Extract from Introduction to Chemical Engineering Computing, 2nd ed., by Bruce A. Finlayson, Wiley (2012).

9.26$_2$. Kirby (2010, p. 259) suggests a change of variable for problems with high Peclet numbers. The problem

$$\frac{\partial c}{\partial t} + Pe\frac{\partial c}{\partial x} = \frac{\partial^2 c}{\partial x^2}, \quad c(0,t) = 1, \quad \left.\frac{\partial c}{\partial x}\right|_{x=1} = 0, \quad c(x,0) = 0 \tag{9.77}$$

would be converted using $c = \exp(\gamma)$ to

$$e^\gamma \frac{\partial \gamma}{\partial t} + Pe\, e^\gamma \frac{\partial \gamma}{\partial x} = \frac{\partial}{\partial x}\left(e^\gamma \frac{\partial \gamma}{\partial x}\right), \quad \gamma(0,t) = 0, \quad \left.\frac{\partial \gamma}{\partial x}\right|_{x=1} = 0, \quad \gamma(x,0) = -10\,. \tag{9.78}$$

The value –10 is simply taken as a large negative number. Use Comsol Multiphysics to solve this problem on the domain x = 0,1 for Pe = 1000 using 30 and 60 elements. Compare the solution with that obtained for the original problem using the same number of elements.

Kirby, B. J., *Micro- and Nanoscale Fluid Mechanics*. Cambridge Univ. Press, New York, NY, 2010.

9.26. Comsol is run with a 1D problem and setting the coefficients as appropriate to the equation. The standard solution is shown for 30 and 60 elements. The oscillations are prominent for 30 elements and are reduced, but still visible, for 60 elements. When the transformed equation is solved, the oscillations are still prominent for 30 elements, although their frequency is less, and they are nearly eliminated for 60 elements. The corresponding solution for γ is shown below.