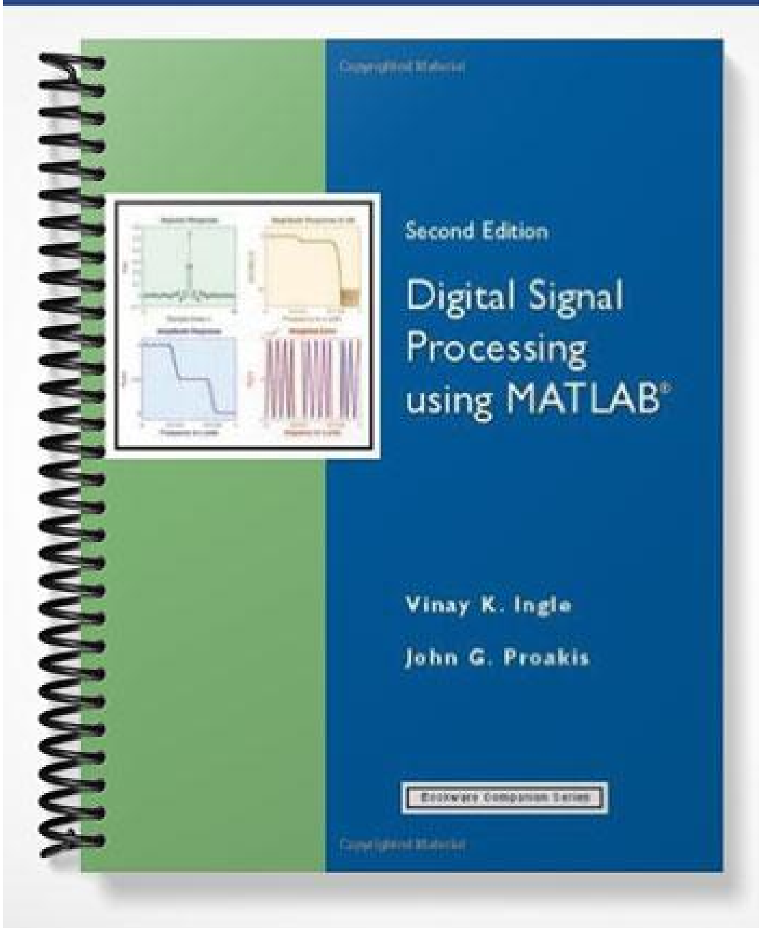
SOLUTIONS MANUAL



Solutions Manual

for

Digital Signal Processing using MATLAB - Second Edition

Chapter 2

Discrete-Time Signals and Systems

P2.1 Generate the following sequences using the basic MATLAB signal functions and the basic MATLAB signal operations discussed in this chapter. Plot signal samples using the `stem` function.

1. $x_1(n) = 3\delta(n+2) + 2\delta(n) - \delta(n-3) + 5\delta(n-7)$, $-5 \le n \le 15$

```
% P0201a: x1(n) = 3*delta(n + 2) + 2*delta(n) - delta(n - 3) +
%                 5*delta(n - 7), -5 <= n <= 15.
clc; close all;

x1 = 3*impseq(-2,-5,15) + 2*impseq(0,-5,15) - impseq(3,-5,15) ...
     + 5*impseq(7,-5,15);
Hf_1 = figure; set(Hf_1,'NumberTitle','off','Name','P0201a'); n1 = [-5:15];
Hs = stem(n1,x1,'filled'); set(Hs,'markersize',2);
axis([min(n1)-1,max(n1)+1,min(x1)-1,max(x1)+1]);
xlabel('n','FontSize',LFS); ylabel('x_1(n)','FontSize',LFS);
title('Sequence x_1(n)','FontSize',TFS);
set(gca,'XTickMode','manual','XTick',n1,'FontSize',8);
print -deps2 ../EPSFILES/P0201a;
```

The plots of $x_1(n)$ is shown in Figure 2.1.

