
Lab 5: Sampling and Discrete Fourier Transform

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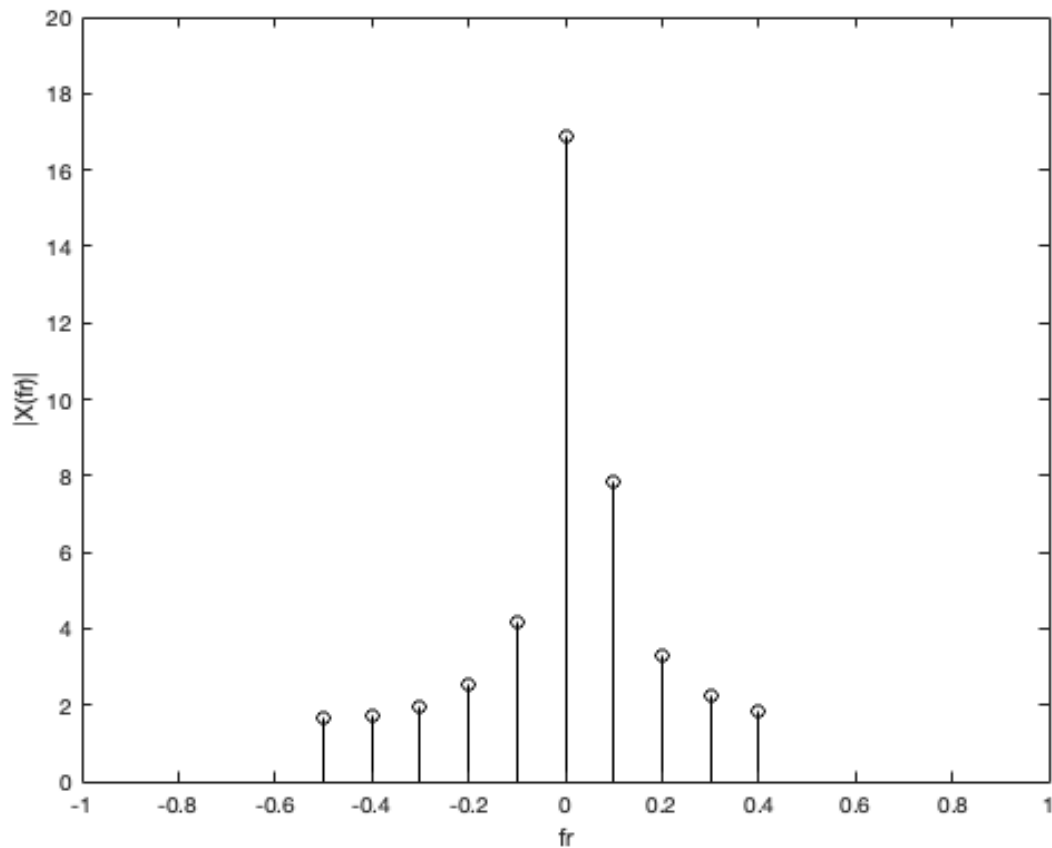
A. DiscreteFourierTransformandzeropadding

1.

