

Name: \_\_\_\_\_

### Mathematical Modeling Exercise: Modeling the spread of disease

In this exercise, you will gather some data, construct a mathematical model of the relationship between two variables, and make predictions, then see how well your predictions matched actual behavior.

#### Step 1: Gathering Data (entire class)

On a class computer, go to the disease simulation at:

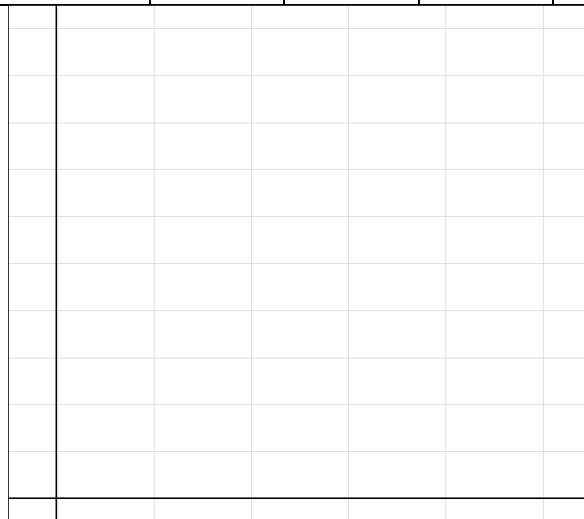
<http://lamar.colostate.edu/~sbenoit/gk12/DiseaseApplet.html>

Run the simulation a few times with different parameters to get an idea of how it works, then choose a grid size and an initial infection percentage that you like and record it here:

Initial Infection Percentage: \_\_\_\_\_ Grid Size: \_\_\_\_\_

Select five different values between 10 and 40 for the initial immunization percentage, and run four simulations for each one. After each simulation, write down the “Total infected” percentage. Then average the infection rates over the four runs. Finally, graph your averages vs. the initial immunization percentage.

Initial Immunization %	Run 1	Run 2	Run 3	Run 4	Average



## Step 2: Building models of the data

You should have 5 dots on your graph. You may want three different colored pens or pencils for this step.

Try drawing a line (using a straightedge) across the graph that stays as close as possible to all the points. This is your **linear model**.

Now, draw a series of lines from each dot to the next dot (like a “connect the dots”), and then extend the first and last lines so they go right to the edge of the graph. This is your **piecewise linear model**.

Finally, draw a smooth curve through all the dots and continue it smoothly at each end until it goes to the edges of the graph. This is your **smooth curve model**.

## Step 3: Making predictions

Now, you will use your models to predict the behavior of the disease system.

Using each model, predict what the total infection percentage will be if the initial immunization rate were 0%. (Making predictions beyond the range of the gathered data is called *extrapolating*):

Linear model prediction \_\_\_\_\_  
Piecewise linear model prediction: \_\_\_\_\_  
Smooth curve model prediction: \_\_\_\_\_

Use your models to predict the total infection percentage if the initial immunization rate were 50%:

Linear model prediction \_\_\_\_\_  
Piecewise linear model prediction: \_\_\_\_\_  
Smooth curve model prediction: \_\_\_\_\_

The whole class should choose some initial infection percentage that falls in between two of your data points (pick two that are as far apart as possible and choose a value about halfway in between).

Initial Immunization Percentage: \_\_\_\_\_

Use your models to predict the total infection percentage (making predictions between gathered data points is called *interpolating*):

Linear model prediction \_\_\_\_\_  
Piecewise linear model prediction: \_\_\_\_\_  
Smooth curve model prediction: \_\_\_\_\_

#### Step 4: Comparing predictions to actual behavior

Go back to the simulation and run the test with immunization rates of 0%, 50%, and the value the class selected. As before, run 4 tests and take the average.

Initial Immunization %	Run 1	Run 2	Run 3	Run 4	Average
0%					
50%					
_____ %					

#### Questions:

1. Which of your models was best for extrapolating?
2. Which was best for interpolating?
3. Which would you have the most confidence in if you had to make more predictions?

4. Do you think the grid size had any effect on how well your models worked? Why or why not?

5. Do you think the number of times you ran the simulation for each starting condition had any effect on your models? Why or why not?

**NOTES:**

Actual researchers working on models of disease spread can't go out into the world and experiment by infecting people and watching what happens. Instead, they have to work with disease outbreaks that have already happened, analyzing data on how fast they spread, what immunization rates were before the outbreak started, and many other factors. Building models that can extrapolate and interpolate accurately is very important in this sort of context.