Modeling and Simulation in MATLAB/GNU Octave 2019

Computer Lab 1:

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Exercise 1.

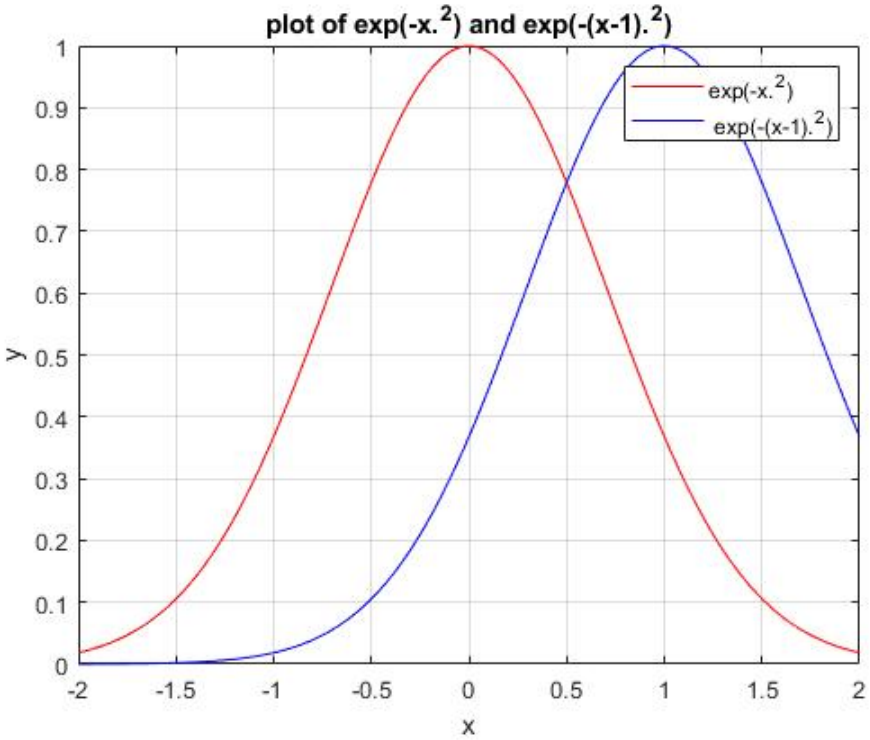
Modelling and simulation is used to calculate or predict an outcome in the real world in a computer model or as mentioned on wikipedia "a computer is used to build a mathematical model which contains key parameters of the physical model". An example of using modelling and simulation is presented by liu in an article about traffic modelling and simulations. The model includes different types of roads and the simulation creates different scenarios that are possible in the traffic.

Exercise 2a.

I enter the commands.

```
x = linspace(-2,2);
y = exp(-x.^2);

figure(1)
plot(x,y,'r')
hold on
grid on

y1 = exp(-(x-1).^2);
plot(x,y1,'b')

title('plot of exp(-x.^2) and exp(-(x-1).^2)')
xlabel('x')
ylabel('y')
legend( 'exp(-x.^2)',' exp(-(x-1).^2)')
```

Matlab plot.

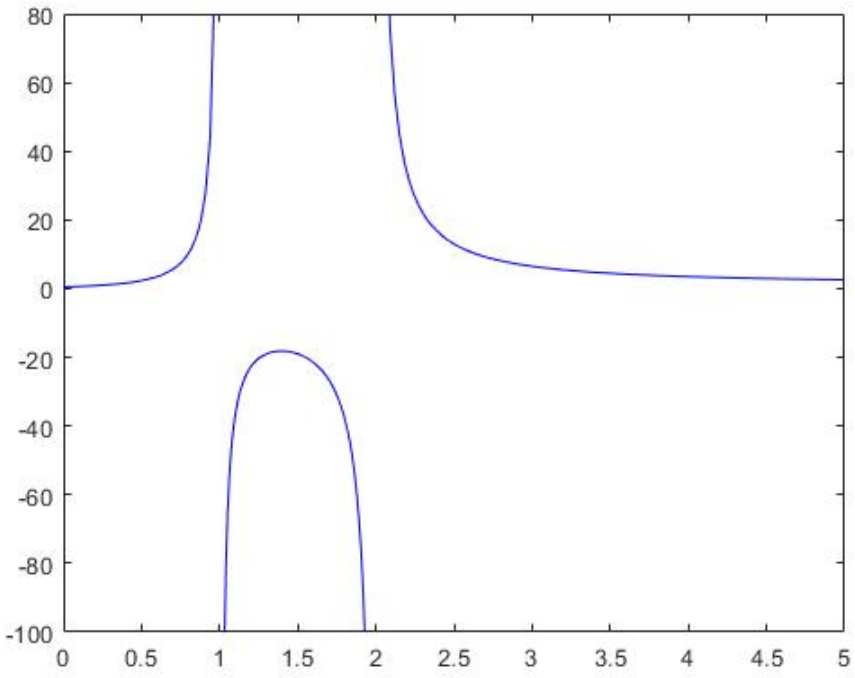


Exercise 2b.

I enter the commands.

```
x1 = linspace(-2,1);
x2 =linspace(1,2);
x3 = linspace(2,5);

y1 = ((x1.^2) + x1 + 1)./((x1-1).*(x1-2));
y2 = ((x2.^2) + x2 + 1)./((x2-1).*(x2-2));
y3 = ((x3.^2) + x3 + 1)./((x3-1).*(x3-2));
figure(2)
plot(x1,y1,'b',x2,y2,'b',x3,y3,'b')
axis([0 5 -100 80])
```

Matlab plot.



