Kathmandu University

Department of Computer Science and Engineering

Dhulikhel, Kavre

Lab 1,2,3,4,5

of

Digital Signal Processing

[Code No.: COMP 407]

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Purpose:

A. To study necessary commands of MATLAB software: clc, close, xlabel, ylabel, zlabel, title, figure, subplot, linespace, stem, bar, plot, Colon, Operator.

Solutions:

Clc command : Clears screen

```
octave:1> x = [1,2,3]
x =

   1   2   3

octave:2> y = [ 2,3,4]
y =

   2   3   4

octave:3> clc
```

Output:

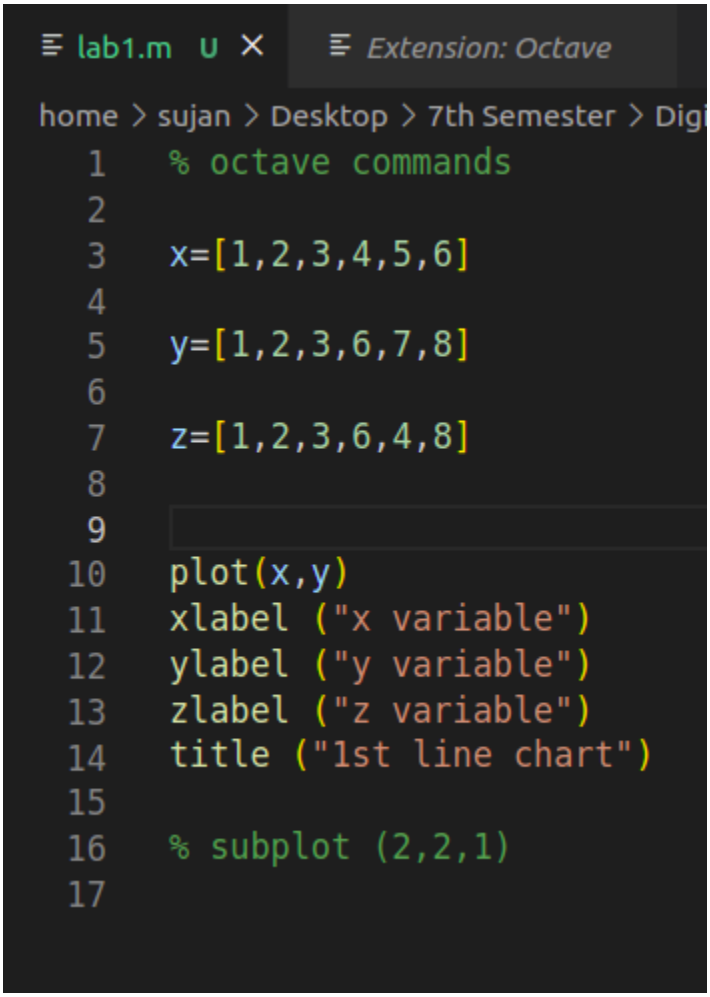
```
TERMINAL  ···   octave-gui - Digital signal processing  +
octave:4>
```

xlabel, ylabel, zlabel, title, figure, plot: For drawing graphs

xlabel = X-axis label

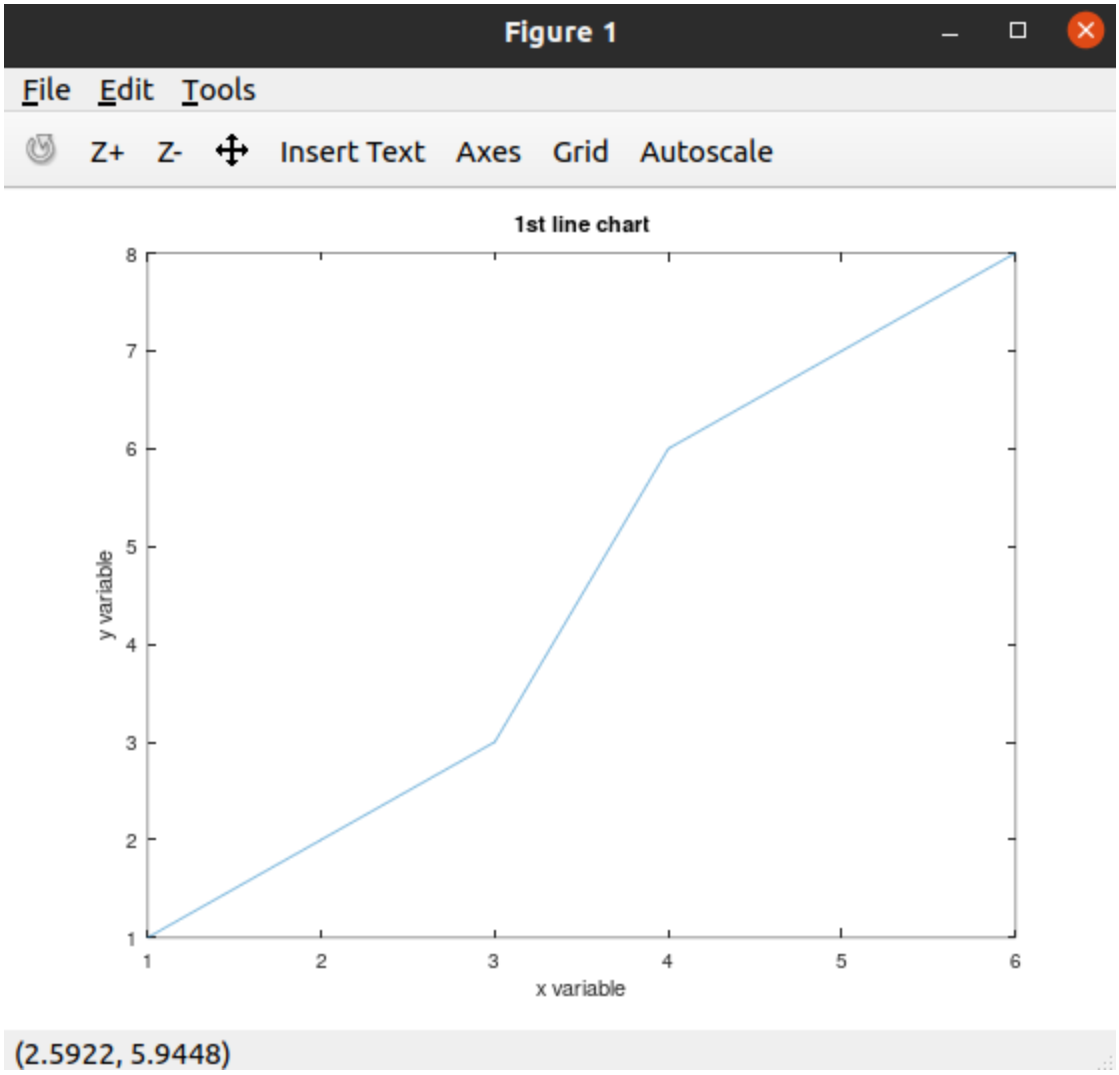
ylabel = Y-axis label

zlabel = Z-axis label
title: title of the figure
Figure: Create a new figure window for plotting.
plot(x,y) = plots the set of lists of data points from x and y as x and y axis respectively.



Output:

```
Read https://www.octave.org/bugs.html to learn how to submit
bug reports.
For information about changes from previous versions, type 'n
ews'.

x =

   1   2   3   4   5   6

y =

   1   2   3   6   7   8

z =

   1   2   3   6   4   8

octave:1>
```



Close command: closes the plot

```
octave:1> close
```

Output: Figure 1 window is closed.

linspace: For creating equal-spaced intervals.

```
octave:3> linspace(1,10,10)
```

Output:

```
octave:3> linspace(1,10,10)
ans =

    1    2    3    4    5    6    7    8    9   10

octave:4>
```

Subplot: used to create different areas in the same window for plotting.

