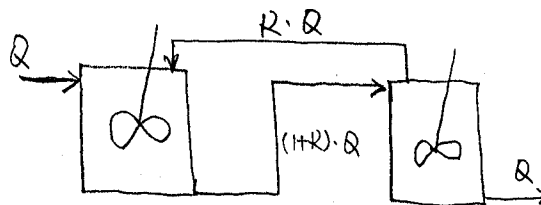


- Modified Euler Method is used to compute the solution of $\frac{dy}{dx} = -ky$, where k is greater than zero. Please derive the order of accuracy and the range of interval to have convergent solution. (20%)
- Two continuous stirred tank reactors with the same volume of V are used in series and fraction of R is recycled from the second reactor to the first reactor, as shown in the following. If the reduction of concentration for only one reactor with first order reaction is 60%, what is the fraction of recycling to achieve more than 80% reduction? (20%)



- If vector $F(x,y,x) = P(x,y,x) \mathbf{i} + Q(x,y,x) \mathbf{j} + R(x,y,x) \mathbf{k}$ and P , Q , and R have continuous second partial derivatives, please evaluate the value of $\iint_S (\text{curl} F \cdot \mathbf{n}) dS$, where \mathbf{n} is the unit vector in normal direction with respect to surface S . (20%)
- Solve the following partial differential equation for the unsteady state diffusion in a droplet with no solute at the beginning: (20%)

$$\frac{\partial C}{\partial t} = D \left(\frac{\partial^2 C}{\partial r^2} + \frac{2}{r} \frac{\partial C}{\partial r} \right) \quad \text{with } C(r,0) = 0, 0 \leq r \leq R_p,$$

$$t > 0, \frac{\partial C}{\partial r} = 0, r = 0 \quad \text{and} \quad C(r,t) = C_s, r = R_p$$

- Please solve the following partial differential equation: (20%)

$$\frac{\partial C}{\partial t} = k \frac{\partial^2 C}{\partial x^2} \quad \text{with } C(x,0) = C_0, x \geq 0$$

$$t > 0, C(0,t) = C_1 \quad \text{and} \quad C(\infty,t) = C_0$$