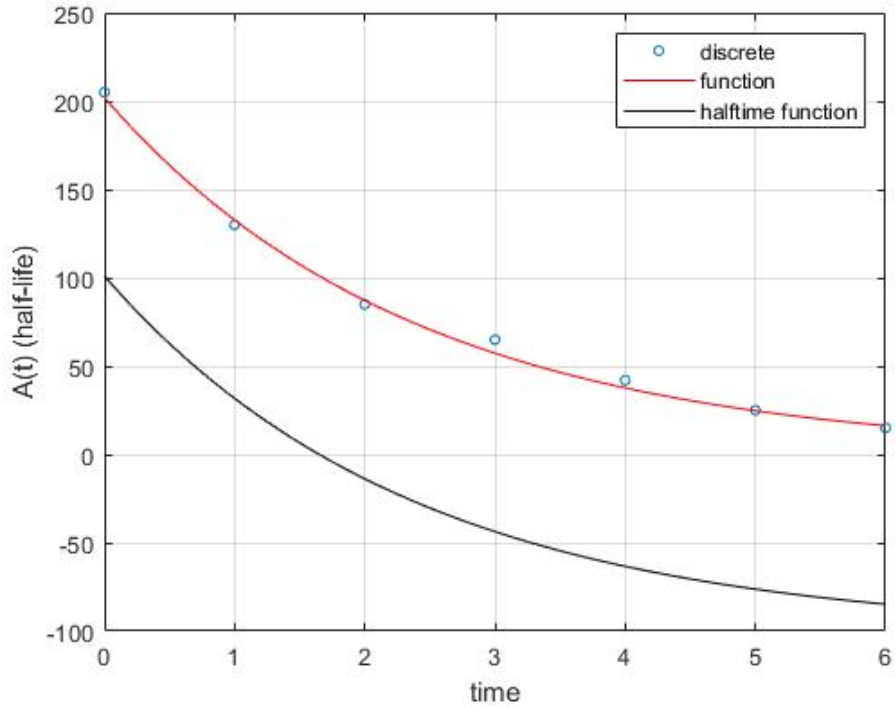
Exercise 3.

I enter the commands.

```
t = 0:0.06:6;
tdot = 0:1:6;
Adot = [205 130 85 65 42 25 15];

A = 202*exp(-0.42*t);
figure(3)
%discrete
plot(tdot,Adot,'o','markers',4)
grid on
hold on
xlabel('time')
ylabel('A(t) (half-life)')
%function
plot(t,A,'r')

%halftime
f = @(t) (202*exp(-0.42*t))-101;
y1 = f(t);
plot(t,y1,'k')
halftime_at_time = fzero(f, 101)
legend( 'discrete','function', 'halftime function')
```

Matlab answers.

```
halftime_at_time =

    1.6504
```


discrete
function
halftime function
A(t) (half-life)
time
250
200
150
100
50
0
-50
-100
0
1
2
3
4
5
6

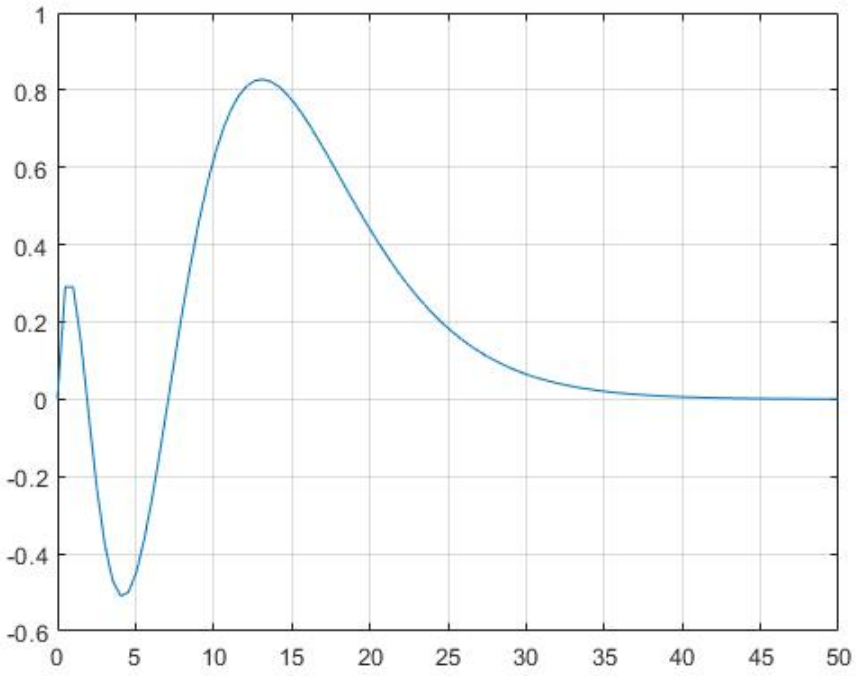
Exercise 4.

I enter the commands.

```
r = linspace(0,50);
P = @(r) r.*exp(-(r/3)).*(1 - ((2*r)/3) + ((2.*(r.^2))/27));
f = @(r) (r.*exp(-(r/3)).*(1 - ((2*r)/3) + ((2.*(r.^2))/27))).^2;
int_p = integral(P,0,inf);
A = sqrt(1/int_p)
y = P(r);
plot(r,y), grid on
r1 = fzero(P, 0)
r2 = fzero(P,1.8182)
r3 = fzero(P,6.969)
```

Matlab answers.

```
int_p =

    9.0000

A =

    0.3333

r1 =

     0

r2 =

    1.9019

r3 =

    7.0981
```

