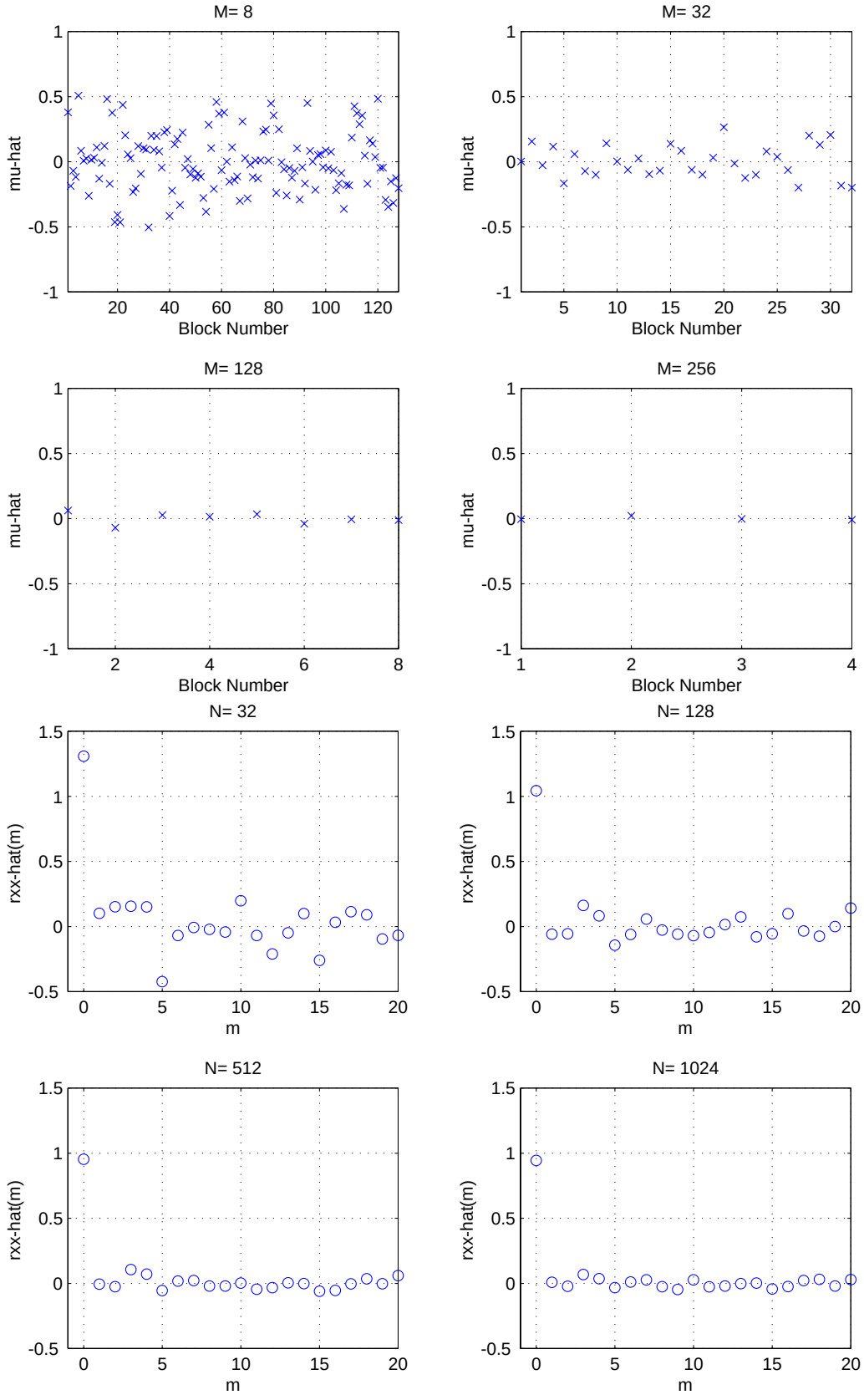
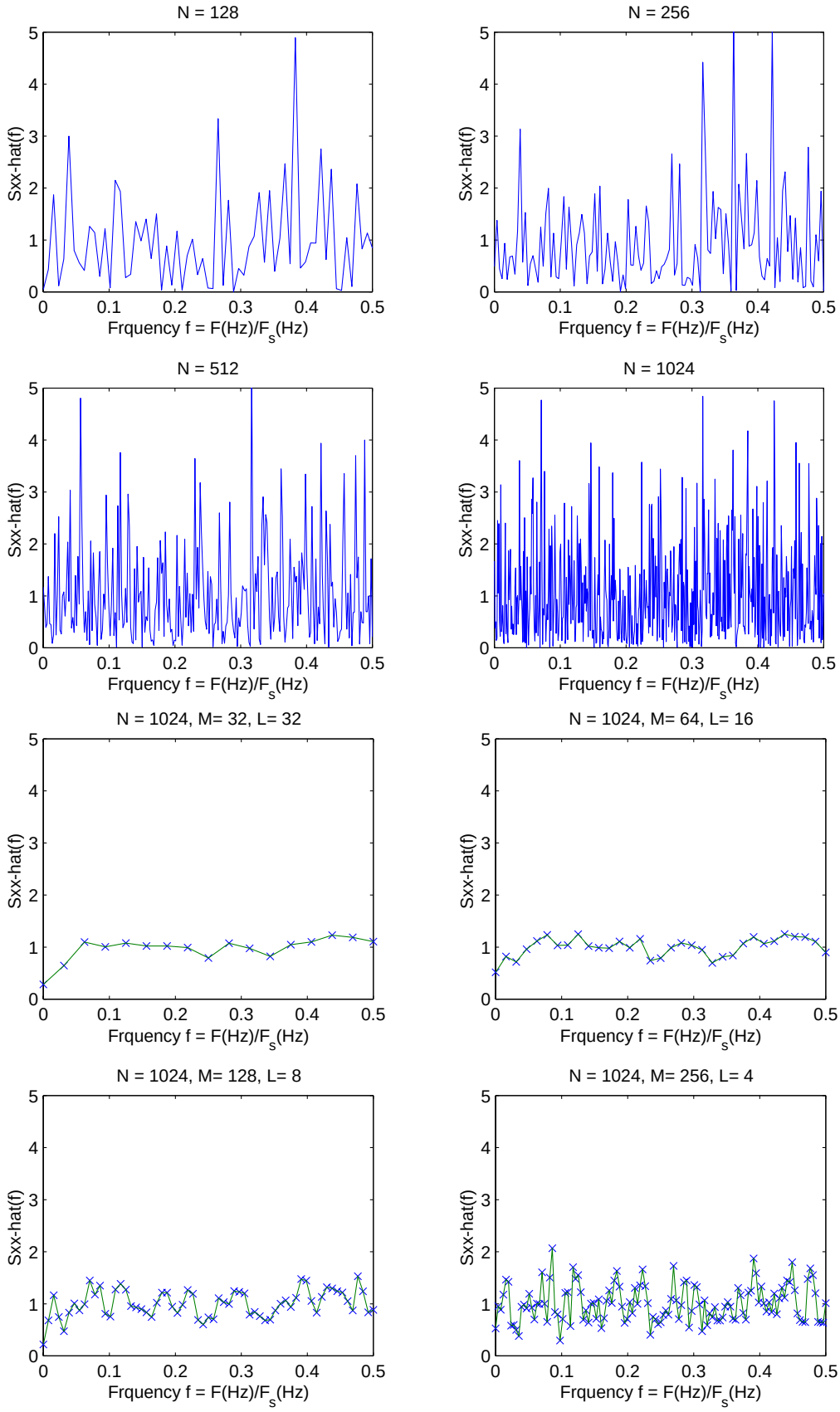
```
% 1-  Estimation of Signal Mean
% ---------------------------------
clear, close all
N=1024;                                 % size of all available data (2^10)
sigma_sq=0.64;
x=sigma_sq*randn(size([1:N]));          % x is WGN of zeo-mean and unit variance
Table=[];                               % Some results are saved in Table
loop=0;
for M=[8 32 128 256];                   % Number of data points per block
        loop=loop+1;
        L=N/M;                                  % Number of data blocks
        for k=1:L,
          mu(k)=sum(x( 1+(k-1)*M : k*M) )/M;    % mu of each block
        end
        Table=[Table; std(mu) sqrt(sigma_sq/M)] % estimate of stdev & true stdev
        subplot(2,2,loop), plot([1:L],mu,'x'),grid      % plot the results
        axis([1 L -1 1]);
        xlabel('Block Number'), ylabel('mu-hat'),
        title(sprintf('M= %d',M))
        mu=[];
end
subplot

Table =                         % list of estimated and true variances
   0.2300    0.2828
   0.1249    0.1414
   0.0423    0.0707
   0.0132    0.0500

% 2) Estimation of the Autocorrelation Function
% ---------------------------------------------------
clear, close all
N=1024;
x=randn(size([1:N]'));                  % X is WGN with zero-mean aand unit varianvce
%
