Birzeit University-Faculty of Engineering and Technology
Electrical and Computer Engineering Department
EE2312 Signals &systems
Signals and Systems with MATLAB _Assignment

Inst.: Dr. Jamal Siam **Summer sem-2022-23**

Question I:

Generate and plot the following signals using MATLAB:

1. X1(t) = u(t-7)- u(t-13)
2. A finite pulse (π(t)) with value = 6 and extension between 2and 8
3. X_2(t)= u(t-4) +r(t-6)-2r(t-7) +r(t-10) in the time interval [0 15]

Question II:

1. Generate and plot the signals y1(t)= sin 100π(t), y2(t)= cos950πt, then determine y1 and plot the signals m(t)= y1+y2 and n(t)= y1-y2
2. Determine, using the MATLAB plots, if the sum and/or difference signals are periodic. In case a signal is periodic, determine its fundamental frequency.)

Question III:

Write the programs that solve the following differential equations using zero initial conditions.

1. $10\frac{dy(t)}{dt} + 20y(t) = 10$
2. $\frac{d^2y(t)}{dt^2} + 2\frac{dy}{dt} + 4y(t) = 5\cos 1000t$

Question IV:

Write the programs that determine the response of the linear time invariant system to the given input and the given initial conditions:

1. $\frac{dy(t)}{dt} + 5y(t) = 10u(t)$ $y(0) = 3;$
2. $\frac{d^2y(t)}{dt^2} + 2\frac{dy}{dt} + 2y(t) = 5\cos 200t$ (y (0) =1, y' (0) =2);

Question V:

Use Simulink (MATLAB) to simulate the following systems then show and plot the step response of the system.

1. $4\frac{d^4y(t)}{dt^4} + 6\frac{dy(t)}{dt} + 8y(t) = 7\frac{d^2x(t)}{dt^2} + 12x(t)$
2. $\frac{d^2y(t)}{dt^2} + 2\frac{dy}{dt} + 4y(t) = 5\,x(t)$

Question VI:

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

$y(t) = (10e^{-10t})$π((t-2)/4), $y(t) = (10e^{-10t}\cos 100t)$ π((t-6)/8)

Question VII:

Write a program that computes and plots the spectral representation of the function

1. $y(t) = (10e^{-2t})$u(t)

2. $y(t) = (10e^{-t}\cos 300t)$u(t)

Question VIII:
Write a program that computes the Laplace transform of the function

3. $y(t) = (10 - 10e^{-2t})$u(t)
4. $y(t) = (30 - 1000e^{-4t}\cos 200\pi t)$u(t)

Question IX:
Write a program that determine the inverse Laplace transform of the transfer functions in IV.

Question XI:

Use Simulink (MATLAB) to simulate the following systems **in Laplace domain** then show and plot the step response of the system.

$$4\frac{d^4y(t)}{dt^4} + 7\frac{d^2y(t)}{dt^2} + 2\frac{\mathrm{dy}}{\mathrm{dt}} + 3y(t) = 2\frac{d^2x(t)}{dt^2} + 3\frac{\mathrm{dx}}{\mathrm{dt}} + 5x(t)$$

Question XII:
Plot the frequency response (semi-log scale) of the system with transfer function

$$H(s) = 10000\frac{s+1}{s^2 + 4s + 3}$$

Question XIII:
A signal tone signal with amplitude 10 and frequency 75Hz modulates a sinusoidal carrier amplitude (with carrier frequency 1500 Hz and amplitude 15. The carrier is transmitted with the modulated signal in what is called standard AM or double sideband with carrier transmitted.

- Compute the modulated signal and say if it is periodic.
- Plot the spectral representation of the message, the carrier, and the modulated signal.
- Plot the power spectral density of the modulated signal.

Faculty of Engineering and Technology

Electrical and Computer Engineering Department

Signals and Systems

Matlab Assignment

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Section: 1.

Birzeit
2023/2024

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1 Questions and solutions

1.1 Question 1

Generate and plot the following signals using MATLAB:

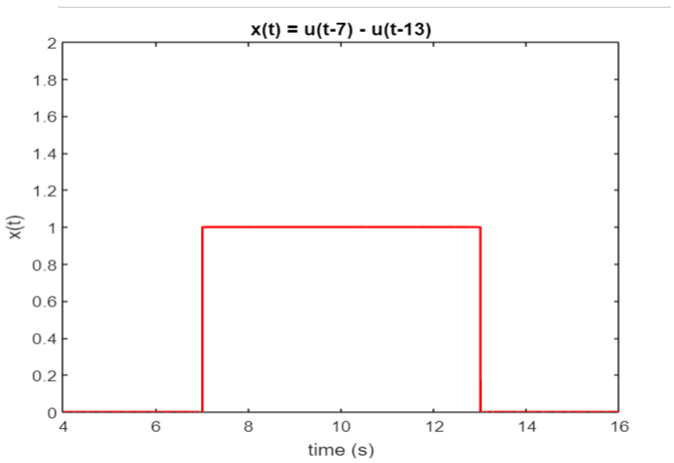
1. $X1(t) = u(t-7) - u(t-13)$
2. A finite pulse ($\pi(t)$) with value = 6 and extension between 2and 8
3. $X_2(t) = u(t-4) + r(t-6) - 2r(t-7) + r(t-10)$ in the time interval [0 15]

