Experiment 6: Convolution on Continuous Time Signals

This experiment is intended to make the student to use MATLAB for experiments, relating to the convolution of continuous time signals. It is expected that the student will write a "readable" code in a file and execute in Editor Window.

In this experiment, we required to perform convolution on two given signals using (i) matlab predefined function 'conv' and (ii) by writing our own program without using the function 'conv'

NOTE :

(1) In the present experiment, though we are performing convolution operation on continuous time signals, but practically in Matlab Programming, it is convolution on discrete time signals only.

(2) To perform convolution operation in matlab, the length of both the signals should be the same. This can be achieved by adding zeros to the signals and change their lengths.

The necessary code for this is given below :

```
%--------------Example 1-------------------------------------------------------------------
% Adding of zeros to the signals
% Given signals :  x(t)=2^t  (0 ≤ t ≤ 1) and  h(t) = u(t - 2) - u(t - 10)
% Signals x(t) & h(t) are of different lengths and let us specify them as 'p' and 'q' respectively.
%  To make them of same length, use the following code :
t = -3:0.01:3;                  % generating time vector

x=(2.^t).*(t>=0 &  t<=1)    % generating input signal x(t)
h= 1.*(t>=2 & t<=10);       % generating input signal h(t)
```

```
p=length(x);          % length of input signals
q=length(h);          % length of input signals

X=[x, zeros(1,q)];    %adding of zeros to signal
H=[h, zeros(1,p)];    %adding of zeros to signal

%-----------------------------------------------------------------------------------------------
```

(3) Use the following convolution expression for writing the matlab code

$$y(n) = x(n) * h(n) = \sum_{k=-\infty}^{\infty} x(k)h(n-k)$$

A. Performing convolution on continuous time signals:

Run #1 : For Given signals x(t) and h(t) perform following operations:

$$x(t) = \begin{cases} 0.95^t \quad , \text{for} \quad (1 \le t \le 5) \\ 0 \quad , \quad \text{otherwise} \end{cases}$$

and

$$h(t) = \begin{cases} 1 \quad , \quad \text{for} \quad (2 \le t \le 10) \\ 0 \quad , \text{otherwise} \end{cases}$$

a) Sketch signals x(t)and h(t) in your note book.
b) Choose the time axis between -10 seconds to + 15 seconds at a resolution of 1 msec.
c) Generate x(t) and plot, using subplot command, color blue and showing the time axis and labels. Index the plot using 'text' command.
d) Generate h(t) and plot it in the above figure window using subplot in green color . Show the time scale and labels. Index the plot using 'text' command.

e) Write matlab program to perform convolution of above signals i.e. y(t)=x(t)*h(t), with appropriate scale, using predefined matlab function 'conv'

f) Plot y(t) in the same above figure window using subplot command in red color. Show the time axis and labels. Index the plot using 'text' command.

g) Perform convolution for above signals z(t) = x(t)*h(t) **without** using predefined function 'conv'.

NOTE : Take the help of **Example 1** given above.

h) Plot z(t) in the same figure window using subplot command in green color.Show the time axis and labels. Index the plot using 'text' command.

i) Verify that y(t) and z(t) are same.

