Group Project Part 3: Least Squares

```
clear all;
clc;
```

Initial Values

```

I0 = 10;
S0 = 990;
R0 = 0;
TestBeta = 0.3;
TestGamma = 0.1;
N = I0 + S0 + R0;
% Betai = .3; Gammai = .1;
% Betaii = 1; Gammaii = .1;
% Betaiii = 2; Gammaiii = .2;

k = ((TestBeta*S0)/N)-TestGamma;

Beta = [.3 1 2];
gamma = [.1 .1 .2];
ti = ["Seasonal Influenza","COVID","Measles"];
leg = ["Infected"];

h = 1;
t0 = 0; tf = 100;
tiledlayout(3,1);
```

Part 1

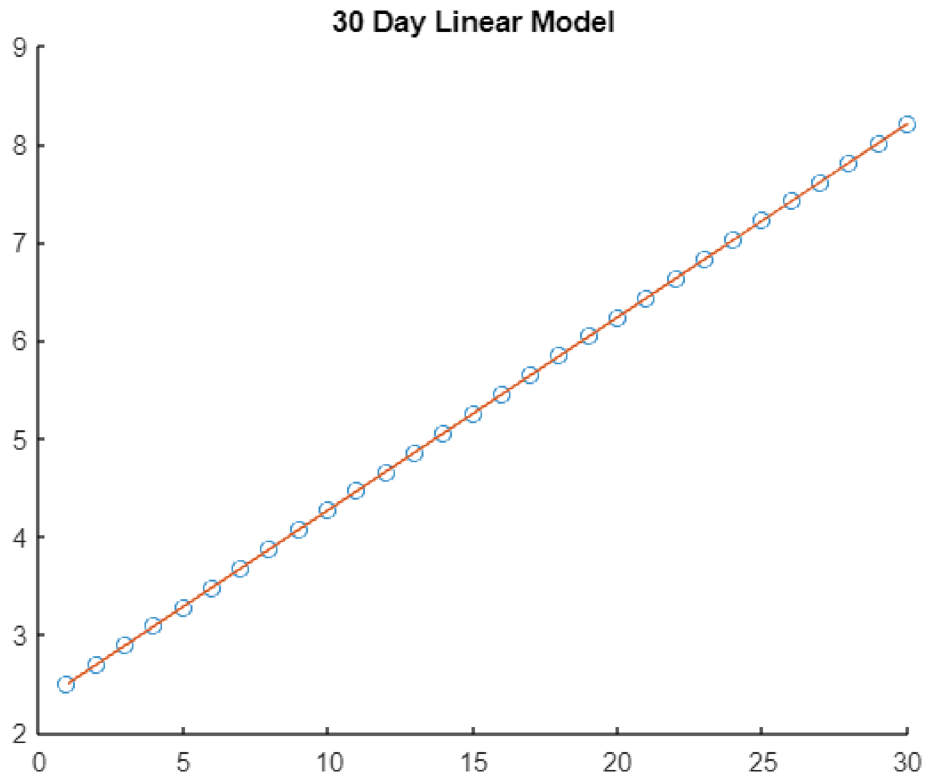
```
for j = 1:length(Beta)
    Gamma=gamma(j);
    BN1=Beta(j)/1000;

    time = t0:h:tf;
    Rvals = zeros(size(time));
    Svals = zeros(size(time));
    Ivals = zeros(size(time));
    Nvals = zeros(size(time));

    Rvals(1) = R0;
    Svals(1) = S0;
    Ivals(1) = I0;
    Nvals(1) = 1000;
    dRdt = @(I) Gamma*I;
    dSdt = @(I,S) -BN1*S*I;
    dIdt = @(I,S) (BN1*S*I)-(Gamma*I);
        for i = 1:length(time)-1
            R=Rvals(i);
            S=Svals(i);
            I=Ivals(i);
```

```
            rk1 = dRdt(I);           % Runge Kutta Recovered K1
            sk1 = dSdt(I,S);            % Runge Kutta Susceptible K1
            ik1 = dIdt(I,S);           % Runge Kutta Infected K1

            ik2 = dIdt((I + ik1 * (h/2)) , S + sk1 * (h/2));           % Runge
Kutta Infected K2
            rk2 = dRdt(I + ik1 * (h/2));           % Runge Kutta Recovered K2
            sk2 = dSdt(I + ik1 * (h/2)  , (S + sk1 * (h/2)));           % Runge
Kutta Susceptible K2

            sk3 = dSdt(I + ik2 * (h/2) ,(S + sk2 * (h/2)));           % Runge
Kutta Susceptible K3
            ik3 = dIdt((I + ik2 * (h/2)) ,S + sk2 * (h/2));           % Runge Kutta
Infected K3
            rk3 = dRdt(I + ik2 * (h/2));           % Runge Kutta Recovered K3

            ik4 = dIdt((I + ik3 * h),S + sk3 * h);           % Runge Kutta Infected
K4
            sk4 = dSdt(I + ik3 * h , (S + sk3 * h));           % Runge Kutta
Susceptible K4
            rk4 = dRdt(I + ik3 * h);

            Rvals(i+1) = R + (1/6) * (rk1 + 2*(rk2) + 2*(rk3) + rk4) * h;
            Svals(i+1) = S + (1/6) * (sk1 + 2*(sk2) + 2*(sk3) + sk4) * h;
            Ivals(i+1) = I + (1/6) * (ik1 + 2*(ik2) + 2*(ik3) + ik4) * h;
            Nvals(i+1) = Rvals(i+1) + Svals(i+1) + Ivals(i+1);
        end
    data(j,1:101)= Ivals;
end

disp(data)
```

```
   10.0000   12.1716   14.7988   17.9694   21.7848   26.3598   31.8225   38.3119   45.9741   54.9553   65.3919   77
   10.0000   24.1358   56.8424  126.7160  253.1347  423.6110  575.0844  655.4489  669.2084  644.3231  602.3596  554
   10.0000   55.2950  244.2420  566.3323  663.8051  601.1200  508.6706  421.6202  347.0348  284.8822  233.5905  191
```

