EE 150

Signals and Systems

Lab 2 System Analysis in Time Domain

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Class Id: Thurs_Lab2

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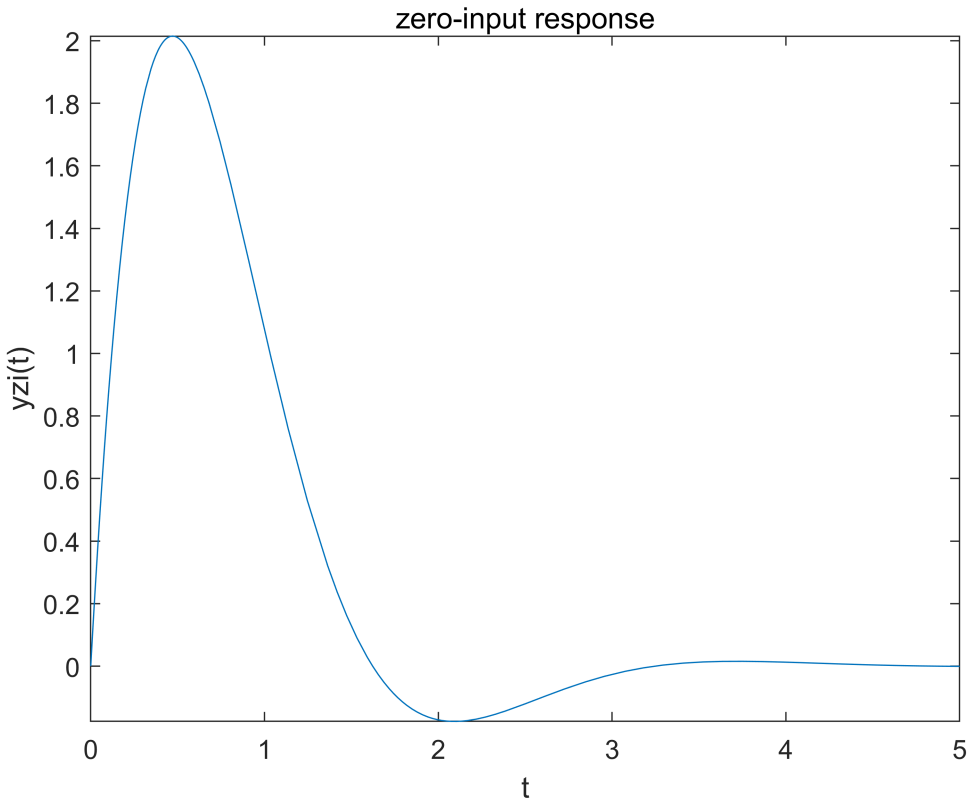
1. $y''(t)+3y'(t)+6y(t)=6f'(t)-8f(t), f(t)=e^{-t}u(t), y(0_-)=0, y'(0_-)=10, y(0_+)=0, y'(0_+)=6$. Find out the zero-input response and plot it.

```
clear;
clf;
syms y(t)
D2y = diff(y,t,2);
Dy = diff(y,t);
eqn1 = D2y+3*Dy+6*y==0;
conds = [y(0)==0, Dy(0)==10];
ysol = dsolve(eqn1, conds);
yzi = simplify(ysol)
```

```
yzi =
```

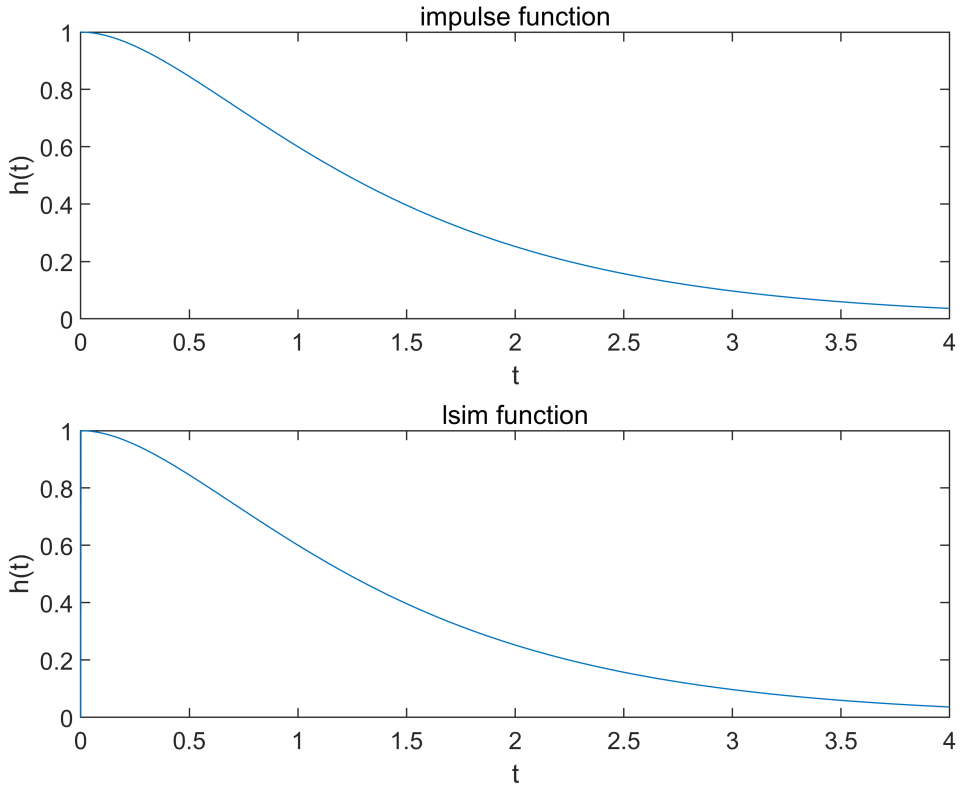
$$\frac{4\sqrt{15}\,e^{-\frac{3t}{2}}\sin\left(\frac{\sqrt{15}\,t}{2}\right)}{3}$$

```
fplot(yzi, [0 5]);
xlabel("t");
ylabel("yzi(t)");
title("zero-input response");
```



