EECS Laboratory 2 : Filter Design

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Q1) The following is a snippet of the code which has the chosen variables defined:

```
syms t w
f1 = 30;
f2 = 50;
f3 = 70;
a1 = 3;
a2 = 4;
a3 = 5;
x = a1*cos(2*pi*f1*t) + a2*cos(2*pi*f2*t) + a3*cos(2*pi*f3*t)
X = fourier(x,t,w)
```

The following is the output:

```
>> Q1_Lab2

x =

3*cos(60*pi*t) + 4*cos(100*pi*t) + 5*cos(140*pi*t)


X =

3*pi*(dirac(w - 60*pi) + dirac(w + 60*pi)) + 4*pi*(dirac(w - 100*pi) + dirac(w + 100*pi)) + 5*pi*(dirac(w - 140*pi) + dirac(w + 140*pi))
```

```
>> Q1_Lab2

x =

3*cos(60*pi*t) + 4*cos(100*pi*t) + 5*cos(140*pi*t)
```

X =

3*pi*(dirac(w - 60*pi) + dirac(w + 60*pi)) + 4*pi*(dirac(w - 100*pi) + dirac(w + 100*pi)) + 5*pi*(dirac(w - 140*pi) + dirac(w + 140*pi))

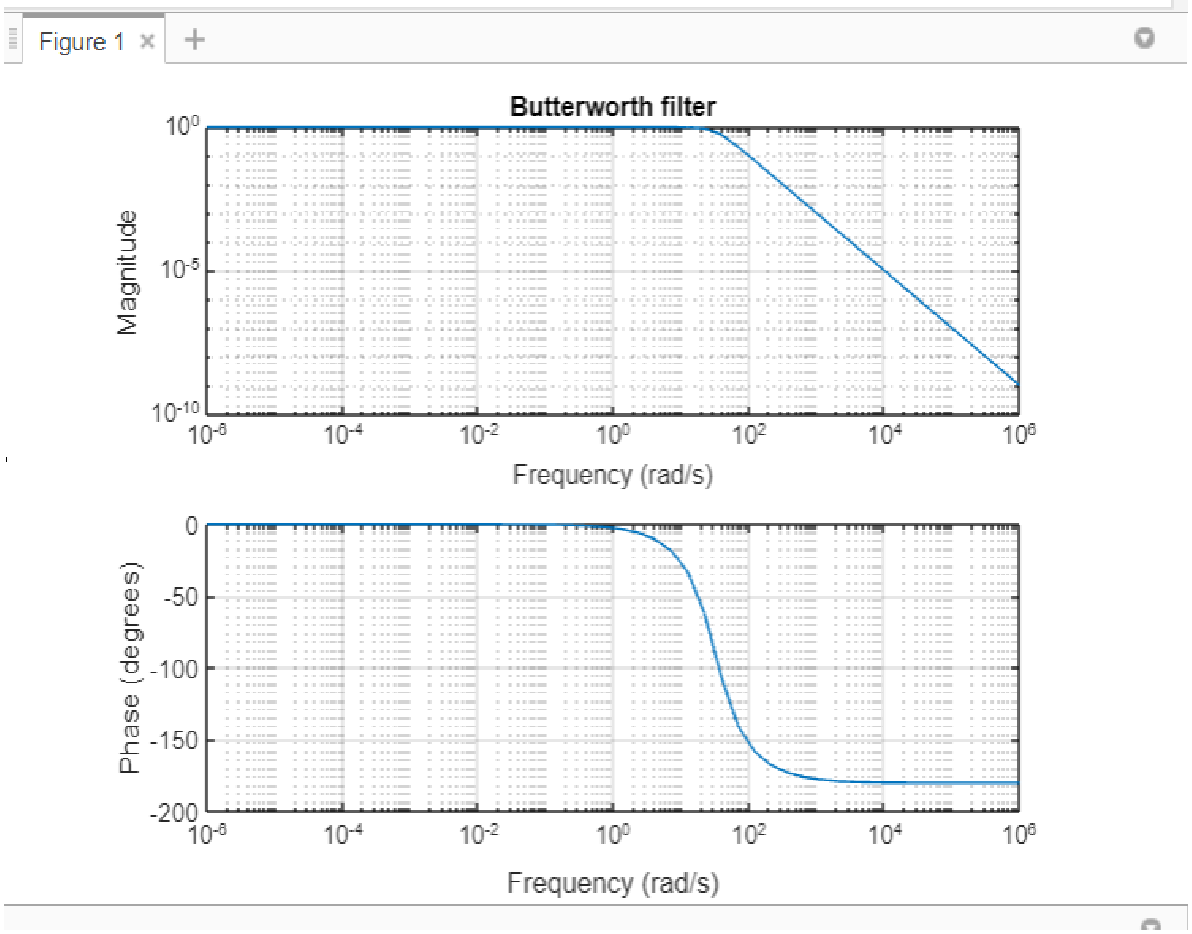
Q2)

