Random Processes III 2018: Project,

to be submitted by 1pm on Friday 12^{th} October.

The Problem

You have been asked by SA Health to provide modelling advice on how they should manage a current 'flu outbreak, and prepare for a potential larger outbreak.

There is currently an outbreak in a School in Mount Gambier and if not contained it has the potential to spread more widely within the community.

Two interventions are at their disposal, the use of face masks and/or the use of antivirals. They are interested in the best use of these interventions in the School population (e.g., how much reduction in infectious cases would result from the interventions, and what would be the total cost), the risk posed to the Mount Gambier population at large (e.g., what is the risk of it spreading from the School to the population at large, and there being a major outbreak in that larger population), and what planning they need in the eventuation of such an outbreak in the broader population (e.g., how long will the epidemic last, how many people will be ultimately infected, and how many people are likely to be ill at the peak of the epidemic, etc.).

Some facts / assumptions:

- You can assume that influenza follows SIR dynamics. This stands for "Susceptible-Infected-Recovered" and means that individuals pass from

  $$\begin{array}{c}\text{susceptible to}\\\text{the disease}\end{array} \underbrace{\longrightarrow}_{\text{infection}} \text{infectious} \underbrace{\longrightarrow}_{\text{recovery}} \begin{array}{l}\text{recovered from and}\\\text{immune to disease.}\end{array}$$

  In a population of N people there are S susceptible individuals, I infected individuals and $R = N - I - S$ recovered individuals and the infection and recovery rates are denoted β and γ, respectively.

  For such diseases, this means that people are infected at a rate of

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

  and recover at a rate of

  $$\gamma I.$$

- The basic reproduction number, R_0, in the absence of interventions, is $\beta/\gamma = 1.6$ (probably with some uncertainty, in practice); and, the average infectious period, in the absence of interventions, is $1/\gamma = 3$ days (probably with some uncertainty, in practice).

- The School population size is $N = 200$.

- Antivirals are given to infectious individuals, and shortens their infectious period to (approximately) 2 days. They cost \$2/person/day.

- Face masks are worn by everyone in the School, and it reduces transmission by (about) 25%. They cost \$0.5/person/day.

What I need from you

(In a University environment “What you need to hand in”.)

$\boxed{5}$ 1. You need to schedule a 20 minute meeting with me in Week 7 or Week 8, to allow both sides a chance to clarify any problems and determine the right questions are being asked (and hopefully answered). Here you will bring along an outline of your report (how it will be set out, what questions you want to answer, how you might answer them), a draft of your report (what you have written up until this point) and any code you have written; this information must be emailed to me 24 hours before your meeting. Everyone in your group needs to attend this meeting. You should email me as soon as you have a list of available times for your group in those weeks, in order to arrange a time.

2. The Report (submitted electronically): You need to provide a written report, which includes the following:

   $\boxed{6}$ (a) **An Executive Summary.** This should be on a separate page at the front of the report and addressed to SA Health. The executive summary should contain just a statement of the questions and the answers to the questions posed by SA Health and a reference to the CTMC analysis (not in too much detail here). It should be very light on mathematical detail, and instead focus on the recommendation / policy conclusions.

   $\boxed{3}$ (b) **The introduction.** This should contain a detailed explanation of the problem and any background material. A breakdown on the contents of the report should also be included, detailing where the reader should find certain parts.

   $\boxed{12}$ (c) **The report body.** This should contain:

      i. Details of the way that you modelled the physical problem at each stage and any modelling assumptions.

      ii. Your analysis of the posed problem, including any analytical expressions and reference to code you used.

      iii. The results of all your analyses.

   $\boxed{5}$ (d) **The discussion.** Here you will discuss and analyse your results. You should also discuss any possible errors (and an estimate of the size of these errors, if possible) or possible extensions of the model should also be given.

   $\boxed{3}$ (e) **The conclusion.** Here you will summarise your results and discussion. The reader should be able to read only the introduction and conclusion and get a very good understanding of what the problem was, how it was solved and what the answer(s) mean(s).

   The purpose of the report is to give your boss (me) confidence in the fact that you understand the problem, and that the answers that you have in your Executive Summary are correct. You should write just enough to do this.

$\boxed{5}$ 3. An electronic copy of all your computer code: In case I need to check something before I report to SA Health, or change something, I need to be able to see and use your computer code. Therefore, there should be comments explaining (at least) how to use the code and also, what each part does.

Further useful information

1. **The main problem.** You should start by specifying the problem as a CTMC. Here you will need to determine the state space, the possible transitions and the transition rates.

$\boxed{8}$ 2. **Extension opportunities to really impress your boss** (in a University environment: If you want an HD you had better do something here!). You can extend your model and/or answer other (relevant!) questions that will help SA Health with their initial query.

$\boxed{5}$ 3. **Writing.** Just as you will do/have done for your assignments, make sure that in all your writing you
   (a) use full and complete sentences,
   (b) include units where necessary,
   (c) give ranges/constraints for parameters in formulas, and
   (d) make sure your layout and mathematical arguments are clear and concise.

Notes to Students

- This mini-project will constitute 15% of your final mark. Generally, the same mark for the project report will be awarded to each member of a group. However, I reserve the right to vary this if there is good reason to do so.
- This exercise aims to replicate the sort of conditions that you might encounter in a job situation. You are expected to solve the problem from start to finish, and present the results in a well-written form. As with all good bosses, I will be available to answer questions and potentially provide direction, but like all brilliant employees, you are to have a go first, try different things, and ask your boss (me) only when you are genuinely stuck.
- Your report should be typed up and spell checked. Hand-written material or hand-drawn figures will not be accepted.
- You will need to use a number of mathematical tools, which you have at your disposal. A big part of the exercise is that you will have to make decisions about which tools to use, and how your report should be written. (If anyone asks how many words or pages they are expected to write, they are thinking like students, not employees.)