

# Pandemic Coding Project Write-Up

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*Computational Physics*

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## Introduction

This project simulates the spread of a pandemic in a simplified 2D grid-based environment. Each person moves independently, can transmit disease upon close contact, and either recovers or dies based on probabilities. I modeled the infection, recovery, and death of individuals over time, and examined the impact of mitigation strategies like masking. I achieved the results seen below using fairly rudimentary Python techniques learned and put to practice in both the Computational Physics course as well as the introductory Scientific Analysis course.

## Code Description

The simulation tracks  $N$  individuals using lists for each of their properties, such as position, velocity, infection status, mask usage, and infection timers. Individuals start on a grid and move according to randomly assigned velocities.

At each time step:

- Each person moves within a bounded 2D space and bounces off the walls/boundary of the grid.
- If two individuals come within an “interaction radius”, their velocities swap (to simulate bouncing) and disease transmission is initiated if the requirements for transmission are met.
- If one person is infected and the other is susceptible (not dead, immune, or already infected), the disease may spread with a 60% probability. If the susceptible person is masked, their chance of infection is reduced by a factor of 10.
- If an individual is infected, they will carry the disease, spreading it to others along the way with some probability, and either recover after the 100 time steps or die with a 5% chance. In the case of recovery, that individual gains immunity and can no longer contract or spread the disease.

No object-oriented code was used; instead, I used parallel lists and basic loops for simplicity. The plotting done through Python was fairly simple; I made a graph to plot the grid the individuals were placed in and then recorded their positions at the start of the simulation and at the end (Figure 3).

## Results

Figure 1 shows the progression of the infection, recovery, and death counts over time for a population of 100 individuals. This trial did not include the masking contributions which, as we can see in Figure 2, mitigated the spread of the disease substantially. In this trial, nearly every single individual contracted the disease meaning a fully immune society was only reached once every individual in the population contracted the disease first. There was a small number of deaths, which makes sense given the low mortality rate of 5%. It’s also interesting to note that, while the trial with masking mitigated the spread of the disease, it did not speed up the immunity of the population. In fact, we see the unmasked population reach full immunity before we see that in the masked population!

To evaluate the effect of masking, I ran the simulation with and without masking enabled (50% of the population masked). The masking reduced the number of infections significantly by lowering the infection probability of masked individuals. It did not, however, have much of an effect on the number of deaths as you can see in Figure 3. This could be due to the fact that a masked individual that contracts the disease experiences the same 5% mortality rate as an unmasked individual. Furthermore, the 50% of the population that remains unmasked can still impact the death toll.

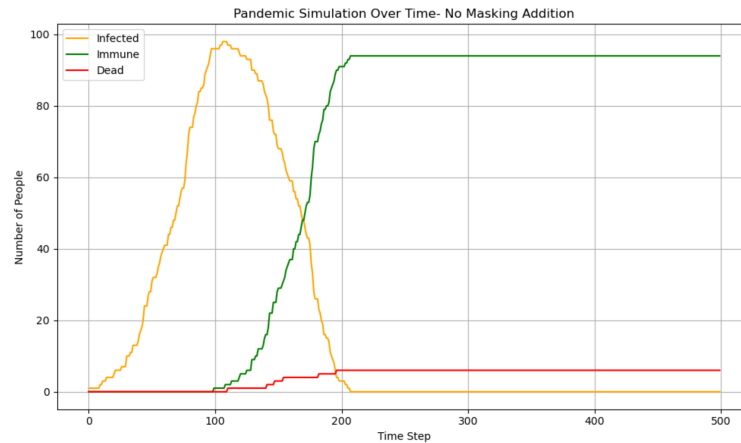


Figure 1: Runtime vs. population size for infection, immunity, and death counts over time without masking.

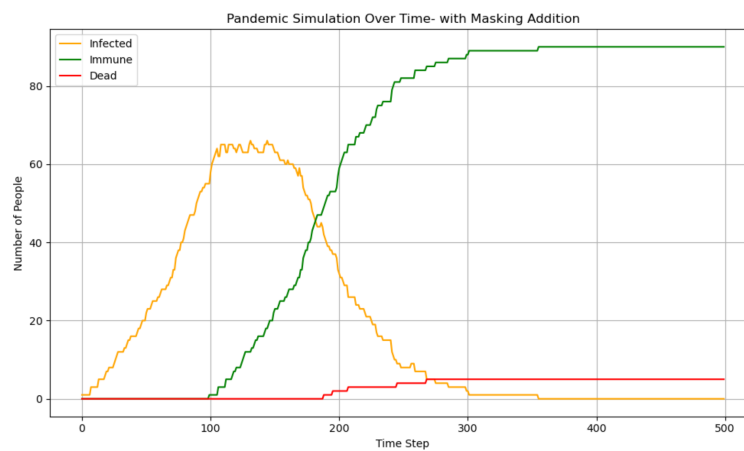


Figure 2: Runtime vs. population size for infection, immunity, and death counts over time with masking.