x1 DTF

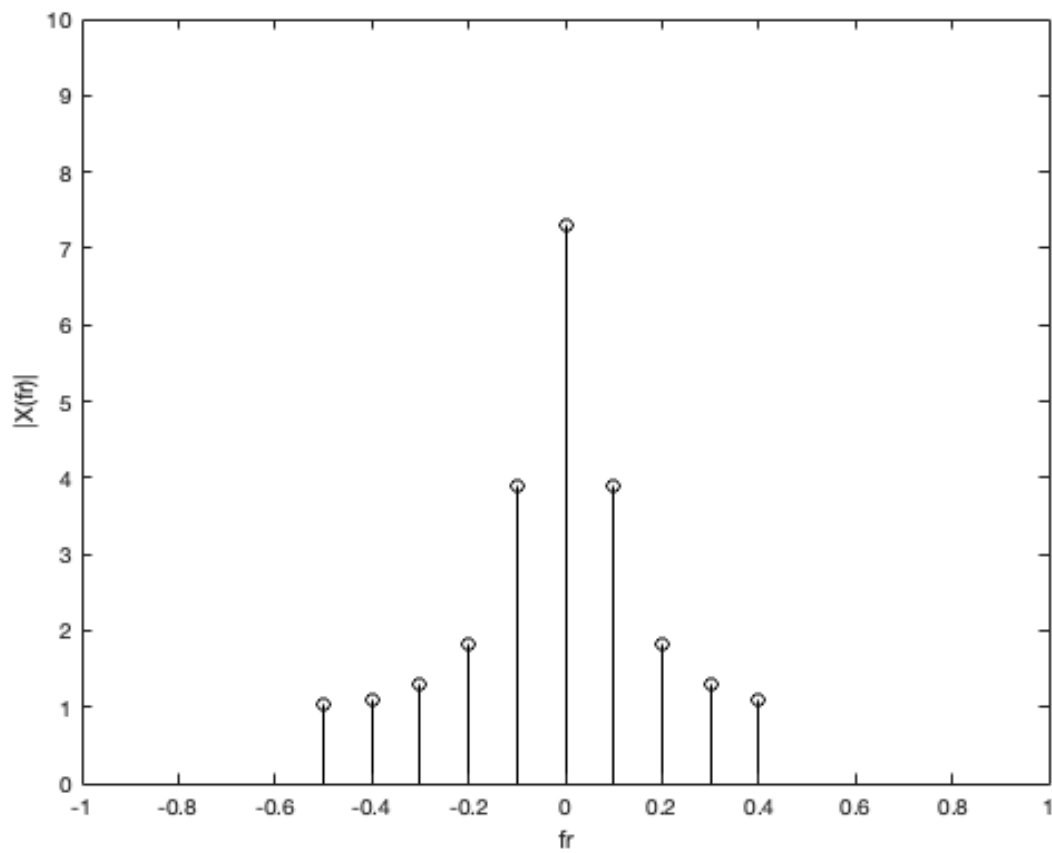
```
T_0 = 1; N_0 = 10; T = T_0/N_0; n = (0:T:T*(N_0-1));  
  
x_1 = exp(1i*2*pi*n*30/100) + exp(1i*2*pi*n*33/100);  
x_2 = cos(2*pi*n*30/100) + 0.5.*cos(2*pi*n*40/100);  
  
X_1 = fft(x_1); r = -N_0/2:N_0/2-1;
```

```
X_2 = fft(x_2);  
fr = r/N_0;  
  
stem(fr,fftshift(abs(X_1)), 'k');  
axis([-1 1 0 20]);  
xlabel('fr'); ylabel('|X(fr)|');
```



x2 DTF

```
stem(fr,fftshift(abs(X_2)), 'k');  
axis([-1 1 0 10]);  
xlabel('fr'); ylabel('|X(fr)|');
```