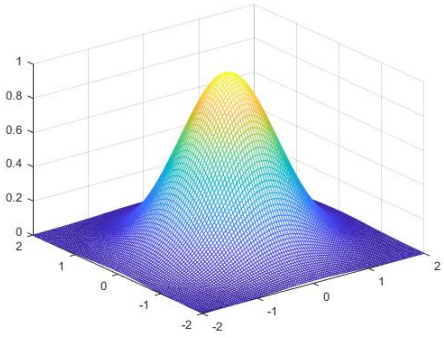

1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
0
5
10
15
20
25
30
35
40
45
50

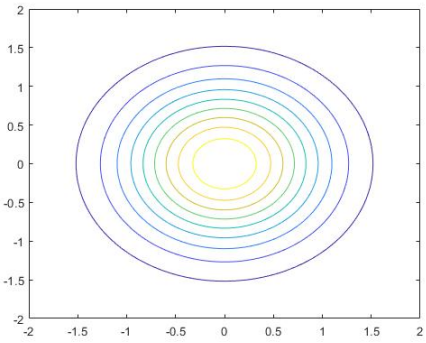
Exercise 5.

I enter the commands.

```
x = linspace(-2,2);
y = linspace(-2,2);
[X,Y] = meshgrid(x,y);
Z = exp(-(X.^2 + Y.^2));
figure(5)
mesh(X,Y,Z)
figure(6)
contour(X,Y,Z)
```

Matlab plot.



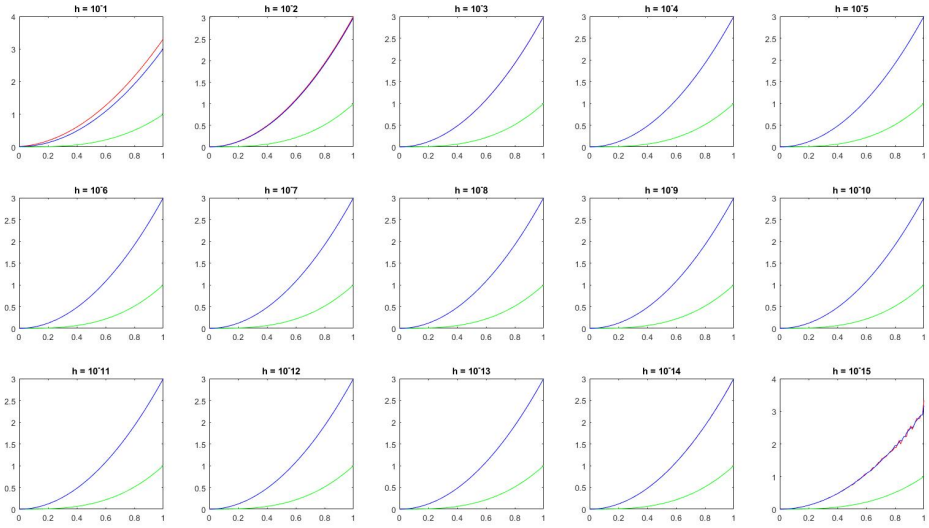


Exercise 6.

I enter the commands.

```
f = @(x) x.^3;
x = linspace(0,1);
y = f(x);

for a = 1:15
    subplot(3,5,a)
    plot(x,y,'g')
    hold on;
    h = 10^(-a);
    df = (f(x+h)-f(x))./h;
    df2 = (f(x+h)-f(x-h))./(2*h);
    plot(x,df,'r',x,df2,'b')
    title("h = 10^" + -a)
end
```

Matlab answers.



PART 2. Exercise 1a.

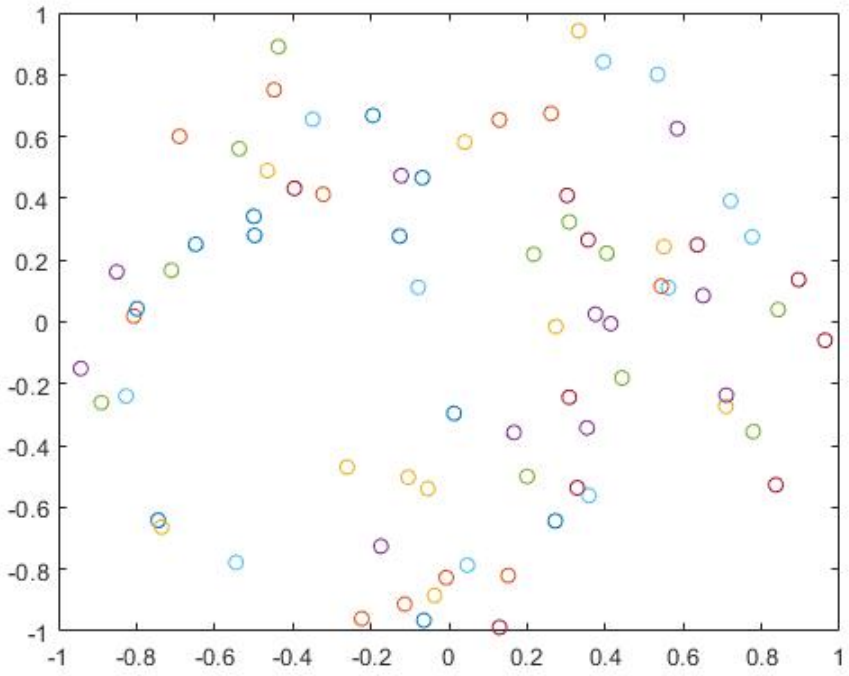
I enter the commands.

```
%throwarrows.m
n = input('enter amount of throws');

x = -1 + 2*rand(1,n);
y = -1 + 2*rand(1,n);
targetCalc = target(x,y,n)
cirkelnsArea = pi

%target.m
function hits = target(x,y,n);
hits = 0;
    for i = 1:n
        if(((x(i)).^2 + (y(i)).^2) < 1)
         %if((((x(i).^2)./(a.^2)) + (y(i).^2)./(b.^2)) <= 1)
             plot(x(i),y(i),'o')
             hold on
            hits = hits + 1;
        end
    end
    hits = 2*2*hits
end
```

Matlab answers.

```
hits =

   304


targetCalc =

   304


cirkelnsArea =

    3.1416
```

Matlab plot 100 throws.