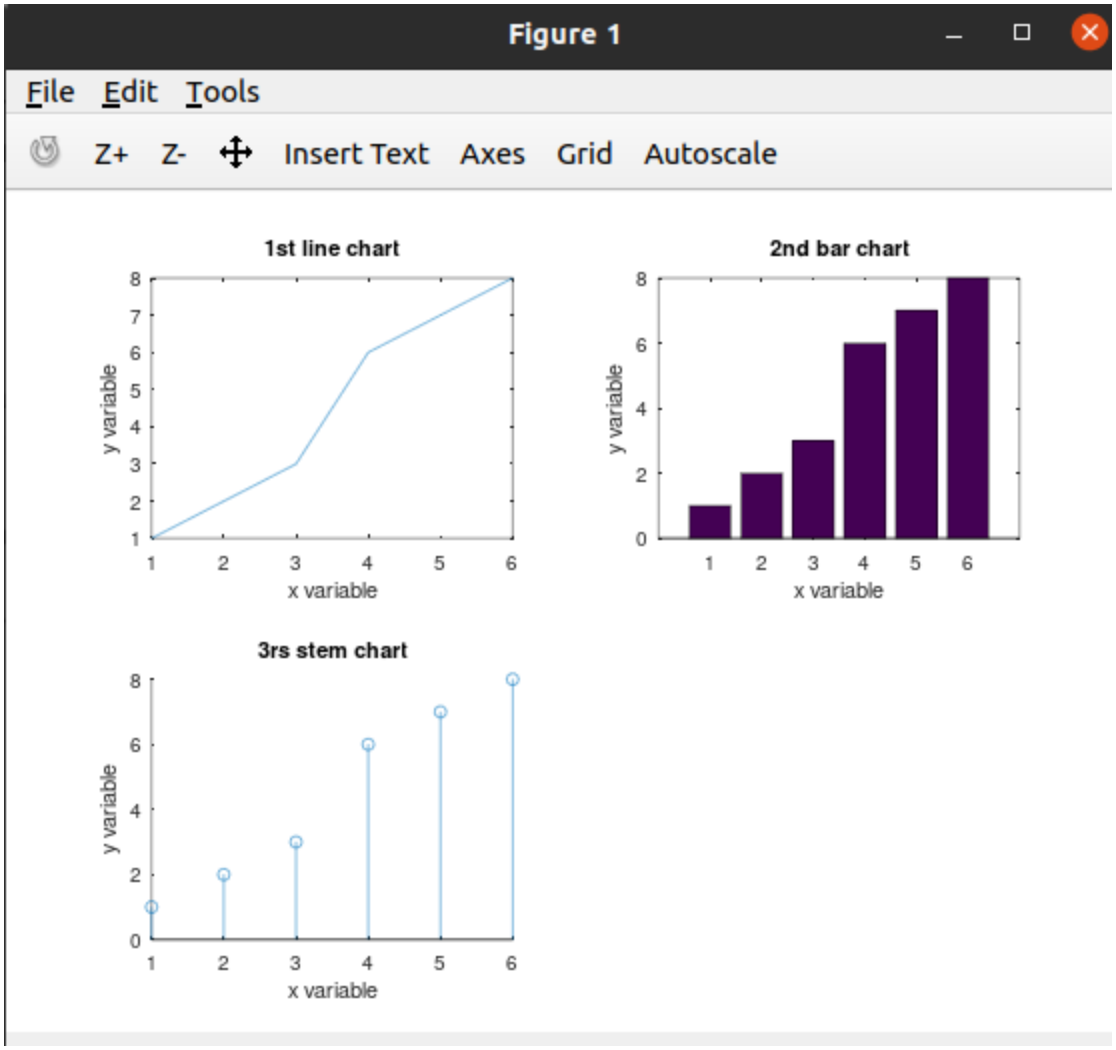
stem, bar, plot, Colon Operator.

lab1.m U ✕ Extension: Octave

home > sujan > Desktop > 7th Semester > Digital si

```
% octave commands

x=[1,2,3,4,5,6]

y=[1,2,3,6,7,8]

z=[1,2,3,6,4,8]

subplot(2,2,1)
plot(x,y)
xlabel ("x variable")
ylabel ("y variable")
zlabel ("z variable")
title ("1st line chart")

subplot(2,2,2)
bar(x,y)
xlabel ("x variable")
ylabel ("y variable")
zlabel ("z variable")
title ("2nd bar chart")


subplot(2,2,3)
stem(x,y)
xlabel ("x variable")
ylabel ("y variable")
zlabel ("z variable")
title ("3rs stem chart")

```

Output:



Colon operator:

Creates a list of numbers by start: increment: end

```
octave:5> a = 1:3:22
a =

    1    4    7   10   13   16   19   22

octave:6>
```

B. Familiarisation with the MATLAB environment.

a. Create a matrix, A of size 3*4. Create another matrix, B of size 4*3.

lab1.m U lab1b.m

home > sujan > Desktop > 7th Semester > Digital signal processing > lab1b.m

```
1
2   x = [1,2,3,4  ; 2,3,4,5 ; 4,5,6,7]
3   y = [1,2,3 ; 2,3,4 ; 4,5,6 ; 7,8,9]
4
5   size(x)
6   size (y)
7
8
9
```

Output:

```
x =

   1   2   3   4
   2   3   4   5
   4   5   6   7

y =

   1   2   3
   2   3   4
   4   5   6
   7   8   9

ans =

   3   4

ans =

   4   3
```

b. Add Matrix A and B. Subtract A from B.

Addition

```
x = [1,2,3,4  ; 2,3,4,5 ; 4,5,6,7]
y = [1,2,3 ; 2,3,4 ; 4,5,6 ; 7,8,9]

plus(x,y)
```

Output:

```
x =

   1   2   3   4
   2   3   4   5
   4   5   6   7

y =

   1   2   3
   2   3   4
   4   5   6
   7   8   9

error: plus: operator +: nonconformant arguments (op1 is 3x4, op2 is 4x3)
error: called from
    lab1b at line 5 column 1
octave:1>
```

Error because the dimension of A and B don't match.

Subtraction :

```
home > sujan > Desktop > 7th Semester > Digital signal processing >
1
2   x = [1,2,3,4  ; 2,3,4,5 ; 4,5,6,7]
3   y = [1,2,3 ; 2,3,4 ; 4,5,6 ; 7,8,9]
4
5   minus(x,y)
```

```
x =

   1   2   3   4
   2   3   4   5
   4   5   6   7

y =

   1   2   3
   2   3   4
   4   5   6
   7   8   9

error: minus: operator -: nonconformant arguments (op1 is 3x4, op2 is 4x3)
error: called from
    lab1b at line 5 column 1
octave:1>
```

Error because the dimension of A and B don't match.

c. Multiply A and B. Multiply B and A [Errors Reason ?].

```
home > sujan > Desktop > 7th Semester > Digital signal processing > lab1b.m
1
2   x = [1,2,3,4  ; 2,3,4,5 ; 4,5,6,7]
3   y = [1,2,3 ; 2,3,4 ; 4,5,6 ; 7,8,9]
4
5   x*y
6
7
```

Output:

```
x =

   1   2   3   4
   2   3   4   5
   4   5   6   7

y =

   1   2   3
   2   3   4
   4   5   6
   7   8   9

ans =

    45    55    65
    59    73    87
    87   109   131

octave:1>
```

d. Transpose matrix A and B. Multiply the transposed matrices.

```
x = [1,2,3,4  ; 2,3,4,5 ; 4,5,6,7]
y = [1,2,3 ; 2,3,4 ; 4,5,6 ; 7,8,9]

x= x'
y= y'

x*y
```

Output:

```
x =

   1   2   3   4
   2   3   4   5
   4   5   6   7

y =

   1   2   3
   2   3   4
   4   5   6
   7   8   9

x =

   1   2   4
   2   3   5
   3   4   6
   4   5   7

y =

   1   2   4   7
   2   3   5   8
   3   4   6   9

ans =

    17    24    38    59
    23    33    53    83
    29    42    68   107
    35    51    83   131
```

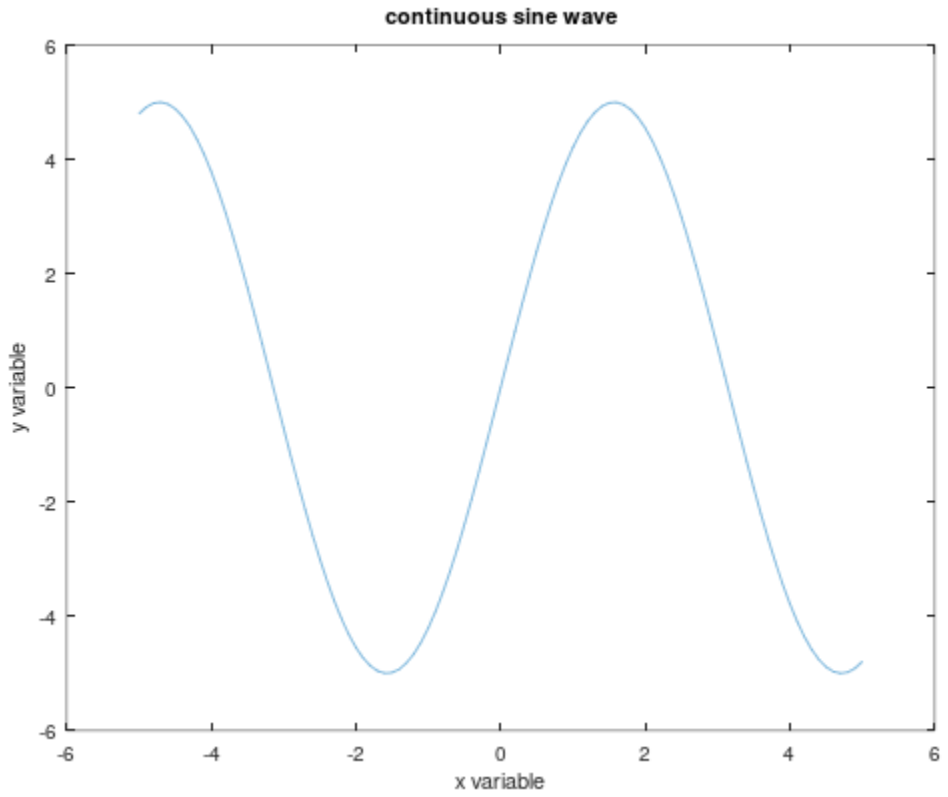
Purpose:

A. Generate a continuous time sinusoidal wave of amplitude 5.

Code:

```
x = [-5:.1:5]
y = 5*sin(x)

plot(x,y)

xlabel ("x variable")
ylabel ("y variable")
title ("continuous sine wave")

```

Output

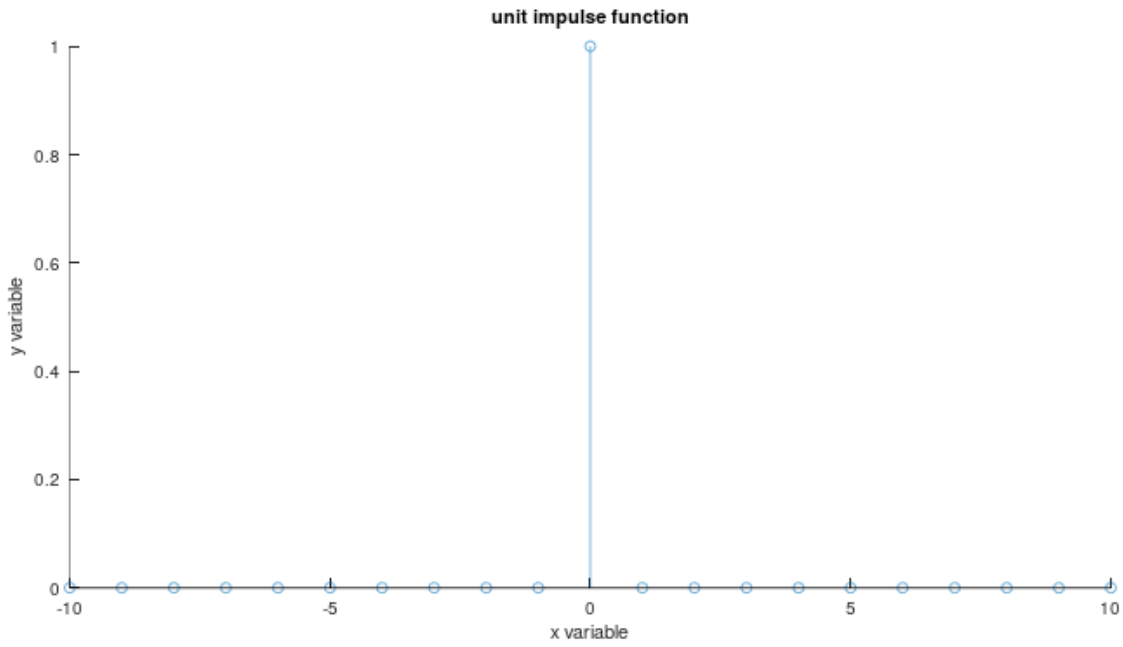


B. Generate a unit impulse function.

Code:

```
t= [-10:1:10];
del =[zeros(1,10), ones(1,1), zeros(1,10)];
stem(t,del)
xlabel ("x variable")
ylabel ("y variable")
title ("unit impulse function")
```

Output:

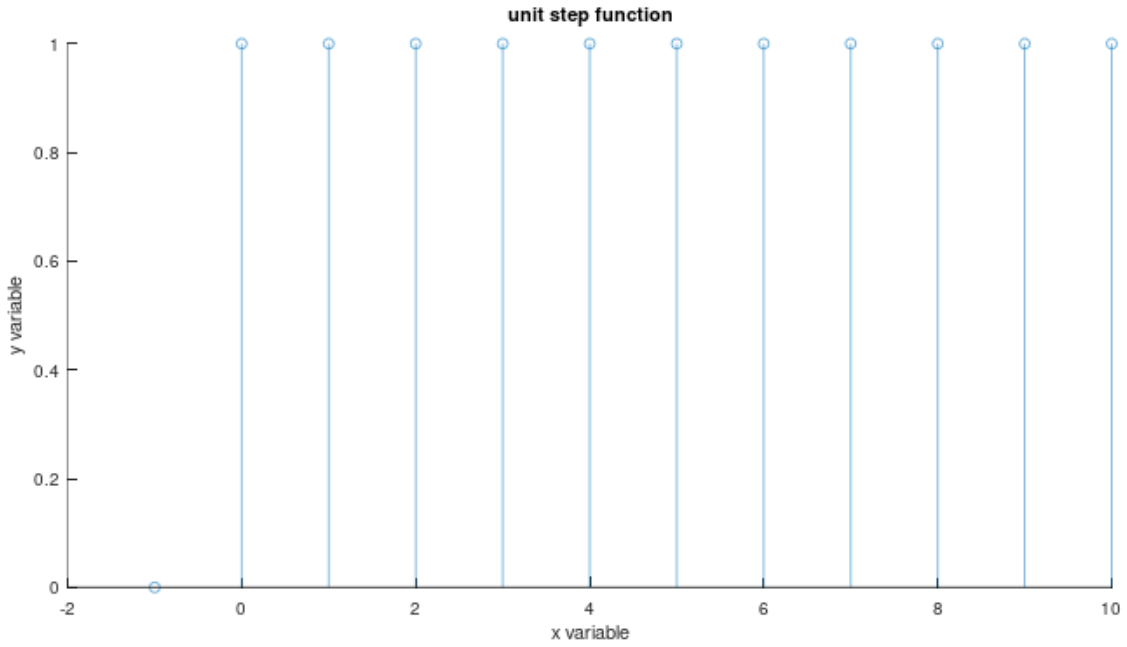


C. Generate a unit step function.

Code:

```
e= [-1:1:10];
del2 = e>=0   %1 when 3>= 0
stem(e,del2)
xlabel ("x variable")
ylabel ("y variable")
title ("unit step function")
```

Output:

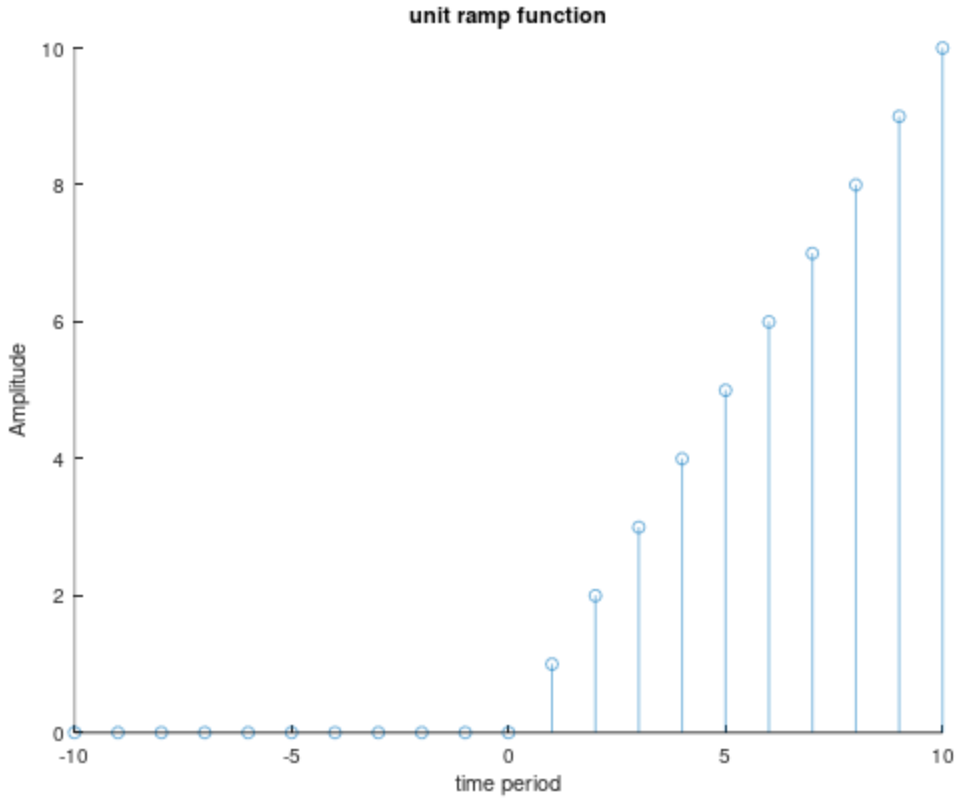


D. Generate a unit ramp function.

Code:

```
e= [-10:1:10];
del2 = (e>=0).*e   %1 when 3>= 0
stem(e,del2)
xlabel ("time period")
ylabel ("Amplitude")
title ("unit ramp function")
```