M=21;                                   % Will estimate rxx(m), 0 <= m <= M-1= 20
                                        % (maximum correlation lag)
loop=0;
for N=[32  128  512  1024];             % number of data samples available
        loop=loop+1;
        for m=0:M-1,
                rxx(m+1)=x(m+1:N)'*x(1:N-m);    % Matlab indices start from 1
        end
```

```
        rxx=rxx/N;                  % the biased estimator

        subplot(2,2,loop), plot([0:M-1],rxx,'o'),grid
        axis([-1 M-1 -0.5 1.5]);
        xlabel('m'), ylabel('rxx-hat(m)'),
        title(sprintf('N= %d', N))
end
% ------------------------------------------------------------------------------------------------------
% Estimation of the Power Spectrum : The Periodogram
% ----------------------------------------------------------
clear, close all
N=1024;
x=randn(size([1:N]'));                          % WGN
loop=0;
for N=[128  256  512 1024];
        loop=loop+1;
        X=fft(x(1:N),N);
        Sxx=X.*conj(X)/N;                       % periodogram estimate
        k=[0:N/2]';                             % Only 0 <= F(Hz)/F_s(Hz) <= 0.5
        fk=k/N;                                 % is plotted; k/N = F(Hz)/F_s(Hz)
        subplot(2,2,loop), plot(fk,Sxx(k+1),'-')    % Matlab indices start from 1
        axis([0 0.5 0 5]);
        xlabel('Frquency f = F(Hz)/F_s(Hz)'),ylabel('Sxx-hat(f)'),
