

# 22S-CSB150-EEB159 Lab5

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TOTAL POINTS

85 / 100

QUESTION 1

1 Ex.1 15 / 25

- 0 pts Correct

✓ - 5 pts Correctly complete code:

```matlab

```
pars.beta = pars.c * pars.p;  
pars.R0 = pars.beta / pars.gamma;  
```
```

✓ - 3 pts Correctly estimate  $\$R_0\$$  - you need to calculate and show this value

$$\$R_0 = \frac{\beta}{\gamma}$$

- 5 pts Correctly identify whether diseases spread or not

- 5 pts Correctly plot #1

- 5 pts Correctly plot #2

- 3 pts Plot aesthetics (graph/axes titles)

✓ - 2 pts Reasoning - diseases spread if  $\$R_0 > 1\$$

QUESTION 2

2 Ex.2 25 / 25

✓ - 0 pts Correct

- 3 pts Plot aesthetics (graph/axes titles)

- 8 pts Correct estimated speed values

```matlab

```
r = pars.gamma * (pars.R0 - 1)
```

```

- 8 pts Correct strength values

- 9 pts 4 correct plots

- 4 pts 2 correct plots

QUESTION 3

3 Ex.3 20 / 25

- 0 pts Correct

- 10 pts Correctly plot SIR model

- 10 pts Correctly plot SI model

✓ - 5 pts Compare plots - you need to talk about  $\$R_0\$$  and the proportion of the population that are susceptible, infectious, and recovered

- 3 pts Plot aesthetics (graph/axes titles)

QUESTION 4

4 Ex.4 25 / 25

✓ - 0 pts Has not been covered completely in lecture

- automatic full credit

- 3 pts Plot aesthetics (graph/axes titles)

- 8 pts Correctly complete code for the 2 rates

```matlab

% Rates

```
infrate = pars.beta*ycur(1)*ycur(2)/pars.N; % can also use y(ind,1)*y(ind,2)
```

```
recrate = pars.gamma*ycur(2); % can also use y(ind,2)
```

```

- 12 pts Correctly complete 4 event type code

```matlab

% Event type

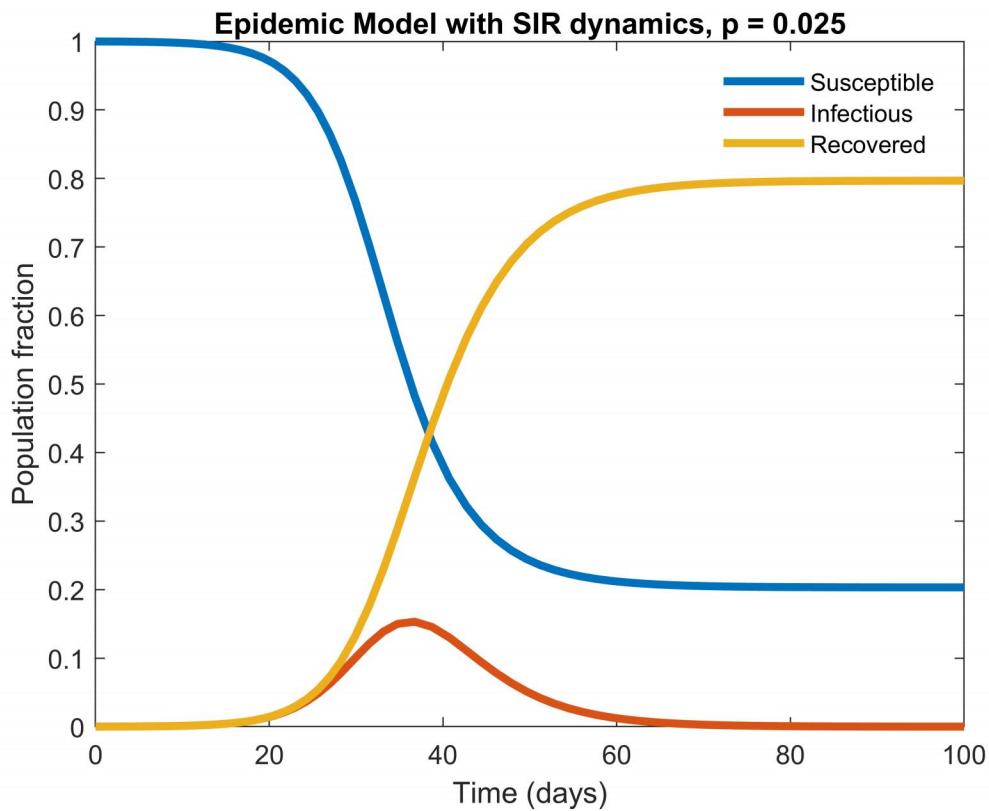
```
if (rand<(infrate/totrate)) % infection  
    ycur(1)=ycur(1)-1;  
    ycur(2)=ycur(2)+1;  
else % recovery  
    ycur(2)=ycur(2)-1;  
    ycur(3)=ycur(3)+1;  
end  
```
```

**- 5 pts** Correctly plot

```

% main data goes here
pars.c = 20; % Contacts per unit time (e.g., days)
pars.p = 0.025; % Probability of infectious contact
pars.beta = pars.c*pars.p ;% Transmission rate
pars.gamma = 1/4; % Recovery rate (days^-1)
pars.R0 = 60;
pars.N = 10000;
pars.I0= 1;
pars.S0= pars.N-pars.I0;
% Run the model
[t,y]=ode45(@(t,y) sir_model(t,y,pars),[0 100],[pars.S0 pars.I0 0]/pars.N);
% Plot the results
tmpfh=plot(t,y);
set(tmpfh,'linewidth',3);
xlabel('Time (days)');
ylabel('Population fraction');
title('Epidemic Model with SIR dynamics, p = 0.025');
tmph = legend('Susceptible','Infectious','Recovered');
legend('boxoff');

```



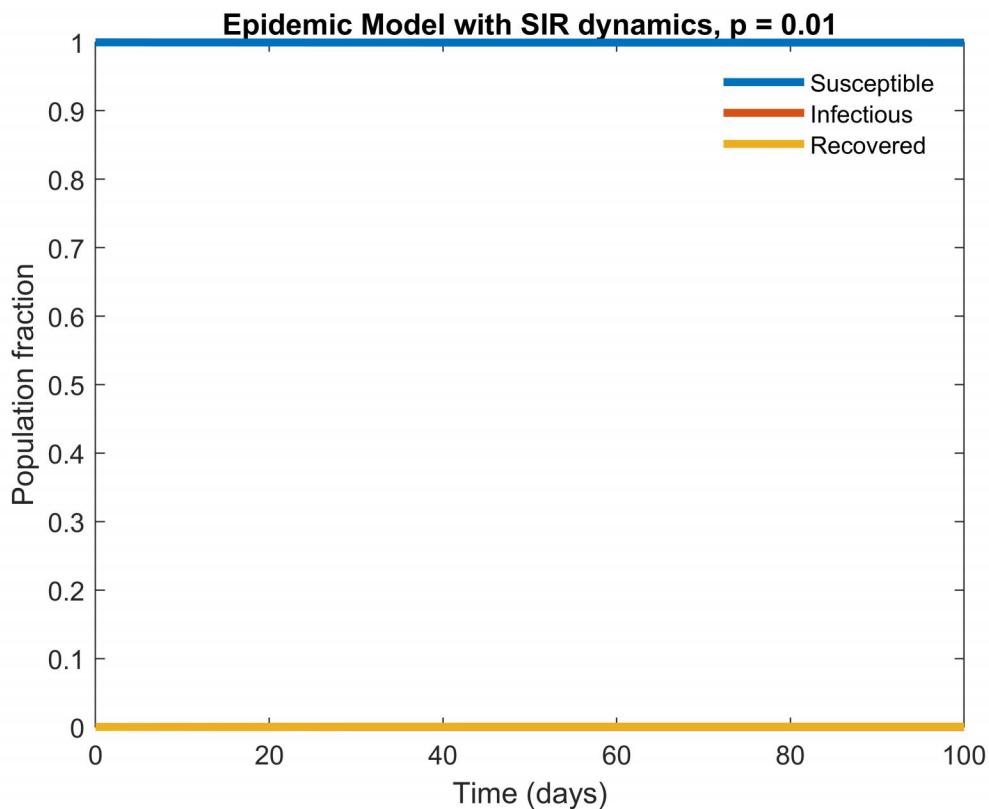
```

% Complete the simulation code below for the spread of an infectious disease beginning
% with 1 individual out of 10000 and estimate the value of R0. And run the code. Do you expect
% to spread or not? Then, change the value of p to 0.01 { will the disease spread, why or why not?
% two plots)