2. $y''(t)+3y'(t)+2y(t)=f'(t)+3f(t), f(t)=e^{-3t}u(t)$, find the unit impulse response with both **impulse** and **lsim** function. Plot them in a 2*1 subplot.

```
clear;
clf;
t = 0:0.001:5;
dt = 0.001;
sys = tf([1,3],[1,3,2]);
h = impulse(sys,t);
subplot(2,1,1);
plot(t,h);
axis([0,4,0,1]);
xlabel("t");
ylabel("h(t)");
title('impulse function');

f = sign(dirac(t))/dt;
y = lsim(sys,f,t);
subplot(2,1,2);
plot(t,y);
axis([0,4,0,1]);
xlabel("t");
ylabel("h(t)");
title('lsim function');
```



3. $y''(t)+4y'(t)+4y(t)=f'(t)+3f(t)$, where $f(t)=e^{-t}u(t), y(0_-)=1, y'(0_-)=0, y(0_+)=0, y'(0_+)=1$. Find out the zero-state response by solving differential equation, using function lsim and convolution. Compare the three results by plotting their result in a 3*1 subplot.

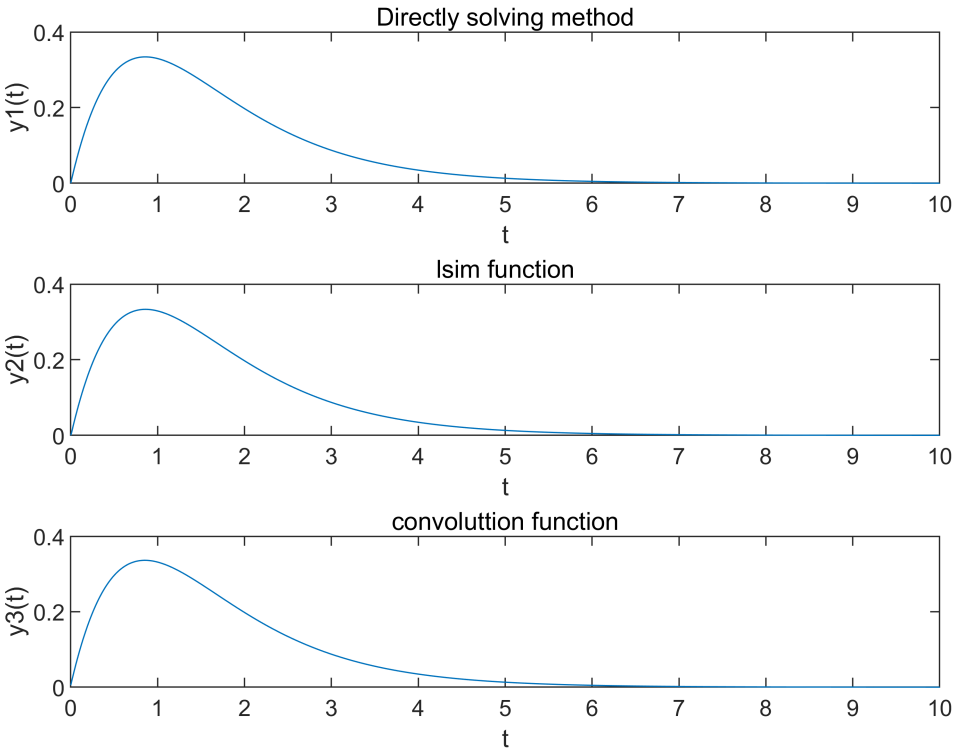
```
clear;clf;
dt = 0.01;
t = 0:0.01:10;


syms y(t1)
D2y = diff(y,t1,2);
Dy = diff(y,t1);
f1 = (exp(-t1)*heaviside(t1));
Df = diff(f1, t1);
eqn1 = D2y+4*Dy+4*y==Df+3*f1;
conds = [y(0)==0, Dy(0)==1];
yzs = dsolve(eqn1, conds)
```

```
yzs =
```

