```
close all
clear all
clc

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% Constants

R=1;    C=1;    L=1;

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%Question #1

% Section b - zero-pole maps
PZ_A=tf( [ 1 ] , [ L*C L/R 1 ] );
PZ_B=tf( [ R*L*C 0 0] , [ R*L*C L R] );
PZ_C=tf( [ L 0 ] , [ R*L*C L R ]);
PZ_D=tf( [ L*C 0 1 ] , [ L*C L/R 1 ]);

figure (1)
subplot(2,2,1);
pzmap(PZ_A);
axis([-2, 2, -2, 2])
xlabel('Real(w))');
ylabel('Im(w)');
title('Pole-Zero Diagram for H_A');

subplot(2,2,2);
pzmap(PZ_B);
axis([-2, 2, -2, 2])
xlabel('Real(w))');
ylabel('Im(w)');
title('Pole-Zero Diagram for H_B');

subplot(2,2,3);
pzmap(PZ_C);
axis([-2, 2, -2, 2])
xlabel('Real(w))');
ylabel('Im(w)');
title('Pole-Zero Diagram for H_C');

subplot(2,2,4);
pzmap(PZ_D);
axis([-2, 2, -2, 2])
xlabel('Real(w))');
ylabel('Im(w)');
title('Pole-Zero Diagram for H_D');

% Section c - bode diagrams

figure(2)
subplot(2,2,1);
bode(PZ_A,{10^-2 10^2});
title('Bode Diagram for H_A');

subplot(2,2,2);
bode(PZ_B,{10^-2 10^2});
```

```
title('Bode Diagram for H_B');

subplot(2,2,3);
bode(PZ_C,{10^-2 10^2});
title('Bode Diagram for H_C');

subplot(2,2,4);
bode(PZ_D,{10^-2 10^2});
title('Bode Diagram for H_D');

%Section d - step response

figure(3)
subplot(2,2,1);
step(PZ_A);
 axis([0, 20, -0.5, 2])
title('Step Response Diagram for A System');

subplot(2,2,2);
step(PZ_B);
axis([0, 20, -1, 1.5])
title('Step Response Diagram for B System');

subplot(2,2,3);
step(PZ_C);
axis([0, 20, -0.5, 0.7])
title('Step Response Diagram for C System');

subplot(2,2,4);
step(PZ_D);
 axis([0, 20, 0, 1.5])
title('Step Response Diagram for D System');

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%Section e - sections b-d for R=C=L=5

% Section b_e

R=5;    C=5;    L=5;

PZ_A=tf( [ 1 ] , [ L*C L/R 1 ] );
PZ_B=tf( [ R*L*C 0 0] , [ R*L*C L R] );
PZ_C=tf( [ L 0 ] , [ R*L*C L R ]);
PZ_D=tf( [ L*C 0 1 ] , [ L*C L/R 1 ]);

figure (4)
subplot(2,2,1);
pzmap(PZ_A);
axis([-0.025, 0.025, -0.25, 0.25])
xlabel('Real(w))');
ylabel('Im(w)');
title('Pole-Zero Diagram for H_A');

subplot(2,2,2);
pzmap(PZ_B);
axis([-0.025, 0.025, -0.25, 0.25])
```

```
xlabel('Real(w))');
ylabel('Im(w)');
title('Pole-Zero Diagram for H_B');

subplot(2,2,3);
pzmap(PZ_C);
axis([-0.025, 0.025, -0.25, 0.25])
xlabel('Real(w))');
ylabel('Im(w)');
title('Pole-Zero Diagram for H_C');

subplot(2,2,4);
pzmap(PZ_D);
axis([-0.025, 0.025, -0.25, 0.25])
xlabel('Real(w))');
ylabel('Im(w)');
title('Pole-Zero Diagram for H_D');

%Section c_e

figure(5)
subplot(2,2,1);
bode(PZ_A,{10^-2 10^3});
title('Bode Diagram for H_A');


