Exploring the SIR-model

Based on a huge simplified mathematical model, you will examine the propagation of an epidemic in a population by implementing the model in a Python program. The model calculates the number of susceptible, infectious and recovered number of individuals from one day to another. You may read about the model here, but most of it is not applicable for this task.

The States

The state of an individual, at a given time, in the population is precisely one of

- S: Susceptible
- I: Infectious
- R: Recovered

An individual not been infected is susceptible, an infected individual is not susceptible and a recovered individual is neither susceptible nor contagious. An individual is recovered after a given time of beeing infectious.

The Data Representation

- N: Number of individuals in the population
- a: The time span an individual is contagious (days, in this example)
- b: A constant being related to the infectivity of the disease (the higher value, the more infectivity)

The Model

The number of individuals whith each status after k days is denoted S_k, I_k and R_k. The number develops from day to day following the model

- $S_{k+1} = S_k - b \cdot I_k \cdot S_k$
- $I_{k+1} = I_k + b \cdot I_k \cdot S_k - I_k/a$
- $R_{k+1} = R_k + I_k/a$

Suppose the starting values $N = 1\,000\,000$, $S_0 = 999\,999$, $I_0 = 1$, $a = 7$ and $b = 2.0 \cdot 10^{-7}$. Note that this is a hugely simplified model which may not be applicable in real world.

The Tasks

1. Describe each equation in the model above.

2. Implement the model in Python and present the outcome as three diagrams, respectively showing graphs of
    - the development of the number of individuals with each status as $b = 2.0 \cdot 10^{-7}$
    - the development of the number of individuals with each status as $b = 1.7 \cdot 10^{-7}$
    - the development of the number of individuals with each status as $b = 2.3 \cdot 10^{-7}$

    for a suitable number of days. Comment these graphs.

3. Present the progress of the number of individuals of each state with respect to time as $b = 2 \cdot 10^{-7}$, but with variation of the number of days an individual is contagious. Let a take the value 6, 7 and 8, one value at a time. Comment the result.

4. Epidemiologs talk about "flattening the curve", read more abut this topic here. Why is this important? Based on your results above, what is important to achieve?