Digital Signal Processing MATLAB HW - q1

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Clear recent data

```
clear; close all; clc;
```

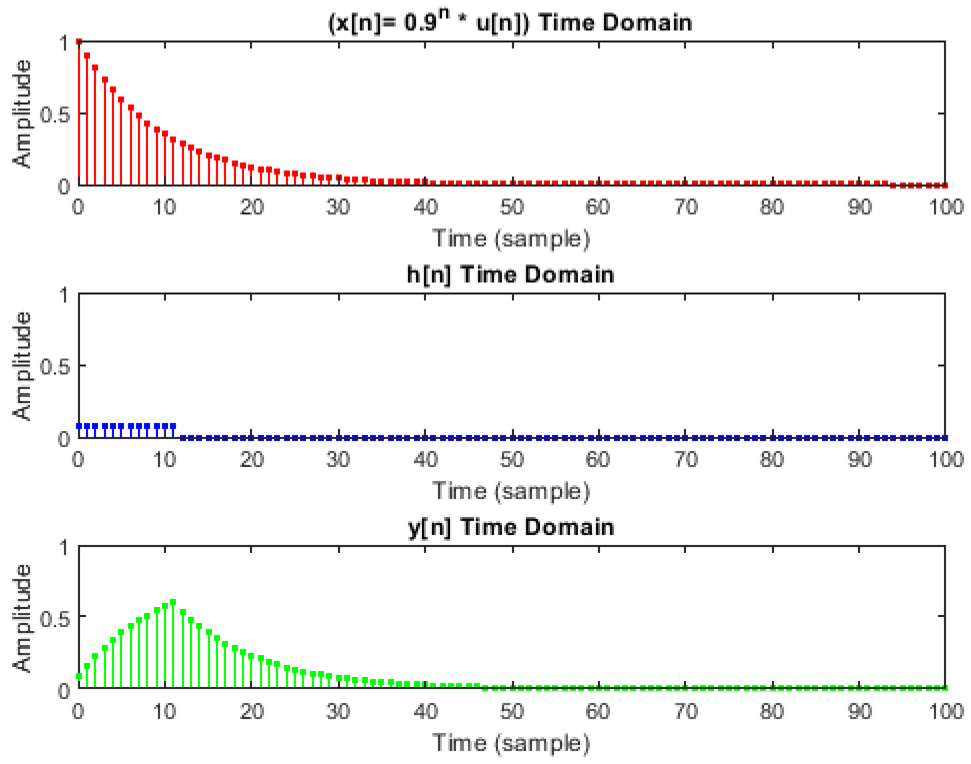
Convolution in time doamain (part c)

```
% define parameters
NoS1 = 100;
n1 = 0 : NoS1;
h = zeros(length(n1), 1);
h(1 : 12) = 1 / 12;
x1 = (0.9 .^ n1);

% calculate convolution
[y1, s1] = convolution(h, n1, x1, n1);

% plot results in time domain
figure();
subplot(3, 1, 1);
stem(n1, x1, 'r.');
axis([0 NoS1 0 1]);
title('(x[n]= 0.9^n * u[n]) Time Domain');
xlabel('Time (sample)');
ylabel('Amplitude');
subplot(3, 1, 2);
stem(n1, h, 'b.');
axis([0 NoS1 0 1]);
title('h[n] Time Domain');
xlabel('Time (sample)');
ylabel('Amplitude');
subplot(3, 1, 3);
stem(s1, y1, 'g.');
```

```
axis([0 NoS1 0 1]);
title('y[n] Time Domain');
xlabel('Time (sample)');
ylabel('Amplitude');
```

