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```
clear all; clc; close all;
```

Task set A

2.1

2.1.2

```
P = [0.7, 0.4, 0,   0.2;   % Row 1: Next state = S
     0.3, 0,   0,   0;     % Row 2: Next state = E
     0,   0.3, 0,   0;     % Row 3: Next state = I
     0,   0.3, 1.0, 0.8];  % Row 4: Next state = R
```

2.1.3

Present state vector

```
x = [0, 1, 0 ,0]';

% Next state vector
x_next = P * x;

% Display the result
disp('2.1.3');
disp(x_next);
```

```
2.1.3
    0.4000
         0
    0.3000
    0.3000
```

2.1.4

```
clear x, x_next;

% Present state vector
x = [1, 0, 0, 0]';

% 5 steps state vector
x_next = P^5 * x;

% Display the result
disp('2.1.4');
disp(x_next);
```

```
2.1.4
    0.4650
    0.1465
    0.0476
    0.3408
```

Task set B

```
clear x, x_next;
```

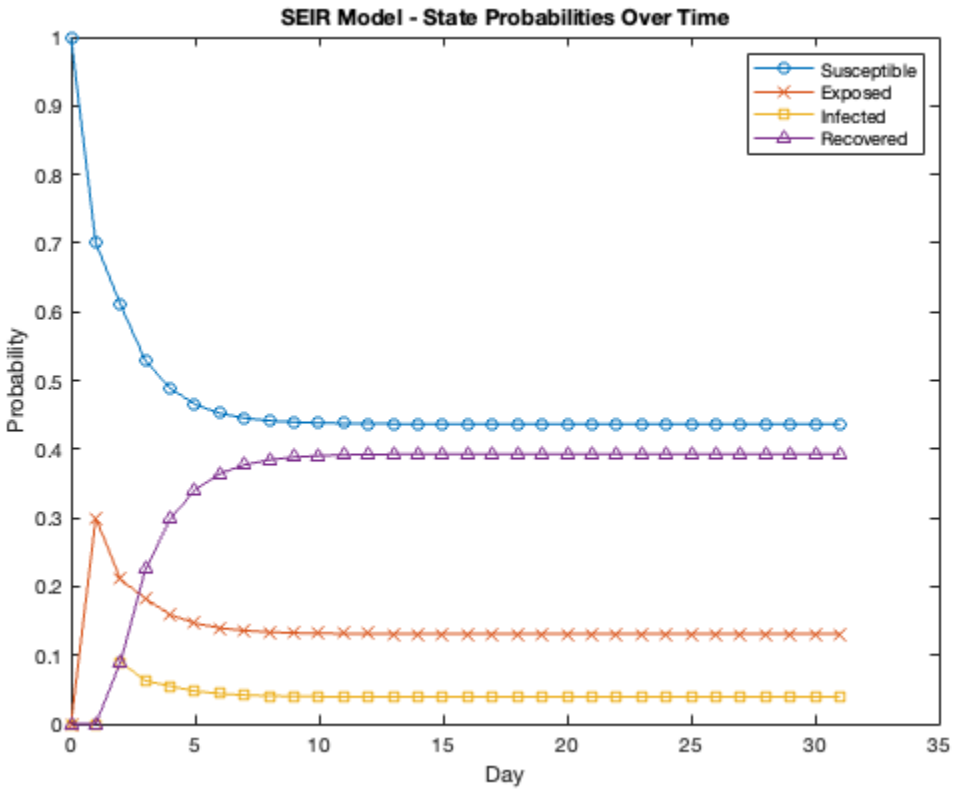
3.1.1.a

```
x = zeros(4, 32);
x(:,1) = [1; 0; 0; 0];

for n = 2:32
    x(:,n) = P * x(:,n-1);
    x(:,n) = x(:,n) / norm(x(:,n), 1);  % normalize
end

