```
clear;
close all;

%%%%%%%%% Part 1 Data Fit %%%%%%%%%



% Step 1: Load the data from the 'COVID_STL.mat' file
load('COVID_STL.mat');

% normalizing cases and deaths by population
normalized_cases = cases_STL / POP_STL;
normalized_deaths = deaths_STL / POP_STL;




% %%%DATA FROM DAYS BEFORE FIRST PHASE%%%%%
selected_dates_phase1 = dates(1:68);
selected_dates_phase1a = dates(1:10);
A = [.9995 0 0 0;
    .0005 .98 0 0;
    0 0 1 0;
    0 .02 0 1];

% Normalized COVID Cases and Deaths in St. Louis for first 68 weeks

% Single plot
figure;
plot(selected_dates_phase1, normalized_cases(1:68), '--r', 'LineWidth', 2);
hold on;
plot(selected_dates_phase1, normalized_deaths(1:68), '--k', 'LineWidth', 2);


% initial condition:
x0 = [1; 0; 0; 0];

phase1 = 10;

% Allocate
sys = ss(A, [], [], [], 1);
[Y, T, X] = lsim(sys, [], 0:phase1-1, x0);



% Use selected_dates for the x-axis
plot(selected_dates_phase1a, X(:,2), 'r', 'LineWidth', 2);
plot(selected_dates_phase1a, X(:,4), 'k', 'LineWidth', 2);
```

```
selected_dates_phase1a = dates(10:17);
A = [.9995 0 0 0;
    .0005 .998 0 0;
    0 0 1 0;
    0 .002 0 1];

% initial condition:
x0 = [0.9955; 0.00414772; 0; 0.000357227];

phase1 = 8;

% Allocate
sys = ss(A, [], [], [], 1);
[Y, T, X] = lsim(sys, [], 0:phase1-1, x0);

% Use selected_dates for the x-axis
plot(selected_dates_phase1a, X(:,2), 'r', 'LineWidth', 2);
plot(selected_dates_phase1a, X(:,4), 'k', 'LineWidth', 2);
```

```
selected_dates_phase1a = dates(17:35);
A = [.9985 0 0 0;
    .0015 .998 0 0;
    0 0 1 0;
    0 .002 0 1];

% initial condition:
x0 = [0.992; 0.00754821; 0; 0.000435766];

phase1 = 19;

% Allocate
sys = ss(A, [], [], [], 1);
[Y, T, X] = lsim(sys, [], 0:phase1-1, x0);

% Use selected_dates for the x-axis
plot(selected_dates_phase1a, X(:,2), 'r', 'LineWidth', 2);
plot(selected_dates_phase1a, X(:,4), 'k', 'LineWidth', 2);
```

```
selected_dates_phase1a = dates(35:40);
A = [.9945 0 0 0;
    .0055 .999 0 0;
    0 0 1 0;
    0 .001 0 1];

% initial condition:
```

```
x0 = [0.966; 0.0332794; 0; 0.00114984];

phase1 = 6;

% Allocate
sys = ss(A, [], [], [], 1);
[Y, T, X] = lsim(sys, [], 0:phase1-1, x0);

% Use selected_dates for the x-axis