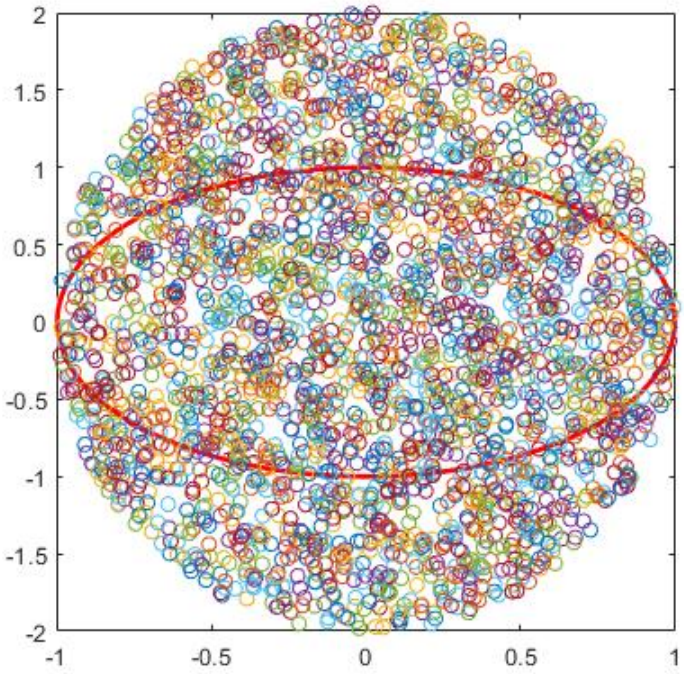

1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1

Exercise 1b.

I enter the commands.

```
%throwarrows.m
n = input('enter amount of throws');
a = input('enter width of target');
b = input('enter height of target');

    centers = [0 0];
    radii = a;
    axis square
    viscircles(centers,radii);

x = -a + 2*a*rand(1,n);
y = -b + 2*b*rand(1,n);
targetCalc = target(x,y,n,a,b)
cirkelnsArea = (a./2)*(b./2)*pi

%target.m
function hits = target(x,y,n,a,b);
hits = 0;

    for i = 1:n
        %if(((x(i)).^2 + (y(i)).^2) < 1)
         if((((x(i).^2)./(a.^2)) + (y(i).^2)./(b.^2)) <= 1)

             plot(x(i),y(i),'o')
             xlim([-a a]);
             ylim([-b b]);
             pause(0.1)
             hold on
            hits = hits + 1;
        end
    end
    hits = ((a*b) * hits/n);
end
```

Matlab plot.

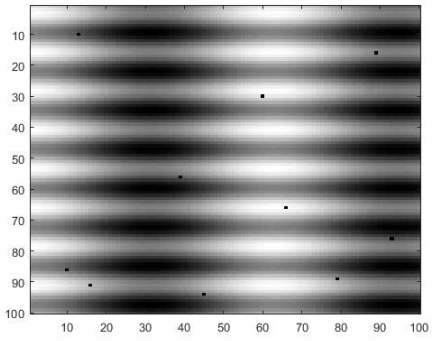

2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
-1
-0.5
0
0.5
1

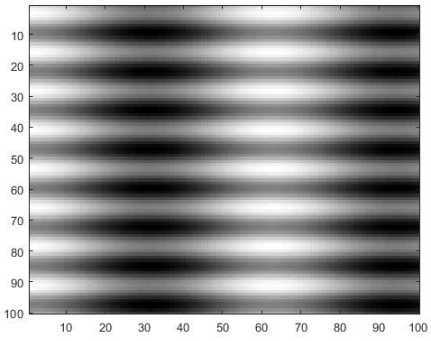
Exercise 2.

I enter the commands.

```
%a
load('CCD.MAT');
%b

figure(1)
imagesc(C,[3,7])
colormap('gray')
%c
for i = 2:99
    for j = 2:99
        if((C(i,j) == 0))
            C(i,j) = median(median(C(-1+i:i+1,-1+j:1+j)));
        end
    end
end
figure(2)
imagesc(C,[3,7])
colormap('gray')
```

Matlab plot.





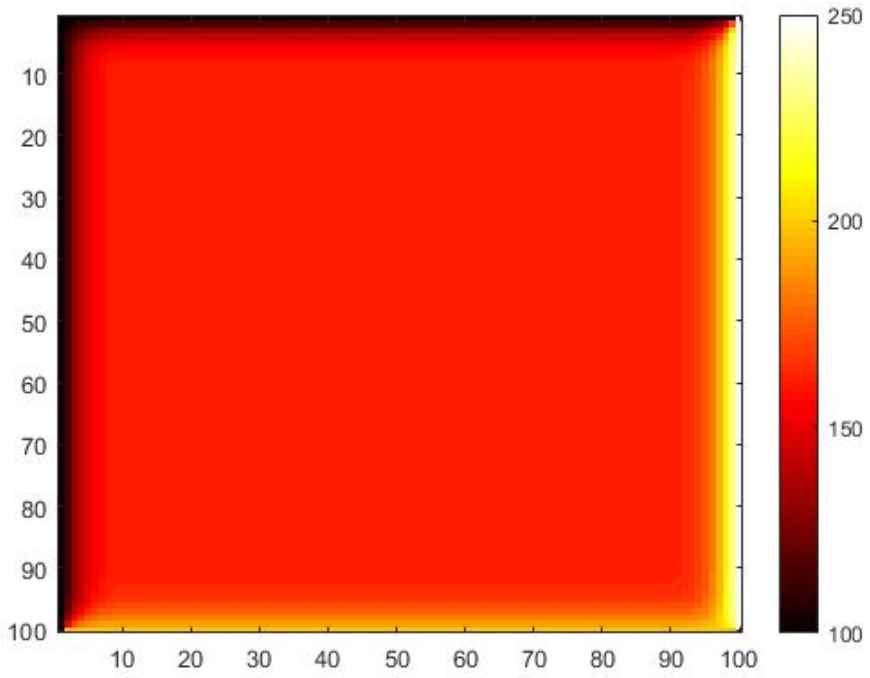
Exercise 3.