% Graph making
figure (1);
days = 0:31;

plot(days, x(1,:), '-o', days, x(2,:), '-x', days, x(3,:), '-s', days,
x(4,:), '-^');
legend('Susceptible', 'Exposed', 'Infected', 'Recovered');
xlabel('Day');
ylabel('Probability');
title('SEIR Model - State Probabilities Over Time');
```



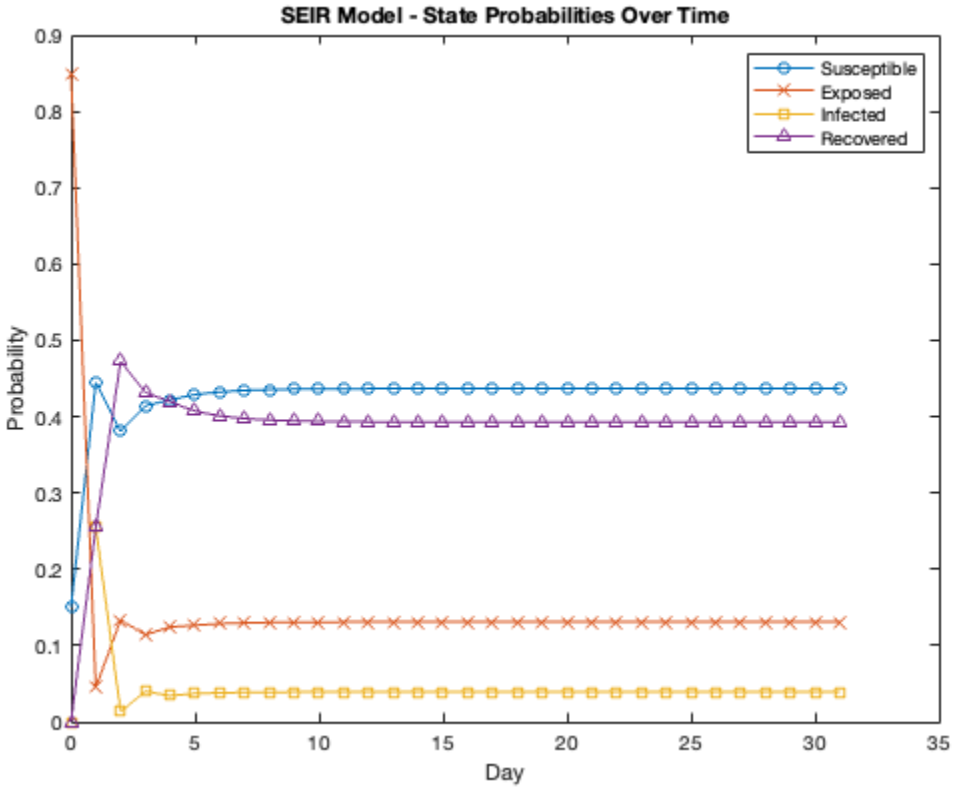
3.1.2.a

```
y = zeros(4, 32);
y(:,1) = [0.15; 0.85; 0; 0];

for n = 2:32
    y(:,n) = P * y(:,n-1);
    y(:,n) = y(:,n) / norm(y(:,n), 1);  % normalize
end

% Graph making
figure (2);

plot(days, y(1,:), '-o', days, y(2,:), '-x', days, y(3,:), '-s', days,
y(4,:), '-^');
legend('Susceptible', 'Exposed', 'Infected', 'Recovered');
xlabel('Day');
ylabel('Probability');
title('SEIR Model - State Probabilities Over Time');
```



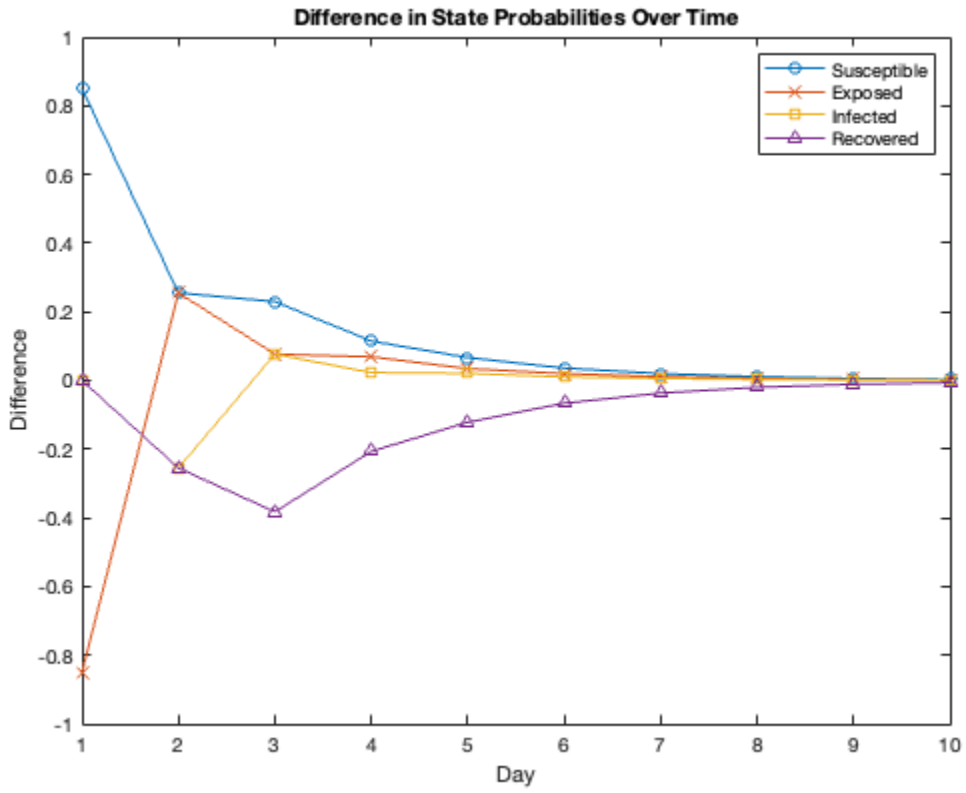
3.1.3

Calculate the difference in the first 10 steps, then graph