Output:

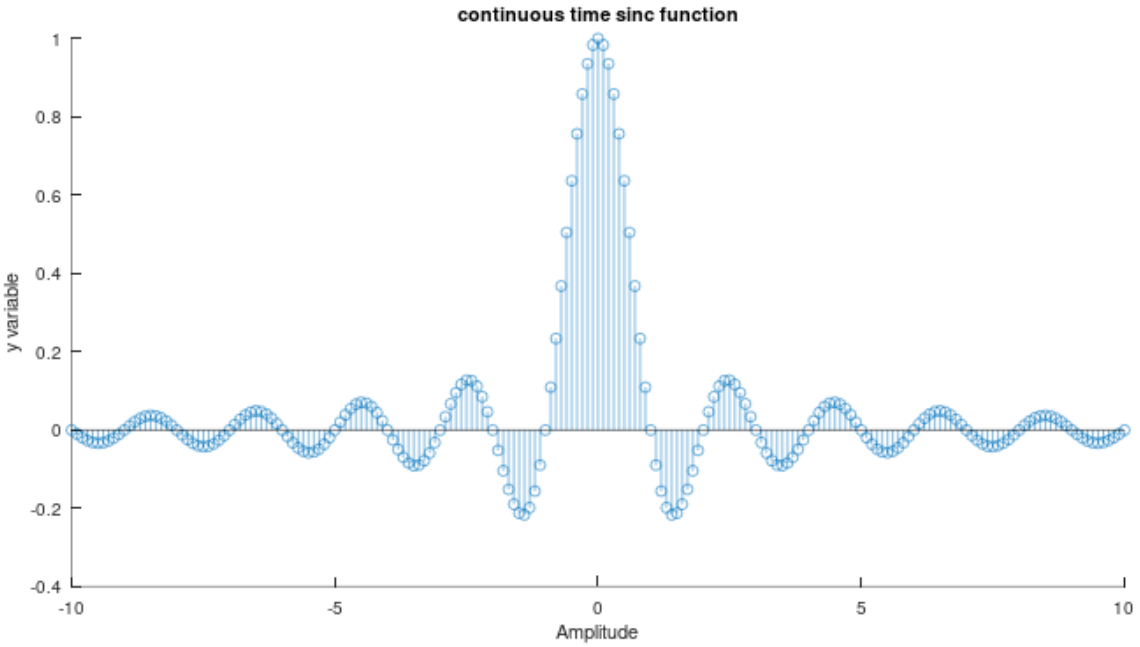


E. Generate a continuous time sinc function

Code:

```
xa= [-10:0.1:10];
ya = sinc(xa)
stem(xa,ya);
xlabel ("Amplitude");
ylabel ("y variable");
title ("continuous time sinc function");
```

Output:

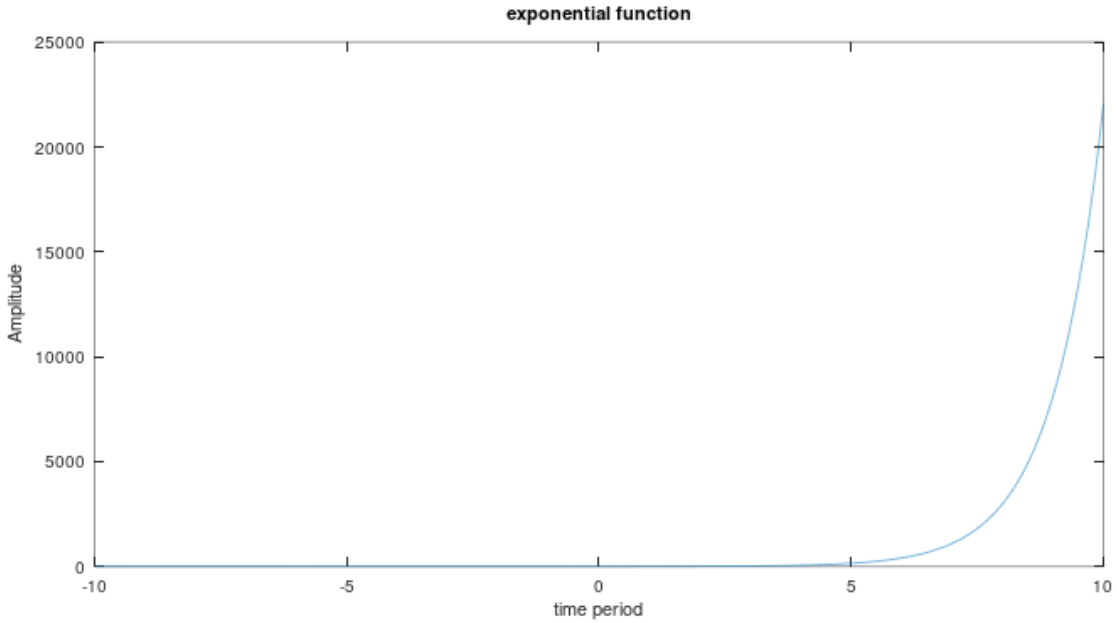


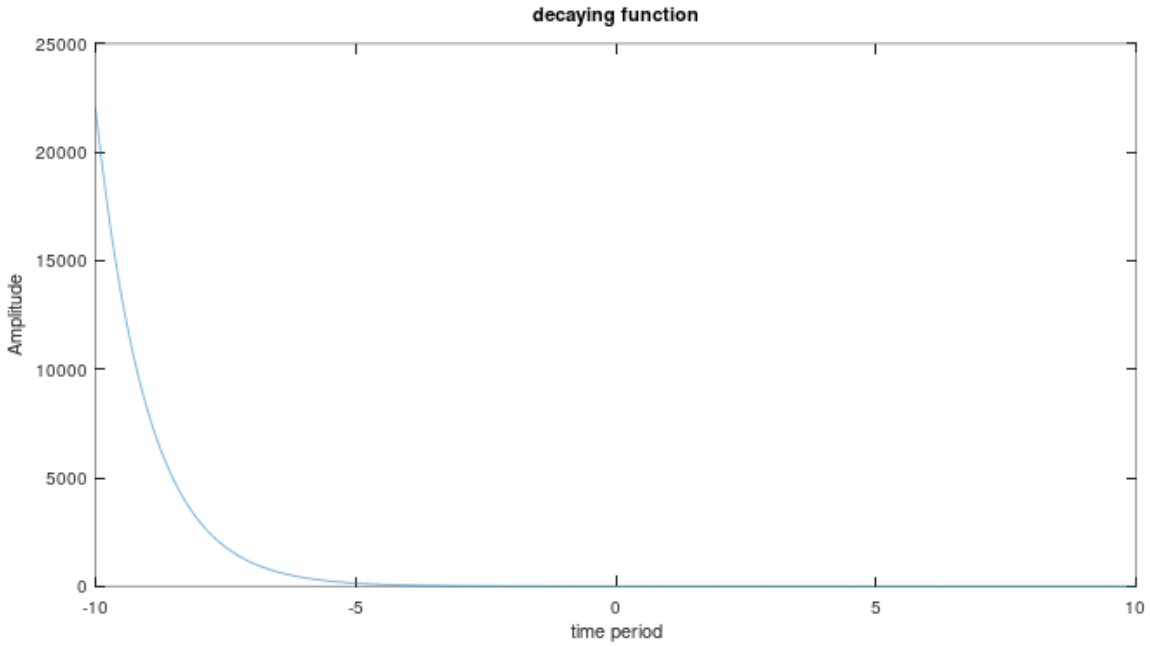
F. Generate a continuous time exponential (growing, decaying, DC signal)