plot(selected_dates_phase1a, X(:,2), 'r', 'LineWidth', 2);
plot(selected_dates_phase1a, X(:,4), 'k', 'LineWidth', 2);



selected_dates_phase1a = dates(40:46);
A = [.9965 0 0 0;
    .0035 .999 0 0;
    0 0 1 0;
    0 .001 0 1];

% initial condition:
x0 = [0.9395; 0.0593349; 0; 0.00136869];

phase1 = 7;

% Allocate
sys = ss(A, [], [], [], 1);
[Y, T, X] = lsim(sys, [], 0:phase1-1, x0);

% Use selected_dates for the x-axis
plot(selected_dates_phase1a, X(:,2), 'r', 'LineWidth', 2);
plot(selected_dates_phase1a, X(:,4), 'k', 'LineWidth', 2);


selected_dates_phase1a = dates(46:60);
A = [.9987 0 0 0;
    .0013 .9998 0 0;
    0 0 1 0;
    0 .0002 0 1];

% initial condition:
x0 = [0.9197; 0.0784884; 0; 0.00177284];

phase1 = 15;

% Allocate
sys = ss(A, [], [], [], 1);
[Y, T, X] = lsim(sys, [], 0:phase1-1, x0);

% Use selected_dates for the x-axis
plot(selected_dates_phase1a, X(:,2), 'r', 'LineWidth', 2);
plot(selected_dates_phase1a, X(:,4), 'k', 'LineWidth', 2);
```

```
selected_dates_phase1a = dates(60:68);
A = [.9995 0 0 0;
    .0005 .9998 0 0;
    0 0 1 0;
    0 .0002 0 1];

% initial condition:
x0 = [0.903; 0.0948451; 0; 0.00199521];

phase1 = 9;

% Allocate
sys = ss(A, [], [], [], 1);
[Y, T, X] = lsim(sys, [], 0:phase1-1, x0);

% Use selected_dates for the x-axis
plot(selected_dates_phase1a, X(:,2), 'r', 'LineWidth', 2);
plot(selected_dates_phase1a, X(:,4), 'k', 'LineWidth', 2);


% Plot
title('COVID Cases & Deaths in St. Louis Before Any Variant');
xlabel('Date');
ylabel('Rate for STL Population');
legend('Infection Rate', 'Death Rate', 'Modeled Infection Rate', 'Modeled
 Death Rate');
grid on;
datetick('x', 'mmm dd yy', 'keepticks');
hold off;
```

```
%%%DELTA PHASE%%%%%
figure;

phase2 = 18;

% Look at first 100 days
selected_dates_phase2 = dates(68:85);


A_phase2 = [.9993 0 0 0;
            .0007 .999984 0 0;
            0 0 1 0;
```

```
            0 .000016 0 1];


% Initial conditions for the second phase
x0_phase2 = [0.89926519; 0.0985651; 0; 0.00216971];


% Create the system for the second phase
sys_phase2 = ss(A_phase2, [], [], [], 1);

% Simulate the system for the second phase
[Y, T, X] = lsim(sys_phase2, [], 0:phase2-1, x0_phase2);

