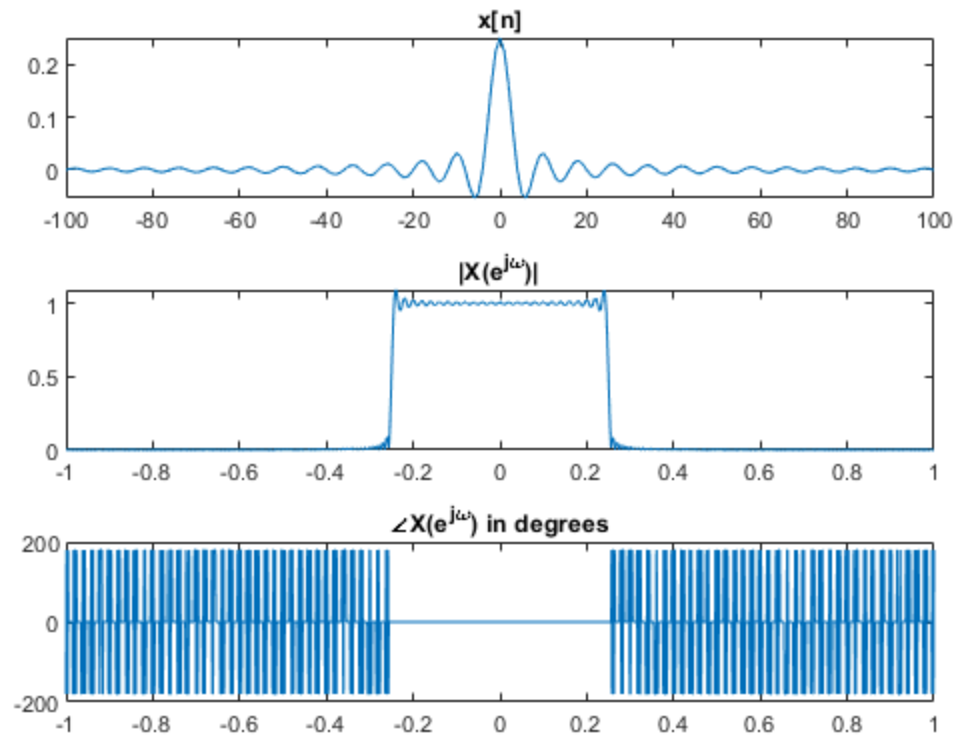

Problem 4

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(a) Initialize and create sinc function

```
clearvars
close all
l=100;
w=(-1024:1024)/(1024); %-pi to pi
n=-l:l; % length of input sequence
x=sinc(n/4)/4;
% using custom function to calculate and plot DTFT
calculatedTandplot(x,n,l,w,'x[n]','X')
```