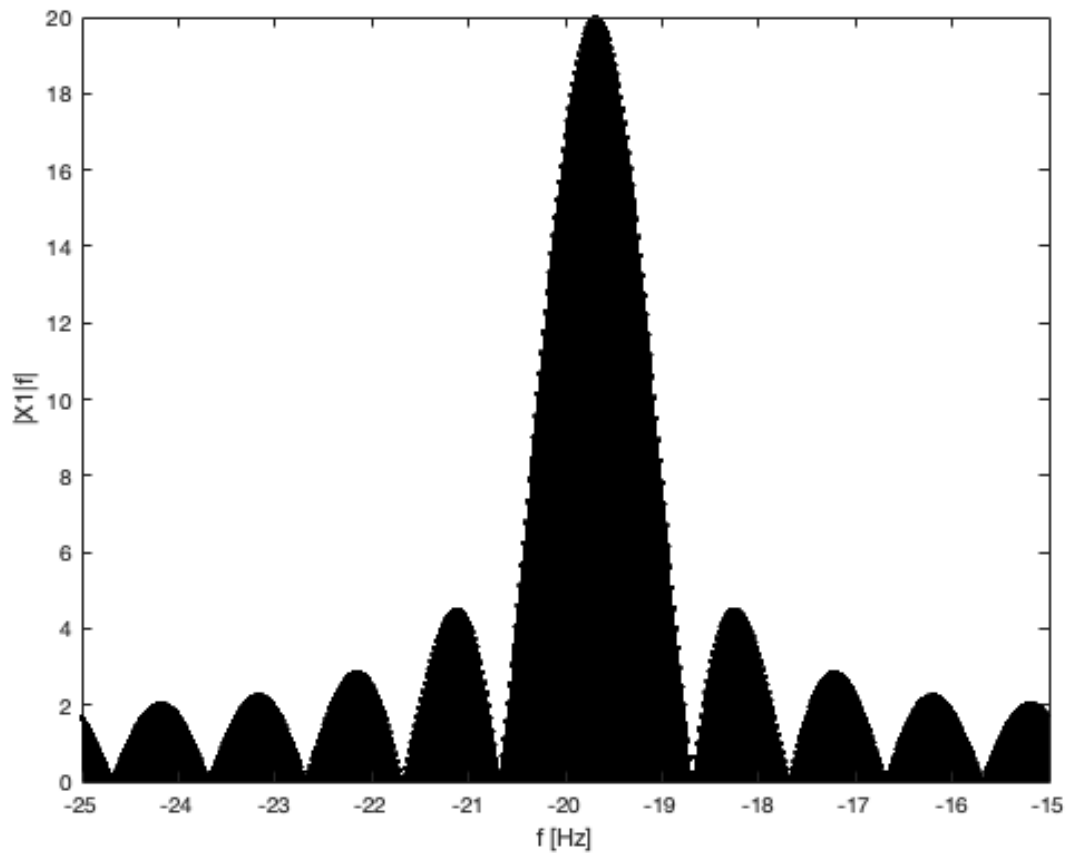
2.

X1 ZERO-PADDING

```
x_1_ZEROPAD = [x_1,zeros(1,48*length(x_1))];  
X_1_ZEROPAD = fft(x_1_ZEROPAD);
```

```
f_zp = (0:49*N_0-1)/(T*49*N_0);  
stem(f_zp-25,fftshift(abs(X_1_ZEROPAD)),'k.');
```

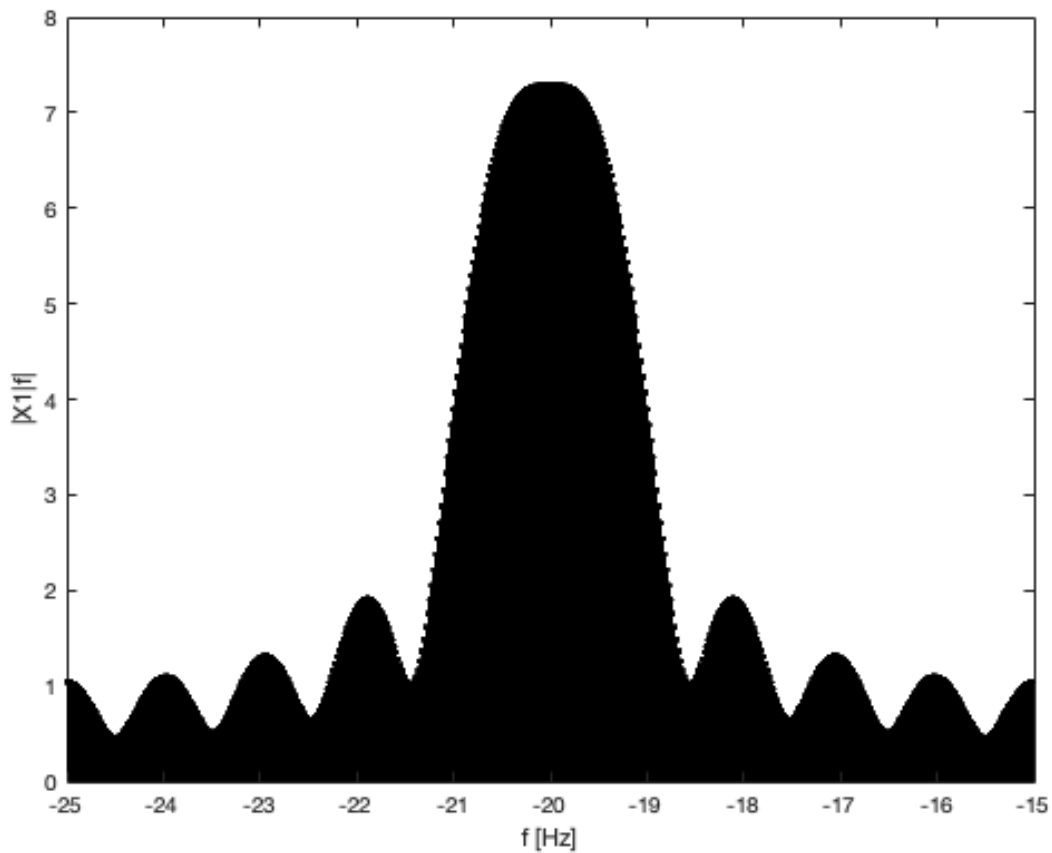
`axis([-25 -15 0 20]); xlabel('f [Hz]'); ylabel('|x1|f|');`