```

```
% answer: When there is only one individual out of 10000 who is infectious
% the respective R0 value was estimated to be 0. After running the code and after 100 days,
% the fraction of population who are susceptible are 30%, the fraction of
% population who are recovered are 80%, and the fraction of people are are
% infectious increased to 20% but eventually reaches a steady state of 0%.
% This signifies spreading of the disease, especially when susceptible
% rates start to drop, coordinating with a rise in infectious rates, and
% then more and more people being recovered.
% With these parameters, I expect the disease to spread.
```

```
% main data goes here
pars.c = 20; % Contacts per unit time (e.g., days)
pars.p = 0.01; % Probability of infectious contact
pars.beta = pars.c*pars.p ;% Transmission rate
pars.gamma = 1/4; % Recovery rate (days^-1)
pars.R0 = 60;
pars.N = 10000;
pars.I0= 1;
pars.S0= pars.N-pars.I0;
% Run the model
[t,y]=ode45(@(t,y) sir_model(t,y,pars),[0 100],[pars.S0 pars.I0 0]/pars.N);
% Plot the results
tmpf=plot(t,y);
set(tmpf,'linewidth',3);
xlabel('Time (days)');
ylabel('Population fraction');
title('Epidemic Model with SIR dynamics, p = 0.01');
tmplh = legend('Susceptible','Infectious','Recovered');
legend('boxoff');
```



```
%reset pars.p
pars.p = 0.025;
```

% The disease will not spread because we have decreased the probability of  
% infectious contact by  $0.025 - 0.01 / 0.025 = 0.6$  or 60%. This means that  
% less people are going to be infected upon the same number of contacts as  
% before. Looking at the epidemic model, the fraction of susceptible remains  
% at 1 and no one is getting infected, thus no one need to recover (0),  
% thereby the disease is not spreading.

## %Exercise 2

```
% main data goes here
pars.c = 20; % Contacts per unit time (e.g., days)
pars.p = 0.01; % Probability of infectious contact
pars.beta = 0.5;% Transmission rate
pars.gamma = 1/4; % Recovery rate (days^-1)
pars.R0 = 1.625;
pars.N = 10000;
pars.I0= 1;
pars.S0= pars.N-pars.I0;
```

```
% Run the model over 10 days
```

- 0 pts Correct

✓ - 5 pts Correctly complete code:

```
'''matlab
```

```
pars.beta = pars.c * pars.p;
```

```
pars.R0 = pars.beta / pars.gamma;
```

```
'''
```

✓ - 3 pts Correctly estimate  $\$R_0\$$  - you need to calculate and show this value

$\$R_0 = \frac{\beta}{\gamma}$

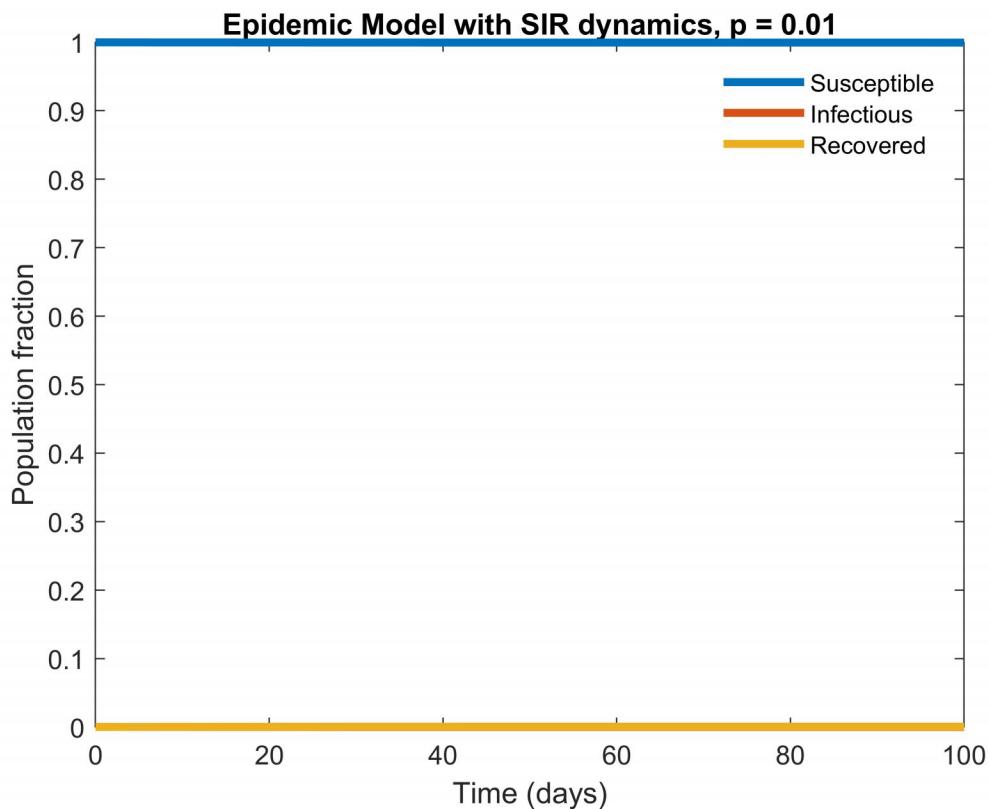
- 5 pts Correctly identify whether diseases spread or not

- 5 pts Correctly plot #1

- 5 pts Correctly plot #2

- 3 pts Plot aesthetics (graph/axes titles)

✓ - 2 pts Reasoning - diseases spread if  $\$R_0 > 1\$$



```
%reset pars.p
pars.p = 0.025;
```

% The disease will not spread because we have decreased the probability of  
% infectious contact by  $0.025 - 0.01 / 0.025 = 0.6$  or 60%. This means that  
% less people are going to be infected upon the same number of contacts as  
% before. Looking at the epidemic model, the fraction of susceptible remains  
% at 1 and no one is getting infected, thus no one need to recover (0),  
% thereby the disease is not spreading.