```
for n = 1:10
    diff(:,n) = x(:,n) - y(:,n);
end

figure (3);

plot(1:10, diff(1,:), '-o', 1:10, diff(2,:), '-x', 1:10, diff(3,:), '-s',
1:10, diff(4,:), '-^');
legend('Susceptible', 'Exposed', 'Infected', 'Recovered');
xlabel('Day');
ylabel('Difference');
title('Difference in State Probabilities Over Time');
```



3.4.a

```
[V, D] = eig(P);
c = V \ x(:,1);

% Display the result
disp('3.4.a');
disp(D);
disp(V);
disp(c);
```

```
3.4.a
   -0.2075         0         0         0
         0    0.1579         0         0
         0         0    1.0000         0
         0         0         0    0.5496

   -0.3136   -0.1291    0.7239   -0.4571
    0.4534   -0.2452    0.2172   -0.2495
   -0.6557   -0.4660    0.0652   -0.1362
    0.5158    0.8403    0.6515    0.8428

   -0.4141
    1.0291
    0.6032
```

-1.2389

3.4.d

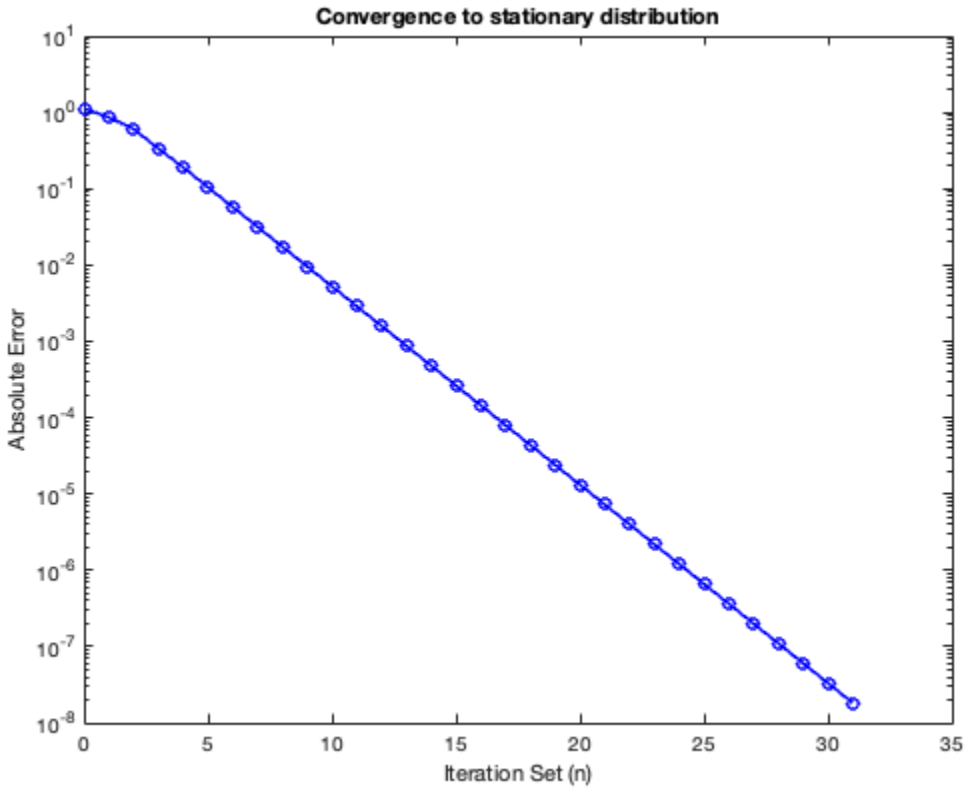
```
lambda = diag(D);
index = 3;
x_stationary = V(:,index);
x_stationary = x_stationary / norm(x_stationary, 1);

