

# Instruction

- **Read this instruction very carefully.**
- You will name the filename as *[StudentIDNumber].cc* (or *.cpp, .c, etc*).
  - Submit the file *[StudentIDNumber].cc* (or *.cpp, .c, etc*) on iCampus before the deadline.
- You should submit the source code only.
- You may submit partial solution (and you'll receive partial credit).
- You may ask questions thru email at [atang@skku.edu](mailto:atang@skku.edu).
  - But please ask your questions early (otherwise, I may not reply in time before your deadline)
  - **Do not ask question on iCampus. Ask question thru email only**
- I will make clarifications about the problem on icampus.
- You may submit multiple versions.
  - I will grade the last version before the deadline you submitted only.
  - Work submitted after the deadline will not be graded
- Make backup!
- The deadline is Thursday 15<sup>th</sup> Apr 2021 18:00 pm.

# Collaboration Policy

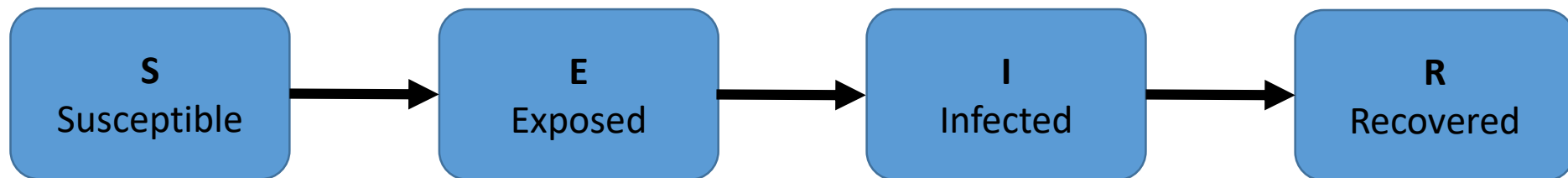
- The work you submit must be the work of your own.
- You are free to give or receive help when doing homework assignments, but you must follow the following restrictions:
- Only the helper can look at the code of others. Student who is receiving help must not look at the code of the helper;
- Student who is receiving help must do all the typing herself/himself. Helper must not touch the computer of the student who is receiving help; and
- All student can not post your code on the web, nor send your code to other students.

# The problem

- In this assignment, you will write a program to conduct a simulation in transmissible diseases (such as COVID-19) in Korea.
- Your program will simulate the infection of a transmissible disease.
- Your program will first ask the user to enter 5 simulation parameters
  1. Number of infected people on Day 0
  2. Beta
  3. Sigma
  4. Gamma
  5. How many days should be simulation be run (max 80 days)
- Your program will display the simulation results in a table.
- Your program will plot the simulation results in a histogram.

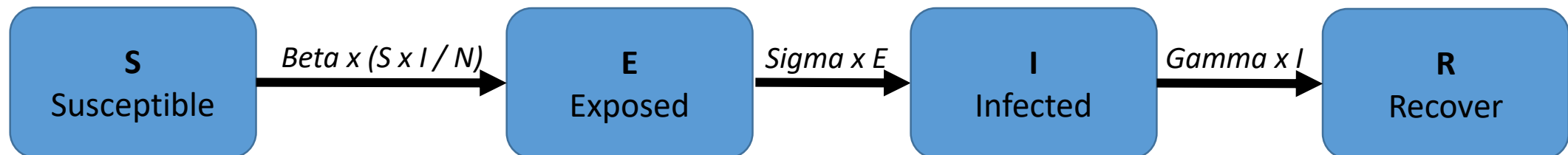
# The transmission model (SEIR Model)

- The SEIR diagram below shows how individuals move through each compartment in the model.
- The model consists of 4 compartments.
- Each compartment represents the number of people in a location currently in the status:
  - Susceptible – People that are healthy
  - Exposed – People that are exposed to the disease, but not sick yet
  - Infected – People that are infected with the disease
  - Recovered – People that are recovered and immune



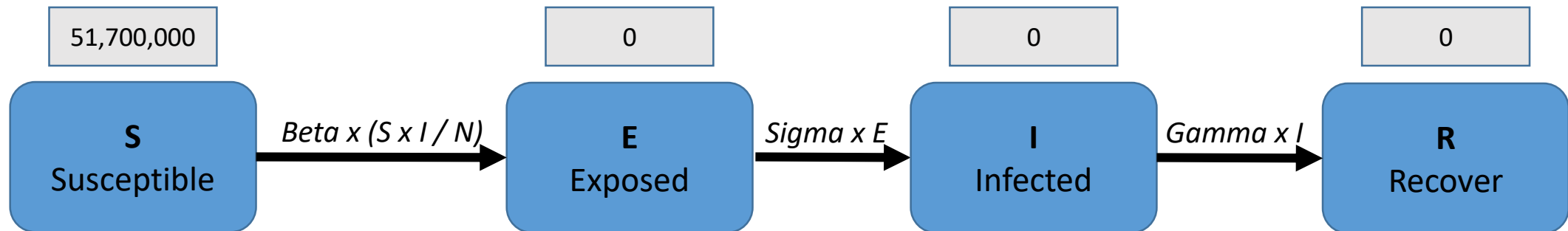
# The transmission model (SEIR Model)

- Disease transmission on each day is defined with three equations:
  - **Beta x (S x I / N)** – Number of people moving from S to E each day
    - Beta: Transmission rate (one person infects Beta people per day)
    - N: Total population number
  - **Sigma x E** – Number of people moving from E to I each day
    - Sigma: Incubation rate (It takes 1/Sigma days for a person get infected after exposed)
  - **Gamma x I** – Number of people moving from I to R each day
    - Gamma: Recovery rate (It takes 1/Gamma days for a person to recover)



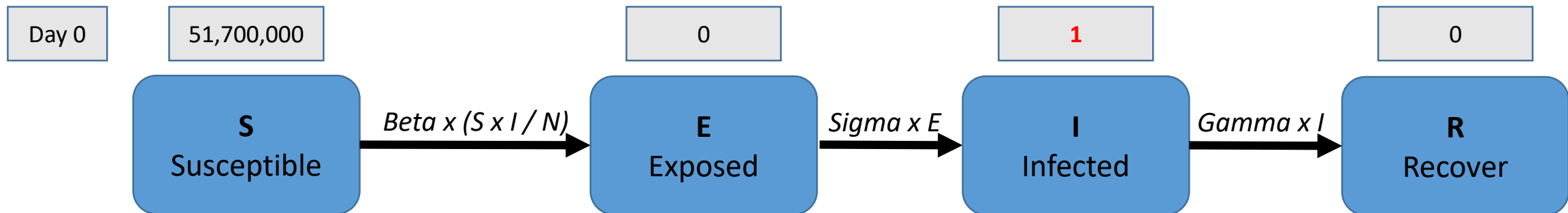
# The transmission model (SEIR Model)

