Nailyn Lopez

1) a) $N = (2)(20000) = 40000$ samples

b) $\delta(0)$

$\delta(4000) \leftarrow 0.2$

$\delta(8000) \downarrow$) by 0.2

$\delta(12000) \quad \infty$

c) $h(n) = \delta(n) + 0.5\delta(n-4000) + 0.25\delta(n-8000) \rightarrow \infty$

d) $x(n) = \sin(2\pi f n / fs)$

$N_{sine} = (0.1)(20000) = 2000$ samples

2) a) $y_l[n] + y_h[n] = s[n]$

$y_l[n] + y_h[n] = [s[n] \times l[n]] + (s[n] \times h[n])$

$y_l[n] + y_h[n] = s[n] \times [l[n] + h[n]]$

b) $y_l(n) + y_h(n) = s(n)$ & $y_l[n] = s[n] \times l[n]$, $y_h[n] = s[n] \times h[n]$

$s[n] \times (l(n) + h(n)) = \delta[n]$

$l(n) + l[n] = \delta[n]$

$h[n] = \delta[n] - l[n]$

$h[n] = \delta[n] - l[n]$

c) low cutoff frequency & $h[n]$ higher cutoff frequency

f_c of $l[n]$ lower than $h[n]$

3) a) $$X(k) = \sum_{n=0}^{N-1} x[n] \times e^{-j\frac{2\pi}{N}kn} \qquad k = 0, 1, 2, N-1$$

$$X[k] = \sum_{n=0}^{N-1} (x_1[n]) \times e^{-j\frac{2\pi}{N}kn}$$

$$X[k] = \sum_{n=0}^{N-1} (x_1[n]) \times \left(e^{-j\frac{2\pi}{N}kn}\right)$$

$X[k] = X_1[k]$

b) $$x[n] = \frac{1}{N} \sum_{k=0}^{N-1} X[k] \left(e^{j\frac{2\pi}{N}kn}\right)$$

Not sure.

4) a) The magnitude of the Fourier spectrum widens because when there is a shorter signal it wants to be as close to the frequency as possible so widening will better help to fit it.

The magnitude of the Fourier spectrum plus narrows since with time it sharpens the frequency.

Nailyn Lopez

1.d

```
fs = 20000;
t = 0:1/fs:0.1-1/fs;
f_sine = 1000;  % 1 kHz sine wave
x = sin(2 * pi * f_sine * t);
h = zeros(1, 40000);  % Assuming 2 seconds length for impulse response
h(1) = 1;  % Original impulse
echo_interval = 4000;
decay_factor = 0.5;
Add echoes at 0.2s, 0.4s, etc. with halving amplitude
for i = 1:9  % Create 9 echoes
    h((i) * echo_interval + 1) = decay_factor^i;  % Echoes at 4000, 8000, 12000, ...
end
y = conv(x, h, 'full');
figure;
subplot(2, 1, 1);
plot(t, x);
title('Original Sine Wave');
xlabel('Time (seconds)');
ylabel('Amplitude');
subplot(2, 1, 2);
t_echo = (0:length(y)-1) / fs;  % Time vector for the convolved signal
plot(t_echo, y);
title('Sine Wave with Echoes');
xlabel('Time (seconds)');
ylabel('Amplitude');
```