% Display the result
errors = zeros(1, 32);

for n = 1:32
    errors(n) = norm(x_stationary - x(:,n), 1);
end

% Graph making
figure (4);
semilogy(0:31, errors, 'b-o', 'LineWidth', 1.5);
xlabel('Iteration Set (n)');
ylabel('Absolute Error');
title('Convergence to stationary distribution');

% Shows us that the convergence is exponential (linear, but on a log scale)
```



3.5.b

```
Pnew = [0.7, 0.4, 0,   0.1, 0;   % Row 1: Next state = S
        0.3, 0,   0,   0,   0;     % Row 2: Next state = E
        0,   0.3, 0,   0,   0;     % Row 3: Next state = I
        0,   0.3, 1.0, 0.8, 0;  % Row 4: Next state = R
        0,   0,   0,   0.1,   1];  % Row 5: Next state = Im
```

3.5.c

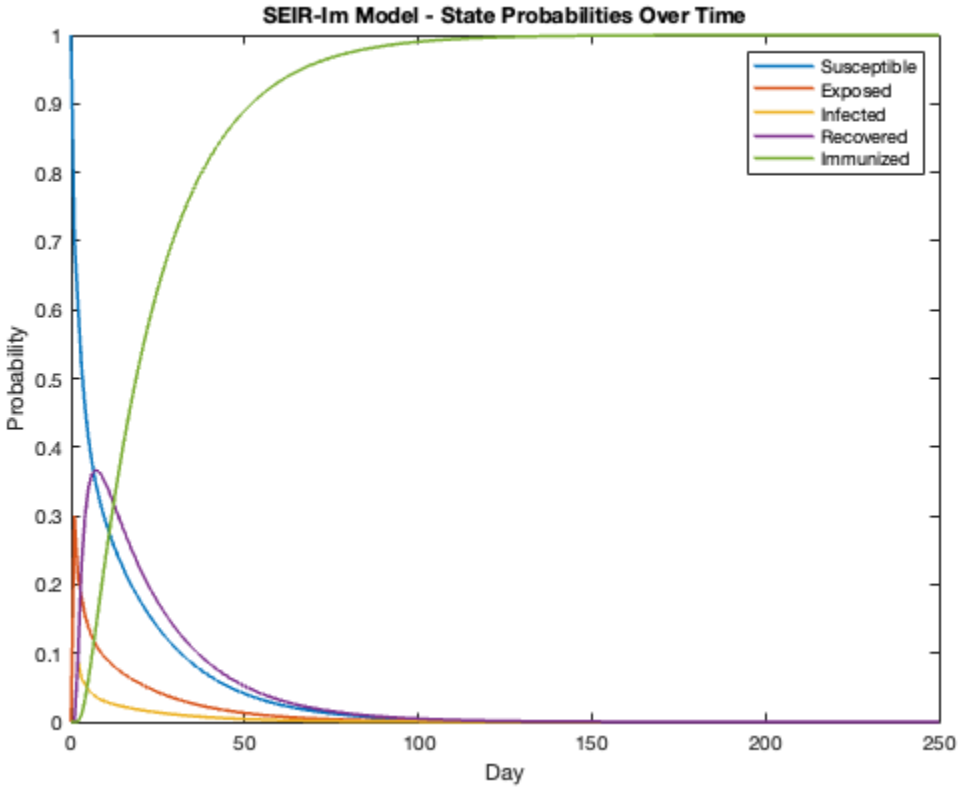
```
x = zeros(5, 251);
x(:,1) = [1; 0; 0; 0; 0];

for n = 2:251
    x(:,n) = Pnew * x(:,n-1);
    x(:,n) = x(:,n) / norm(x(:,n), 1);  % normalize
end