I enter the commands.

```
tol = input(' Give value of tol ')
T0 = (650/4)*ones(100,100); % initial distribution T0
T0(1,:) = 100;
T0(100,:) = 200; % set edge temp
T0(:,1) = 100;
T0(:,100) = 250; % set edge temp
T1 = T0; % dimension T1
diff = Inf; % make sure to enter the loop
while diff > tol
    diff = 0; % set max difference to 0
    for i = 2:99
        for j = 2:99
            if (i > 49 && j > 29) && (i < 70 && j < 50)

            else
                T1(i,j)=(T0(i+1,j)+T0(i-1,j)+T0(i,j+1)+T0(i,j-1))/4;
                if abs(T1(i,j) - T0(i,j)) > diff
                    diff = T1(i,j) - T0(i,j); % Update difference
                end
            end
        end
    end
    imagesc(T1) % plot temp. distribution
    colormap('hot'), colorbar % color sclae
    pause(0.1)
    T0 = T1; % uppdate temp. distribution
end
```

```
tol =

    0.0100
```

Matlab plot.

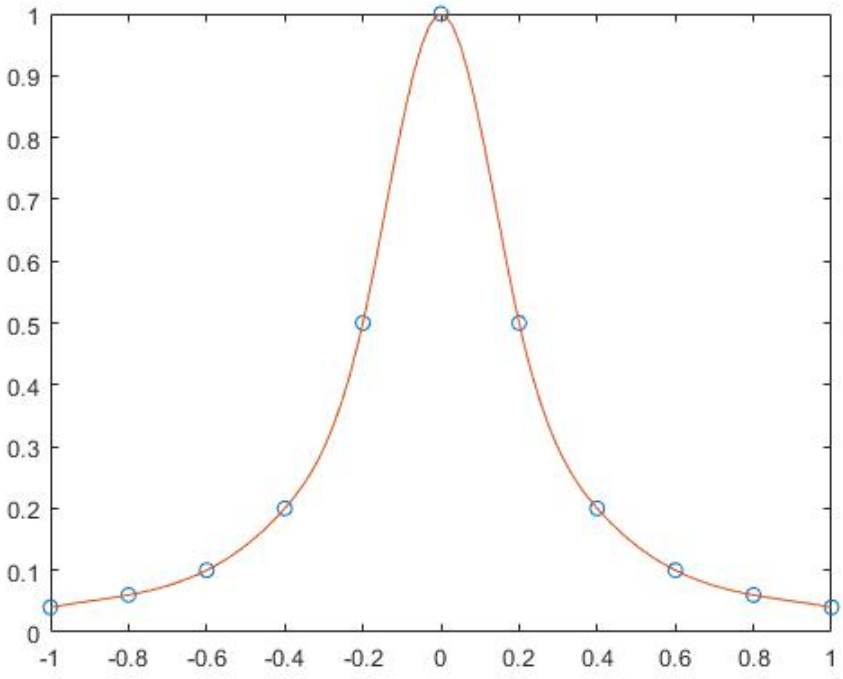

10
20
30
40
50
60
70
80
90
100
10
20
30
40
50
60
70
80
90
100
250
200
150
100

DEL 3. Exercise 1.

I enter the commands.

```
x = -1:0.2:1;
y = [0.04 0.06 0.1 0.2 0.5 1 0.5 0.2 0.1 0.06 0.04];
xip = linspace(-1,1); % x-values between -1 and 1
yip = interp1(x,y,xip,'spline');
plot(x,y,'o',xip,yip)
```

Matlab plot.



Exercise 3.

I enter the commands.

```
load('aktivitet.mat');
a0 = [5000 ; 0.05 ; 20000 ; 0.1];
format long
[a,n] = gaussnewton(@fun,@dfun,a0,t,y,1e-5)

%dfun.m
function df = dfun(a,t)
dfa1 = exp(-a(2)*t);
dfa2 = -a(1)*t.*exp(-a(2)*t);
dfa3 = exp(-a(3)*t);
dfa4 = -a(3)*t.*exp(-a(4)*t);
df = [dfa1 dfa2 dfa3 dfa4];
end

%fun.m
function f = fun(a,t)
f = a(1)*exp(-a(2)*t) + a(3)*exp(-a(4)*t);
end
```

Matlab answers.