Part 2

```
% Linear Model
lnIt = @(t) log(I0) +(k*t);
t30 = 1:30;
a130 = (30*sum(t30.*lnIt(t30))-(sum(t30)*sum(lnIt(t30))))/(30*sum(t30.^2)-
sum(t30)^2);
a030 = ((1/30)*sum(lnIt(t30)))-(a130*(1/30)*sum(t30));
scatter(t30,lnIt(t30))
hold on
title('30 Day Linear Model')
plot(a130*t30+a030)
hold off
```



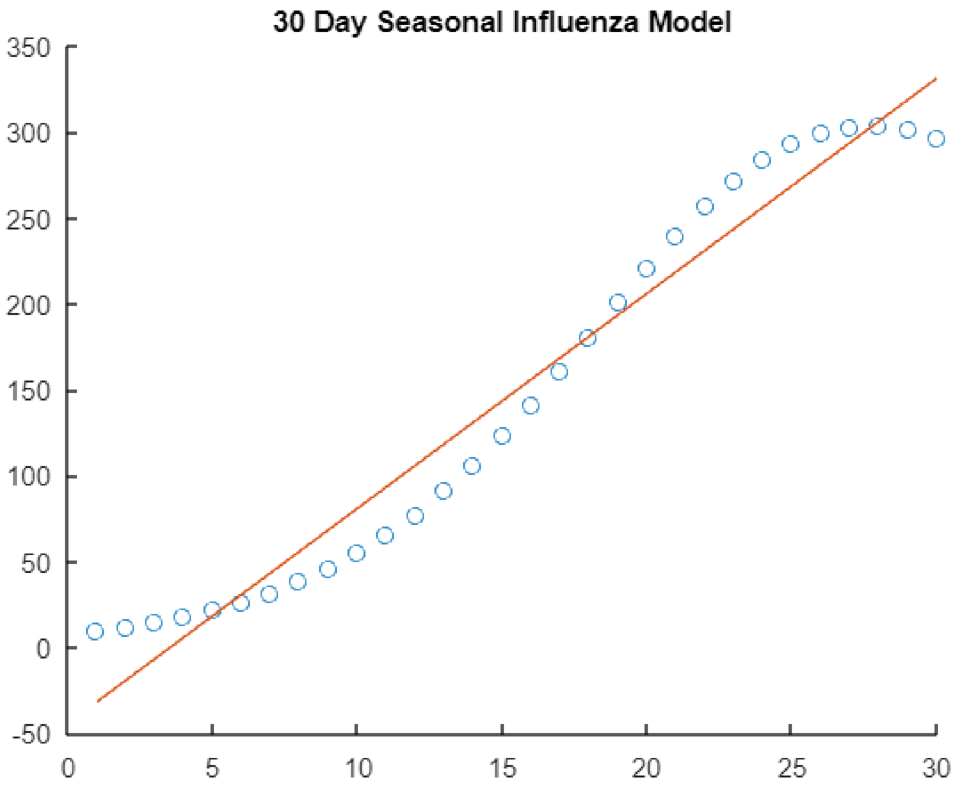

```
I0estLIN30 = a030
```

```
I0estLIN30 = 2.3026
```

```
BestLIN30 = (N*(a130 + Gamma(1)))/S0
```

```
BestLIN30 = 0.4010
```

```
% Seasonal Influenza
a1SI30 = (30*sum(t30.*data(1,1:30))-(sum(t30)*sum(data(1,1:30))))/(30*sum(t30.^2)-
sum(t30)^2);
a0SI30 = ((1/30)*sum(data(1,1:30)))-(a1SI30*(1/30)*sum(t30));
scatter(t30,data(1,1:30))
hold on
title('30 Day Seasonal Influenza Model')
plot(a1SI30*t30+a0SI30)
hold off
```