% Graph making
figure (5);
days = 0:250;

plot(days, x(1,:), '-', days, x(2,:), '-', days, x(3,:), '-', days, x(4,:),
'-', days, x(5,:), '-', 'LineWidth', 1.5);
legend('Susceptible', 'Exposed', 'Infected', 'Recovered', 'Immunized');
xlabel('Day');
ylabel('Probability');
title('SEIR-Im Model - State Probabilities Over Time');

% Well ofc its different... its a new model!
```



Task Set C

```
clear all;
```

4.1.1

```
P = [
    0.7, 0,   0,  0.2, 0,    0;   % S
    0.3, 0,   0,  0,   0,    0;   % E
    0,   0.5, 0,  0,   0,    0;   % I
    0,   0.5, 1,  0.8, 0,    0;   % R
    0,   0,   0,  0,   0.25, 0;   % V
    0,   0,   0,  0,   0.75, 1.0  % Im
];
```

4.1.2

```
disp('4.1.2');
[V, D] = eig(P);
eigenvalues = real(D);  % Get only the real parts

disp(eigenvalues);
% Multiplicty is 2 for lambda = 1
```

```
4.1.2
   -0.1714         0         0         0         0         0
         0    0.3357         0         0         0         0
         0         0    0.3357         0         0         0
         0         0         0    1.0000         0         0
         0         0         0         0    1.0000         0
         0         0         0         0         0    0.2500
```

4.1.3

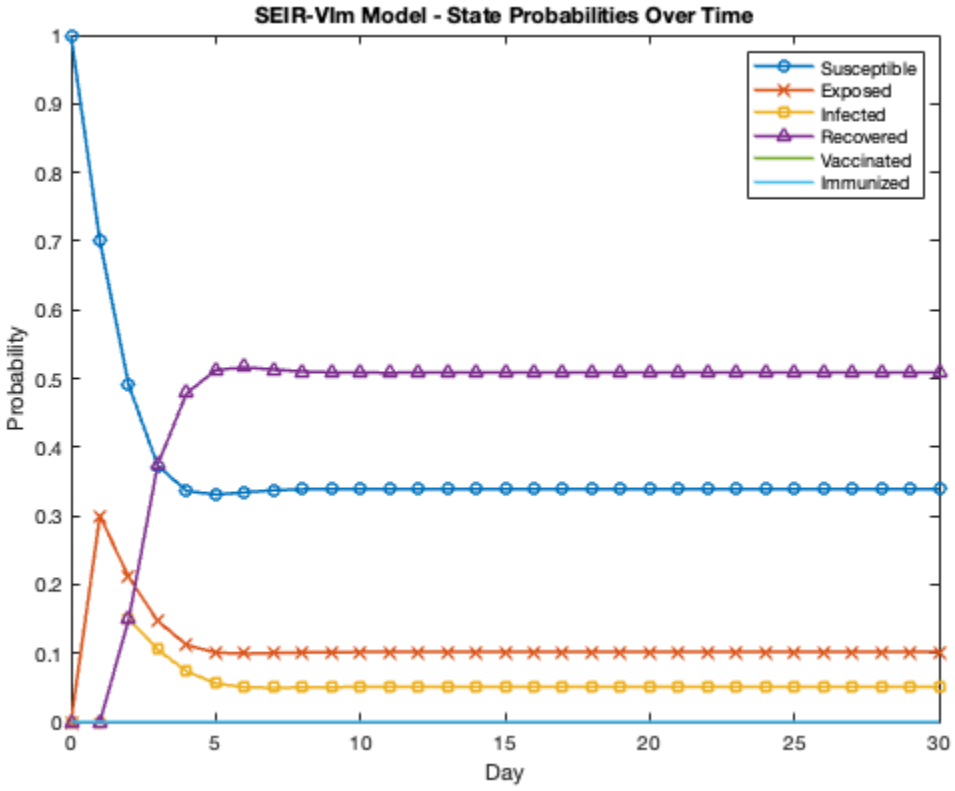
```
x = zeros(6, 31);
x(:,1) = [1; 0; 0; 0; 0; 0]';

for n = 2:31
    x(:,n) = P * x(:,n-1);
    x(:,n) = x(:,n) / norm(x(:,n), 1);  % normalize
end