X2 ZERO-PADDING

```
x_2_ZEROPAD = [x_2,zeros(1,48*length(x_2))];  
X_2_ZEROPAD = fft(x_2_ZEROPAD);  
  
f_zp = (0:49*N_0-1)/(T*49*N_0);  
stem(f_zp-25,fftshift(abs(X_2_ZEROPAD)),'k.');
```

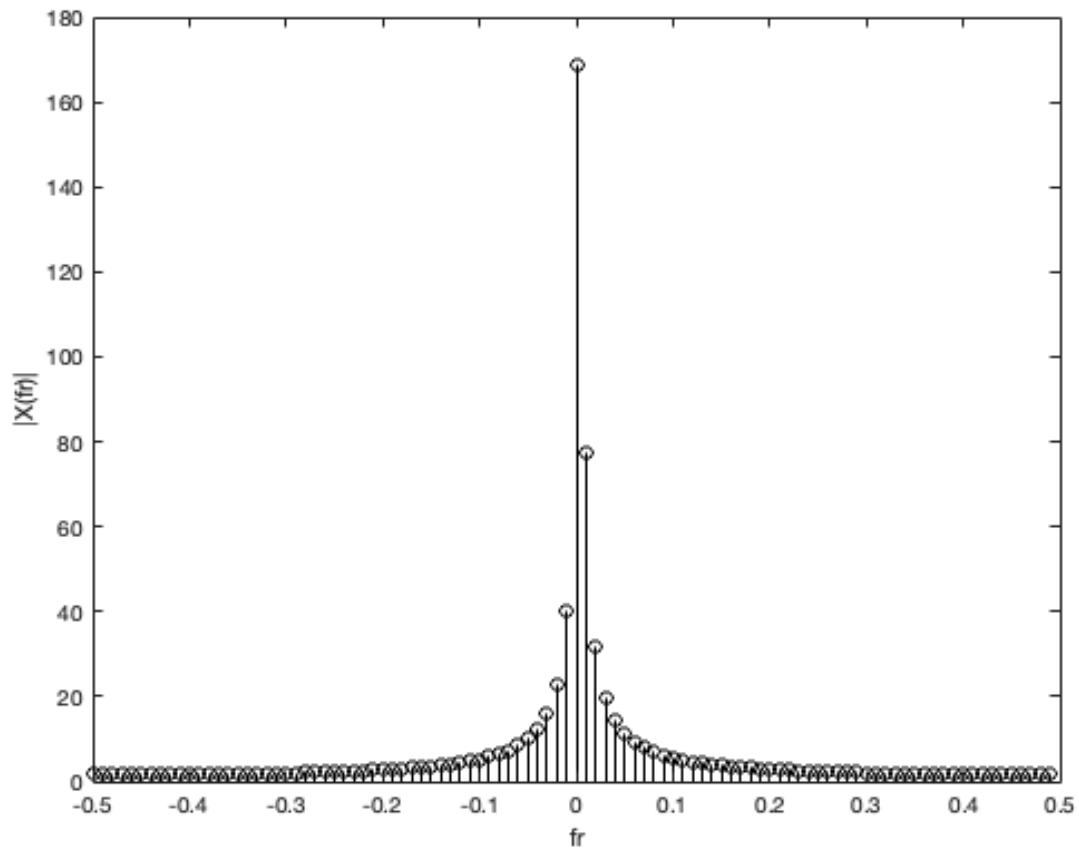
axis([-25 -15 0 8]); xlabel('f [Hz]'); ylabel('|X1|f|');



3.