% Plot normalized cases and deaths for the second phase

plot(selected_dates_phase2, X(:,4), 'k', 'LineWidth', 2);
hold on;
plot(selected_dates_phase2, normalized_cases(68:85), '--r', 'LineWidth', 2);
plot(selected_dates_phase2, normalized_deaths(68:85), '--k', 'LineWidth', 2);

%Making the tuned model exact
selected_dates_phase2a = dates(68:69);
phase2 = 2;
x0_phase2 = [0.89926519; 0.0985651; 0; 0.00216971];
sys_phase2 = ss(A_phase2, [], [], [], 1);
[Y, T, X] = lsim(sys_phase2, [], 0:phase2-1, x0_phase2);
plot(selected_dates_phase2a, X(:,2), 'r', 'LineWidth', 2);



%Tuning for model 2nd week
A_phase2 = [.999 0 0 0;
            .001 .999984 0 0;
            0 0 1 0;
            0 .000016 0 1];
selected_dates_phase2a = dates(69:70);
phase2 = 2;
x0_phase2 = [0.89926519; 0.099193; 0; 0.00216971];
sys_phase2 = ss(A_phase2, [], [], [], 1);
[Y, T, X] = lsim(sys_phase2, [], 0:phase2-1, x0_phase2);
plot(selected_dates_phase2a, X(:,2), 'r', 'LineWidth', 2);


%Tuning for linear weeks following 2nd week
A_phase2 = [.99782 0 0 0;
            .00218 .999984 0 0;
            0 0 1 0;
            0 .000016 0 1];
selected_dates_phase2a = dates(70:80);
phase2 = 11;
x0_phase2 = [0.89926519; 0.100091; 0; 0.00216971];
sys_phase2 = ss(A_phase2, [], [], [], 1);
[Y, T, X] = lsim(sys_phase2, [], 0:phase2-1, x0_phase2);
plot(selected_dates_phase2a, X(:,2), 'r', 'LineWidth', 2);
```

```
%Tuning for linear weeks following 2nd week
A_phase2 = [.9981 0 0 0;
            .0019 .999984 0 0;
            0 0 1 0;
            0 .000016 0 1];
selected_dates_phase2a = dates(80:81);
phase2 = 2;
x0_phase2 = [0.89926519; 0.119486; 0; 0.00216971];
sys_phase2 = ss(A_phase2, [], [], [], 1);
[Y, T, X] = lsim(sys_phase2, [], 0:phase2-1, x0_phase2);
plot(selected_dates_phase2a, X(:,2), 'r', 'LineWidth', 2);


%Tuning for linear weeks following 2nd week
A_phase2 = [.9989 0 0 0;
            .0011 .999984 0 0;
            0 0 1 0;
            0 .000016 0 1];
selected_dates_phase2a = dates(81:82);
phase2 = 2;
x0_phase2 = [0.89926519; 0.121193; 0; 0.00216971];
sys_phase2 = ss(A_phase2, [], [], [], 1);
[Y, T, X] = lsim(sys_phase2, [], 0:phase2-1, x0_phase2);
plot(selected_dates_phase2a, X(:,2), 'r', 'LineWidth', 2);