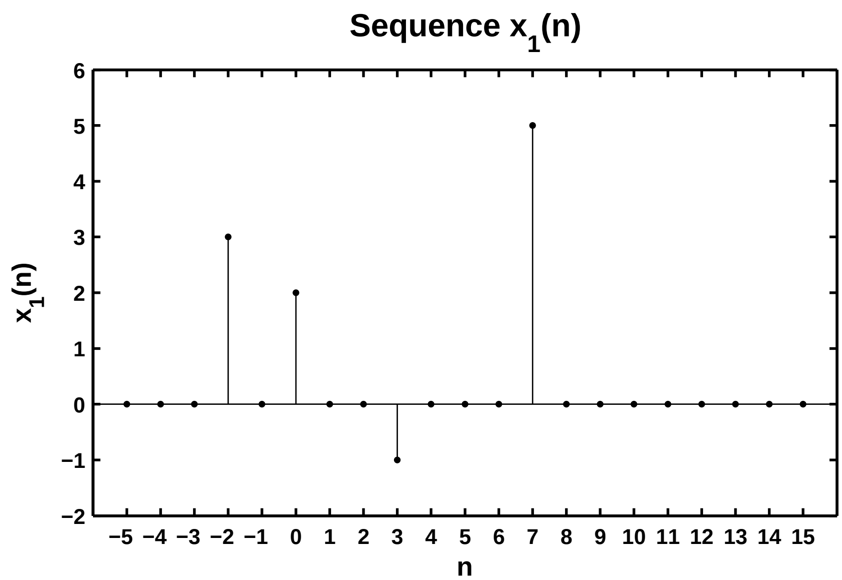


Figure 2.1: Problem P2.1.1 sequence plot

2. $x_2(n) = \sum_{k=-5}^{5} e^{-|k|}\delta(n-2k), -10 \le n \le 10.$

```
% P0201b: x2(n) = sum_{k = -5}^{5} e^{-|k|}*delta(n - 2k), -10 <= n <= 10
clc; close all;

n2 = [-10:10]; x2 = zeros(1,length(n2));
for k = -5:5
    x2 = x2 + exp(-abs(k))*impseq(2*k ,-10,10);
end
Hf_1 = figure; set(Hf_1,'NumberTitle','off','Name','P0201b');
Hs = stem(n2,x2,'filled'); set(Hs,'markersize',2);
axis([min(n2)-1,max(n2)+1,min(x2)-1,max(x2)+1]);
xlabel('n','FontSize',LFS); ylabel('x_2(n)','FontSize',LFS);
title('Sequence x_2(n)','FontSize',TFS);
set(gca,'XTickMode','manual','XTick',n2);
print -deps2 ../EPSFILES/P0201b;
```

The plots of $x_2(n)$ is shown in Figure 2.2.

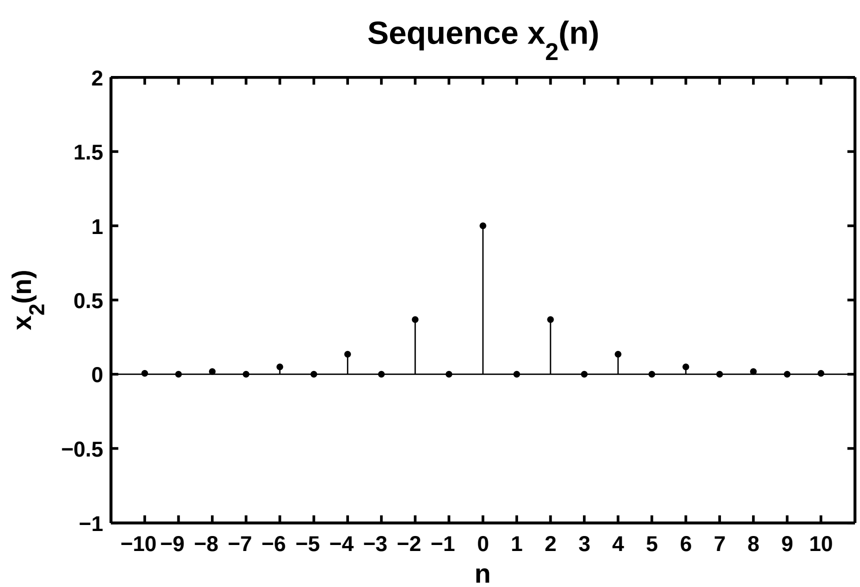


Figure 2.2: Problem P2.1.2 sequence plot

3. $x_3(n) = 10u(n) - 5u(n-5) - 10u(n-10) + 5u(n-15)$.

```
% P0201c: x3(n) = 10u(n) - 5u(n - 5) + 10u(n - 10) + 5u(n - 15).
clc; close all;

x3 = 10*stepseq(0,0,20) - 5*stepseq(5,0,20) - 10*stepseq(10,0,20) ...
     + 5*stepseq(15,0,20);
n3 = [0:20];
Hf_1 = figure; set(Hf_1,'NumberTitle','off','Name','P0201c');
Hs = stem(n3,x3,'filled'); set(Hs,'markersize',2);
axis([min(n3)-1,max(n3)+1,min(x3)-1,max(x3)+2]);
ytick = [-6:2:12];
xlabel('n','FontSize',LFS); ylabel('x_3(n)','FontSize',LFS);
title('Sequence x_3(n)','FontSize',TFS);
set(gca,'XTickMode','manual','XTick',n3);
set(gca,'YTickMode','manual','YTick',ytick);
print -deps2 ../EPSFILES/P0201c;
```

The plots of $x_3(n)$ is shown in Figure 2.3.

