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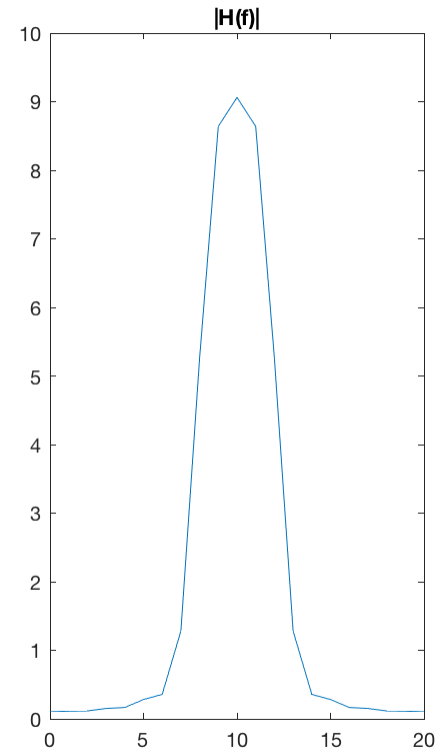
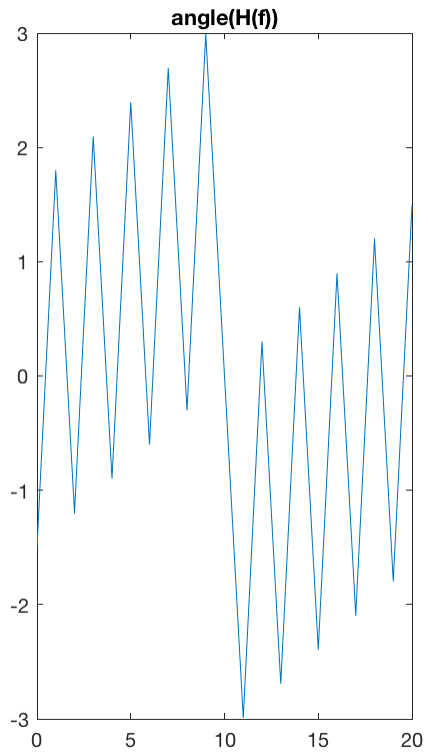
Task 1: Design the impulse response h[n] of a low pass filter by first determining $h_0[n]$ the inverse DTFT of $H_0(f)=\begin{cases}1 & |f|\le 0.1\\ 0 & 0.1<|f|<0.5\end{cases}$ and then computing $h[n]=h_0[n-n_0]w[n]$ with $w[n]=\begin{cases}n & 0\le n\le n_0\\ 2n_0-n & n_0\le n\le 2n_0\end{cases}$ and $n_0=20$. Compute, plot and discuss the amplitude and phase spectra, i.e., $|H(f)|$ and $\angle H(f)$, of $h[n]$. Compare the amplitude and phase spectra of $h[n]$ with those of $h_0[n]$. If you increase or decrease n_0, what effects do you observe?