%Tuning for very last few linear weeks
A_phase2 = [.99882 0 0 0;
            .00118 .999984 0 0;
            0 0 1 0;
            0 .000016 0 1];
selected_dates_phase2a = dates(82:85);
phase2 = 4;
x0_phase2 = [0.89926519; 0.12218; 0; 0.00216971];
sys_phase2 = ss(A_phase2, [], [], [], 1);
[Y, T, X] = lsim(sys_phase2, [], 0:phase2-1, x0_phase2);
plot(selected_dates_phase2a, X(:,2), 'r', 'LineWidth', 2);


title('COVID Cases & Deaths in St. Louis During Delta Variant');
xlabel('Date');
ylabel('Rate for STL Population');
legend('Modeled Infection Rate', 'Modeled Death Rate', 'Infection
 Rate', 'Death Rate');
grid on;
datetick('x', 'mmm dd yy', 'keepticks');
hold off;
```

```
%%OMICRON PHASE%%%%%

% IMPLEMENT 5 SEPARATE SLOPES FOR ONE MODEL
%
% plot all the data in a new figure


figure;
phase3 = 4;
selected_dates_phase3 = dates(85:106);
selected_dates_phase3a = dates(85:88);
x0_phase3 = [0.874624; 0.125376; 0; 0.00244247];

A_phase3_slope1 = [.99882 0 0 0;
            .00118 .999984 0 0;
            0 0 1 0;
            0 .000016 0 1];


sys_slope1 = ss(A_phase3_slope1, [], [], [], 1);
[Y1, T1, X1] = lsim(sys_slope1, [], 0:phase3-1, x0_phase3);


plot(selected_dates_phase3a, X1(:,2), 'r', 'LineWidth', 2);
hold on;
plot(selected_dates_phase3a, X1(:,4), 'k', 'LineWidth', 2);


plot(selected_dates_phase3, normalized_cases(85:106), '--r', 'LineWidth', 2);
plot(selected_dates_phase3, normalized_deaths(85:106), '--k', 'LineWidth', 2);


phase3 = 5;
selected_dates_phase3a = dates(88:92);
x0_phase3 = [0.874624; 0.128733; 0; 0.00244247];

A_phase3_slope1 = [.998 0 0 0;
            .002 .999984 0 0;
            0 0 1 0;
            0 .000016 0 1];
```

```
sys_slope1 = ss(A_phase3_slope1, [], [], [], 1);
[Y1, T1, X1] = lsim(sys_slope1, [], 0:phase3-1, x0_phase3);


plot(selected_dates_phase3a, X1(:,2), 'r', 'LineWidth', 2);
plot(selected_dates_phase3a, X1(:,4), 'k', 'LineWidth', 2);




phase3 = 3;
selected_dates_phase3a = dates(92:94);
x0_phase3 = [0.874624; 0.135701; 0; 0.00244247];

A_phase3_slope1 = [.993 0 0 0;
            .007 .999984 0 0;
            0 0 1 0;
            0 .000016 0 1];


sys_slope1 = ss(A_phase3_slope1, [], [], [], 1);