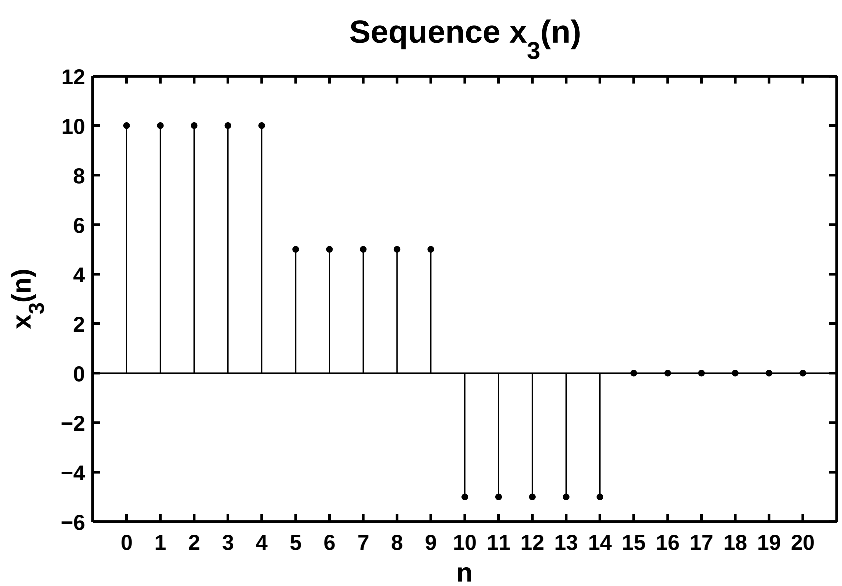


Figure 2.3: Problem P2.1.3 sequence plot

4. $x_4(n) = e^{0.1n}[u(n+20) - u(n-10)]$.

```
% P0201d: x4(n) = e ^ {0.1n} [u(n + 20) - u(n - 10)].
clc; close all;

n4 = [-25:15];
x4 = exp(0.1*n4).*(stepseq(-20,-25,15) - stepseq(10,-25,15));

Hf_1 = figure; set(Hf_1,'NumberTitle','off','Name','P0201d');
Hs = stem(n4,x4,'filled'); set(Hs,'markersize',2);
axis([min(n4)-2,max(n4)+2,min(x4)-1,max(x4)+1]);
xlabel('n','FontSize',LFS); ylabel('x_4(n)','FontSize',LFS);
title('Sequence x_4(n)','FontSize',TFS); ntick = [n4(1):5:n4(end)];
set(gca,'XTickMode','manual','XTick',ntick);
print -deps2 ../CHAP2_EPSFILES/P0201d; print -deps2 ../../Latex/P0201d;
```

The plots of $x_4(n)$ is shown in Figure 2.4.