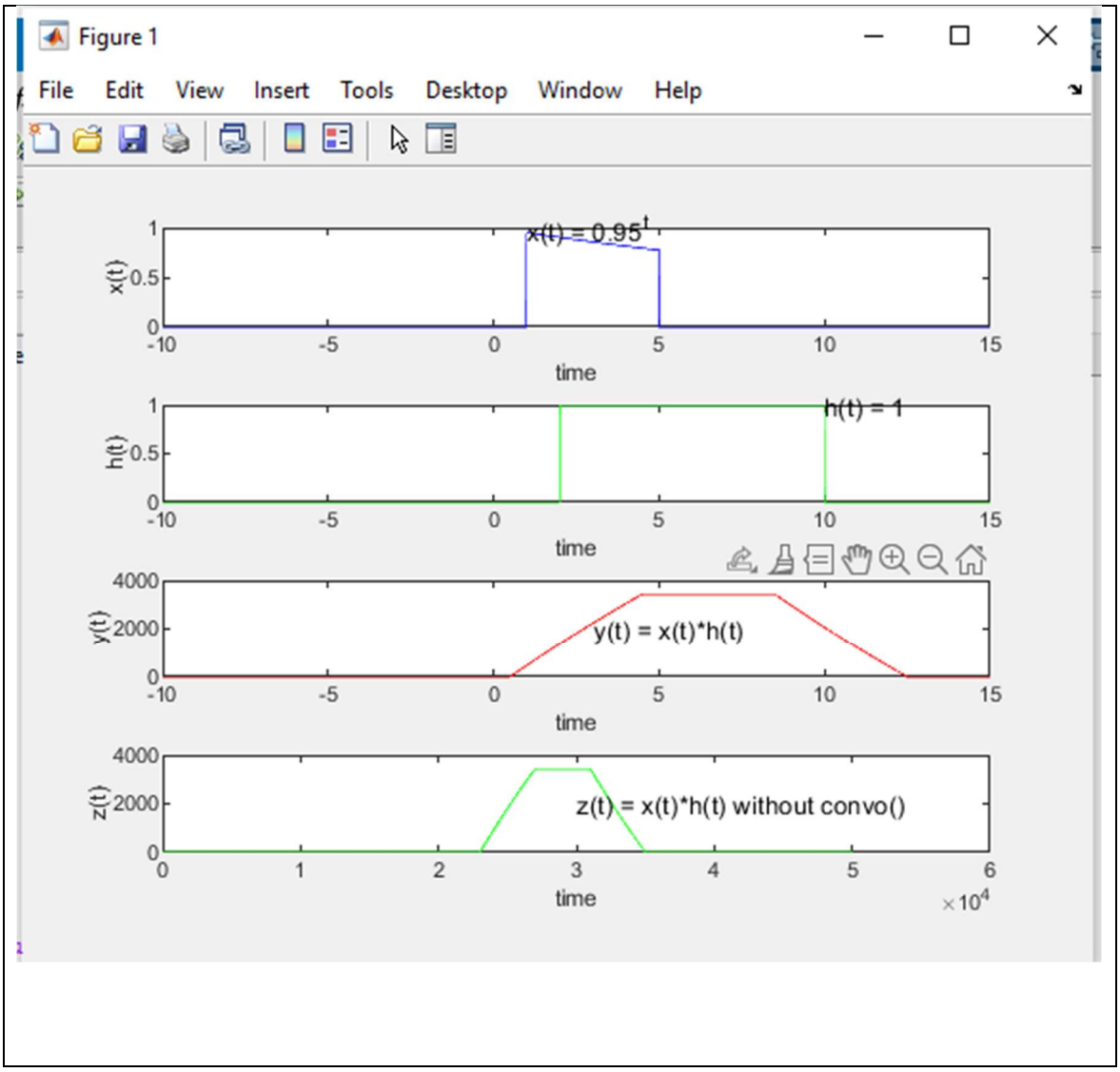
j) Find the length of convolved signals i.e y(t) and z(t)

Answer (paste the written code and plots):

```
clear
clc

t = -10:0.001:15;
length(t)
x = 0.95.^t.*(t>=1 & t<=5);

clf
subplot(411);
plot(t,x,'b');
xlabel("time"), ylabel("x(t)")
text(1, 01, "x(t) = 0.95^t")

h = 1.*(t>=2 & t<=10);

subplot(412);
plot(t,h,'g');
xlabel("time"), ylabel("h(t)")
text(10, 1, "h(t) = 1")

p = length(x);
q = length(h);

X = [x, zeros(1,q)];
H = [h, zeros(1,p)];

y = conv2(h,x,'same');

subplot(413);
```

```
plot(t,y,'r');
xlabel("time"), ylabel("y(t)");
text(3, 2000, "y(t) = x(t)*h(t)")

for n = 1:(p+q-1)
    z(n) = 0;
    for m = 1:p
        if((n-m+1)>0)
            z(n) = z(n) + X(m)*H(n-m+1);
        else
        end
    end
end
length(z)

T = -10:15;

subplot(414)
plot(z,'g');
xlabel("time"), ylabel("z(t)");
text(30000, 2000, "z(t) = x(t)*h(t) without convo()")
```