[Y1, T1, X1] = lsim(sys_slope1, [], 0:phase3-1, x0_phase3);


plot(selected_dates_phase3a, X1(:,2), 'r', 'LineWidth', 2);
plot(selected_dates_phase3a, X1(:,4), 'k', 'LineWidth', 2);


phase3 = 5;
selected_dates_phase3a = dates(94:98);
x0_phase3 = [0.874624; 0.147898; 0; 0.00244247];

A_phase3_slope1 = [.983 0 0 0;
            .017 .999984 0 0;
            0 0 1 0;
            0 .000016 0 1];


sys_slope1 = ss(A_phase3_slope1, [], [], [], 1);
[Y1, T1, X1] = lsim(sys_slope1, [], 0:phase3-1, x0_phase3);


plot(selected_dates_phase3a, X1(:,2), 'r', 'LineWidth', 2);
plot(selected_dates_phase3a, X1(:,4), 'k', 'LineWidth', 2);



phase3 = 9;
selected_dates_phase3a = dates(98:106);
x0_phase3 = [0.874624; 0.205862; 0; 0.00244247];

A_phase3_slope1 = [.999 0 0 0;
            .001 .999984 0 0;
```

```
            0 0 1 0;
            0 .000016 0 1];


sys_slope1 = ss(A_phase3_slope1, [], [], [], 1);
[Y1, T1, X1] = lsim(sys_slope1, [], 0:phase3-1, x0_phase3);


plot(selected_dates_phase3a, X1(:,2), 'r', 'LineWidth', 2);
plot(selected_dates_phase3a, X1(:,4), 'k', 'LineWidth', 2);
title('COVID Cases & Deaths in St. Louis During Omicron Variant');
xlabel('Date');
ylabel('Rate for STL Population');
legend('Modeled Infection Rate', 'Modeled Death Rate', 'Infection
 Rate', 'Death Rate');
grid on;
datetick('x', 'mmm dd yy', 'keepticks');
hold off;




%%%AFTER OMICRON PHASE%%%%%%
figure;
phase4 = 7;
selected_dates_phase4 = dates(106:158);

selected_dates_phase4a = dates(106:112);
x0_phase4 = [0.874624; 0.213465; 0; 0.00244247];

A_phase4_slope1 = [.9991 0 0 0;
            .0008 .999984 0 0;
            0 0 1 0;
            0 .000016 0 1];


sys_slope1 = ss(A_phase4_slope1, [], [], [], 1);
[Y1, T1, X1] = lsim(sys_slope1, [], 0:phase4-1, x0_phase4);


plot(selected_dates_phase4a, X1(:,2), 'r', 'LineWidth', 2);
hold on;
plot(selected_dates_phase4a, X1(:,4), 'k', 'LineWidth', 2);


plot(selected_dates_phase4, normalized_cases(106:158), '--r', 'LineWidth', 2);
plot(selected_dates_phase4, normalized_deaths(106:158), '--k', 'LineWidth',
 2);
```

```
phase4 = 16;
selected_dates_phase4a = dates(112:127);
x0_phase4 = [0.874624; 0.217708; 0; 0.00244247];

A_phase4_slope1 = [.997 0 0 0;
            .003 .999984 0 0;