## %Exercise 2

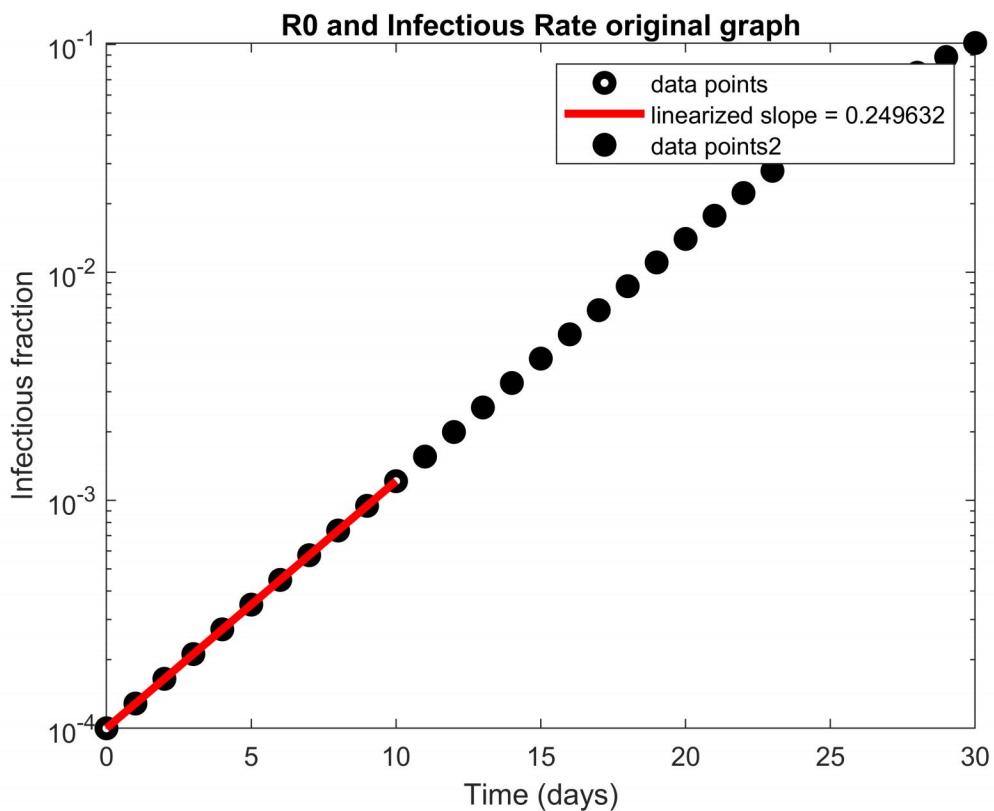
```
% main data goes here
pars.c = 20; % Contacts per unit time (e.g., days)
pars.p = 0.01; % Probability of infectious contact
pars.beta = 0.5;% Transmission rate
pars.gamma = 1/4; % Recovery rate (days^-1)
pars.R0 = 1.625;
pars.N = 10000;
pars.I0= 1;
pars.S0= pars.N-pars.I0;
```

```
% Run the model over 10 days
```

```

[t,y]=ode45(@(t,y) sir_model(t,y,pars),0:1:10,[pars.S0 pars.I0 0]/pars.N);
% Find the slope
[p,s]=polyfit(t,log(y(:,2)),1);
c = polyfit(t,log(y(:,2)),1);
% Plot the data and overlay the best-fit exponential
tmpf=semilogy(t,y(:,2),'ko');
set(tmpf,'linewidth',3);
hold on
tmpf=semilogy(t,exp(p(1)*t+p(2)),'r-');
set(tmpf,'linewidth',3);
% Use solid points for the future k
[t,y]=ode45(@(t,y) sir_model(t,y,pars),0:1:30,[pars.S0 pars.I0 0]/pars.N);
tmpi=find(t>10);
tmpf=semilogy(t(tmpi),y(tmpi,2),'ko');
set(tmpf,'linewidth',3,'markerfacecolor','k');
xlabel('Time (days)');
ylabel('Infectious fraction');
title('R0 and Infectious Rate original graph');
legend('data points', sprintf('linearized slope = %f', c(1)), 'data points2');

```



```

%% plot 1
% main data goes here
pars.c = 20; % Contacts per unit time (e.g., days)
pars.p = 0.01; % Probability of infectious contact

```

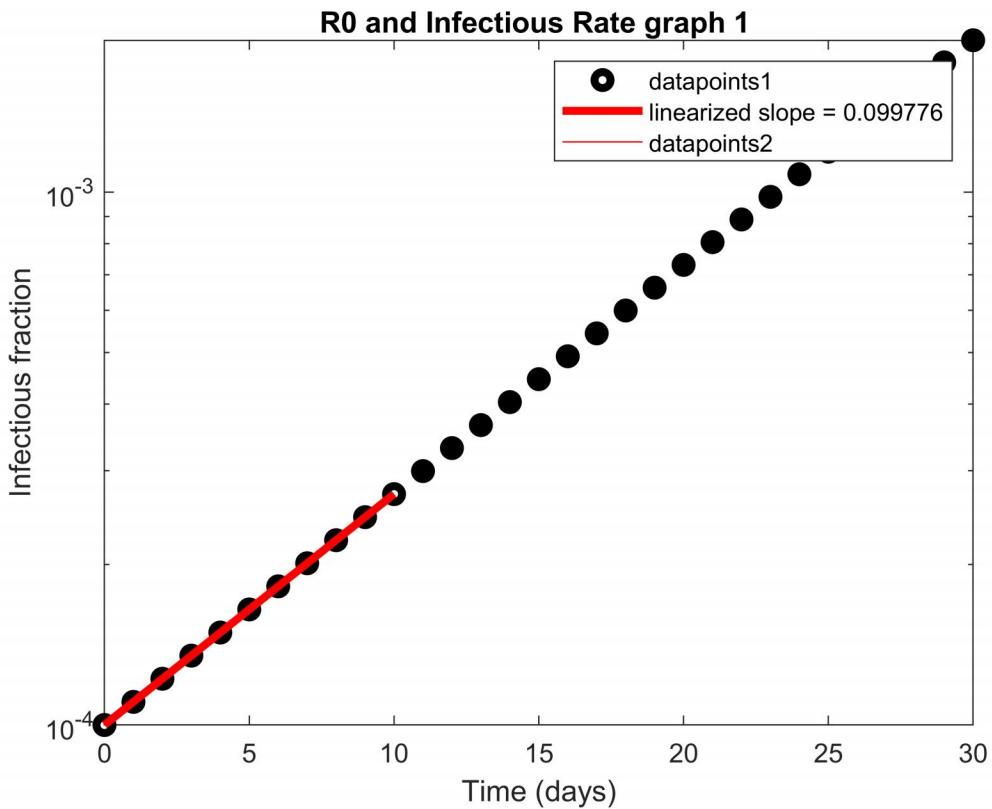
```

pars.beta = 0.5;% Transmission rate
pars.gamma = 0.4; % Recovery rate (days^-1)
pars.R0 = 1.025;
pars.N = 10000;
pars.I0= 1;
pars.S0= pars.N-pars.I0;

% Run the model over 10 days
[t,y]=ode45(@(t,y) sir_model(t,y,pars),0:1:10,[pars.S0 pars.I0 0]/pars.N);
% Find the slope
[p,s]=polyfit(t,log(y(:,2)),1);
c = polyfit(t,log(y(:,2)),1);
% Plot the data and overlay the best-fit exponential
tmpf=semilogy(t,y(:,2), 'ko');
set(tmpf,'linewidth',3);
hold on
tmpf=semilogy(t,exp(p(1)*t+p(2)), 'r-');
f = semilogy(t,exp(p(1)*t+p(2)), 'r-');
set(tmpf,'linewidth',3);

% Use solid points for the future k
[t,y]=ode45(@(t,y) sir_model(t,y,pars),0:1:30,[pars.S0 pars.I0 0]/pars.N);
tmpi=find(t>10);
tmpf=semilogy(t(tmpi),y(tmpi,2), 'ko');
set(tmpf,'linewidth',3,'markerfacecolor','k');
hold on
xlabel('Time (days)');
ylabel('Infectious fraction');
title('R0 and Infectious Rate graph 1 ');
legend('datapoints1', sprintf('linearized slope = %f', c(1)), 'datapoints2');

```



**the expected r values and R0 values are as follows:**

%	Transmission (beta)	Recovery (gamma)	Strength(R0)	Speed(r)
%	0.5	0.4	1.25	0.10
%	1	0.5	2	0.5
%	0.25	0.5	0.5	-0.25
%	0.75	0.25	3	0.5

```
% We can calculate strength R0 by the equation given as r = gamma*(R0 -1)
% or =recovery rate * (unitless strength -1), the strength here is r0 =
% r/gamma + 1
```

