EECS 360

Discrete Fourier Transform

Use the FFT algorithm in Matlab to answer the given questions concerning the following discrete time signals:

$$x_a(n) = 10 \sin Bn \qquad 0 \le n \le 255, \quad B = 0.049087$$

$$x_b(n) = 10 \sin Bn \qquad 0 \le n \le 200, \quad B = 0.049087$$

$$x_c(n) = \begin{cases} 0 & n=0 \\ 10\left(1 - \frac{|n-32|}{32}\right) & n = 1, \ldots 64 \\ 0 & n = 65, \ldots 127 \end{cases}$$

$$x_d(n) = \begin{cases} 0 & n=0 \\ 10\left(1 - \frac{|n-32|}{32}\right) & n = 1, \ldots 64 \\ 0 & n = 65, \ldots 255 \end{cases}$$

$$x_e(n) = \begin{cases} 0 & n=0 \\ 10\left(1 - \frac{|n-16|}{16}\right) & n = 1, \ldots 33 \\ 0 & n = 34, \ldots 127 \end{cases}$$

$$x_f(n) = \begin{cases} 0 & n=0 \\ 10 & n = 1, 49 \\ 0 & n = 50, \ldots 63 \end{cases}$$

1: Use the FFT program to calculate the FFT of $x_a(n)$, $x_b(n)$, $x_c(n)$, $x_d(n)$, $x_e(n)$, and $x_f(n)$ and plot the magnitude of the resulting FFTs.

2: Explain the difference between the FFT's of $x_a(n)$ and $x_b(n)$.

3: Explain the differences between the FFT's of $x_c(n)$ and $x_d(n)$.

4: Explain the differences between the FFT's of $x_c(n)$ and $x_e(n)$.

5: If the sampling rate is 10,000 samples/sec., how long is the time record of $x_c(n)$ in seconds, what is the frequency resolution of the FFT in Hz, what is the highest frequency present in the FFT in Hz? Re-lable your graph of the magnitude of the FFT for $x_c(n)$ in Hz in assuming a sampling rate of 10,000 samples/sec.

6: Form product of the FFT of $x_f(n)$ with itself, i.e., Y(m)=FFT[$x_f(n)$]FFT[$x_f(n)$]. Then take the inverse FFT of Y(m).

a) Use Matlab conv function to find the discrete convolution of $x_f(n)$ with $x_f(n)$.
b) Comment on the relationship between the result of the inverse FFT of Y(m) and the discrete convolution of $x_f(n)$ with $x_f(n)$ found using conv.
c) Pad $x_f(n)$ with N_{pad} zeros to create $x_{fpad}(n)$ and then form product of the FFT of padded version of $x_{fpad}(n)$ with itself, i.e., $Y_{pad}(m)$=FFT[$x_{fpad}(n)$] FFT[$x_{fpad}(n)$]. Then take the inverse FFT of $Y_{pad}(m)$. Use a value of N_{pad} such that the inverse FFT of Y(m) is the same the discrete convolution of $x_f(n)$ with $x_f(n)$ found using conv, i.e., the same as the result for part a).