Table of Contents


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% Assignment title: APPM 2360 Project 2
% Creation date: 10/26/2023

%Purpose: Analyze probability and susceptibility to disease using Markov
%chains.
% S = susceptible
% E = exposed
% I = infected
% R = Recovered
% Im = immune
% V = vaccinated

clear, clc, close all
```

Task A

```
%Initial probabilities for task set A
Ps = 0.7;
Pe = 0.4;
Pi = 1;
Pr = 0.8;

%P matrix
%         S     E            I   R
P_SEIR = [Ps,   Pe,          0,  1-Pr; %S
          1-Ps, 0,           0,  0;    %E
          0,    0.5*(1-Pe), 0,  0;    %I
          0,    0.5*(1-Pe), Pi, Pr];  %R


%Initial state for problem A3
S = [0; 1; 0; 0];

%Probability for Problem A3
A3 = Markov(P_SEIR,S,1);

% Initial state for problem A4
S = [1; 0; 0; 0];

% Probability for Problem A4
```

```
A4 = Markov(P_SEIR,S,5);
```

Task B

```
%Initial state
S1 = [1; 0; 0; 0];

%time vector for all the days being calculated
interval = 1:31;

%Plotting results for the time interval and initial state
x_b1 = PlotPls(P_SEIR,S1,interval);
x_finalb1 = x_b1(:,end);

%Second initial state, B2.
S2=[.15;.85;0;0];
x_b2 = PlotPls(P_SEIR,S2,interval);
x_finalb2 = x_b2(:,end);

%Calculating the stationary distribution using a function
x_inf = StationaryDistribution(P_SEIR,S2);

% Comparing the probabilities for 2 different initial states 1-10
% iterations
compare_interval = 1:10;
compare_steps(x_b1,x_b2,compare_interval,3);

%Calculating the error between the limit and the actual solution
err = abs_error(x_inf,x_b2,interval);

% B5

%Same process, now with an immune state
Pim = 0.5;
%.          S.    E.          I.     R.    Im
P_SEIRIm = [Ps,   Pe,         0,     0.5*(1-Pr), 0;  %S
            1-Ps, 0,          0,     0,    0;  %E
            0,    0.5*(1-Pe), 0,     0,    0;  %I
            0,    0.5*(1-Pe), Pi, Pr,   0;  %R
            0,    0,          0,   0.5*(1-Pr),    1]; %Im

%Initial state, time interval
S3 = [1; 0; 0; 0; 0];
interval2 = 1:250;

