Lab-5

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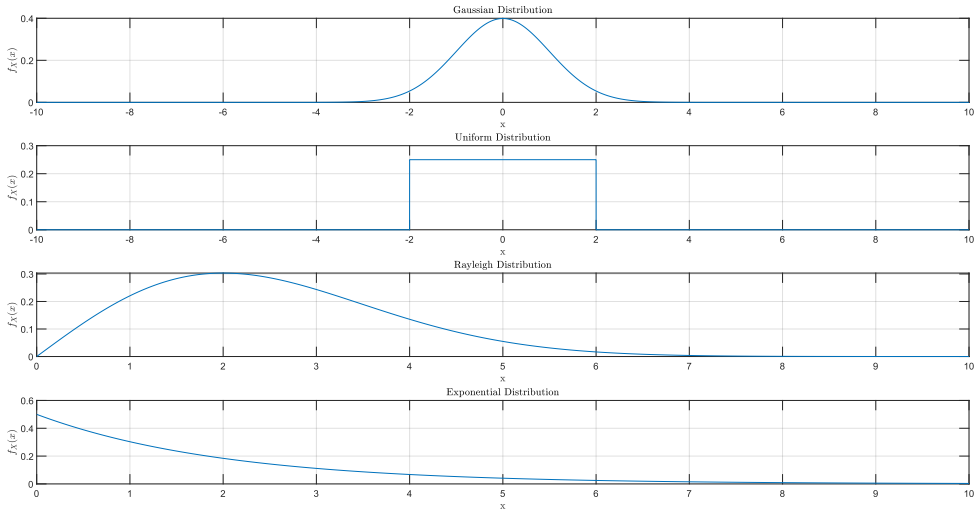
Task1

Code

```
x = -10:0.001:10;
gauss = @(x) pdf('norm', x, 0, 1);
figure;
subplot(4, 1, 1);
plot(x, gauss(x));
title('Gaussian Distribution', 'Interpreter', 'latex');
xlabel('x', 'Interpreter', 'latex');
ylabel('$f_{X}(x)$', 'Interpreter', 'latex');
fprintf(" ---- \nTotal Probability : %f \n", integral(gauss, -inf, inf));
grid on;

uni = @(x) pdf('unif', x, -2, 2);
subplot(4, 1, 2);
plot(x, uni(x));
title('Uniform Distribution', 'Interpreter', 'latex');
xlabel('x', 'Interpreter', 'latex');
ylabel('$f_{X}(x)$', 'Interpreter', 'latex');
fprintf("Total Probability : %f \n", integral(uni, -inf, inf))
grid on;

rayl = @(x) pdf('rayl', x, 2);
subplot(4, 1, 3);
plot(x(x>0), rayl(x(x>0)));
title('Rayleigh Distribution', 'Interpreter', 'latex');
xlabel('x', 'Interpreter', 'latex');
ylabel('$f_{X}(x)$', 'Interpreter', 'latex');
fprintf("Total Probability : %f \n", integral(rayl, -inf, inf))
grid on;


expo = @(x) pdf('exp', x, 2);
subplot(4, 1, 4);
plot(x(x>0), expo(x(x>0)));
title('Exponential Distribution', 'Interpreter', 'latex');
xlabel('x', 'Interpreter', 'latex');
ylabel('$f_{X}(x)$', 'Interpreter', 'latex');
fprintf("Total Probability : %f \n ------ \n", integral(expo, -inf, inf))
grid on;
```