            0 0 1 0;
            0 .000016 0 1];


sys_slope1 = ss(A_phase4_slope1, [], [], [], 1);
[Y1, T1, X1] = lsim(sys_slope1, [], 0:phase4-1, x0_phase4);


plot(selected_dates_phase4a, X1(:,2), 'r', 'LineWidth', 2);
hold on;
plot(selected_dates_phase4a, X1(:,4), 'k', 'LineWidth', 2);
```

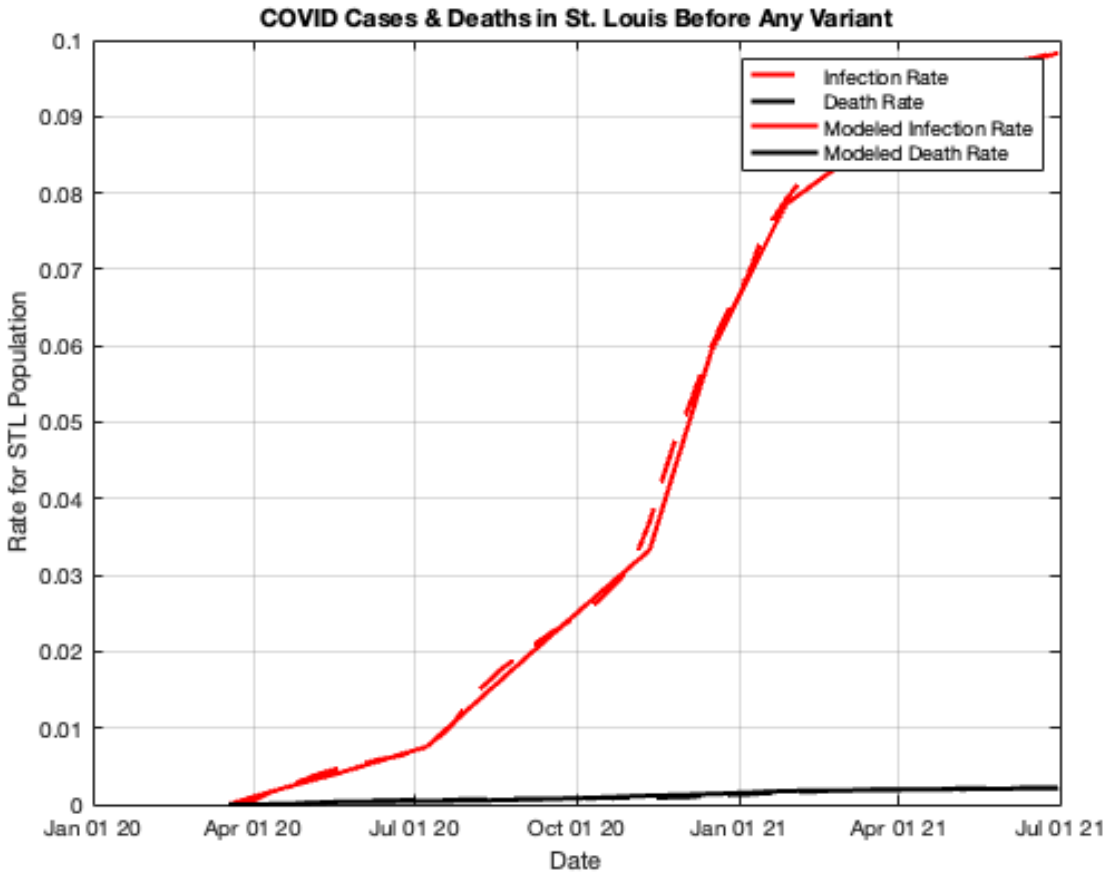
```
phase4 = 13;
selected_dates_phase4a = dates(127:139);
x0_phase4 = [0.874624; 0.256194; 0; 0.00244247];

A_phase4_slope1 = [.9985 0 0 0;
            .0015 .999984 0 0;
            0 0 1 0;
            0 .000016 0 1];


sys_slope1 = ss(A_phase4_slope1, [], [], [], 1);
[Y1, T1, X1] = lsim(sys_slope1, [], 0:phase4-1, x0_phase4);


plot(selected_dates_phase4a, X1(:,2), 'r', 'LineWidth', 2);
hold on;
plot(selected_dates_phase4a, X1(:,4), 'k', 'LineWidth', 2);
```

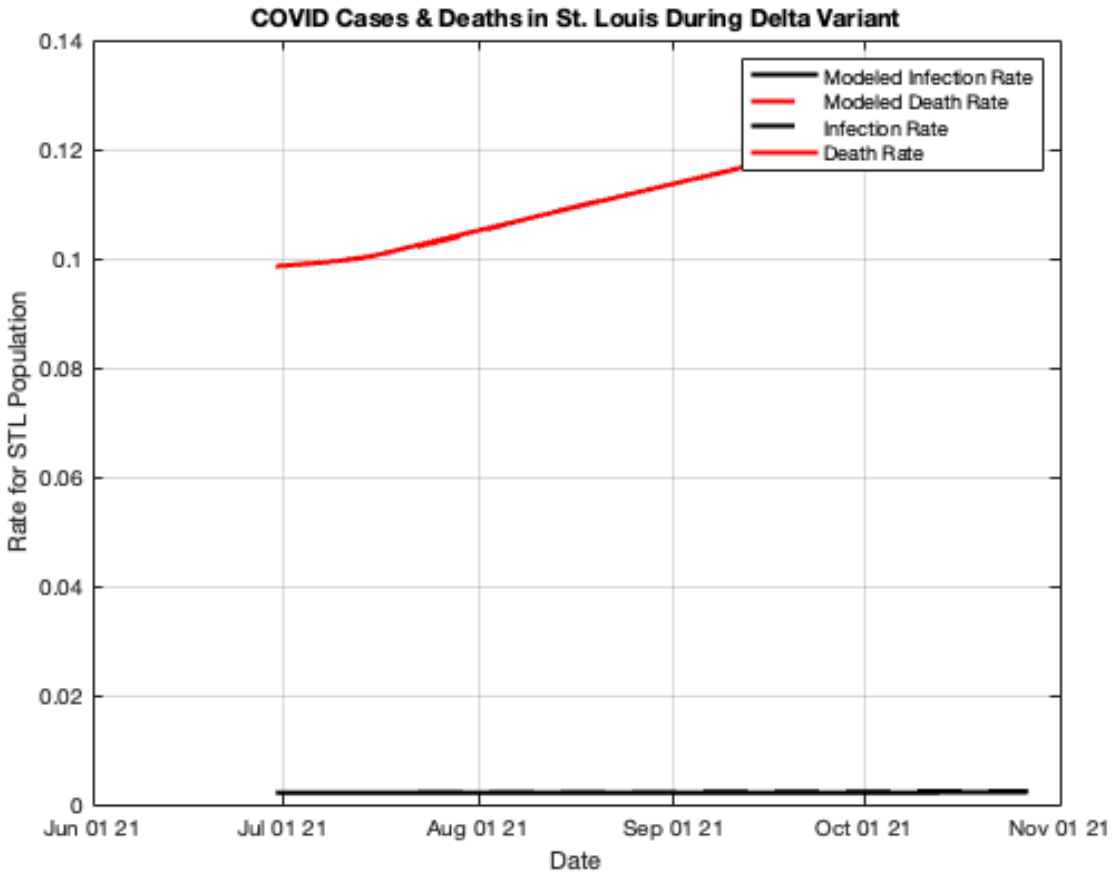
```
phase4 = 20;
selected_dates_phase4a = dates(139:158);
x0_phase4 = [0.874624; 0.271757; 0; 0.00244247];

A_phase4_slope1 = [.999 0 0 0;
            .001 .999984 0 0;
```

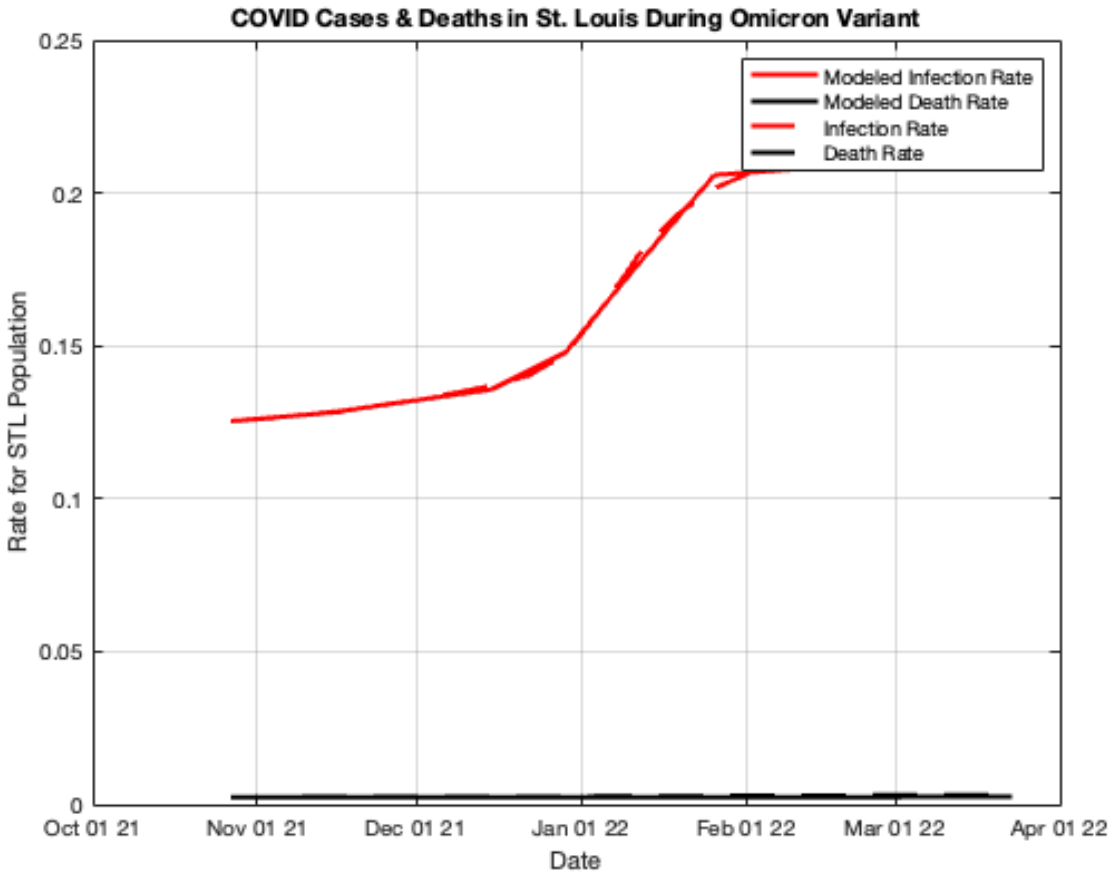
```
            0 0 1 0;
            0 .000016 0 1];


sys_slope1 = ss(A_phase4_slope1, [], [], [], 1);
[Y1, T1, X1] = lsim(sys_slope1, [], 0:phase4-1, x0_phase4);


plot(selected_dates_phase4a, X1(:,2), 'r', 'LineWidth', 2);
hold on;
plot(selected_dates_phase4a, X1(:,4), 'k', 'LineWidth', 2);


title('COVID Cases & Deaths in St. Louis After Omicron Variant');
xlabel('Date');
ylabel('Rate for STL Population');
legend('Modeled Infection Rate', 'Modeled Death Rate', 'Infection
 Rate', 'Death Rate');
grid on;
datetick('x', 'mmm dd yy', 'keepticks');
hold off;




%%WHAT IF SCENARIO (25% CASE REDUCTION IN CASES & DEATHS DURING OMICRON
%%WAVE)

figure;
selected_dates_phase5 = dates(85:106);
phase5 = 22;
plot(selected_dates_phase5, normalized_cases(85:106), '--r', 'LineWidth', 2);
hold on;
plot(selected_dates_phase5, normalized_deaths(85:106), '--k', 'LineWidth', 2);



%REAL DATA FOR END OF OMICRON HAS 0.21 (POPULATION FRACTION/NORMALIZED VALUE)
%INFECTED AND 0.0031(POPULATION FRACTION/NORMALIZED VALUE) DEAD. WE MUST
%REDUCE BOTH BY 25% (SO MULTIPLY THESE VALUES BY .75) AND THAT IS WHERE END
%VALUES WILL BE.

