Problem Solving Task 1

MXN501

Due date	29/08/21 11:59pm
Last name	
First name	
Student number	

About this Problem Solving Task

In this problem solving task you will be using your knowledge of probability and combinatorics to address a real-world problem. This problem solving task is worth 10% of your final grade.

Submit the full working for your PST solutions to TurnItIn (through Blackboard) by Sunday 29/08/21 at 11:59pm.

Remember to:

- define events and probabilities
- state all rules used
- show all working
- write neatly/ type

This is individual assessment. You should not work with others to complete the task, share your work, or ask other students for their work. Sharing work with others, or working together too closely, constitutes academic collusion.

Your solution must be your own. You are not permitted to copy, summarise, or paraphrase the work of others in your solution.

You are not permitted to share this content online. You must not use online services to assist in your work.

Please ensure you are familiar with QUT's policy on Academic Integrity

Introduction

Probability and stochastic modelling are used in many real-world industries. In this assignment, we will focus on some applications in epidemiology through networks.

You have been hired as a research assistant at a company that focuses on how social networks can result in the spread of viruses. In your role, you will be working on investigating the spread of coronavirus. This project consists of three main phases: spread through existing networks, managing health messaging, and understanding susceptible demographics.

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Question 1 [4 marks]

The connection between a group of people can be represented using a graph. An individual is represented with a node, and the relationship between two people is an arc. Some of these social networks can be very complex, e.g. Figure 1.
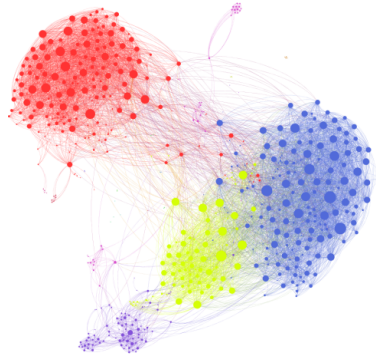

Figure 1: A social network represented as a graph. Source: Brendan Griffen.

Consider two people, A and B. Person A works in a fever clinic and is at risk of contracting coronavirus. Person B works in an aged care home. Person A and person B typically interact with a similar group of friends. During lockdown, with limitations in the number of visitors per household, the friendship group is trying to determine how best to limit their interactions to reduce the chance of spreading coronavirus into an aged care facility. The two possible networks of interaction are shown below.
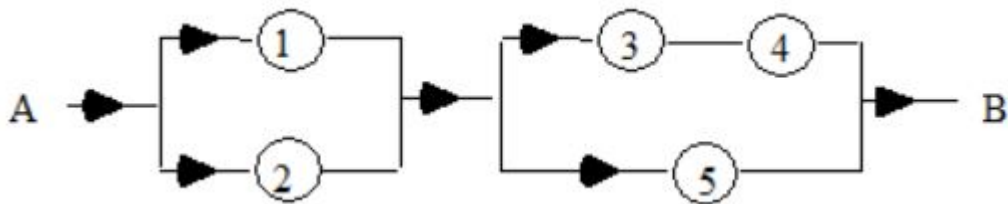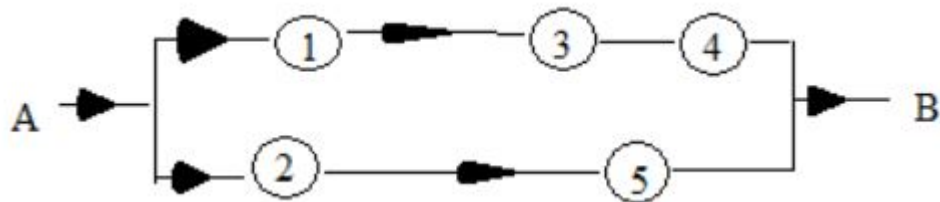

Figure 2: Strategy 1.

Figure 3: Strategy 2.

Assume that friends 1 through 5 pass on coronavirus independently of each other with probability p. Hence, for coronavirus to reach person B, it must be transferred from person A through the network of contacts.

Two simplify this scenario, assume that it is not possible for anyone in the network to contract coronavirus any other way.

   i. What is the probability that coronavirus will infect person B using strategy one?
   ii. What is the probability that coronavirus will infect person B using strategy two?
   iii. Show that strategy one is always at least as likely to infect person B as strategy two using your solutions to i and ii.

[1 mark for notation, definitions, rules, and working; 1 mark each for parts i, ii and iii]

Question 2 [4 Marks]

A local government is managing ads aimed at improving public health awareness. The government pays a social networking app to show their ads in users' news feeds. The social networking app has a variety of adds to show. If the government pays a fee, the app will guarantee that the ad will be shown, but that the add will be randomly mixed with other ads. The government believes that they will improve health outcomes if users see two consecutive ads with health initiatives.

The app will show a user exactly one ad each minute. The apps algorithm also states that if an ad has been shown then it will not be shown to the user again. The social media site shows all ads that it has been contracted to display.

The app is currently contracted to display 5 health related ads, and 11 ads that are not health initiatives. Every ad is considered 'unique', i.e. there are no repetitions.

   i. How many ways can the app arrange these ads?
   ii. How many ways can the app arrange these ads, where there are at least two health ads in a row?
   iii. How many ads should the government have in their portfolio if they wish to ensure there is a probability of at least 0.5 of a user seeing at least two of their ads in a row?

[1 mark for notation, definitions, rules, and working; 1 mark each for i, ii, iii]

Question 3 [2 marks]

A hospital has recorded data around patients presenting with coronavirus. From this data, they know that 20% of patients are under 50, 40% of patients are between 50 and 80, and the remaining 40% of patients are over 80. The hospital estimates that 30% of the local population have contracted coronavirus. A research team at the hospital have surveyed locals who haven't contracted coronavirus and estimate that 60% are under 50, 20% are between 50 and 80, and 20% are over 80.

   i. What is the probability that a person from each age range will contract coronavirus?

[1 mark for defining events, notation, layout; 1 mark for part i]