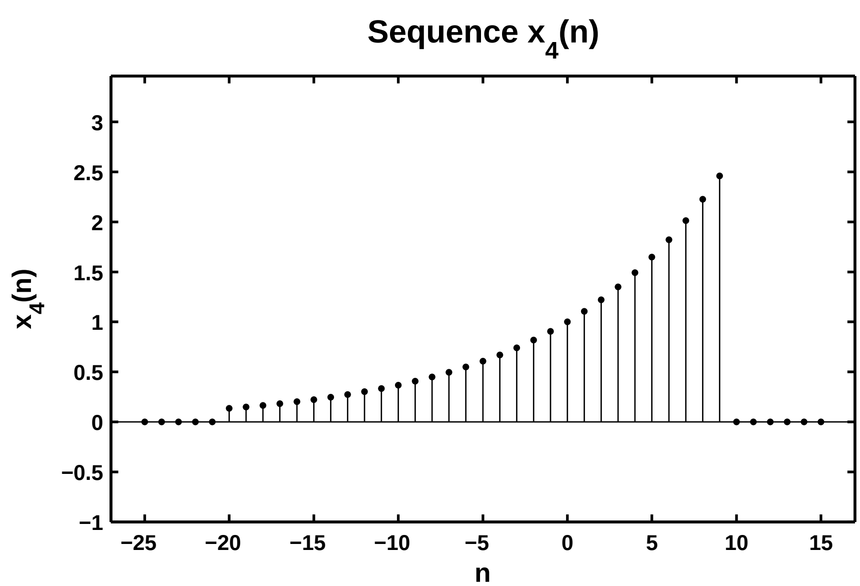


Figure 2.4: Problem P2.1.4 sequence plot

5. $x_5(n) = 5[\cos(0.49\pi n) + \cos(0.51\pi n)]$, $-200 \le n \le 200$. Comment on the waveform shape.

```
% P0201e: x5(n) = 5[cos(0.49*pi*n) + cos(0.51*pi*n)], -200 <= n <= 200.
clc; close all;

n5 = [-200:200]; x5  = 5*(cos(0.49*pi*n5) + cos(0.51*pi*n5));

Hf_1 = figure; set(Hf_1,'NumberTitle','off','Name','P0201e');
Hs = stem(n5,x5,'filled'); set(Hs,'markersize',2);
axis([min(n5)-10,max(n5)+10,min(x5)-2,max(x5)+2]);
xlabel('n','FontSize',LFS); ylabel('x_5(n)','FOntSize',LFS);
title('Sequence x_5(n)','FontSize',TFS);
ntick = [n5(1): 40:n5(end)]; ytick = [-12 -10:5:10 12];
set(gca,'XTickMode','manual','XTick',ntick);
set(gca,'YTickMode','manual','YTick',ytick);
print -deps2 ../CHAP2_EPSFILES/P0201e; print -deps2 ../../Latex/P0201e;
```

The plots of $x_5(n)$ is shown in Figure 2.5.

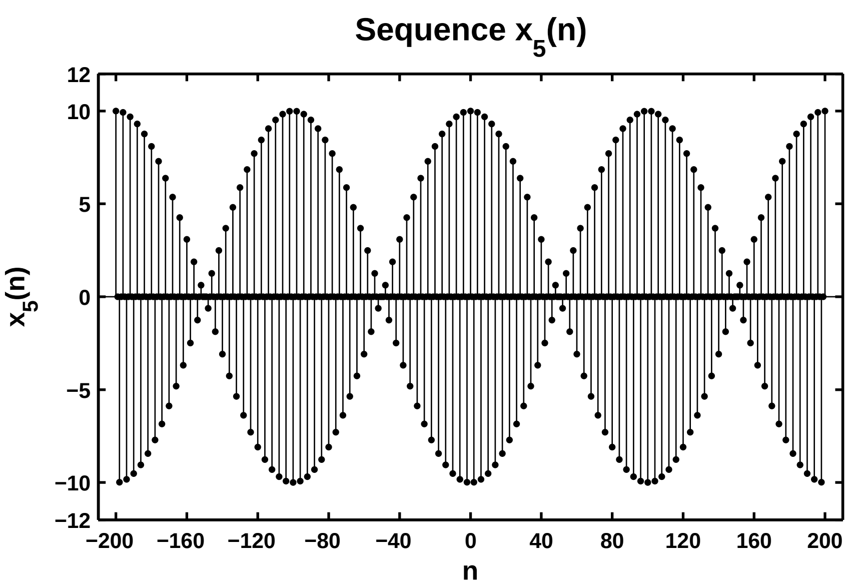


Figure 2.5: Problem P2.1.5 sequence plot

6. $x_6(n) = 2\sin(0.01\pi n)\cos(0.5\pi n),\ -200 \le n \le 200.$

```
%P0201f: x6(n) = 2 sin(0.01*pi*n) cos(0.5*pi*n), -200 <= n <= 200.
clc; close all;

n6 = [-200:200]; x6 = 2*sin(0.01*pi*n6).*cos(0.5*pi*n6);

Hf_1 = figure; set(Hf_1,'NumberTitle','off','Name','P0201f');
Hs = stem(n6,x6,'filled'); set(Hs,'markersize',2);
axis([min(n6)-10,max(n6)+10,min(x6)-1,max(x6)+1]);
xlabel('n','FontSize',LFS); ylabel('x_6(n)','FontSize',LFS);
title('Sequence x_6(n)','FontSize',TFS);
ntick = [n6(1): 40:n6(end)];
set(gca,'XTickMode','manual','XTick',ntick);
print -deps2 ../CHAP2_EPSFILES/P0201f; print -deps2 ../../Latex/P0201f;
```

The plots of $x_6(n)$ is shown in Figure 2.6.