% The two shapes of the convolved signals are there the same, however they are distributed differently on the time axis hence there is a difference in the location of the convolved signal



Run # 2 : Consider the given signals

x(t) = exp (- 0.7t); for $0 < t < 1$ and

h(t)= 1 + t ; for $0 < t < 2$

a) Sketch signal x(t) in your note book.

b) Choose the time axis between -3 seconds to + 3 seconds at a resolution of 1 msec.

c) Generate x(t) and plot, using color blue and showing the time axis and labels. Index

the plot using ‘text’ command.

d) Sketch signal h(t)in your note book.

e) Generate h(t) and plot it in the same figure window as x(t)using subplot in green color . Show the time scale and labels. Index the plot using ‘text’ command.

f) Write matlab program to perform convolution of above signals i.e. y(t) = x(t)*h(t), with appropriate scale, using predefined function ‘conv’ in matlab.

g) Plot the y(t) in the same figure window as x(t) using subplot command in red color. Show the time axis and labels. Index the plot using ‘text’ command.

h) Perform convolution for above signals z(t) = x(t)*h(t) without using predefined function ‘conv’ , taking help of example given above.

i) Plot the z(t) in the same figure window as x(t) using subplot command in green color. Show the time axis and labels. Index the plot using ‘text’ command.

j) Verify that y(t) and z(t) are same.

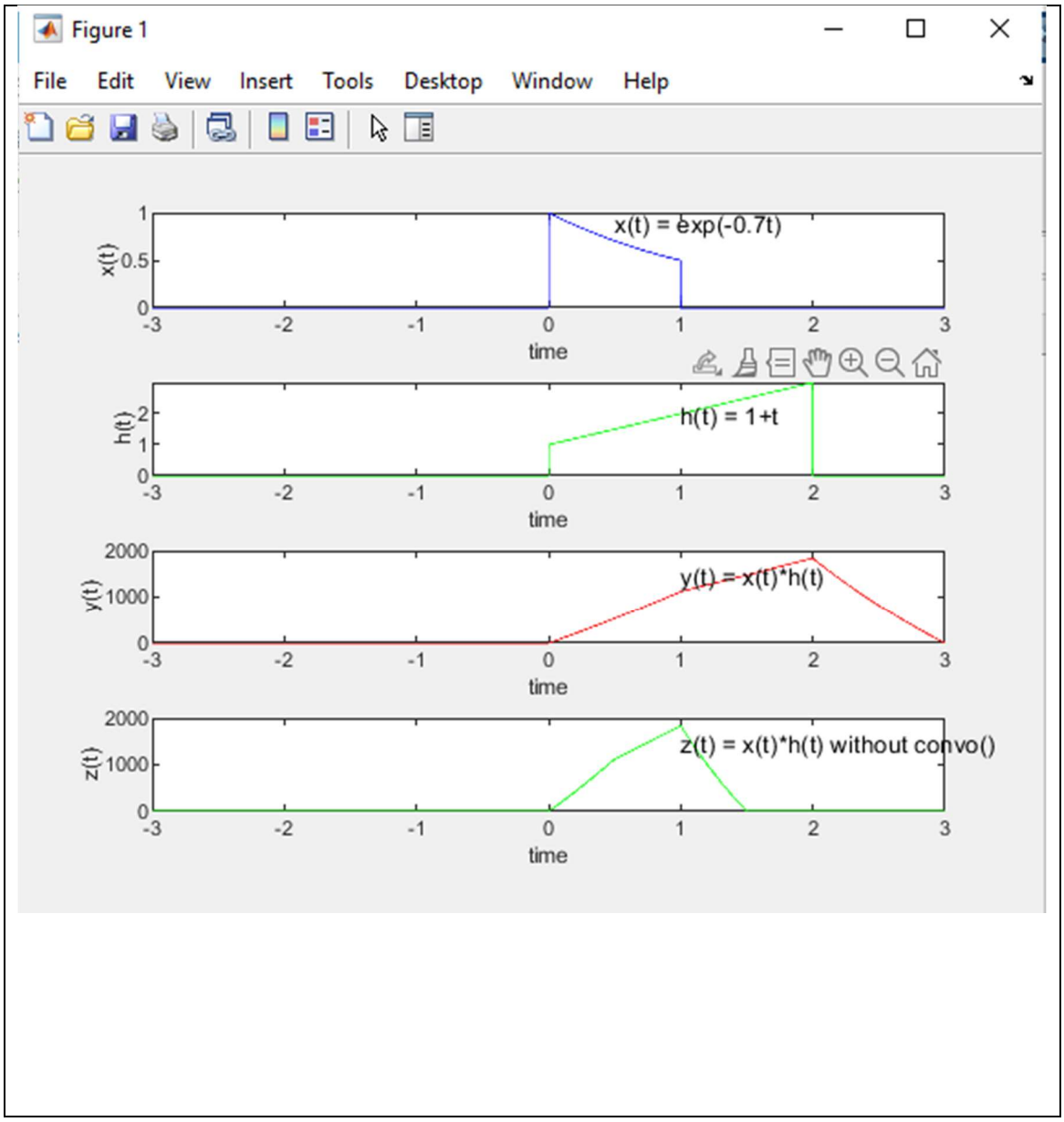
k) Find the length of convolved signals i.e. y(t) and z(t).