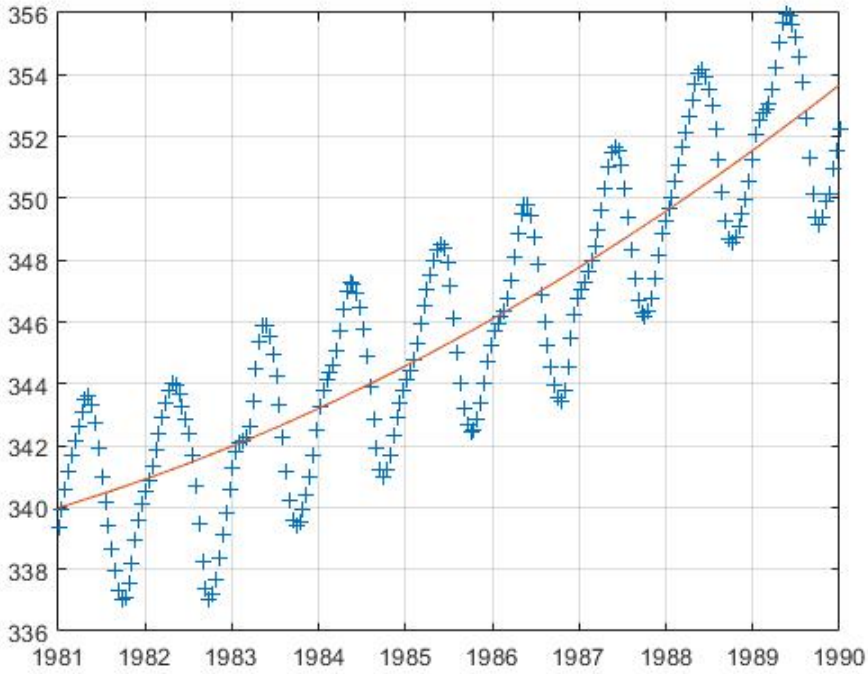
```
a =

   1.0e+04 *

   0.564160483064775
   0.000003339472104
   1.767389987183404
   0.000017116972022


n =

    20
```

Exercise 4 i.

I enter the commands.

```
%a
load('co2.data');
%b
x = linspace(1981,1990,234);
y = co2;
plot(x,co2,'+')
hold on
grid on

%c
%i
t = linspace(1981,1990,234);
y = co2;

a = polyfit(x.',co2,2);
y = a(1) + a(2)*t + a(3)*(t.^2);

xm = linspace(1981,1990,234);
ym = polyval(a,xm);
plot(xm,ym)
```

Matlab plot.


356
354
352
350
348
346
344
342
340
338
336
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990

Exercise 4 ii.

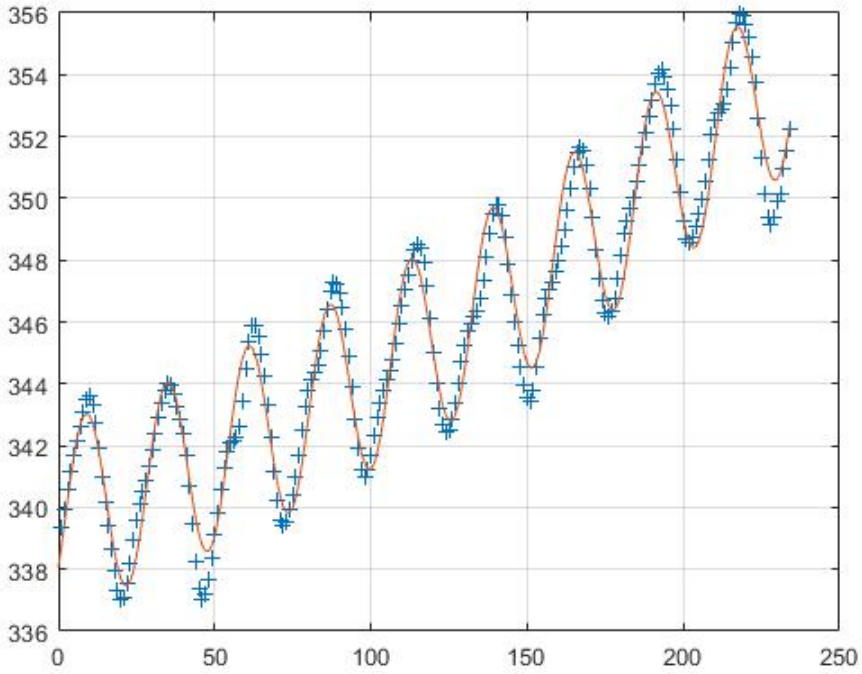
I enter the commands.

```
%a
load('co2.data');
%b
x = linspace(1981,1990,234);
y = co2;
plot(x,co2,'+')
hold on
grid on

%c
%i
t = linspace(1981,1990,234);
y = co2;

a = polyfit(x.',co2,2);
y = a(1) + a(2)*t + a(3)*(t.^2);

xm = linspace(1981,1990,234);
ym = polyval(a,xm);
plot(xm,ym)
```

Matlab answers.

```
a =

   1.0e+02 *

   3.396904594167922
   0.000343784467235
   0.000001141421962
   0.025561974892270
  -0.016281698560505
```

Matlab plot.


356
354
352
350
348
346
344
342
340
338
336
0
50
100
150
200
250

Exercise 4 iii.