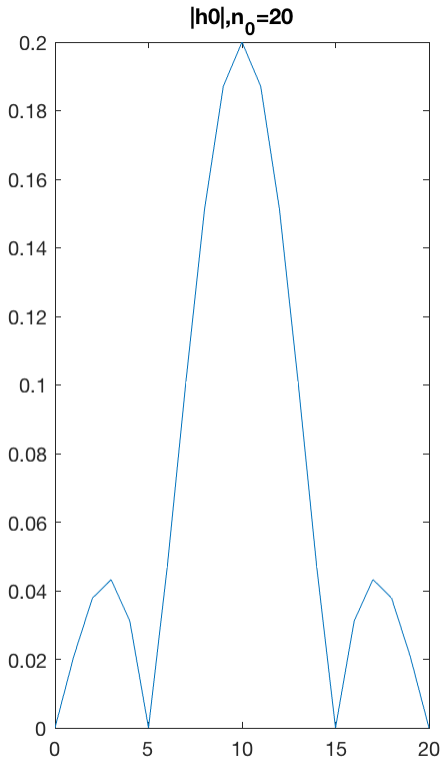
task 1

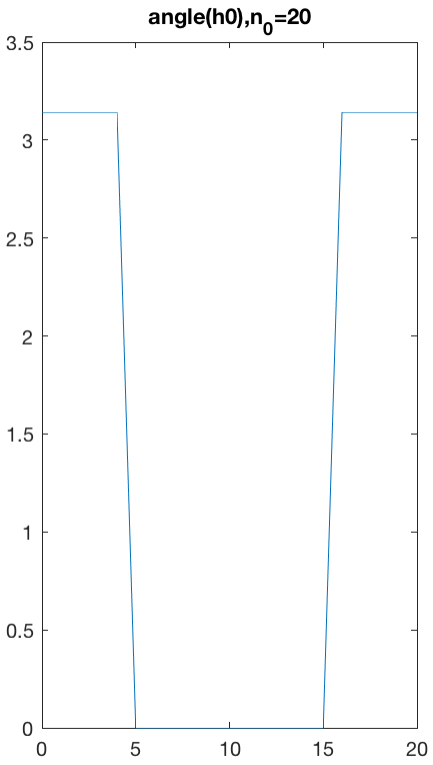
```
clear all
close all
n0 = 10;
n = 0:2*n0;
h0 = 1/5*sinc((n-n0)/5);
w = [0:(n0-1), n0:-1:0];
%plot(0:length(w)-1,w)
%plot(n,h0)
h = h0.*w;
%plot(0:length(h)-1,abs(h));
figure
subplot(1,2,1)
H = fftshift(fft(h));
plot(0:length(H)-1,abs(H))
title('|H(f)|')
subplot(1,2,2)
plot(0:length(H)-1,angle(H))
title('angle(H(f))')
figure
subplot(1,2,1);
plot(n,abs(h0))
title('|h0|,n_0=20')
subplot(1,2,2);
plot(n,angle(h0))
```

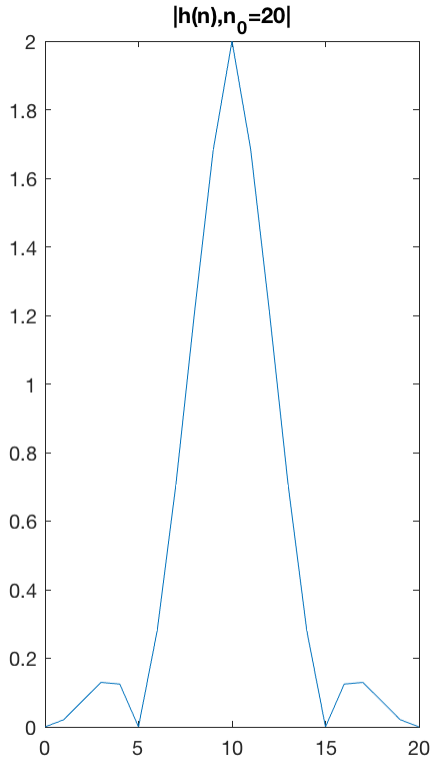
```
title('angle(h0),n_0=20')
h = h0.*w;
figure
subplot(1,2,1);
plot(0:length(h)-1,abs(h));
title('|h(n),n_0=20|')
subplot(1,2,2);
plot(0:length(h)-1,angle(h));
title('angle(h(n)),n_0=20')
n0 = 10;
figure
subplot(1,2,1);
plot(n,abs(h0))
title('|h0|,n_0=10')
subplot(1,2,2);
plot(n,angle(h0))
title('angle(h0),n_0=10')
figure
subplot(1,2,1);
plot(0:length(h)-1,abs(h));
title('|h(n),n_0=10|')
subplot(1,2,2);
plot(0:length(h)-1,angle(h));
title('angle(h(n)),n_0=10')
n0 = 5;
figure
subplot(1,2,1);
plot(n,abs(h0))
title('|h0|,n_0=5')
subplot(1,2,2);
plot(n,angle(h0))
title('angle(h0),n_0=5')
figure
subplot(1,2,1);
plot(0:length(h)-1,abs(h));
title('|h(n),n_0=5|')
subplot(1,2,2);
plot(0:length(h)-1,angle(h));
title('angle(h(n)),n_0=5')

n0 = 20; % reset value fopr n0

% As n0 decreases the image apears to zoom in. The overall shape
% loses detail as n0 decreases.
```

