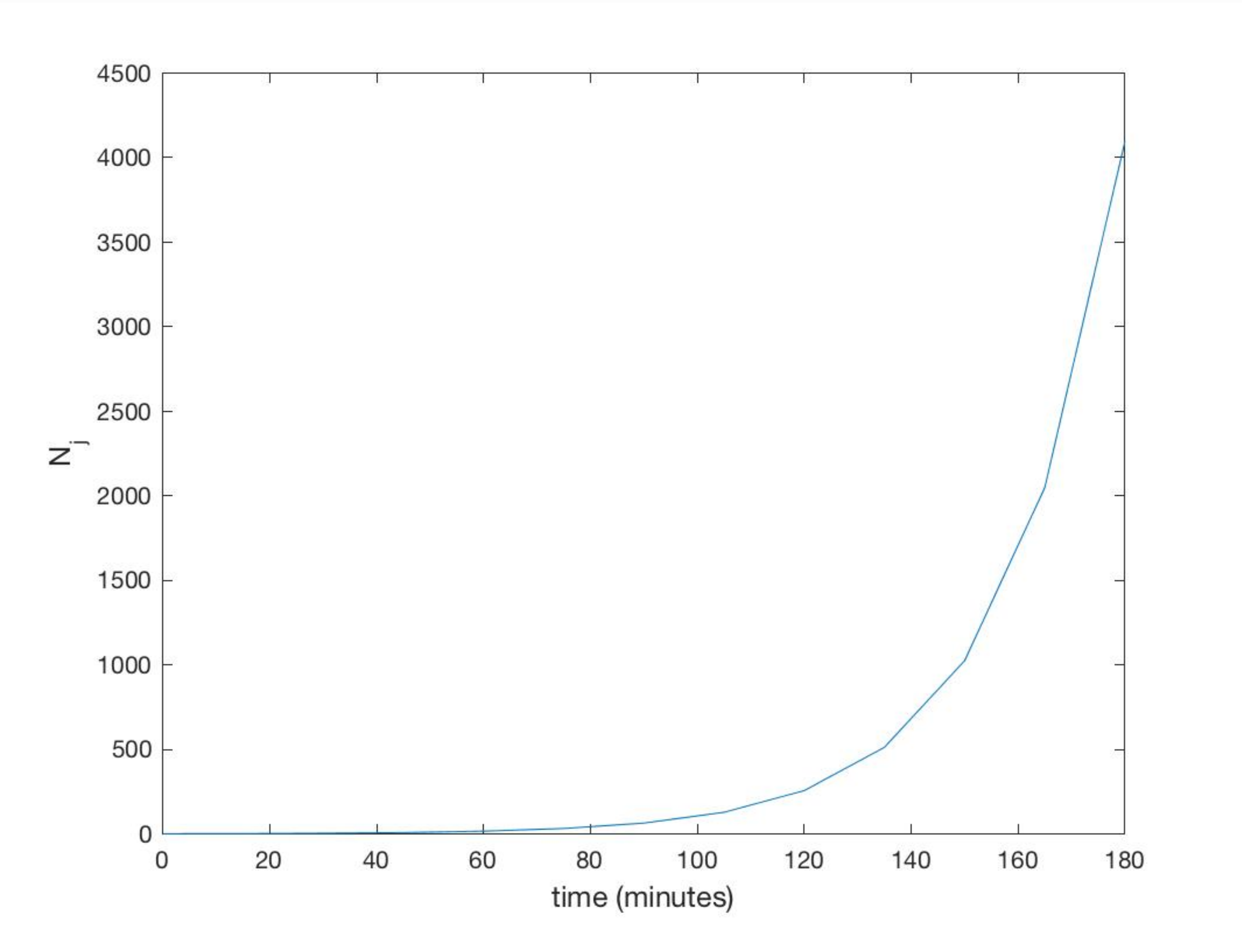
ASSIGNMENT 5

Exercise 1.1.5

1. A single cell of *E-coli* divides every 15 minutes. Write a loop to generate population values over a three hour period and plot them on a graph.

```
time = 0:15:180;
N = zeros(1, length(time));
N(1) = 1;
for j = 2:length(time)
    N(j) = 2*N(j-1);
end

fig = figure;
plot(time, N)
xlabel('time (minutes)','fontsize',12)
ylabel('N_j','fontsize',12)
saveas(fig, 'plot1','jpg');
```