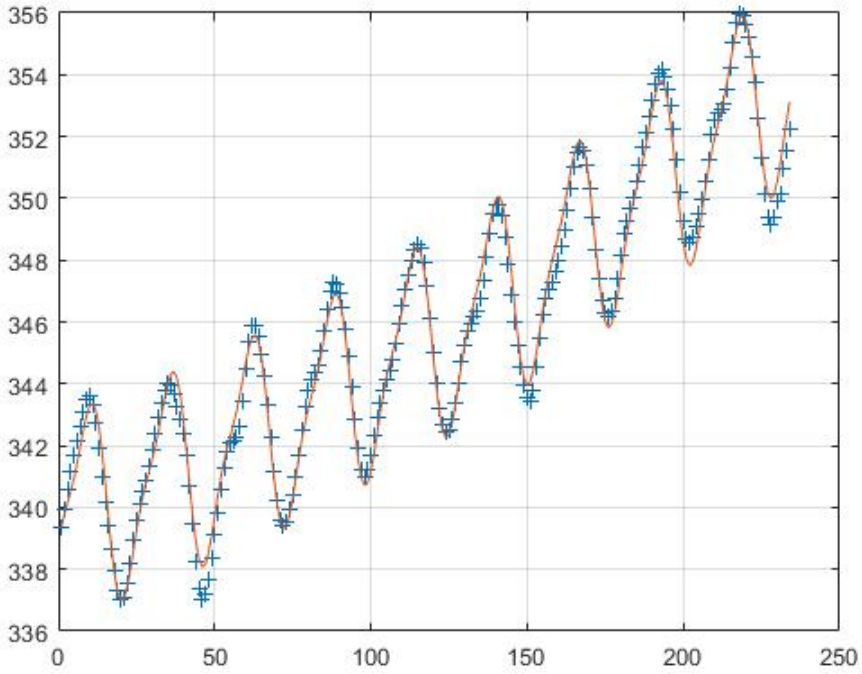
I enter the commands.

```
load('co2.data');
t =  linspace(1,234,234);
plot(t,co2,'+')
hold on
grid on

t = t.';
y = co2;

x = (linspace(1,234,234)')
k = (18*pi)./234;
A = [x.^0 x.^1 x.^2 sin(k.*t) cos(k.*t) sin(2*k.*t) cos(2*k.*t)];
a = A\y
xm = linspace(1,234,234);
ym = a(1)*xm.^0 + a(2)*xm.^1 + a(3)*xm.^2 + a(4)*sin(k*xm)
+ a(5)*cos(k*xm) + a(6)*sin(2*k*xm) + a(7)*cos(2*k*xm);

plot(xm,ym)
```

Matlab answers.

```
a =

   1.0e+02 *

   3.397087009783377
   0.000342805135033
   0.000001137755814
   0.025546844099963
  -0.016279609018161
  -0.002150470229092
   0.007948032784944
```

Matlab plot.


356
354
352
350
348
346
344
342
340
338
336
0
50
100
150
200
250

Exercise 4 d.

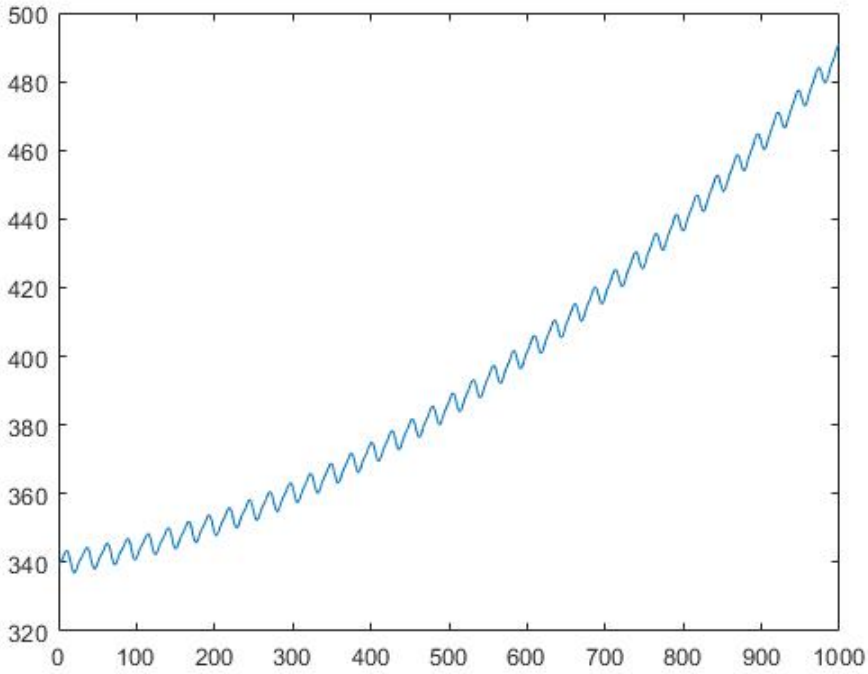
I enter the commands.

```
load('co2.data');
x =  [linspace(1,234,234)]';
y = co2;
k = (18*pi)./234;
A  = [x.^0 x.^1 x.^2 sin(k*x) cos(k*x) sin(2*k*x) cos(2*k*x)];
a = A\y

xm = linspace(1,1000,1000);
ym = a(1)*xm.^0 + a(2)*xm.^1 + a(3)*xm.^2 + a(4)*sin(k*xm) + a(5)*cos(k*xm) + a(
spl = interp1(xm,ym,xm,'spline');
plot(xm, spl)
t = 817;
st = spl(817)
y1 = a(1)*t.^0 + a(2)*t.^1 + a(3)*t.^2 + a(4)*sin(k*t) + a(5)*cos(k*t)
+ a(6)*sin(2*k*t) + a(7)*cos(2*k*t)
```

Matlab answers.

```
a =

   1.0e+02 *

   3.397087009783377
   0.000342805135033
   0.000001137755814
   0.025546844099963
  -0.016279609018161
  -0.002150470229092
   0.007948032784944


st =

     4.469170183248435e+02


y1 =

     4.469170183248435e+02
```

Matlab plot.


500
480
460
440
420
400
380
360
340
320
0
100
200
300
400
500
600
700
800
900
1000

Exercise 5a.