        title(sprintf('N = %d', N))
end
% ------------------------------------------------------------------------------------------------------
% Estimation of the Power Spectrum : The Welch Estimator
% ----------------------------------------------------------------
clear, clf
N=1024;
x=randn(size([1:N]'));                          %  WGN
%
loop=0;
for M=[32 64 128 256];
        loop=loop+1;
        [Sxx,f]=spectrum(x,M,M/2,hanning(M));    % Welch estimate; In Matlab,f=1
                                                % corresponds to F(hz)/Fs(Hz) = 1
                                                % type 'help spectrum '
        subplot(2,2,loop), plot(f/2,Sxx(:,1),'x',f/2,Sxx(:,1),'-')
        axis([0 0.5 0 5]);
        xlabel('Frquency f = F(Hz)/F_s(Hz)'),ylabel('Sxx-hat(f)'),
        title(sprintf('N = %d, M= %d, L= %d',N, M, N/M))
        Sxx=[];
end
% ------------------------------------------------------------------------------------------------------
```


M= 8
mu-hat
Block Number
M= 32
mu-hat
Block Number
M= 128
mu-hat
Block Number
M= 256
mu-hat
Block Number
N= 32
rxx-hat(m)
m
N= 128
rxx-hat(m)
m
N= 512
rxx-hat(m)
m
N= 1024
rxx-hat(m)
m


N = 128
N = 256
N = 512
N = 1024
N = 1024, M= 32, L= 32
N = 1024, M= 64, L= 16
N = 1024, M= 128, L= 8
N = 1024, M= 256, L= 4
Sxx-hat(f)
Frquency f = F(Hz)/F_s(Hz)
0
1
2
3
4
5
0.1
0.2
0.3
0.4
0.5