%Plotting and calculating the matrix of SEIR values
x_B5 = PlotPls(P_SEIRIm,S3,interval2);
```

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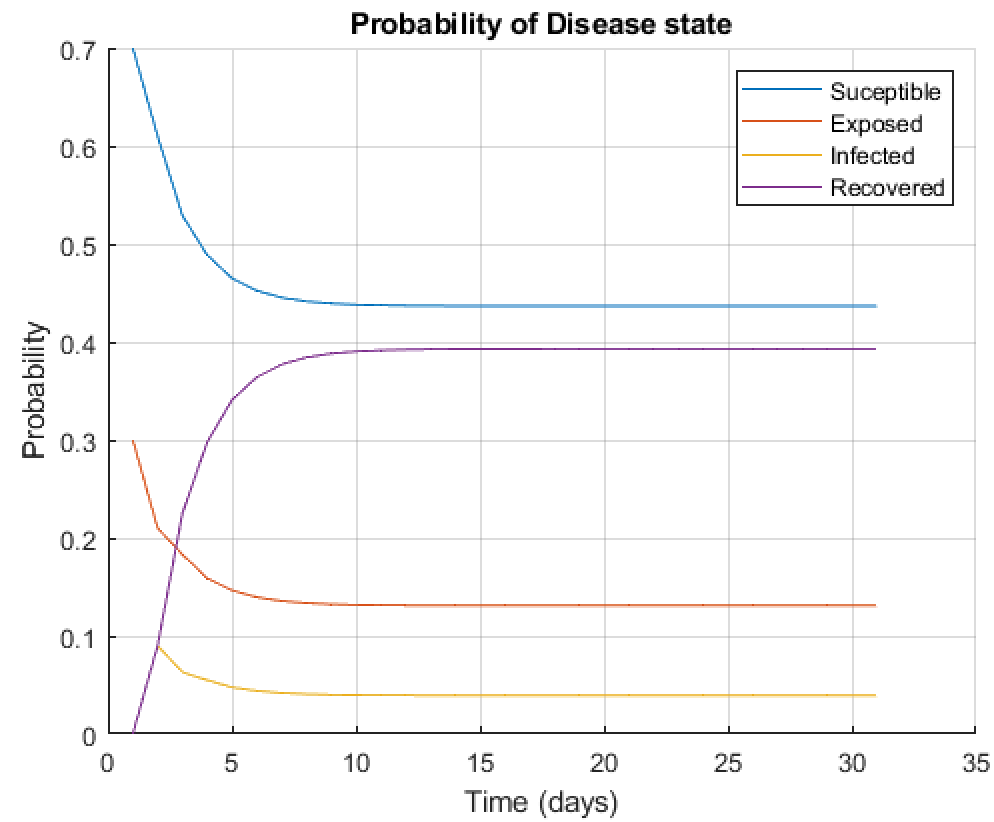
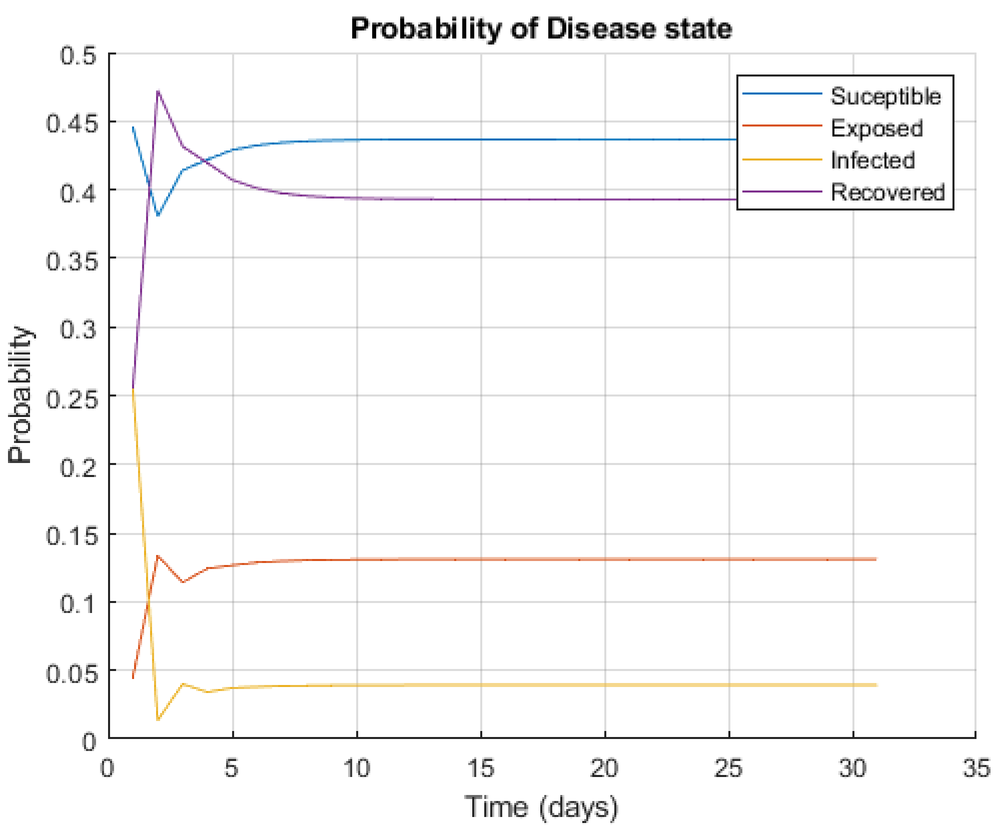
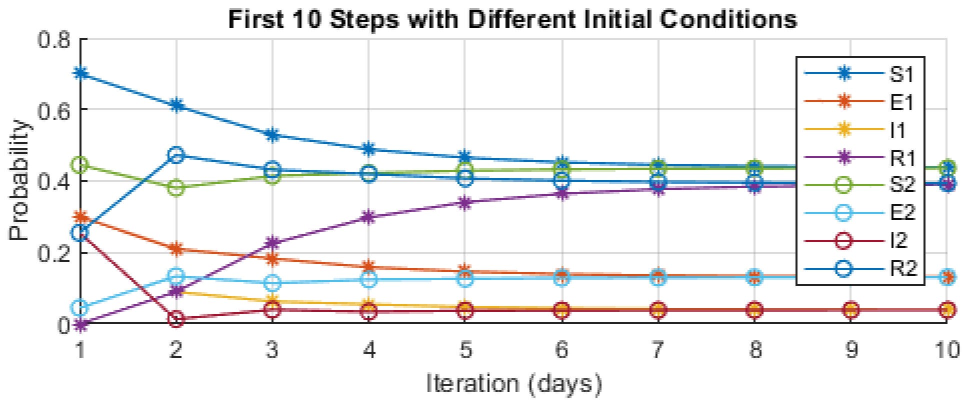
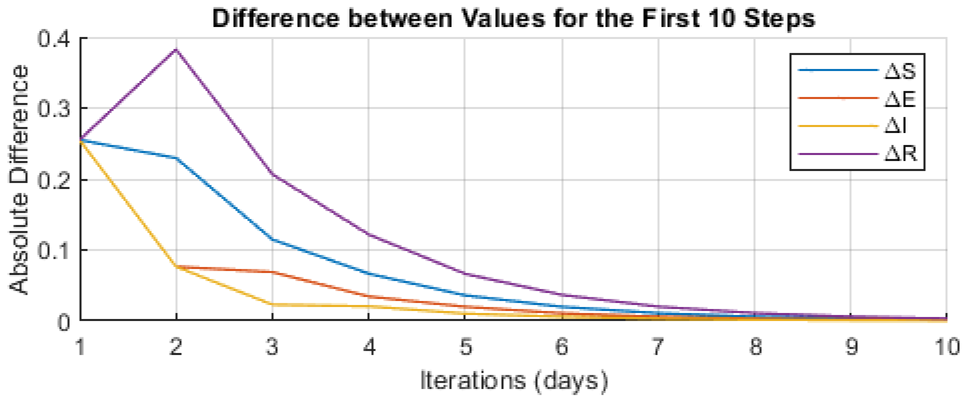
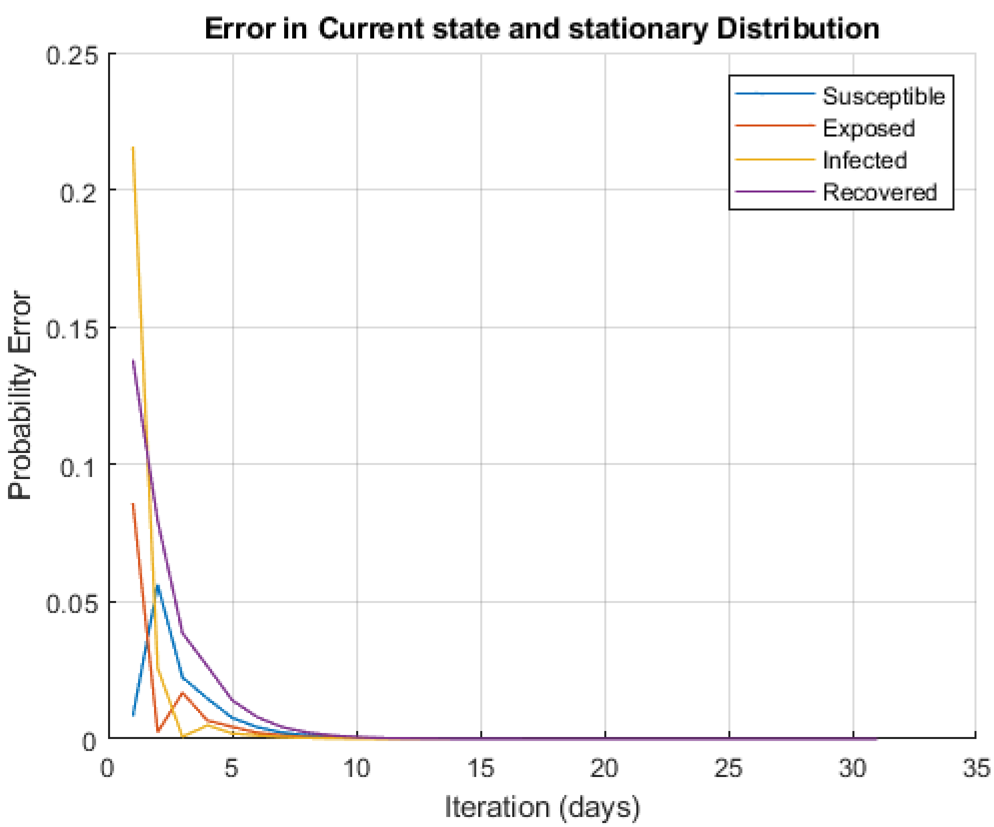