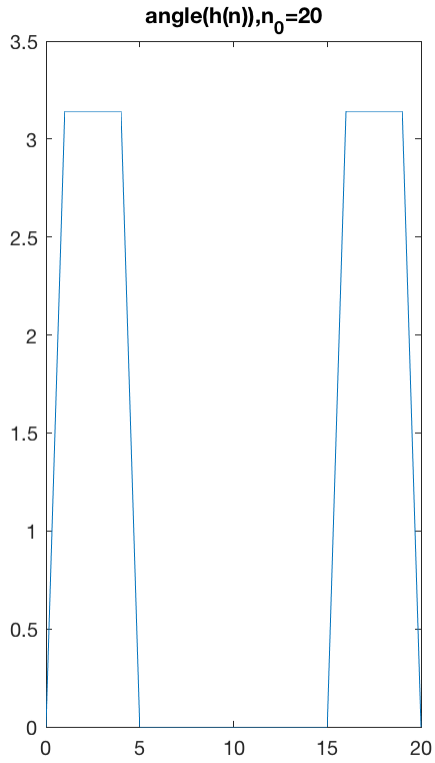

|H(f)|
10
9
8
7
6
5
4
3
2
1
0
0
5
10
15
20

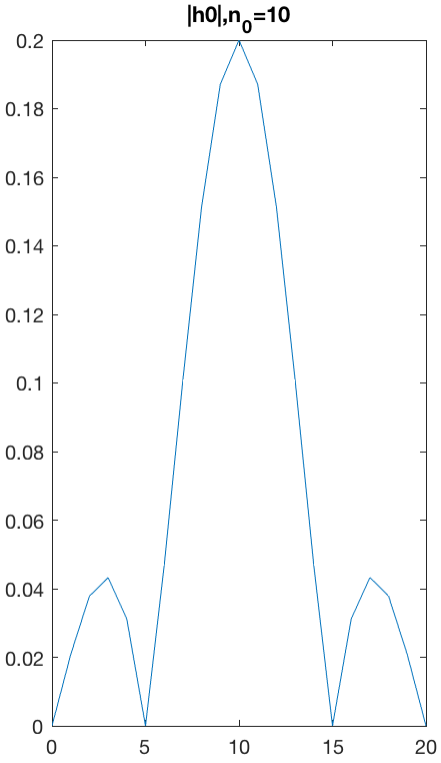

angle(H(f))
3
2
1
0
-1
-2
-3
0
5
10
15
20

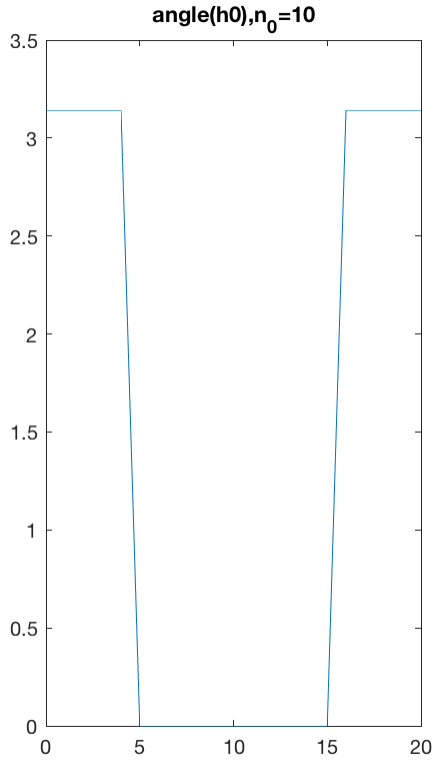

|h0|,n0=20
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
5
10
15
20

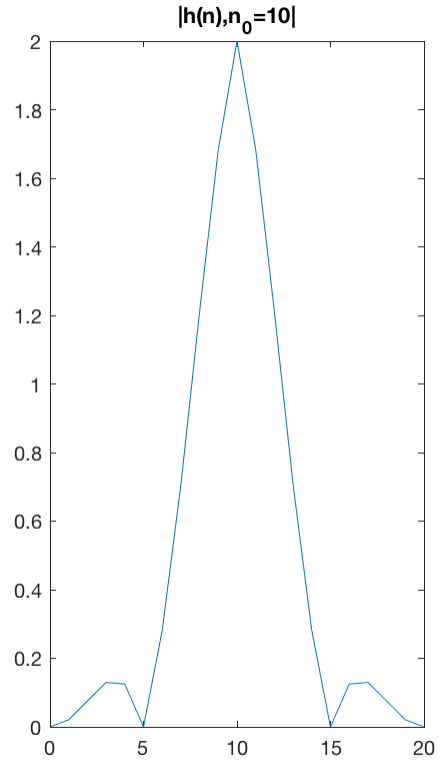

angle(h0),n0=20
3.5
3
2.5
2
1.5
1
0.5
0
0
5
10
15
20

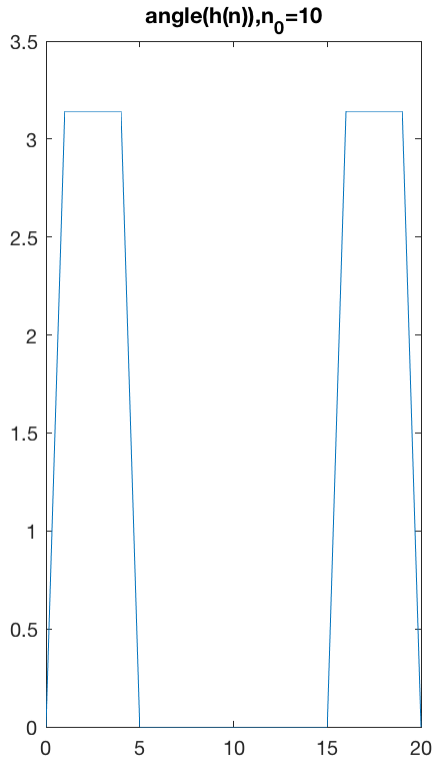

|h(n),n0=20|
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
5
10
15
20

