MATHS 2103 Probability and Statistics
Project 1 - Epidemics

Due: Friday, 2 June 2017, 4 PM (week 12).

An infectious disease has started to spread through communities in various parts of the world. SA Health has requested a short report (no more than 10 pages) about the impact such a disease would have on the city of Adelaide. They would like to see examples of how the disease might spread if one infected individual were to arrive in Adelaide, as well as if a plane load of infected individuals were to arrive in Adelaide. A discussion pointing out the differences between these two scenarios is also required.

As this report is for nonmathematicians, any mathematical techniques/tools/equations will need to be explained clearly and concisely. You will need to address any limitations, possible sources of errors and any modelling assumptions, while detailing possible solutions or fixes to these probems.

Facts that you need to know:

- The population of Adelaide is assumed to be 1.317 million. However, to simplify the mathematics for SA Health, the report should look at a population of 100 ($N = 100$) and use the results of the analysis to hypothesise what might happen for larger populations. For example, would there be a difference, or would there be similar outcomes?
  Note: A "plane load" is considered to be 10 people, when the total population is only 100.

- The infection rate, β, of this disease is unknown, but estimates have it between 5 and 10. Similary, the rate of recovery, γ, is not certain but should also be between 5 and 10. Any analysis should look at the range of possible combinations for β and γ and discuss any major differences in outcomes.

- The disease is known to follow SIS dynamics. This stands for "Susceptible-Infected-Susceptible" and means that individuals pass from

  $$\text{susceptible to the disease } \underbrace{\rightarrow}_{\text{infection}} \text{ being infected } \underbrace{\rightarrow}_{\text{recovery}} \text{ return to be susceptible.}$$

  For such diseases, this means that the number of infected individuals, I, (in a population of N) increases (over a time period of $\Delta t = 10^{-3}$) with probability

  $$\frac{\beta I(N-I)}{(N-1)}\Delta t,$$

  and decreases with probability

  $$\gamma I \Delta t.$$

  As such, the probability the nothing happens (no infection or recovery) over the same time period is

  $$1 - \Delta t \left(\frac{\beta I(N-I)}{(N-1)} + \gamma I \right).$$

- Make sure you think about the edge cases; $I = 0$ and $I = N$. Can a decrease happen in these states? Can an increase happen?