Ediz Ferit Kula
2017405087

Report 1: Modeling the Spread of a Virus

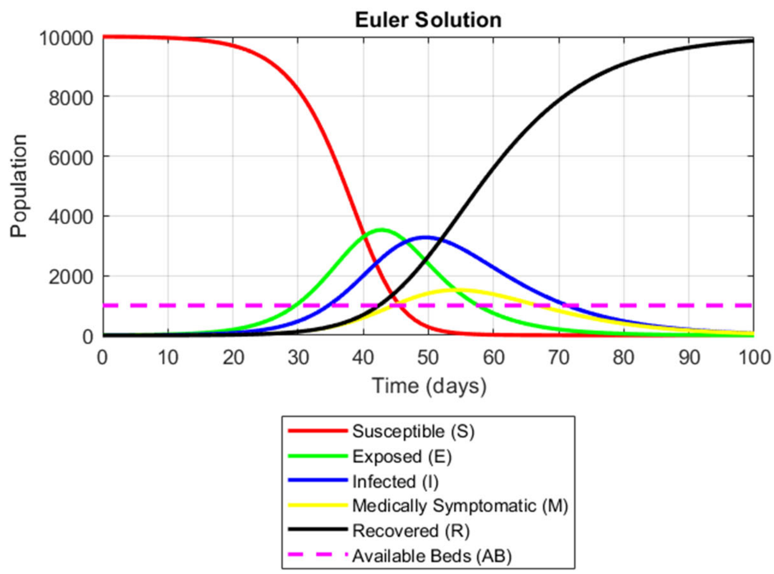
Before start, I will explain why I used both scripts and live scripts. I used the script file to answer (a), (b) and (c) parts of the question. Then I created live scripts to make my code more readable and it also makes it easier to analyze different situations for the report. I created most of the graphs used in this report using live script.

<u>Discussion about methods:</u>

I will start my report with answering (d) that asks which method is the most suitable for solving this problem.

Even though the Euler method is a very simple and direct method; it is first order convergent, so its accuracy is poor compared to other methods. We need too small step sizes to make a good approximation. On the other hand, with this step size h=1/500, we can see that there isn't any big difference between the Euler method and the others. There are some reasons that leads Euler solution to be accurate enough in this specific problem. Foremost reason is the small values of y' near the end points since it is the truncation error that causes big errors.

Although this method gives reasonable results, still it isn't the best choice if we care about computational efficiency, due to the computational work it requires. Other methods like ode45 can solve the same problem with less step size with less work. In conclusion, if a quick and direct solution needed with unimportant computational work, the Euler method could be appropriate to solve this problem.



Even for smaller step sizes like h = 1, this method works fine because of the reason we pointed before.

The figure on the left is created with h=1 step size and m=100 iterations.

I calculated the elapsed time for every solution and the results showed us ode45 method is far faster than both Euler and Runge Kutta methods. Faster the computation time, lesser the computational work.

- `elapsedTime_e = 0.5453 sec`
- `elapsedTime_rk4 = 3.7547 sec`
- `elapsedTime_ode = 0.0108 sec`

The fastest one is ode45 that is due to the adaptive step size of ode45 and of course it is an optimized function. It achieved the appropriate result in 125 steps as we see. On the other hand Euler and RK4 methods used 50000 steps for h=1/500, which makes them more time consuming. Even for too large step sizes like h=1, ode45 is still faster. There is also another interesting fact that Runge Kutta takes much more time than Euler method. Since RK4 is a fourth order method, it requires four extra iterations in every step compared to Euler method; hence it takes more time to complete. But we should note that RK4 method can achieve similar accuracy of Euler method in less steps.

In conclusion, it is obvious that best choice would be ode45 due to its efficiency and accuracy.