Figure 1: Question 1

1.1.1 part 1

```
%Ali Shaikh Qasem 1212171
%Q1.1

syms x(t);
x(t) = heaviside(t-7) - heaviside(t-1
fplot(x,'r','LineWidth',1.4);
title('x(t) = u(t-7) - u(t-13)');
ylabel('x(t)');
xlabel('time (s)');
axis([4 16 0 2]);

```

(a) the code



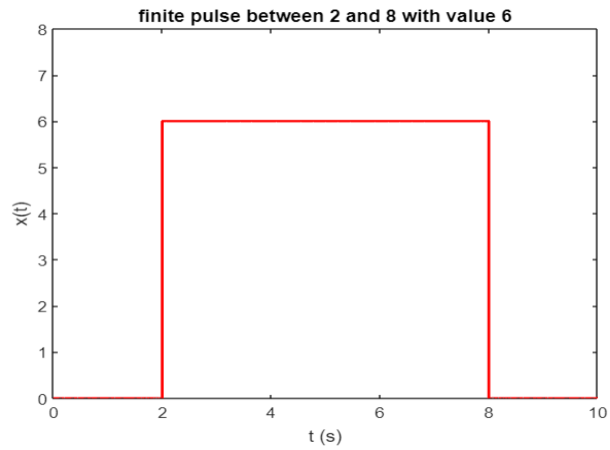
(b) the graph

Figure 2: Question 1 part 1

1.1.2 part 2

```
% Ali Shaikh Qasem 1212171
% Q1.2

syms x;
syms t;
x = 6*rectangularPulse(2,8,t);
fplot(x,'r','LineWidth',1.5);

title ('finite pulse between 2 and 8 with val
ylabel ('x(t)');
xlabel ('t (s)');
axis ([0 10 0 8]);
```

(a) the code



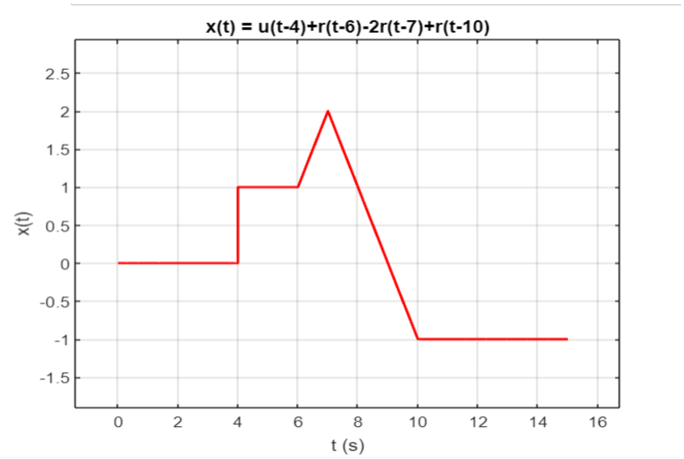
(b) the graph

Figure 3: Question 1 part 2

1.1.3 part 3

```
% Ali Shaikh Qasem 1212171
% Q1.2

syms x;
syms t;
r(t) = heaviside(t)*(t);
x = heaviside(t-4) + r(t-6) - 2*r(t-7) + r
fplot(x,'r',[0 15],'LineWidth',1.5);
axis([0 15 0 4]);
grid on;
title('x(t) = u(t-4)+r(t-6)-2r(t-7)+r(t-10
xlabel ('t (s)');
ylabel ('x(t)');
```

(a) the code



(b) the graph

Figure 4: Question 1 part 3

1.2 Question 2

1. Generate and plot the signals y1(t)= sin 100π(t), y2(t)= cos950πt, then determine y1 and plot the signals m(t)= y1+y2 and n(t)= y1-y2
2. Determine, using the MATLAB plots, if the sum and/or difference signals are periodic. In case a signal is periodic, determine its fundamental frequency.)

Figure 5: Question 2

1.2.1 part 1

```
% Ali Shaikh Qasem 1212171
% Q2.1

syms t;
y1(t) = sin(100*pi*t);
subplot(2,2,1);
fplot(y1,'r');
title('y1(t) = sin(100*pi*t)');
xlabel('t (s)');
ylabel ('y1(t)');
axis([-0.06 0.06 -2 2]);

y2(t) = cos(950*pi*t);
subplot(2,2,2);
fplot(y2,'g');
title('y2(t) = cos(950*pi*t)');
xlabel('t (s)');
ylabel ('y2(t)');
axis([-0.006 0.006 -2 2]);
```

(a) the code part 1

```
m(t) = y1 + y2;
subplot(2,2,3);
fplot(m);
title('m(t) = y1+y2');
xlabel('t (s)');
ylabel ('m(t)');
axis([-0.025 0.025 -2 2]);

n(t) = y1 - y2;
subplot(2,2,4);
fplot(n);
title('n(t) = y1-y2');
xlabel('t (s)');
ylabel ('n(t)');
axis([-0.025 0.025 -2 2]);
```

