Signals And Systems

ENEE 2312

MATLAB Assignment

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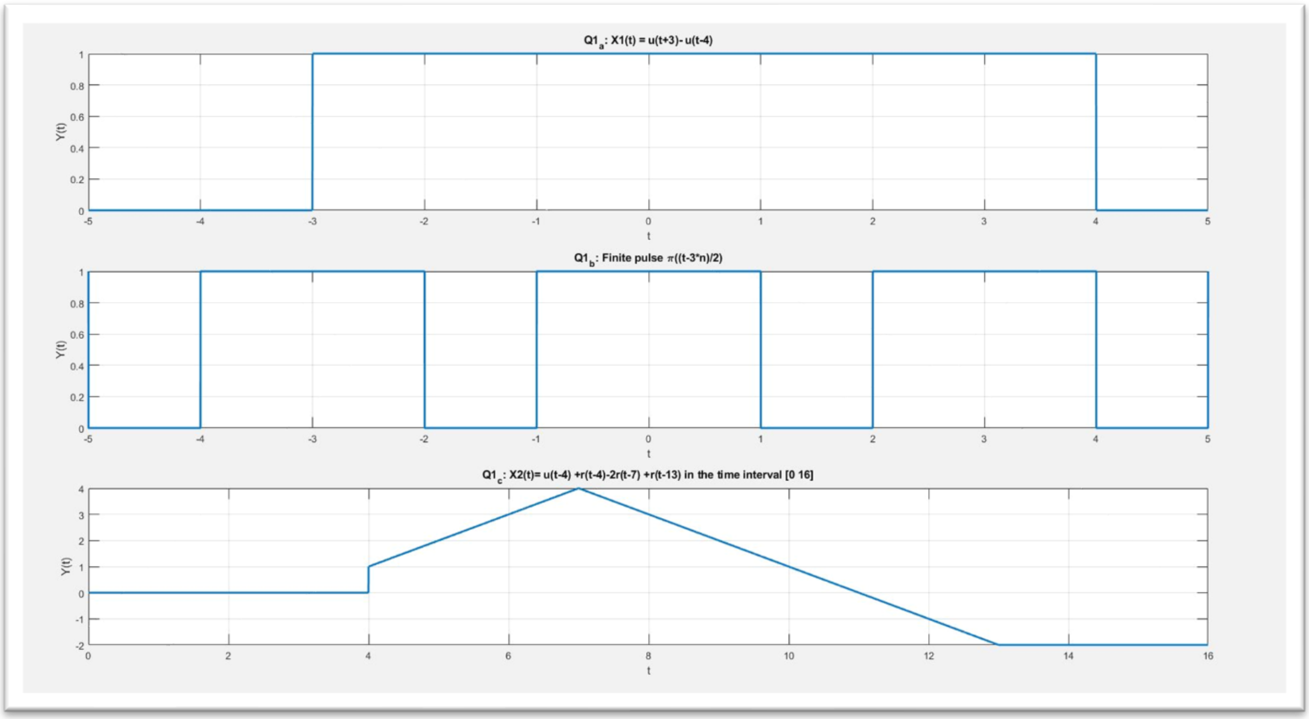
Question I:

Generate and plot the following signals using MATLAB:

1. $X_1(t) = u(t+3) - u(t-4)$
2. A finite pulse $\sum_{n=-\infty}^{\infty} \pi(\frac{t-3n}{2})$
3. $X_2(t) = u(t-4) + r(t-4) - 2r(t-7) + r(t-13)$ in the time interval [0 16]

➢ The graphs:



➢ The code:

a)

```
time1=-5:0.002:5;
x1=stp_fn(time1+3)-stp_fn(time1-4);
subplot(3,1,1),plot(time1,x1),grid
xlabel('t')
ylabel('Y(t)')
title('Q1_a: X1(t) = u(t+3)- u(t-4)')
```

b)

```
syms time2 n
summation = symsum(rectangularPulse((time2-(3.*n))/2),n,-Inf,Inf);
subplot(3,1,2),fplot(summation),grid
xlabel('t')
ylabel('Y(t)')
title('Q1_b: Finite pulse \pi((t-3*n)/2)')
```