Warning: Ignoring extra legend entries.

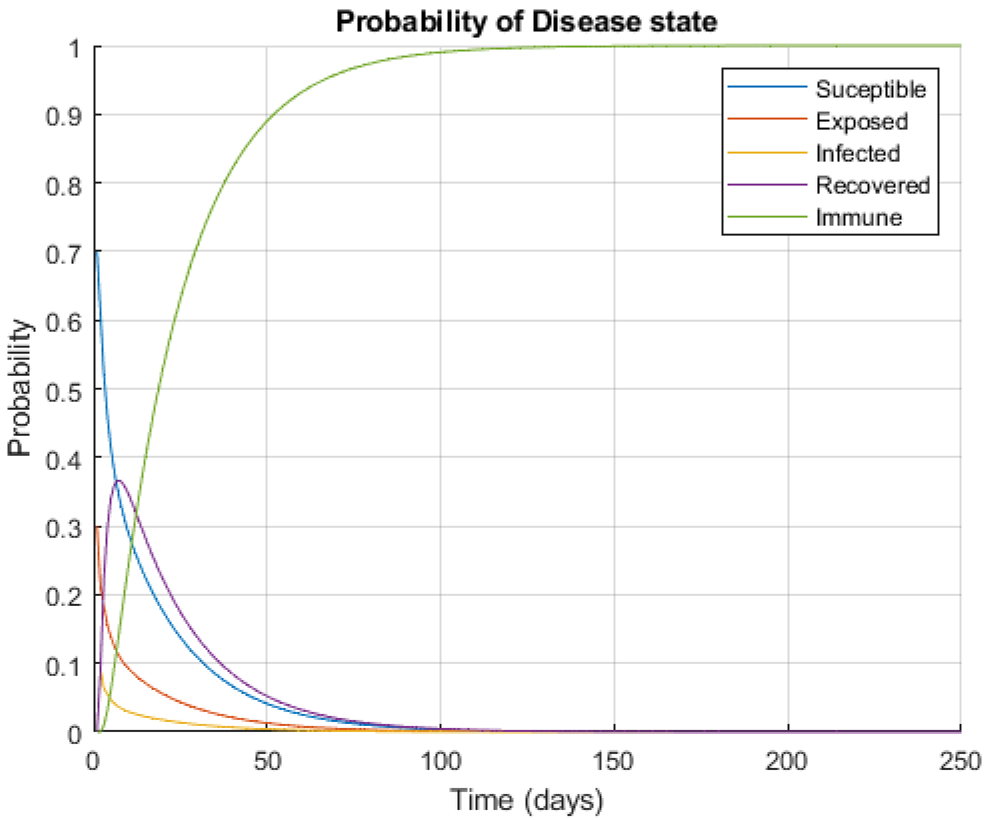

Probability of Disease state
Suceptible
Exposed
Infected
Recovered
Probability
Time (days)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0
5
10
15
20
25
30
35


Probability of Disease state
Suceptible
Exposed
Infected
Recovered
Probability
Time (days)
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5
0
5
10
15
20
25
30
35


First 10 Steps with Different Initial Conditions
Probability
Iteration (days)
S1
E1
I1
R1
S2
E2
I2
R2


Difference between Values for the First 10 Steps
Absolute Difference
Iterations (days)
ΔS
ΔE
ΔI
ΔR


Error in Current state and stationary Distribution
Probability Error
Iteration (days)
Susceptible
Exposed
Infected
Recovered



Task C