(b) the code part 2

Figure 6: Question 2 part 1 code

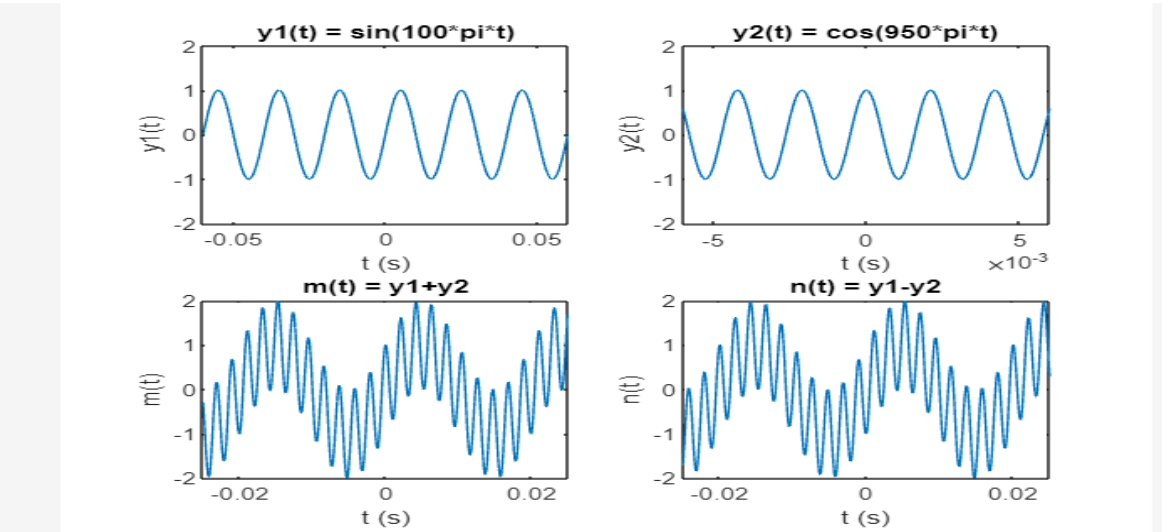


Figure 7: Question 2 part 1 graph

1.2.2 part 2

- It's clear from the figure above that both y1+y2 and y1-y2 are periodic signals, that their signals repeat in a certain time period, we can compute the fundemental frequency using the ratio of the original signals frequency , f1/f2 = 50 / 475 = 2/19 , f0 = 25 Hz, since 25 * 2 = 50 (f1), 25*19 = 475(f2).

1.3 Question 3

Write the programs that solve the following differential equations using zero initial conditions.

1. $10\frac{dy(t)}{dt} + 20y(t) = 10$
2. $\frac{d^2y(t)}{dt^2} + 2\frac{dy}{dt} + 4y(t) = 5\cos 1000t$

Figure 8: Question 3

1.3.1 part 1

```
% Ali Shaikh Qasem 1212171
% Q3

syms y(t);
D1 = diff(y);
D2 = y(0)==0;
x = (10*D1) + (20*y) == 10;
dsolve(x,D2)
```

(a) the code

```
ans =

1/2 - exp(-2*t)/2
```

(b) the solution

Figure 9: Question 3 part 1

1.3.2 part 2

```
% Ali Shaikh Qasem 1212171
% Q3

syms y(t);
D1 = diff(y);
D2 = diff(y,2);
D3 = y(0)==0;
D4 = D1(0)==0;
x = D2 + 2*D1 + 4*y == 5*cos(1000*t);
dsolve(x,D3,D4)
```

Figure 10: Question 3 part 2 code

```
ans =

sin(3^(1/2)*t)*((625*cos(1000*t - 3^(1/2)*t))/124999500002 - (625*cos(1000*t + 3^(1/2)*t))/124999500002 - (1249995*sin(1000*t + 3
^(1/2)*t))/499998000008 + (1249995*sin(1000*t - 3^(1/2)*t))/499998000008 + (1250005*3^(1/2)*cos(1000*t + 3^(1/2)*t))/1499994000024 +
(1250005*3^(1/2)*cos(1000*t - 3^(1/2)*t))/1499994000024 + (312499375*3^(1/2)*sin(1000*t + 3^(1/2)*t))/374998500006 + (312499375*3
^(1/2)*sin(1000*t - 3^(1/2)*t))/374998500006) - (5*3^(1/2)*cos(3^(1/2)*t)*((sin(t*(3^(1/2) - 1000)) - cos(t*(3^(1/2) - 1000))*(3^(1/2) -
1000))/((3^(1/2) - 1000)^2 + 1) + (sin(t*(3^(1/2) + 1000)) - cos(t*(3^(1/2) + 1000))*(3^(1/2) + 1000))/((3^(1/2) + 1000)^2 + 1)))/6 -
(1250005*3^(1/2)*exp(-t)*sin(3^(1/2)*t))/749997000012 - (1249995*exp(-t)*cos(3^(1/2)*t))/(4*(500*3^(1/2) - 250001)*(500*3^(1/2) + 250001))
```