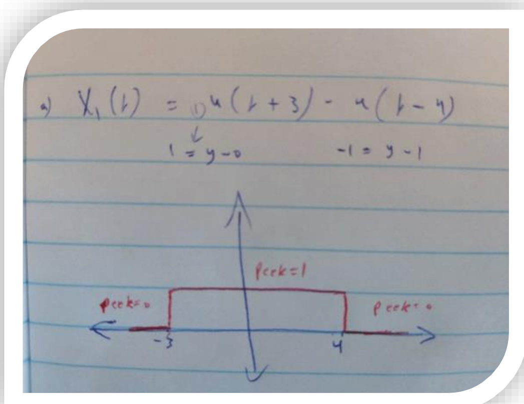
c)

```
time3=0:0.002:16;
x2=stp_fn(time3-4)+rmp_fn(time3-4)-2.*rmp_fn(time3-7)+rmp_fn(time3-13);
subplot(3,1,3),plot(time3,x2),grid
xlabel('t')
ylabel('Y(t)')
title('Q1_c: X2(t)= u(t-4) +r(t-4)-2r(t-7) +r(t-13) in the time interval [0
16]')
```

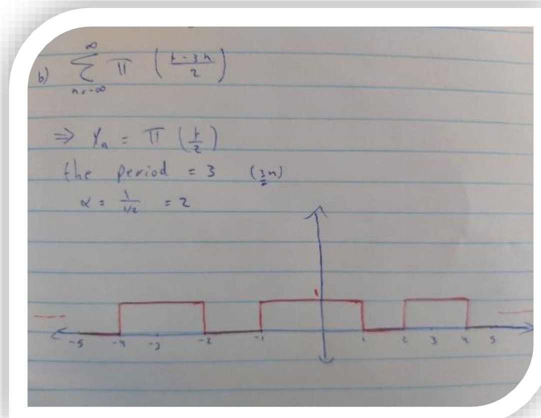
- Discussion:

I used the functions given at the book even though I could be able to use pre-defined functions such as (Heaviside and Rectangularpulse). I also used the definition of summation at part ‘b’ and it can be solved also using ‘for’ loop.

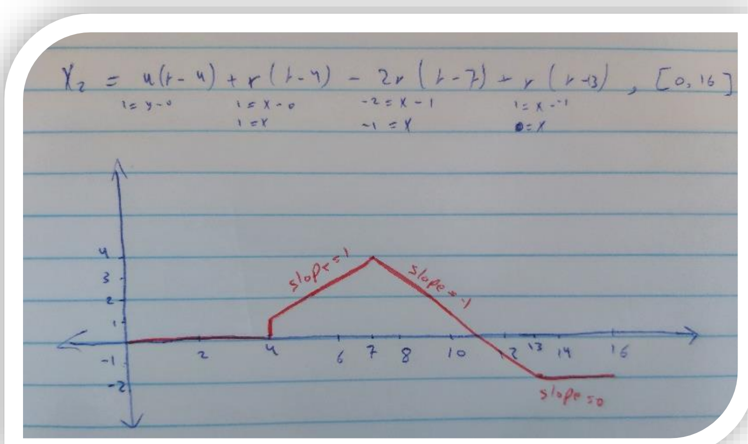
- Written solution:



‘a’



‘b’

