CT248: Introduction to Modeling

Assignment 5: Infectious Disease Dynamics with the SIR Model

The aim of this assignment is to build an extended SIR model (in a MATLAB m file function), and the perform a scenario analysis that will, for a given set of contacts, show:

- The infectiousness stock
- The number of people in hospital
- The relationship between the average daily contacts and the peak number in hospital.

The following are the five model equations, and are based on the well-known SIR model.

(1)	$\frac{dS}{dt} = -cS\,\frac{I}{N}\,i$	S = Number susceptible (9999)
(2)	$\frac{dI}{dt} = cS\,\frac{I}{N}\,i - \alpha I$	I = Number infectious
(3)	$\frac{dR}{dt} = \alpha I - \beta R$	R = Number recovered
(4)	$\frac{dH}{dt} = \beta R - \gamma H$	H = Number Hospitalised
(5)	$\frac{dRH}{dt} = \gamma H$	RH = Number recovered following hospitalisation
(6)	$N = S + I + R + H + RH$	N should always equal 10000

The following parameter values should be used.

Parameter	Description	Value(s)
c	Average daily contacts	$3 \leq c \leq 8$
i	Infectivity	0.125
α	Proportion removed from infectious stock	0.25
β	Proportion hospitalised	0.02
γ	Proportion removed from hospital stock	0.10

The model function should be parameterised for all these parameters, and the following is an example of a function call.

```
[t,y] = ode45(@SIR, ...
              time_vec, ...
              init_vec, ...
              odeset, ...
              contacts, ...
              infectivity, ...
              alpha, ...
              beta, ...
              gamma);
```

Assume the following values for the time vector and the initial conditions.

```
time_vec = 0:.25:100;
init_vec   = [9999 1 0 0 0];
```

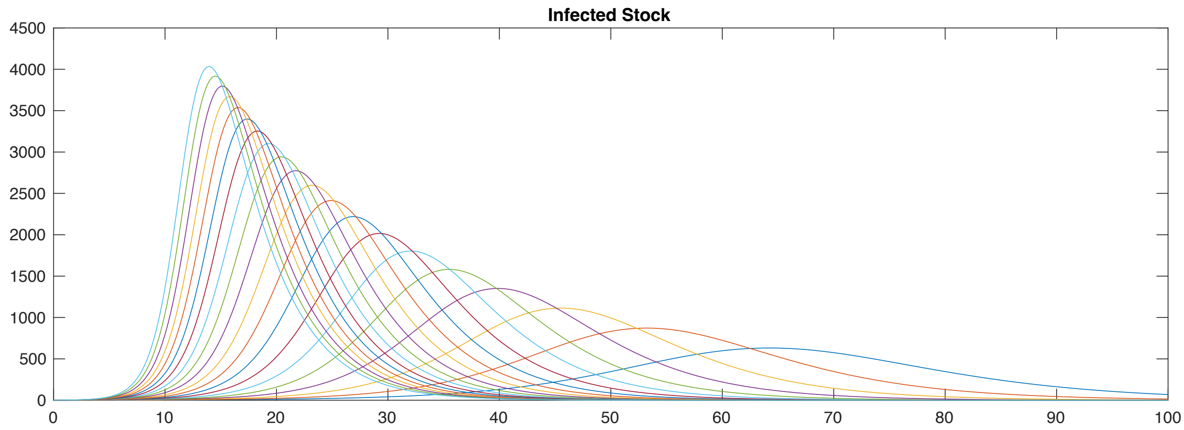
For example, the 20 values for contacts should be.