Discussion about the model:

Assumptions that this model makes:

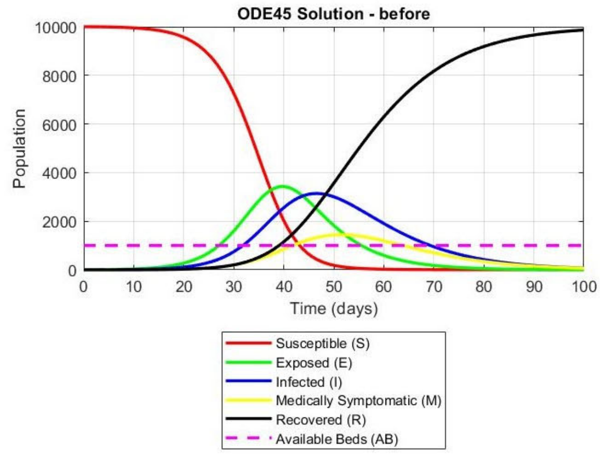
- There is no death related to coronavirus or any other cause.
- The population is a closed system that there isn't any immigrants.
- Everyone has same pre-existing health situations.
- There is no contact tracing related lockdowns.
- Either no vaccine used in this population or everybody in this population is vaccinated.

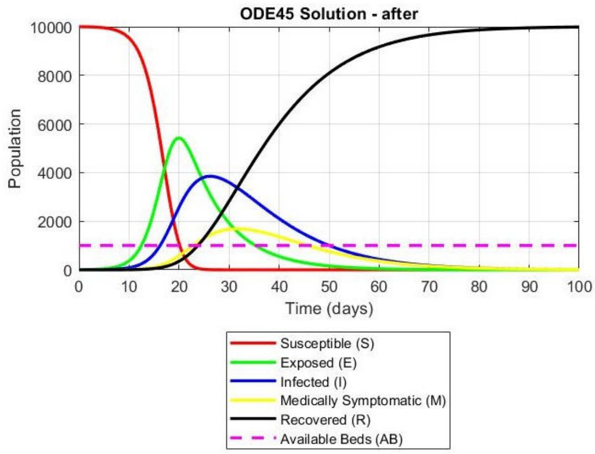
Encounters per Day:

At first, investigate the effect of changing encounters on the graphs. I will increase the encounter rate 3 times. So;

Original c = 4

New c = 12



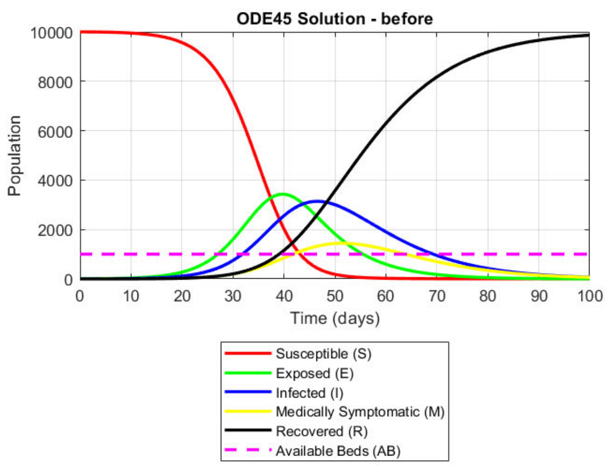


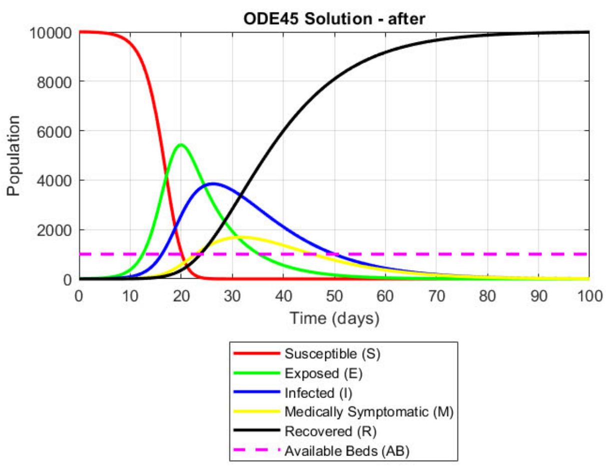
It can be seen clearly that changing encounter rate affects the spread of the virus. It tells us, if everybody in the population go outside and see 3 times more people than before; then the spread speed of the virus will be almost 2 times faster. It also slightely increases the overwhelming of the medical facilities as can be seen from the peak of yellow curve.