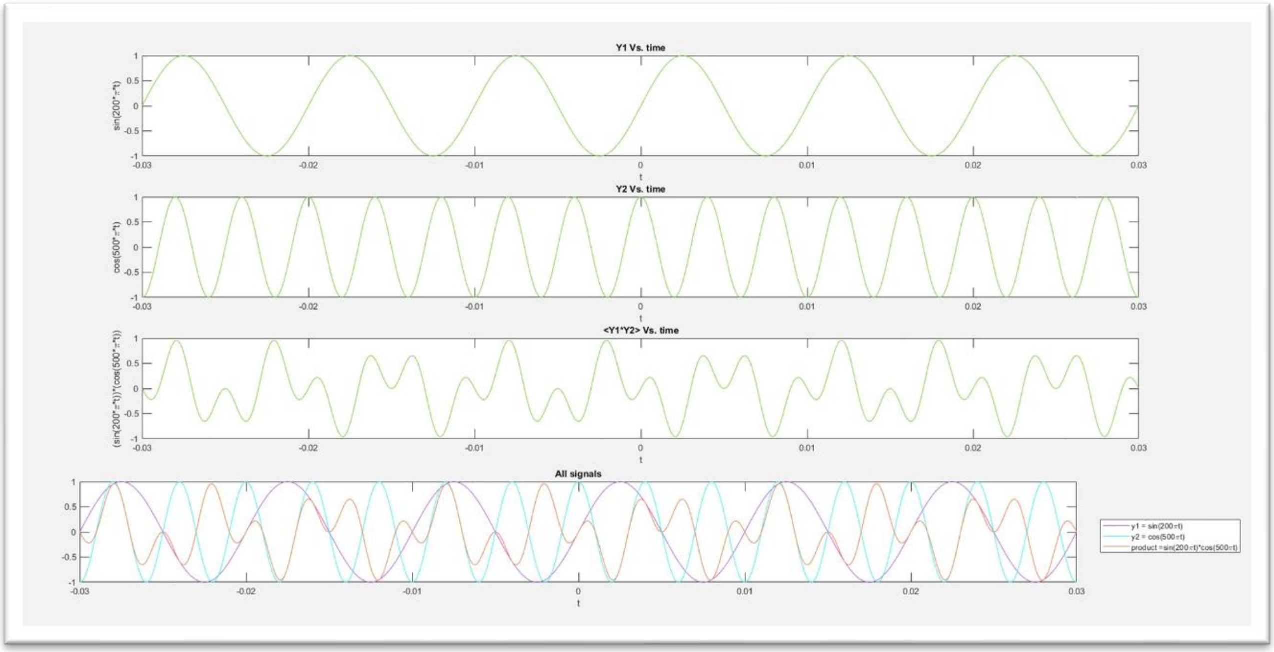


‘c’

Question II:

1. Generate and plot the signals y1(t)= sin (200πt), y2(t)= cos(500πt), then determine y1 and plot the product of two signals.
2. Determine, using the MATLAB plots, if the generated signal is periodic. In case a signal is periodic, determine its fundamental frequency.

- The graphs:



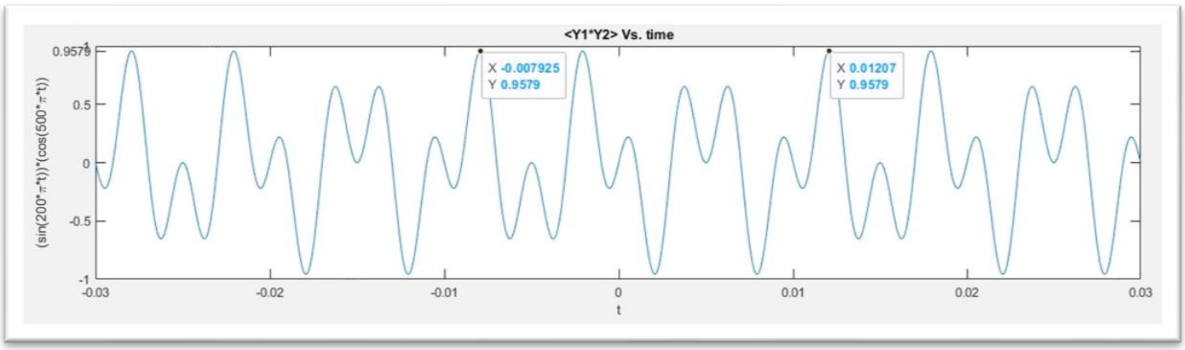
- The code:

```
t = -0.03:0.000005:0.03;
y1 = sin(200*pi*t);
y2 = cos(500*pi*t);
productOfTwoSignals = y1.*y2;
subplot(4,1,1),plot(t,y1);
ylabel("sin(200*\pi*t)");
xlabel("t");
title("Y1 Vs. time");
subplot(4,1,2),plot(t,y2);
title("Y2 Vs. time");
ylabel("cos(500*\pi*t)");
xlabel("t");
subplot(4,1,3),plot(t,productOfTwoSignals);
title("<Y1*Y2> Vs. time");
ylabel("(sin(200*\pi*t))*(cos(500*\pi*t))");
xlabel("t");
subplot(4,1,4),plot(t,y1,t,y2,t,productOfTwoSignals);
title("All signals");
xlabel("t");
```

```
legend({'y1 = sin(200\pit)','y2 = cos(500\pit)','product
=sin(200\pit)*cos(500\pit)'},'Location','eastoutside')
pks = findpeaks(productOfTwoSignals)
```