## plot 2

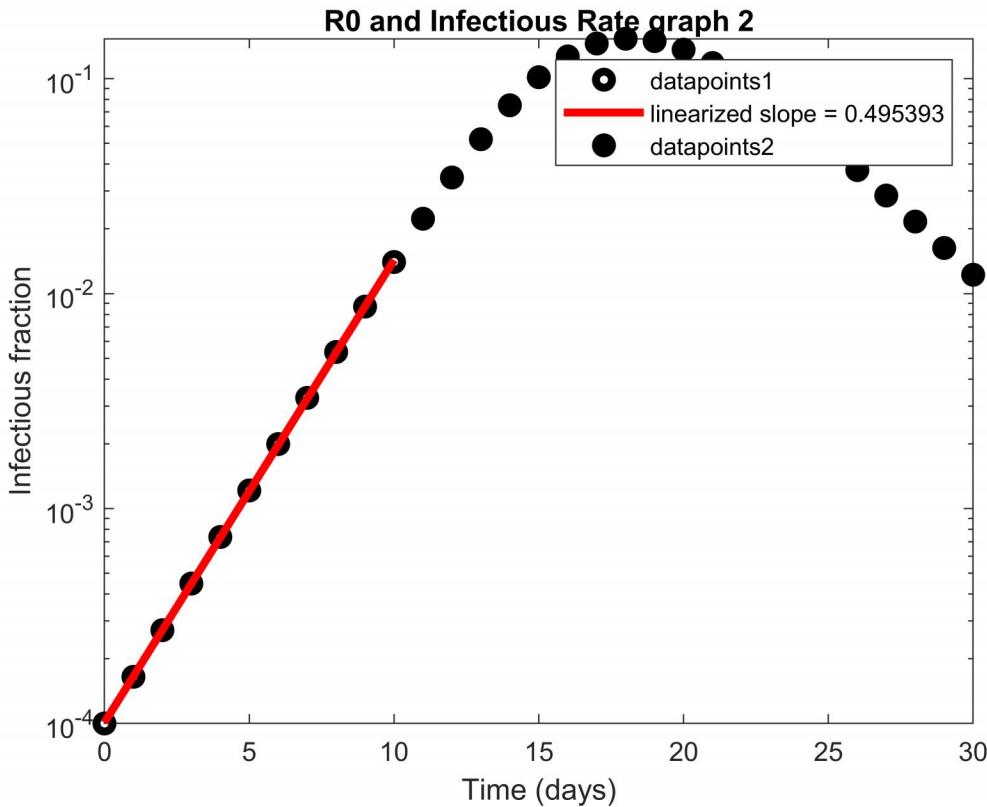
```
% main data goes here
pars.c = 20; % Contacts per unit time (e.g., days)
pars.p = 0.01; % Probability of infectious contact
pars.beta = 1;% Transmission rate
pars.gamma = 0.5; % Recovery rate (days^-1)
pars.R0 = 2;
pars.N = 10000;
pars.I0= 1;
pars.S0= pars.N-pars.I0;
```

```

% Run the model over 10 days
[t,y]=ode45(@(t,y) sir_model(t,y,pars),0:1:10,[pars.S0 pars.I0 0]/pars.N);
% Find the slope
[p,s]=polyfit(t,log(y(:,2)),1);
c = polyfit(t,log(y(:,2)),1);
% Plot the data and overlay the best-fit exponential
tmpf=semilogy(t,y(:,2),'ko');

set(tmpf,'linewidth',3);
hold on
tmpf=semilogy(t,exp(p(1)*t+p(2)),'r-');
%f = semilogy(t,exp(p(1)*t+p(2)),'r-');
set(tmpf,'linewidth',3);
% Use solid points for the future k
[t,y]=ode45(@(t,y) sir_model(t,y,pars),0:1:30,[pars.S0 pars.I0 0]/pars.N);
tmpi=find(t>10);
tmpf=semilogy(t(tmpi),y(tmpi,2),'ko');
set(tmpf,'linewidth',3,'markerfacecolor','k');
hold off
xlabel('Time (days)');
ylabel('Infectious fraction');
title('R0 and Infectious Rate graph 2');
legend('datapoints1', sprintf('linearized slope = %f', c(1)), 'datapoints2');

```



```

% graph 3
% main data goes here

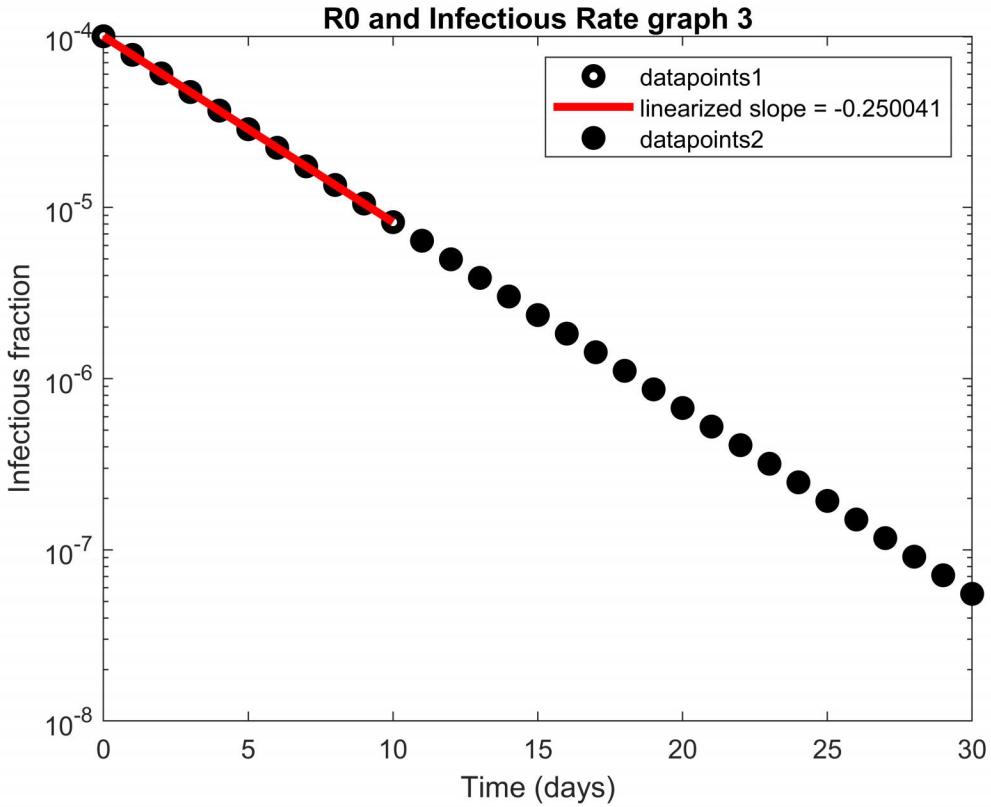
```

```

pars.c = 20; % Contacts per unit time (e.g., days)
pars.p = 0.01; % Probability of infectious contact
pars.beta = 0.25;% Transmission rate
pars.gamma = 0.5; % Recovery rate (days^-1)
pars.R0 = 0.5;
pars.N = 10000;
pars.I0= 1;
pars.S0= pars.N-pars.I0;

% Run the model over 10 days
[t,y]=ode45(@(t,y) sir_model(t,y,pars),0:1:10,[pars.S0 pars.I0 0]/pars.N);
% Find the slope
[p,s]=polyfit(t,log(y(:,2)),1);
c = polyfit(t,log(y(:,2)),1);
% Plot the data and overlay the best-fit exponential
tmpf=semilogy(t,y(:,2),'ko');
set(tmpf,'linewidth',3);
hold on
tmpf=semilogy(t,exp(p(1)*t+p(2)),'r-');
%f = semilogy(t,exp(p(1)*t+p(2)),'r-');
set(tmpf,'linewidth',3);
% Use solid points for the future k
[t,y]=ode45(@(t,y) sir_model(t,y,pars),0:1:30,[pars.S0 pars.I0 0]/pars.N);
tmpi=find(t>10);
tmpf=semilogy(t(tmpi),y(tmpi,2),'ko');
set(tmpf,'linewidth',3,'markerfacecolor','k');
hold off
xlabel('Time (days)');
ylabel('Infectious fraction');
title('R0 and Infectious Rate graph 3');
legend('datapoints1', sprintf('linearized slope = %f', c(1)), 'datapoints2');