Figure 11: Question 3 part 2 solution

1.4 Question 4

Write the programs that determine the response of the linear time invariant system to the given input and the given initial conditions:

1. $\frac{dy(t)}{dt} + 5y(t) = 10u(t) \qquad y(0) = 3;$

2. $\frac{d^2y(t)}{dt^2} + 2\frac{dy}{dt} + 2y(t) = 5\cos 200t \qquad (y(0) = 1,\ y'(0) = 2);$

Figure 12: Question 4

1.4.1 part 1

```
% Ali Shaikh Qasem 1212171
% Q3

syms y(t);
D1 = diff(y);
C1 = y(0) == 3;

x = D1 + 5*y ==10*heaviside(t);
dsolve(x,C1)
```

(a) the code

```
ans =

2*exp(-5*t) - exp(-5*t)*(sign(t) - exp(5*t)*(sign(t) + 1))
```

(b) the solution

Figure 13: Question 4 part 1

1.4.2 part 2

```
% Ali Shaikh Qasem 1212171
% Q3

syms y(t);

D1 = diff(y);
D2 = diff(y,2);

C1 = y(0) ==1;
C2 = D1(0) == 2;

x = D2 + 2*D1 + 2*y == 5*cos(200*t);
dsolve(x,C1,C2)
```

Figure 14: Question 4 part 2 code

```
ans =

sin(t)*((5*cos(199*t))/79204 + (5*cos(201*t))/80804 + (995*sin(199*t))/79204 + (1005*sin(201*t))/80804) - cos(t)*((995*cos(199*t))/79204 - (1005*cos(201*t))/80804 - (5*sin(199*t))/79204 + (5*sin(201*t))/80804) + (800099997*exp(-t)*cos(t))/800000002 + (2399900001*exp(-t)*sin(t))/800000002
```

Figure 15: Question 4 part 2 solution

1.5 Question 5

Use Simulink (MATLAB) to simulate the following systems then show and plot the step response of the system.

1. $4\frac{d^4y(t)}{dt^4} + 6\frac{dy(t)}{dt} + 8y(t) = 7\frac{d^2x(t)}{dt^2} + 12x(t)$
2. $\frac{d^2y(t)}{dt^2} + 2\frac{dy}{dt} + 4y(t) = 5\,x(t)$

