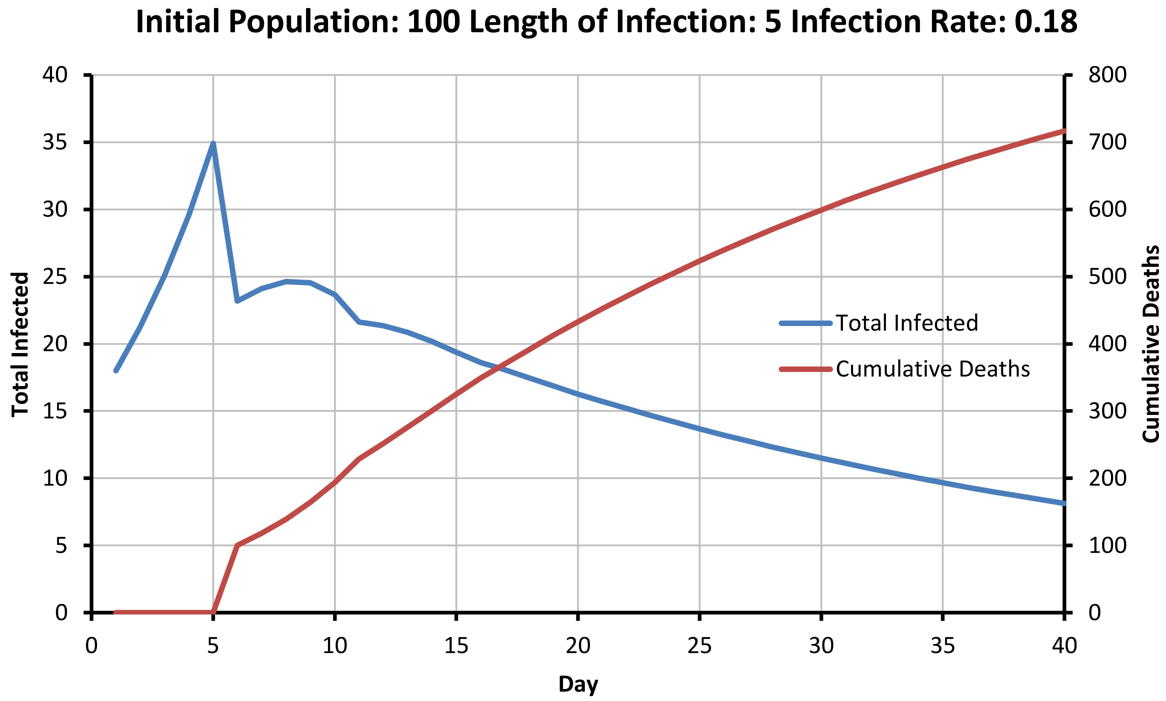
Modelling the Spread of Infectious Diseases

From 1918 to 1920 between 50 and 100 million people worldwide died from an N1H1 influenza pandemic. In 2009 there was another outbreak killing around 250,000 people. What causes infectious diseases to spread so rapidly and what can we do to slow down or even stop the spread?



Task 1

Suppose that ten people in a population are initially infected with a disease and infection lasts for five days, after which the person develops immunity to the disease. Every day each infected person infects two more people. Use this information to complete the following table.

Day	Length of Infection (Days)					Total Infected	Newly Infected
	1	2	3	4	5		
1	10	0	0	0	0	10	20
2	20	10					
3							
4							
5							
6							
7							
8							

Task 2

Set up a model in Excel using the following rules:

- the number of people initially infected with the disease is 100
- a person dies after having the disease for ten days
- the number of new infections each day is equal to 10% of the total number of people who already have the disease

This is called an *infinite population model*.

Plot a scatterplot showing the total number of infected people each day, and the cumulative number of deaths, for the first 40 days.

Change some of the above variables and use your model to investigate under which conditions i) the disease will thrive, ii) the number of people who are infected will eventually remain constant from one day to the next and iii) the disease will be eradicated.

Perform a thorough investigation. Remember, there are three variables you could change in this model.

Task 3

Set up a model in Excel using the following rules:

- the total population is 10,000
- the number of people initially infected with the disease is 100
- a person dies after having the disease for ten days

To determine the number of new infections per day use the following rule:

The number of people the infected come into contact with each day, x, is equal to 10% of the total number of infected people. Since the people who they come into contact with may or may not already have the disease, to determine how many new infections there are multiply the value of x by the probability that a randomly selected person does not have the disease.

This is called a *finite population model.*

Plot a scatterplot showing the total number of infected people each day, the cumulative number of deaths, and the total population for the first 100 days.

Change some of the variables to perform an investigation. You may take the investigation in any direction you choose.