In order to lower encounter rate, people should meet each other less. Thus; closing restaurants and cafes, distant education, temporary lockdowns can reduce this encounter rate.

Transmission Probability per Encounter:

To see the comparison of changing each effect, I will also increase this rate with the same amount as I used in the first example.
Original B = 0.2
New B = 0.6





As we see from the graphs, changing transmission probability per encounter has similar effects on the outcomes with encounter rates. Increasing this rate caused a sudden increase in exposed group, hence all other groups of people affected by this change immediately. Again we see small increment in medically symptomatics.

I think we came to an important point. Focusing on lowering transmission rates can be an effective solution to the overwhelming in medical facilities. The simple way to reduce this rate is 'wearing masks'. On the other hand, lowering encounter rates could be harder and it requires more strict measures.

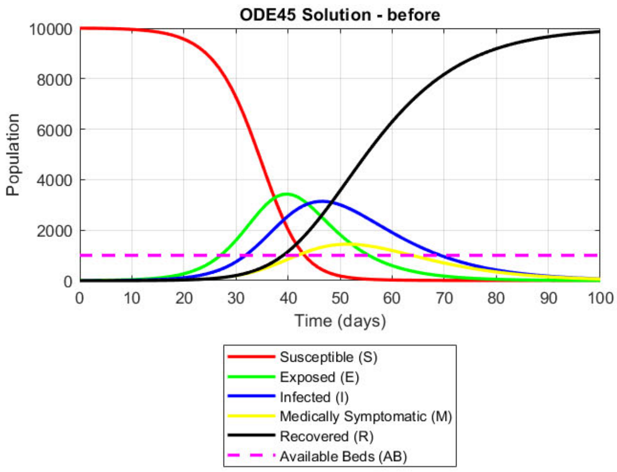
Note that both encounter rate and transmission rate have direct effect only to the 'exposed' group. Other groups are affected by the changes in the exposed group.

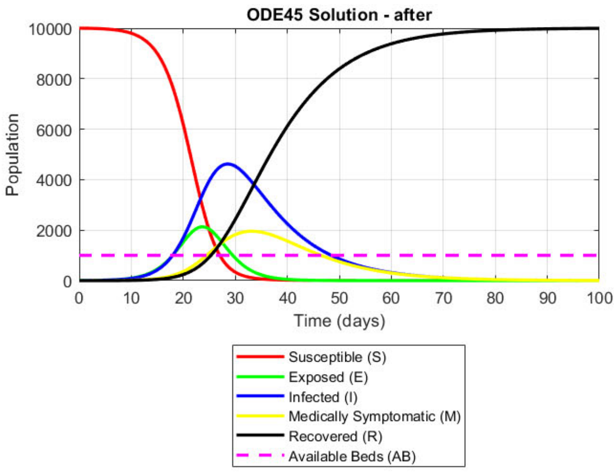
Rate at which Infected Becomes Infectious:

Again we will increase this parameter by 3 times. As we increase this rate, it means we are lowering the incubation time.

Original a = 0.125

New a = 0.375





Now we have come to an intereseting point. The first two parameters we investigated affected mostly the exposed group which makes sense. But lowering the incubation time caused a dramatic increase in the infected people. Higher the infected people, higher to be the medically symptomatic. Thus, medically symptomatics increased more this time. So we conclude that an increment in this rate causes more problems in the health sector than an increment in the encounter rate and transmission rate.

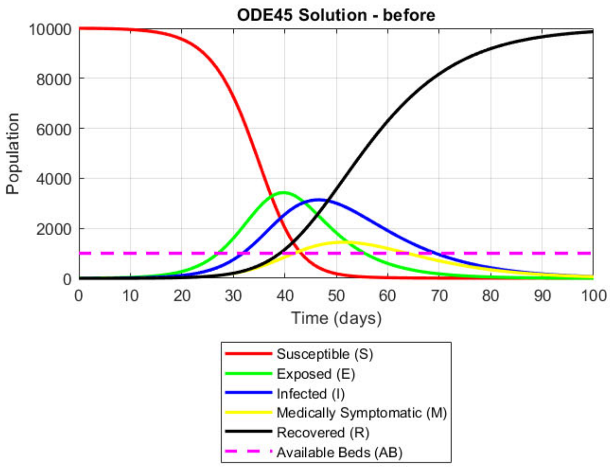
It is actually hard to control this parameter in real life. Maybe contact tracing and early detection of the disease can reduce this rate. But in this model, we can't simulate the effects of contact tracing.