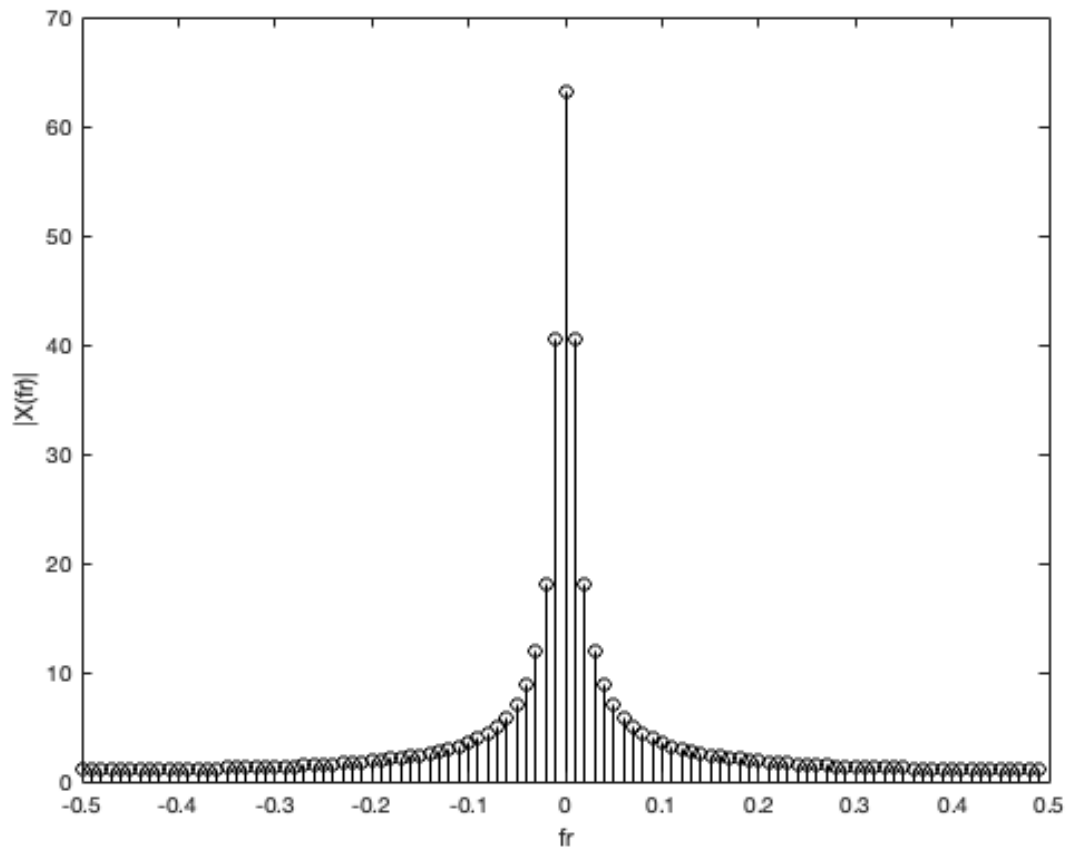
X1. 100 SAMPLES

```
T_0 = 1; N_0 = 100; T = T_0/N_0; n = (0:T:T*(N_0-1));  
  
x_1 = exp(1i*2*pi*n*30/100) + exp(1i*2*pi*n*33/100);  
x_2 = cos(2*pi*n*30/100) + 0.5.*cos(2*pi*n*40/100);  
  
X_1 = fft(x_1); r = -N_0/2:N_0/2-1;  
X_2 = fft(x_2);  
fr = r/N_0;  
  
stem(fr,fftshift(abs(X_1)),'k');  
axis([-0.5 0.5 0 180]);  
xlabel('fr'); ylabel('|X(fr)|');
```



X2. 100 Samples

```
stem(fr,fftshift(abs(X_2)),'k');  
axis([-0.5 0.5 0 70]);  
xlabel('fr'); ylabel('|X(fr)|');
```