```



```
%plot 4
% main data goes here
pars.c = 20; % Contacts per unit time (e.g., days)
pars.p = 0.01; % Probability of infectious contact
pars.beta = 0.75;% Transmission rate
pars.gamma = 0.25; % Recovery rate (days^-1)
pars.R0 = 1.025;
pars.N = 10000;
pars.I0= 1;
pars.S0= pars.N-pars.I0;

% Run the model over 10 days
[t,y]=ode45(@(t,y) sir_model(t,y,pars),0:1:10,[pars.S0 pars.I0 0]/pars.N);
% Find the slope
[p,s]=polyfit(t,log(y(:,2)),1);
c = polyfit(t,log(y(:,2)),1);
% Plot the data and overlay the best-fit exponential
tmpf=semilogy(t,y(:,2),'ko');
set(tmpf,'linewidth',3);
hold on
tmpf=semilogy(t,exp(p(1)*t+p(2)),'r-');
%f = semilogy(t,exp(p(1)*t+p(2)),'r-');
set(tmpf,'linewidth',3);
% Use solid points for the future k
[t,y]=ode45(@(t,y) sir_model(t,y,pars),0:1:30,[pars.S0 pars.I0 0]/pars.N);
```

2 Ex.2 25 / 25

✓ - 0 pts Correct

- 3 pts Plot aesthetics (graph/axes titles)

- 8 pts Correct estimated speed values

```matlab

```
r = pars.gamma * (pars.R0 - 1)
```

```

- 8 pts Correct strength values

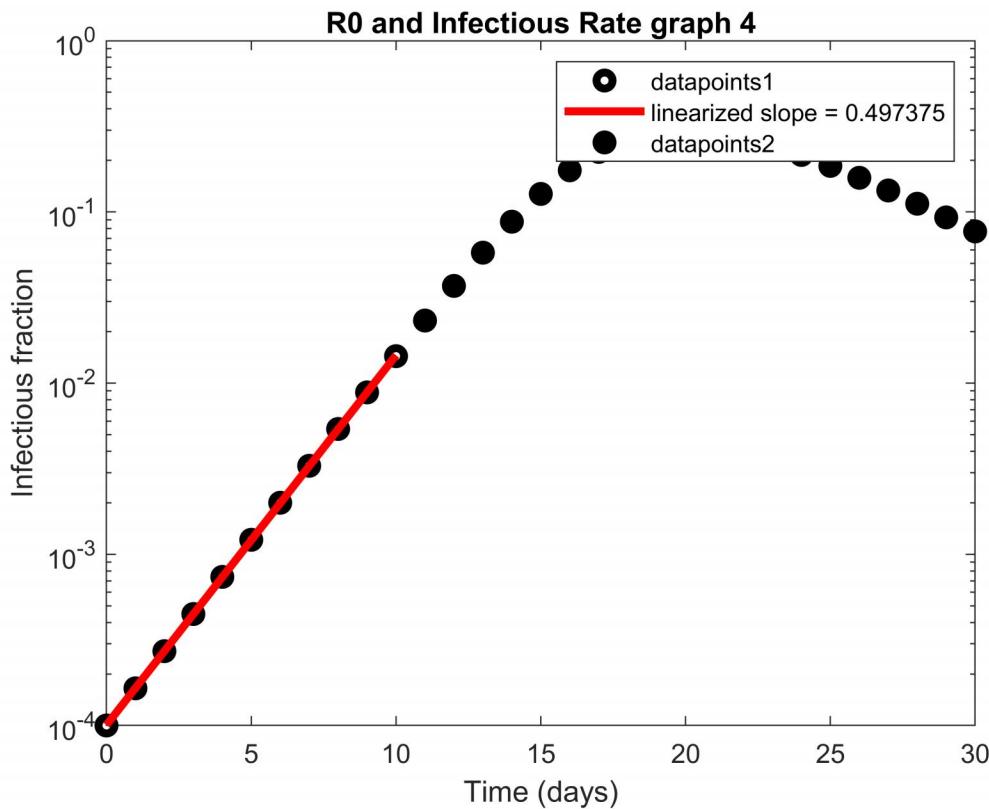
- 9 pts 4 correct plots

- 4 pts 2 correct plots

```

tmpi=find(t>10);
tmpf=semilogy(t(tmpi),y(tmpi,2),'ko');
set(tmpf,'linewidth',3,'markerfacecolor','k');
hold off
xlabel('Time (days)');
ylabel('Infectious fraction');
title('R0 and Infectious Rate graph 4');
legend('datapoints1', sprintf('linearized slope = %f', c(1)), 'datapoints2');

```



### % Exercise 3

```

% Modify the initial values
pars.N = 10000;
pars.S0_range=[0.6 0.7 0.8 0.9 0.999];
pars.I0_range=1/pars.N*ones(1,5);
pars.R0_range=1-pars.S0_range-pars.I0_range;
% Run the model
for i=1:length(pars.S0_range),
[t,y]=ode45(@(t,y) sir_model(t,y,pars),[0:1:200],[pars.S0_range(i) pars.I0_range(i) pars.R0_ran
tmpf=plot(y(:,1),y(:,2),'k-');
set(tmpf,'linewidth',3);
hold on
tmpf=plot(y(end,1),y(end,2),'ro');
set(tmpf,'markerfacecolor','r');

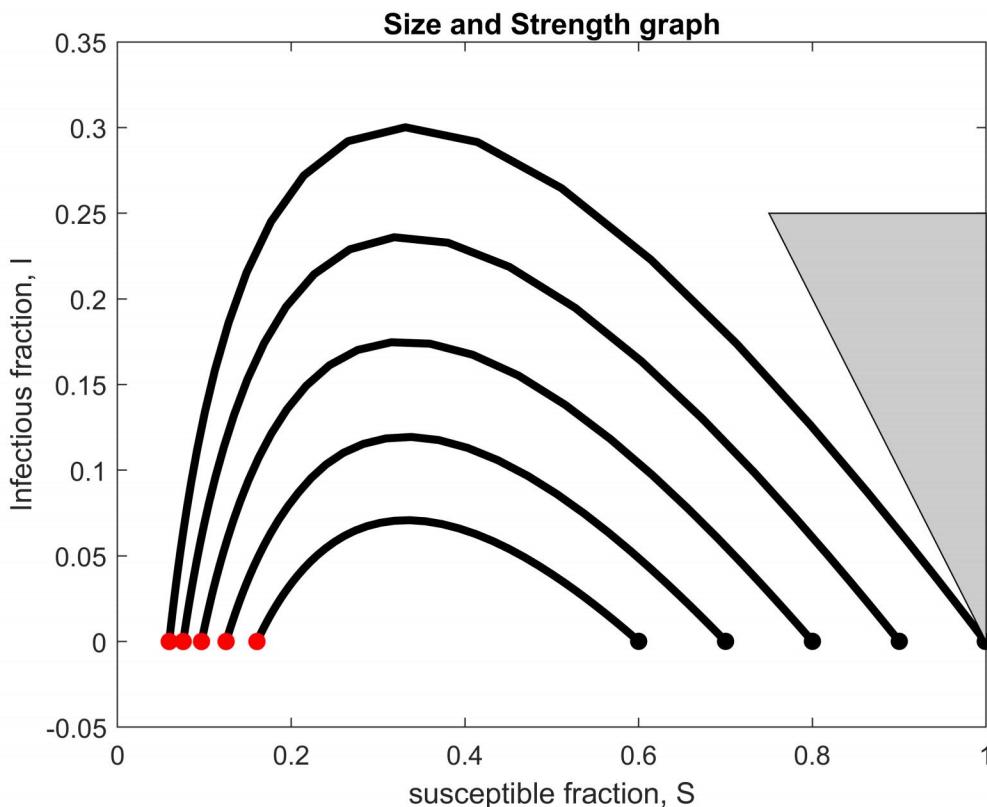
```

```

tmpf=plot(y(1,1),y(1,2), 'ko');
set(tmpf, 'markerfacecolor', 'k');
end

xlabel('susceptible fraction, S');
ylabel('Infectious fraction, I');
title('Size and Strength graph');
% Show the excluded regime
patch([1 1 0.75 1],[0 0.25 0.25 0],[0.8 0.8 0.8]);