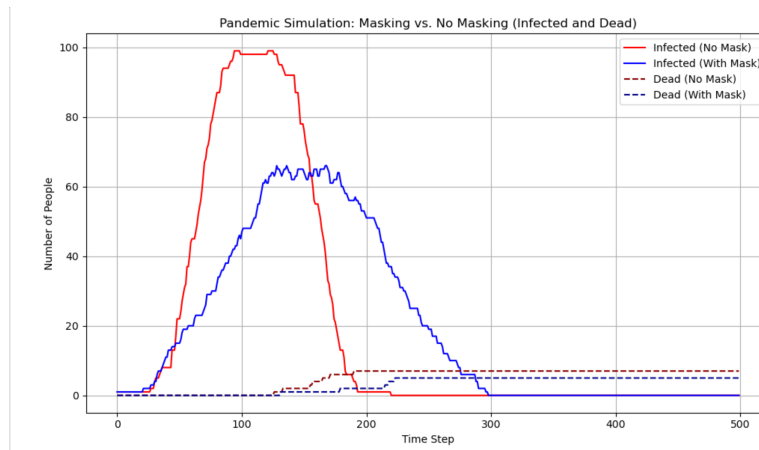


Figure 3: Runtime vs. population size for infection and death counts over time with and without masking.

## Discussion

I inevitably ran into some issues throughout this coding project that I'd like to make note of. I decided pretty early on that I was going to stick to the rudimentary functions such as lists, strings, Booleans, and for loops because I feel most comfortable working with those; however, I did find myself looking into how to do certain things and being directed to the object-route as suggested in the project rubric. I also had issues with Figure

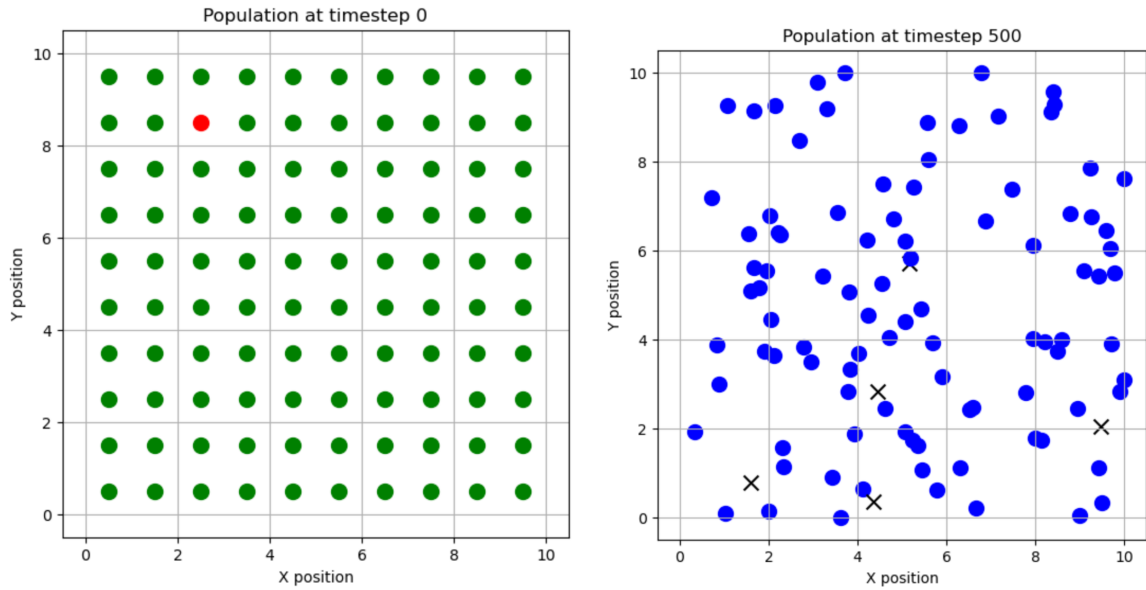


Figure 4: Grid of population at time 0 (left) and time 500 (right). The red dot in the left graph represents patient zero and the Xs on the right graph represent the "dead" patients.

1, specifically getting the grid image at timestep 0. This was a very simple fix, I simply just ran the code for that graph before running the simulation. In the future I would like to rewrite this code to work regardless of the order in which I run the code.

The simulation demonstrates how quickly a simple disease can spread in a mobile population without mitigation. The infection generally spreads to the majority of the population unless interventions are applied or in this case unrealistic interpretations of how immunity plays a factor in mitigating the spread.

Masking did seem to have a somewhat strong impact on transmission, even when only 50% of people wear masks. This simplified model supports the real-world understanding that non-pharmaceutical interventions may substantially reduce transmission rates.

Future improvements of this simulation could include more complex collision handling, social distancing, and/or varying recovery times.