Roy Xavier DSP Quiz #2

1. a) $f(t) = A/2 + \sum_{n=1}^{\infty} B_n \sin(\frac{2\pi n}{T} t)$

$B_n = 4/n\pi$ represents odd values for n.

$f(t) = \frac{4}{\pi}(\sin(2\pi f_1 t) + \frac{1}{3}\sin(2\pi 3 f_1 t) + \frac{1}{5}\sin(2\pi 5 f_1 t) \ldots)$ continues on for odd values.

b)
```
f1 = 1.4e6;
T = 1/f1;
Fs = 10*f1;
Tmax = 10*T;

sq_wave = zeros(size(t));
N_harm = 15;

for n = 1:2:(2*N_harm - 1)
    sq_wave = (4/(n*pi))*sin(2*pi*n*f1*t);
end
```

c)
```
N = length(sq_wave);
dft_sq_wave = fft(sq_wave);
f = (0:N-1)*Fs/N;
```

d) graph

2) Yes, the Gibbs effect is observed in the fourier series approximation of the square wave. This is due to the square wave having very sharp discontinuities and the Fourier series not being able to represent the jumps. This then produces ripples near the discontinuities.

3 a) N = 1,000;
delta = zeros(1,N);
delta(1) = 1;

b) graph

c) graph

d) The phase in the frequency domain becomes linear but due to periodic nature of phase, it will then wrap around at $\pm \pi$ then causing discontinuities in the phase plot.

e) Yes, the group delay of the $\delta[n]$ signal is 100 samples as its value is constant.

f) the noise causes irregularities in the group delay plot and shows fluctuations in the value. This alters the phase and makes it less smooth.

4. a)

```
Fs = 10e6;
f = 100e3;
A = 1.0;
Tmax = 6e-3;
t = 0:1/Fs:Tmax-1/Fs;
x = A*sin(2*pi*f*t);
```

b)

```
x(find(x >= 0.75)) = 0.75;
x(find(x <= -0.75)) = -0.75
```

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4.c) There is a huge frequency spike at 100kHz which highlights the fundamental frequency is preserved after clipping.

d) Yes the harmonics were observed in the frequency spectrum of the clipped signal. The waveform was not a pure sine wave after clipping. The distortion caused spikes in the DFT. Clipping causes nonlinear distortion.

8a) $y[n] = (1-\alpha) \cdot x[n] + \alpha \cdot y[n-1]$

This demonstrates how a recursive low-pass filter responds to the sudden changes making it smoother.

8b) graph

8c) The phase response of the filtered signal is non-linear. The phase shift is not constant across frequencies. This results in a non-linear phase response as the phase shift varies with frequencies.

10.a) $s(t) = A\cos(2\pi(f_0 - \beta t)t)$

$s(t-t_d) = A\cos(2\pi(f_0 - \beta(t-t_d))(t-t_d))$

$s(t-t_d) = A\cos(2\pi f_0 t - 2\pi f_0 t_d - 2\pi\beta(t^2 - 2t_d + t_d^2))$

$\cos A \cdot \cos B = 1/2 [\cos(A-B) + \cos(A+B)]$

There is a starting frequency f_0, being the frequency of the chip and one at the lower frequency βt_d which is determined by chirp rate and delay time.

5 b) It appears the sharp drop occurs around day 100-105. It shows a sharp decrease.

c) It appears from day 200 to 220 there was a significant increase from 19,341.83 to 20,041.26

d) the moving average does not capture rapid shifts in economic policy effectively due to a lag being introduced before reflecting changes and the sharp sudden movements are smoothed out making it difficult to spot.

7 bonus)

```
sq_audio = real(conv_result)/max(abs(conv_result));
sound(sq_audio,7000);
pause(2);
saw = real(conv_saw)/max(abs(conv_saw));
sound(saw,7000);
```