```



```

% main data goes here
pars.c = 20; % Contacts per unit time (e.g., days)
pars.p = 0.01; % Probability of infectious contact
pars.beta = 0.3;% Transmission rate
pars.gamma = 0.25; % Recovery rate (days^-1)
pars.R0 = 1.2;
pars.N = 10000;
pars.I0= 1;
pars.S0= pars.N-pars.I0;

% Modify the initial values
pars.N = 10000;
pars.S0_range=[0.6 0.7 0.8 0.9 0.999];
pars.I0_range=1/pars.N*ones(1,5);
pars.R0_range=1-pars.S0_range-pars.I0_range;

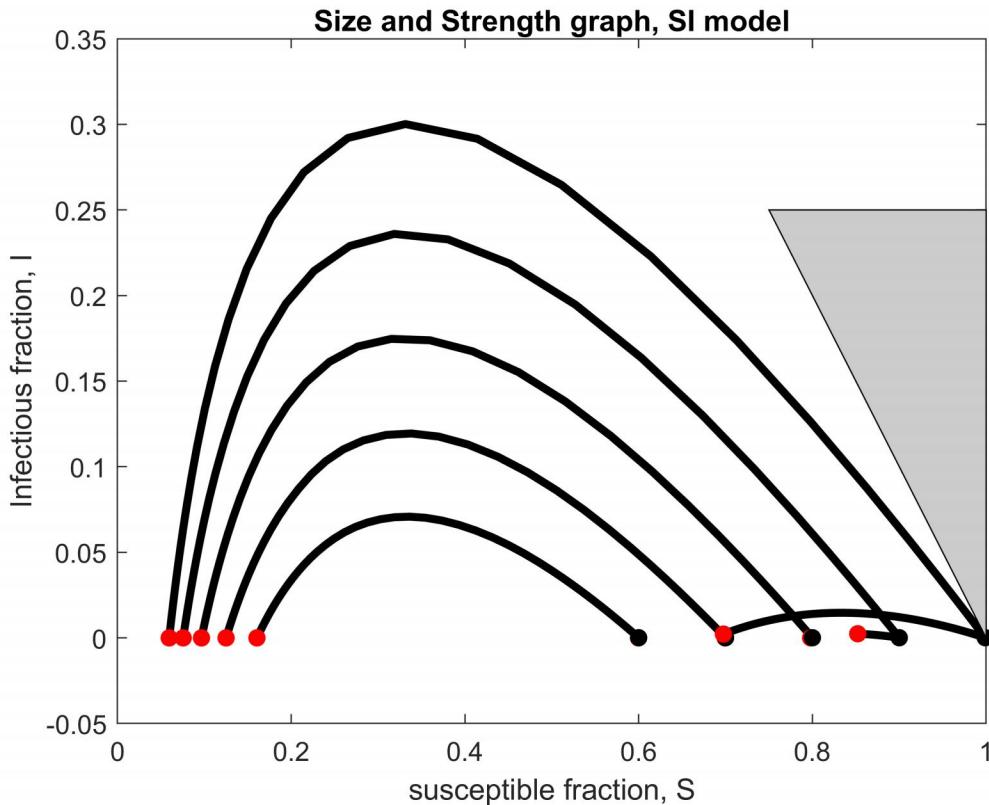
```

```

% Run the model
for i=1:length(pars.S0_range),
[t,y]=ode45(@(t,y) sir_model(t,y,pars),[0:1:200],[pars.S0_range(i) pars.I0_range(i) pars.R0_range(i)]);
tmpf=plot(y(:,1),y(:,2),'k-');
set(tmpf,'linewidth',3);
hold on
tmpf=plot(y(end,1),y(end,2),'ro');
set(tmpf,'markerfacecolor','r');
tmpf=plot(y(1,1),y(1,2),'ko');
set(tmpf,'markerfacecolor','k');
xlabel('susceptible fraction, S');
ylabel('Infectious fraction, I');
title('Size and Strength graph, SI model');

end
% Show the excluded regime
patch([1 1 0.75 1],[0 0.25 0.25 0],[0.8 0.8 0.8]);

```



```

% main data goes here
pars.c = 20; % Contacts per unit time (e.g., days)
pars.p = 0.01; % Probability of infectious contact
pars.beta = 0.3;% Transmission rate
pars.gamma = 0.25; % Recovery rate (days^-1)
pars.R0 = 1.2;
pars.N = 10000;
pars.I0= 1;

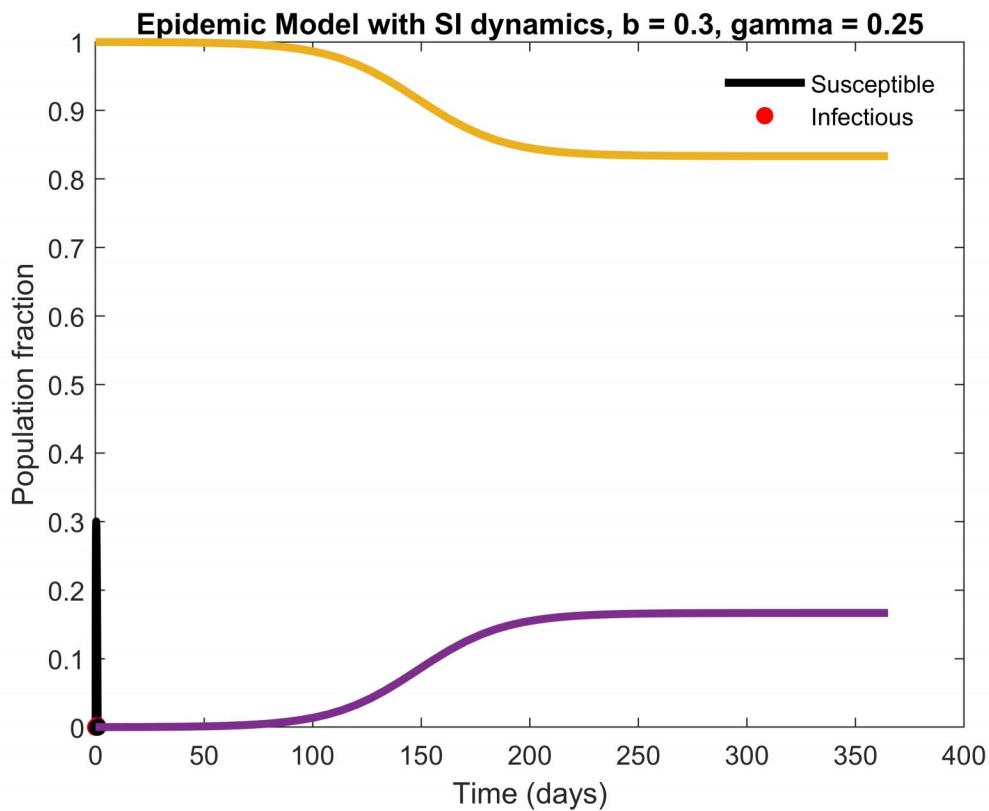
```

```

pars.S0= pars.N-pars.I0;

% Run the model
[t,y]=ode45(@(t,y) si_model(t,y,pars),[0 365],[pars.S0 pars.I0]/pars.N);
% Plot the results
tmpf=plot(t,y);
set(tmpf, 'linewidth',3);
xlabel('Time (days)');
ylabel('Population fraction');
title('Epidemic Model with SI dynamics, b = 0.3, gamma = 0.25');
tmplh = legend('Susceptible','Infectious');
legend('boxoff');