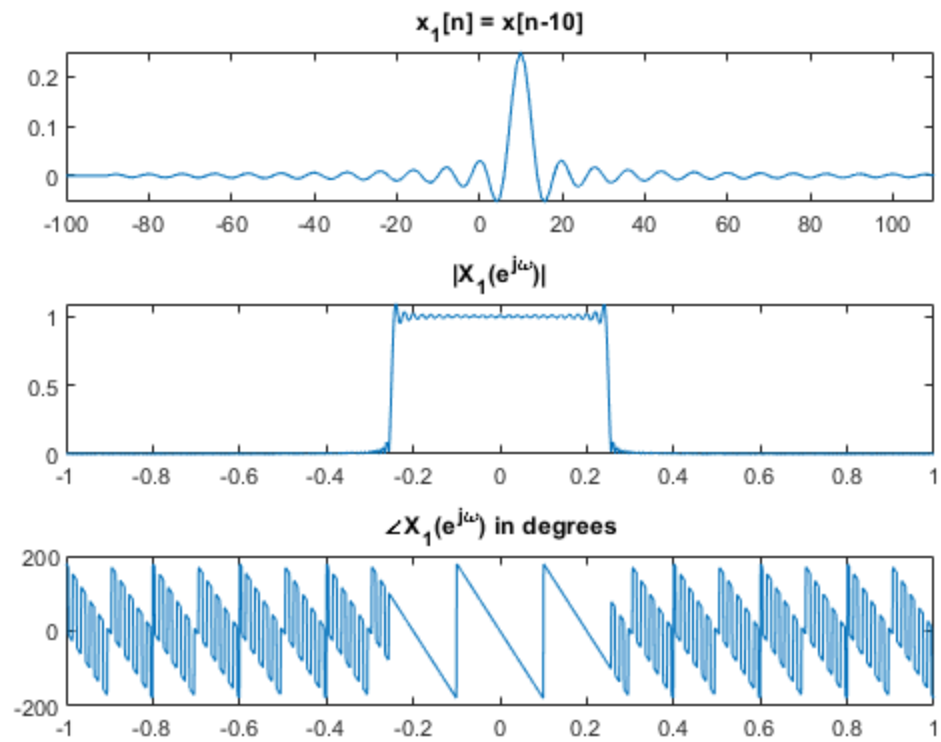


(b) Delay input by 10 samples

```

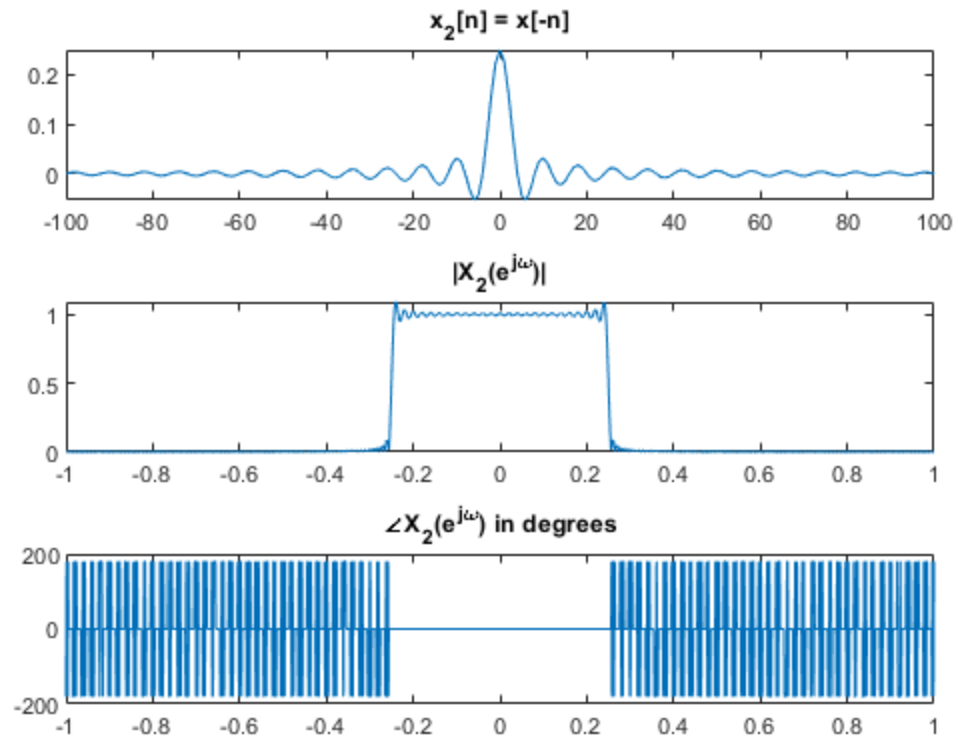
delay=10;
xb=zeros(1,delay) x];
nb=-1:(1+delay);
calculatedDTFTandplot(xb,nb,l,w,'x_1[n] = x[n-10]','X_1')