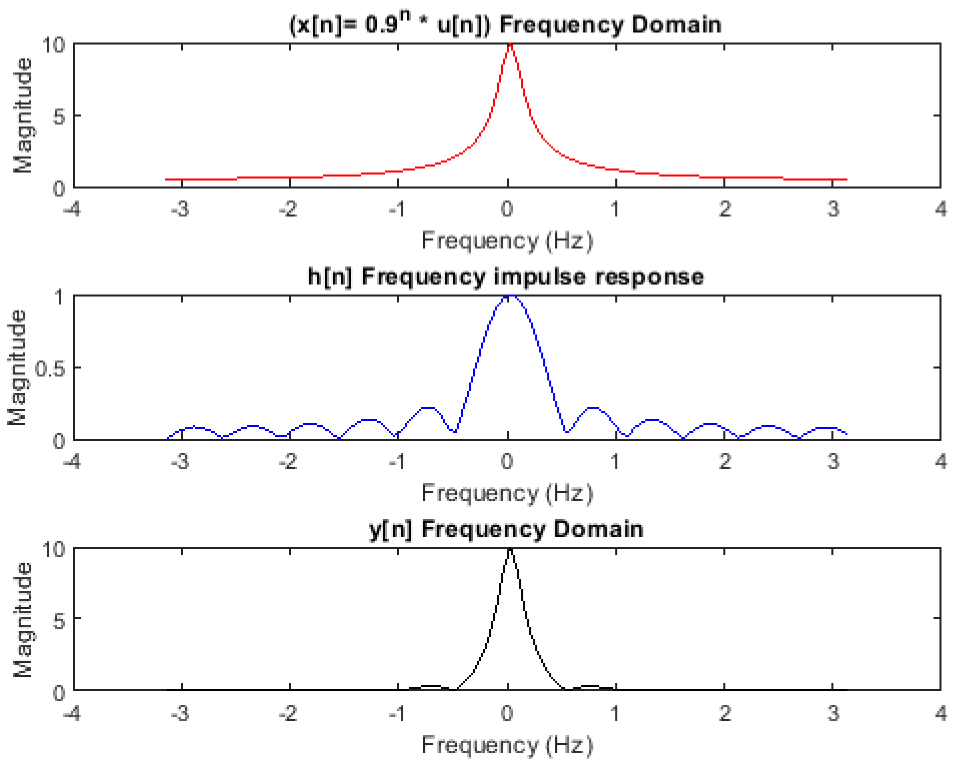


Convolution in frequency doamain (part c)

```
% calculate DTFT of signals
[f_x1, fft_x1] = DTFT(x1, NoS1);
[f_h, fft_h] = DTFT(h, NoS1);
[f_y1, fft_y1] = DTFT(y1, NoS1);

% show results in frequency domain
figure();
subplot(3, 1, 1);
plot(f_x1, fft_x1, 'r');
title('(x[n]= 0.9^n * u[n]) Frequency Domain');
xlabel('Frequency (Hz)');
ylabel('Magnitude');
subplot(3, 1, 2);
plot(f_h, fft_h, 'b');
title('h[n] Frequency impulse response');
xlabel('Frequency (Hz)');
ylabel('Magnitude');
subplot(3, 1, 3);
plot(f_y1, fft_y1, 'k');
```

```
title('y[n] Frequency Domain');
xlabel('Frequency (Hz)');
ylabel('Magnitude');
```



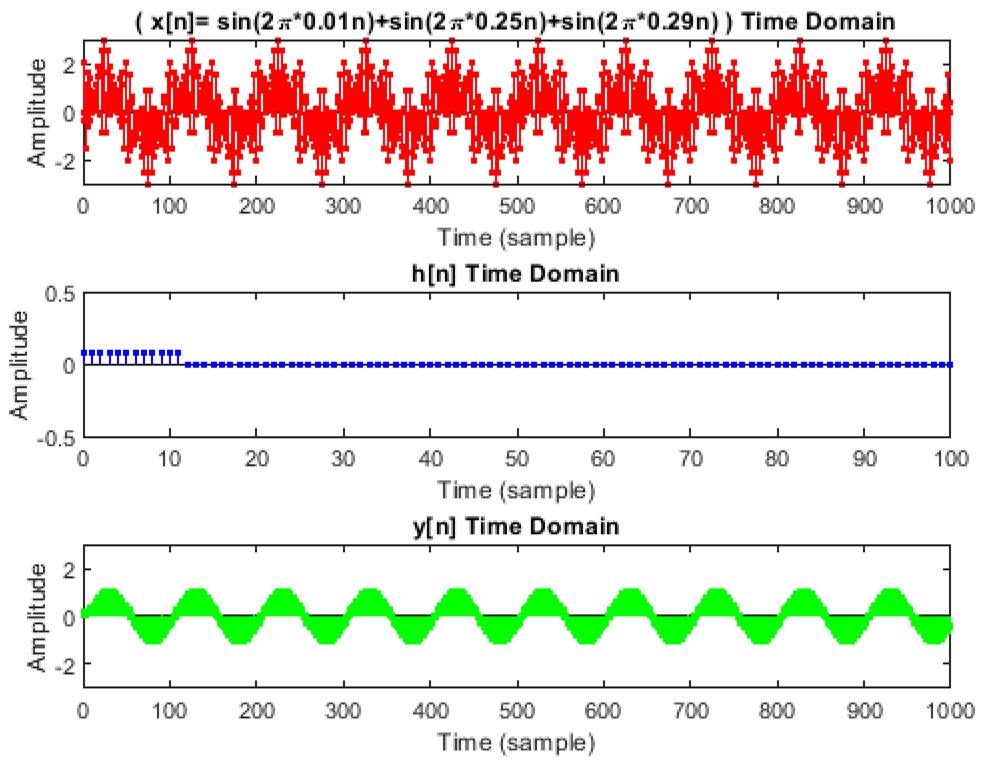
Convolution in time doamain (part d)

```
% define parameters
NoS2 = 1000;
n2 = 0 : 1000;
x2 = sin(2 * pi * 0.01 * n2) + sin(2 * pi * 0.25 * n2) + sin(2 * pi *
 0.29 * n2);

% calculate convolution
[y2, s2] = convolution(h, n1, x2, n2);

% show results in time domain
figure();
subplot(3, 1, 1);
stem(n2, x2, 'r.');
axis([0 NoS2 -3 3]);
title('( x[n]= sin(2\pi*0.01n)+sin(2\pi*0.25n)+sin(2\pi*0.29n) ) Time
 Domain');
xlabel('Time (sample)');
ylabel('Amplitude');
subplot(3, 1, 2);
stem(n1, h, 'b.');
```

```
axis([0 NoS1 -0.5 0.5]);
title('h[n] Time Domain');
xlabel('Time (sample)');
ylabel('Amplitude');
subplot(3, 1, 3);
stem(s2, y2, 'g.');
axis([0 NoS2 -3 3]);
title('y[n] Time Domain');
xlabel('Time (sample)');
ylabel('Amplitude');
```