- Original state:
  - Population of Korea = 51,700,000
  - 51,700,000 people who are healthy, no one is sick



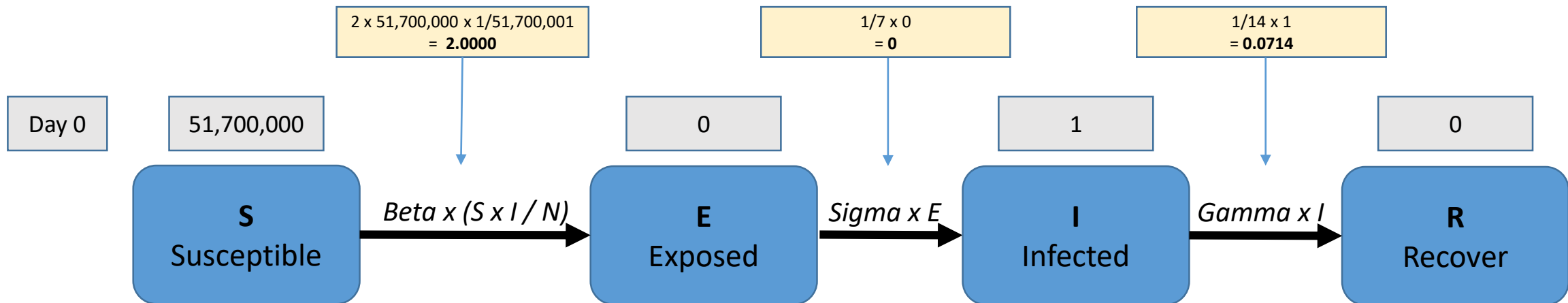
# The transmission model (SEIR Model)

- Day 0:
  - 1 infected person entered the country
- Question:
  - How is the disease going to be transmitted in the country for the first 50 days?
  - Suppose Beta = 2, Sigma = 1/7, Gamma = 1/14



# The transmission model (SEIR Model)

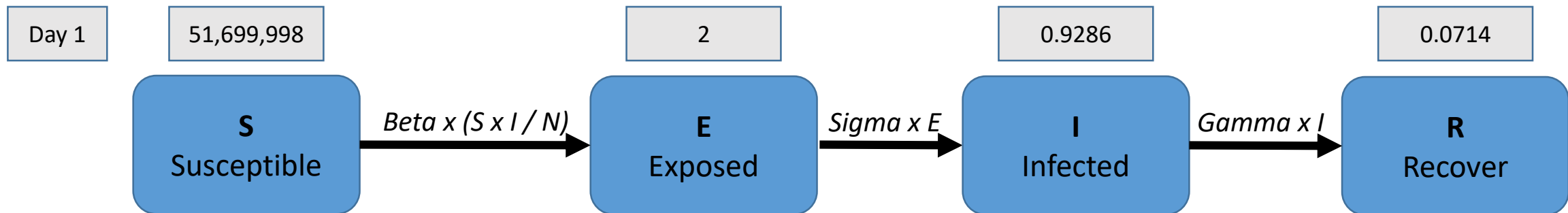
- Question:
  - How is the disease going to be transmitted in the country for the first 50 days?
  - Suppose Beta = 2, Sigma = 1/7, Gamma = 1/14
- Calculate the number of people in each of the 4 compartments in Day 1





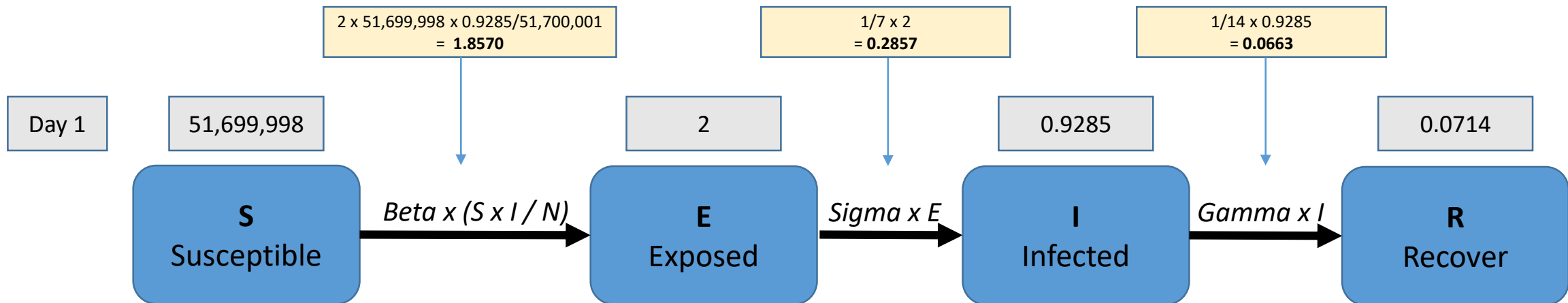
# The transmission model (SEIR Model)

- Number of people in each compartment on Day 1
- Next, calculate the number of people in each compartment on Day 2 .....



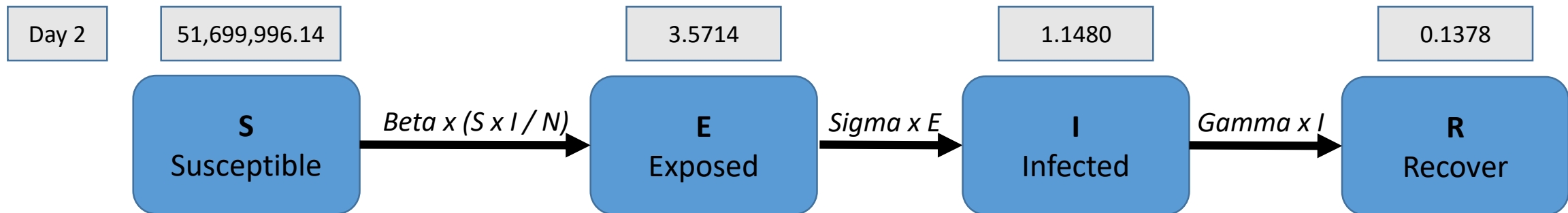
# The transmission model (SEIR Model)

- Calculate Day 2:



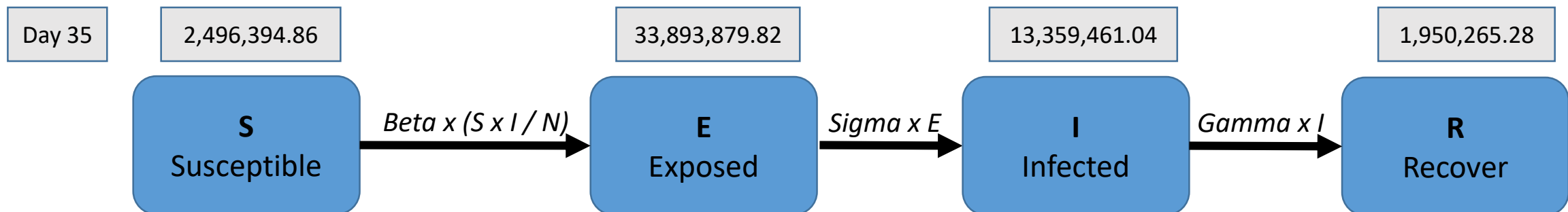
# The transmission model (SEIR Model)

- Number of people in each compartment on Day 2
- Next, calculate the number of people in each compartment on Day 3 .....



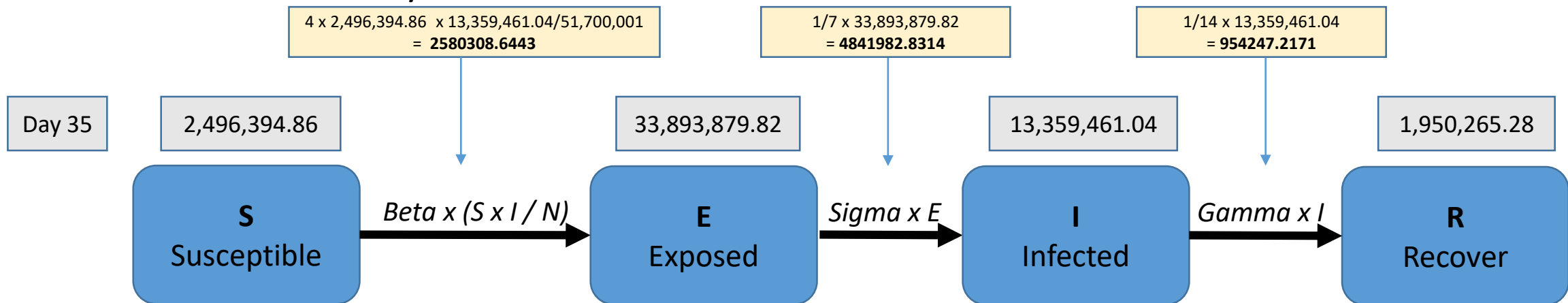
# The transmission model (SEIR Model)

- Caution!!!
- The number of people in the 4 compartments should not be negative number
- Consider the following case:
  - Number of infected people in Day 0 = 1
  - Beta = 4
  - Sigma = 1/7
  - Gamma = 1/14



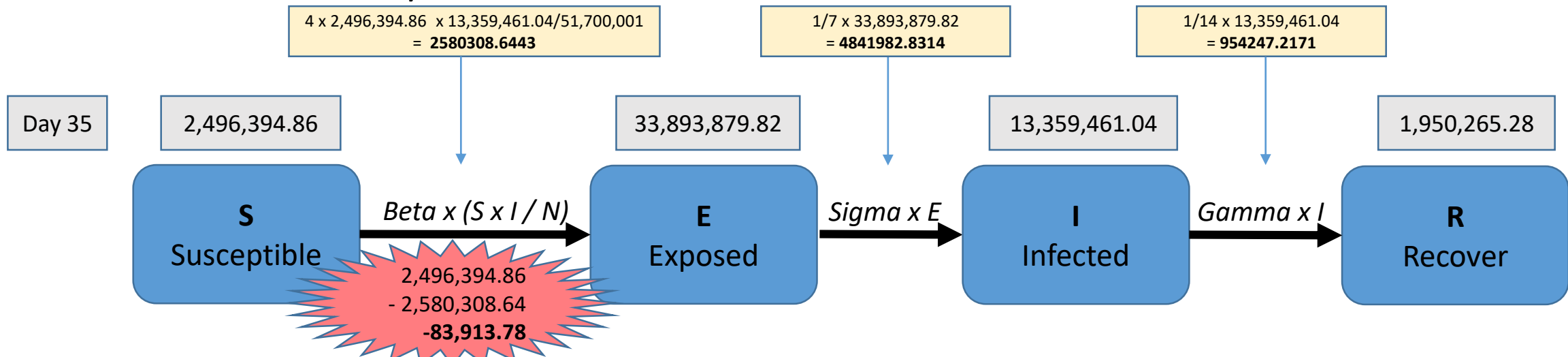
# The transmission model (SEIR Model)

- Caution!!!
- **The number of people in the 4 compartments should not be negative number**
- Consider the following case:
  - Number of infected people in Day 0 = 1
  - Beta = 4
  - Sigma = 1/7
  - Gamma = 1/14



# The transmission model (SEIR Model)

- Caution!!!
- **The number of people in the 4 compartments should not be negative number**
- Consider the following case:
  - Number of infected people in Day 0 = 1
  - Beta = 4
  - Sigma = 1/7
  - Gamma = 1/14



# The simulation program

- Specifications for the program:

- Your program should ask the user to enter the following:

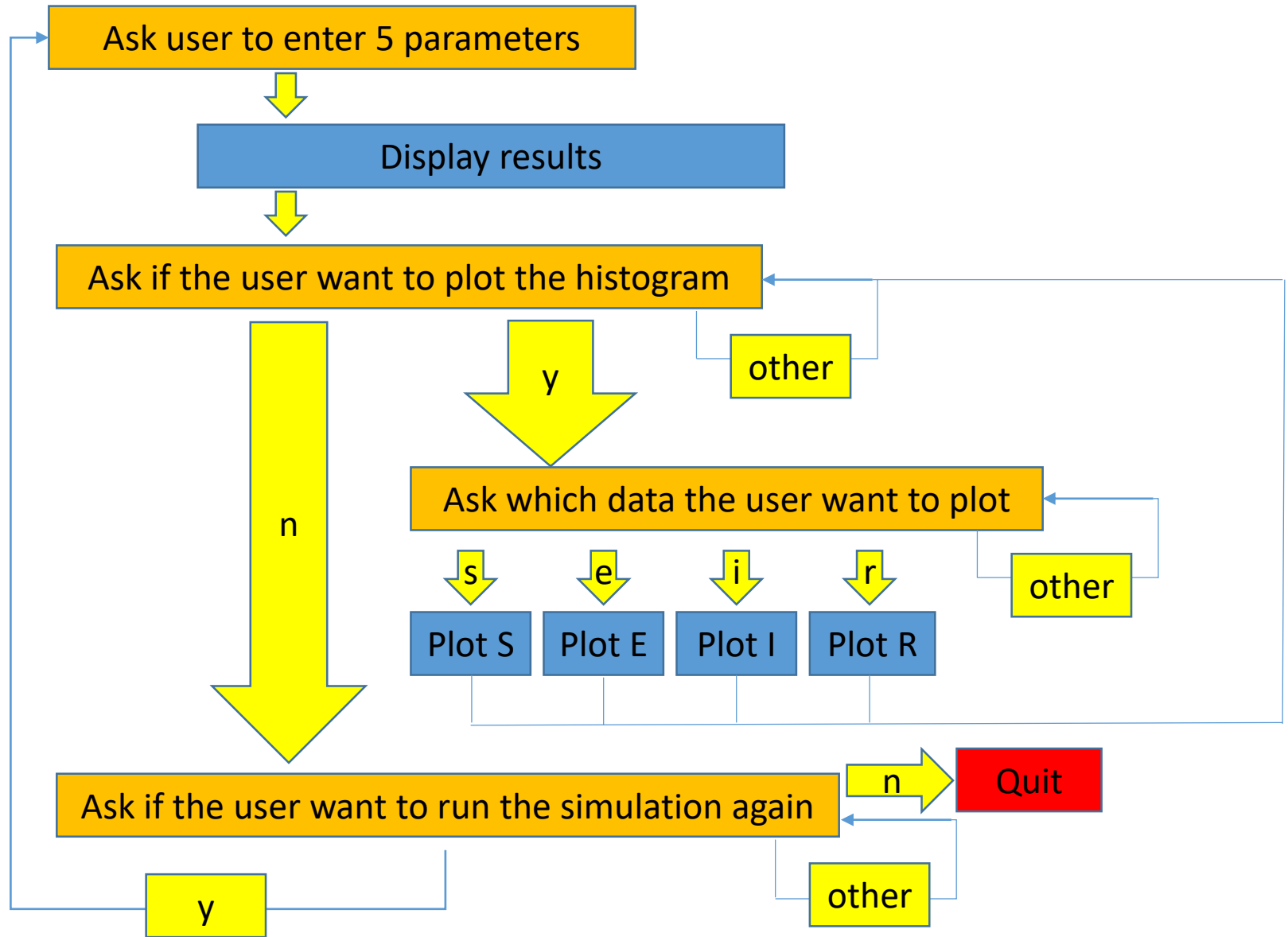
1. Number of infected people entering the country on Day 0
2. Beta
3. Sigma
4. Gamma
5. How many days should be simulation be run (max 80 days)

You may assume users always enter a positive float point numbers in these four input

You may assume users always enter one positive integer number smaller or equal to 80 in this input

- Your program will calculate the number of people in each of the 4 compartments from Day 0 to Day X (X is the 5<sup>th</sup> parameter input by the user).
    - Your program will display these results in a table form.
  - Your program will also ask if the user want to plot the results in a histogram
  - Your program execution will following the flow diagram in the follow page.
  - You should avoid using external library, except the `<stdio.h>`, `<conio.h>`, `<math.h>` libraries

# The simulation program (cont.)





# The output table

- Specifications for the program:
  - Your program should ask the user to enter the following:
    1. Number of infected people entering the country on Day 0
    2. Beta
    3. Sigma
    4. Gamma
    5. How many days should be simulation be run (max 80 days)
  - Your program will calculate the number of people in each of the 4 compartments from Day 0 to Day X (X is the 5<sup>th</sup> parameter input by the user).
    - Your program will display these results in a table form.
  - Your program will also ask if the user want to plot the results in a histogram
  - Your program execution will following the flow diagram in the follow page.

Asking user input

Enter the number of infected people in Day 0: 1  
 Enter the value of Beta (Transmission Rate): 2  
 Enter the value of Sigma (Incubation Rate): 0.1428571428571429  
 Enter the value of Gamma (Recovery Rate): 0.0714285714285714  
 How many days do you want to run the simulation: 50

Print out header first

Day	S	E	I	R
Day 0:	51700000.000000	0.000000	1.000000	0.000000
Day 1:	51699998.000000	2.000000	0.928571	0.071429
Day 2:	51699996.142857	3.571428	1.147959	0.137755
Day 3:	51699993.846939	5.357143	1.576166	0.219752
Day 4:	51699990.694607	7.744168	2.228889	0.332335
Day 5:	51699986.236830	11.095636	3.175992	0.491542
Day 6:	51699979.884847	15.862528	4.534227	0.718398
Day 7:	51699970.816398	22.664902	6.476429	1.042272
Day 8:	51699957.863548	32.379908	9.251670	1.504874

Print out the value of S, E, I and R from Day 0 to Day X in 4 columns

.....

Day 40:	47942056.142225	2799118.740250	820407.267844	138418.849680
Day 41:	46420508.345951	3920792.430775	1161680.854462	197019.368812
Day 42:	44334403.326343	5446784.245986	1638816.854969	279996.572702
Day 43:	41523727.658225	7479347.878963	2299870.543326	397054.919485
Day 44:	37829368.035669	10105229.233096	3204072.344369	561331.386866
Day 45:	33140469.405743	13350523.686865	4418814.210213	790193.697178
Day 46:	27475418.175155	17108357.247902	6010402.293322	1105823.283622
Day 47:	21087088.843791	21052635.543851	8025138.879213	1535137.733145
Day 48:	14540597.035029	24591607.989205	10459434.036963	2108361.938803
Day 49:	8657176.818231	26961941.350403	13225418.461352	2855464.370014
Day 50:	4227978.214733	27539434.046700	16132451.621313	3800137.117254