```
Pv = 0.25;
%.            S.     E.          I.      R.     Im.    V
P_SEIRVIm = [Ps,   0,          0,      1-Pr,  0,     0;    %S
             1-Ps, 0,          0,      0,     0,     0;    %E
             0,    0.5,        0,      0,     0,     0;    %I
             0,    0.5,        Pi,     Pr,    0,     0;    %R
             0,    0,          0,      0,     1,     1-Pv; %Im
             0,    0,          0,      0,     0,     Pv];  %V


%Initial state S4
S4 = [1 ;0; 0; 0; 0; 0];

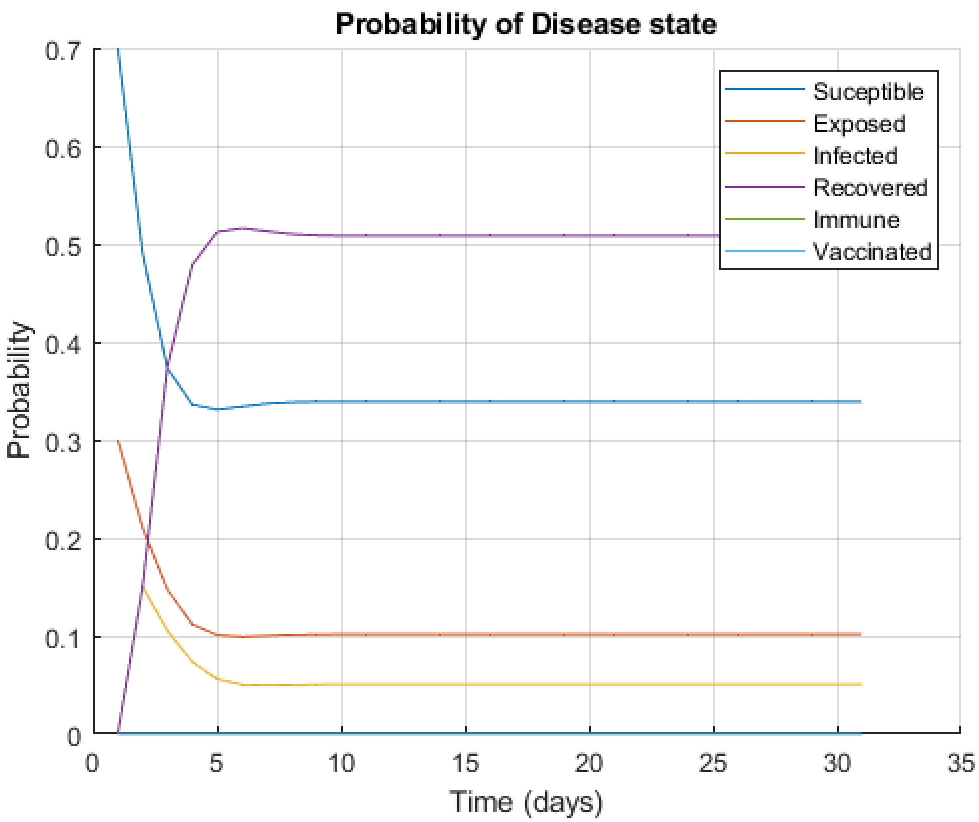
%Calculating the probabilites with interval states, for S4 initial
x_c1 = PlotPls(P_SEIRVIm,S4,interval);