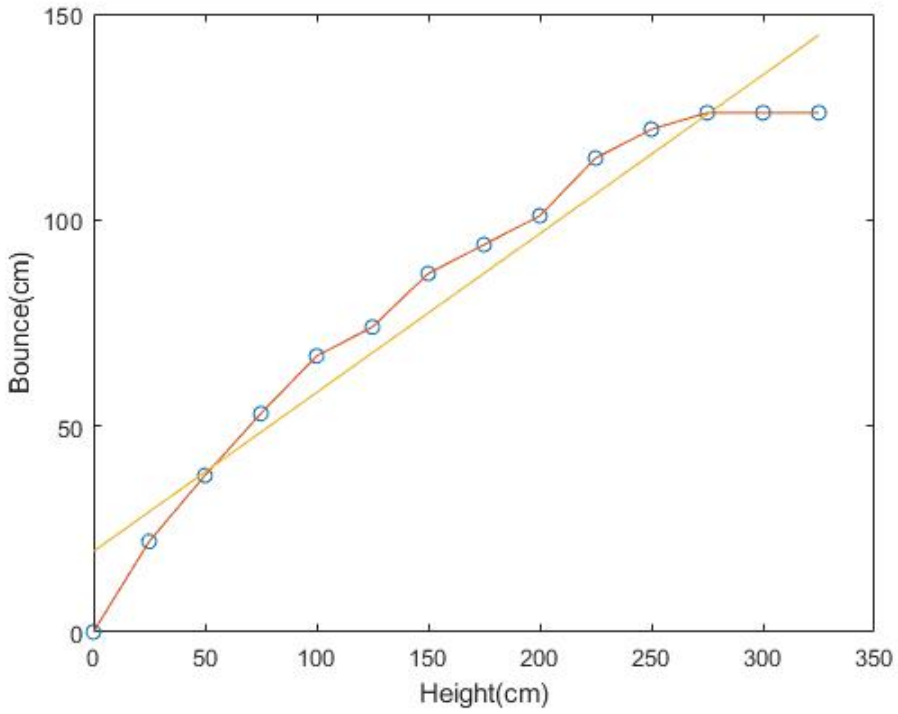
I enter the commands.

```
x = [0 25 50 75 100 125 150 175 200 225 250 275 300 325]';
y = [0 22 38 53 67 74 87 94 101 115 122 126 126 126]';

plot(x,y,'o',x,y)
hold on
xlabel('Height(cm)')
ylabel('Bounce(cm)')
%b
A = [x.^1 x.^0];
a = A\y
xm = linspace(0,325);
ym = a(1)*xm.^1 + a(2)*xm.^0;
plot(xm,ym)
```

Matlab answers.

```
a =

   0.385494505494505
  19.571428571428566
```

Matlab plot.



Exercise 5c.

I enter the commands.

```
t = [0 25 50 75 100 125 150 175 200 225 250 275 300 325]';
y = [0 22 38 53 67 74 87 94 101 115 122 126 126 126]';

a0 = [1 ; 0.005];
[a,n] = gaussnewton(@fun,@dfun,a0,t,y,1e-5)
yplot = a(1)*t ./(1+a(2)*t);
%f
maxheight = (a(1)/a(2))
plot(t,y,'o',t,yplot)
xlabel('Release')
ylabel('Bounce')
title('Table tennis ball release')
```

Matlab answers.

```
a =

   0.918393544877750
   0.003878636824902

n =

     4

maxheight =

     2.367825569492288e+02
```

Matlab plot.

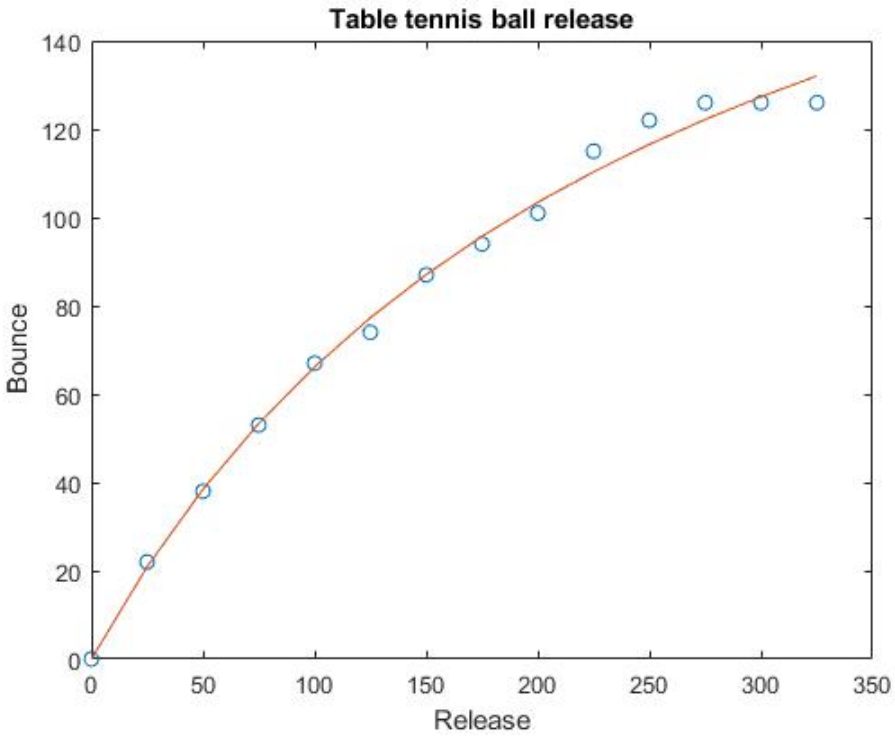


Table tennis ball release
Bounce
Release
0
20
40
60
80
100
120
140
0
50
100
150
200
250
300
350

0.1 Website

- Wikipedia Contributor.2018.*Modeling and simulation.*Wikipedia
  https://en.wikipedia.org/wiki/Modeling$_a nd_s imulation$
  ($H\ddot{a}mtad 2019-12-11$)

  Traffic Modeling and Simulation .liu.
  $https://liu.se/en/research/traffic-modelling-and-simulation$
  ($H\ddot{a}mtad 2019-12-11$)