Ask if the user want to plot the result in histogram

Do you want to plot the result [y/n]? \_

- Check user's input
- If user enter "y",
  - ask which data the user want to plot
- If user enter n,
  - Ask if user want to run another simulation
- If user enter anything else,
  - Display error message and ask again

```
Day 44: 37829368.035669 10105229.233096 3204072.344369 561331.386866
Day 45: 33140469.405743 13350523.686865 4418814.210213 790193.697178
Day 46: 27475418.175155 17108357.247902 6010402.293322 1105823.283622
Day 47: 21087088.843791 21052635.543851 8025138.879213 1535137.733145
Day 48: 14540597.035029 24591607.989205 10459434.036963 2108361.938803
Day 49: 8657176.818231 26961941.350403 13225418.461352 2855464.370014
Day 50: 4227978.214733 27539434.046700 16132451.621313 3800137.117254
```

```
Do you want to plot the result [y/n]? 1
Input Error! Please enter [y/n].
Do you want to plot the result [y/n]? s
Input Error! Please enter [y/n].
Do you want to plot the result [y/n]? 1
Input Error! Please enter [y/n].
Do you want to plot the result [y/n]? i
Input Error! Please enter [y/n].
Do you want to plot the result [y/n]? o
Input Error! Please enter [y/n].
Do you want to plot the result [y/n]? y
Which data would you like to plot? [s/e/i/r]
```

```
Day 49: 8657176.818231 26961941.350403 13225418.461352
Day 50: 4227978.214733 27539434.046700 16132451.621313
```

```
Do you want to plot the result [y/n]? d
Input Error! Please enter [y/n].
Do you want to plot the result [y/n]? w
Input Error! Please enter [y/n].
Do you want to plot the result [y/n]? 0
Input Error! Please enter [y/n].
Do you want to plot the result [y/n]? n
Do you want to run the simulation again [y/n]? _
```

# The histogram

- The user select one of the 4 data set (S, E, I or R) to be plotted in the histogram
- The histogram is represented in percentage value
- Your program will plot one “\*” for one percentage value

# Some hints

- You may consider using double as the type for the population (Population of Korea is 51,700,000, the number is large)
- A sample code segment for taking double input by the user using the `scanf()` function is shown as follow:

```
double S;  
scanf("%lf", &S);          // %lf stands for long float
```
- You may use the `int()` function to convert a float point value to an integer value
- I suggest you to implement your program using functions

```

Enter the number of infected people in Day 0: 100
Enter the value of Beta (Transmission Rate): 8
Enter the value of Sigma (Incubation Rate): 0.1428571428571429
Enter the value of Gamma (Recovery Rate): 0.0714285714285714
How many days do you want to run the simulation: 15
Day      S          E          I          R
=====
Day 0:   51700000.000000  0.000000      100.000000    0.000000
Day 1:   51699200.001547  799.998453    92.857143     7.142857
Day 2:   51698457.157336  1428.557171   200.509983    13.775510
Day 3:   51696853.128444  2828.506467   390.267437    28.097652
Day 4:   51693731.185023  5546.377535   766.463544    55.973897
Day 5:   51687600.232021  10884.990889  1504.055796   110.721293
Day 6:   51675570.694793  21359.529420  2951.621938   218.153850
Day 7:   51651968.922556  41909.940311  5792.153145   428.983989
Day 8:   51605674.835816  82216.892721  11365.562250  842.709213
Day 9:   51514916.402495  161230.055653  22299.006764  1654.535088
Day 10:  51337163.327463  315950.265591  43739.085660  3247.321286
Day 11:  50989707.042572  618270.798255  85750.617483  6371.541690
Day 12:  50313128.256199  1206525.184878  167949.973128  12496.585796
Day 13:  49005573.564645  2341719.135734  328314.287173  24493.012448
Day 14:  46515948.987152  4496812.408123  639394.571765  47944.032960
Day 15:  41913707.168217  8456652.454468  1236125.303514  93615.073801

```

```

Do you want to plot the result [y/n]? y
Which data would you like to plot? [s/e/i/r]s

```

```

Day 0 (99%) *****
Day 1 (99%) *****
Day 2 (99%) *****
Day 3 (99%) *****
Day 4 (99%) *****
Day 5 (99%) *****
Day 6 (99%) *****
Day 7 (99%) *****
Day 8 (99%) *****
Day 9 (99%) *****
Day 10 (99%) *****
Day 11 (98%) *****
Day 12 (97%) *****
Day 13 (94%) *****
Day 14 (89%) *****
Day 15 (81%) *****

```

Plot the percentage value from Day 0 to Day X in the histogram

Ask if the user want to plot the result in histogram again

99 "\*"

81 "\*"

```

Do you want to plot the result [y/n]?

```

# Another example

```
Do you want to plot the result [y/n]? y
Which data would you like to plot? [s/e/i/r]e
Day 0 (0%)
Day 1 (0%)
Day 2 (0%)
Day 3 (0%)
Day 4 (0%)
Day 5 (0%)
Day 6 (0%)
Day 7 (0%)
Day 8 (0%)
Day 9 (0%)
Day 10 (0%)
Day 11 (1%)
Day 12 (2%)
Day 13 (4%)
Day 14 (8%)
Day 15 (16%)
Do you want to plot the result [y/n]? _
```

Day 0	(0%)	
Day 1	(0%)	
Day 2	(0%)	
Day 3	(0%)	
Day 4	(0%)	
Day 5	(0%)	
Day 6	(0%)	
Day 7	(0%)	
Day 8	(0%)	
Day 9	(0%)	
Day 10	(0%)	
Day 11	(1%)	*
Day 12	(2%)	**
Day 13	(4%)	****
Day 14	(8%)	*****
Day 15	(16%)	*****

# Example results:

I on Day 0 = 1

Beta = 2

Sigma = 1/7

Gamma = 1/14

Number of day = 40

C:\X\PortableApps\Dev-Cpp32\ConsolePauser.exe

```
Enter the number of infected people in Day 0: 1
Enter the value of Beta (Transmission Rate): 2
Enter the value of Sigma (Incubation Rate): 0.1428571428571429
Enter the value of Gamma (Recovery Rate): 0.0714285714285714
How many days do you want to run the simulation: 40
```