Exercise 1.1.7

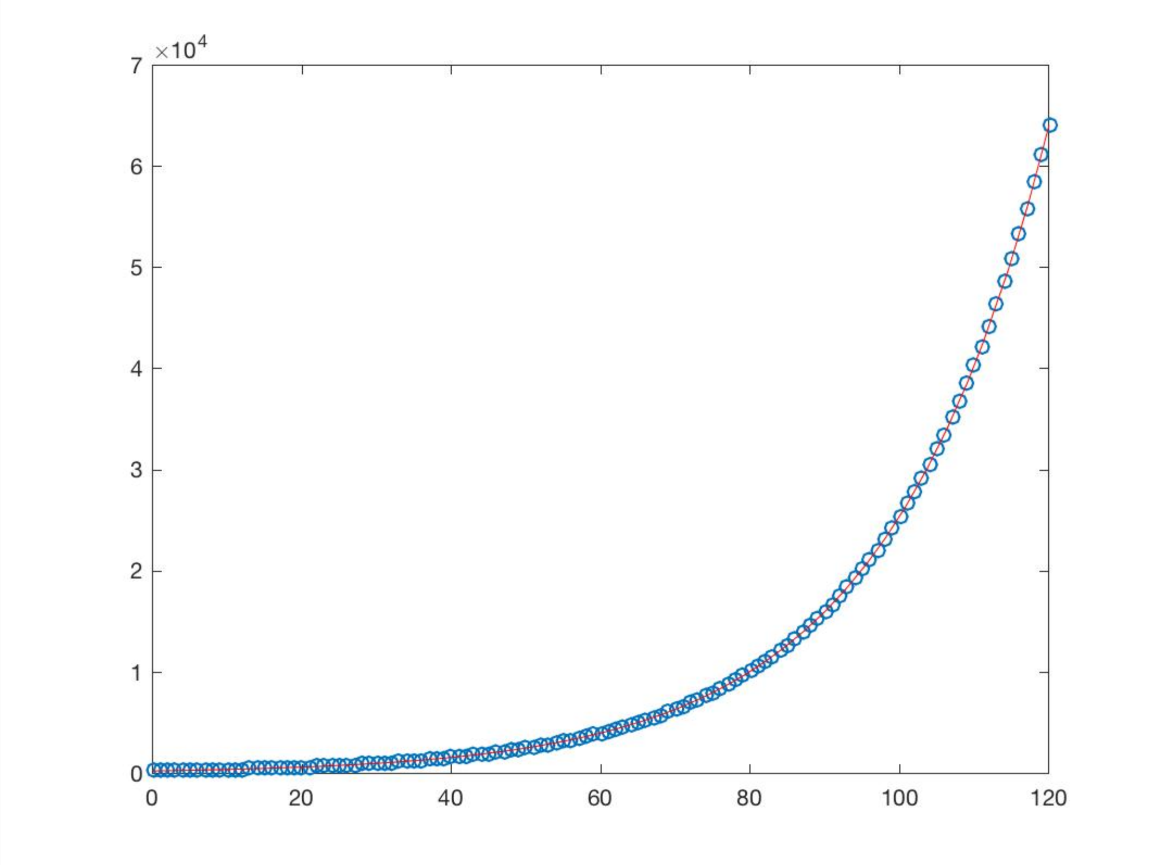
1. A colony of 250 *E-coli* bacteria has a reproductive cycle of 15 minutes. Its population growth can be modelled with the equivalent equations 1.1.3 and 1.1.5. What are the values of N_0 , R, and k for this colony?

```
syms N0 R
assume(R,'real')
assume(R>0)
R = solve( 2*N0 == N0*(1+R)^15, R)
%   R = 2^(1/15) - 1
eval (R)
%  0.0473

k = log(1+R)
eval (k)
%  0.0462
N_o = 250 % given in question
```

Therefore as shown above, $N_0 = 250$, $R = 0.0473$ and $k = 0.0462$.