```



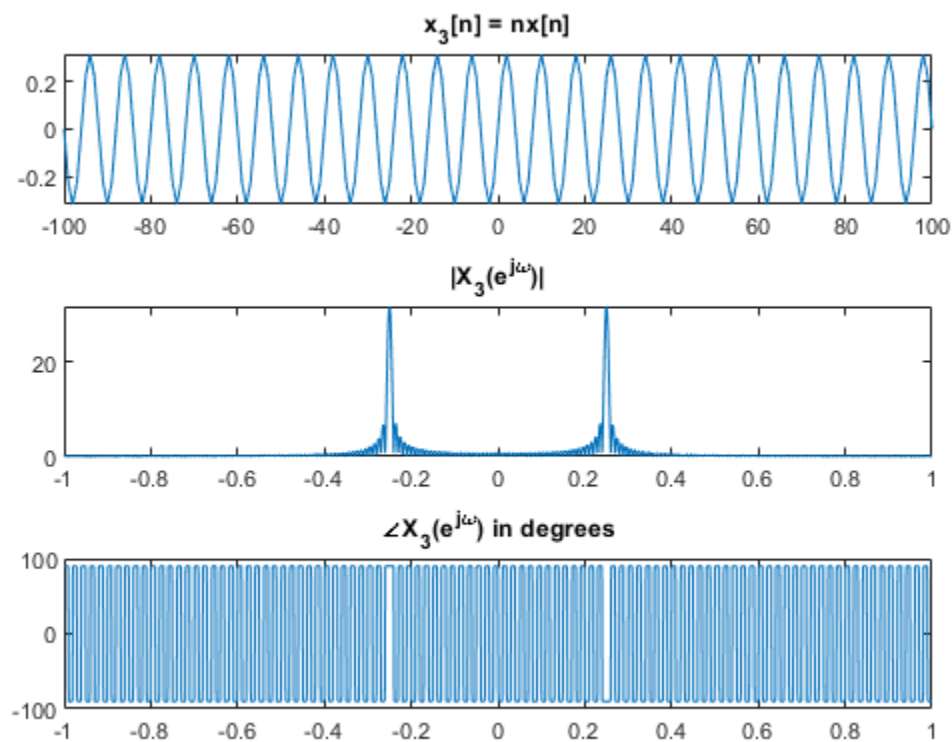
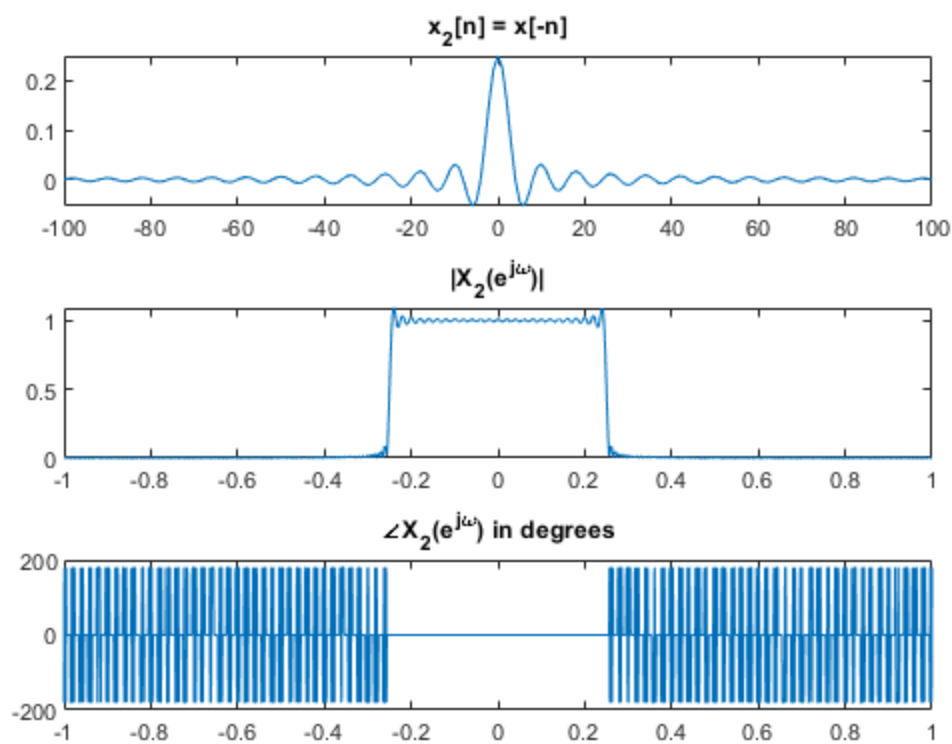
(c) Reversing sequence: $x[-n]$

```
xc=flip(x);
calculatedDTFTandplot(xc,n,l,w,'x_2[n] = x[-n]','X_2')
```



