CT561 Assignment 2

Using the SIR Model to Explore the Impact of Mask Wearing on Hospitalisations

1. Run Information

The run information is shown in Table 1.

INITIAL TIME	0
FINISH TIME	100
TIME STEP	0.0625
Units for Time	Day
Integration Type	Euler

Table 1: Run information for the model

There are two main parts to the model (see sections 2 and 3), and the total population is 100,000.

2. The Mask Wearing Adoption Model

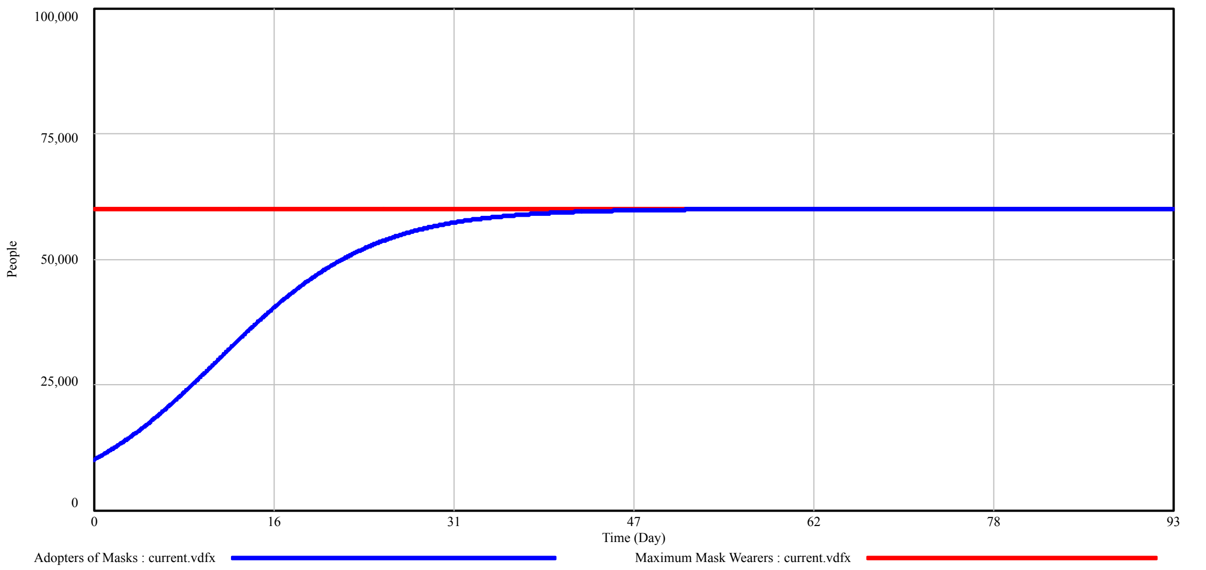
Mask wearing is based on the **Verhulst model**, where the stock is *Adopters of Masks*. A variable, *Maximum Mask Wearer Percent* determines the maximum number of the population that will wear masks (this is the limit to growth). Based on this model, the *Adoption Fraction* can be calculated, which is the fraction of the population that wear masks.

For the test case, the following values should be used, as shown in Table 2.

Adopters of Masks	INITIAL VALUE = 10000	The initial value of the stock of mask adopters (assumed at 10% of the population)
Growth Rate	0.15	The growth rate of people adopting masks (15% per day). This is modified for one of the scenarios.
Maximum Mask Wearer Proportion	0.6	The "ceiling" on mask wearing in the population, 0.6 is *for the test case*

Table 2: Mask model information

When the model runs for the test case, the following output should be obtained for the stock *Adopters of Masks*.



As a check, the following values should be observed in and around TIME=50 days.

Time (Time)	75	49.8125	49.875	49.9375	50	50.0625	50.125	50.1875	50.25
Adopters of Masks : current	9831.3	59832.9	59834.5	59836	59837.6	59839.1	59840.6	59842.1	59843.5

3. The SIR and Hospital Model

An SIR model is used to model the spread of infection. An additional stock is added to model people in hospital, and a fixed fraction enter hospital once they are no longer infectious. Here are the key stocks, and their initial values. People in hospital will then flow to recovered (see time lags in parameter table). The stocks and their initial values are shown in Table 3.

Stock	**Initial Value**	**Description**
Susceptible	999,990	The number of susceptible people in the population
Infected	10	The number of infectious people in the population
In Hospital	0	The number of people in hospital
Recovered	0	The number recovered

Table 3: Key disease-related stocks and their initial values

The following fixed parameters (Table 4) are used for calculating the different flows.