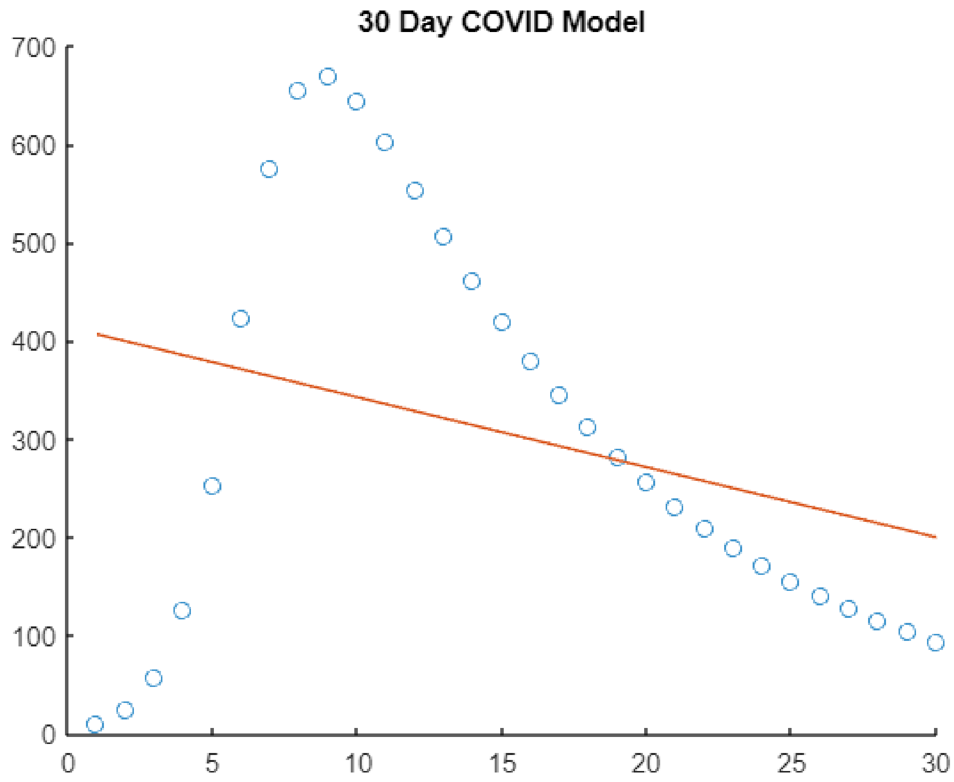

```
I0estSI30 = a0SI30
```

```
I0estSI30 = -44.3022
```

```
BestSI30 = (N*(a1SI30 + gamma(1)))/S0
```

```
BestSI30 = 12.7518
```

```
% COVID
a1C30 = (30*sum(t30.*data(2,1:30))-(sum(t30)*sum(data(2,1:30))))/(30*sum(t30.^2)-
sum(t30)^2);
a0C30 = ((1/30)*sum(data(2,1:30)))-(a1C30*(1/30)*sum(t30));
scatter(t30,data(2,1:30))
hold on
title('30 Day COVID Model')
plot(a1C30*t30+a0C30)
hold off
```



