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## A.1

```
I = imread("A1.jpg");  
imshow(I)
```

$$\begin{aligned}
 x_1(t) &= \cos\left(\frac{3\pi}{10}t\right) + \frac{1}{2}\cos\left(\frac{\pi}{10}t\right) \\
 &= \underbrace{\frac{1}{2}e^{-j\frac{3\pi}{10}t}}_{\rho_3 = \frac{1}{2}} + \underbrace{\frac{1}{2}e^{j\frac{3\pi}{10}t}}_{\rho_3 = \frac{1}{2}} + \underbrace{\frac{1}{4}e^{-j\frac{\pi}{10}t}}_{\rho_1 = \frac{1}{4}} + \underbrace{\frac{1}{4}e^{j\frac{\pi}{10}t}}_{\rho_1 = \frac{1}{4}}
 \end{aligned}$$

$\omega_{0,1} = \frac{3\pi}{10}$      $\omega_{0,2} = \frac{\pi}{10}$   
 $\frac{\text{GCF}}{\text{LCM}} = \frac{\pi}{10}$      $T_0 = \frac{2\pi}{\frac{\pi}{10}} = 20$   
 for  $\frac{3\pi}{10}, n=3$   
 for  $\frac{\pi}{10}, n=1$

## A.2

```

I2 = imread("A2.jpg");
imshow(I2)

```

$  \begin{aligned}  &\underline{x_2(t)} \\  &T_0 = 20 \\  &\omega_0 = \frac{2\pi}{20} = \frac{\pi}{10}  \end{aligned}  $	$  \begin{aligned}  &\underline{x_3(t)} \\  &T_0 = 40 \\  &\omega_0 = \frac{2\pi}{40} = \frac{\pi}{20}  \end{aligned}  $
$  \begin{aligned}  p_n &= \frac{1}{20} \int_0^5 (1) e^{-j\frac{\pi}{10}nt} dt \\  &= \frac{1}{20} \left[ \frac{10}{-j\pi n} \int_0^5 e^u du \right] \quad u = -\frac{\pi j n t}{10}, \quad du = -\frac{\pi j n}{10} \\  &= \frac{1}{20} \left[ \frac{10}{j\pi n} (e^u) \Big _0^5 \right] \\  &= \frac{10}{20 j\pi n} \left[ e^{-\frac{5\pi j n}{10}} - e^{-\frac{5\pi j n}{10}} \right] \\  &= \frac{1}{2 j\pi n} \left[ e^{-\frac{\pi j n}{2}} - e^{\frac{\pi j n}{2}} \right] \\  &= \frac{e^{\frac{\pi j n}{2}} - e^{-\frac{\pi j n}{2}}}{2 j\pi n} \quad \sin(x) = \frac{e^x - e^{-x}}{j2} \\  &= \underline{\frac{1}{n\pi} \sin\left(\frac{n\pi}{2}\right)}  \end{aligned}  $	$  \begin{aligned}  p_n &= \frac{1}{40} \int_0^5 (1) e^{-j\frac{\pi}{20}nt} dt \\  &= \frac{1}{40} \left[ \frac{20}{-j\pi n} \int_0^5 e^u du \right] \quad u = -\frac{\pi j n t}{20}, \quad du = -\frac{\pi j n}{20} \\  &= \frac{1}{40} \left( \frac{20}{j\pi n} \right) \left[ e^u \Big _0^5 \right] \\  &= \frac{20}{40 j\pi n} \left[ e^{-\frac{5\pi j n}{20}} - e^{-\frac{5\pi j n}{20}} \right] \\  &= \frac{1}{2 j\pi n} \left[ e^{-\frac{\pi j n}{4}} - e^{\frac{\pi j n}{4}} \right] \\  &= \frac{e^{\frac{\pi j n}{4}} - e^{-\frac{\pi j n}{4}}}{2 j\pi n} \\  &= \underline{\frac{1}{n\pi} \sin\left(\frac{n\pi}{4}\right)}  \end{aligned}  $