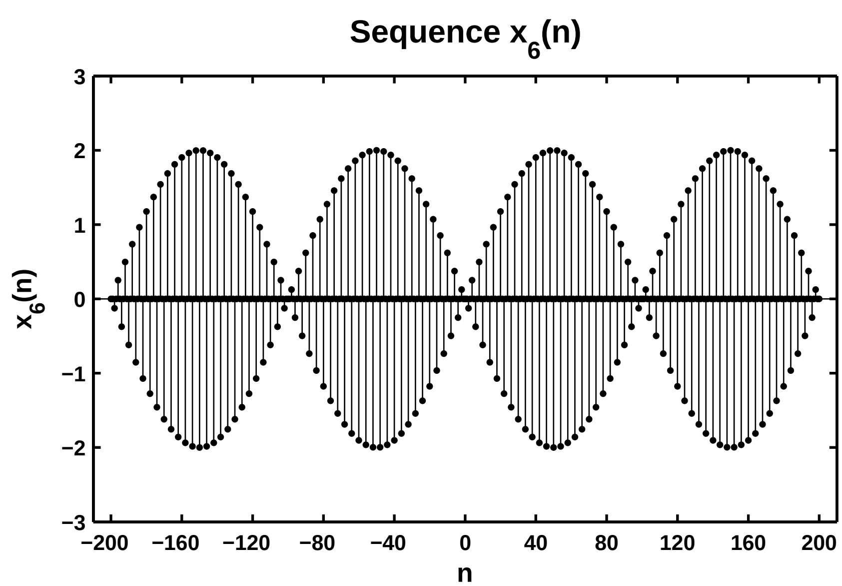


Figure 2.6: Problem P2.1.6 sequence plot

7. $x_7(n) = e^{-0.05n}\sin(0.1\pi n + \pi/3),\ 0 \le n \le 100.$

```
% P0201g: x7(n) = e ^ {-0.05*n}*sin(0.1*pi*n + pi/3), 0 <= n <=100.
clc; close all;

n7 = [0:100]; x7  = exp(-0.05*n7).*sin(0.1*pi*n7 + pi/3);

Hf_1 = figure; set(Hf_1,'NumberTitle','off','Name','P0201g');
Hs = stem(n7,x7,'filled'); set(Hs,'markersize',2);
axis([min(n7)-5,max(n7)+5,min(x7)-1,max(x7)+1]);
xlabel('n','FontSize',LFS); ylabel('x_7(n)','FontSize',LFS);
title('Sequence x_7(n)','FontSize',TFS);
ntick = [n7(1): 10:n7(end)]; set(gca,'XTickMode','manual','XTick',ntick);
print -deps2 ../CHAP2_EPSFILES/P0201g;
```

The plots of $x_7(n)$ is shown in Figure 2.7.