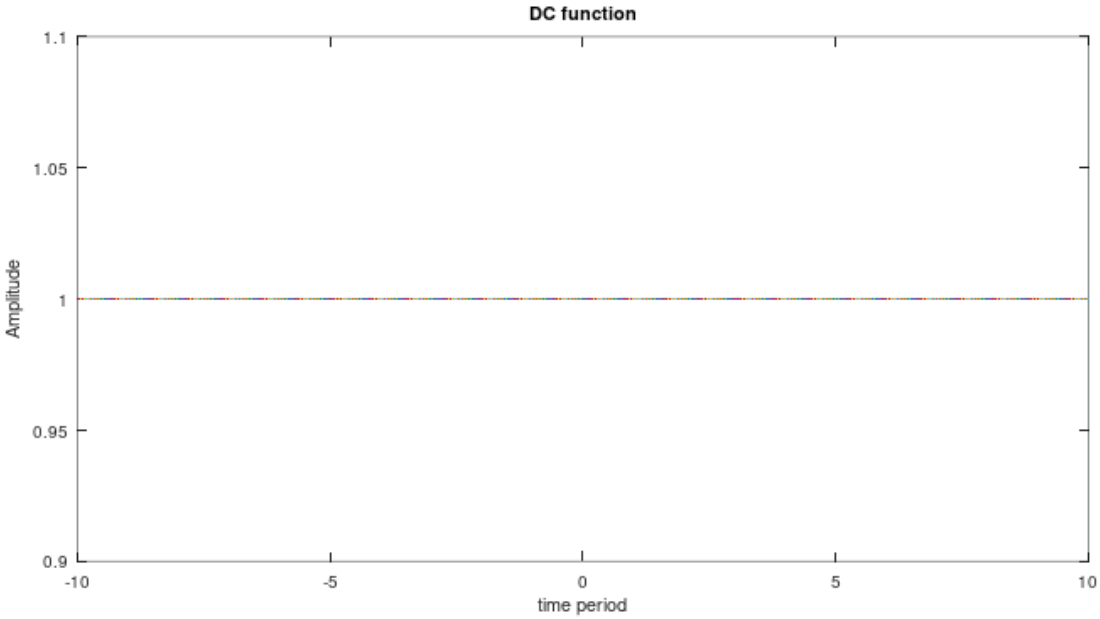
Code:

```
subplot(2,2,2)
e1= [-10:.1:10];
del = exp(e1)
plot(e1,del)
xlabel ("time period")
ylabel ("Amplitude")
title ("exponential function")

subplot(2,2,3)
e2= [-10:.1:10];
de = exp(-e2)
plot(e2,de)
xlabel ("time period")
ylabel ("Amplitude")
title ("decaying function")

subplot(2,2,4)
e3= [-10:.01:10];
d = 1
plot(e3,d)
xlabel ("time period")
ylabel ("Amplitude")
title ("DC function")
```

Output:


exponential function
25000
20000
15000
10000
5000
0
Amplitude
-10
-5
0
5
10
time period


decaying function
25000
20000
15000
10000
5000
0
Amplitude
-10
-5
0
5
10
time period


DC function
1.1
1.05
1
0.95
0.9
Amplitude
-10
-5
0
5
10
time period

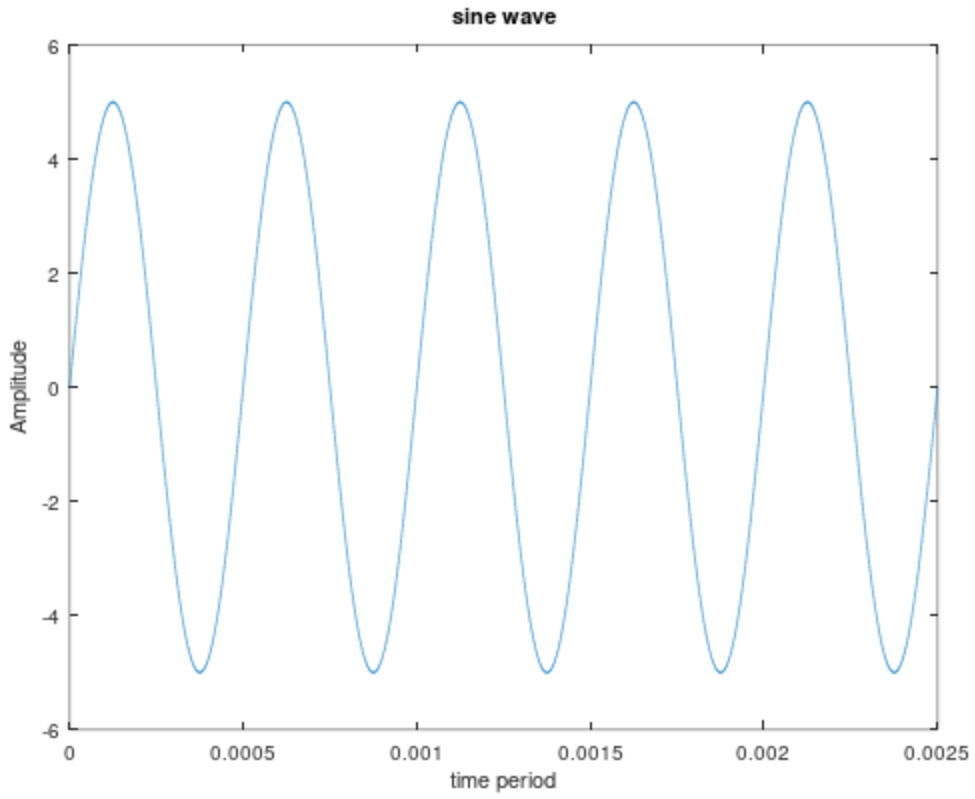
Purpose:

1. Generate the signal x = 5sin(2 pi f t) with 5 cycles, where f = 2 kHz signal and sample the signal with frequency 5 KHz, 10 Khz, 20 KHz. (Title and label each figure)

Creating a the signal x:

```
cycles =5
f =2000
t = 0:0.000001:cycles*1/f;
x= 5*sin(2*pi*f*t);
plot (t,x);
xlabel ("time period")
ylabel ("Amplitude")
title ("sine wave")
```

Output:

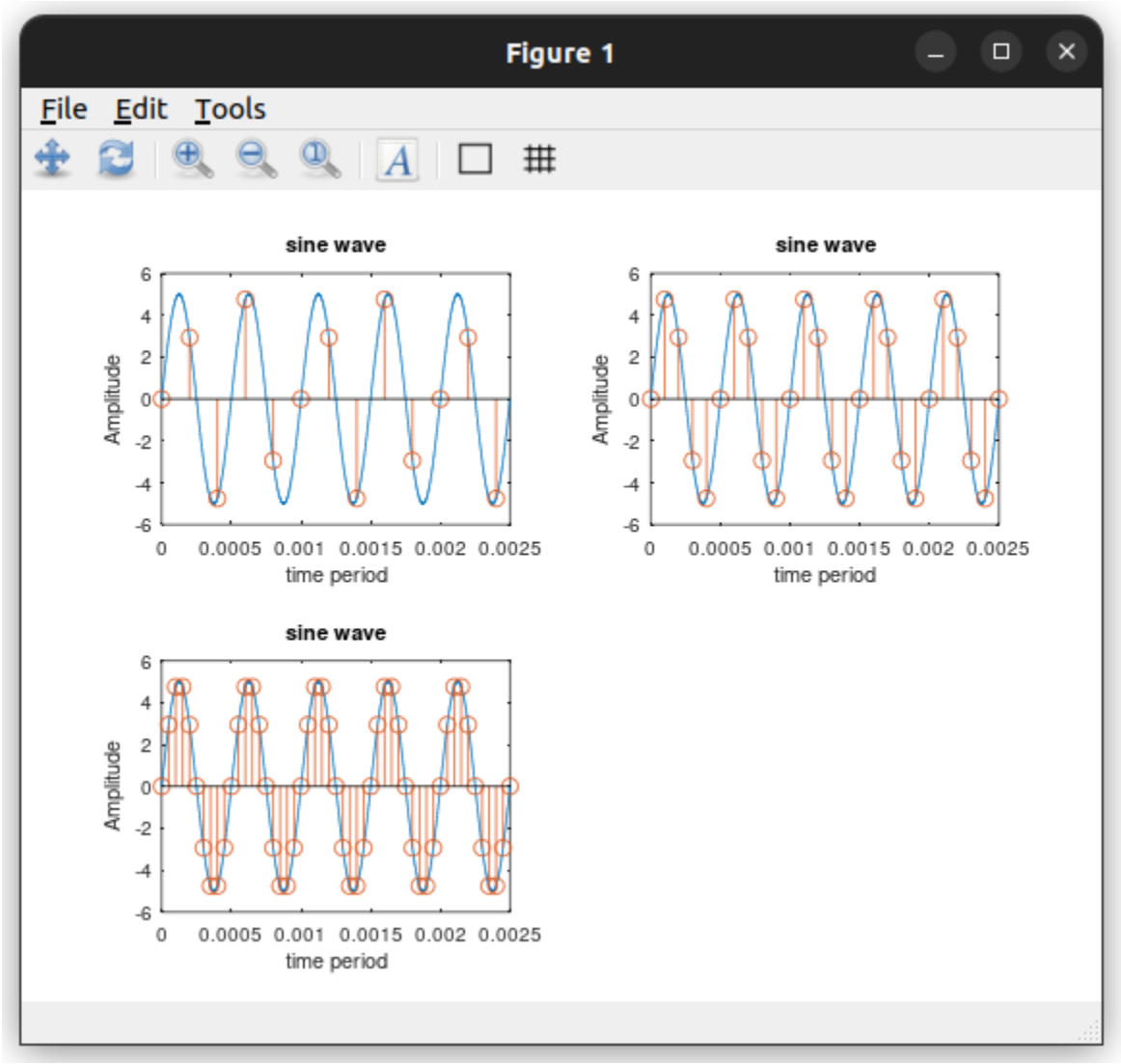


Sampling with y 5 KHz, 10 Khz, 20 KHz as:

```
subplot(2,2,1)
cycles =5
f =2000
t = 0:0.000001:cycles*1/f;
x= 5*sin(2*pi*f*t);
freq1 = 5000;
t1=0:1/ freq1:cycles*1/f;
x1= 5*sin(2*pi*f*t1);
plot (t,x);
hold on;
stem(t1,x1);
xlabel ("time period")
ylabel ("Amplitude")
title ("sine wave")

subplot(2,2,2)
cycles =5
f =2000
t = 0:0.000001:cycles*1/f;
x= 5*sin(2*pi*f*t);
freq1 = 10000;
t1=0:1/ freq1:cycles*1/f;
x1= 5*sin(2*pi*f*t1);
plot (t,x);
hold on;
stem(t1,x1);
xlabel ("time period")
ylabel ("Amplitude")
title ("sine wave")

subplot(2,2,3)
cycles =5
f =2000
t = 0:0.000001:cycles*1/f;
x= 5*sin(2*pi*f*t);
freq1 = 20000;
t1=0:1/ freq1:cycles*1/f;
x1= 5*sin(2*pi*f*t1);
plot (t,x);
```

```
hold on;
stem(t1,x1);
xlabel ("time period")
ylabel ("Amplitude")
title ("sine wave")
```