EndVal_of_Infected = 0.213465;
EndVal_of_Dead = 0.00313678;

%REDUCE 25%;

WhatIf_Infected = 0.75 * EndVal_of_Infected;
WhatIf_Dead = 0.75 * EndVal_of_Dead;
```

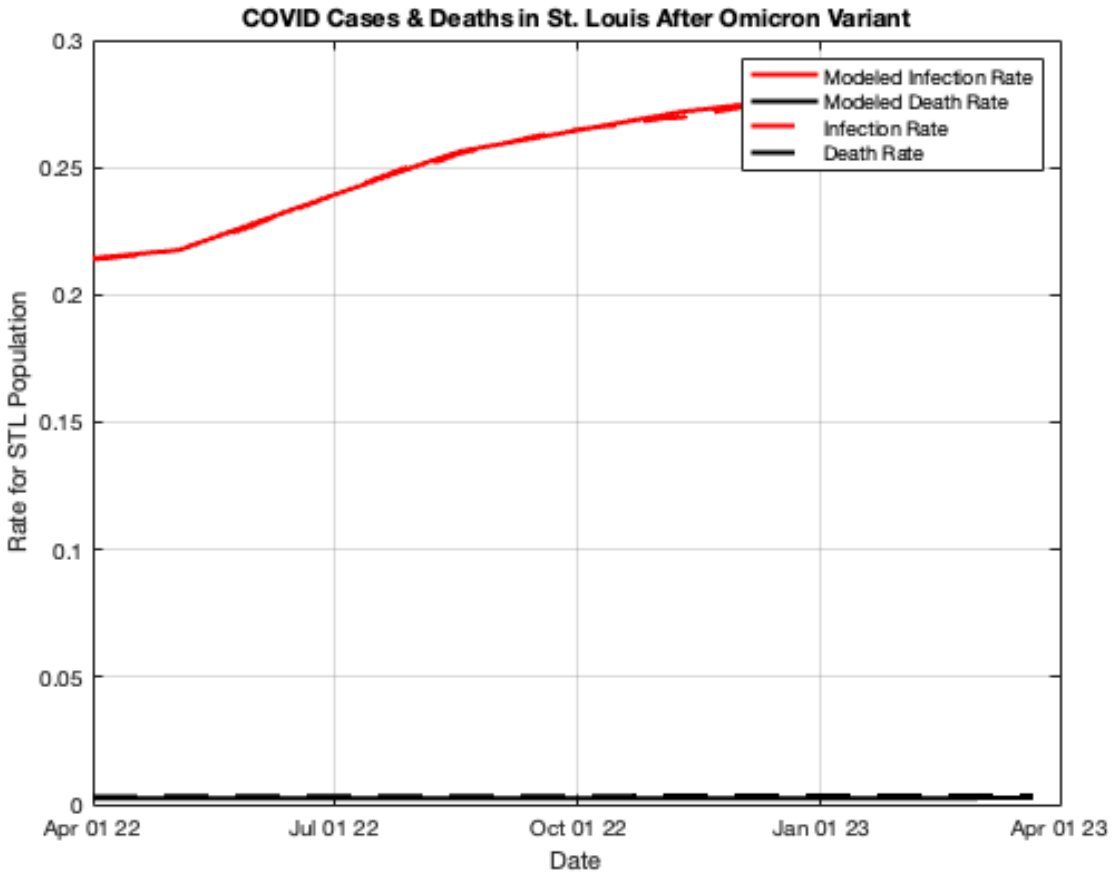
```
format = 'What if Value for Infected (where the tuned model will end) is %8.3f
 \n';
fprintf(format,WhatIf_Infected);


format = 'What if Value for Dead (where the tuned model will end) is %8.3f
 \n';
fprintf(format,WhatIf_Dead);


x0_phase5 = [0.874624; 0.125376; 0; 0.00244247];

A_phase5_slope1 = [.99815 0 0 0;
            .00195 .99999999 0 0;
            0 0 1 0;
            0 .00000001 0 1];


sys_slope1 = ss(A_phase5_slope1, [], [], [], 1);
[Y1, T1, X1] = lsim(sys_slope1, [], 0:phase5-1, x0_phase5);
plot(selected_dates_phase5, X1(:,2), 'r', 'LineWidth', 2);
plot(selected_dates_phase5, X1(:,4), 'k', 'LineWidth', 2);



title('COVID Cases & Deaths in St. Louis What If Scenario');
xlabel('Date');
ylabel('Rate for STL Population');
legend('Actual Data for Case Rate', 'Actual Data for Death Rate', '"What If"
 Infected" Rate', '"What If" Deceased Rate');
grid on;
datetick('x', 'mmm dd yy', 'keepticks');
hold off;
```

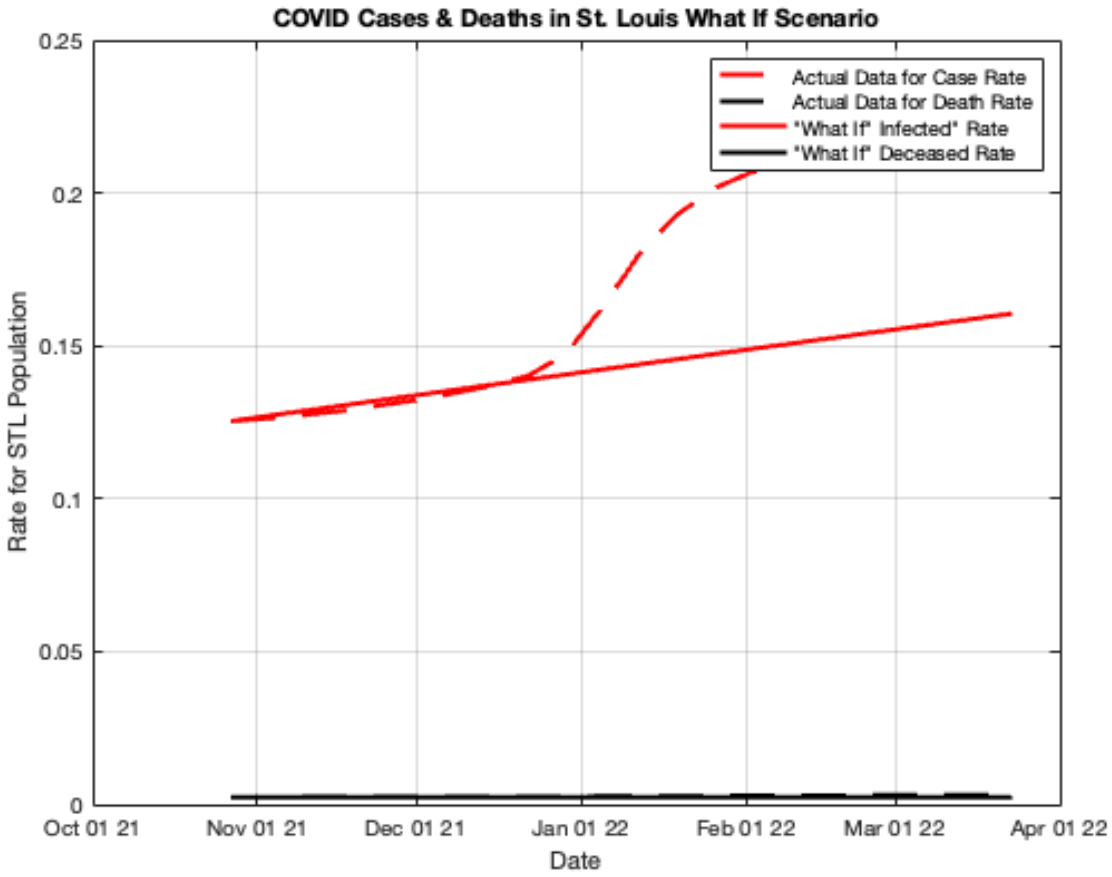
```