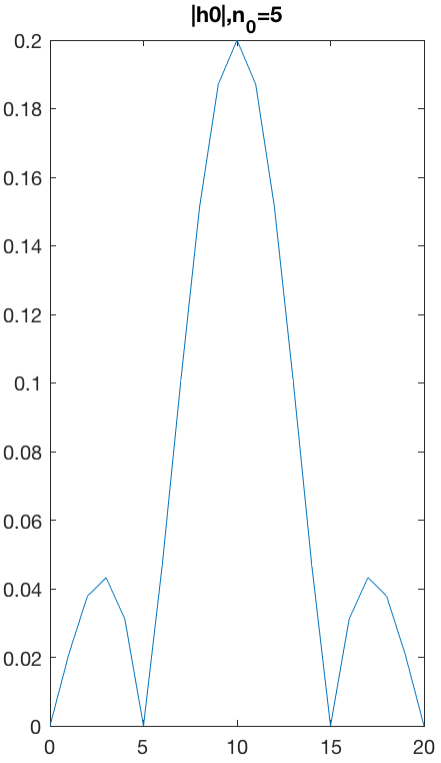

angle(h(n)),n0=20
3.5
3
2.5
2
1.5
1
0.5
0
0
5
10
15
20

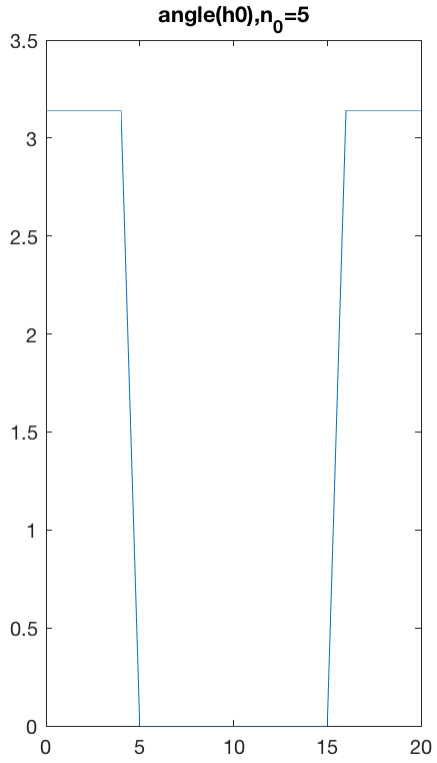

|h0|,n0=10
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
5
10
15
20

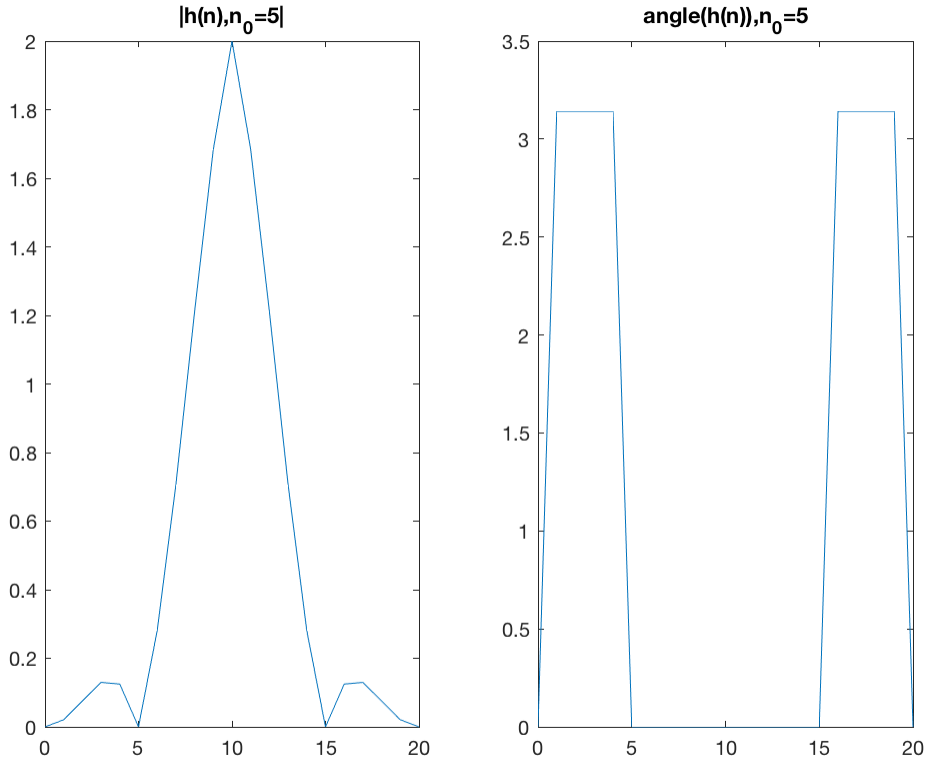

angle(h0),n0=10
3.5
3
2.5
2
1.5
1
0.5
0
0
5
10
15
20


|h(n),n0=10|
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
5
10
15
20


angle(h(n)),n0=10
3.5
3
2.5
2
1.5
1
0.5
0
0
5
10
15
20


|h0|,n0=5
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
