EE 313 Linear Systems and Signals – Spring 2023
Prof. Neal Hall

Homework #1

1. Let $x[n] = u[n+2] - u[n-4]$. Sketch the following signals: $x[n]$, $x[n-3]$, $x[n+4]$, $x[-n]$, $x[-n+2]$, $x[-n-2]$.

Please answer the following questions from "Signals and Systems, 2nd Edition, by Alan V. Oppenheim, Alan S. Willsky, with S. Hamid."

2. 1.1 (only the first 4 listed) and 1.2 (only the first 4 listed).
3. 1.5 (*a* through *c*)
4. 1.8 (*d*)
5. 1.22 (*a, b, e, f*)
6. 1.31
7. Let $x(t) = 2.5\cos\left(\pi t + \frac{\pi}{4}\right) + \cos(\pi t) = A\cos(\pi t + \theta)$. Solve for A and θ.

Simulation:

8. Use Matlab or Python to plot $X(t) = cos(2\pi t)$ in three different ways:

$$X_1(t) = cos(2\pi t)$$

$$X_2(t) = Re\{e^{j2\pi t}\}$$

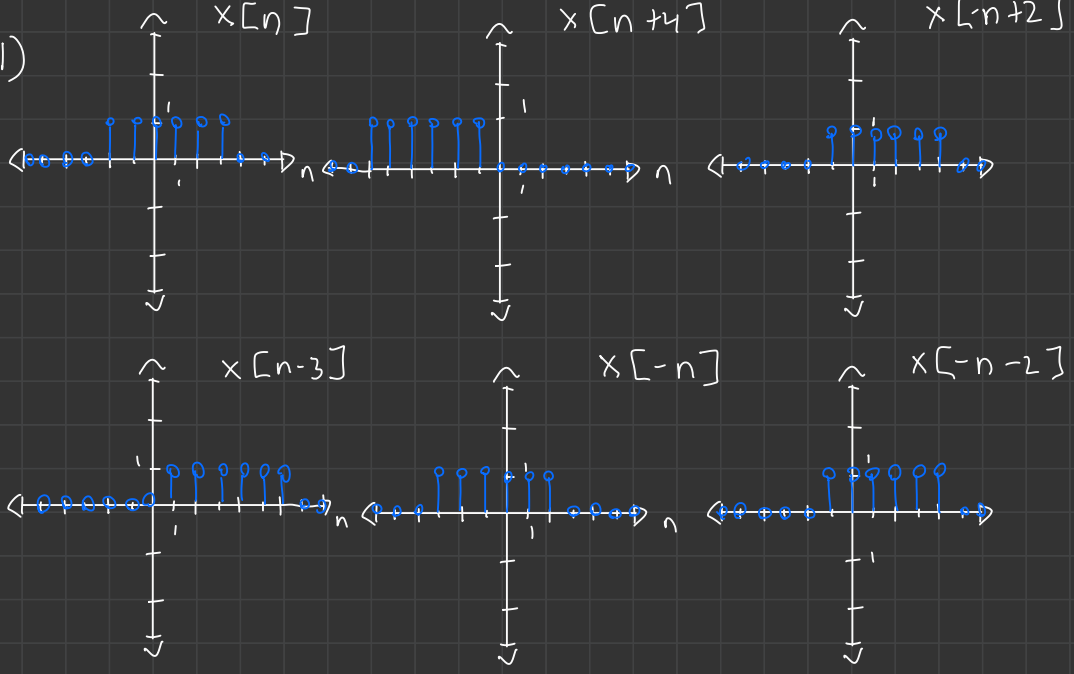
$$X_3(t) = \frac{e^{j2\pi t} + e^{-j2\pi t}}{2}$$

Hint: For *Matlab and Python,* define t as follows:

t = linspace(0,1,1000)

9. Evaluate the following integral: $\int_{-\infty}^{+\infty} t^2\delta(t-3)dt$.

1)



2) 1.1)

$\frac{1}{2}e^{j\pi}$, $\frac{1}{2}e^{-j\pi}$, $e^{j\pi/2}$, $e^{-j\pi/2}$ in Cartesian

$\frac{1}{2}e^{j\pi} = \frac{1}{2}\cos\pi + \frac{1}{2}\sin\pi j$
$= \frac{1}{2}\cdot -1 + 0$
$= \boxed{-\frac{1}{2}} + 0j$

$\frac{1}{2}e^{-j\pi}$
$= \frac{1}{2}\cos -\pi + \frac{1}{2}\sin -\pi \cdot j$
$= \frac{1}{2}\cdot -1 + 0 = \boxed{-\frac{1}{2}} + 0j$