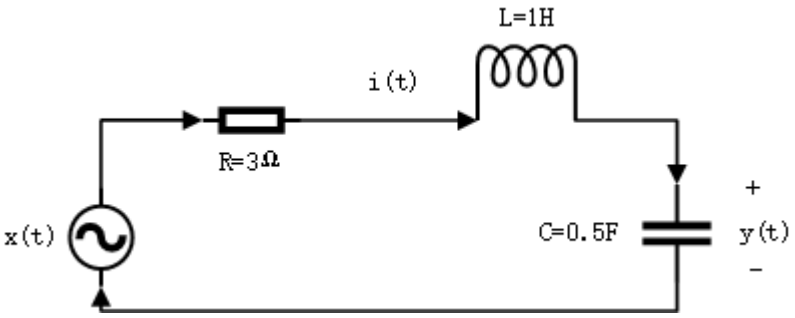
$$-\frac{e^{-2t_1}\left(t_1-2e^{t_1}+2\,\mathrm{sign}(t_1)-2e^{t_1}\,\mathrm{sign}(t_1)-2t_1\,\mathrm{heaviside}(t_1)+3t_1\,\mathrm{sign}(t_1)+2\right)}{2}$$

```
y1= double(subs(yzs,"t1",t));
subplot(3,1,1);
plot(t,y1);
xlabel("t");ylabel("y1(t)");title("Directly solving method");
```

```
axis([0 10 0 0.4])


sys = tf([1,3],[1,4,4]);
f = exp(-t).*heaviside(t);

y2 = lsim(sys, f, t);
subplot(3,1,2);
plot(t,y2);
xlabel("t");ylabel("y2(t)");title("lsim function");
axis([0 10 0 0.4])

h = impulse(sys, t);
y3 = conv(h, f)*dt;
n = length(y3);
tt = (0:n-1)*dt;
subplot(3,1,3);
plot(tt,y3);
xlabel("t");ylabel("y3(t)");title("convoluttion function");
axis([0 10 0 0.4])
```



4. For the following circuit, $R = 3\Omega, L = 1H, C = 0.5F, x(t) = \sin(t) + \sin(20t)$. The initial state of the circute is zero.



Tips: the circute can be described as:

$$LC \cdot y''(t) + RC \cdot y'(t) + y(t) = x(t)$$

1) Following the tips, complete the differential equation describing the system.

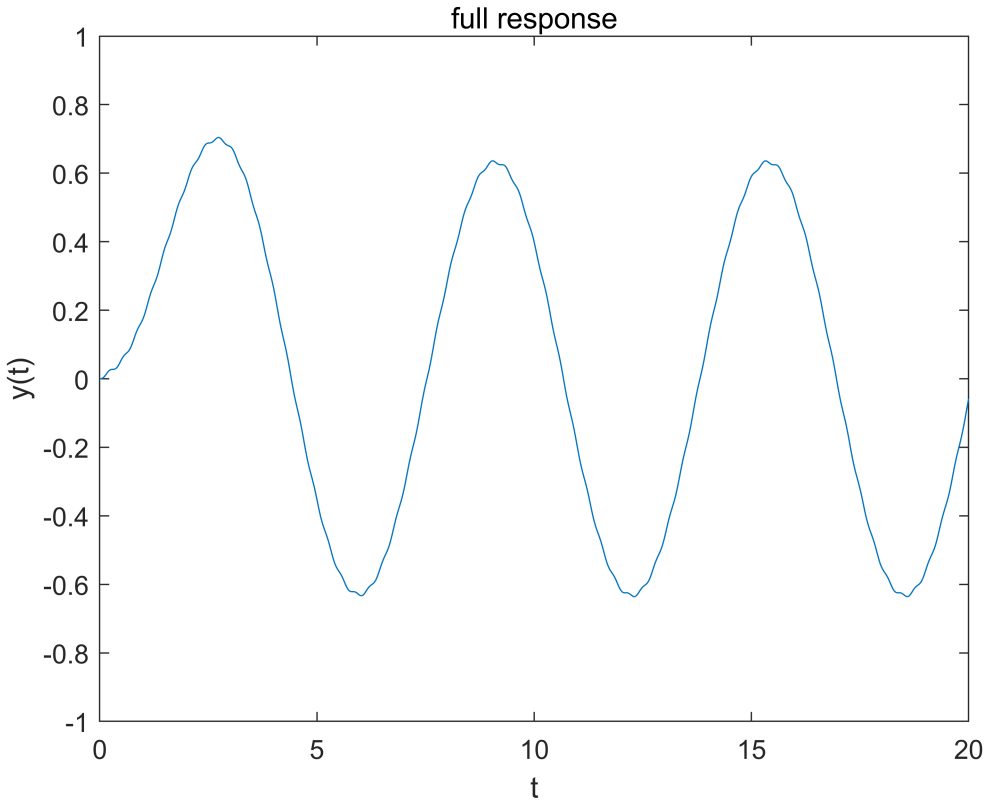
2) Find out the full response of the system. Plot the result.

```
clear;clf;
R = 3;
L = 1;
C = 0.5;
LC = L*C;
RC = R*C;

t1 = 0:0.01:20;

syms y(t);
D2y = diff(y, t, 2);
Dy = diff(y, t);
eqn1 = LC*D2y+RC*Dy+y == sin(t)+ sin(20*t)
```

```
eqn1(t) =
```