What if Value for Infected (where the tuned model will end) is    0.160
What if Value for Dead (where the tuned model will end) is    0.002
```


COVID Cases & Deaths in St. Louis Before Any Variant
Infection Rate
Death Rate
Modeled Infection Rate
Modeled Death Rate
Rate for STL Population
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
Jan 01 20
Apr 01 20
Jul 01 20
Oct 01 20
Jan 01 21
Apr 01 21
Jul 01 21
Date


COVID Cases & Deaths in St. Louis During Delta Variant
Modeled Infection Rate
Modeled Death Rate
Infection Rate
Death Rate
Rate for STL Population
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
Jun 01 21
Jul 01 21
Aug 01 21
Sep 01 21
Oct 01 21
Nov 01 21
Date


COVID Cases & Deaths in St. Louis During Omicron Variant
Modeled Infection Rate
Modeled Death Rate
Infection Rate
Death Rate
Rate for STL Population
0.25
0.2
0.15
0.1
0.05
0
Oct 01 21
Nov 01 21
Dec 01 21
Jan 01 22
Feb 01 22
Mar 01 22
Apr 01 22
Date


COVID Cases & Deaths in St. Louis After Omicron Variant
Modeled Infection Rate
Modeled Death Rate
Infection Rate
Death Rate
Rate for STL Population
0.3
0.25
0.2
0.15
0.1
0.05
0
Apr 01 22
Jul 01 22
Oct 01 22
Jan 01 23
Apr 01 23
Date



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