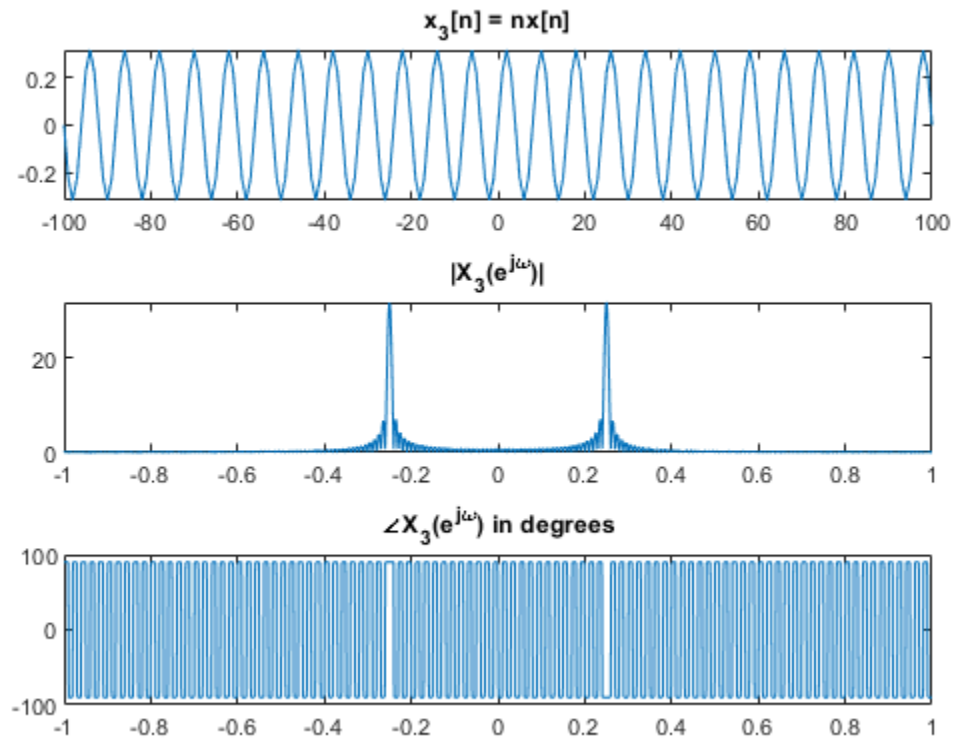
(d) Multiply by n

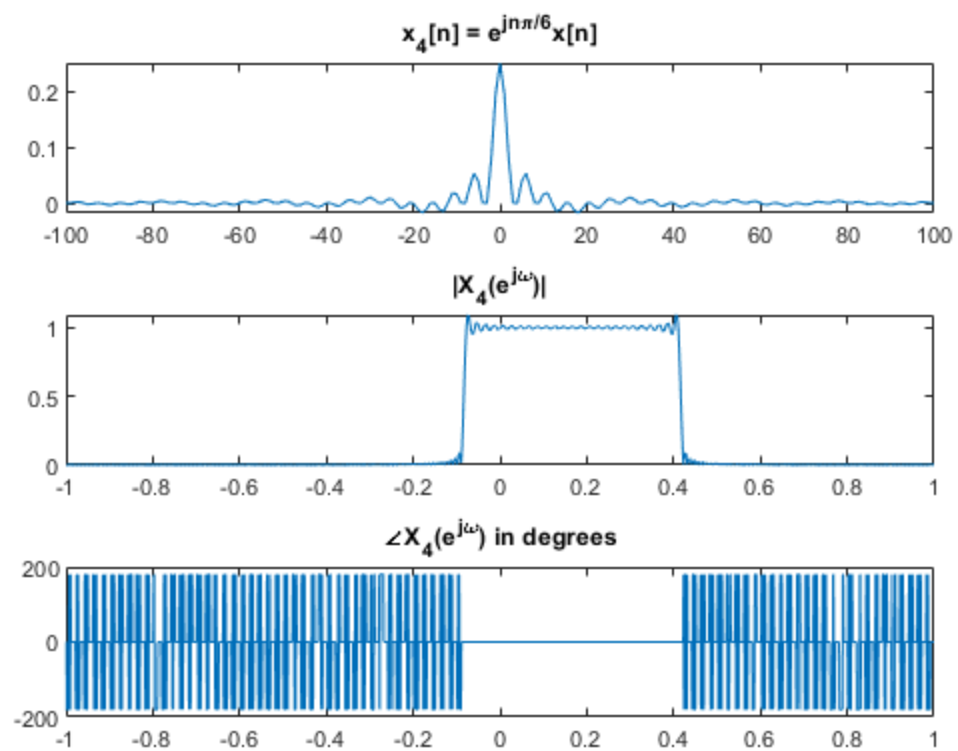
```
xd=n.*x;
calculatedDTFTandplot(xd,n,l,w,'x_3[n] = nx[n]','X_3')
```