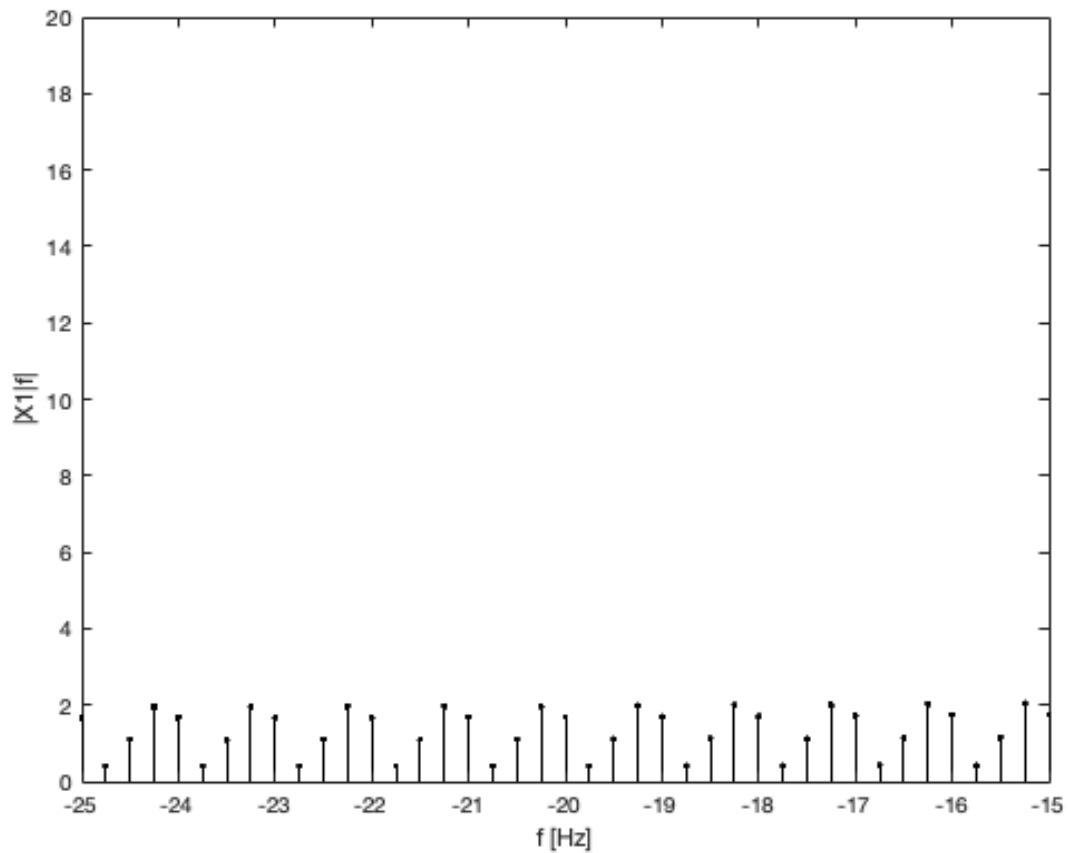


4.

X1 ZERO-PADDING 100 samples

```
x_1_ZEROPAD = [x_1,zeros(1,3*length(x_1))];  
X_1_ZEROPAD = fft(x_1_ZEROPAD);  
  
f_zp = (0:4*N_0-1)/(T*4*N_0);  
stem(f_zp-25,fftshift(abs(X_1_ZEROPAD)),'k.');
```