Code snippet:

Lab2Q2.m

```
[b,a]=butter(2,32,'s');
wband=logspace(-6,6);
figure(1);
freqs(b,a,wband);
title('Butterworth filter')
```

The output is as follows :



Q3)

```
H = poly2sym(b,w)/poly2sym(a,w);
```

Output:

```
H =

1024/(w^2 + 32*2^(1/2)*w + 1024)
```

Q4)

```
Y=X.*H
y=ifourier(Y,w,t)
```

Output:

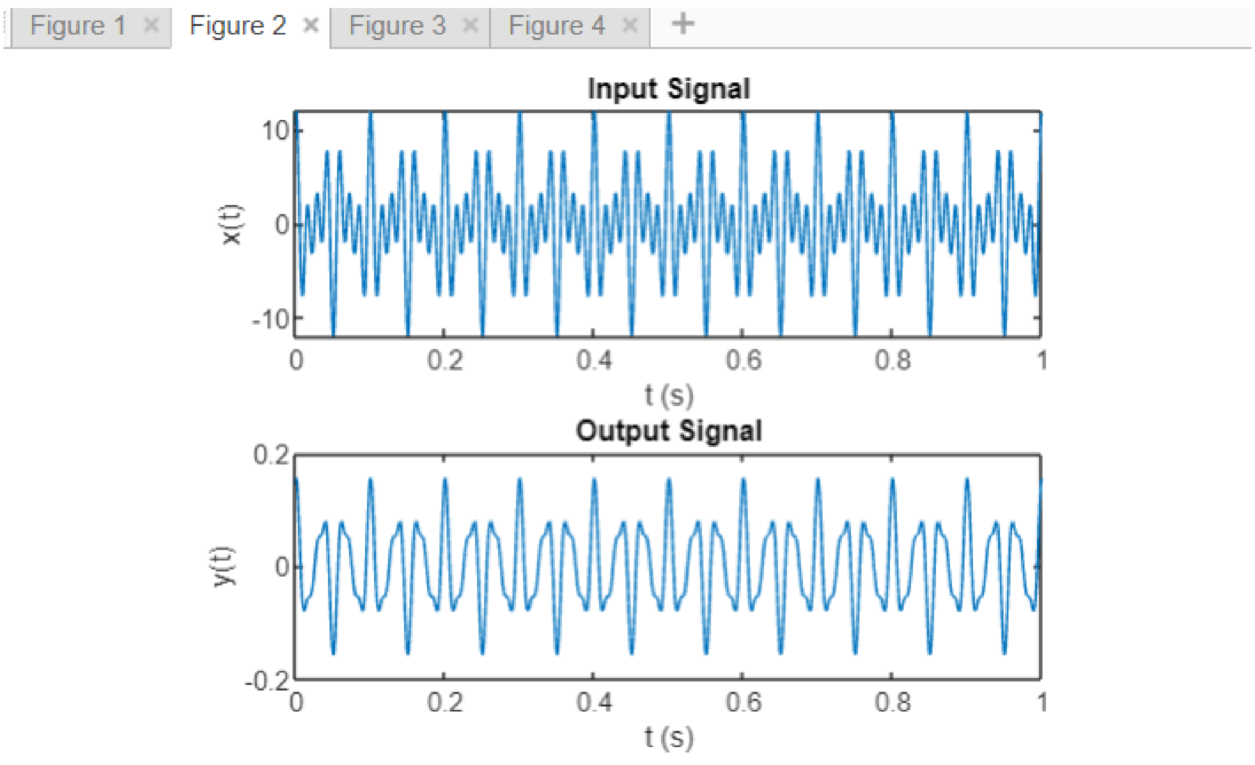
```
Y =

(1024*(3*pi*(dirac(w - 60*pi) + dirac(w + 60*pi)) + 4*pi*(dirac(w - 100*pi) + dirac(w + 100*pi)) + 5*pi*(dirac(w - 140*pi) + dirac(w + 140*pi))))/(w^2 + 32*2^(1/2)*w + 1024)


y =

((192*pi*exp(-pi*t*60i))/(225*pi^2 - 120*2^(1/2)*pi + 64) + (192*pi*exp(pi*t*60i))/(225*pi^2 + 120*2^(1/2)*pi + 64) + (256*pi*exp(-pi*t*100i))/(625*pi^2 - 200*2^(1/2)*pi + 64) + (256*pi*exp(pi*t*100i))/(625*pi^2 + 200*2^(1/2)*pi + 64) + (320*pi*exp(-pi*t*140i))/(1225*pi^2 - 280*2^(1/2)*pi + 64) + (320*pi*exp(pi*t*140i))/(1225*pi^2 + 280*2^(1/2)*pi + 64))/(2*pi)
```