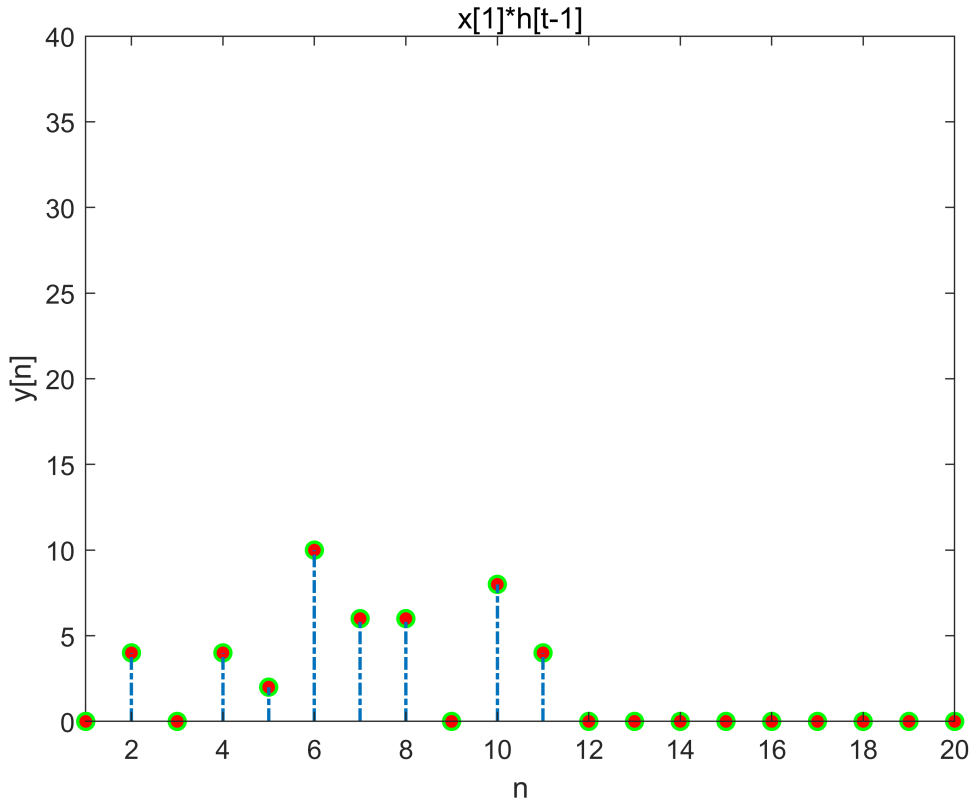
$$\frac{\frac{\partial^2}{\partial t^2}\,y(t)}{2} + \frac{3\,\frac{\partial}{\partial t}\,y(t)}{2} + y(t) = \sin(20\,t) + \sin(t)$$

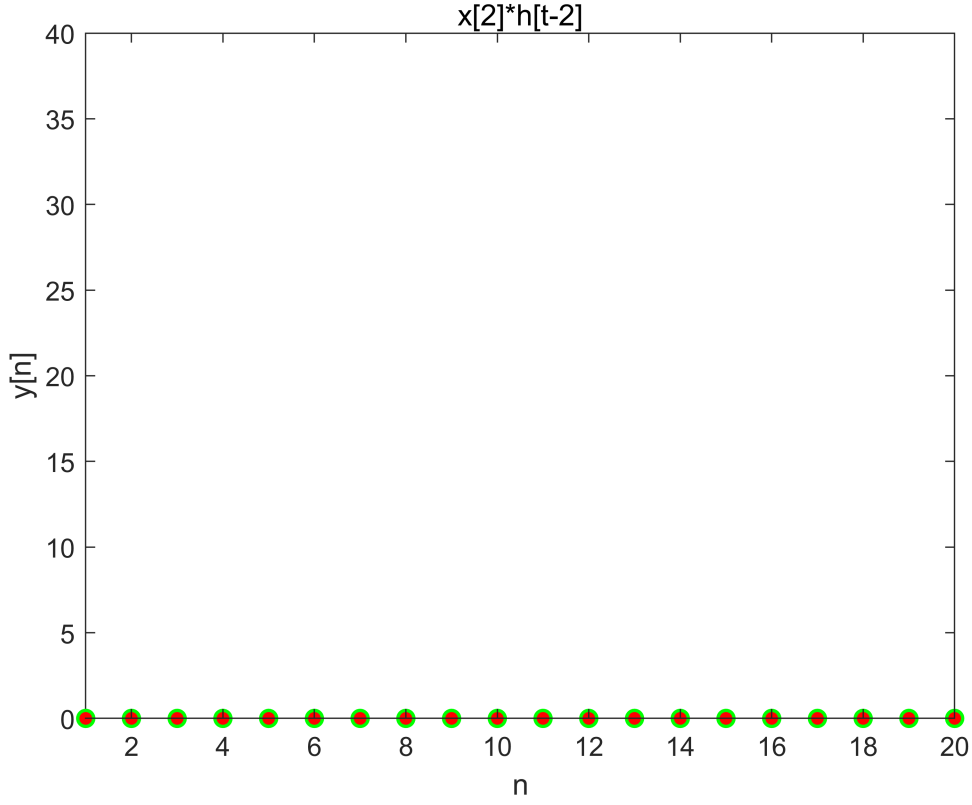
```
conds = [y(0)==0, Dy(0)==0];
ysol = dsolve(eqn1, conds);
yzs= double(subs(ysol,"t",t1));


eqn2 = LC*D2y+RC*Dy+y == 0;
ysol2 = dsolve(eqn2, conds);
yzi = double(subs(ysol2,"t",t1));

y = yzi + yzs;

plot(t1,y);
xlabel("t");ylabel("y(t)");title("full response");
axis([0 20 -1 1])
```