(e) Multiplying by exponential

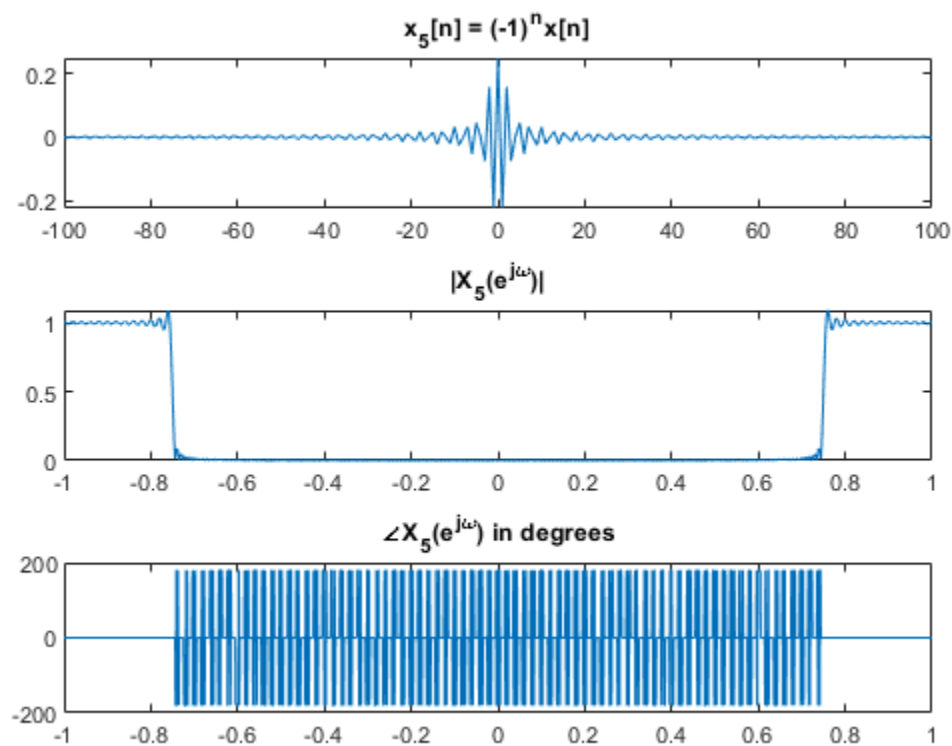
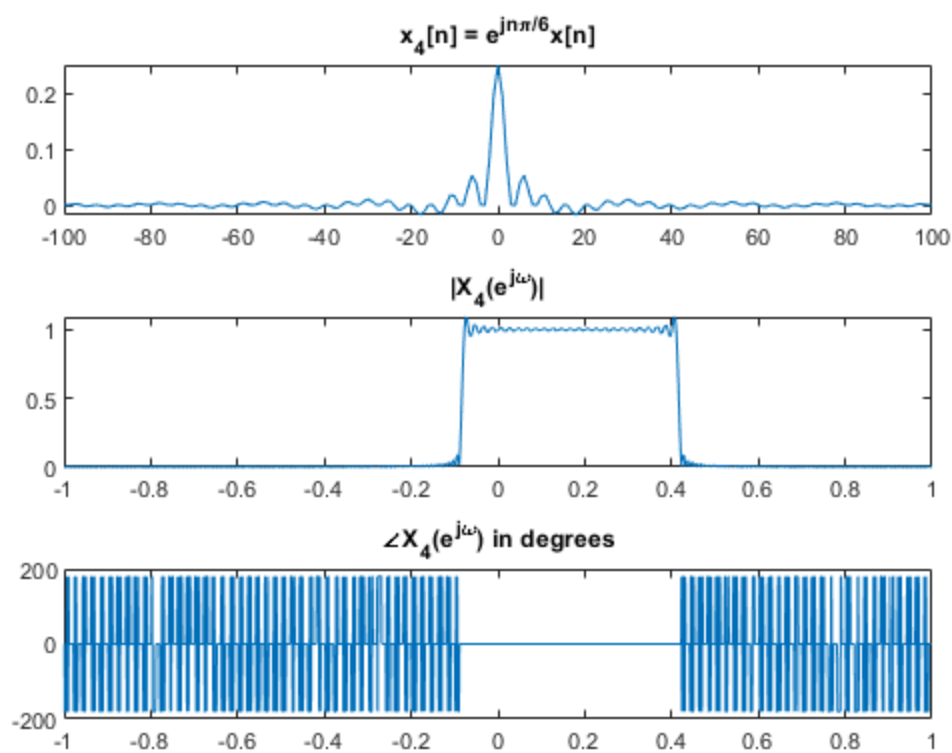
```
xe=exp(1i*n*pi/6).*x;
calculatedDTFTandplot(xe,n,l,w,'x_4[n] = e^{jn\pi/6}x[n]', 'X_4')
```





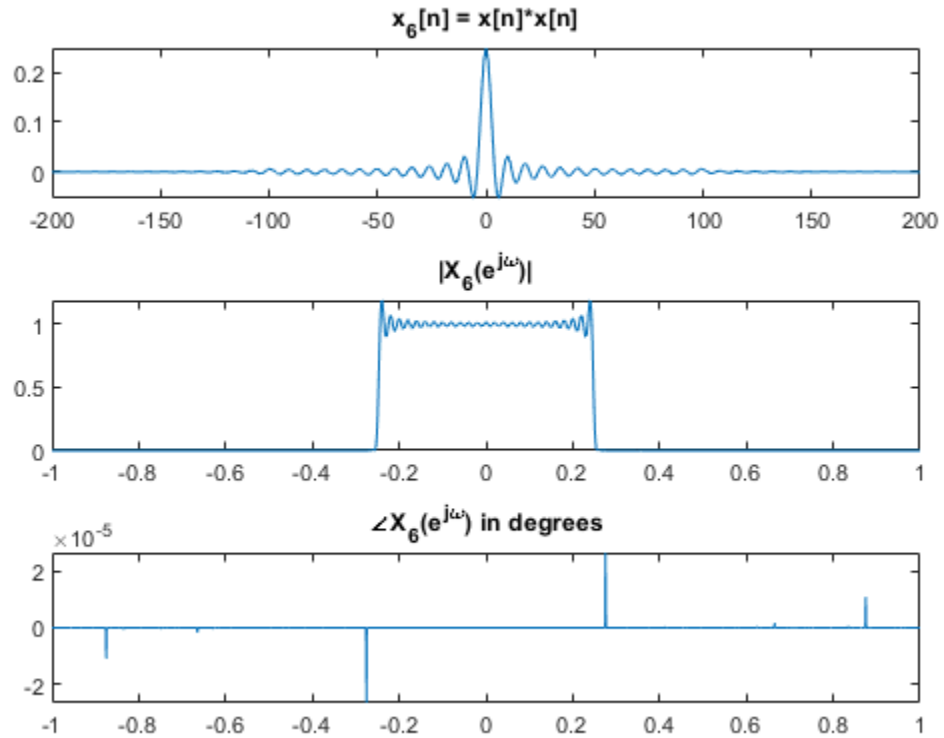
(f) Multiplying by $(-1)^n$

```
xf = ((-1).^n) .* x;
calculateDTFTandplot(xf,n,l,w, 'x_5[n] = (-1)^{n}x[n]', 'X_5')
```