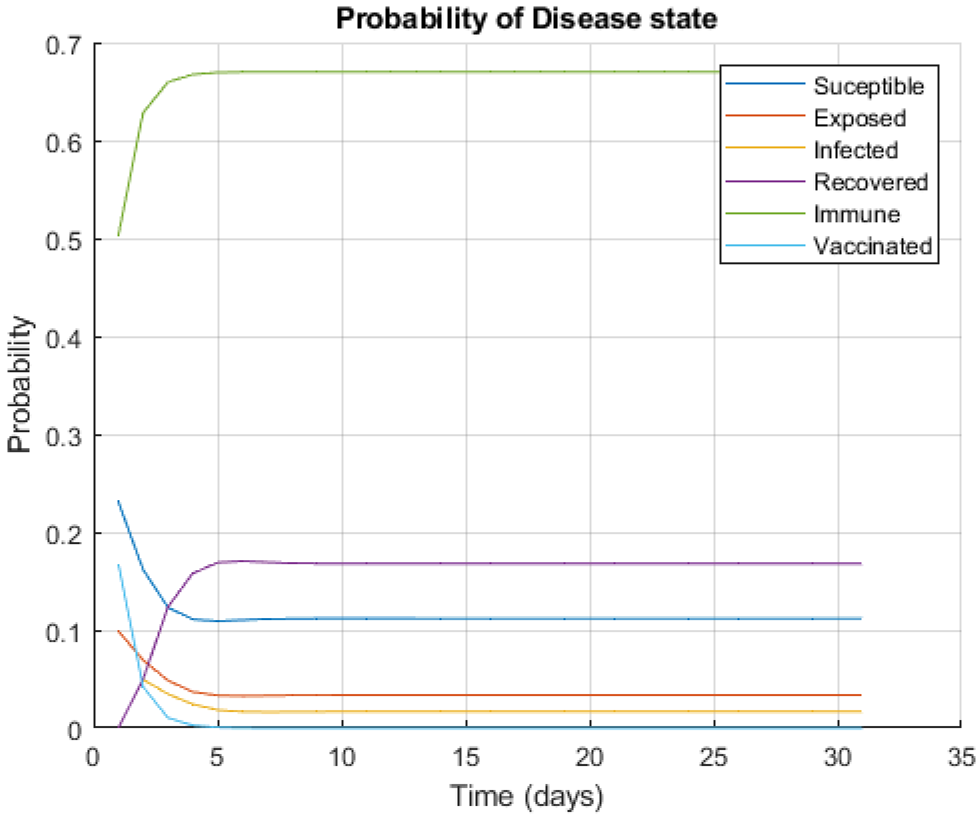
%Calculating the stationary distribution of the P_SEIRVIm matrix
x_inf_C1 = StationaryDistribution(P_SEIRVIm,S4);

%Initial state S5
S5 = [.33; 0; 0; 0; 0; 0.67];
```

```
%Calculating probabilities with interval states, for S5 initial
x_C2 = PlotPls(P_SEIRVIm,S5,interval);

%Calculating the stationary distribution of the P_SEIRVIm matrix with S5
x_inf_C2 = StationaryDistribution(P_SEIRVIm,S5);
```





Displaying Values

```
fprintf('A3: Probability with S1, 1 iteration = %f\n',A3);
disp(' ');
% disp(A3);
%disp(A4(4));
fprintf('A4: Probability of Recovered after 5 steps = %f\n',A4(4));
disp(' ');
fprintf('B1: Approximate Stationary Distribution: %f\n',x_finalb1);
disp(' ');
fprintf('B2: Approximate Stationary Distribution: %f\n',x_finalb2);
disp(' ');
fprintf('B4: Actual Stationary Distribution: %f\n',x_inf);
disp(' ');
fprintf('C1: Stationary Distribution: %f\n',x_inf_C1);
disp(' ');
fprintf('C1: Stationary Distribution: %f\n',x_inf_C2);
```

```
A3: Probability with S1, 1 iteration = 0.400000
A3: Probability with S1, 1 iteration = 0.000000
A3: Probability with S1, 1 iteration = 0.300000
A3: Probability with S1, 1 iteration = 0.300000

A4: Probability of Recovered after 5 steps = 0.340830

B1: Approximate Stationary Distribution: 0.436681
```

```
B1: Approximate Stationary Distribution: 0.131004
B1: Approximate Stationary Distribution: 0.039301
B1: Approximate Stationary Distribution: 0.393013

B2: Approximate Stationary Distribution: 0.436681
B2: Approximate Stationary Distribution: 0.131004
B2: Approximate Stationary Distribution: 0.039301
B2: Approximate Stationary Distribution: 0.393013

B4: Actual Stationary Distribution: 0.436681
B4: Actual Stationary Distribution: 0.131004
B4: Actual Stationary Distribution: 0.039301
B4: Actual Stationary Distribution: 0.393013

C1: Stationary Distribution: 0.000000
C1: Stationary Distribution: 0.000000
C1: Stationary Distribution: 0.000000
C1: Stationary Distribution: 0.000000
C1: Stationary Distribution: 0.000000
C1: Stationary Distribution: 0.000000

C1: Stationary Distribution: 0.000000
C1: Stationary Distribution: 0.000000
C1: Stationary Distribution: 0.000000
C1: Stationary Distribution: 0.000000
C1: Stationary Distribution: 0.000000
C1: Stationary Distribution: 0.000000
```

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