$e^{j\pi/2}$
$= \cos\frac{\pi}{2} + \sin\frac{\pi}{2}\cdot j$
$= 0 + 1\cdot j$
$= \boxed{0+j}$

$e^{-j\pi/2}$
$= \cos -\frac{\pi}{2} + \sin -\frac{\pi}{2}\, j$
$0 + -1\cdot j$
$= \boxed{0-j}$

3) $x(1-t) = 0$ for $t > -2$

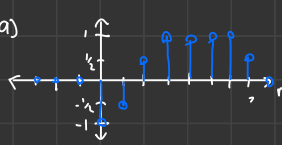
$x(1-t) + x(2-t) = 0$ for $t > -1$

$x(1-t)\cdot x(2-t) = 0$ for $t > -2$

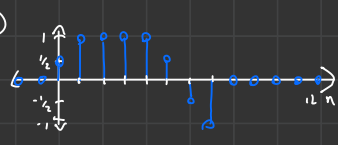
4) $x_4(t) = je^{(-2+j100)t}$
$= je^{-2t}e^{100jt}$
$= je^{-2t}(\cos 100t + \sin 100t\, j)$
$= je^{-2t}\cos 100t - e^{-2t}\sin 100t$
$= je^{-2t}\cos 100t + e^{-2t}\sin(100t+\pi)$
$= \mathrm{Re}\{\uparrow\} = e^{-2t}\sin(100t+\pi)$
$= e^{-2t}\cos\left(\frac{\pi}{2} - 100t - \pi\right)$
$= e^{-2t}\cos\left(-\frac{\pi}{2} - 100t\right) = e^{-2t}\cos\left(100t + \frac{\pi}{2}\right)$

$\boxed{A=1\ a=-2\ W=100\ \phi=\pi/2}$

5) a)

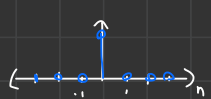


b)

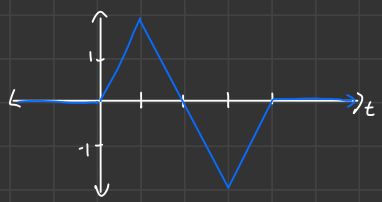


e)

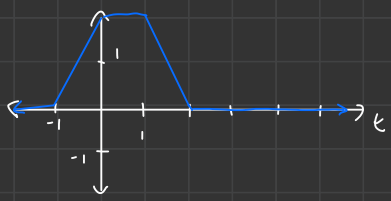
f)



6) $x_2(t) = x_1(t) - x_1(t-2)$



b) $x_3(t) = x_1(t) + x_1(t+1)$



7) $2.5\cos\left(\pi t + \frac{\pi}{4}\right) + \cos \pi t = A\cos(\pi t + \theta)$

$= 2.5\left(\cos(\pi t)\cos\left(\frac{\pi}{4}\right) - \sin(\pi t)\sin\left[\frac{\pi}{4}\right]\right] + \cos(\pi t)$

$= 1.77\left[\cos(\pi t) - \sin(\pi t)\right] + \cos(\pi t)$

$= \left(1.77 + 1\right)\cos(\pi t) - 1.77\sin(\pi t)$

Trig Property $a\cos(\omega t) \pm b\sin(\omega t)$

$A\cos(\omega t + \theta)$, $A = \sqrt{a^2 + b^2}$ $\quad \theta = \cos^{-1}\left(\frac{a}{A}\right)$

$a = 2.77$ $\quad b = 1.77$ $\quad A = 3.28$ $\quad \theta = .5683$

$\therefore$ $A\cos(\omega t + \theta) = 3.28\cos(\pi t + .5683)$

$\boxed{A = 3.28,\ \theta = 0.5683}$

9) $\int_{-\infty}^{\infty} t^2 \delta(t-3)\,dt = T^2\big|_{t=3} = \boxed{9}$

```
clear
close all
clc

%Equation 1
subplot(2,2,1);
t = linspace(0, 1 ,1000);
y = cos(2*pi*t);
plot(t, y)
title('X1');
ylabel('f(x1)')
xlabel('t')

%Equation 2
subplot(2,2,2)
t = linspace(0,1,1000);
y = cos(2*pi*t);
plot(t,y)
title('X2');
ylabel('f(x2)');
xlabel('t');

%Equation 3
subplot(2,2,3);
t = linspace(0,1,1000);
y = (cos(2*pi*t) + cos(-2*pi*t))/2;
plot(t,y)
title('X3')
xlabel('t');
ylabel('f(x3)');
```