➢ Discussion:

First, I initialized the values of time as I saw suitable to get proper drawing. Then I initialized the values of Y1 & Y2. Finally, I found the value of the product and plotted it. The final signal is periodic. So, I used ‘findpeaks’ function in order to see the highest peaks and check the distance between them for a full period.
So, $T_0 = 0.01207+0.007925 = 0.02s$
$f_0 = 1/ T_0 = 50Hz$



➢ Written solution:

$y_1 = \sin(200\pi t)$, $y_2 = \cos(500\pi t)$

$y = y_1 . y_2$

$y = \frac{1}{2}\sin(700\pi t) + \frac{1}{2}\sin(-300\pi t)$ $\quad \sin(-\theta) = -\sin\theta$

$= \frac{1}{2}\sin(700\pi t) - \frac{1}{2}\sin(300\pi t)$

$w_1 = 2\pi n_1 f_0 \qquad w_2 = 2\pi n_2 f_0$

$350 = n_1 f_0$ — (1) $\qquad 150 = n_2 f_0$ — (2)

$\frac{7}{3} = \frac{n_1}{n_2} \Rightarrow$ from (1) $\Rightarrow f_0 = 50$ Hz

I have got the same answer when I solved it using MATLAB.

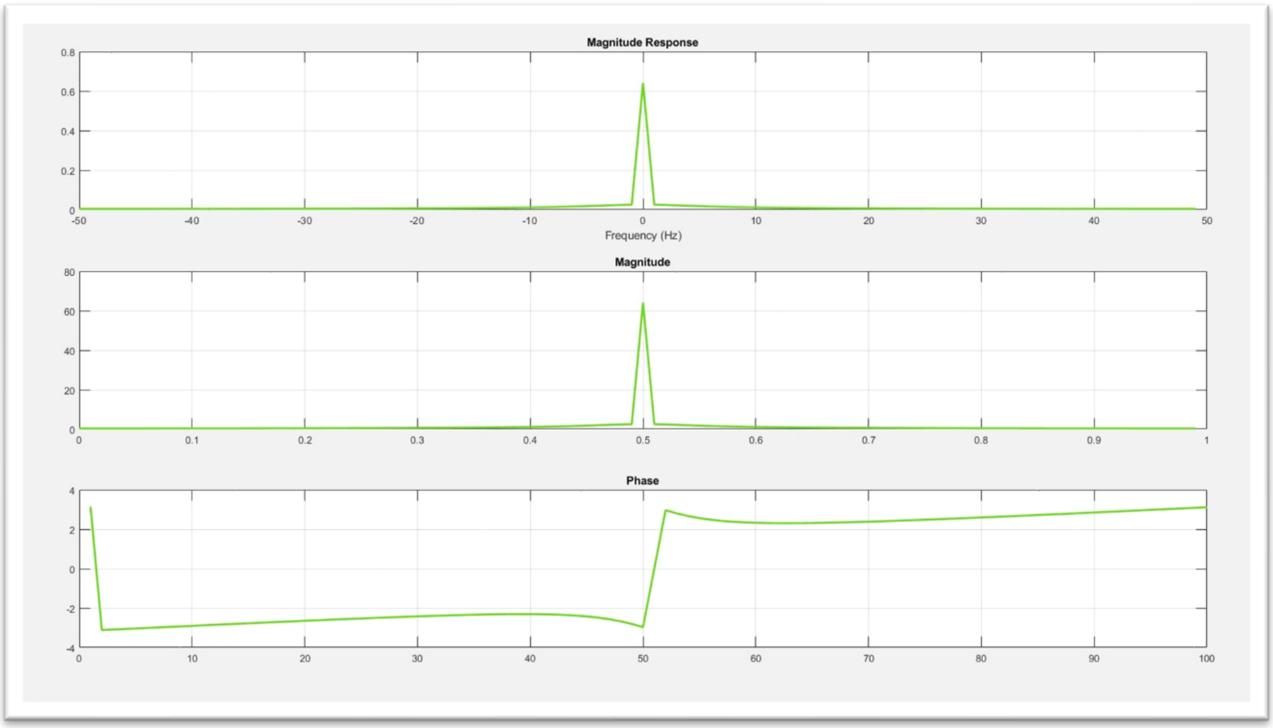
Question III:

Write For the following differential equation

$$\frac{dy(t)}{dt} + 30y(t) = 20$$

1. Write the program that solve the following differential equation (for t>0) using zero initial conditions.
2. Evaluate the Fourier Transform of the Transfer Function H(f)=Y(f)/X(f).
3. Plot the magnitude and phase of the Transfer Function H(f).

➢ The graphs:



➢ The code:

```
syms y(t)
equation = diff(y,t) == 20 - 30*y(t);
Solution_before_using_zero_initial_conditions = dsolve(equation);
condition = y(0) == 0;

a)

Fina_Answer = dsolve(equation,condition)
```

b)

```
Fs = 100;
dt = 1/Fs;
StopTime = 1;
t = (0:dt:StopTime-dt)';
N = size(t,1);
Fc = 12;
x = 2/3 - (2*exp(-30*t))/3;
F_T = fft(x);
F_T = fftshift(fft(x));
F_T
dF = Fs/N;
f=-Fs/2:dF:Fs/2-dF;
subplot(3,1,1),plot(f,abs(F_T)/N),grid;
xlabel("Frequency (Hz)");
title ("Magnitude Response");
```

c)

```
Value_Of_F_T = abs(F_T)
Phase_Of_F_T = angle(F_T)
subplot(3,1,2),plot(t,abs(F_T)),grid;
title ("Magnitude");
subplot(3,1,3),plot(angle(F_T)),grid;
title ("Phase");
```

- Discussion:

First, I initialized the first order differential equation. Second, I found the solution of the differential equation using ‘dsolve’ function. Then, I initialized the zero initial condition and found the final solution of the differential equation. After that, I found the Fourier transform using ‘fft’ function and then I used ‘fftshift’ function to shift it to the origin. And by using some calculations I changed into the frequency domain. Finally, I used ‘abs’ & ‘angle’ functions to plot the magnitude and the phase of the transfer function.

➢ Written solution:

The answer we get from matlab is:

$$y(t) = \underbrace{\frac{2}{3}}_{x_1} - \underbrace{\frac{2}{3} e^{-30t}}_{x_2} \qquad * \ \mathcal{F}\{x_1(t) + x_2(t)\} = X_1(f) + X_2(f)$$

$$\mathcal{F}\left[x_1(t)\right] = \frac{2}{3}\,\delta(f)$$

$$\mathcal{F}\{x_2(t)\} = \int_{-\infty}^{\infty} \frac{2}{3} e^{-30t} \cdot e^{-j\omega t}\, dt \qquad \text{, but } t > 0 \text{ (given)}$$

$$= \frac{2}{3} \int_{0}^{\infty} e^{-30t} \cdot e^{-j\omega t}\, dt$$

$$= \frac{2}{3} \int_{0}^{\infty} e^{-t(30+j\omega)}\, dt$$

$$= \frac{2}{3} \cdot \frac{-1}{30+j\omega} \left[e^{-t(30+j\omega)} \Big|_{0}^{\infty} \right] \Rightarrow 0 - 1 = -1$$