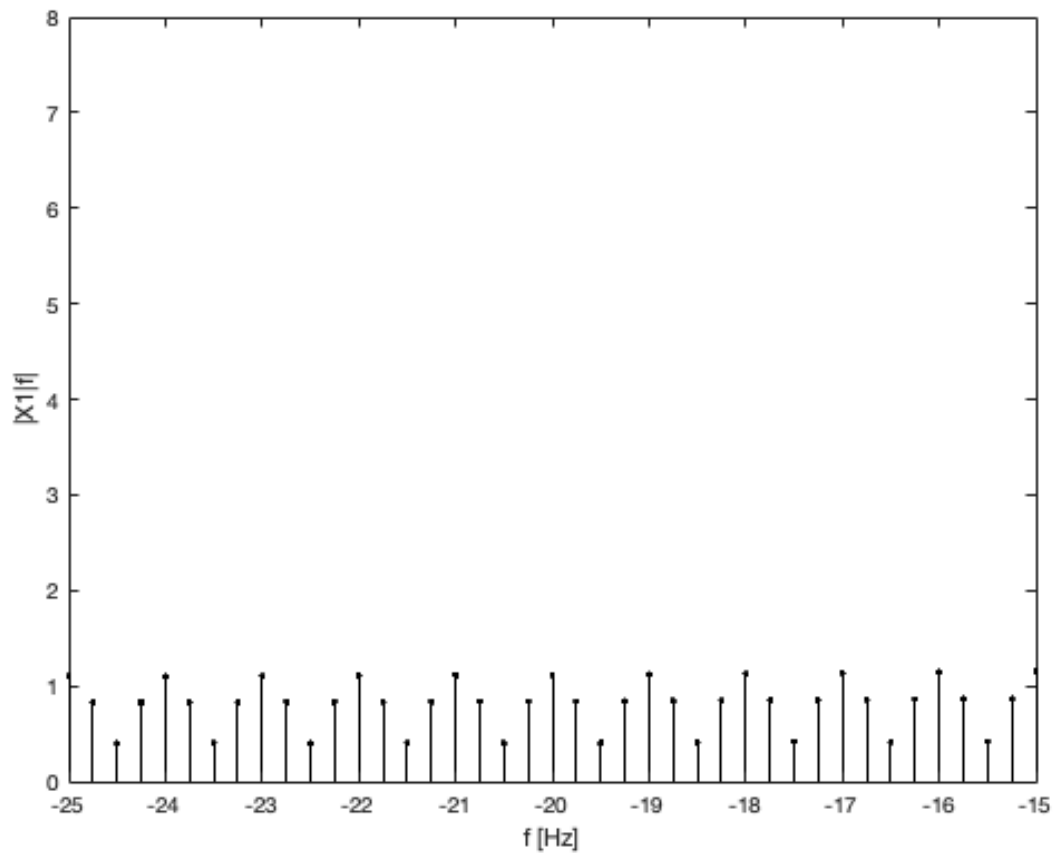
`axis([-25 -15 0 20]); xlabel('f [Hz]'); ylabel('|x1|f|');`



X2 ZERO-PADDING 100 samples

```
x_2_ZEROPAD = [x_2,zeros(1,3*length(x_2))];  
X_2_ZEROPAD = fft(x_2_ZEROPAD);  
  
f_zp = (0:4*N_0-1)/(T*4*N_0);  
stem(f_zp-25,fftshift(abs(X_2_ZEROPAD)),'k.');
```

`axis([-25 -15 0 8]); xlabel('f [Hz]'); ylabel('|X1|f|');`



B. Sampling

```
[y,fs] = audioread ('handel.wav');  
sound(y,fs);
```

```
Error using sound  
Device Error: Internal Device error
```

```
Error in lab5 (line 98)  
sound(y,fs);
```

1. $N_0 = 73113$, $T_0 = 8.93$, $T = 1.2e-4$

```
sampleTime = length(y);  
totalTimeSpan = sampleTime/fs;  
  
t = linspace(0, sampleTime/fs, sampleTime);
```

2.

```
plot(t, y)
```

3.

```
Y = fft(y);  
  
stem(t,abs(Y), 'k');
```

4.

```
subsample = downsample(y,2);  
sampleTime = length(subsample);  
  
t = linspace(0, sampleTime/fs, sampleTime);
```

5.

```
stem(t,abs(subsample), 'k');
```

6.

```
SUB = fft(subsample);  
  
stem(t,abs(SUB), 'k');
```

7.

```
sound(y,fs);
```

The sound has sped up and higher pitched

```
sound(subsample,fs);
```

C. Filter design

1.

```
LP = lowpass(y,2000,fs);
```

```
stem(t, LP);  
sound(LP,fs);
```

```
% 2. It sounds like it has gotten more echo, in other words there is more  
% depth compared to the original
```

3.

```
BS = bandstop(y,[16 256],fs);
```

```
stem(t,BS);  
sound(BS,fs);  
  
% After using the bandstop filter to filter out frequencies 16 - 256 Hz.  
% But the difference between this filtered signal and the original is not  
% very noticable
```

4.

```
% 5. We used the fft property to get signal to amplify
```

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