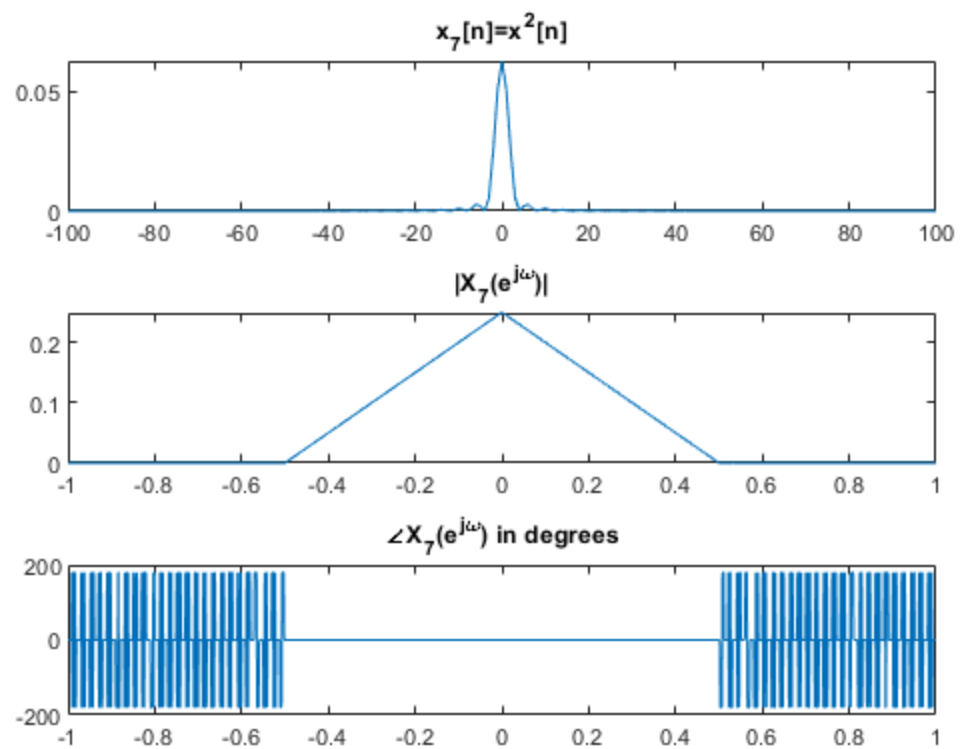
(g) Self-Convolution

```
xg=conv(x,x);
ng=-2*1:2*1;
calculatedTFTandplot(xg,ng,2*1,w,'x_6[n] = x[n]*x[n]','X_6')
```



