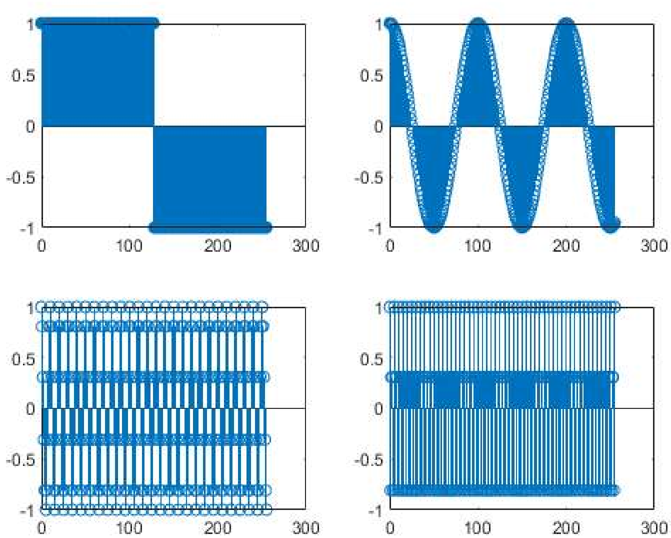
Contents


```
clc
close all;
clear all;
```

Section 1 and 2

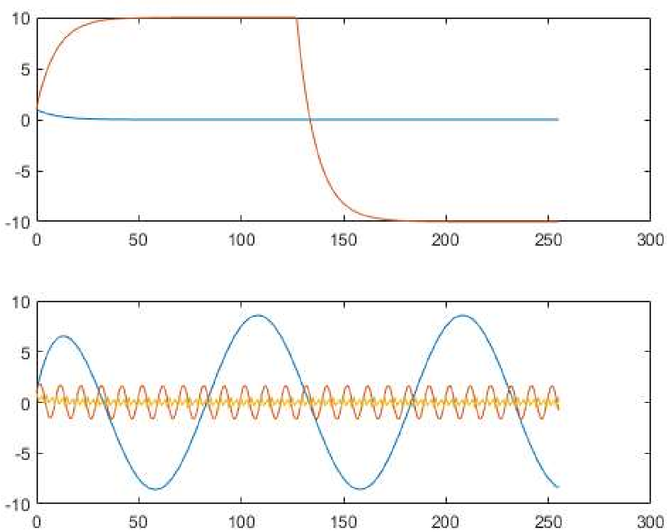
```
freq1 = 0.01;
freq2 = 0.1;
freq3 = 0.4;
n_in = 256;

nv = 0:(n_in - 1);

x1 = [1 , zeros(1,255)];

figure(1)
subplot(2,2,1)
x2 = square(nv*2*pi/256);
stem(nv(1:n_in),x2(1:n_in))

subplot(2,2,2)
x3 = cos(freq1*2*pi*nv);
stem(nv(1:n_in),x3(1:n_in))

subplot(2,2,3)
x4 = cos(freq2*2*pi*nv);
stem(nv(1:n_in),x4(1:n_in))

subplot(2,2,4)
x5 = cos(freq3*2*pi*nv);
stem(nv(1:n_in),x5(1:n_in))
```



Section 3

```
a = [1.0,-0.9];
b = 1;

figure(2)
subplot(2,1,1)
y1 = filter(b,a,x1);
plot(nv(1:n_in),y1(1:n_in))
hold on
```

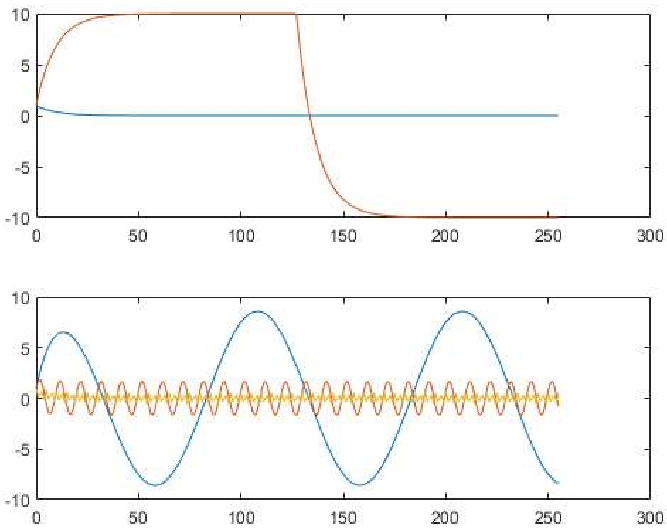
```
y2 = filter(b,a,x2);
plot(nv(1:n_in),y2(1:n_in))

hold off

subplot(2,1,2)
y3 = filter(b,a,x3);
plot(nv(1:n_in),y3(1:n_in))
hold on

y4 = filter(b,a,x4);
plot(nv(1:n_in),y4(1:n_in))

y5 = filter(b,a,x5);
plot(nv(1:n_in),y5(1:n_in))

hold off
```