Parameter/Auxiliary	Value	Description
Contacts	10	The average number of daily contacts
Infectivity	0.05	The chance of an infectious person spreading if not wearing a mask
Infectivity Masks	0.03	The chance of an infectious person spreading if wearing a mask.
Hospitalisation Fraction	0.10	Percentage of people hospitalized after becoming infected.
Recovery Delay	4	Average duration of recovery (first order delay)
Average Length of Stay (ALOS)	10	The average length of stay in hospital.

Table 4: Fixed parameter values for the model.

The force of infection equation must take into account the contributions from:

- Those wearing masks (Infected Wearing Masks)
- Those not wearing masks (Infected Not Wearing Masks).

Note: A simple proportion can be used to compute how many of the infectious stock are in each category, based on the *Adoption Fraction* variable.

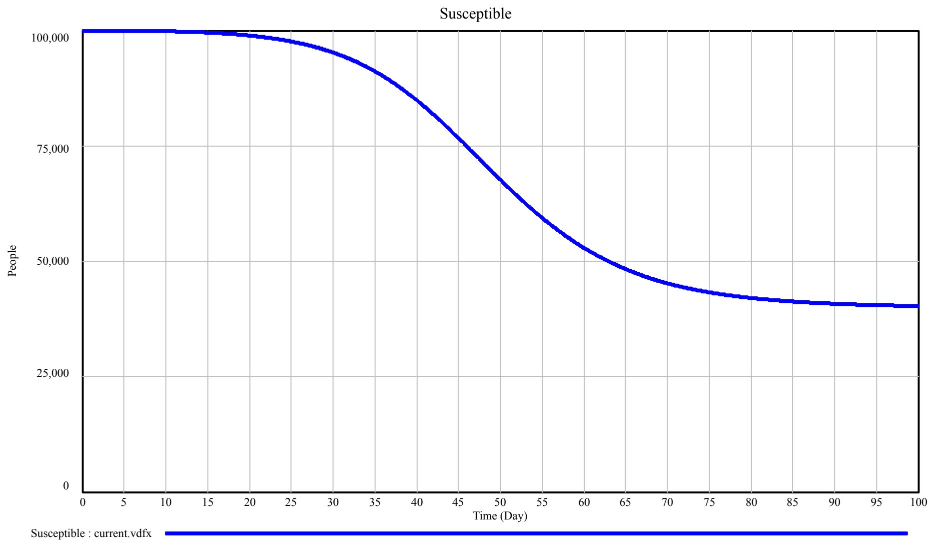
Two additional (cumulative) stocks must be added to the model. These are "reporting variables".

Stock	Initial Value	Description
Total Infected	0	Keeps track of the total number of infections.
Total Hospitalised	0	Keeps track of the total number hospitalised

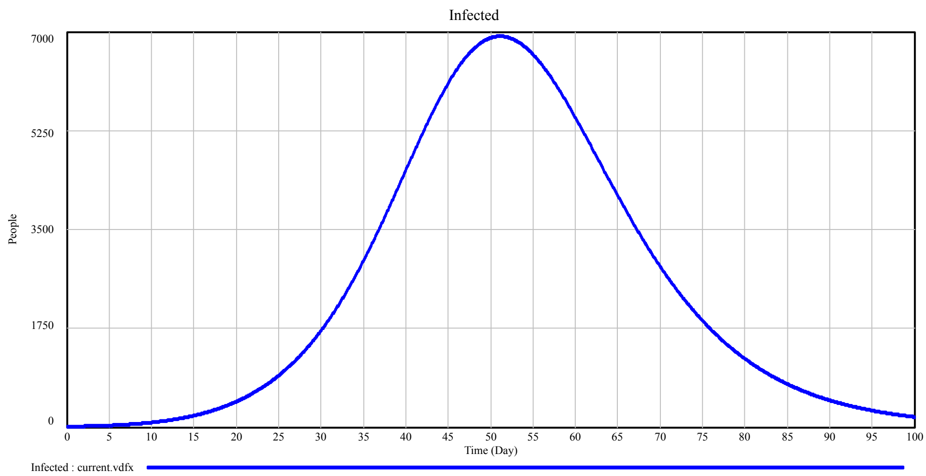
Table 5: Additional reporting stocks for the model

A further variable *Hospitalised Proportion* should be calculated, which is the total number hospitalised <u>divided by</u> the total population.