subplot(2,2,2);
bode(PZ_B,{10^-3 10^2});
title('Bode Diagram for H_B');

subplot(2,2,3);
bode(PZ_C,{10^-10 10^10});
title('Bode Diagram for H_C');

subplot(2,2,4);
bode(PZ_D,{10^-4 10^2});
title('Bode Diagram for H_D');

%Section d_e

figure(6)
subplot(2,2,1);
step(PZ_A);
 axis([0, 200, -0.5, 2])
title('Step Response Diagram for A System');

subplot(2,2,2);
step(PZ_B);
axis([0, 200, -1, 1.5])
title('Step Response Diagram for B System');

subplot(2,2,3);
step(PZ_C);
axis([0, 200, -0.5, 0.7])
title('Step Response Diagram for C System');
```

```
subplot(2,2,4);
step(PZ_D);
 axis([0, 200, 0, 1.5])
title('Step Response Diagram for D System');


%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%Question #2

% Reading the signal
[Y,FS] = wavread('guitar.wav');

sound(Y,FS);

% Furier trans of the signal
Y_F=fft(Y);

f = linspace(-FS/2,FS/2,length(Y_F));
figure(25)
plot(f,fftshift(real(Y_F)));
ylim([-3000 3000]);
xlabel('f [Hz]');
ylabel('Real  Y-F');
title('Real  Y-F ','fontsize',12);

% Defining Buterworth filter
f_s = 5000;     f_p = f_s-1000;
d_s = 0.01;      d_p = 0.01;

k = f_p/f_s;
d=sqrt ( ( (1-d_p)^(-2) - 1) / (( d_s^-2 ) -1) );
N=30;   f_n = (f_s-500)/(0.5*FS);

[B,A] = butter( 30,f_n );

% Freq response of the filter
figure(26)
freqz ( B,A,128,FS );

% Zero-pole map of the filter
figure(27)
zplane( B,A )

% Filtering....
Y_filt = filtfilt( B,A,Y );
sound(Y_filt,FS)

% Furier trans of the filtered signal
F_Y_filt=fft(Y_filt);

% Graphs....
figure(28);
subplot(3,1,1);
plot(f,fftshift(real(Y_F)));
ylim=([-3000 3000]);
title('Y(\omega)');
```

```
xlabel('f [Hz]');
ylabel('Y(\omega)');

subplot(3,1,2);
plot(f,fftshift(real(F_Y_filt)));
ylim=([-3000 3000]);
title('Yfilt(\omega)');
xlabel('f [Hz]');
ylabel('Yfilt(\omega)');

subplot(3,1,3);
plot(f,fftshift(real(Y_F-F_Y_filt)));
ylim=([-3000 3000]);
title('Y(\omega)-Yfilt(\omega)');
xlabel('f [Hz]');
ylabel('Y(\omega)-Yfilt(\omega)');


%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%Question #3

% Constants for calculation
A = [ 0,1,0,0 ; 0,0,1,0 ; 0,0,0,1 ; -1/2,-7/16,-1/8,3/64 ];
B = [ 0,0,0,1 ]';  C = [ 1,2,3,4 ];  D=0;

syms z;
I = eye(4);

% Section a
% Transfer function calc
H_Z_calc  =  C*((z*I - A)^(-1))*B+D;
simplify(H_Z_calc)

[num den] = ss2tf(A,B,C,D);
H_Z_formula = tf(num,den)

% Section b
x = ones(1,100);
q = zeros(4,1,100);

for n=1:1:100
    for k=1:1:n
        q(:,:,n) =q(:,:,n)+A^(k-1)*B;
    end
end

for n=1:1:100
    y(n) = C*q(:,:,n);
end

n = linspace(1,100,100);
figure(29);
plot(n,y(n));
title('Y(n) vs. n','fontsize',12);
xlabel('n');
ylabel('Y(n)');
```