Q5)

The code for this question encompasses 3 figures. It is as follows:

```
fs = 2000;
t1 = 0:1/fs:1-1/fs;
x_numeric = double(subs(x,t,t1));
y_numeric = double(subs(y,t,t1));
X_mag=abs(fft(x_numeric));
Y_mag=abs(fft(y_numeric));
figure(2);
subplot(2,1,1);
plot(t1,x_numeric);
title("Input Signal");
xlabel("t (s)");
ylabel("x(t)");
subplot(2,1,2);
plot(t1,y_numeric);
hold on;
title("Output Signal");
xlabel("t (s)");
ylabel("y(t)");
f1=fs*(0:length(x_numeric)-1)/length(x_numeric);
f2=fs*(0:length(y_numeric)-1)/length(y_numeric);
figure(3);
subplot(2,1,1);
plot(f1,X_mag);
title("Input Signal's Magnitude Spectrum");
xlabel("f (Hz)");
ylabel("|X(f)|");
hold on;
subplot(2,1,2);
plot(angle(fft(x_numeric)));
title("Input Signal's Phase Spectrum");
xlabel("f (Hz)");
ylabel("X(f) Phase");
figure(4);
subplot(2,1,1);
plot(f2,Y_mag);
hold on;
title("Output Signal's Magnitude Spectrum");
xlabel("f (Hz)");
ylabel("|Y(f)|");
subplot(2,1,2);
```

```
plot(angle(fft(y_numeric)));
title("Output Signal's Phase Spectrum");
xlabel("f (Hz)");
ylabel("Y(f) Phase");
```



