IB120/201 - Lab 4

Modeling Disease Transmission

Due Date: February 21, 2020

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In this lab, we will practice modeling disease transmission and ecological phenomena with systems of differential equations.

Background

Corona Virus Transmission

Let us devise a model for the transmission of COVID-19. Here is what we know about the outbreak so far:

- long incubation period (around 6 days)
- $R_0 = 2006$
- symptoms last about 3 days
- highly transmittable
- Population of Bay Area = 7 million

The info above allows us to define our parameters:

$\sigma = (incubation\ period)^{-1} = \frac{1}{6}$

$\gamma = (duration\ of\ symptoms)^{-1} = \frac{1}{3}$

$N = 7,000,000$

$\beta = transmission\ rate = 1.238\mathrm{e} - 7$

$$\text{S} \xrightarrow[\beta]{transmission\ rate} \text{E} \xrightarrow[\sigma]{incubation\ period} \text{I} \xrightarrow[\gamma]{recovery\ rate} \text{R}$$

With the assumption of a closed population (no births or deaths), we can write out the differential equations for the model:

$$\begin{cases} \frac{dS}{dt} = -\beta SI \\ \frac{dE}{dt} = \beta SI - \sigma E \\ \frac{dI}{dt} = \sigma E - \gamma I \\ \frac{dR}{dt} = \sigma I \end{cases}$$

where $N = S + E + I + R$.

Questions

1. Plot the results from the code that implements the model described above using the `ggplot` package instead of R's built-in plot function. Use this as an opportunity to acquaint yourself with the various parameters in this package.
2. Calculate the number of infected patients after 30 days
3. How many people must be vaccinated to stop the infection?
4. Think about how to modify this model to be more realistic (e.g. account for births and deaths)
5. ***Alternate Assignment:*** Create your own model, implement it, plot the results and describe briefly the justification and assumptions of such model.