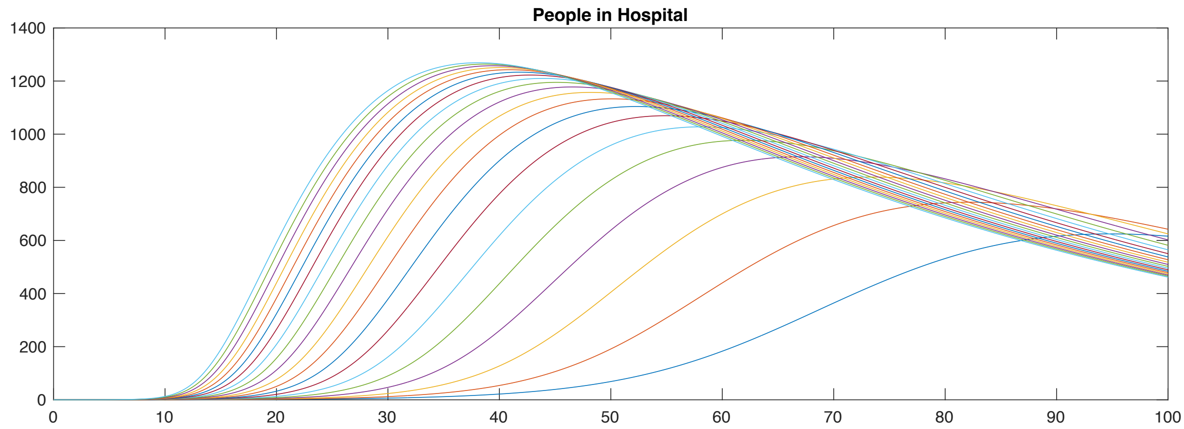
```
contacts =

  Columns 1 through 13

    3.0000    3.2632    3.5263    3.7895    4.0526    4.3158
4.5789    4.8421    5.1053    5.3684    5.6316    5.8947
6.1579

  Columns 14 through 20

    6.4211    6.6842    6.9474    7.2105    7.4737    7.7368
8.0000
```

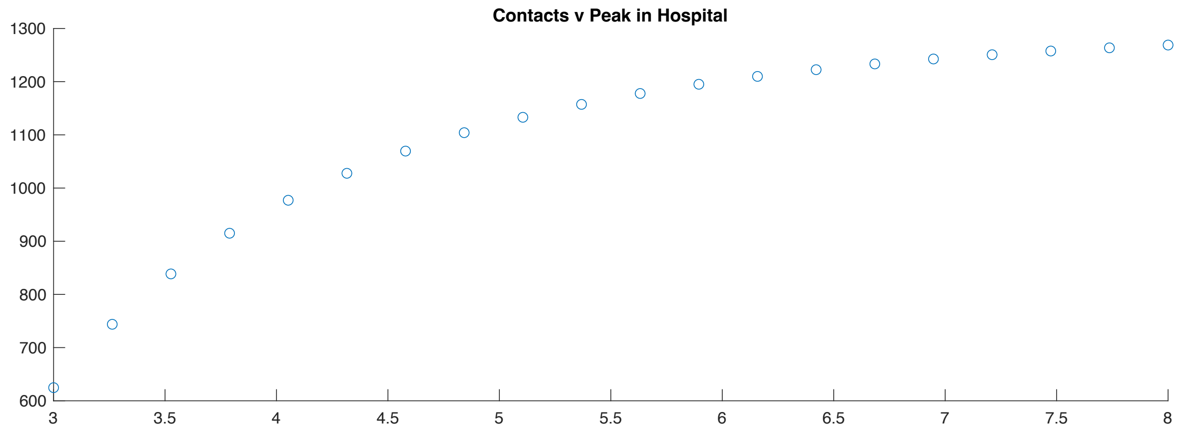
The model should then be run 20 times, once for each contact value. In advance of these runs, two output arrays should be created, one for the Infected stock, the other for the hospitalised stock. These structures should hold the results for each simulation (20 in all). For example:

```
>> whos
  Name                    Size             Bytes  Class
Attributes
  out_in_hospital       401x20             64160  double
  out_infected          401x20             64160  double
```

With the outputs stored in these structures, and given that the time vector is also available, the following three plots should be generated (see overleaf), using subplot(


Infected Stock
4500
4000
3500
3000
2500
2000
1500
1000
500
0
0
10
20
30
40
50
60
70
80
90
100


People in Hospital
1400
1200
1000
800
600
400
200
0
0
10
20
30
40
50
60
70
80
90
100


Contacts v Peak in Hospital
1300
1200
1100
1000
900
800
700
600
3
3.5
4
4.5
5
5.5
6
6.5
7
7.5
8