Figure 16: Question 5

1.5.1 part 1

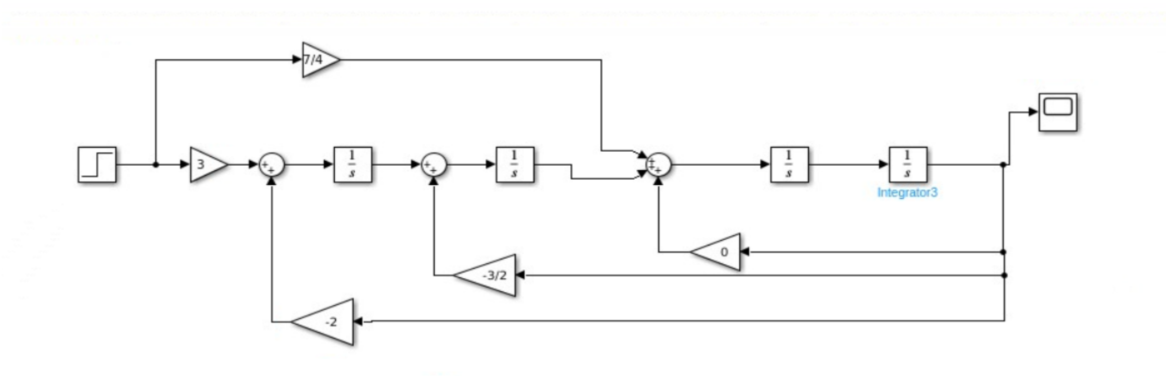


Figure 17: Question 5 part 1 simulink

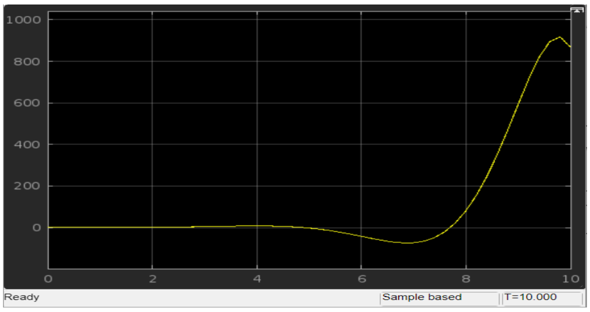


Figure 18: Question 5 part 1 response

1.5.2 part 2

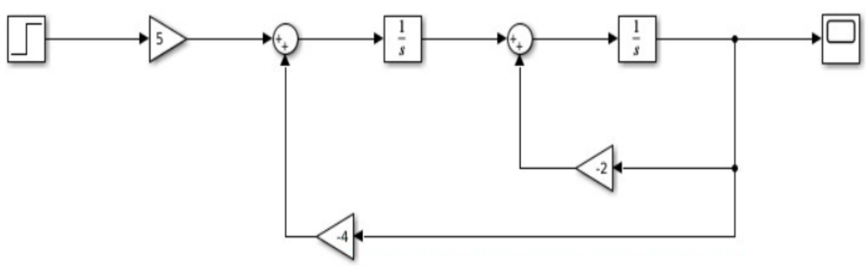


Figure 19: Question 5 part 2 simulink

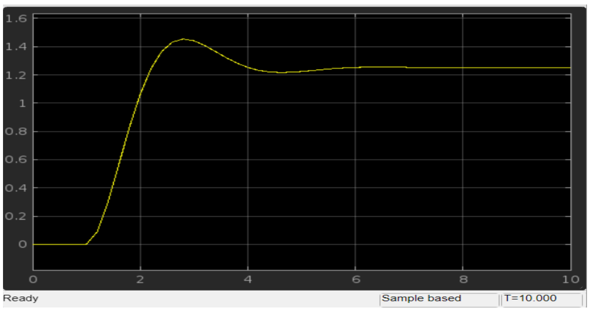


Figure 20: Question 5 part 2 response

1.6 Question 6

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

$y(t) = (10e^{-10t})\pi((t\text{-}2)/4),\ \ y(t) = (10e^{-10t}\cos 100t)\ \pi((t\text{-}6)/8)$

Figure 21: Question 6

```
% Ali Shaikh Qasem 1212171
% Q6

syms t lambda;

y1(t) = 10 * exp(-10 * t) * rectangularPulse(0,4,t);
y2(t) = 10 * exp(-10 * t) * cos (100 * t) * rectangularPulse(2,10,t);
conv = int(y1(t-lambda) * y2(lambda), lambda,-inf,inf);
simplify(conv);
fplot(conv,'r');
title('convolution');
xlabel('t (s)');
ylabel('y1(t) concolve y2(t)');
axis([1 4 0 3*10^(-9)])
```

Figure 22: Question 6 code

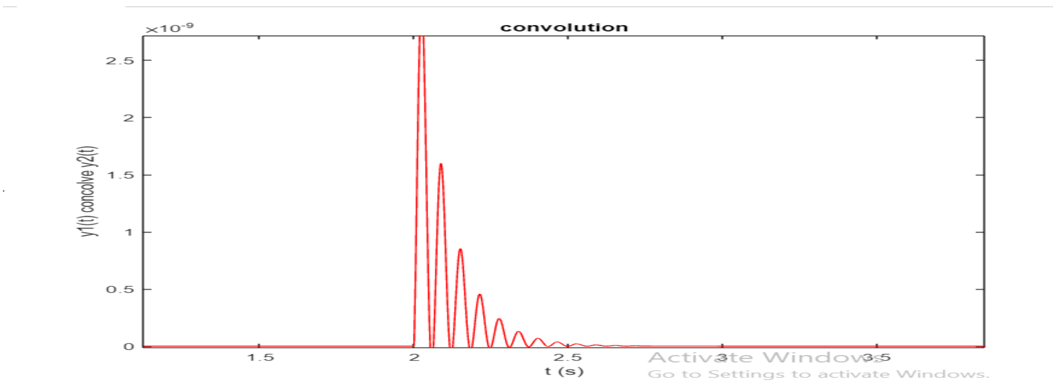


Figure 23: Question 6 graph

1.7 Question 7

Write a program that computes and plots the spectral representation of the function

1. $y(t) = (10e^{-2t})u(t)$

2. $y(t) = (10e^{-t}\cos 300t)u(t)$

Figure 24: Question 7

1.7.1 part 1

```
% Ali Shaikh Qasem 1212171
% Q7

syms t f ;
y(t) = 10*exp(-2*t) * heaviside(t);
Y(f) = fourier(y,f);

magnitude = abs(Y);
subplot(2,1,1);
fplot(magnitude,'r');
title('magnitude spectra');
xlabel ('frequency (Hz)')
ylabel('magnitude');
axis([-60 60 0 6]);

phase = angle(Y);
subplot(2,1,2);
fplot(phase,'r');
axis([-200 200  -3 3]);
title('phase spectra');
xlabel ('frequency (Hz)')
ylabel('phase');
```