Output:

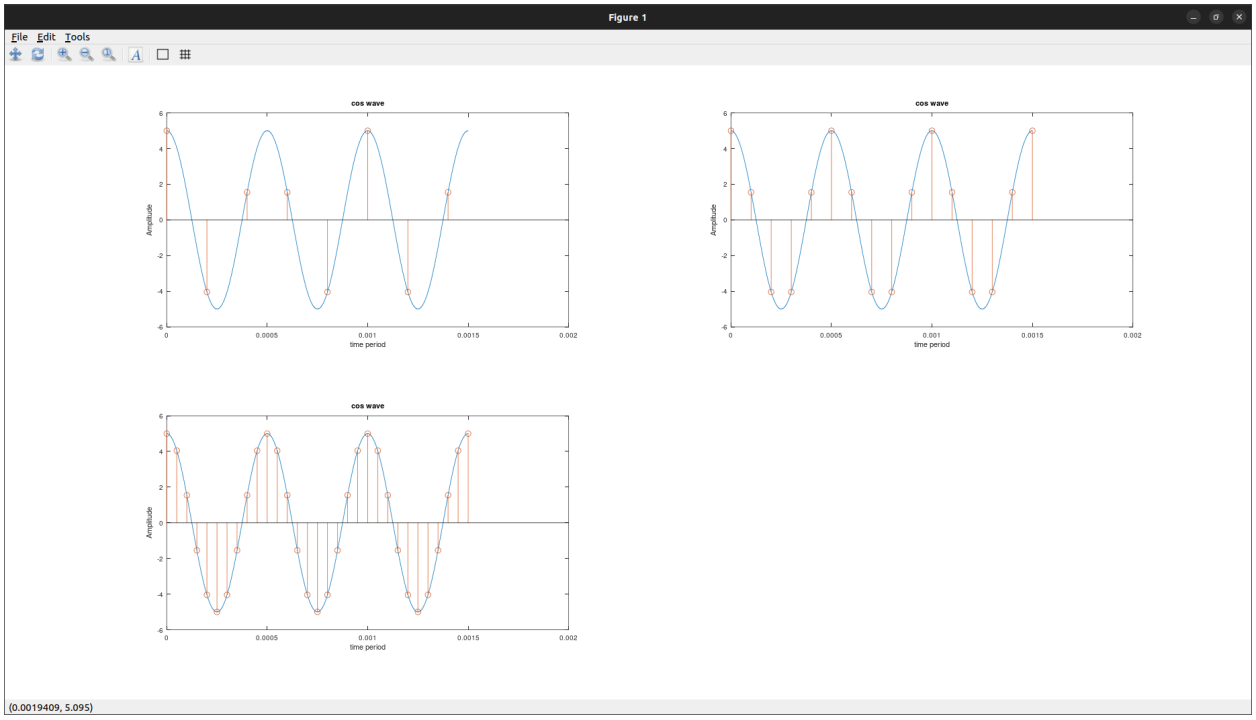


2. Generate the signal x = 5cos(2 pi f t) with 3 cycles, where f = 2 kHz signal and sample the signal with frequency 5 KHz, 10 Khz, 20 KHz. (Title and label each figure)

```
subplot(2,2,1)
cycles =3
f =2000
t = 0:0.000001:cycles*1/f;
x= 5*cos(2*pi*f*t);
freq1 = 5000;
t1=0:1/ freq1:cycles*1/f;
x1= 5*cos(2*pi*f*t1);
plot (t,x);
hold on;
stem(t1,x1);
xlabel ("time period")
ylabel ("Amplitude")
title ("cos wave")

subplot(2,2,2)
cycles =3
f =2000
t = 0:0.000001:cycles*1/f;
x= 5*cos(2*pi*f*t);
freq1 = 10000;
t1=0:1/ freq1:cycles*1/f;
x1= 5*cos(2*pi*f*t1);
plot (t,x);
hold on;
stem(t1,x1);
xlabel ("time period")
ylabel ("Amplitude")
title ("cos wave")

subplot(2,2,3)
cycles =3
f =2000
t = 0:0.000001:cycles*1/f;
```

```
x= 5*cos(2*pi*f*t);
freq1 =20000;
t1=0:1/ freq1:cycles*1/f;
x1= 5*cos(2*pi*f*t1);
plot (t,x);
hold on;
stem(t1,x1);
xlabel ("time period")
ylabel ("Amplitude")
title ("cos wave")
```

Output:



Tasks:

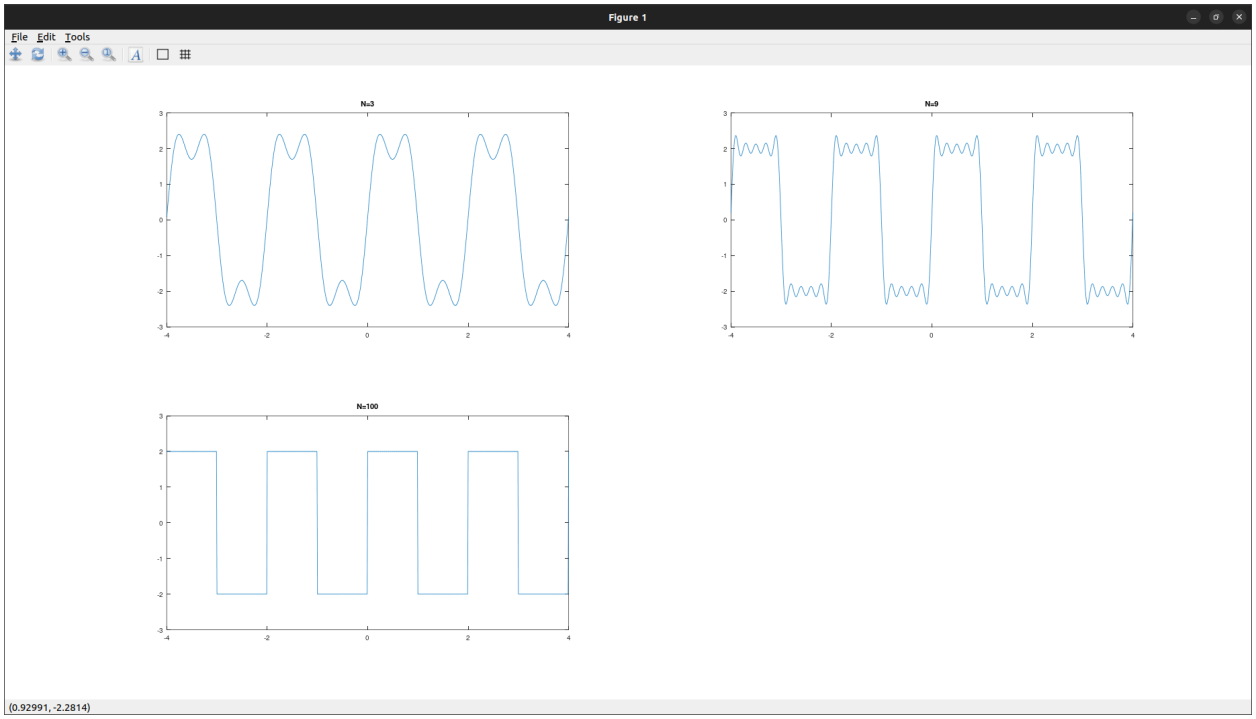
1. Fourier series expansion of odd signals for different N.(N= 3, 9, 100).