Results



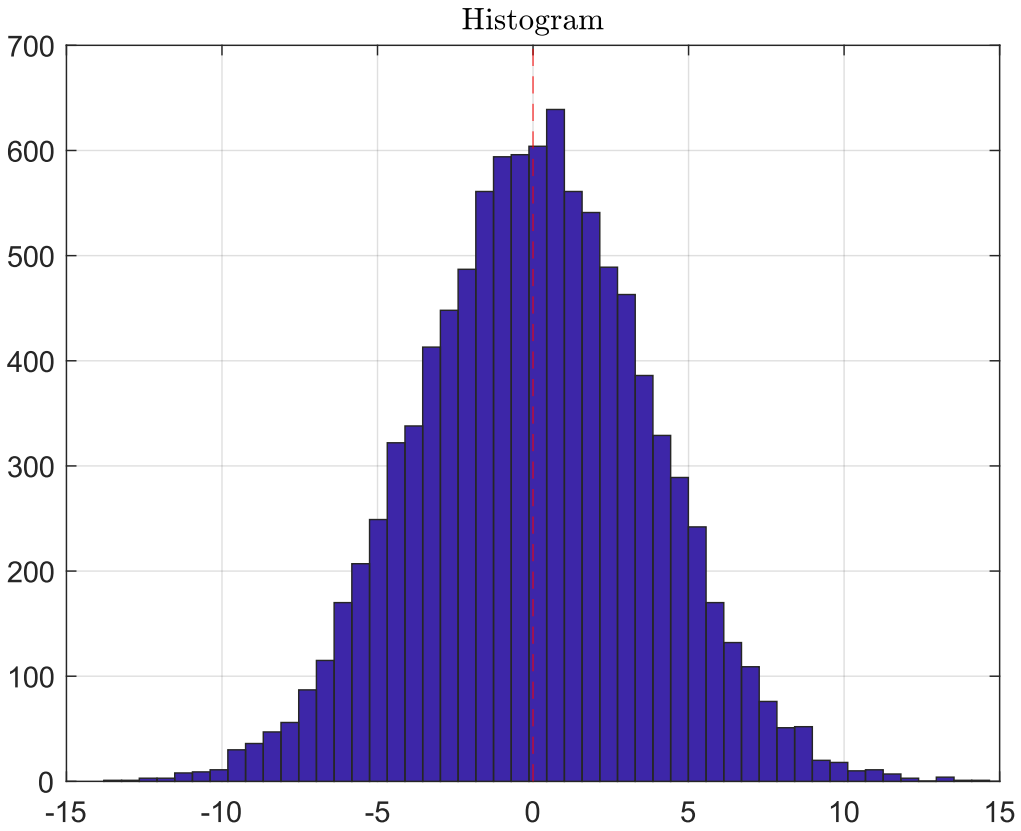
Task-2

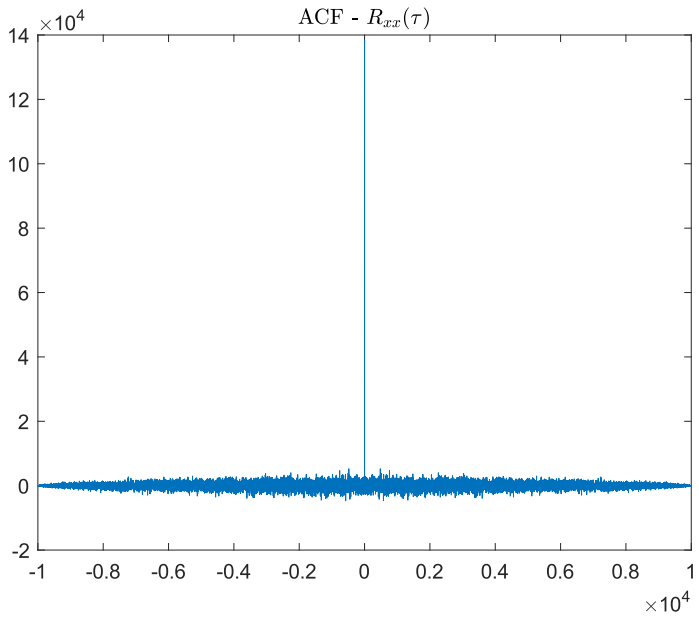
Code

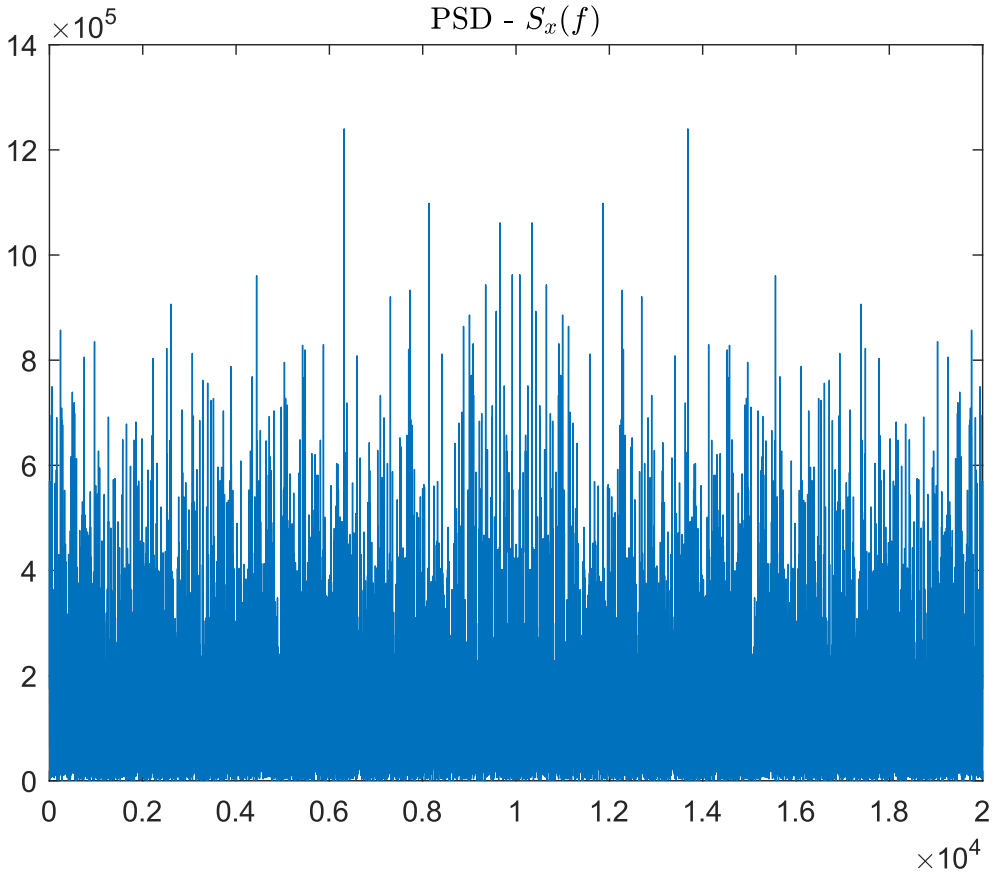
```
mu = 0;
sigma = sqrt(14);

N = 1e4;
n_t = [];
p = 0;
for k=1:N
    no = sigma*(randn()) + mu;
    if no > sigma
        p = p+1;
    end

    n_t = [n_t no];
end
% Simulated
p_calc = p/N;

% Thoretical
p_th = qfunc(1);
disp(sprintf("Calculated Probability : %f and Thoretical Probability : %f", p_calc, p_th));
% ---------

figure;
hist(n_t, 50);
title('Histogram', 'Interpreter', 'latex');
```

```
hold on;
xline([mu], 'r--');
hold off;
grid on;

[n_acf, lags] = xcorr(n_t);
n_acf = n_acf;
figure;
plot(lags, n_acf);
title('ACF - $R_{xx}(\tau)$', 'Interpreter', 'latex');

nt_PSD = fftshift(abs(fft(n_acf)));
figure;
plot(nt_PSD);
title('PSD - $S_x(f)$', 'Interpreter', 'latex');
```

Results




ACF - $R_{xx}(\tau)$
$\times 10^4$
14
12
10
8
6
4
2
0
-2
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1
$\times 10^4$