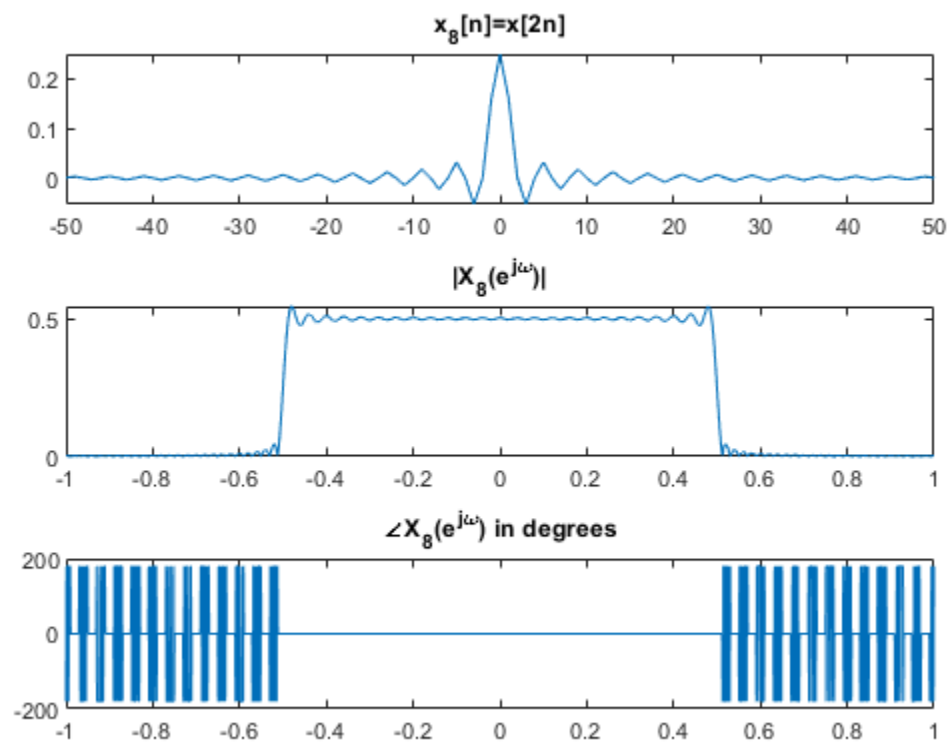
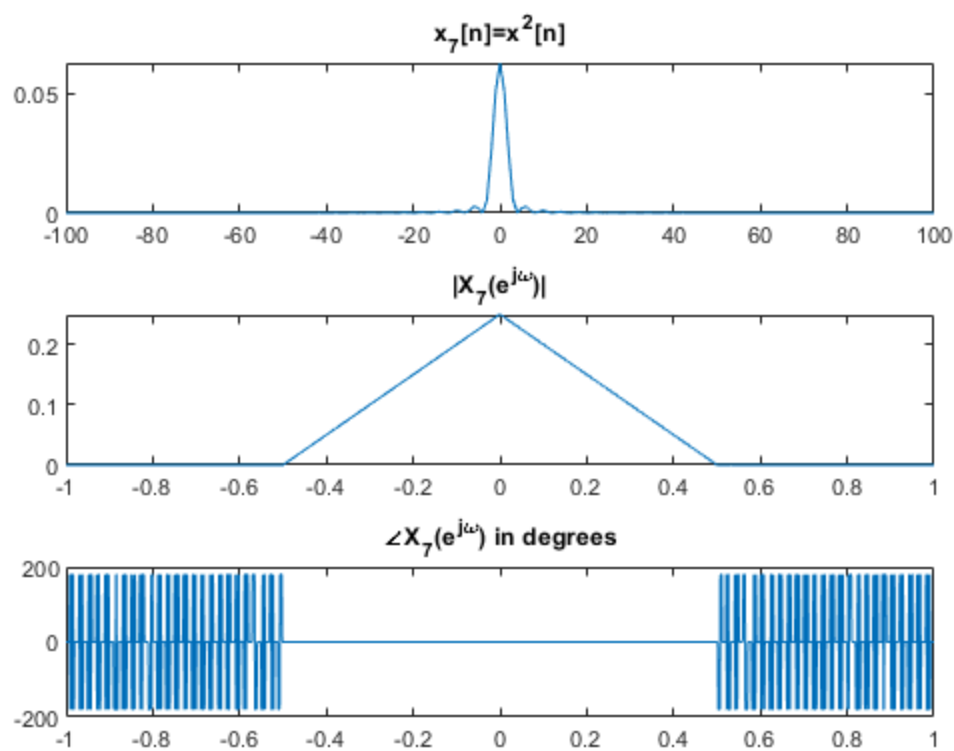
(h) Square

```
xh=x.*x; % or x.^2
calculatedTFTandplot(xh,n,1,w,'x_7[n]=x^2[n]','X_7')
```



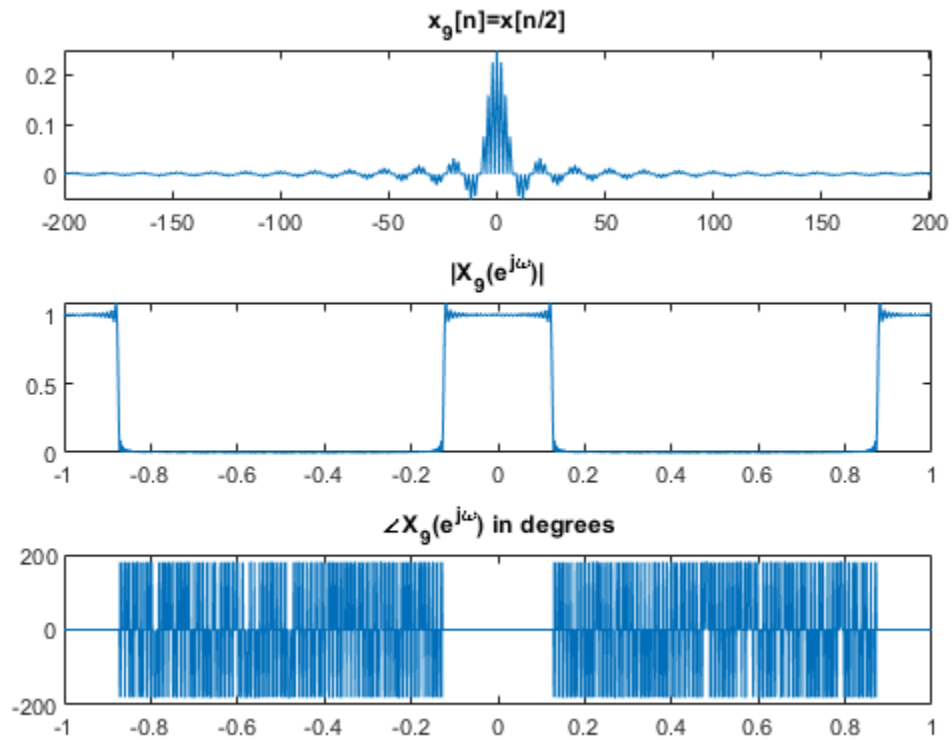
(i) Downsampling by 2

```
xi=downsample(x,2);
ni=-1/2:1/2;
calculatedDTFTandplot(xi,ni,1/2,w,'x_8[n]=x[2n]','x_8')
```