Day	S	E	I	R
Day 0:	51700000.000000	0.000000	1.000000	0.000000
Day 1:	51699998.000000	2.000000	0.928571	0.071429
Day 2:	51699996.142857	3.571428	1.147959	0.137755
Day 3:	51699993.846939	5.357143	1.576166	0.219752
Day 4:	51699990.694607	7.744168	2.228889	0.332335
Day 5:	51699986.236830	11.095636	3.175992	0.491542
Day 6:	51699979.884847	15.862528	4.534227	0.718398
Day 7:	51699970.816398	22.664902	6.476429	1.042272
Day 8:	51699957.863548	32.379908	9.251670	1.504874
Day 9:	51699939.360225	46.257531	13.216537	2.165707
Day 10:	51699912.927182	66.082355	18.880718	3.109746
Day 11:	51699875.165811	94.403389	26.972431	4.458368
Day 12:	51699821.221080	134.861922	38.532028	6.384971
Day 13:	51699744.157293	192.659720	55.045729	9.137258
Day 14:	51699634.066382	275.227814	78.636708	13.069096
Day 15:	51699476.794082	393.181855	112.338060	18.686004
Day 16:	51699252.120241	561.686859	160.482749	26.710151
Day 17:	51698931.159393	802.406728	229.260675	38.173204
Day 18:	51698472.647530	1146.289057	327.514445	54.548967
Day 19:	51697817.638004	1637.543004	467.876136	77.942856
Day 20:	51696881.925250	2339.321043	668.391127	111.362580
Day 21:	51695545.223645	3341.833928	954.837624	159.104803
Day 22:	51693635.712983	4773.939743	1364.039783	227.307491
Day 23:	51690907.969296	6819.692038	1948.599762	324.738904
Day 24:	51687011.455214	9741.964401	2783.655785	463.924601
Day 25:	51681445.542423	13916.167992	3976.532429	662.757157
Day 26:	51673495.331970	19878.354445	5680.518397	946.795188
Day 27:	51662140.119778	28393.801717	8114.532004	1352.546502
Day 28:	51645922.940618	40554.723488	11591.179963	1932.155931
Day 29:	51622764.829378	57919.302802	16556.770464	2760.097357
Day 30:	51589700.757755	82709.188311	23648.330117	3942.723818
Day 31:	51542505.003381	118089.344353	33774.762010	5631.890255
Day 32:	51475161.258460	168563.182938	48232.185345	8044.373256
Day 33:	51379116.404670	240527.582023	68867.483955	11489.529352
Day 34:	51242236.311588	343046.591959	98309.461104	16408.635349
Day 35:	51047358.302299	488917.945254	140294.012734	23430.739713
Day 36:	50770312.321751	696118.505051	200118.432575	33451.740623
Day 37:	50377272.665015	989712.661066	285269.759541	47745.914378
Day 38:	49821330.220856	1404267.582216	406280.871155	68122.325774
Day 39:	49038295.286515	1986692.861954	577870.463532	97142.387999
Day 40:	47942056.142225	2799118.740250	820407.267844	138418.849680



# Example results:

I on Day 0 = 10

Beta = 2

Sigma =  $1/7$

Gamma =  $1/14$

Number of day = 40

C:\X\PortableApps\Dev-Cpp32\ConsolePauser.exe

```
Enter the number of infected people in Day 0: 10
Enter the value of Beta (Transmission Rate): 2
Enter the value of Sigma (Incubation Rate): 0.1428571428571429
Enter the value of Gamma (Recovery Rate): 0.0714285714285714
How many days do you want to run the simulation: 40
Day      S          E          I          R
=====
Day 0: 51700000.000000 0.000000 10.000000 0.000000
Day 1: 51699980.000004 19.999996 9.285714 0.714286
Day 2: 51699961.428586 35.714272 11.479591 1.377551
Day 3: 51699938.469425 53.571394 15.761659 2.197522
Day 4: 51699906.946150 77.441613 22.288883 3.323355
Day 5: 51699862.368474 110.956202 31.759907 4.915418
Day 6: 51699798.848841 158.624949 45.342228 7.183982
Day 7: 51699708.164754 226.648328 64.764205 10.422713
Day 8: 51699578.637101 323.797649 92.516523 15.048728
Day 9: 51699393.605600 462.572343 132.165007 21.657051
Day 10: 51699129.278738 660.817441 188.806412 31.097408
Day 11: 51698751.672346 944.021341 269.722732 44.583581
Day 12: 51698212.240013 1348.593483 385.317014 63.849490
Day 13: 51697441.632782 1926.544502 550.450582 91.372134
Day 14: 51696340.786310 2752.170331 786.353326 130.690033
Day 15: 51694768.191274 3931.598177 1123.352422 186.858127
Day 16: 51692521.714222 5616.418347 1604.769845 267.097586
Day 17: 51689312.639404 8023.147686 2292.488906 381.724004
Day 18: 51684728.610280 11461.012856 3274.903654 545.473211
Day 19: 51678180.738952 16371.596633 4678.269515 779.394901
Day 20: 51668828.150527 23385.385538 6682.906926 1113.557009
Day 21: 51655470.398005 33402.368698 9546.325794 1590.907504
Day 22: 51636394.194753 47706.804993 13636.212337 2272.787917
Day 23: 51609155.328241 68130.413649 19477.455026 3246.803084
Day 24: 51570268.875343 97283.950311 27819.124474 4638.049872
Day 25: 51514770.250527 138884.867940 39729.751342 6625.130191
Day 26: 51435595.449111 198218.973936 56732.607380 9462.969573
Day 27: 51322710.540888 282786.885882 80997.274558 13515.298672
Day 28: 51161898.205388 403201.094828 115609.881501 19300.818283
Day 29: 50933085.058586 574414.085226 164952.189227 27558.666962
Day 30: 50608074.526306 817365.462474 235229.045028 39340.966192
Day 31: 50147552.795592 1161120.698548 335193.465023 56143.040837
Day 32: 49497296.364928 1645502.743706 477125.460171 80085.431196
Day 33: 48583701.945688 2324025.342416 678116.890688 114165.821208
Day 34: 47309217.515162 3266506.152597 961683.590270 162602.741971
Day 35: 45549198.584688 4559881.346985 1359635.641336 231294.426991
Day 36: 43153442.226807 6304226.083869 1913930.430810 328411.258515
Day 37: 39958367.940667 8598696.643741 2677824.840590 465120.575001
Day 38: 35819045.326959 11509634.022629 3714936.872511 656393.777900
Day 39: 30671445.076079 15013000.841706 5093817.670565 921746.411651
Day 40: 24627548.801773 18912182.710053 6874687.957196 1285590.530977
```