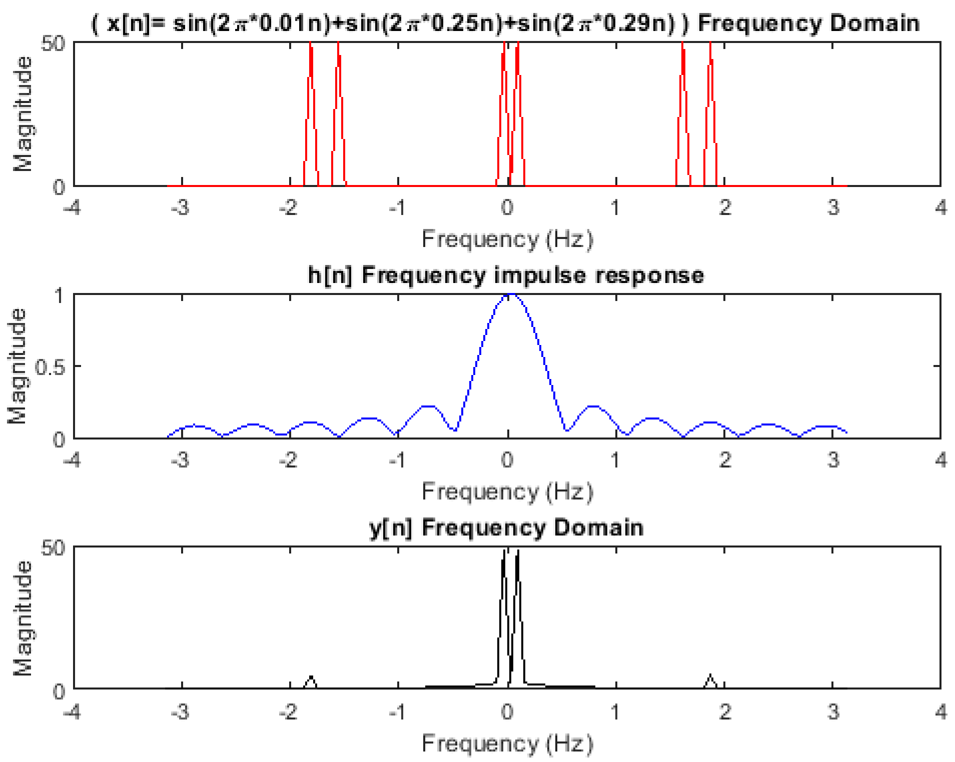


Convolution in frequency doamain (part d)

```
% calculate DTFT of signals
[f_x2, fft_x2] = DTFT(x2, NoS1);
[f_y2, fft_y2] = DTFT(y2, NoS1);

% show results in frequency domain
figure();
subplot(3, 1, 1);
plot(f_x2, fft_x2, 'r');
title('( x[n]= sin(2\pi*0.01n)+sin(2\pi*0.25n)+sin(2\pi*0.29n) )
 Frequency Domain');
xlabel('Frequency (Hz)');
ylabel('Magnitude');
subplot(3, 1, 2);
```

```
plot(f_h, fft_h, 'b');
title('h[n] Frequency impulse response');
xlabel('Frequency (Hz)');
ylabel('Magnitude');
subplot(3, 1, 3);
plot(f_y2, fft_y2, 'k');
title('y[n] Frequency Domain');
xlabel('Frequency (Hz)');
ylabel('Magnitude');
```



Part e

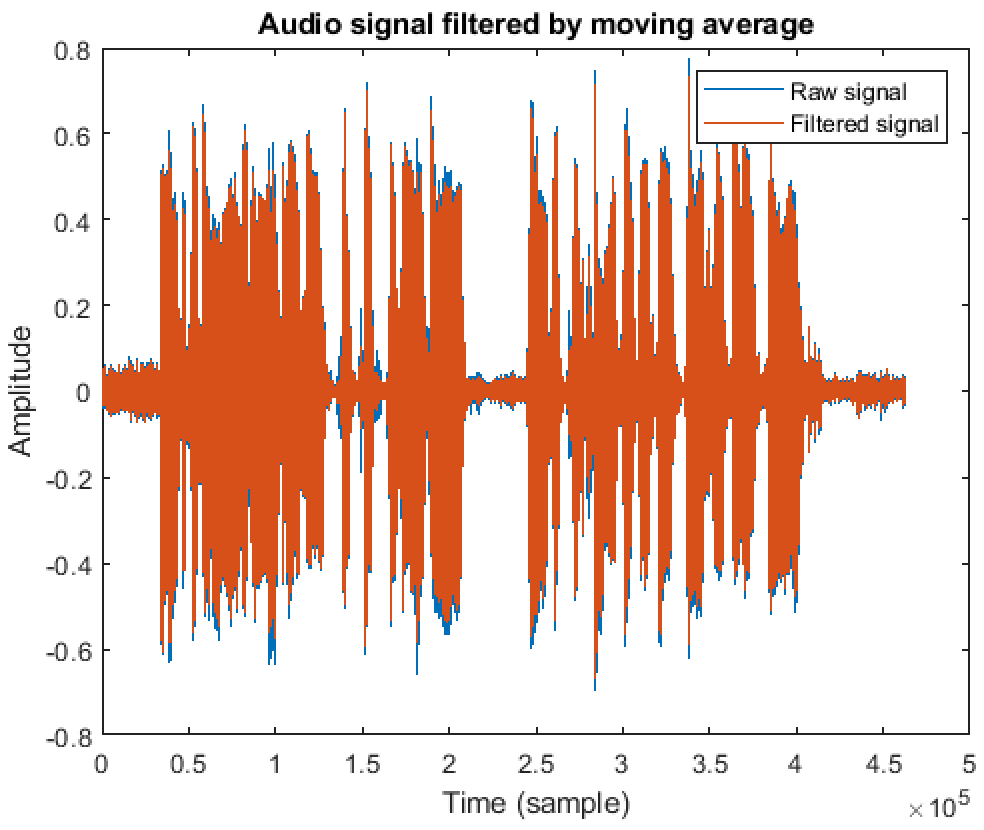
```
% read audio file
[sig, Fs] = audioread('voice.wav');
% sound(sig, Fs);

% calculate convolution
oSig = convolution(h, n1, sig, 0:length(sig));

% audio results
figure();
plot(sig);
hold on;
plot(oSig);
title('Audio signal filtered by moving average');
xlabel('Time (sample)');
```

```
ylabel('Amplitude');
legend('Raw signal', 'Filtered signal')

% generate output sound and write audio
audiowrite('voice_q1_output.wav', oSig, Fs);
% sound(oSig, Fs);
```



M point DTFT (part a)

```
function [f, fft_sig] = DTFT(signal, M)
    if (length(signal) < M)
        error('M point is not larger than signal length!!');
    end
    fft_sig = abs(fftshift(fft(signal, M)));
    f = linspace(-pi, pi, M);
end
```

Convolution with time index (part b)

```
function [y, s] = convolution(u, n, v, m)
    y = conv(u, v);
    s = (m(1) + n(1)) : (m(end) + n(end));
end
```