Source Code:

```
%lab 4
close
N=3


function void = Fourier(N)
   Ts= 0.01
   T=2
   t=0:Ts:T-Ts
   f(t<T/2)= 2
   f(t >= T/2)= -2
   a= zeros(1,N+1)
   b= zeros(1,N+1)

   for n=0:N
       a(n+1)= (2*Ts/T) * sum(f .* cos(2*pi*n*t/T))
       b(n+1)= (2*Ts/T) * sum(f .* sin(2*pi*n*t/T))
   endfor

   t= -2*T:Ts:2*T
   fs = (a(1)/2)*ones(size(t))
   for n=1:N
       fs= fs +(a(n+1)* cos(2*pi*n*t/T)) +(b(n+1) * sin(2*pi*n*t/T))
   endfor
   plot(t,fs)
endfunction


subplot (2,2,1)

Fourier(3)
```

```
title ("N=3")


subplot (2,2,2)
Fourier(9)
title ("N=9")


subplot (2,2,3)
Fourier(100)
title ("N=100")
```

Output



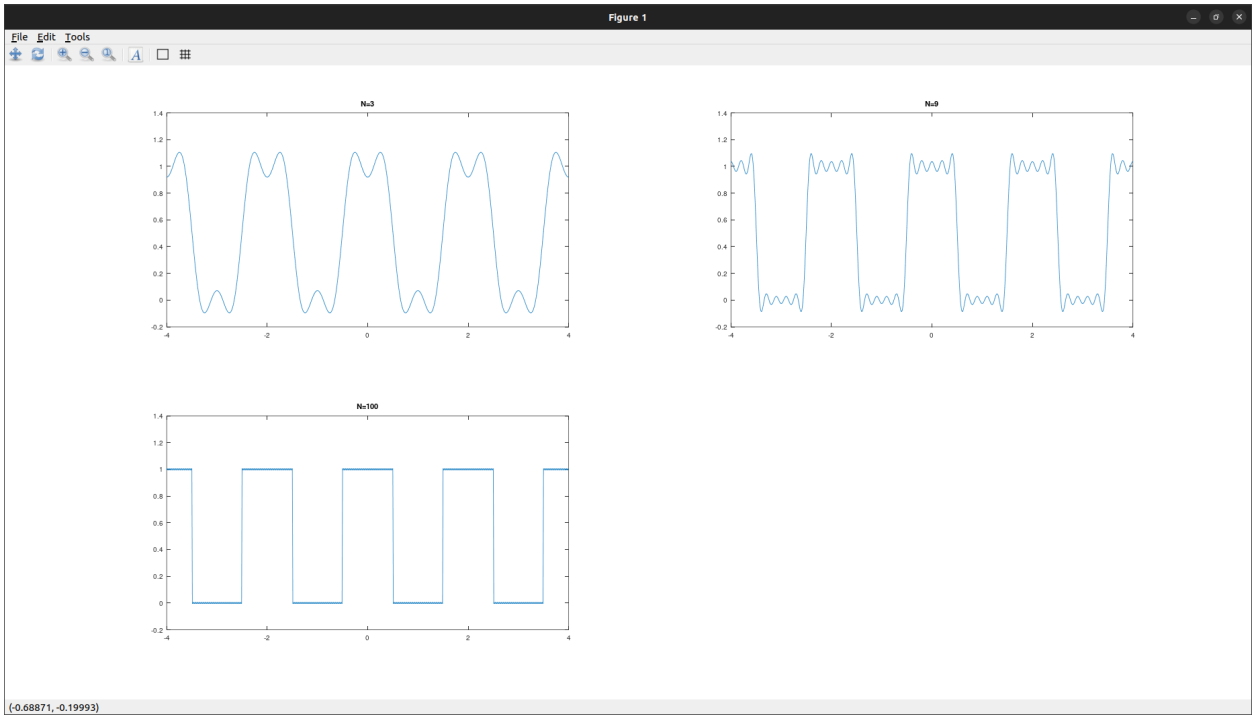
1. Fourier series expansion of even signals for different N.(N= 3, 9, 100).

Source Code:

```
%lab 4
close
N=3


function void = Fourier(N)
   Ts= 0.01
   T=2
   t=-T/2:Ts:T/2
   f(t< -T/4)= 0
   f((t >=-T/4) & (t<= T/4))= 1
   f(t > T/4 )=0
   a= zeros(1,N+1)
   b= zeros(1,N+1)

   for n=0:N
       a(n+1)= (2*Ts/T) * sum(f .* cos(2*pi*n*t/T))
       b(n+1)= (2*Ts/T) * sum(f .* sin(2*pi*n*t/T))
   endfor

   t= -2*T:Ts:2*T
   fs = (a(1)/2)*ones(size(t))
   for n=1:N
       fs= fs +(a(n+1)* cos(2*pi*n*t/T)) +(b(n+1) * sin(2*pi*n*t/T))
   endfor
   plot(t,fs)
endfunction


subplot (2,2,1)

Fourier(3)
title ("N=3")
```

```
subplot (2,2,2)
Fourier(9)
title ("N=9")


subplot (2,2,3)
Fourier(100)
title ("N=100")
```

Output:

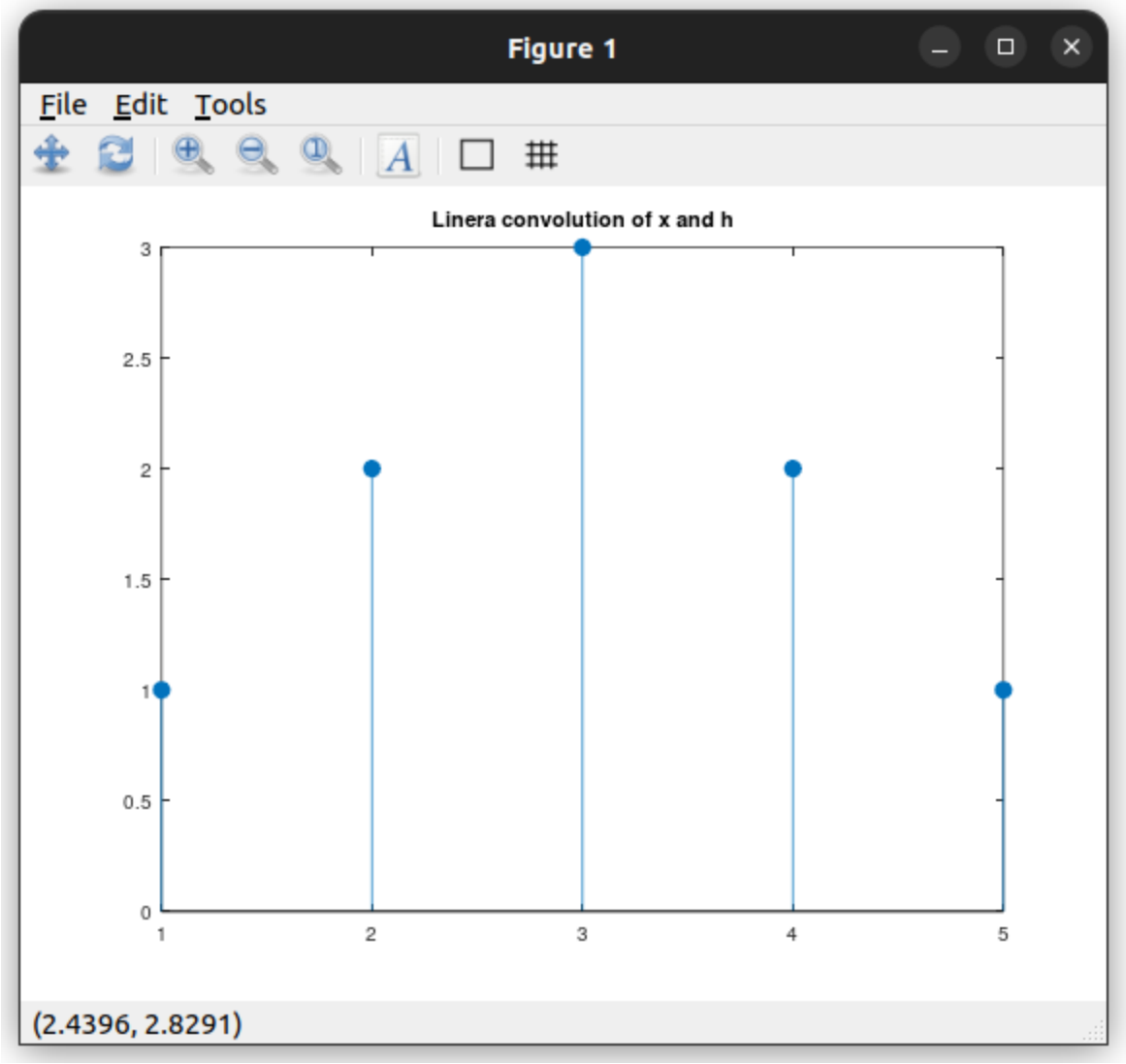


Purpose:

A. Perform Linear Convolution:

1. x[n]= {1,1,1} & h[n]={1,1,1}.

```
clc
close

%linear convolution

x=[1 1 1]
h=[1 1 1]

fig = conv(x,h)
stem(fig, 'filled')
title('Linera convolution of x and h')
```