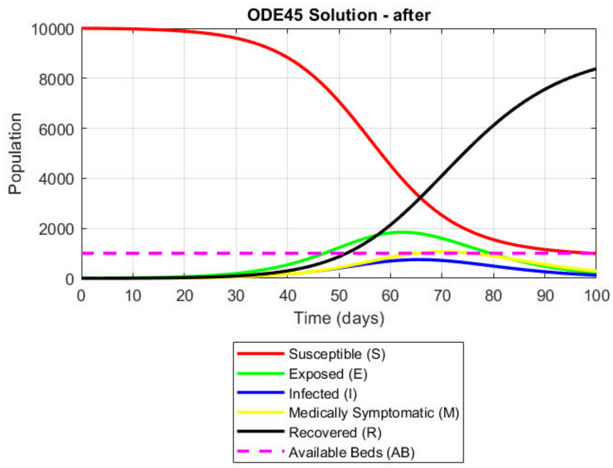
Rate at which an Infected Person Becomes Symptomatic:

Similar to the earlier examples, we will increase this rate by 3 times which means it takes 3 times less time to become symptomatic.

Original g = 0.1

New g = 0.3





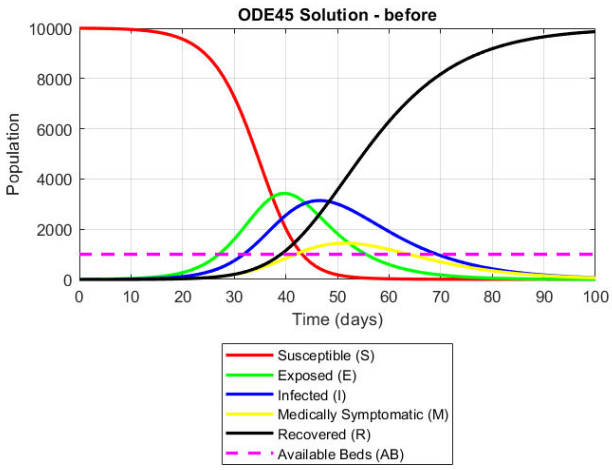
Actually this is an interesting result that we don't expect to see. People become symptomatic faster and this causes a decrease in all exposed, infected and medically symptomatic people. We can infer from that, if people become symptomatic faster, the detection of the virus would be easier. This gives the opportunity to the people to control the spread of the virus.

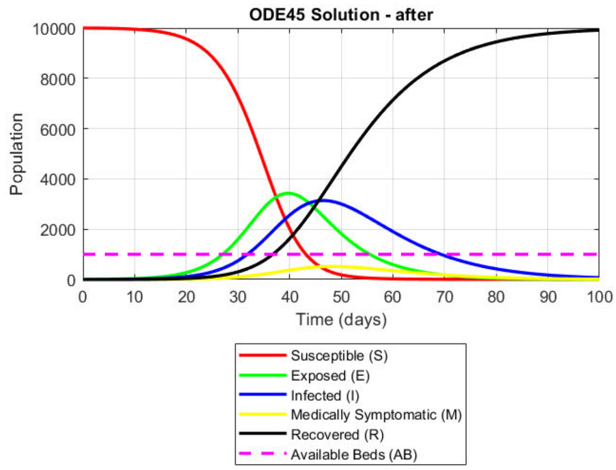
Recovery Rate:

Increase the recovery rate 3 times.

Original w = 0.2

New w = 0.6





At first glance, it seems like there isn't much difference between both graphs. It might be true but there is an significant difference in medically symptomatics. The number of them were about 1500 and they are now down to 500 people. If we consider we have only 1000 beds available, this change can decrease the burden on the medical personnels. Also we can the slight difference in recovered people.

Recovery rates could be increased by vaccine treatment.