CS210 – Machine Problem 4

Zombie Infection Model
20 Points
Assigned: February 9, 13, 2017
Due: February 16, 20, 2017

In order to educate the general populace about the dangers of the impending undead uprising, we are going to create a computer model of what will happen in the immediate aftermath of the first zombie infection. The Kermack-McKendrick model is an SIR model for the number of people infected with a contagious illness in a closed population over time. We are going to use a variation of this model to determine how long humanity will survive after the initial zombie outbreak.

The Kermack-McKendrick model looks like this:

$$\begin{aligned} \frac{dS}{dt} &= -\beta SI \\ \frac{dI}{dt} &= \beta SI - \gamma I \\ \frac{dR}{dt} &= \gamma I \end{aligned}$$

Where β is the infection rate, γ is the recovery rate, which for zombism is 0%, $S(t)$ is the number of susceptible people, which for zombism is everyone, $I(t)$ is the number of people infected, and $R(t)$ is the number who have recovered, which for zombism is no one. Therefore, all these equations reduce to:

$$\begin{aligned} \frac{dS}{dt} &= -\beta SI \\ \frac{dI}{dt} &= \beta SI \end{aligned}$$

Although, zombism is 100% infective, β actually measures the number of zombie/human encounters that result in new zombies. Humans adhering to the principle outlined in *The Zombie Survival Guide* will result in β values that are lower.

For this project, you are going to write a program that will ask the user for an initial population size and an infection rate. It will then generate a file showing the human population after each time step until there are no survivors remaining. To solve the differential equations for each step, we can use the following equations:

$$\begin{aligned} S_1 &= \text{Initial Population} \\ I_1 &= 1 \\ \Delta &= \begin{cases} \beta S_t I_t & \text{if} \beta S_t I_t < S_t \\ S_t & \text{otherwise} \end{cases} \\ S_{t+1} &= S_t - \Delta \end{aligned}$$

$$I_{t+1} = I_t + \Delta$$

If $\Delta > S_i$ then $\Delta = S_i$. In other words, if the number of humans that are going to turn into zombies according the formulae is greater than the number of remaining humans, they all turn into zombies.

Your program must consist of at least **three** functions: your main function; a single input function that gets *both* the initial population and the infection rate from the user and passes them back to the main program; and a function that generates the report which takes three arguments, the file variable, the initial population, and the infection rate.

Your output file must be named `modelOutput.txt` and must be formatted exactly like the sample. The first column is 5 characters wide, and the other two columns are 12 characters wide. The columns are separated by the tab (`'\t'`) character. The report should run until either the number of humans is the same as the previous step.

To facilitate debugging, you should also generate the report to the console in addition to the file. Once the output is correct, you must remove the console output in order to pass the submission script.

Please note, the online testing script is going to test more cases than the sample run below shows. Make sure that your code checks for all illegal inputs. Also note, that when you are testing your program, you will need very small infection rates to keep simulation from only running a few steps.

Sample Run

```
Zombie Infection Model
Please enter initial population:-3
Population must be non-negative. Try again.
Please enter initial population:100
Please enter infection rate as a decimal (e.g. 25% = 0.25):2
Infection rate must be between 0 and 1 inclusive. Try again.
Please enter infection rate as a decimal (e.g. 25% = 0.25):0.01
Report generated!
```

The above parameters will generate the following `modelOutput.txt` file:

```
 Time	      Humans	     Zombies
    1	         100	           1
    2	          99	           2
    3	          98	           3
    4	          96	           5
    5	          92	           9
    6	          84	          17
    7	          70	          31
    8	          49	          52
    9	          24	          77
   10	           6	          95
   11	           1	         100
   12	           0	         101
```