Create a report of your investigations. You should include the following:

- Explain what you are investigating and how you are investigating it.
- Conclusions to your investigation.
- In your spreadsheet you can change the infection rate or the length of infection by simply changing a number. How can we change these values in the real world?
- Which of your models is the most realistic? Is there any way you could make it even more realistic (you don't have to perform these modifications).

Criterion C: Communication in Mathematics		
Achievement Level	Level Descriptor	Task Specific Clarification
0	The student does not reach a standard described by any of the descriptors below.	
1 – 2	The student is able to: I. **use** limited mathematical language II. **use** limited forms of mathematical representation to present information III. **communicate** through lines of reasoning that are difficult to interpret.	The student is able to: ○ attempt to explain what is being investigated and how it is being investigated. ○ organize data in tables where appropriate.
3 – 4	The student is able to: I. **use** some appropriate mathematical language II. **use** different forms of mathematical representation to present information adequately III. **communicate** through lines of reasoning that are able to be understood, although these are not always clear IV. adequately **organize** information using a logical structure.	The student is able to: ○ explain what is being investigated, how it is being investigated, results and conclusions of the investigation. ○ organize data in tables where appropriate. ○ create graphs according to the rules of the investigations.
5 – 6	The student is able to: I. usually **use** appropriate mathematical language II. usually **use** different forms of mathematical representation to present information correctly III. move between different forms of mathematical representation with some success IV. **communicate** through lines of reasoning that are clear although not always coherent or complete V. present work that is usually **organized** using a logical structure.	The student is able to: ○ explain what is being investigated and how it is being investigated, results and conclusions of the investigation. ○ organize data in tables where appropriate. ○ explain the few rows of each table of each investigation ○ create graphs according to the rules of the investigations. ○ move effectively between explanations, calculations, tables and diagrams ○ create a report that is mostly able to be understood without referring to the task sheet
7 – 8	The student is able to: I. consistently use appropriate mathematical language II. use different forms of mathematical representation to consistently present information correctly III. move effectively between different forms of mathematical representation IV. communicate through lines of reasoning that are complete and coherent V. present work that is consistently organized using a logical structure.	The student is able to: ○ clearly explain what is being investigated and how it is being investigated, results and conclusions of the investigation. ○ organize data in tables where appropriate. ○ clearly explain the few rows of each table of each investigation ○ display formulae clearly and accurately using the equation editor ○ create clear and accurate graphs according to the rules of the investigations. ○ move effectively between explanations, calculations, tables and diagrams with appropriate linking sentences (the following table shows, figure 3 demonstrates, etc.) ○ make good use of space on the page (no unnecessary white space, items positioned thoughtfully etc.) ○ create a report that is able to be understood without referring to the task sheet

Criterion D: Applying Mathematics in Real Life Contexts		
Achievement Level	Level Descriptor	Task Specific Clarification
0	The student does not reach a standard described by any of the descriptors below.	
1 – 2	The student is able to: I. **identify** some of the elements of the authentic real-life situation II. **apply** mathematical strategies to find a solution to the authentic real-life situation, with limited success.	The student is able to: ○ suggest when a disease will thrive, remain stable or be eradicated. ○ suggest which model is more realistic
3 – 4	The student is able to: I. **identify** the relevant elements of the authentic real-life situation II. **select**, with some success, adequate mathematical strategies to model the authentic real-life situation III. **apply** mathematical strategies to reach a solution to the authentic real life situation IV. **describe** whether the solution makes sense in the context of the authentic real-life situation.	The student is able to: ○ suggest when a disease will thrive, remain stable or be eradicated. ○ perform an investigation in the second model. ○ suggest how we can change infection rates and length of infection in the real world. ○ suggest which model is more realistic and why.
5 – 6	The student is able to: I. **identify** the relevant elements of the authentic real-life situation II. **select** adequate mathematical strategies to model the authentic real-life situation III. **apply** the selected mathematical strategies to reach a valid solution to the authentic real-life situation IV. **describe** the degree of accuracy of the solution V. **discuss** whether the solution makes sense in the context of the authentic real-life situation.	The student is able to: ○ determine when a disease will thrive, remain stable or be eradicated for variables of any value in the first model. ○ perform an investigation in the second model. ○ explain how we can change infection rates and length of infection in the real world. ○ explain which model is more realistic and why.
7 – 8	The student is able to: I. **identify** the relevant elements of the authentic real-life situation II. **select** appropriate mathematical strategies to model the authentic real life situation III. **apply** the selected mathematical strategies to reach a correct solution IV. **explain** the degree of accuracy of the solution V. explain whether the solution makes sense in the context of the **authentic** real-life situation.	The student is able to: ○ determine when a disease will thrive, remain stable or be eradicated for variables of any value in the first model. ○ perform a thorough investigation in the second model with a clear objective. ○ thoroughly explain how we can change infection rates and length of infection in the real world. ○ thoroughly explain which model is more realistic and why, and suggest improvements to this model to make it even more realistic.