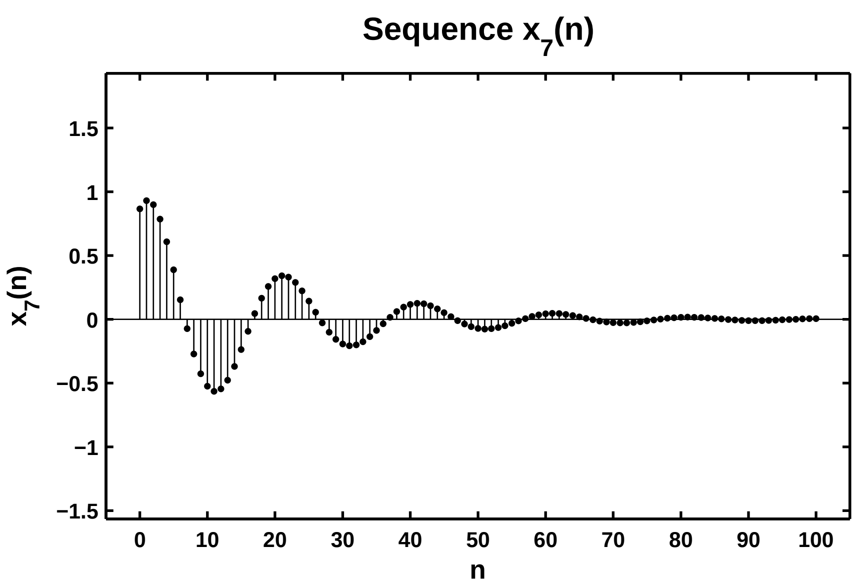


Figure 2.7: Problem P2.1.7 sequence plot

8. $x_8(n) = e^{0.01n}\sin(0.1\pi n),\ 0 \le n \le 100.$

```
% P0201h: x8(n) = e ^ {0.01*n}*sin(0.1*pi*n), 0 <= n <=100.
clc; close all;

n8 = [0:100]; x8  = exp(0.01*n8).*sin(0.1*pi*n8);

Hf_1 = figure; set(Hf_1,'NumberTitle','off','Name','P0201h');
Hs = stem(n8,x8,'filled'); set(Hs,'markersize',2);
axis([min(n8)-5,max(n8)+5,min(x8)-1,max(x8)+1]);
xlabel('n','FontSize',LFS); ylabel('x_8(n)','FontSize',LFS);
title('Sequence x_8(n)','FontSize',TFS);
ntick = [n8(1): 10:n8(end)]; set(gca,'XTickMode','manual','XTick',ntick);
print -deps2 ../CHAP2_EPSFILES/P0201h
```

The plots of $x_8(n)$ is shown in Figure 2.8.

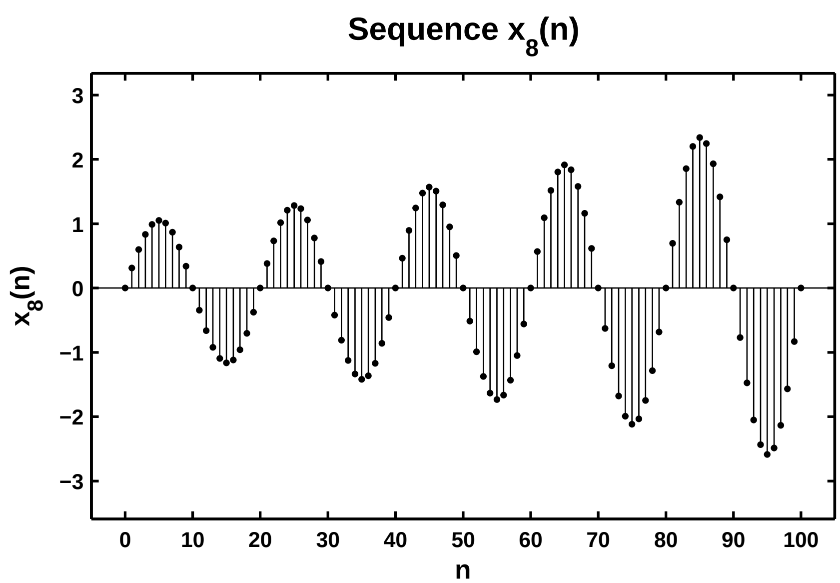


Figure 2.8: Problem P2.1.8 sequence plot

P2.2 Generate the following random sequences and obtain their histogram using the `hist` function with 100 bins. Use the `bar` function to plot each histogram.

1. $x_1(n)$ is a random sequence whose samples are independent and uniformly distributed over [0, 2] interval. Generate 100,000 samples.

```
% P0202a: x1(n) = uniform[0,2]
clc; close all;

n1 = [0:100000-1]; x1 = 2*rand(1,100000);

Hf_1 = figure; set(Hf_1,'NumberTitle','off','Name','P0202a');
[h1,x1out] = hist(x1,100); bar(x1out, h1);
axis([-0.1 2.1 0 1200]);
xlabel('interval','FontSize',LFS);
ylabel('number of elements','FontSize',LFS);
title('Histogram of sequence x_1(n) in 100 bins','FontSize',TFS);
print -deps2 ../CHAP2_EPSFILES/P0202a;
```

The plots of $x_1(n)$ is shown in Figure 2.9.