Answer (paste the written code and plots):

```
clear
clc

t = -3:0.001:3;

x = exp(-0.7*t).*(t>0 & t<1);

clf
subplot(411);
plot(t,x,'b');
xlabel("time"), ylabel("x(t)")
text(.5, 0.9, "x(t) = exp(-0.7t)")

h = (1+t).*(t>0 & t<2);

subplot(412);
plot(t,h,'g');
xlabel("time"), ylabel("h(t)")
text(1, 2, "h(t) = 1+t")

p = length(x);
q = length(h);

X = [x, zeros(1,q)];
```

```
H = [h, zeros(1,p)];

y = conv2(h,x,'same');

subplot(413);
plot(t,y,'r');
xlabel("time"), ylabel("y(t)");
text(1, 1500, "y(t) = x(t)*h(t)")

for n = 1:(p+q-1)
    z(n) = 0;
    for m = 1:p
        if((n-m+1)>0)
            z(n) = z(n) + X(m)*H(n-m+1);
        else
        end
    end
end

T = -3:0.0005:3;
subplot(414)
plot(T, z,'g');
xlabel("time"), ylabel("z(t)");
text(1, 1500, "z(t) = x(t)*h(t) without convo()")
```

% The two shapes of the convolved signals are there the same, however they are distributed differently on the time axis hence there is a difference in the location of the convolved signal



Link to upload files

Tuesday Batch

https://forms.gle/3FZoboxmLLijXcqN8

Sunday of the week in which you perform this experiment mostly March 28, 5 PM

Thursday batch

Link

https://forms.gle/k3X86i3M5aqc58xZ9 Due on March 14, 5 PM

Additional Problems

1) Write a mat lab program to perform convolution of the following two signals

$$x_1(t) = 1; \quad 0 < t < 2$$

$$\&$$

$$x_2(t) = \begin{cases} 1; & 0 < t < 1 \\ -1; & 1 < t < 2 \end{cases}$$

Plot $x_1(t)$, $x_2(t)$ and output y(t). use subplot.

2) Write a program in matlab to perform convolution of x1(t) and x2(t), Where

$$x_1(t) = u(t) - u(t-1)$$

$$\&$$

$$x_2(t) = u(t-1) - u(t-2)$$

Plot $x_1(t)$, $x_2(t)$ and output y(t). use subplot.

3) Write a matlab program to perform Convolution of

$$x_1(t) = e^{-0.7t}; \quad 0 \le t < 2$$

$$\&$$

$$x_2(t) = 1; \quad 0 \le t < 2$$