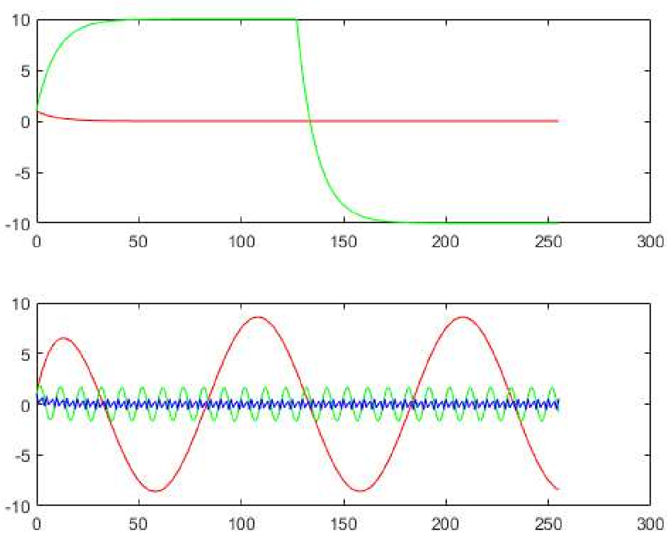


Section 4

```
a = [1.0,-0.9];
b = 1;

figure(3)
title('System 2')
subplot(2,1,1)
y1 = filter(b,a,x1);
plot(nv(1:n_in),y1(1:n_in),'r')
hold on

y2 = filter(b,a,x2);
plot(nv(1:n_in),y2(1:n_in),'g')

hold off

subplot(2,1,2)
y3 = filter(b,a,x3);
plot(nv(1:n_in),y3(1:n_in),'r')
hold on

y4 = filter(b,a,x4);
plot(nv(1:n_in),y4(1:n_in),'g')

y5 = filter(b,a,x5);
plot(nv(1:n_in),y5(1:n_in),'b')

hold off
% y3 = 8.59, y4 = 1.6, y5 = 0.5291
% y3 has the highest amplitude and y5 has the lowest amplitude

% The impulse response is the output when presented witha brief input
% signal.
% For the step response you can see that the filter function created a rise
% time for the values to reach its peak and a fall time for it to reach its
% minimum. The impulse function shows the small falltime untilit reached
% zero.
```

```
% What is the steady state response after a step input?
% It oscillates from -10 to 10
% y(n) = x(n) +1y(n-1)- 0.9y(n-2)
```