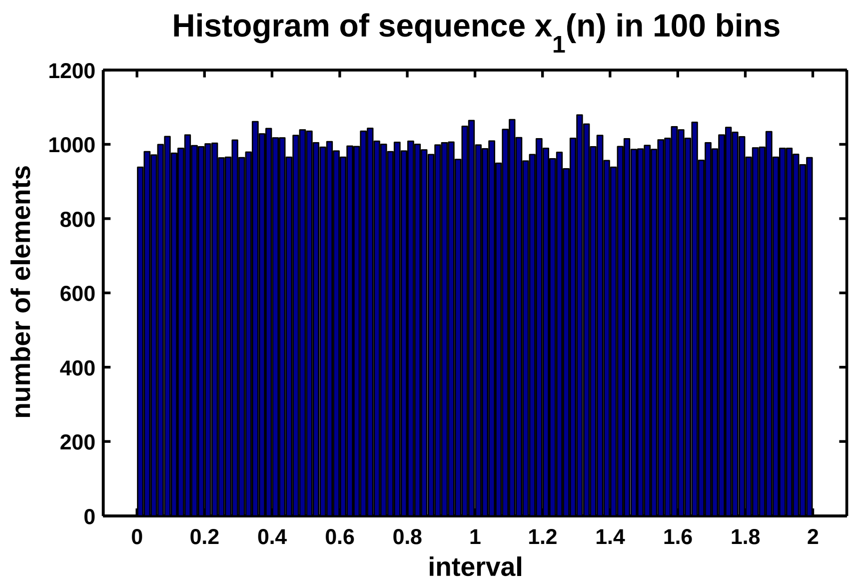


Figure 2.9: Problem P2.2.1 sequence plot

2. $x_2(n)$ is a Gaussian random sequence whose samples are independent with mean 10 and variance 10. Generate 10,000 samples.

```
% P0202b: x2(n) = gaussian{10,10}
clc; close all;

n2 = [1:10000]; x2 = 10 + sqrt(10)*randn(1,10000);

Hf_1 = figure; set(Hf_1,'NumberTitle','off','Name','P0202b');
[h2,x2out] = hist(x2,100); bar(x2out,h2);
xlabel('interval','FontSize',LFS);
ylabel('number of elements','FontSize',LFS);
title('Histogram of sequence x_2(n) in 100 bins','FontSize',TFS);
print -deps2 ../CHAP2_EPSFILES/P0202b;
```

The plots of $x_2(n)$ is shown in Figure 2.10.

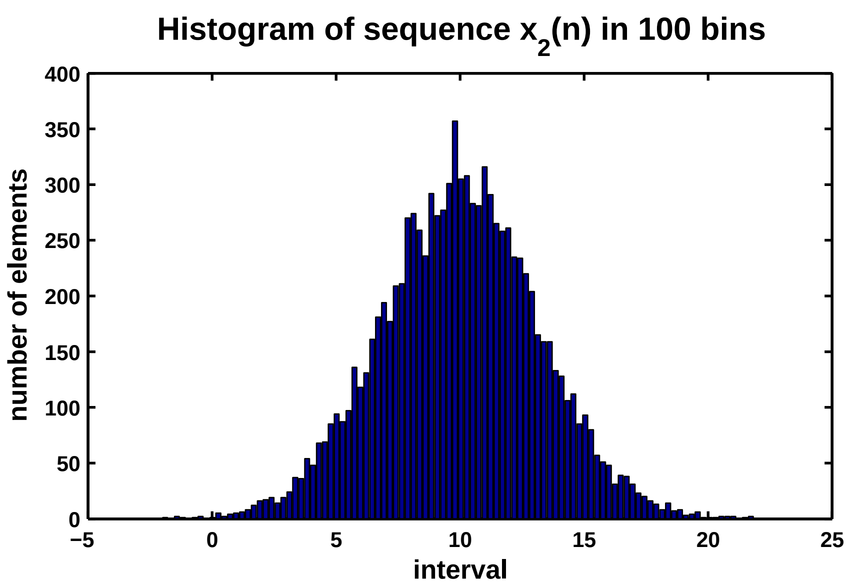


Figure 2.10: Problem P2.2.2 sequence plot

3. $x_3(n) = x_1(n) + x_1(n-1)$ where $x_1(n)$ is the random sequence given in part 1 above. Comment on the shape of this histogram and explain the shape.

```
% P0202c: x3(n) = x1(n) + x1(n - 1) where  x1(n) = uniform[0,2]
clc; close all;

n1 = [0:100000-1]; x1 = 2*rand(1,100000);

Hf_1 = figure; set(Hf_1,'NumberTitle','off','Name','P0202c');
[x11,n11] = sigshift(x1,n1,1);
[x3,n3] = sigadd(x1,n1,x11,n11);
[h3,x3out] = hist(x3,100);
bar(x3out,h3); axis([-0.5 4.5 0 2500]);
xlabel('interval','FontSize',LFS);
ylabel('number of elements','FontSize',LFS);
title('Histogram of sequence x_3(n) in 100 bins','FontSize',TFS);
print -deps2 ../CHAP2_EPSFILES/P0202c;
```

The plots of $x_3(n)$ is shown in Figure 2.11.