$$= \frac{3}{3} \cdot \frac{1}{30+j\omega}$$

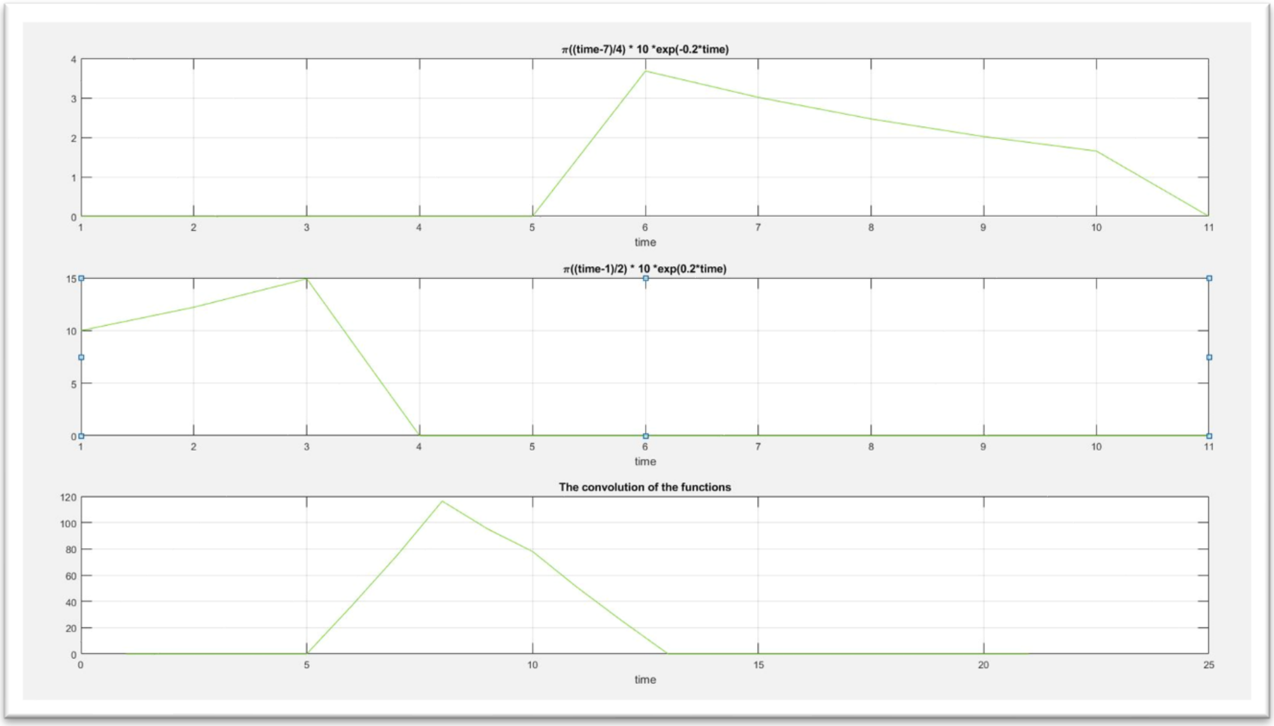
$$\mathcal{F} = \frac{2}{3}\,\delta(f) + \frac{2}{90 + 6\pi f j}$$

Question IV:

Write a program that computes and plots the convolution of the functions

$$x(t) = (10e^{-0.2t})\pi\left(\frac{t-7}{4}\right), h(t) = (10e^{0.2t})\pi\left(\frac{t-1}{2}\right),$$

- The graphs:



- The code:

```
time=0:10;
x = rectangularPulse((time-7)/4) .* 10.*exp(-0.2.*time);
subplot(3, 1,1),plot(x),grid
xlabel('time')
title('\pi((time-7)/4) * 10 *exp(-0.2*time)')
h = rectangularPulse((time-1)/2) .* 10.*exp(0.2.*time);
subplot(3, 1,2),plot(h),grid
xlabel('time')
title('\pi((time-1)/2) * 10 *exp(0.2*time)')
y=conv(x,h)
subplot(3, 1,3),plot(y),grid
xlabel('time')
title('The convolution of the functions')
```

- Discussion:

  I used the pre-defined function ‘rectangularpulse’ and then multiplied it by the given exponential. Then I used the ‘conv’ function to calculate the convolution and plot it.

Appendix:

The Code used for the MATLAB Assignment

```
%%%%%%%%%%%%  Question 1
clear all
close all
clc

%Q1_a
time1=-5:0.002:5;
x1=stp_fn(time1+3)-stp_fn(time1-4);
subplot(3,1,1),plot(time1,x1),grid
xlabel('t')
ylabel('Y(t)')
title('Q1_a: X1(t) = u(t+3)- u(t-4)')


%Q1_b
syms time2 n
summation = symsum(rectangularPulse((time2-
(3.*n))/2),n,-Inf,Inf);
subplot(3,1,2),fplot(summation),grid
xlabel('t')
ylabel('Y(t)')
title('Q1_b: Finite pulse \pi((t-3*n)/2)')


%Q1_c
time3=0:0.002:16;
x2=stp_fn(time3-4)+rmp_fn(time3-4)-2.*rmp_fn(time3-
7)+rmp_fn(time3-13);
subplot(3,1,3),plot(time3,x2),grid
xlabel('t')
ylabel('Y(t)')
title('Q1_c: X2(t)= u(t-4) +r(t-4)-2r(t-7) +r(t-13) in
the time interval [0 16]')
```

```
%%%%%%%%%%%%  Question 2
clear all
close all
clc

t = -0.03:0.000005:0.03;
y1 = sin(200*pi*t);
y2 = cos(500*pi*t);
productOfTwoSignals = y1.*y2;

%sin(200*\pi*t)
subplot(4,1,1),plot(t,y1);
ylabel("sin(200*\pi*t)");
xlabel("t");
title("Y1 Vs. time");

%cos(500*\pi*t)
subplot(4,1,2),plot(t,y2);
title("Y2 Vs. time");
ylabel("cos(500*\pi*t)");
xlabel("t");

%(sin(200*\pi*t))*(cos(500*\pi*t))
subplot(4,1,3),plot(t,productOfTwoSignals);
title("<Y1*Y2> Vs. time");
ylabel("(sin(200*\pi*t))*(cos(500*\pi*t))");
xlabel("t");

%All signals
subplot(4,1,4),plot(t,y1,t,y2,t,productOfTwoSignals);
title("All signals");
xlabel("t");
legend({'y1 = sin(200\pit)','y2 = cos(500\pit)','product
=sin(200\pit)*cos(500\pit)'},'Location','eastoutside')

pks = findpeaks(productOfTwoSignals)
```

```
%%%%%%%%%%%%  Question 3
clear all
close all
clc

syms y(t)
equation = diff(y,t) == 20 - 30*y(t);
Solution_before_using_zero_initial_conditions =
dsolve(equation);
condition = y(0) == 0;

%Q3_a
Fina_Answer = dsolve(equation,condition)

%Q3_b
Fs = 100;
dt = 1/Fs;
StopTime = 1;
t = (0:dt:StopTime-dt)';
N = size(t,1);
Fc = 12;

%The value of x has been taken from Q3_a and then it
was added to Q3_b
x = 2/3 - (2*exp(-30*t))/3;
F_T = fft(x);
F_T = fftshift(fft(x));
F_T
dF = Fs/N;
f=-Fs/2:dF:Fs/2-dF;
subplot(3,1,1),plot(f,abs(F_T)/N),grid;
xlabel("Frequency (Hz)");
title ("Magnitude Response");

%Q3_c
Value_Of_F_T = abs(F_T)
Phase_Of_F_T = angle(F_T)
subplot(3,1,2),plot(t,abs(F_T)),grid;
title ("Magnitude");
subplot(3,1,3),plot(angle(F_T)),grid;
title ("Phase");
```

```
%%%%%%%%%%%%  Question 4
clear all
close all
clc


time=0:10;
x = rectangularPulse((time-7)/4) .* 10.*exp(-0.2.*time);
subplot(3, 1,1),plot(x),grid
xlabel('time')
title('\pi((time-7)/4) * 10 *exp(-0.2*time)')
h = rectangularPulse((time-1)/2) .* 10.*exp(0.2.*time);
subplot(3, 1,2),plot(h),grid
xlabel('time')
title('\pi((time-1)/2) * 10 *exp(0.2*time)')
y=conv(x,h)
subplot(3, 1,3),plot(y),grid
xlabel('time')
title('The convolution of the functions')



%%%%%%%%%%%%The functions used:


function u = stp_fn(t)
u = 0.5 *(sign(t+eps) + 1);

function r = rmp_fn(t)
r=0.5*t.*(sign(t)+1);

function y = pls_fn(t)
y = stp_fn (t+0.5 ) - stp_fn (t - 0.5 - eps) ;
```

Conclusion:

This was my first-time using MATLAB. It was a great opportunity to learn more things about the program, as I used several functions that I even didn’t know they were exist. At first, it was hard. But after I practiced it for a long time, it became easier to deal with it.