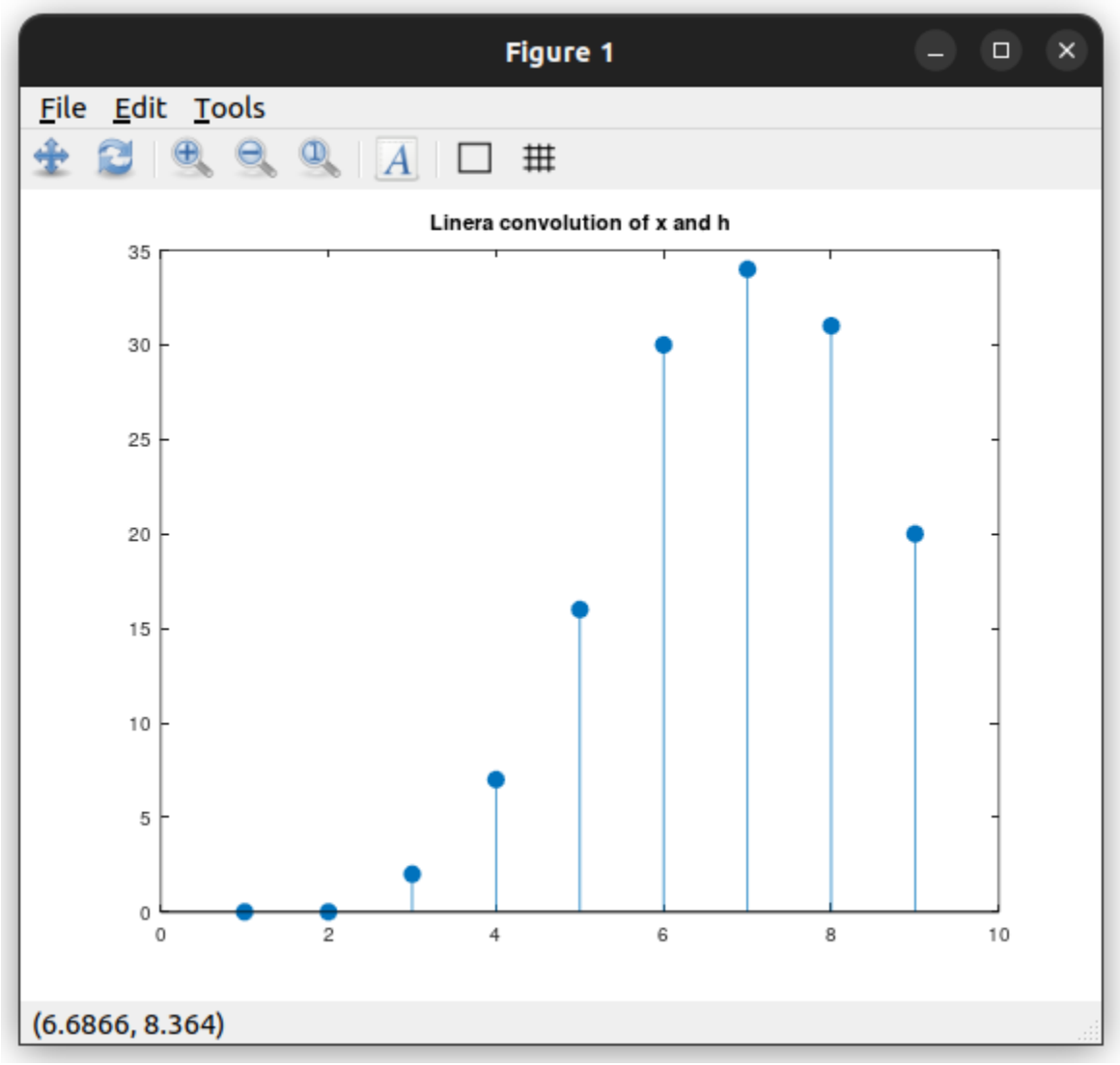


2. x[n]={0,1,2,3,4} & h[n]={0,2,3,4,5}

```
clc
close

%linear convolution

x=[0 1 2 3 4]
h=[0 2 3 4 5]

fig = conv(x,h)
stem(fig, 'filled')
```

```
title('Linera convolution of x and h')
```

Output:



B. Perform Circular Convolution:

1. x1=[1 2 2 0] & x2=[1 2 3 4]

```
clc
close
```

```
%cicrcular convolution

x1=[1,2,2,0]
x2=[1,2,3,4]

l1=length(x1)
l2=length(x2)

n=max(l1,l2)
y= zeros(1,n);

if l1>l2
   x2= [ x2, zeros(1,l1-l2)]
elseif l1<l2
   x1= [ x1, zeros(1,l2-l1)]
endif

for m=[0:n-1]
   for o = [0:n-1]
   z=mod(m-o,n);
   y(m+1)=y(m+1)+x1(o+1).* x2(z+1);
   end
end

stem(y)
xlabel('convolution x and y ');
ylabel('Samples');
title("Circular Convolution")
```

Output:

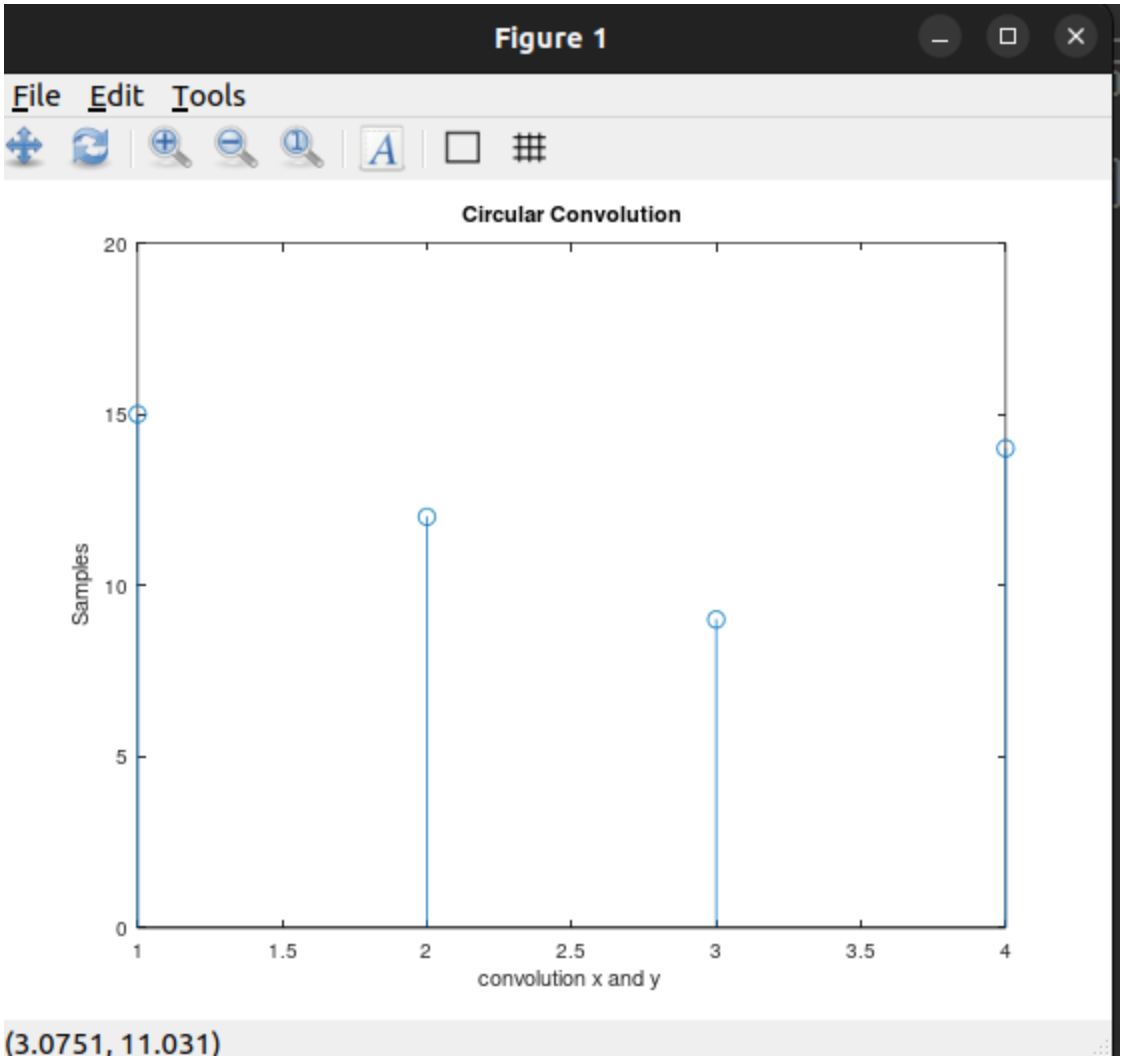


Figure 1
File Edit Tools
Circular Convolution
Samples
convolution x and y
0
5
10
15
20
1
1.5
2
2.5
3
3.5
4
(3.0751, 11.031)