2. Plot the population over 2 hours.

```
t2 = 0:1:120;
N2 = zeros(1, length(t2););
N2(1) = 250;
for j=2:length(t2);
     N2(j) = 1.0473*N2(j-1);
end

fig = figure;
plot(t2,N2,'o')
hold on
fun2 = @(t) 250*exp(log(1.0473)*t);
limits = [0 120];
fplot(fun2,limits,'r')
saveas(fig, 'plot2','jpg');
```



Exercise 1.1.9

1. A colony of 10,000 *E-coli* bacteria halves its population every hour. Write code to model the population.

```
fun = @(t) 10000*exp(-0.0116*t);
t = 0:420;
N = zeros (1,length(t));
N(1) = 10000;
for j=2:length(t)
    N(j)=0.5*N(j-1);
end
```

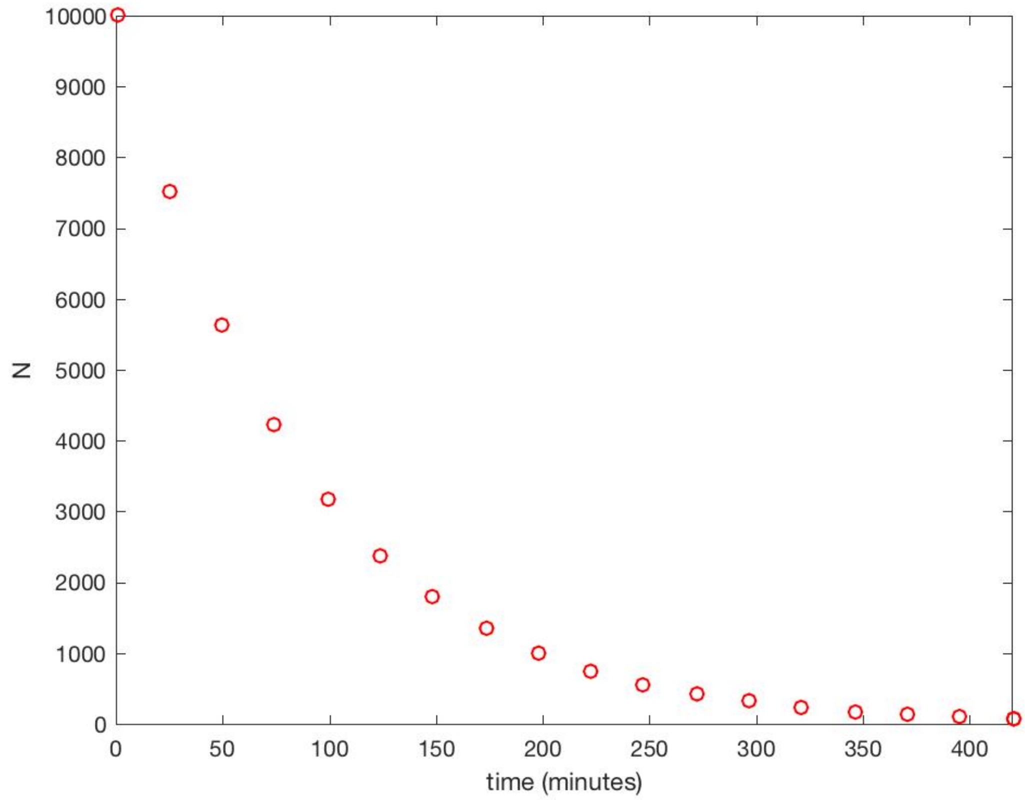
2. How many hours would it take for the number of bacterial to fall below 100 members?

```
line ([10,100],[100,100])
values_above_100 = find (N>100);
t_100 = time(values_above_100(end)+1)
% 7 minutes
```

   Therefore the colony would fall below100 members within 7 minutes.