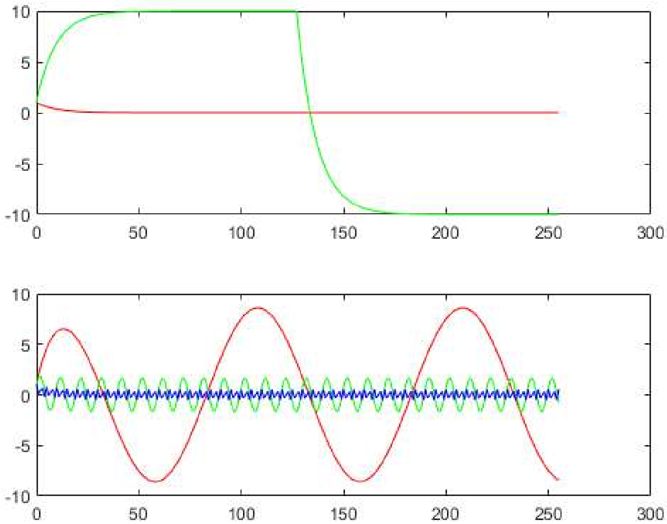


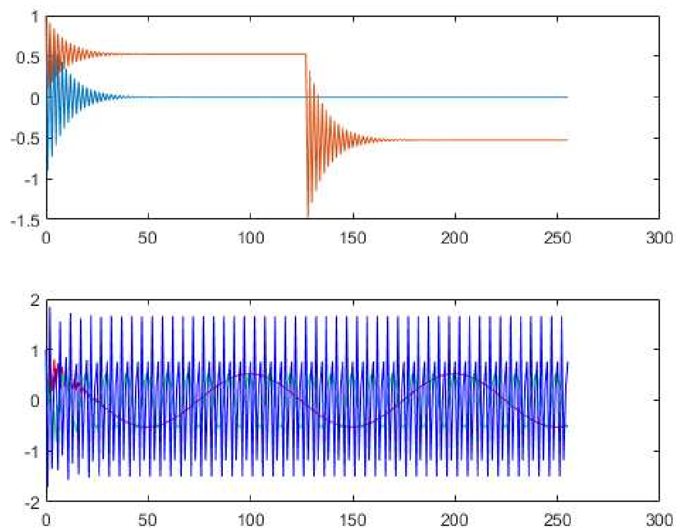
Section 5

Comparison of two first order systems.

```
a = [1.0,0.9];
b = 1;

figure(4)
subplot(2,1,1)
y1 = filter(b,a,x1);
plot(nv(1:n_in),y1(1:n_in))

hold on
y2 = filter(b,a,x2);
plot(nv(1:n_in),y2(1:n_in))
hold off

subplot(2,1,2)
y3 = filter(b,a,x3);
plot(nv(1:n_in),y3(1:n_in),'r')
hold on

y4 = filter(b,a,x4);
plot(nv(1:n_in),y4(1:n_in),'g')
```

```
y5 = filter(b,a,x5);
plot(nv(1:n_in),y5(1:n_in),'b')
hold off

% 4. y3 = 0.524, y4 = 0.529, y5 = 1.66
% y5 has the highest amplitude and y3 has the lowest amplitude

% For the impulse there is an initial oscillation that stabilizes at 0 after a short time
%for the step function there is an oscillation during the rise period to the
%high value until it stabilizes and then another delayed oscillation during the fall time
%to the low value until it stabilizes after a short period of time

% It oscillates from -1.75 to 1.75
% y(n) = x(n) +1y(n-1)+ 0.9y(n-2)

% 5. Compare System 1 and System 2.
% • What is the effect of changing the sign of a(2) on the impulse and step
% response for these two systems?
% The LPF will become a HPF as the second value will be the negative of the
% original

% • What do you think will happen if the absolute value of a(2) is decreased?
% Why?
%The steady state amplitude will be lower becasue the denominator is
%higher.

% • What do you think will happen if the absolute value of a(2) is increased?
% Why?
%The steady state amplitude will be higher becasue the denominator is
%smaller.

% • If System 1 is used as an “exponential average”, what value should b(1) have
% to insure that for a constant input value, the output will be that same value?
% We should have 0.1 or 1/10 because the times constant is 10 samples.
```