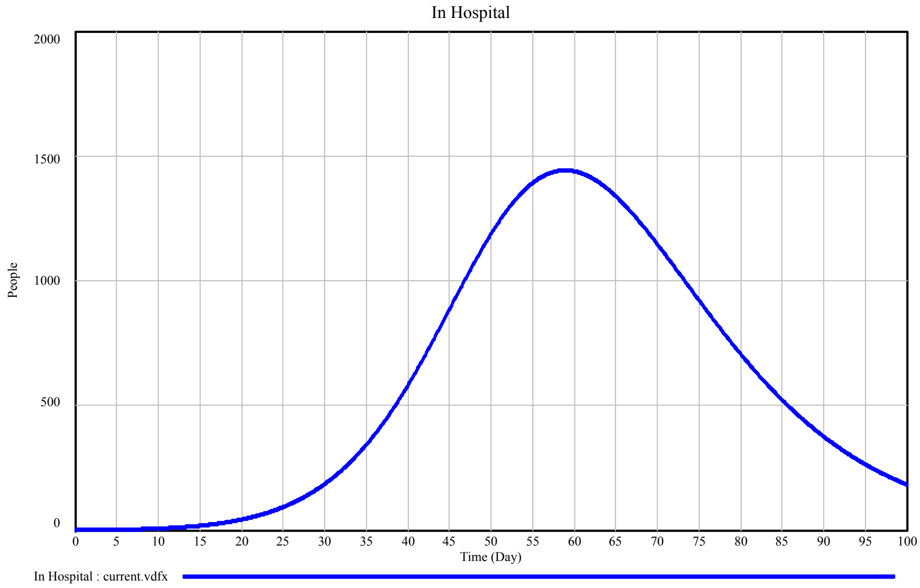
4. Some Test Case Results (Based on default values)



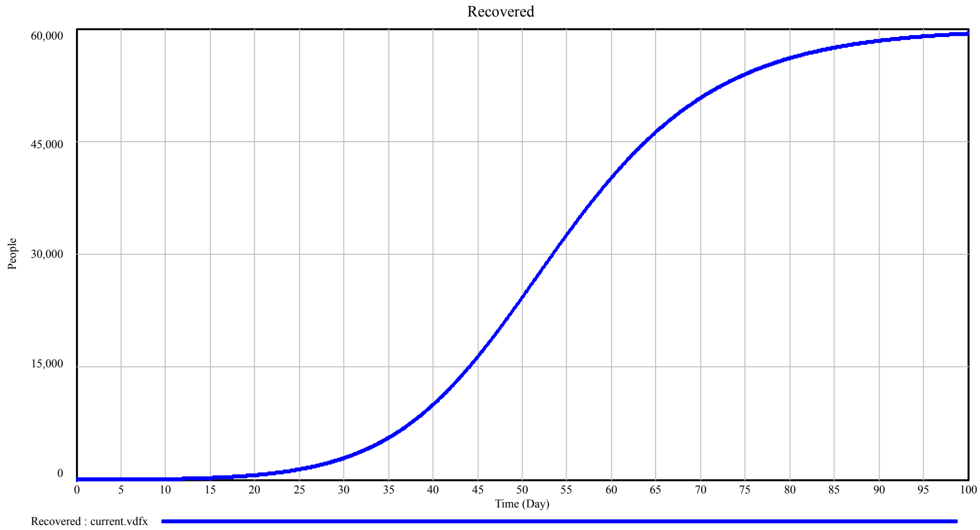
Time (Time)	3125	49.875	49.9375	50	50.0625	50.125	50.1875	50.25	50.3125	50.3
Susceptible : current	68000.6	67889.4	67778.3	67667.3	67556.4	67445.7	67335.1	67224.7	67114.4	(