Figure 25: Question 7 part 1 code

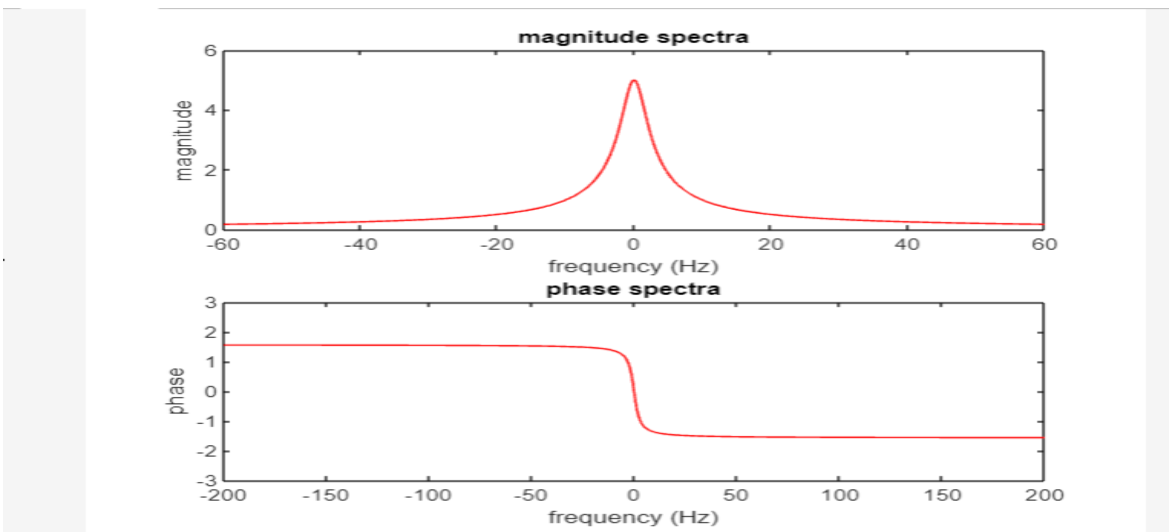


Figure 26: Question 7 part 1 graph

1.7.2 part 2

```
% Ali Shaikh Qasem 1212171
% Q7

syms t f ;
y(t) = 10*exp(-1*t) * cos(300 * t) * heaviside(t);
Y(f) = fourier(y,f);

magnitude = abs(Y);
subplot(2,1,1);
fplot(magnitude,'r');
title('magnitude spectra');
xlabel ('frequency (Hz)')
ylabel('magnitude');
axis([-1000 1000 0 3]);

phase = angle(Y);
subplot(2,1,2);
fplot(phase,'r');
title('phase spectra');
xlabel ('frequency (Hz)')
ylabel('phase');
axis([-1000 1000 -3 3]);
```

Figure 27: Question 7 part 2 code

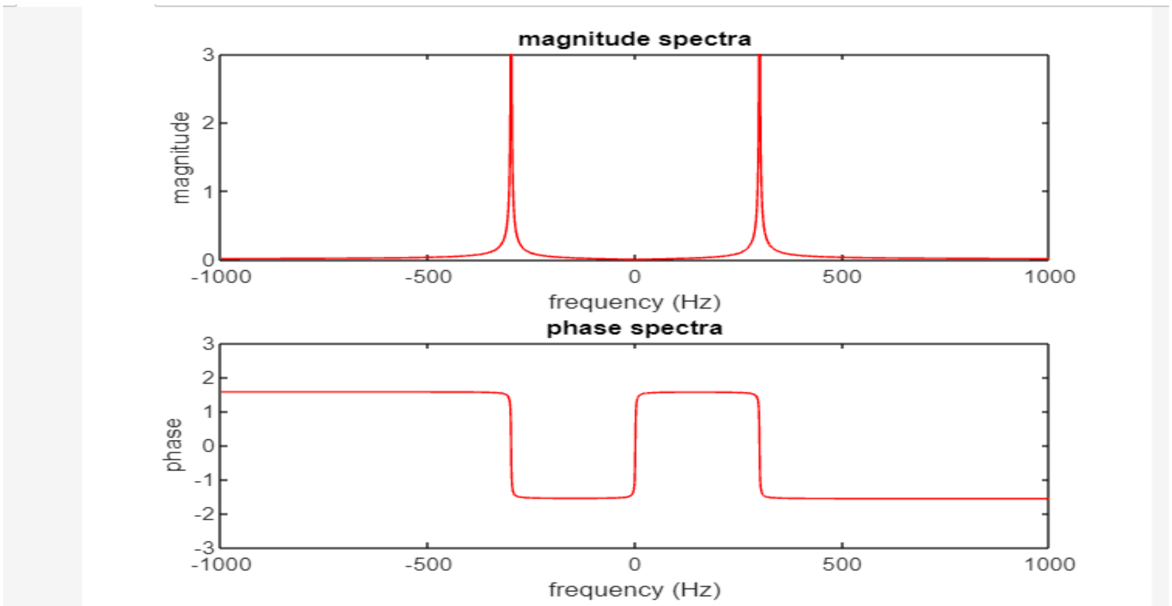


Figure 28: Question 7 part 2 graph

1.8 Question 8

Write a program that computes the Laplace transform of the function

3. $y(t) = (10 - 10e^{-2t})$u(t)
4. $y(t) = (30 - 1000e^{-4t} \cos 200\pi t)$u(t)

Figure 29: Question 8

```
% Ali Shaikh Qasem 1212171
% Q8

syms t;
y(t) = (10 - 10*exp(-2*t)) * heaviside(t);
y2(t) = (30 - 1000 * exp(-4*t) * cos(200*pi*t)) * heaviside(t);
laplace(y)
laplace(y2)
```

(a) the code

```
ans =

10/s - 10/(s + 2)

ans =

30/s - (1000*(s + 4))/((s + 4)^2 + 40000*pi^2)
```

(b) the solution

Figure 30: Question 8 answer

1.9 Question 9

Write a program that determine the inverse Laplace transform of the transfer functions in IV.