% Graph making
figure (6);
days = 0:30;

plot(days, x(1,:), '-o', days, x(2,:), '-x', days, x(3,:), '-s', days,
x(4,:), '-^', days, x(5,:), '-', days, x(6,:), '-', 'LineWidth', 1.5);
legend('Susceptible', 'Exposed', 'Infected', 'Recovered', 'Vaccinated',
'Immunized');
xlabel('Day');
ylabel('Probability');
title('SEIR-VIm Model - State Probabilities Over Time');

% Exact same distribution as if there was no vaccination / immune state
```



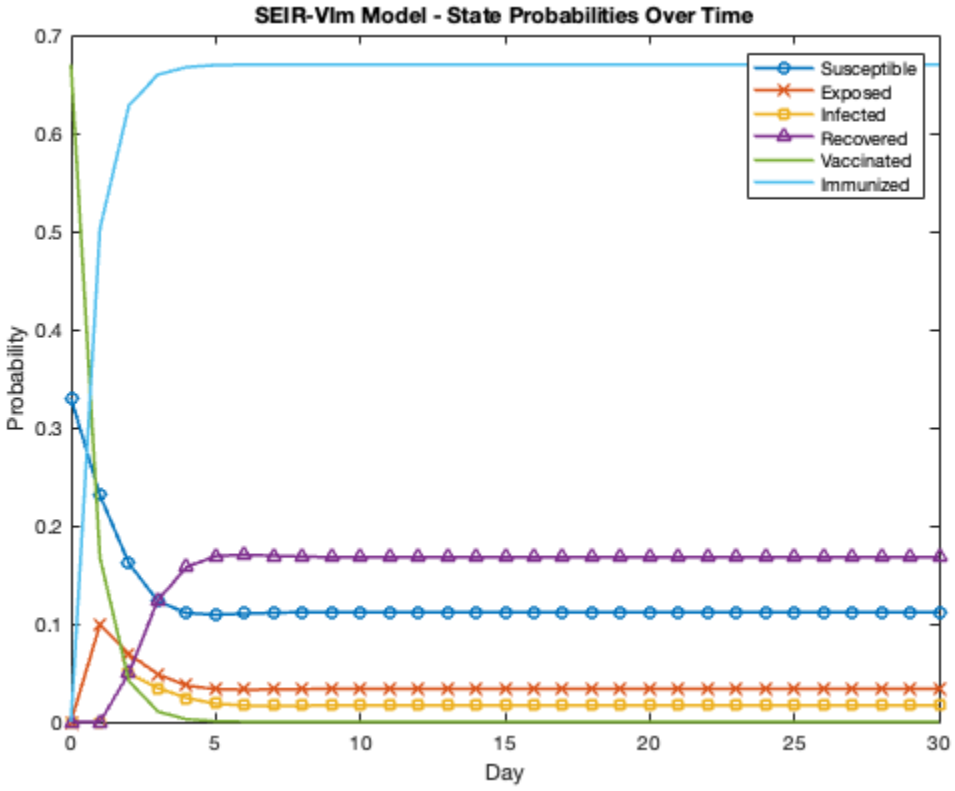
4.1.4

```
x = zeros(6, 31);
x(:,1) = [.33; 0; 0; 0; .67; 0]';

for n = 2:31
    x(:,n) = P * x(:,n-1);
    x(:,n) = x(:,n) / norm(x(:,n), 1);  % normalize
end

% Graphe making
figure (7);

plot(days, x(1,:), '-o', days, x(2,:), '-x', days, x(3,:), '-s', days,
x(4,:), '-^', days, x(5,:), '-', days, x(6,:), '-', 'LineWidth', 1.5);
legend('Susceptible', 'Exposed', 'Infected', 'Recovered', 'Vaccinated',
'Immunized');
xlabel('Day');
ylabel('Probability');
title('SEIR-VIm Model - State Probabilities Over Time');
```



Saving the Figures

numFigures = 7; for i = 1:numFigures fig = figure(i); % pause(5) print(fig, sprintf('/Users/rowdyer/Documents/Coding/APPM2360_Project_2/Figures/figure%d', i), '-dpng', '-r1000'); end

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