# Example results:

I on Day 0 = 2

Beta = 2

Sigma = 1/7

Gamma = 1/14

Number of day = 40

```
C:\X\PortableApps\Dev-Cpp32\ConsolePauser.exe
Enter the number of infected people in Day 0: 2
Enter the value of Beta (Transmission Rate): 2
Enter the value of Sigma (Incubation Rate): 0.1428571428571429
Enter the value of Gamma (Recovery Rate): 0.0714285714285714
How many days do you want to run the simulation: 40
Day      S          E          I          R
=====
Day 0: 51700000.000000 0.000000      2.000000      0.000000
Day 1: 51699996.000000 4.000000      1.857143      0.142857
Day 2: 51699992.285715 7.142857      2.295918      0.275510
Day 3: 51699987.693879 10.714284     3.152332      0.439504
Day 4: 51699981.389216 15.488335     4.457778      0.664671
Day 5: 51699972.473664 22.191268     6.351984      0.983084
Day 6: 51699959.769703 31.725048     9.068452      1.436797
Day 7: 51699941.632813 45.329788    12.952855     2.084543
Day 8: 51699915.727133 64.759784    18.503335     3.009747
Day 9: 51699878.720524 92.514996    26.433066     4.331414
Day 10: 51699825.854517 132.164574   37.761418     6.219490
Day 11: 51699750.331938 188.806500   53.944827     8.916734
Day 12: 51699642.442809 269.723272   77.063983    12.769936
Day 13: 51699488.315915 385.318270  110.091308    18.274507
Day 14: 51699268.135486 550.453232  157.273111    26.138172
Day 15: 51698953.593730 786.358812  224.675493    37.371965
Day 16: 51698504.251856 1123.363713 320.964217    53.420215
Day 17: 51697862.342019 1604.793019 458.518732    76.346230
Day 18: 51696945.342509 2292.536384 655.023539   109.097568
Day 19: 51695635.372884 3275.000811 935.741341   155.884964
Day 20: 51693764.048269 4678.468167 1336.759933  222.723631
Day 21: 51691090.850982 6683.312859 1909.629676  318.206483
Day 22: 51687272.249928 9547.154933 2727.986536  454.608603
Day 23: 51681817.620245 13637.905340 3897.009631  649.464784
Day 24: 51674026.342364 19480.911030 5566.923992  927.822615
Day 25: 51662898.088366 27826.177738 7952.273854 1325.460043
Day 26: 51647004.954989 39744.142866 11359.422541 1893.479604
Day 27: 51624309.398720 56761.964440 16225.769912 2704.866928
Day 28: 51591905.370335 81057.140762 23175.638409 3863.850493
Day 29: 51545651.006797 115731.912763 33099.827203 5519.253237
Day 30: 51479648.992275 165200.796890 47268.684226 7883.526608
Day 31: 51385514.555982 235735.119341 67492.463480 11259.861196
Day 32: 51251350.732756 336222.496948 96348.018852 16080.751445
Day 33: 51060326.906235 479214.538190 137497.802783 22962.752791
Day 34: 50788733.773260 682348.451424 196135.750898 32784.024419
Day 35: 50403376.479240 970227.395240 279604.404608 46793.720911
Day 36: 49858192.513068 1376807.447806 398236.575028 66765.464098
Day 37: 49090093.671468 1948219.511149 566477.883641 95210.933742
Day 38: 48014331.532397 2745664.577199 804332.250688 135673.639717
Day 39: 46520348.017784 3847410.295069 1139117.743810 193125.943337
Day 40: 44470361.486825 5347766.783875 1607382.232833 274491.496467
```

# Example results:

I on Day 0 = 1

Beta = 4

Sigma = 1/7

Gamma = 1/14

Number of day = 40

This result has problem!!!

Number of susceptible  
on Day 36, 38 and 40  
are negative!

C:\X\PortableApps\Dev-Cpp32\ConsolePauser.exe

Enter the number of infected people in Day 0: 1  
Enter the value of Beta (Transmission Rate): 4  
Enter the value of Sigma (Incubation Rate): 0.1428571428571429  
Enter the value of Gamma (Recovery Rate): 0.0714285714285714  
How many days do you want to run the simulation: 40

Day	S	E	I	R
Day 0:	51700000.000000	0.000000	1.000000	0.000000
Day 1:	51699996.000000	4.000000	0.928571	0.071429
Day 2:	51699992.285715	7.142857	1.433673	0.137755
Day 3:	51699986.551022	11.857141	2.351676	0.240160
Day 4:	51699977.144319	19.569967	3.877577	0.408137
Day 5:	51699961.634019	32.284557	6.396317	0.685107
Day 6:	51699936.048772	53.257724	10.551516	1.141987
Day 7:	51699893.842760	87.855491	17.406083	1.895666
Day 8:	51699824.218572	144.928894	28.713576	3.138958
Day 9:	51699709.364662	239.078676	47.366734	5.189928
Day 10:	51699519.898796	394.390446	78.137492	8.573266
Day 11:	51699207.351735	650.596014	128.897735	14.154515
Day 12:	51698691.768710	1073.236752	212.633042	23.361496
Day 13:	51697841.258082	1770.427844	350.764503	38.549571
Day 14:	51696438.258681	2920.508982	578.628159	63.604178
Day 15:	51694123.905541	4817.646553	954.513145	104.934761
Day 16:	51690306.286984	7947.029888	1574.568857	173.114271
Day 17:	51684009.192601	13108.834287	2597.389637	285.583475
Day 18:	51673622.847745	21622.488530	4284.552418	471.111307
Day 19:	51656493.382257	35663.027085	7067.439892	777.150765
Day 20:	51628247.412821	58814.278367	11657.340912	1281.967900
Day 21:	51581682.765305	96976.886116	19226.713471	2114.635108
Day 22:	51504951.916896	159853.893652	31707.217668	3487.971785
Day 23:	51378601.534704	263368.005321	52278.686928	5752.773047
Day 24:	51170786.774746	433558.764520	86168.495765	9486.964970
Day 25:	50829640.961347	712767.611559	141950.569570	15641.857525
Day 26:	50271397.530327	1169187.098070	233635.187680	25781.183923
Day 27:	49362680.534600	1910877.365502	383973.688285	42469.411614
Day 28:	47896222.496544	3104352.922772	629529.477050	69896.103634
Day 29:	45563372.723412	4993723.706936	1028042.074800	114862.494852
Day 30:	41939305.928562	7904401.400795	1667999.599019	188294.071624
Day 31:	36526946.615689	12187560.513555	2678056.970631	307436.900125
Day 32:	28958571.984514	18014855.071365	4227847.260380	498726.683742
Day 33:	19486044.567794	24913831.763604	6499408.894833	800715.773769
Day 34:	9687377.725289	31153379.782737	9594284.225717	1264959.266257
Day 35:	2496394.862577	33893879.819344	13359461.035700	1950265.282380
Day 36:	-83913.783554	31632205.634140	17247196.650199	2904512.499215
Day 37:	28061.264695	27001344.066728	20534140.551490	4136455.117087
Day 38:	-16520.084795	23188590.549543	22924751.093059	5603179.442193
Day 39:	12781.178233	19846633.493723	24599924.664918	7240661.663126
Day 40:	-11545.012527	17035726.328237	25678020.545099	8997799.139191

# Example results:

I on Day 0 = 1

Beta = 4

Sigma = 1/7

Gamma = 1/14

Number of day = 40

This is the correct  
result!!!