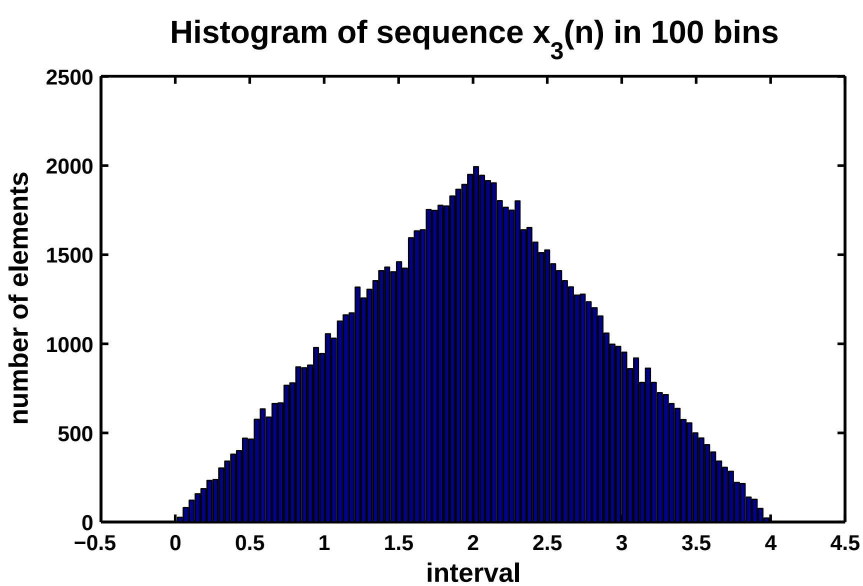


Figure 2.11: Problem P2.2.3 sequence plot

4. $x_4(n) = \sum_{k=1}^{4} y_k(n)$ where each random sequence $y_k(n)$ is independent of others with samples uniformly distributed over $[-0.5, 0.5]$. Comment on the shape of this histogram.

```
%P0202d: x4(n) = sum_{k=1} ^ {4} y_k(n), where each independent of others
%         with samples uniformly distributed over [-0.5,0.5];
clc; close all;

y1 = rand(1,100000) - 0.5; y2 = rand(1,100000) - 0.5;
y3 = rand(1,100000) - 0.5; y4 = rand(1,100000) - 0.5;
x4 = y1 + y2 + y3 + y4;

Hf_1 = figure; set(Hf_1,'NumberTitle','off','Name','P0202d');
[h4,x4out] = hist(x4,100); bar(x4out,h4);
xlabel('interval','FontSize',LFS);
ylabel('number of elements','FontSize',LFS);
title('Histogram of sequence x_4(n) in 100 bins','FontSize',TFS);
print -deps2 ../CHAP2_EPSFILES/P0202d;
```

The plots of $x_4(n)$ is shown in Figure 2.12.

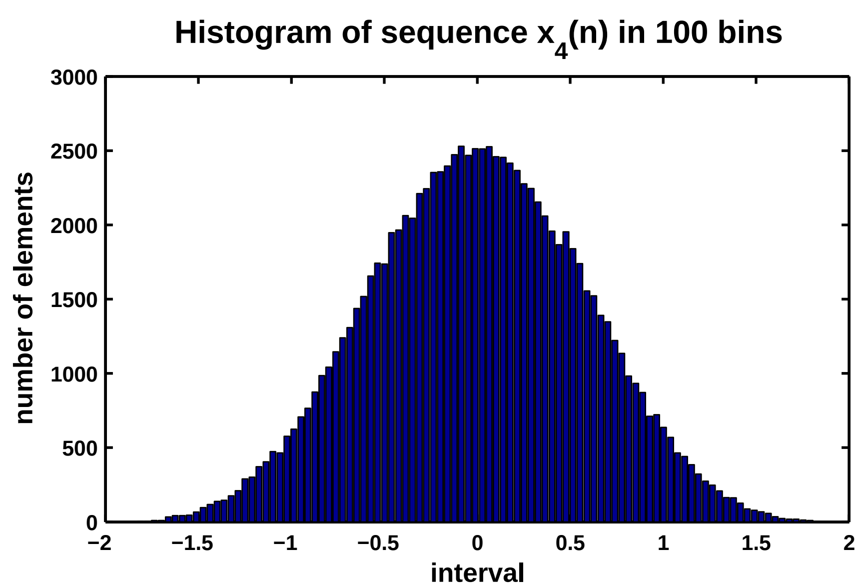


Figure 2.12: Problem P2.2.4 sequence plot