<u>2nd Lab Test on 13.02.25</u>

Problem 1. Given an initial population of 1000 individuals, with 990 susceptible, 10 infected, and 0 recovered, simulate the spread of the infection over 50 days. Use the parameters $\beta = 0.3$ (infection rate) and $\gamma = 0.1$ (recovery rate). Plot the number of susceptible, infected, and recovered individuals over time.

Problem 2: Modify the basic SIR model to include seasonal variation in the infection rate, such that $\beta(t) = 0.3 + 0.1cos(2\pi t/365)$. Simulate the spread of the infection over one year and plot the results. Choose $\gamma(t) = 0.1 + 0.05sin(2\pi t/30)$.

Problem 3. Extend the basic SIR model to include two age groups: young (under 18) and adults. Assume that the infection rates differ between age groups: $\beta_y = 0.4$, $\gamma_y = 0.3$ and $\beta_a = 0.2, \gamma_a = 0.1$. Simulate the spread of the infection over 100 days, with initial conditions of 100 young and 900 adults, with 5 young and 5 adults infected. Choose

Problem 4. Consider the same initial conditions as above, but introduce a vaccination campaign that vaccinates 50 people per day, starting from day 10. Simulate the spread of the infection and compare the results with the basic model. Assume vaccinated individuals move directly to the recovered compartment.

Problem 5. Given the basic SIR model parameters, calculate the herd immunity threshold. Then, simulate the spread of the infection in a population where 40% of individuals are already immune. Compare the infection dynamics with the basic model.

Problem 6. Consider a reversible reaction $A \leftrightarrow B$ \leftrightarrow B with forward rate constant $k_1 = 0.2$ and reverse rate constant $k_{\{-1\}} = 0.1$. Given initial concentrations $[A] = 1.0\, mol/L$ and $[B] = 0.0\, mol/L$, solve the system of differential equations and plot the concentrations over time.

Problem 7. For a set of coupled reactions:

$$A \rightarrow B \text{ with } k_1 = 0.1$$

and

$$B \rightarrow C \text{ with } k_2 = 0.05$$

Given initial concentration $[A] = 1.0\, mol/L$ and $[B] = [C] = 0.0\, mol/L$, solve the differential equations and plot the concentrations over time.

Problem 8: Consider the reactions:

$$A + X \rightarrow 2X\ (k1 = 1.0)$$

$$X + Y \rightarrow 2Y\ (k2 = 0.5)$$

$$Y \rightarrow B\ (k3 = 1.0)$$

Simulate the reaction dynamics and plot the oscillations in $[X]$ and $[Y]$.

Problem 9: Simulate a reaction network with multiple steps:

$$A \rightarrow B\ (k1 = 0.2)$$

$$B \rightarrow C\ (k2 = 0.1)$$

$$C \rightarrow D\ (k3 = 0.05)$$

Given initial concentration [A]=1.0mol/L, simulate and plot the concentrations of [A], [B], [C], and [D] over time.

Problem 10: Consider an autocatalytic reaction

$$A + 2B \rightarrow 3B$$

with rate constant $k = 0.05$. Given initial concentrations $[A] = 1.0\ mol/L$ and $[B] = 0.1 mol/L$, simulate the reaction and plot the concentration dynamics.