C:\X\PortableApps\Dev-Cpp32\ConsolePauser.exe

```
Enter the number of infected people in Day 0: 1
Enter the value of Beta (Transmission Rate): 4
Enter the value of Sigma (Incubation Rate): 0.1428571428571429
Enter the value of Gamma (Recovery Rate): 0.0714285714285714
How many days do you want to run the simulation: 40
```

Day	S	E	I	R
Day 0:	51700000.000000	0.000000	1.000000	0.000000
Day 1:	51699996.000000	4.000000	0.928571	0.071429
Day 2:	51699992.285715	7.142857	1.433673	0.137755
Day 3:	51699986.551022	11.857141	2.351676	0.240160
Day 4:	51699977.144319	19.569967	3.877577	0.408137
Day 5:	51699961.634019	32.284557	6.396317	0.685107
Day 6:	51699936.048772	53.257724	10.551516	1.141987
Day 7:	51699893.842760	87.855491	17.406083	1.895666
Day 8:	51699824.218572	144.928894	28.713576	3.138958
Day 9:	51699709.364662	239.078676	47.366734	5.189928
Day 10:	51699519.898796	394.390446	78.137492	8.573266
Day 11:	51699207.351735	650.596014	128.897735	14.154515
Day 12:	51698691.768710	1073.236752	212.633042	23.361496
Day 13:	51697841.258082	1770.427844	350.764503	38.549571
Day 14:	51696438.258681	2920.508982	578.628159	63.604178
Day 15:	51694123.905541	4817.646553	954.513145	104.934761
Day 16:	51690306.286984	7947.029888	1574.568857	173.114271
Day 17:	51684009.192601	13108.834287	2597.389637	285.583475
Day 18:	51673622.847745	21622.488530	4284.552418	471.111307
Day 19:	51656493.382257	35663.027085	7067.439892	777.150765
Day 20:	51628247.412821	58814.278367	11657.340912	1281.967900
Day 21:	51581682.765305	96976.886116	19226.713471	2114.635108
Day 22:	51504951.916896	159853.893652	31707.217668	3487.971785
Day 23:	51378601.534704	263368.005321	52278.686928	5752.773047
Day 24:	51170786.774746	433558.764520	86168.495765	9486.964970
Day 25:	50829640.961347	712767.611559	141950.569570	15641.857525
Day 26:	50271397.530327	1169187.098070	233635.187680	25781.183923
Day 27:	49362680.534600	1910877.365502	383973.688285	42469.411614
Day 28:	47896222.496544	3104352.922772	629529.477050	69896.103634
Day 29:	45563372.723412	4993723.706936	1028042.074800	114862.494852
Day 30:	41939305.928562	7904401.400795	1667999.599019	188294.071624
Day 31:	36526946.615689	12187560.513555	2678056.970631	307436.900125
Day 32:	28958571.984514	18014855.071365	4227847.260380	498726.683742
Day 33:	19486044.567794	24913831.763604	6499408.894833	800715.773769
Day 34:	9687377.725289	31153379.782737	9594284.225717	1264959.266257
Day 35:	2496394.862577	33893879.819344	13359461.035700	1950265.282380
Day 36:	0.000000	31548291.850586	17247196.650199	2904512.499215
Day 37:	0.000000	27041393.014788	20522152.868126	4136455.117087
Day 38:	0.000000	23178336.869818	22919340.951086	5602323.179096
Day 39:	0.000000	19867145.888416	24593436.150268	7239418.961316
Day 40:	0.000000	17028982.190070	25674925.837880	8996092.972049

# Example results:

I on Day 0 = 2

Beta = 8

Sigma = 1

Gamma = 1

Number of day = 40

```
C:\X\PortableApps\Dev-Cpp32\ConsolePauser.exe
Enter the number of infected people in Day 0: 2
Enter the value of Beta (Transmission Rate): 8
Enter the value of Sigma (Incubation Rate): 1
Enter the value of Gamma (Recovery Rate): 1
How many days do you want to run the simulation: 40
Day      S              E              I              R
=====
Day 0: 51700000.000000 0.000000      2.000000      0.000000
Day 1: 51699984.000001 15.999999      0.000000      2.000000
Day 2: 51699984.000001 0.000000      15.999999      2.000000
Day 3: 51699856.000050 127.999950      0.000000      17.999999
Day 4: 51699856.000050 0.000000      127.999950      17.999999
Day 5: 51698832.003338 1023.996712      0.000000      145.999950
Day 6: 51698832.003338 0.000000      1023.996712      145.999950
Day 7: 51690640.215030 8191.788308      0.000000      1169.996662
Day 8: 51690640.215030 0.000000      8191.788308      1169.996662
Day 9: 51625117.775449 65522.439581      0.000000      9361.784970
Day 10: 51625117.775449 0.000000      65522.439581      9361.784970
Day 11: 51101697.500102 523420.275347      0.000000      74884.224551
Day 12: 51101697.500102 0.000000      523420.275347      74884.224551
Day 13: 46962794.050745 4138903.449357      0.000000      598304.499898
Day 14: 46962794.050745 0.000000      4138903.449357      598304.499898
Day 15: 16885507.742236 30077286.308509      0.000000      4737207.949255
Day 16: 16885507.742236 0.000000      30077286.308509      4737207.949255
Day 17: 0.000000      16885507.742236      0.000000      34814494.257764
Day 18: 0.000000      0.000000      16885507.742236      34814494.257764
Day 19: 0.000000      0.000000      0.000000      51700002.000000
Day 20: 0.000000      0.000000      0.000000      51700002.000000
Day 21: 0.000000      0.000000      0.000000      51700002.000000
Day 22: 0.000000      0.000000      0.000000      51700002.000000
Day 23: 0.000000      0.000000      0.000000      51700002.000000
Day 24: 0.000000      0.000000      0.000000      51700002.000000
Day 25: 0.000000      0.000000      0.000000      51700002.000000
Day 26: 0.000000      0.000000      0.000000      51700002.000000
Day 27: 0.000000      0.000000      0.000000      51700002.000000
Day 28: 0.000000      0.000000      0.000000      51700002.000000
Day 29: 0.000000      0.000000      0.000000      51700002.000000
Day 30: 0.000000      0.000000      0.000000      51700002.000000
Day 31: 0.000000      0.000000      0.000000      51700002.000000
Day 32: 0.000000      0.000000      0.000000      51700002.000000
Day 33: 0.000000      0.000000      0.000000      51700002.000000
Day 34: 0.000000      0.000000      0.000000      51700002.000000
Day 35: 0.000000      0.000000      0.000000      51700002.000000
Day 36: 0.000000      0.000000      0.000000      51700002.000000
Day 37: 0.000000      0.000000      0.000000      51700002.000000
Day 38: 0.000000      0.000000      0.000000      51700002.000000
Day 39: 0.000000      0.000000      0.000000      51700002.000000
Day 40: 0.000000      0.000000      0.000000      51700002.000000
```