**Numerical methods, ODE**

**Exercise 1**  
Consider a plug flow reactor where a reactant is converted via a heterogeneously catalyzed reaction following Langmuir-Hinshelwood kinetics, that is the axial concentration profile can be described with the following differential mass balance:

With the following parameters:

Volumetric flow rate:

Inlet concentration:

Reactor length:

Reactor diameter:

Specific catalyst volume:

Reaction rate constant:

1. Use Excel to calculate the conversion for the case that the adsorption constant *K* = 0 using:
   1. Forward Euler
   2. Explicit midpoint rule
   3. 4th order Runge-Kutta method

Compare the numerical solution with the analytical solution and demonstrate for each case the order of convergence.

1. Calculate the conversion for the case that the adsorption constant *K* = 0.5 m3/mol using
   1. 4th order Runge-Kutta method with Excel
   2. Ode45 using Matlab

**Exercise 2:**

Consider the following system of equations:

with boundary conditions: and

Calculate the *c*1 and *c*2 at *t* = 2 using the forward (explicit) and backward (implicit) Euler methods and compare the required time steps for the two methods.