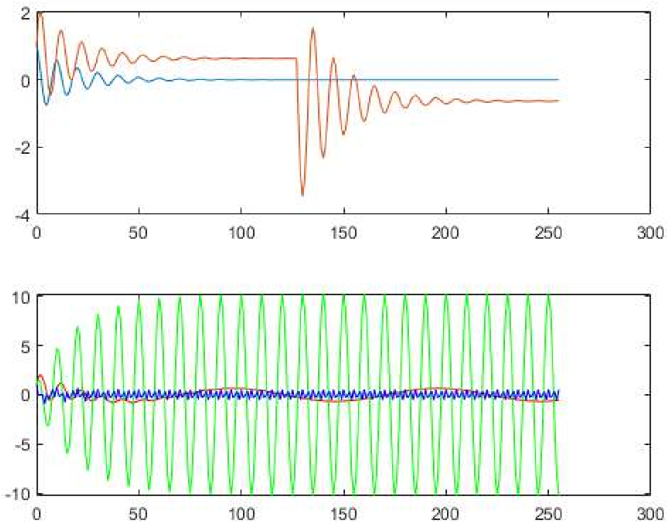


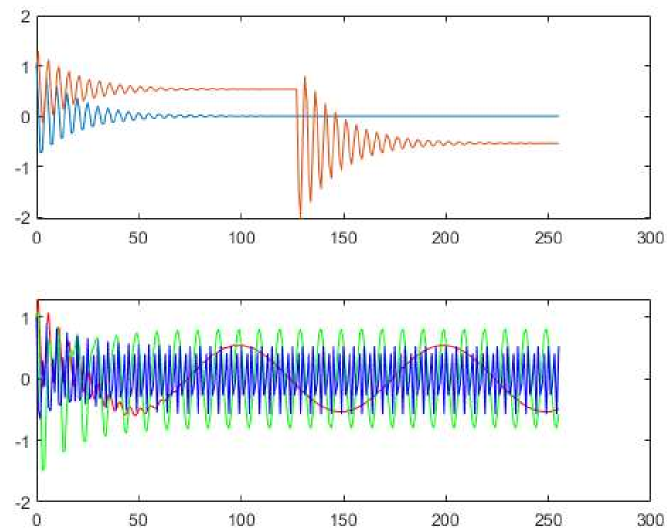
Comparison of Four Second Order Systems

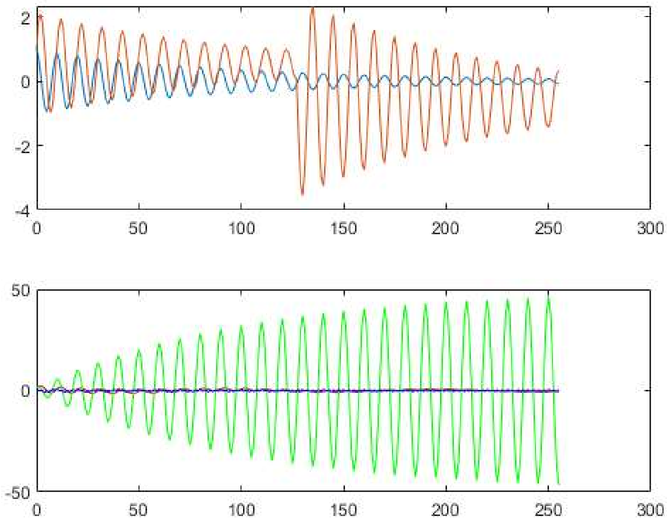
```
alpha  = 0.95;
alpha2 = 0.99;
w = 2 * pi * 0.1;
% System 3
a3 = [1, -2*alpha*cos(w), alpha^2];
b3 = [1, -alpha*cos(w)];
figure(5)
subplot(2,1,1)
y1 = filter(b3,a3,x1);
plot(nv(1:n_in),y1(1:n_in))
hold on

y2 = filter(b3,a3,x2);
plot(nv(1:n_in),y2(1:n_in))

hold off

subplot(2,1,2)
y3 = filter(b3,a3,x3);
plot(nv(1:n_in),y3(1:n_in),"r")
hold on

y4 = filter(b3,a3,x4);
plot(nv(1:n_in),y4(1:n_in),"g")

y5 = filter(b3,a3,x5);
plot(nv(1:n_in),y5(1:n_in),"b")
```