```



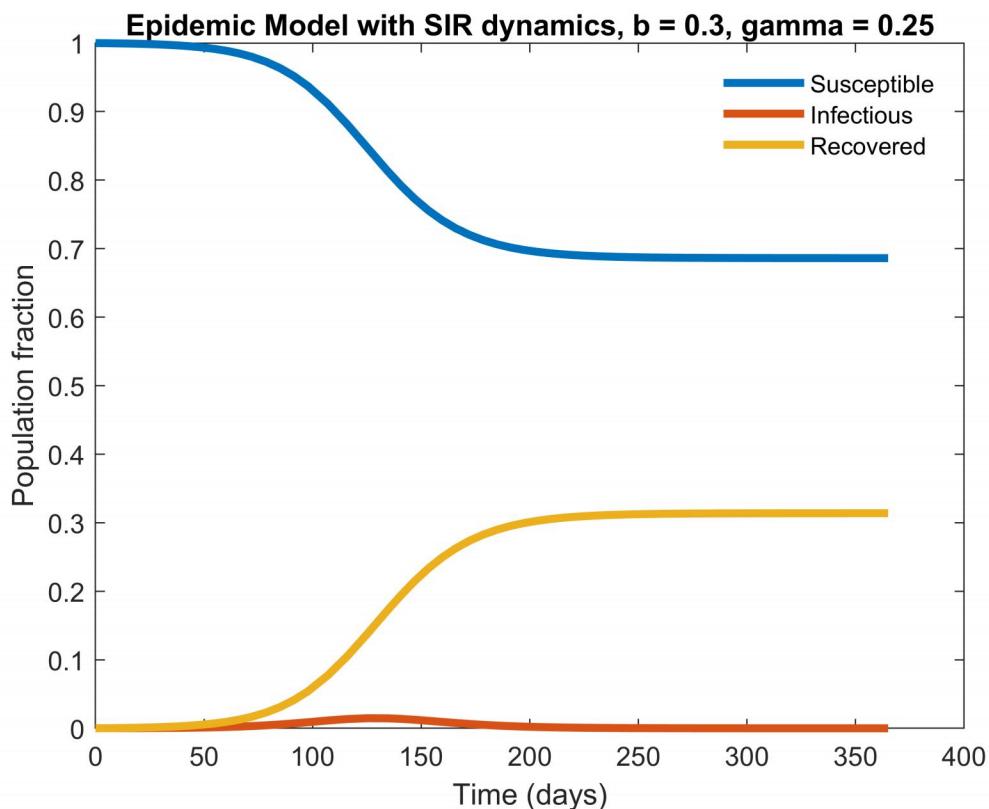
```

% main data goes here
pars.c = 20; % Contacts per unit time (e.g., days)
pars.p = 0.01; % Probability of infectious contact
pars.beta = 0.3;% Transmission rate
pars.gamma = 0.25; % Recovery rate (days^-1)
pars.R0 = 1.2;
pars.N = 10000;
pars.I0= 1;
pars.S0= pars.N-pars.I0;

% Run the model

```

```
[t,y]=ode45(@(t,y) sir_model(t,y,pars),[0 365],[pars.S0 pars.I0 0]/pars.N);
figure(67);
% Plot the results
tmpf=plot(t,y);
set(tmpf,'linewidth',3);
xlabel('Time (days)');
ylabel('Population fraction');
title('Epidemic Model with SIR dynamics, b = 0.3, gamma = 0.25');
tmplh = legend('Susceptible','Infectious', 'Recovered');
legend('boxoff');
```



## exercise 4

```
% Run the ODE model

pars.c = 20; % Contacts per unit time (e.g., days)
pars.p = 0.025; % Probability of infectious contact
pars.beta = pars.c*pars.p; % Transmission rate
pars.gamma = 1/4; %
pars.tf=60;
pars.R0 = pars.beta/pars.gamma;
pars.N = 1000;
pars.I0= 10;
pars.S0= pars.N-pars.I0;

[t,y]=ode45(@(t,y) sir_model(t,y,pars),[0 pars.tf],[pars.S0 pars.I0 0]/pars.N);
```

3 Ex.3 20 / 25

- 0 pts Correct

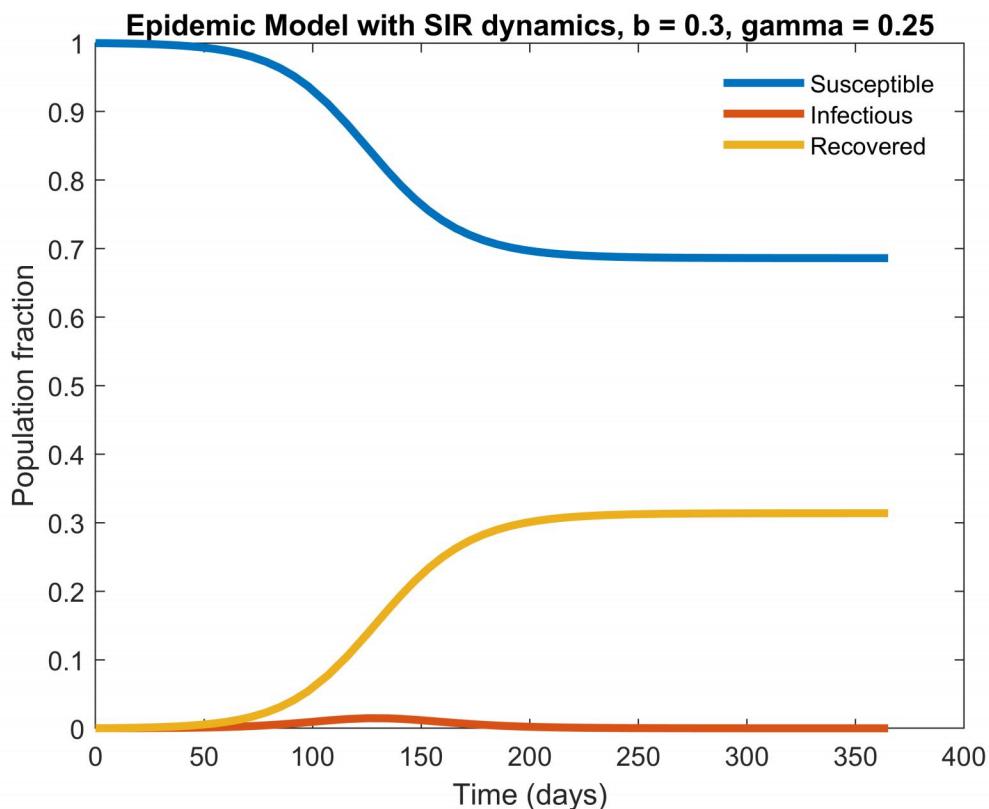
- 10 pts Correctly plot SIR model

- 10 pts Correctly plot SI model

✓ - 5 pts Compare plots - you need to talk about  $R_0$  and the proportion of the population that are susceptible, infectious, and recovered