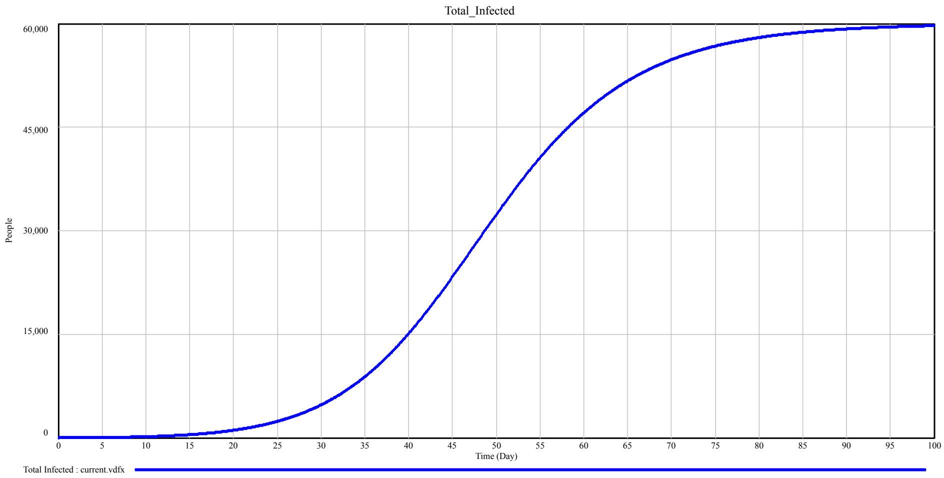
Time (Time)	49.8125	49.875	49.9375	50	50.0625	50.125	50.1875	50.25	50.3125	5(
Infected : current	6880.87	6884.58	6888.11	6891.46	6894.63	6897.61	6900.42	6903.05	6905.49	



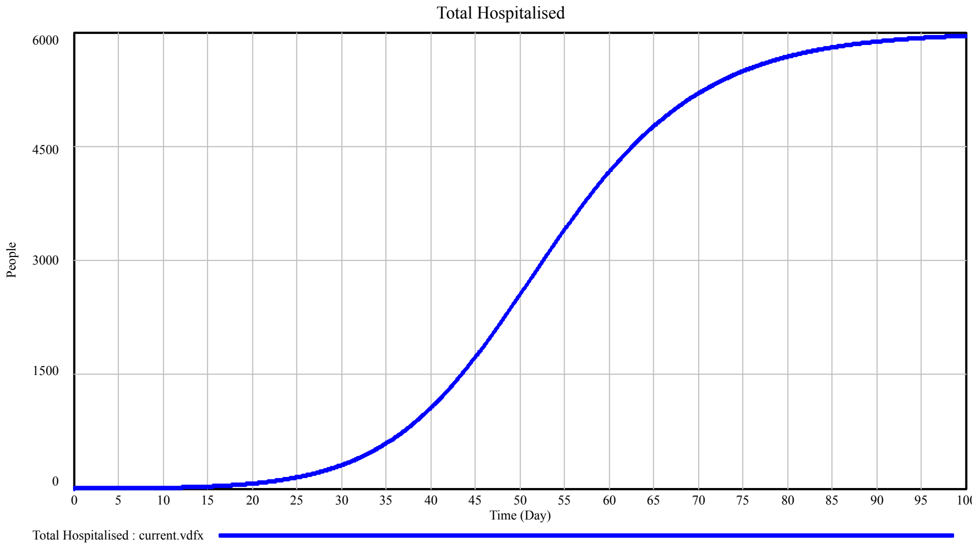
Time (Time)	75	49.9375	50	50.0625	50.125	50.1875	50.25	50.3125	50.375	50.43
In Hospital : current	179.78	1183.17	1186.54	1189.89	1193.22	1196.54	1199.85	1203.13	1206.4	12



Time (Time)	49.875	49.9375	50	50.0625	50.125	50.1875	50.25	50.3125	50.375
Recovered : current	24046.3	24150.5	24254.7	24359	24463.4	24567.9	24672.4	24777	24881.6



Time (Time)		49.8125	49.875	49.9375	50	50.0625	50.125	50.1875	50.25	50.31
Total Infected : current	78.1	31989.4	32100.6	32211.7	32322.7	32433.6	32544.3	32654.8	32765.3	32



Time (Time)	49.875	49.9375	50	50.0625	50.125	50.1875	50.25	50.3125	50.375
Total Hospitalised : current	2522.6	2533.36	2544.12	2554.89	2565.67	2576.44	2587.22	2598.01	2608.8

Also, add a variable checksum, which is the sum of all stocks from the disease-related stocks (see Table 3). This variable should always equal 100,000