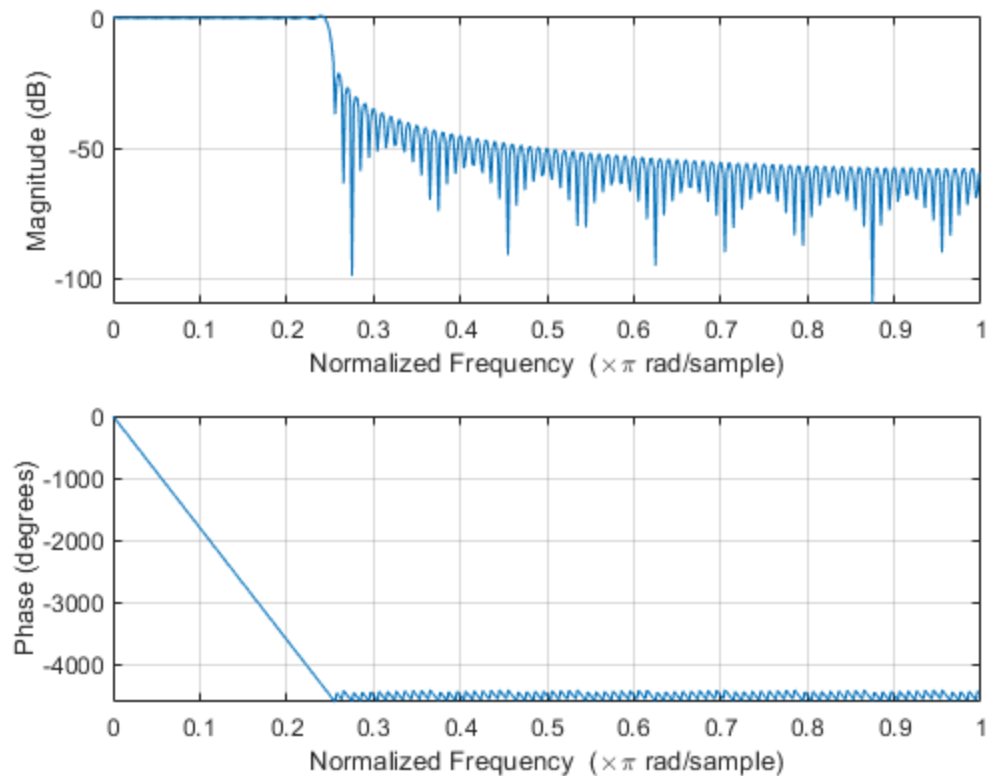
(j) Upsampling by 2

```
xj=upsample(x,2);
nj=-2*1:2*1+1;
calculatedTFTandplot(xj,nj,2*1,w,'x_9[n]=x[n/2]','X_9')
```



Testing freqz function

```
figure
freqz(x) % Can be repeated for all the sequences
```



Function Definition

```
function calculatedDTFTandplot(x,n,l,w,imtitle1,seq)
    H=zeros(1,length(w));
    for k=min(n):max(n)
        H=H+x(k+l+1)*exp(-1i*w*pi*k);
    end
    figure
    subplot(3,1,1)
    plot(n,real(x))
    % Section(e) produces complex values for x. Hence real(x)
    title(imtitle1)
    xlim([min(n) max(n)])
    subplot(3,1,2)
    plot(w,abs(H))
    imtitle1="| "+seq+"(e^{j\omega})| ";
    title(imtitle1)
    subplot(3,1,3)
    plot(w,angle(H)*180/pi)
    imtitle1="\angle "+seq+"(e^{j\omega}) in degrees";
    title(imtitle1)
end
```

Comments

The DTFT is not a perfect rectangle for the sinc signal, and the magnitude plot of X_3 varies from theoretical calculation. These occur as we do not use an infinitely long sinc signal / we use a windowed version of an infinitely long sinc signal.

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