Figure 31: Question 9

```
% Ali Shaikh Qasem 1212171
% Q9

syms s t;

T1(s) = 10/(s+5);
T2(s) = 5/(s*s + 2*s + 2);
ilaplace(T1)
ilaplace(T2)
```

(a) the code

```
ans =

10*exp(-5*t)

ans =

5*exp(-t)*sin(t)
```

(b) the solution

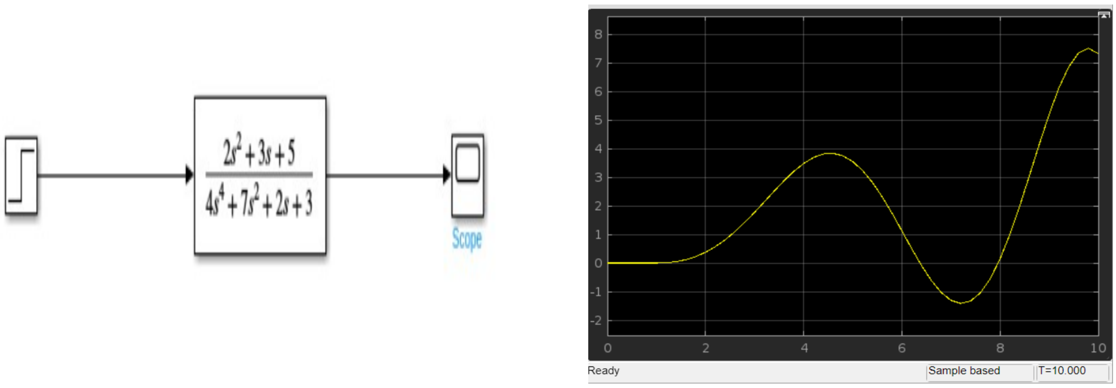
Figure 32: Question 9 answer

1.10 Question 10

Use Simulink (MATLAB) to simulate the following systems **in Laplace domain** then show and plot the step response of the system.

$$4\frac{d^4y(t)}{dt^4} + 7\frac{d^2y(t)}{dt^2} + 2\frac{\mathrm{dy}}{\mathrm{dt}} + 3y(t) = 2\frac{d^2x(t)}{dt^2} + 3\frac{\mathrm{dx}}{\mathrm{dt}} + 5x(t)$$

Figure 33: Question 10



(a) the simulink

(b) the response

Figure 34: Question 10 answer

1.11 Question 11

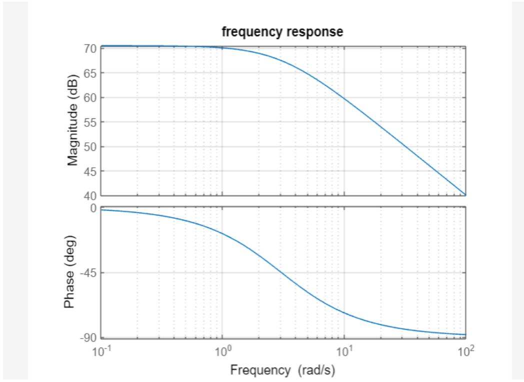
Plot the frequency response (semi-log scale) of the system with transfer function

$$H(s) = 10000\frac{s+1}{s^2+4s+3}$$

Figure 35: Question 11

```
% Ali Shaikh Qasem 1212171
% Q11

syms s t;
% H(s) = 10000 (s+1) / (s^2 + 4s + 3)
num = [10000 10000];
den = [1 4 3];
sys = tf(num,den);
bode(sys)
title('frequency response');

grid on;
```

(a) the code



(b) the response

Figure 36: Question 11 answer

1.12 Question 12

A signal tone signal with amplitude 10 and frequency 75Hz modulates a sinusoidal carrier amplitude (with carrier frequency 1500 Hz and amplitude 15. The carrier is transmitted with the modulated signal in what is called standard AM or double sideband with carrier transmitted.

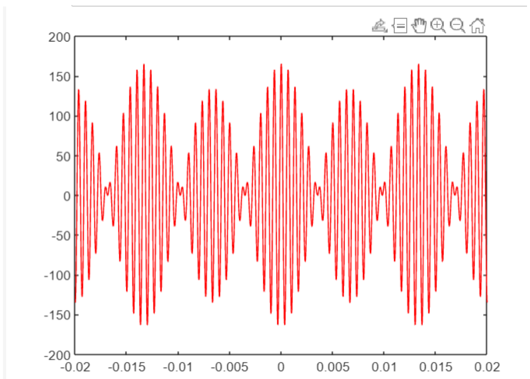
- Compute the modulated signal and say if it is periodic.
- Plot the spectral representation of the message, the carrier, and the modulated signal.
- Plot the power spectral density of the modulated signal.