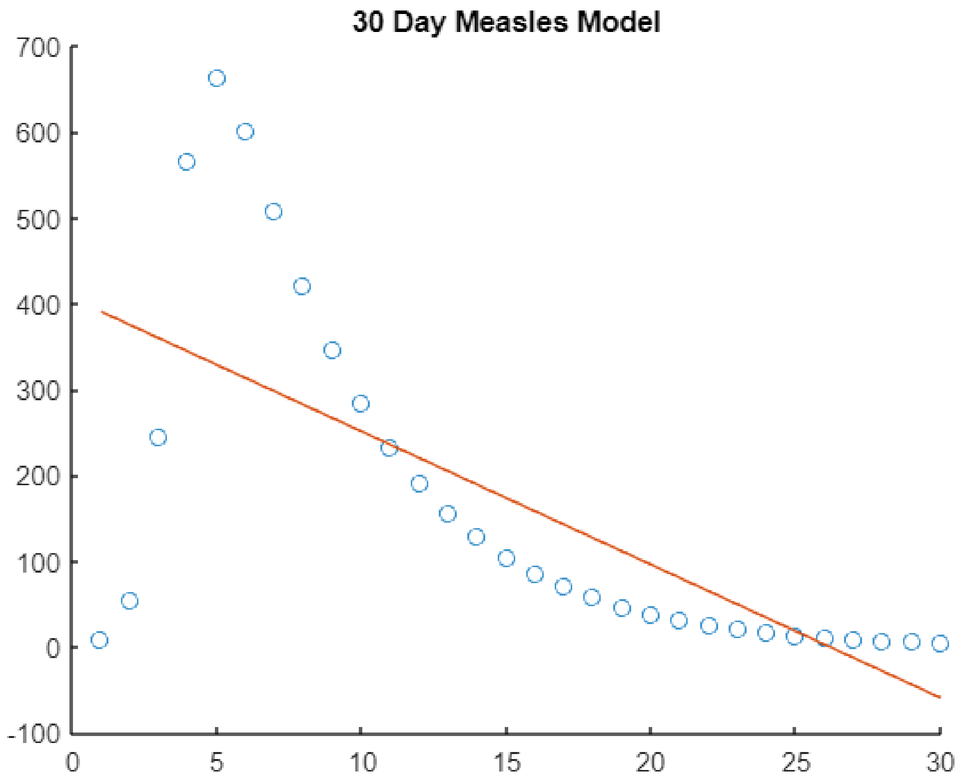

```
I0estC30 = a0C30
```

```
I0estC30 = 414.0370
```

```
BestC30 = (N*(a1C30 + gamma(1)))/S0
```

```
BestC30 = -7.1046
```

```
% Measles
a1M30 = (30*sum(t30.*data(3,1:30))-(sum(t30)*sum(data(3,1:30))))/(30*sum(t30.^2)-
sum(t30)^2);
a0M30 = ((1/30)*sum(data(3,1:30)))-(a1M30*(1/30)*sum(t30));
scatter(t30,data(3,1:30))
hold on
title('30 Day Measles Model')
plot(a1M30*t30+a0M30)
hold off
```




```
I0estM30 = a0M30
```

