**Oberwolfach Seminar**
**Mathematical Modelling in Systems Biology**
**Nov 19-25, 2017**

**Task 1 (Epodemiological model)**
Consider an epidemiologic model of a virulent outbreak (also called susceptible-infected-recovered (SIR) model):

$$\emptyset \xrightarrow{\lambda} x_1$$

$$x_1 \xrightarrow{\delta} \emptyset$$

$$x_1 + x_2 \xrightarrow{\beta} 2x_2$$

$$x_2 \xrightarrow{3 \cdot 10^7 \cdot \delta} x_4$$

$$x_2 \xrightarrow{k_r} x_3$$

$$x_3 \xrightarrow{\delta} \emptyset$$

where $x_1$ denotes the number of susceptible individuals, $x_2$ are the number of infected individuals, $x_3$ are the number of individuals that recovered and are subsequently resistant to infection, and $x_4$ are the number of individuals that died from the infection. Parameter values are $\lambda = 1 \cdot 10^{-4}$, $\delta = 1 \cdot 10^{-8}$, $\beta = 5 \cdot 10^{-5}$, $k_r = 0.3$, and the initial state is $x_1(0) = \lambda/\delta$, $x_2(0) = 5$, $x_3(0) = 0$, $x_4(0) = 0$.

(a) Write a program implementing this model and generate trajectories using the stochastic simulation algorithm.

(b) Plot the trajectories for $N = 3$ simulations up to time $T = 10$.

(c) Perform $N = 1000$ simulations, generate a histogram of the number of $x_2$ at time $T = 10$ and depict the probability that $0, \ldots, 20$ individuals are infected by $T = 10$. What is the probability that the infection is still ongoing at $T = 10$?

(d) From the $N = 1000$ simulations, generate a histogram of the number of $x_4$ at time $T = 10$ (number of casualties), depicting the probability that $0, \ldots, 35$ individuals died by $T = 10$. How many individuals died on average ($\pm$ standard deviation)?