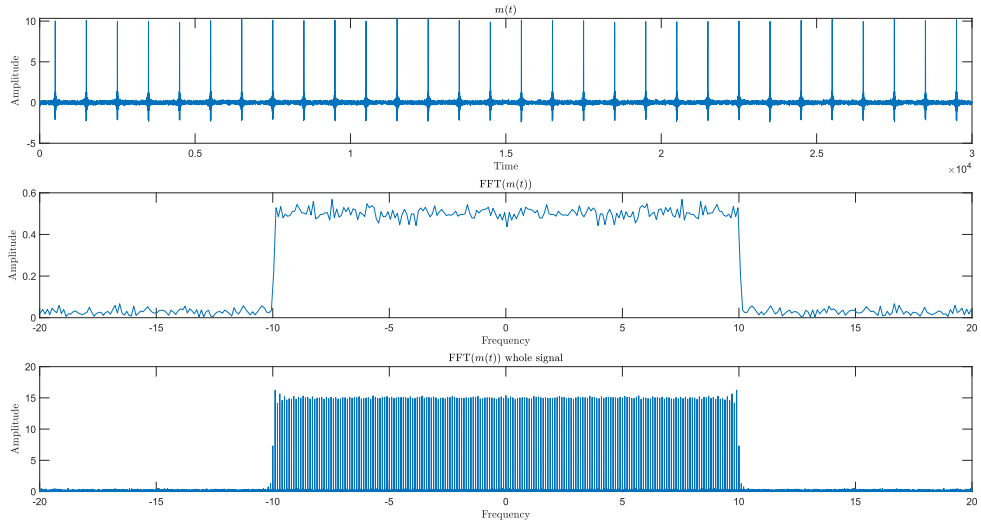

PSD - $S_x(f)$
$\times 10^5$
14
12
10
8
6
4
2
0
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
$\times 10^4$

Task-3

Code

```
sigma = 0.1; % sqrt(variance) of noise(AWGN)
fs = 100;
N = 30*fs;
N1 = 10;
m_t = @(t) 2*N1*sinc(2*N1*t);
a = 0.5;


% ---- Transmitting -----
sig_tx = [];
figure;
T_int = 10;
t = -T_int/2:1/fs:T_int/2-1/fs;
for k=1:30
    n_t = randn(1, fs*T_int)*sigma;
    x = m_t(t);
    y = a*x + n_t;
    sig_tx = [sig_tx y];
    f = linspace(-fs/2, fs/2, fs*T_int);
    y_f = fftshift(abs(fft(y)))/fs;
    sig_fft = fftshift(abs(fft(sig_tx)))/fs;
    sig_freq = linspace(-fs/2, fs/2, k*fs*T_int);

    subplot(3, 1, 2);
    plot(f, y_f);
    xlim([-2*N1 2*N1]);
    title('FFT($m(t)$)', 'Interpreter', 'latex');
    xlabel('Frequency', 'Interpreter', 'latex');
    ylabel('Amplitude', 'Interpreter', 'latex');
    subplot(3, 1, 3);
    plot(sig_freq, sig_fft);
    title('FFT($m(t)$) whole signal', 'Interpreter', 'latex');
    xlabel('Frequency', 'Interpreter', 'latex');
    ylabel('Amplitude', 'Interpreter', 'latex');
    xlim([-2*N1 2*N1])
    subplot(3, 1, 1);
    plot(sig_tx);
    title('$m(t)$', 'Interpreter', 'latex');
    xlabel('Time', 'Interpreter', 'latex');
    ylabel('Amplitude', 'Interpreter', 'latex');
    xlim([0 T_int*N]);
    pause(1);
end
```