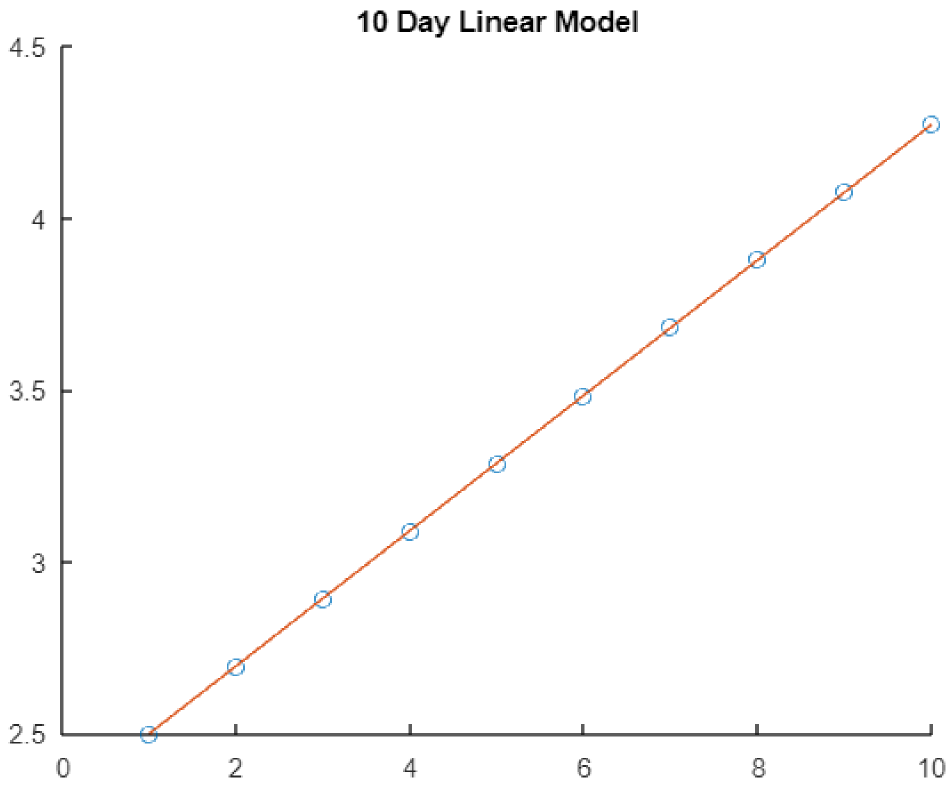
```
I0estM30 = 406.3158
```

```
BestM30 = (N*(a1M30 + gamma(1)))/S0
```

```
BestM30 = -15.5805
```

Part 3

```
% Linear Model
lnIt = @(t) log(I0) +(k*t);
t10 = 1:10;
a110 = (10*sum(t10.*lnIt(t10))-(sum(t10)*sum(lnIt(t10))))/(10*sum(t10.^2)-
sum(t10)^2);
a010 = ((1/10)*sum(lnIt(t10))-(a110*(1/10)*sum(t10));
scatter(t10,lnIt(t10))
hold on
title('10 Day Linear Model')
plot(a110*t10+a010)
hold off
```



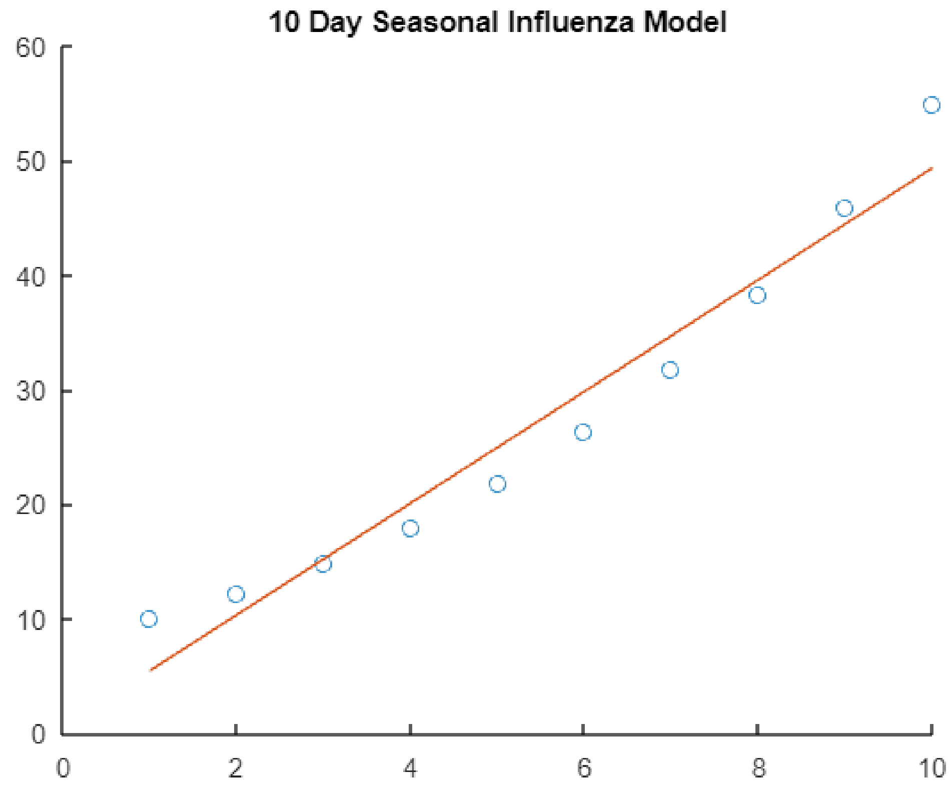

```
IOestLIN10 = a010
```

```
IOestLIN10 = 2.3026
```

```
BestLIN10 = (N*(a110 + gamma(1)))/S0
```

```
BestLIN10 = 0.3000
```

```
% Seasonal Influenza
a1SI10 = (10*sum(t10.*data(1,1:10))-(sum(t10)*sum(data(1,1:10))))/(10*sum(t10.^2)-sum(t10)^2);
a0SI10 = ((1/10)*sum(data(1,1:10)))-(a1SI10*(1/10)*sum(t10));
scatter(t10,data(1,1:10))
hold on
title('10 Day Seasonal Influenza Model')
plot(a1SI10*t10+a0SI10)
hold off
```