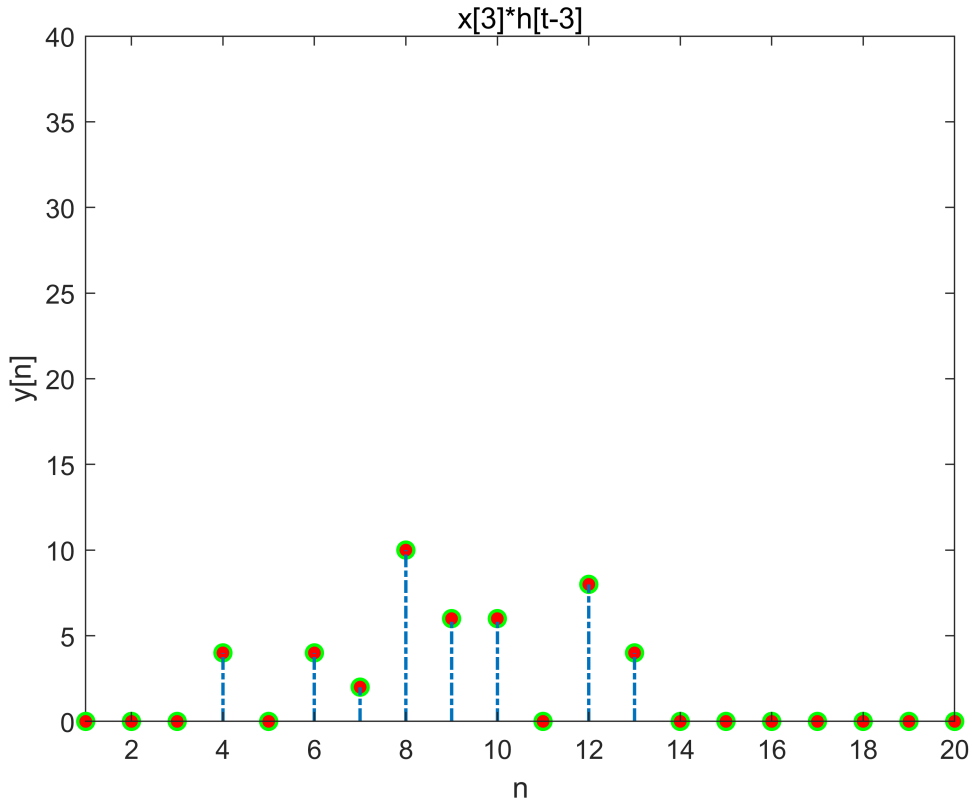


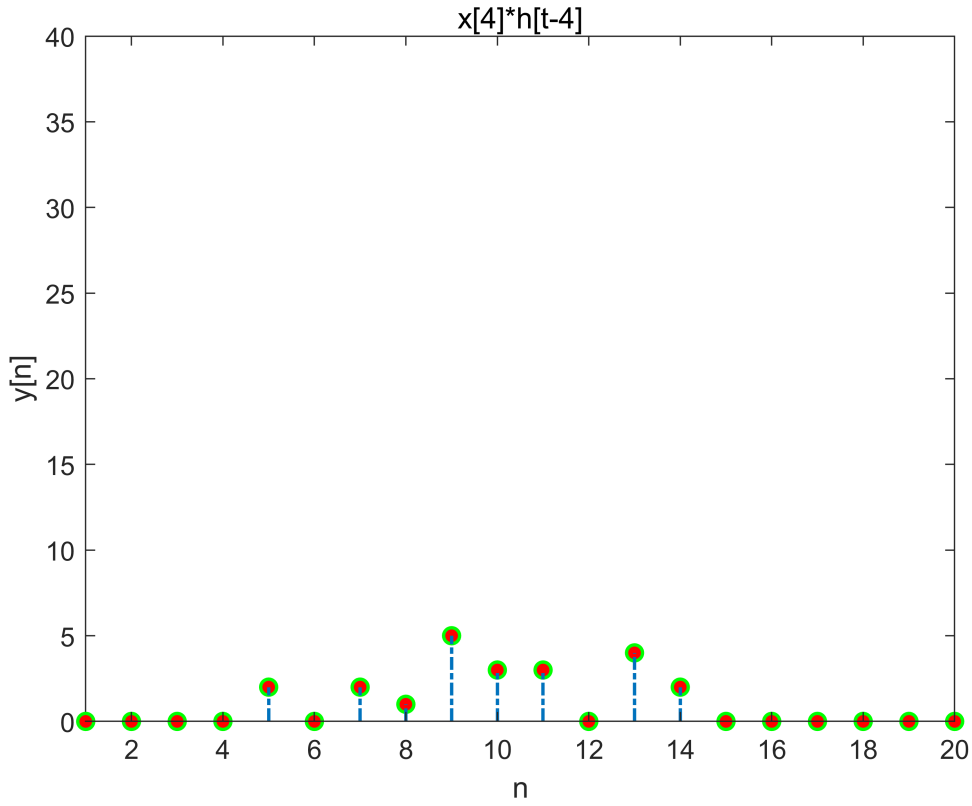
5. Please implement the convolution function of the discrete sequence by yourself (do not use MATLAB build-in function for convolution). Use the your student ID as the inputs and display the convolution result.