3. Plot a graph showing how the population changes over this time

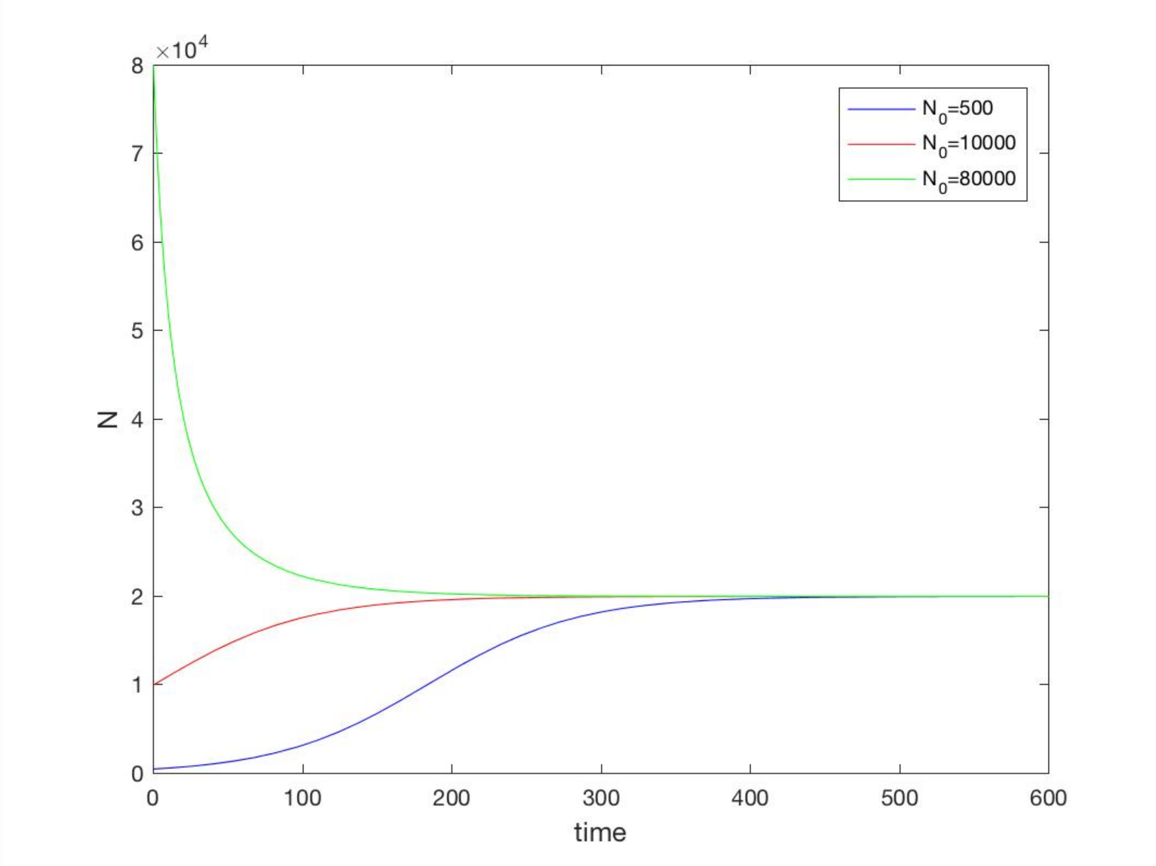
```
fig = figure;
limits = [0 420];
fplot(fun,limits, 'ro')
xlabel('time (minutes)')
ylabel('N')
saveas(fig, 'plot3','jpg');
```



Exercise 1.1.11

1. The population of a bacteria colony can be modeled by the logistic growth function with parameters $r_0 = 0.02$ and $K = 20000$. Write a MATLAB function to model the population and make a plot of the population over 10 hours for initial populations of 500, 10,000, and 80,000.

```
fun = @(t, r0, N0, K) K*N0*exp(r0*t)/(K-N0+N0*exp(r0*t));
fun1 = @(t) fun(t, 0.02, 500, 20000);
fun2 = @(t) fun(t, 0.02, 10000, 20000);
fun3 = @(t) fun(t, 0.02, 80000, 20000);
limits = [0 600];
fig = figure;
fplot(fun1,limits,'b')
hold on
fplot(fun2,limits,'r')
hold on
fplot (fun3,limits, 'g')
xlabel('time','fontsize',12)
ylabel('N','fontsize',12)
legend('N_0=500','N_0=10000','N_0=80000')
axis([-inf,600,0,80000])
saveas(fig, 'plot4','jpg');
```



2. Comment on the trend shown in the graph

   When the N_0 is lower than K, the population size slowly increases toward steady state, where $N = K$. Here the population is at its maximum capacity.

   On the other hand, if the N_0 is larger than K, the population size is much larger than its maximum capacity and as such the population quickly decreases in size towards its maximum capacity.

3. If r_0 is increased how do these plots change?

   As r_0 increases, the initial gradient of the graphs will become steeper as the population reaches steady state quicker. In the above example, the blue and red populations will show a marked, steeper increase in population towards the steady state while the green population will show a marked, steeper decline in population size towards the steady state.