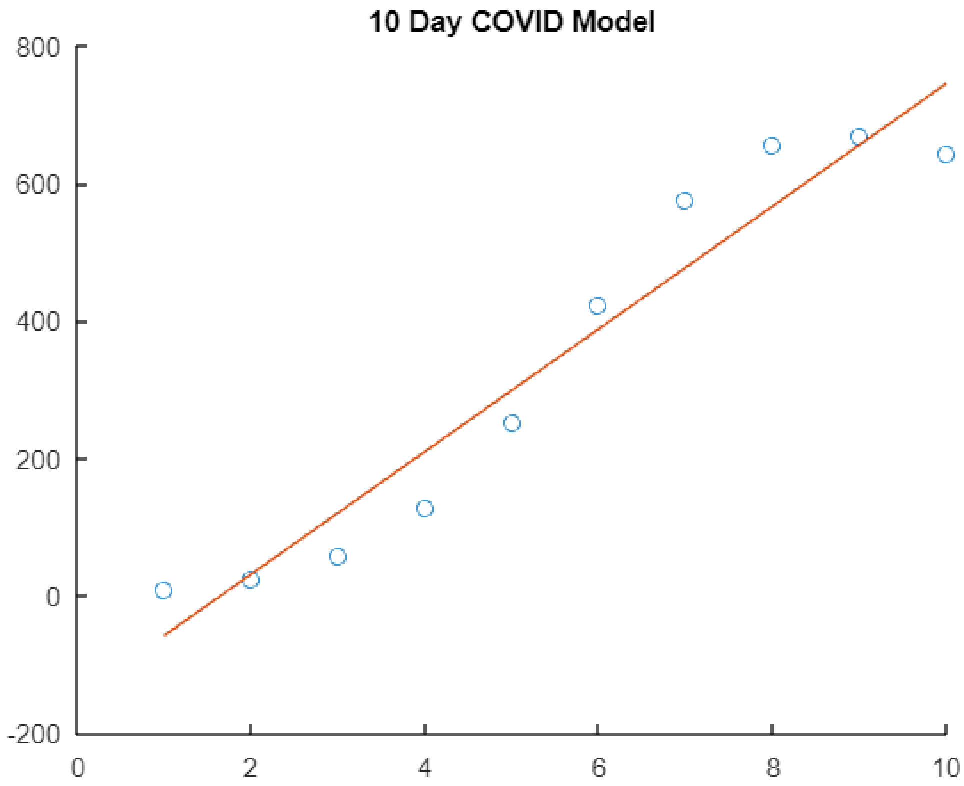

```
I0estSI10 = a0SI10
```

```
I0estSI10 = 0.5843
```

```
BestSI10 = (N*(a1SI10 + gamma(1)))/S0
```

```
BestSI10 = 5.0286
```

```
% COVID
a1C10 = (10*sum(t10.*data(2,1:10))-(sum(t10)*sum(data(2,1:10))))/(10*sum(t10.^2)-
sum(t10)^2);
a0C10 = ((1/10)*sum(data(2,1:10)))-(a1C10*(1/10)*sum(t10));
scatter(t10,data(2,1:10))
hold on
title('10 Day COVID Model')
plot(a1C10*t10+a0C10)
hold off
```