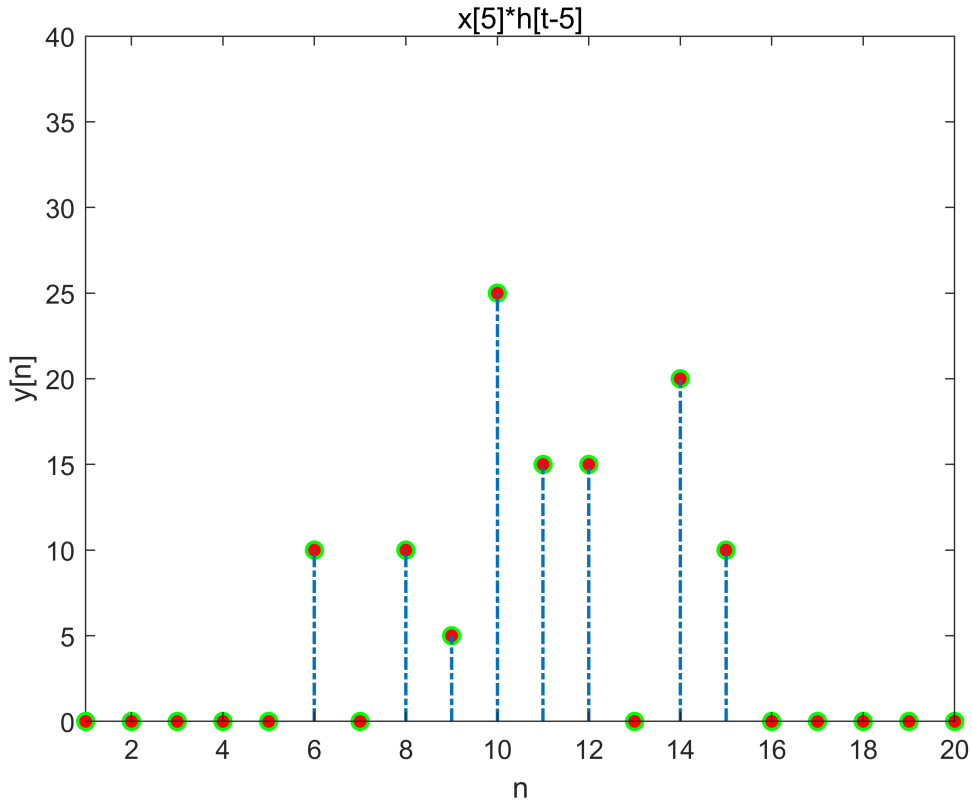
```
clear;
clf;
x = [2 0 2 1 5 3 3 1 3 8];
h = [2 0 2 1 5 3 3 0 4 2];
y=zeros(1,(length(x)+length(h)));
for i=(1:length(x))
    yi=zeros(1,(length(x)+length(h)));
    for j=(1:length(h))
        yi(i+j)=x(i)*h(j);
    end
    y=y+yi;
figure(i)
    stem((1:20),yi,'LineStyle','-.',...
    'LineWidth',1.25,...
     'MarkerFaceColor','red',...
     'MarkerEdgeColor','green') ;
    axis([1,20,0,40]);
    xlabel("n");
    ylabel("y[n]");
    title("x["+num2str(i)+"]*h[t-"+num2str(i)+"]");
end
```