Results



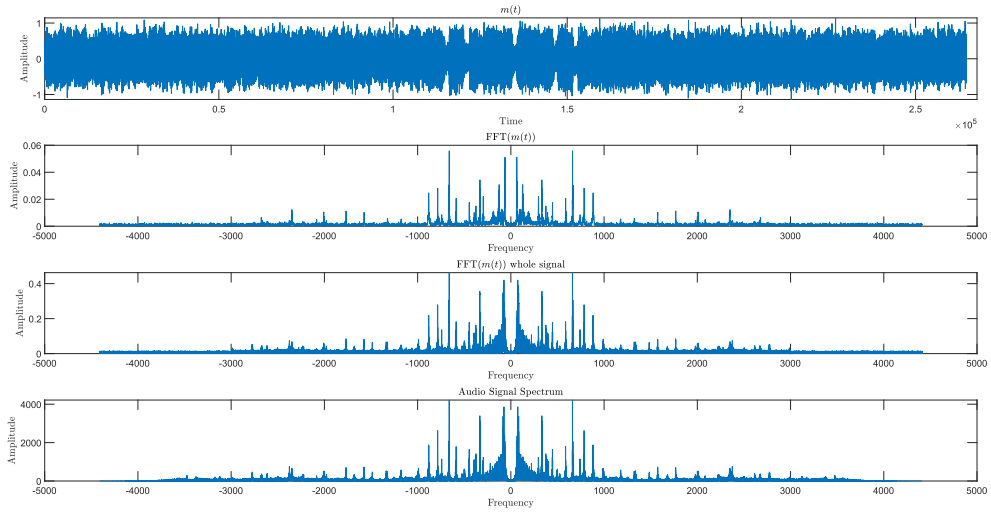
Task-4

Code

```
% ----- Task-4 ------

[audio, afs] = audioread('sample_a.wav');
audio = audio(:, 1)';
audio = decimate(audio, 5);
afs = afs/5;
N = length(audio);
freq = linspace(-afs/2, afs/2, N);
t_ch = 1;
t = -t_ch:1/afs:t_ch-1/afs;

% ------------
B = 1.5e3; % Bandwidth of Channel
sigma = 0.1; % sqrt(variance) of noise(AWGN)
% ------------

h = 2*B*sinc(2*B*t); % Channel Response

Y_f = fftshift(abs(fft(audio)));

figure(1);
subplot(4, 1, 4);
plot(freq, Y_f);
title('Audio Signal Spectrum', 'Interpreter', 'latex');
xlabel('Frequency', 'Interpreter', 'latex');
ylabel('Amplitude', 'Interpreter', 'latex');

% Y_t = conv(audio, h, 'same');
```

```
% Y_f = fftshift(abs(fft(Y_t)))';
% figure;
% plot(freq, Y_f);

% ---- Transmitting -----
sig_tx = [];

for k=1:30
    if k*afs <= N
        x = audio((k-1)*afs+1:k*afs);
    else
        x = audio((k-1)*afs+1:end);
    end
    n_t = randn(1, afs)*sigma;
    y = conv(x, h, 'same')/afs + n_t;
    sig_tx = [sig_tx y];
    f = linspace(-afs/2, afs/2, afs);
    y_f = fftshift(abs(fft(y)))/afs;
    sig_fft = fftshift(abs(fft(sig_tx)))/afs;
    sig_freq = linspace(-afs/2, afs/2, k*afs);

    subplot(4, 1, 2);
    plot(f, y_f);
    title('FFT($m(t)$)', 'Interpreter', 'latex');
    xlabel('Frequency', 'Interpreter', 'latex');
    ylabel('Amplitude', 'Interpreter', 'latex');

    subplot(4, 1, 3);
    plot(sig_freq, sig_fft);
    title('FFT($m(t)$) whole signal', 'Interpreter', 'latex');
    xlabel('Frequency', 'Interpreter', 'latex');
    ylabel('Amplitude', 'Interpreter', 'latex');
    subplot(4, 1, 1);
    plot(sig_tx);
    title('$m(t)$', 'Interpreter', 'latex');
    xlabel('Time', 'Interpreter', 'latex');
    ylabel('Amplitude', 'Interpreter', 'latex');
    xlim([0 N]);
    pause(1);
end
```

Results



> **Change the value of `B` to see the effect of bandwidth in spectrum**