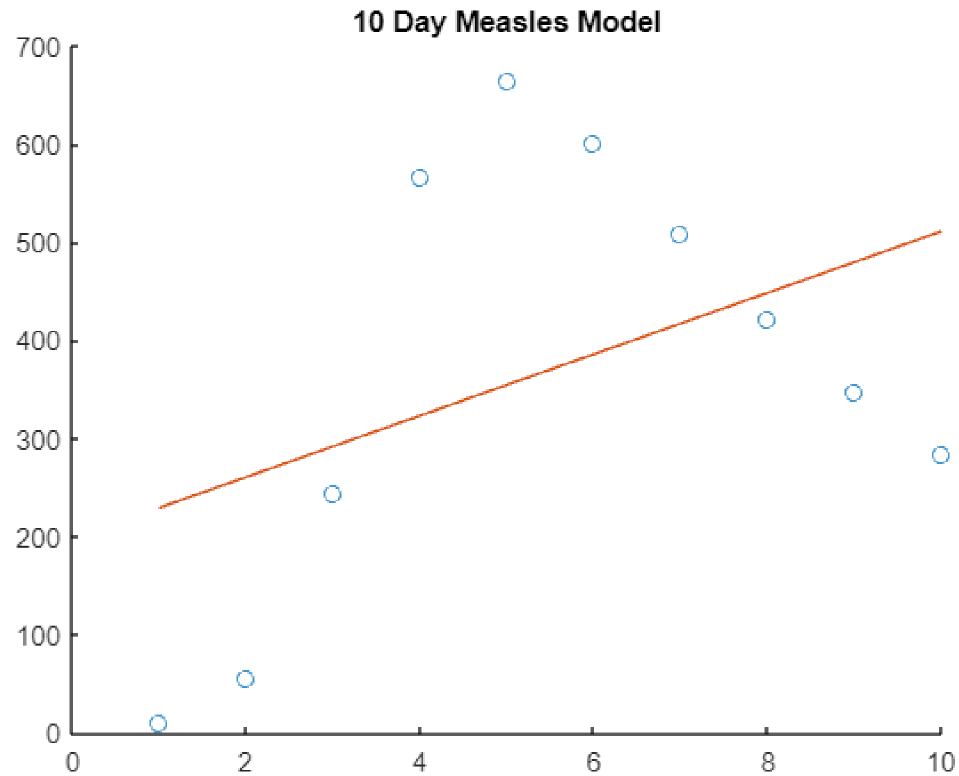

```
I0estC10 = a0C10
```

I0estC10 = -147.2505

```
BestC10 = (N*(a1C10 + gamma(1)))/S0
```

BestC10 = 90.2940

```
% Measles
a1M10 = (10*sum(t10.*data(3,1:10))-(sum(t10)*sum(data(3,1:10))))/(10*sum(t10.^2)-
sum(t10)^2);
a0M10 = ((1/10)*sum(data(3,1:10)))-(a1M10*(1/10)*sum(t10));
scatter(t10,data(3,1:10))
hold on
title('10 Day Measles Model')
plot(a1M10*t10+a0M10)
hold off
```




```
I0estM10 = a0M10
```

```
I0estM10 = 198.0556
```

```
BestM10 = (N*(a1M10 + gamma(1)))/S0
```

```
BestM10 = 31.7346
```

```
% By decreasing the amount of values, the estimated I(0) improves to a
% greater accuracy to the actual value. This trend will continue because as
% the slope value of infected increases, the x-intercept of the graphs will
% decrease greater. This occurs because the least-squares regression is
% trying its best to match a non-linear model. If the model was reduced to
% even smaller value, for example half a day, the estimated I(0) would be
% signifcantly closer to 10. This a major downfall of the least squares
% regression method.

% Beta values displayed more of the key issues of running a linear least squares
model on a non-linear
% model because it ultimately leads to poor approximations across the board with a
lot of error.
% Although a helpful tool to get an idea, the results can not be trusted as highly
accurate when the
% data doesn't follow some linear pattern.
```