- 3 pts Plot aesthetics (graph/axes titles)

```
[t,y]=ode45(@(t,y) sir_model(t,y,pars),[0 365],[pars.S0 pars.I0 0]/pars.N);
figure(67);
% Plot the results
tmpf=plot(t,y);
set(tmpf,'linewidth',3);
xlabel('Time (days)');
ylabel('Population fraction');
title('Epidemic Model with SIR dynamics, b = 0.3, gamma = 0.25');
tmplh = legend('Susceptible','Infectious', 'Recovered');
legend('boxoff');
```



## exercise 4

```
% Run the ODE model

pars.c = 20; % Contacts per unit time (e.g., days)
pars.p = 0.025; % Probability of infectious contact
pars.beta = pars.c*pars.p; % Transmission rate
pars.gamma = 1/4; %
pars.tf=60;
pars.R0 = pars.beta/pars.gamma;
pars.N = 1000;
pars.I0= 10;
pars.S0= pars.N-pars.I0;

[t,y]=ode45(@(t,y) sir_model(t,y,pars),[0 pars.tf],[pars.S0 pars.I0 0]/pars.N);
```

```

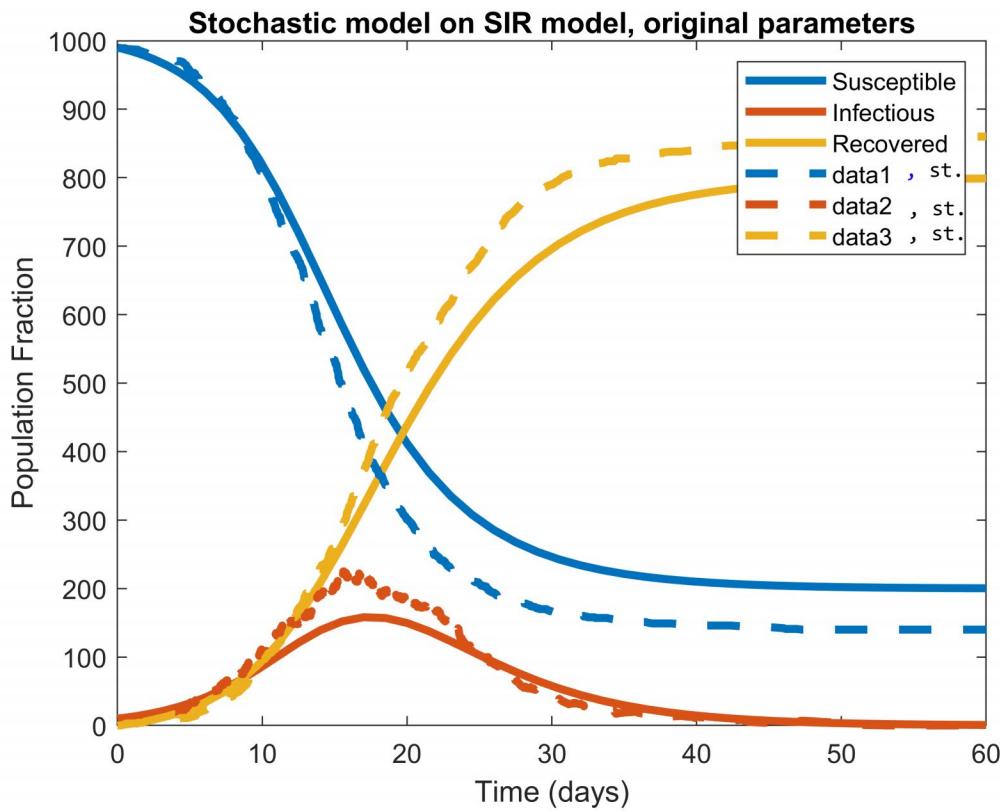
figure(56);
tmpf=plot(t,pars.N*y);
title('Stochastic model on SIR model, original parameters');
xlabel('Time (days)');
ylabel('Population Fraction');
legend('Susceptible', 'Infectious', 'Recovered');
set(tmpf,'linewidth',3);
hold on

% Run the stochastic model
[tsim,ysim]=stochsim_SIR([0 pars.tf],[pars.S0 pars.I0 0],pars);
tmpfsm=plot(tsim,ysim,'--');
set(tmpfsm,'linewidth',3);

% Color the lines the same way (where dashes are for stochastic)
for i=1:3
set(tmpfsm(i),'color',get(tmpf(i),'color'));

legend;
end

```



```

% the dashed lines are following the shapes of the curves but the trajectories are leading
% to dropping a little too early or increasing too early. For example, I
% noticed that the stochastic model for susceptible fraction decreased at a
% faster rate than the deterministic model.

```

```

function [t,y] = stochsim_SIR(trange,y0,pars)
% function [t,y] = stochsim_SIR(trange,y0,pars)
%
% Simulates an SIR model via the Gillespie algorithm
% from t0 to tf in trange given initial
% conditions in y0 = [S0 I0 R0] and parameters
% in pars. Returns time and values
% Conditions
t0=trange(1);
tf=trange(2);
t(1)=t0;
y(1,:)=y0;
tcur=t0;
ycur=y0;
ind=1;
% Model
while (tcur<tf)
% Check to see if there is an infection
if (ycur(2)==0)
    ind=ind+1;
    t(ind)=tf;
    y(ind,:)=ycur;
    break;
end

% Rates
infrate = (pars.beta * ycur(1) * ycur(2))/ pars.N; % infection rate
recrate = pars.gamma * ycur(2); % recovery rate
totrate = infrate + recrate;
dt = -1/totrate*log(rand);
tcur=tcur+dt;
tcur=tcur+dt;
% Event type
if (rand<(infrate/totrate)) % infection
ycur(1) = ycur(1) -1;
ycur(2) = ycur(2) +1;
else % recovery
ycur(2) = ycur(2) - 1;
ycur(3) = ycur(3) + 1;
end
ind=ind+1;
t(ind)=tcur;
y(ind,:)=ycur;
end
end

function dydt = si_model(t,y,pars)
% function dydt = si_model(t,y,pars)

```

```
% SI Model
S=y(1);
I=y(2);
% The model
dSdt = -pars.beta*S*I+pars.gamma*I;
dIdt = pars.beta*S*I-pars.gamma*I;
dydt = [dSdt; dIdt];
end

function dydt = sir_model(t,y,pars)
% function dydt = sir_model(t,y,pars)
% SIR Model
S=y(1);
I=y(2);
% The model
dSdt = -pars.beta*S*I;
dIdt = pars.beta*S*I-pars.gamma*I;
dRdt = pars.gamma*I;
dydt = [dSdt; dIdt; dRdt];
end
```

4 Ex.4 25 / 25

✓ - 0 pts Has not been covered completely in lecture - automatic full credit

- 3 pts Plot aesthetics (graph/axes titles)

- 8 pts Correctly complete code for the 2 rates

```matlab

% Rates

```
infrate = pars.beta*ycur(1)*ycur(2)/pars.N; % can also use y(ind,1)*y(ind,2)
```

```
recrate = pars.gamma*ycur(2); % can also use y(ind,2)
```

```

- 12 pts Correctly complete 4 event type code

```matlab

% Event type

```
if (rand<(infrate/totrate)) % infection
```

```
ycur(1)=ycur(1)-1;
```

```
ycur(2)=ycur(2)+1;
```

```
else % recovery
```

```
ycur(2)=ycur(2)-1;
```

```
ycur(3)=ycur(3)+1;
```

```
end
```

```

- 5 pts Correctly plot