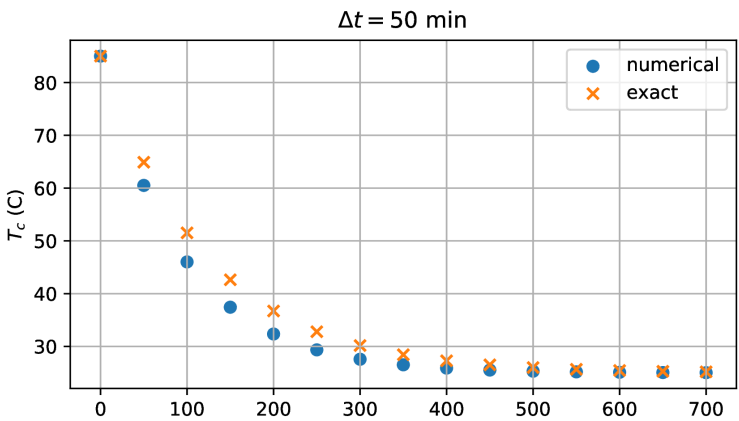
$$e_{\max} = O\left(\Delta t^p\right) \tag{9.4}$$

$$\log e_{\max} = O\left(\log\left(\Delta t^p\right)\right) \tag{9.5}$$

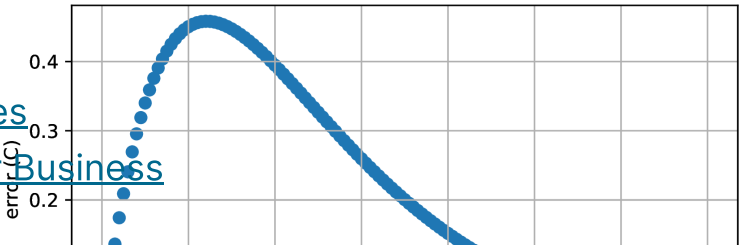$$\Rightarrow \log e_{\max} = O\left(p \log \Delta t\right) \tag{9.6}$$

Thus, p is the slope of the $\log e_{\max}$ versus $\log \Delta t$ plot. As can be seen in Figure 9.2, the slope is 1.

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