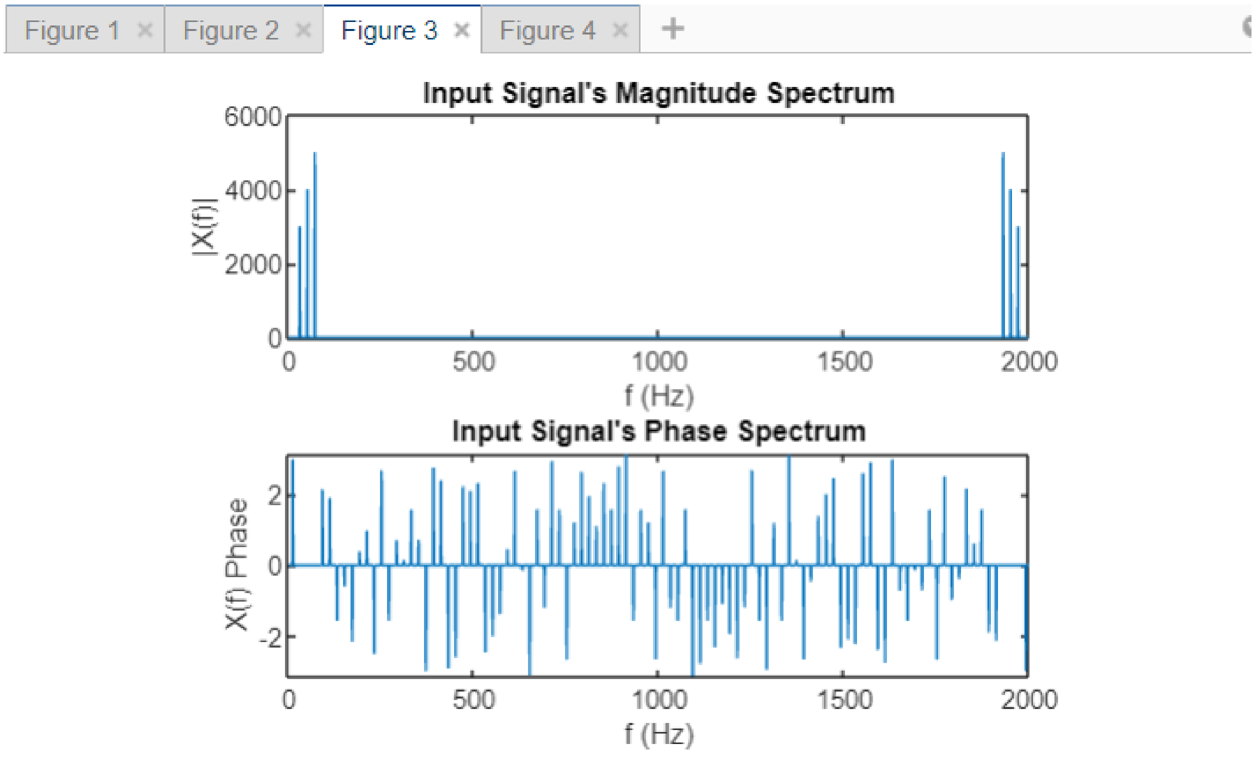


Figure 1
Figure 2
Figure 3
Figure 4
Input Signal's Magnitude Spectrum
|X(f)|
f (Hz)
Input Signal's Phase Spectrum
X(f) Phase
f (Hz)

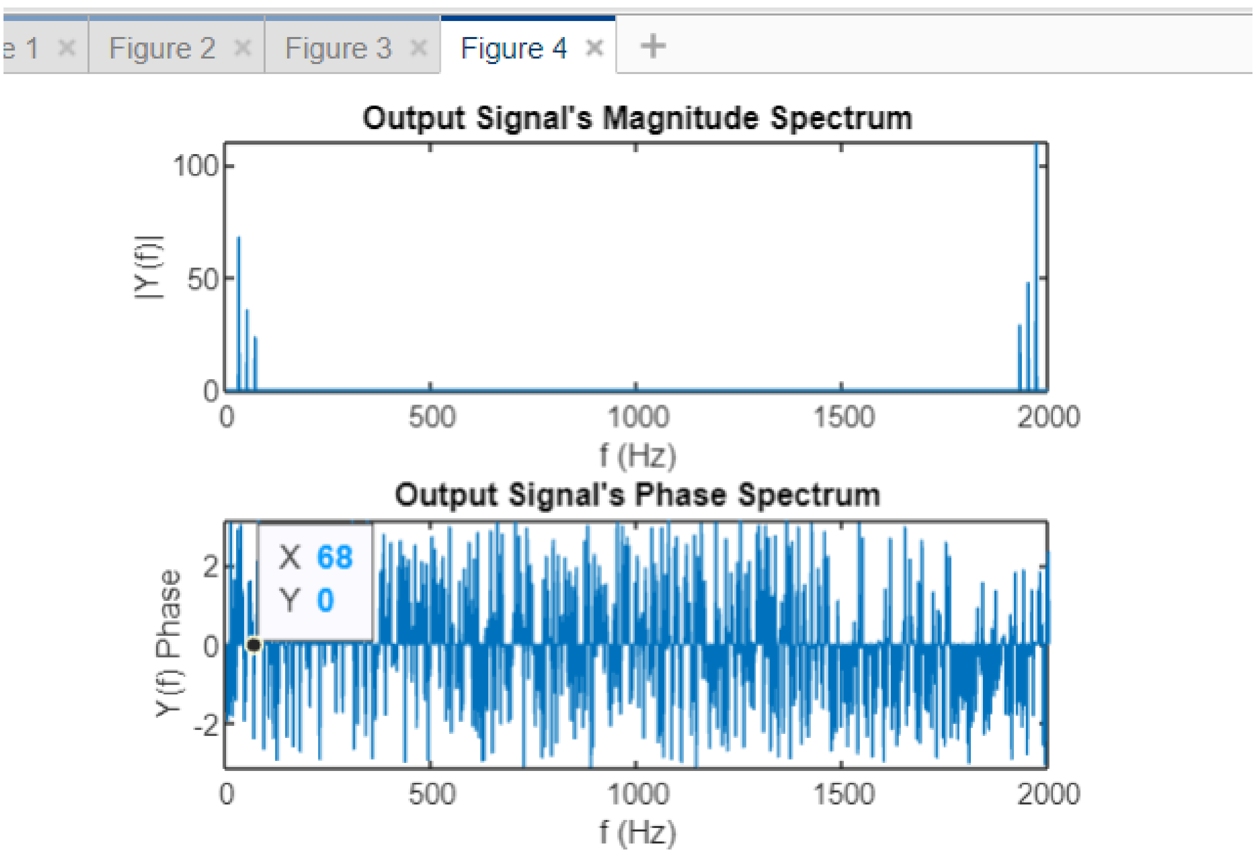


Figure 2
Figure 3
Figure 4
Output Signal's Magnitude Spectrum
|Y(f)|
f (Hz)
Output Signal's Phase Spectrum
Y(f) Phase
X 68
Y 0
f (Hz)