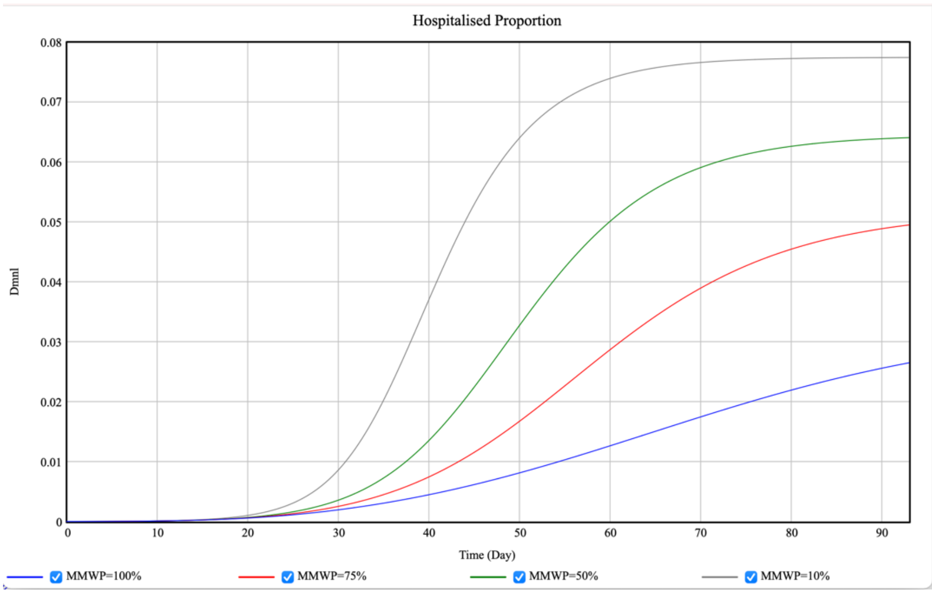
5. Scenarios

(1) Exploring the impact of the Maximum Mask Wearer Proportion

Run the following five experiments, varying the Maximum Mask Wearer Proportion (MMWP) for each one as follows.

Experiment	1	2	3	4	5
MMWP	0.1	0.25	0.5	0.75	1.0

Show the variable ***Hospitalised Proportion*** for all of these runs on graphs. A sample graph is shown below.



Export the data from each run into Excel to show the relationship between:

- MMWP (x-axis)
- Final Hospitalised Proportion (y-axis)

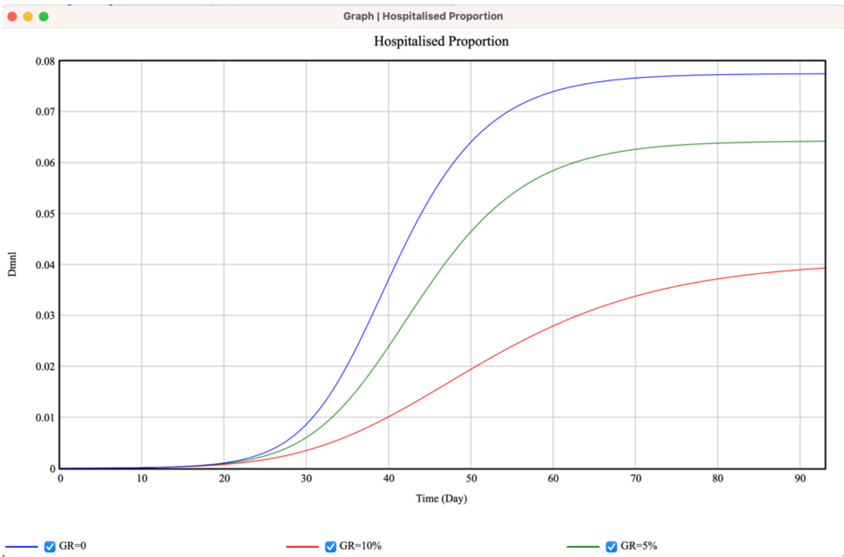
Comment on the relationship between these two variables.

(2) <u>Exploring the impact of different growth rates for **MMWP=1.0**</u>

Run the following five experiments, where the growth rate of mask adoption is varied across a range.

Experiment	1	2	3	4	5
Growth Rate	0.0	0.05	0.10	0.15	0.20

Show the variable ***Hospitalised Proportion*** for all of these runs on graphs. Sample output is shown below.



Export the data from each run into Excel to show the relationship between:

- Growth Rate (x-axis)
- Final Hospitalised Proportion (y-axis)

Comment on the relationship between these two variables.

6. Submission Guidelines

Submit your work in a ZIP file.

Please name the ZIP file <Your ID>_<Your Surname>_<Class Code>.zip

For example, *000000_Duggan_1MAI1.zip*

Your ZIP file should contain the following:

- The Vensim MDL file (dimensionally consistent)
- An Excel file with the data for each experiment.
- A powerpoint file showing two slides for each experiment:
  - The plots for each run on one graph – 5 in all.
  - the x-y relationships, along with comments annotated to each slide