Figure 37: Question 12

1.12.1 part 1

```
% Ali Shaikh Qasem 1212171
% Q12.1

%Am = 10 , fm = 75 Hz, Ac = 15, fc = 1500 Hz.
syms t;
m(t) = 10*cos(150 * pi * t);
c(t) = 15 * cos(3000 * pi * t);

modulatedSig =  (1 + m(t)) * c(t);
fplot(modulatedSig,'r');
axis([-0.02 0.02 -200 200]);
```

(a) the code



(b) the figure

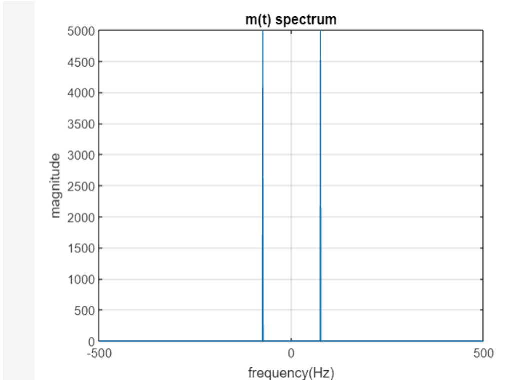
Figure 38: Question 12 part one

- From the figure above , we can conclude that the modulated signal is periodic.

1.12.2 part two

```
% Ali Shaikh Qasem 1212171
%Q12.2

duration = 1;
t = 0:1/1000:duration-1/1000;
m = 10 * cos(150*pi*t);
M = fft(m);
mag1 = abs(M);
f = linspace(-500, 500, length(m));

plot(f, fftshift(mag1));
grid on;
title('m(t) spectrum');
xlabel('frequency(Hz)');
ylabel('magnitude');
```

(a) the code

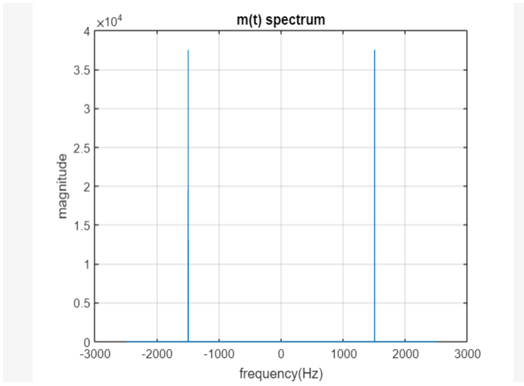


(b) the figure

Figure 39: Question 12 part two

```
% Ali Shaikh Qasem 1212171
%Q12.2

duration = 1;
t = 0:1/5000:duration-1/5000;
c = 15 * cos(3000*pi*t);
C = fft(c);
mag2 = abs(C);
f = linspace(-2500, 2500, length(c));

plot(f, fftshift(mag2));
grid on;
title('m(t) spectrum');
xlabel('frequency(Hz)');
ylabel('magnitude');
```

(a) the code

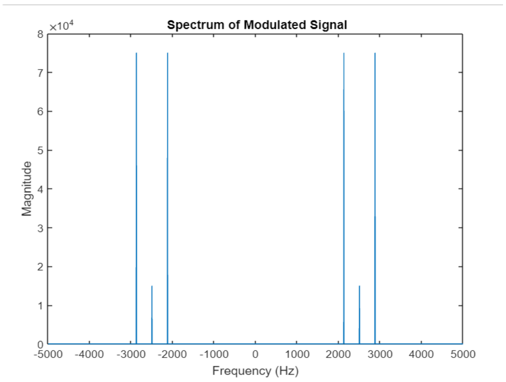


(b) the figure

Figure 40: Question 12 part two

```
% Ali Shaikh Qasem 1212171
%Q12.2

fs = 10000;
t = 0:5/fs:0.99999;

m = 10 * cos(150*pi*t);
c = 15 * cos(3000*pi*t);
ms = (1 + m) .* c;

MS = fft(ms);
f = linspace(-fs/2, fs/2, length(MS));
MSSH = fftshift(MS);

plot(f, abs(MSSH));
title(' Spectrum of Modulated Signal');
xlabel('Frequency (Hz)');
ylabel('Magnitude');
```

(a) the code



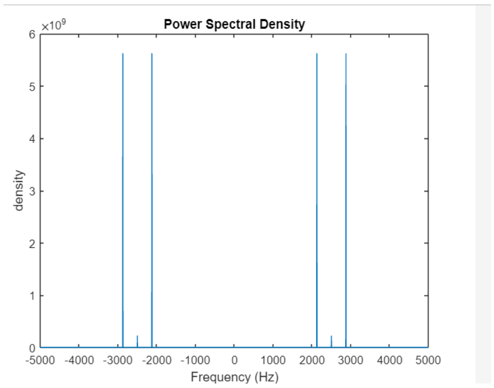
(b) the figure

Figure 41: Question 12 part two

1.12.3 part 3

```
% Ali Shaikh Qasem 1212171
%Q12.2

fs = 10000;
t = 0:5/fs:0.99999;

m = 10 * cos(150*pi*t);
c = 15 * cos(3000*pi*t);
ms = (1 + m) .* c;

MS = fft(ms);
f = linspace(-fs/2, fs/2, length(MS));
MSSH = fftshift(MS);

density = abs(MSSH).^2;

plot(f, density);
title('Power Spectral Density');
xlabel('Frequency (Hz)');
ylabel('density');
```

(a) the code



(b) the figure

Figure 42: Question 12 part three