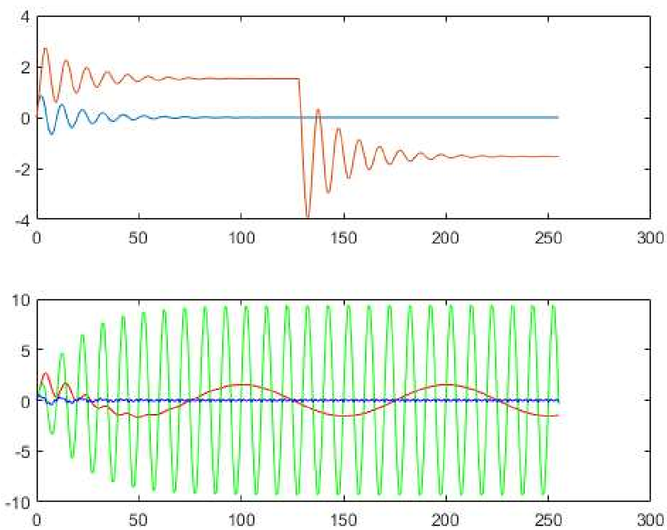
```
hold off


% System 4
a4 = [1, -2*alpha*cos(2*w), alpha^2];
b4 = [1, -alpha*cos(2*w)];
figure(6)
subplot(2,1,1)
y1 = filter(b4,a4,x1);
plot(nv(1:n_in),y1(1:n_in))
hold on

y2 = filter(b4,a4,x2);
plot(nv(1:n_in),y2(1:n_in))

hold off
subplot(2,1,2)
y3 = filter(b4,a4,x3);
plot(nv(1:n_in),y3(1:n_in),"r")
hold on

y4 = filter(b4,a4,x4);
plot(nv(1:n_in),y4(1:n_in),"g")

y5 = filter(b4,a4,x5);
plot(nv(1:n_in),y5(1:n_in),"b")

hold off

% System 5

a5 = [1, -2*alpha2*cos(w), alpha2^2];
b5 = [1, -alpha2*cos(w)];
figure(7)
subplot(2,1,1)
y1 = filter(b5,a5,x1);
plot(nv(1:n_in),y1(1:n_in))
hold on

y2 = filter(b5,a5,x2);
plot(nv(1:n_in),y2(1:n_in))

hold off

subplot(2,1,2)
y3 = filter(b5,a5,x3);
plot(nv(1:n_in),y3(1:n_in),"r")
hold on

y4 = filter(b5,a5,x4);
plot(nv(1:n_in),y4(1:n_in),"g")

y5 = filter(b5,a5,x5);
plot(nv(1:n_in),y5(1:n_in),"b")

hold off

% System 6
a6 = [1, -2*alpha*cos(w), alpha^2];
b6 = [0, alpha*sin(w)] ;

figure(8)
subplot(2,1,1)
y1 = filter(b6,a6,x1);
plot(nv(1:n_in),y1(1:n_in))
hold on

y2 = filter(b6,a6,x2);
plot(nv(1:n_in),y2(1:n_in))

hold off

subplot(2,1,2)
y3 = filter(b6,a6,x3);
plot(nv(1:n_in),y3(1:n_in),"r")
hold on

y4 = filter(b6,a6,x4);
plot(nv(1:n_in),y4(1:n_in),"g")

y5 = filter(b6,a6,x5);
plot(nv(1:n_in),y5(1:n_in),"b")

hold off

% 2. Compare System 3 and System 4.
```

```
% • Describe the impulse response of each system.
%The impulse response for both systems is initial oscillation whose magnitude approaches 0. System 4 has a greater frequency of oscillation than system 3.

% • How does using 2w instead of w affect the impulse and step responses?
% Doubling the freqeuncy increases the oscillation for both the impulse and step responses, but only affects the magnitude for the step response.

% • How does using 2w instead of w affect the response to the cosines at the
% three different input frequencies?
% The 0.01 Hz signal has a transient oscillation with a larger fundamental amplitude is lower in magnitude but lasts longer,
% The 0.1 Hz signal takes longer to reach steady state, amplitude is greater
% The 0.4 Hz signal has less transient oscillation but it lasts longer, amplitude is greater

% 3. Compare System 3 and System 5. How does increasing alpha affect:
% • the duration of the impulse responses?
% Increasing the alpha effect causes the system to take longer to reach steady state
% and as a result, the impulse response for system 5 is still oscillating by the final sample.

% • the relative response to the three different input frequencies?
% The 0.01 Hz signal has a transient oscillation with a larger fundamental amplitude is lower in magnitude but lasts longer,
% The 0.1 Hz signal takes longer to reach steady state, amplitude is greater
% The 0.4 Hz signal has less transient oscillation but it lasts longer, amplitude is greater

% 4. Compare System 3 and System 6:
% • Compare the impulse and frequency responses over the full time interval.
% Zoom in on the first 20 samples and compare again.
% The impulse response is very similar, but system 6 starts a sine
% behaviour while the system 3 starts a cosine behaviour. All with the same
% frequency.

% • Compare the steady state amplitudes of the responses to cosines at the
% three different input frequencies.
% The 0.1Hz has a similar amplitudes while the 0.01Hz is rejected by the
% System 3, while the system 6 rejects the 0.4Hz better
```


2
0
-2
-4
0 50 100 150 200 250 300
10
5
0
-5
-10
0 50 100 150 200 250 300


2
1
0
-1
-2
0 50 100 150 200 250 300
1
0
-1
-2
0 50 100 150 200 250 300





Cascade connection of two first order systems

```
a1 = [1.0,-0.9];
b1 = 1;

a7 = 1;
b7 = [1,-0.9];

% impulse response
figure(9)
subplot(2,1,1)
h1 = filter(b1,a1,x1);
stem(nv(1:50),h1(1:50))

subplot(2,1,2)
h7 = filter(b7,a7,x1);
stem(nv(1:50),h7(1:50))

% cascade connections
figure(10)
subplot(2,1,1)
z7 = filter(b7,a7,h1);
stem(nv(1:10),z7(1:10))

subplot(2,1,2)
z1 = filter(b1,a1,h7);
stem(nv(1:10),z1(1:10))

% 3. Draw block diagrams for the two cascaded systems and label h1, z7, h7, and z1.
%    Check external figure.
```

```
%
% 4. Analytically compute the first 5 values of y1, z1, y7, and z7.
% y1 = 1, 0.9, 0.81 , 0.7290, 0.6561
% z1 = 1, 0  , 0    , 0     , 0;
% y7 = 1,-0.9, 0    , 0     , 0;
% z7 = 1,   0, 0    , 0     ,  0;
%
% 5. y7 and z7 has an extra impulse at n=1 and would decrease to zero slower.
```