5
10
15
20


angle(h0),n0=5
3.5
3
2.5
2
1.5
1
0.5
0
0
5
10
15
20



Task 2: Generate a pseudo random signal $v[n]$ and then filter it by performing $x[n] = v[n] * h[n]$ where h[n] is obtained from Task 1. Compute, plot and discuss the following:

(a) The amplitude DTFT of $v[n]$, for |f|<0.5;

(b) The amplitude DTFT of $x[n]$, for |f|<0.5;

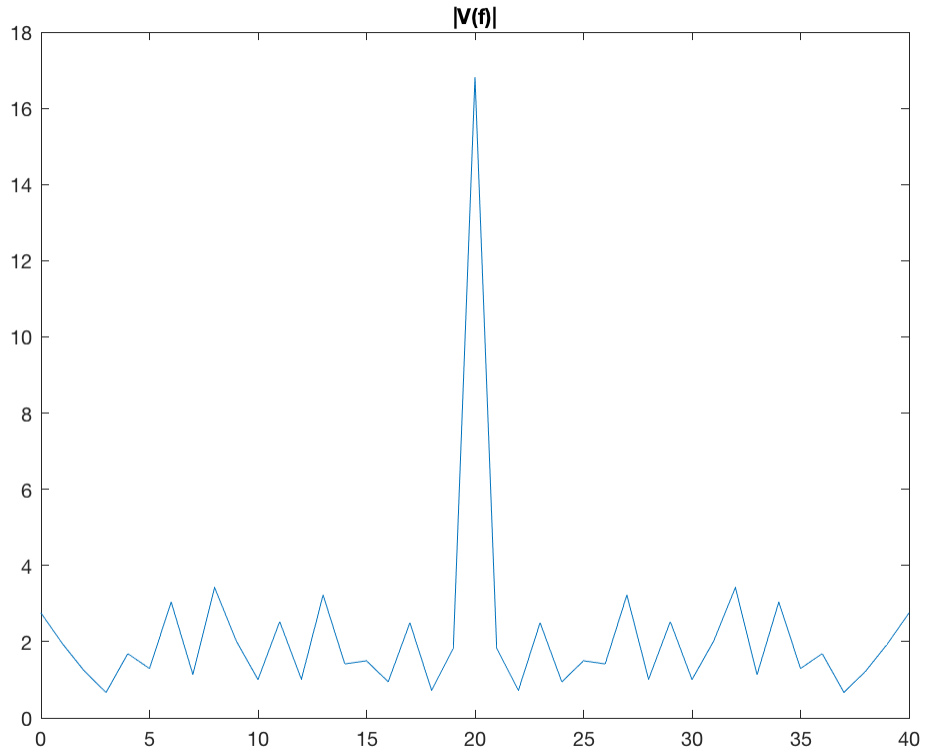
(c) The amplitude DTFT of $x_{up}[n] = \begin{cases} x[m] & n = 3m \\ 0 & n \neq 3m \end{cases}$, for |f|<0.5;