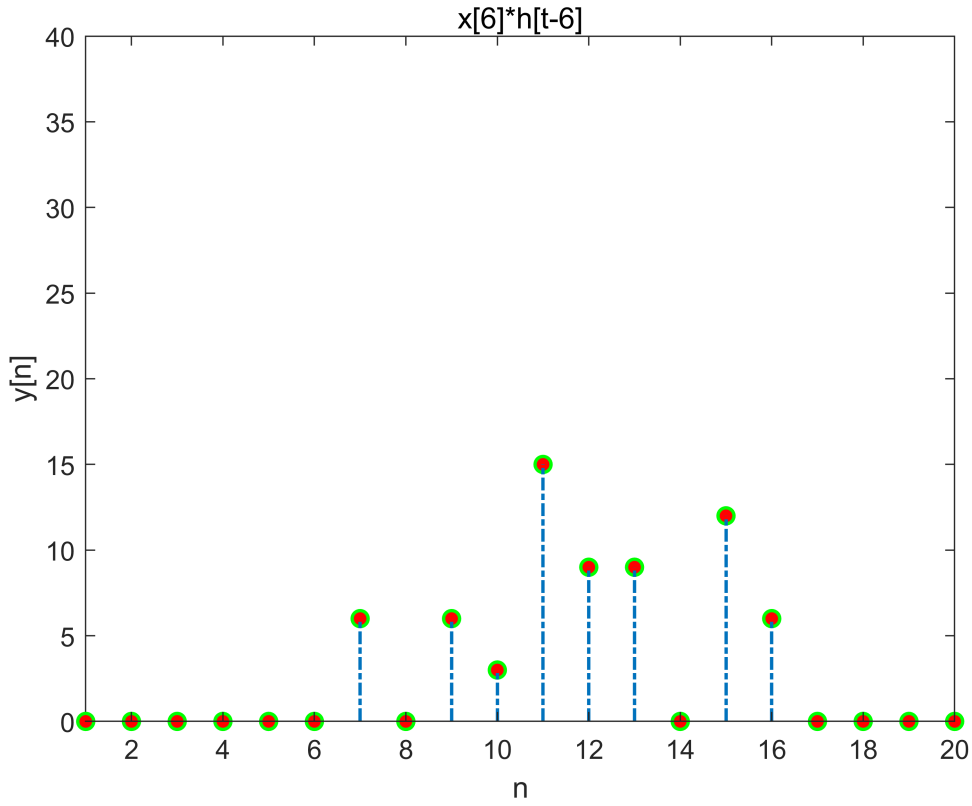

x[1]*h[t-1]
y[n]
n
0
5
10
15
20
25
30
35
40
2
4
6
8
10
12
14
16
18
20

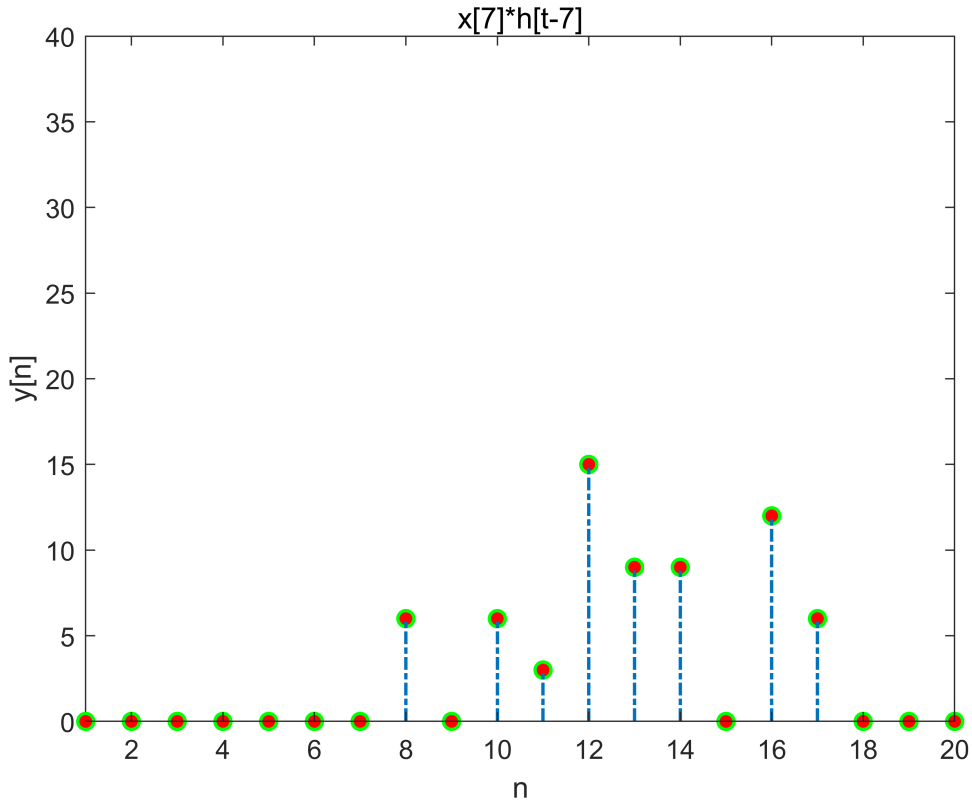

x[2]*h[t-2]
y[n]
n
0
5
10
15
20
25
30
35
40
2
4
6
8
10
12
14
16
18
20

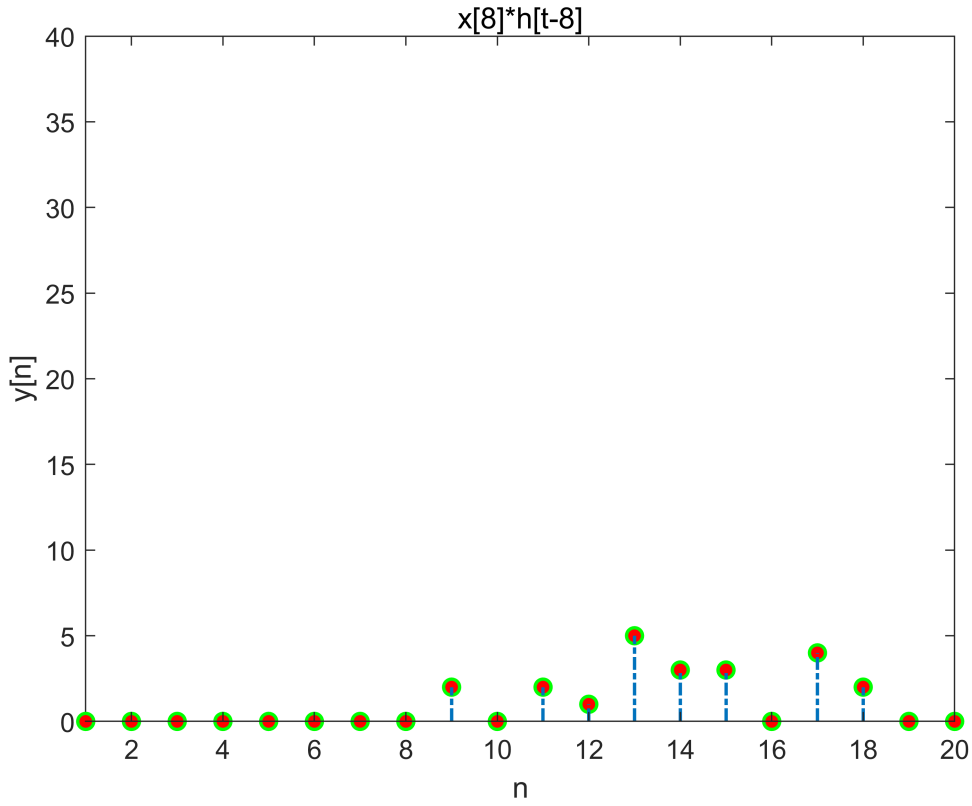

x[3]*h[t-3]
y[n]
n
0
5
10
15
20
25
30
35
40
2
4
6
8
10
12
14
16
18
20

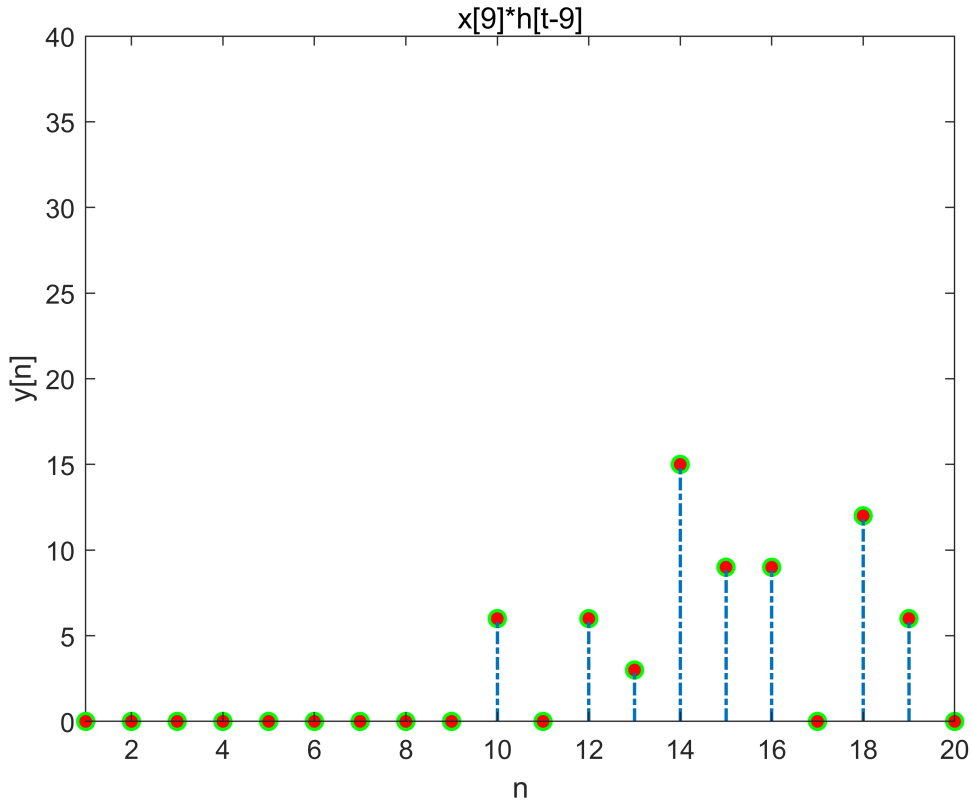

x[4]*h[t-4]
y[n]
n
0
5
10
15
20
25
30
35
40
2
4
6
8
10
12
14
16
18
20

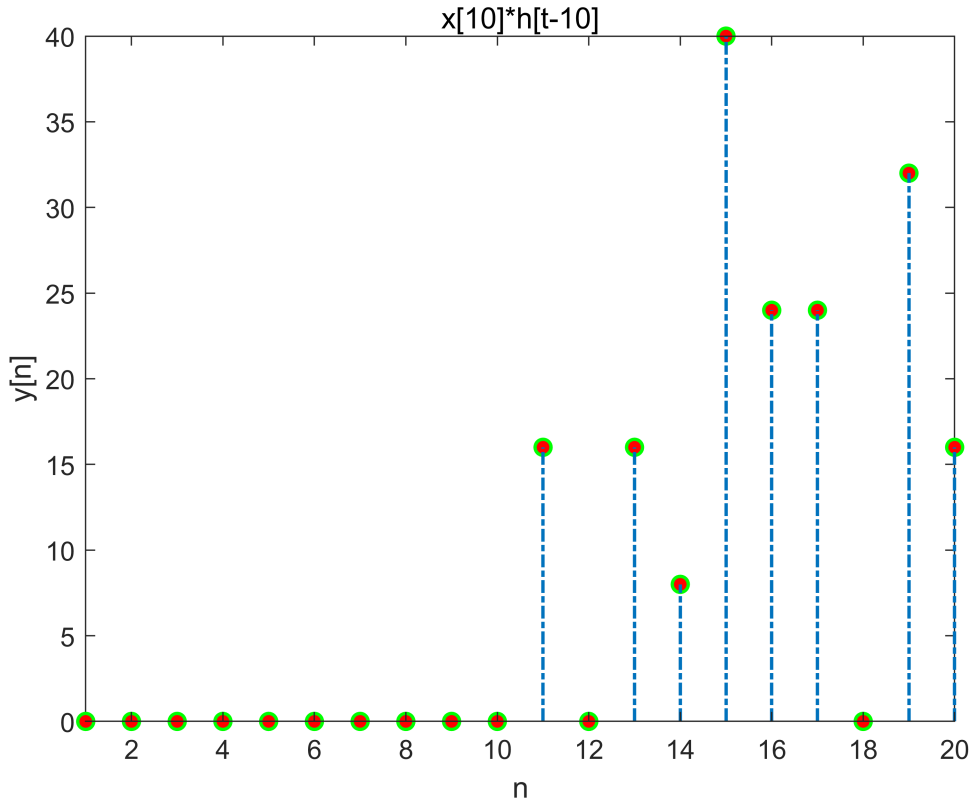

x[5]*h[t-5]
y[n]
n
0
5
10
15
20
25
30
35
40
2
4
6
8
10
12
14
16
18
20


x[6]*h[t-6]
y[n]
n
0
5
10
15
20
25
30
35
40
2
4
6
8
10
12
14
16
18
20


x[7]*h[t-7]
y[n]
n
0
5
10
15
20
25
30
35
40
2
4
6
8
10
12
14
16
18
20


x[8]*h[t-8]
y[n]
n
0
5
10
15
20
25
30
35
40
2
4
6
8
10
12
14
16
18
20






```
stem((1:20),y,'LineStyle','-.',...
    'LineWidth',1.25,...
     'MarkerFaceColor','red',...
```

```
 'MarkerEdgeColor','green') ;
axis([1,20,0,80]);
xlabel("n");
ylabel("y[n]");
title("convolution reseult (x*h)[t]");
```