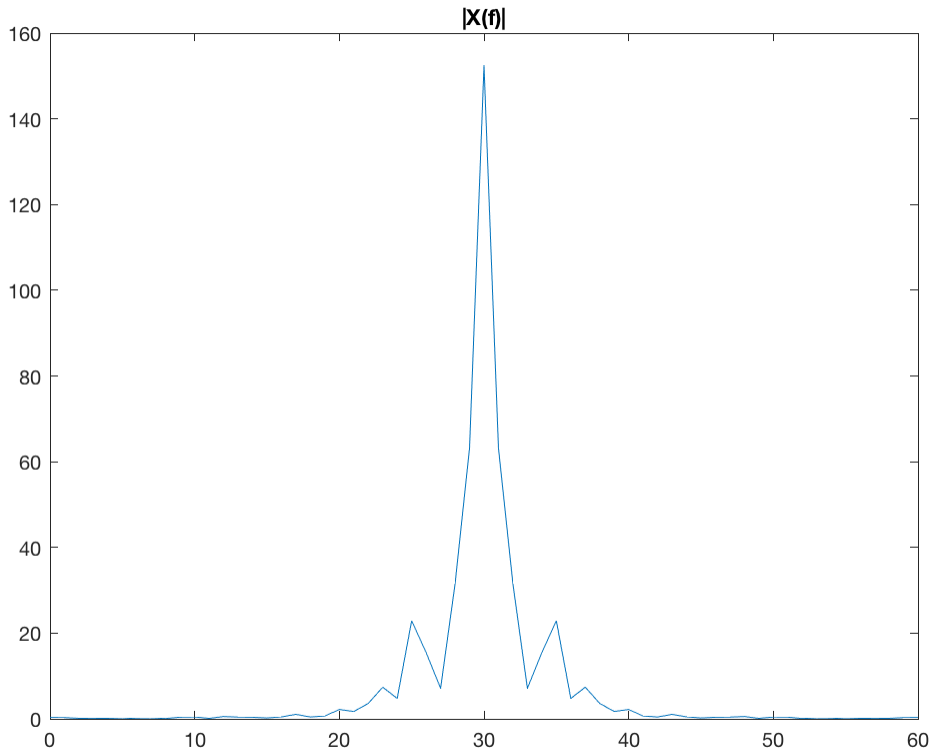
(d) The amplitude DTFT of $x_{down}[n] = x[3n]$, for |f|<0.5.

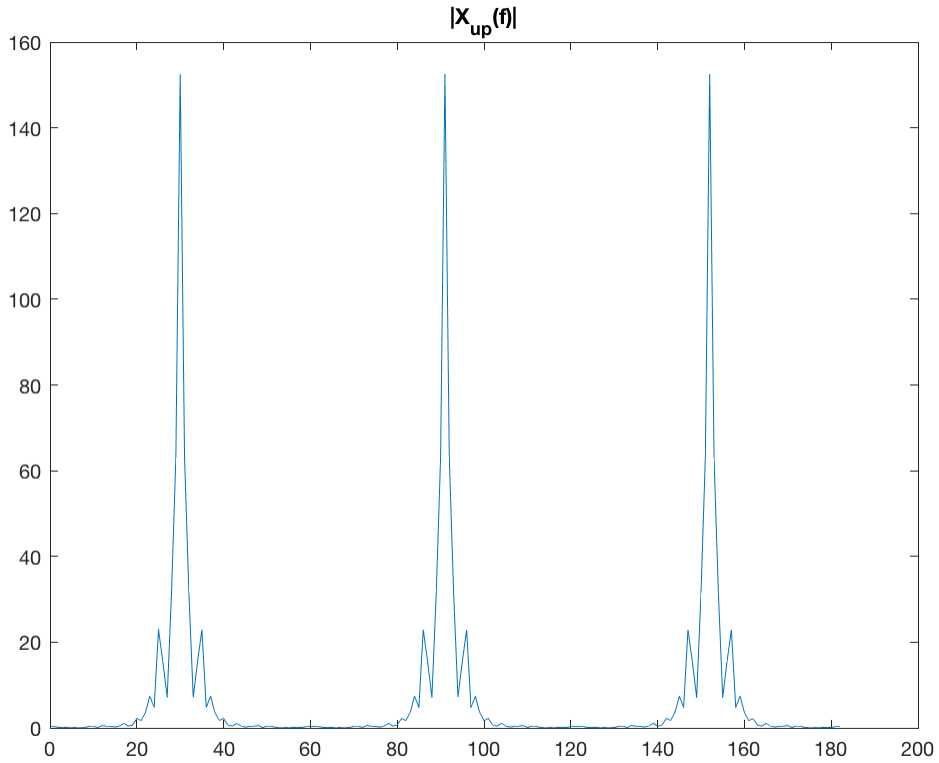
task 2

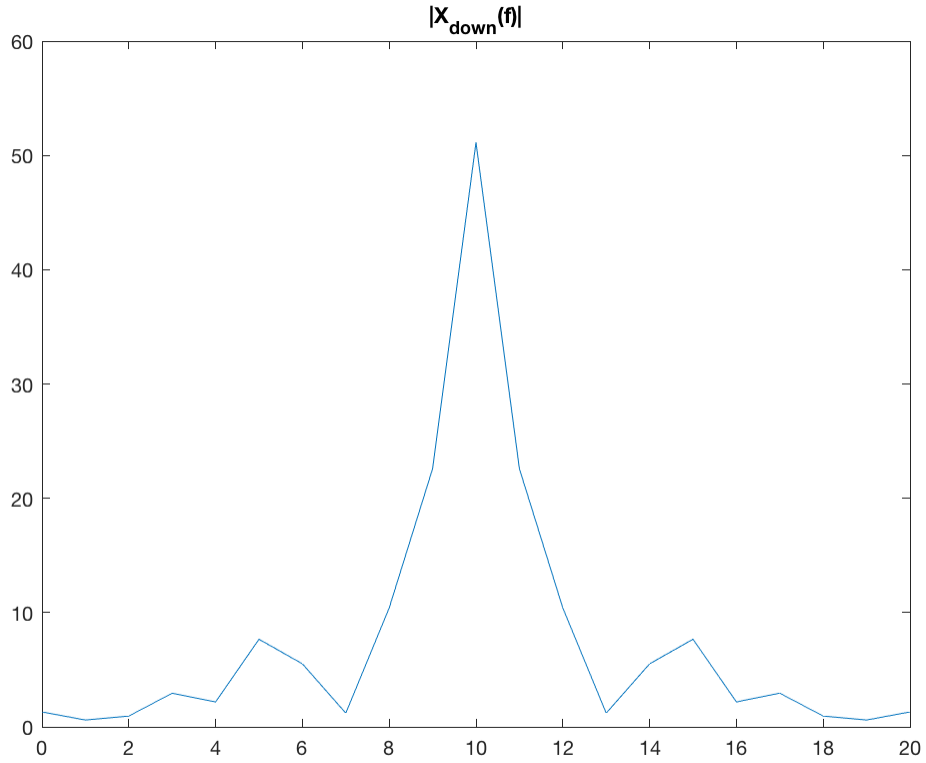
```
%close all
v = rand(1,41);
x = conv(v,h);
V = fftshift(fft(v));

%plot the DTFT of v[n]
figure
plot(0:length(V)-1,abs(V))
title('|V(f)|')

X = fftshift(fft(x));
%plot the DTFT of x[n]
figure
```

```
plot(0:length(X)-1,abs(X))
title('|X(f)|')

figure
x1 = upsample(x,3);
X = fftshift(fft(x1));
plot(0:length(X)-1,abs(X))
title('|X_u_p(f)|')

figure
x2 = downsample(x,3);
X = fftshift(fft(x2));
plot(0:length(X)-1,abs(X))
title('|X_d_o_w_n(f)|')

% Down-sampling produced a wider, less detailed signal than up-
sampling.
```




|X(f)|
160
140
120
100
80
60
40
20
0
0
10
20
30
40
50
60


|X_up(f)|
160
140
120
100
80
60
40
20
0
0
20
40
60
80
100
120
140
160
180
200



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