## A.3 (x1)

```

n = (-10:10);
D_n = (n==1).*(1/4)+(n==-1).*(1/4)+(n==3).*(1/2)+(n==-3).*(1/2);
subplot(2,1,1);
stem(n,abs(D_n));
title('X1');
xlabel('n');
ylabel('|D_n|');

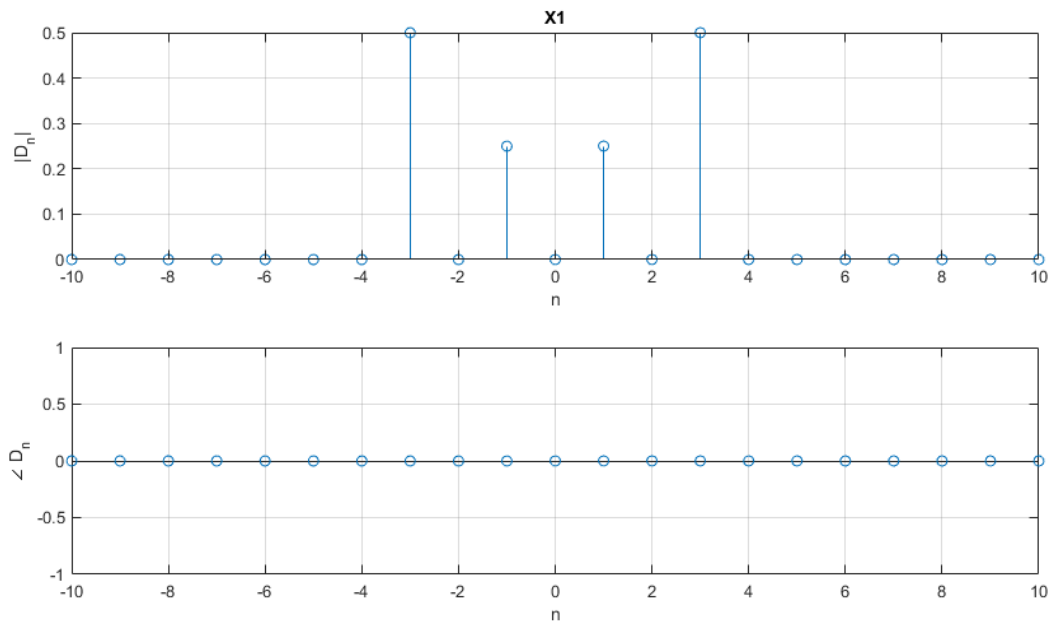
```

---

```

grid;
subplot(2,1,2);
stem(n,angle(D_n));
xlabel('n');
ylabel('\angle D_n');
grid;

```

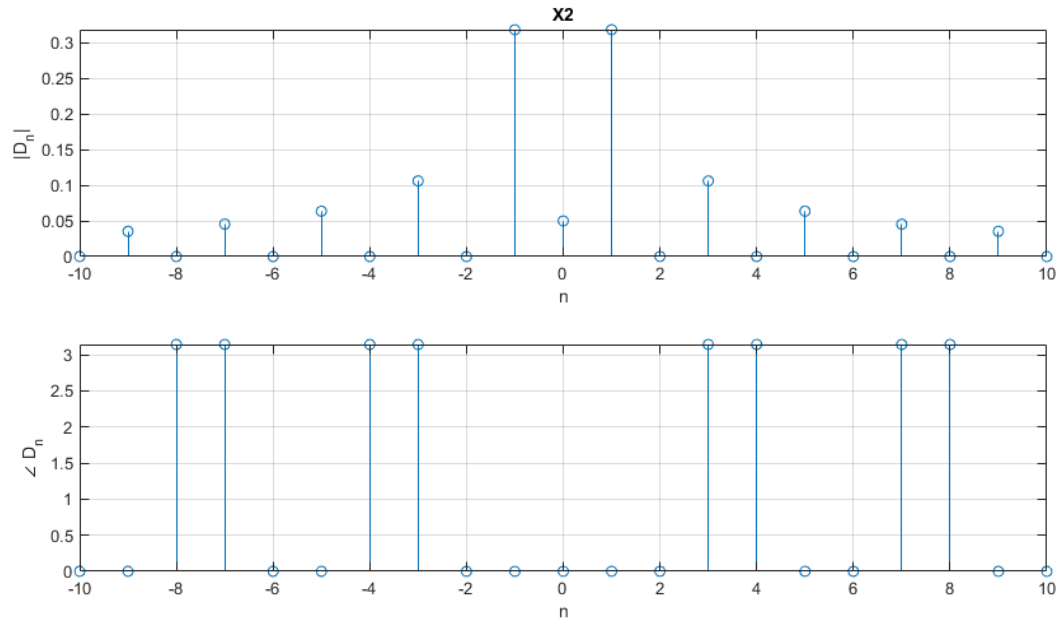


## A.3 (x2)

```

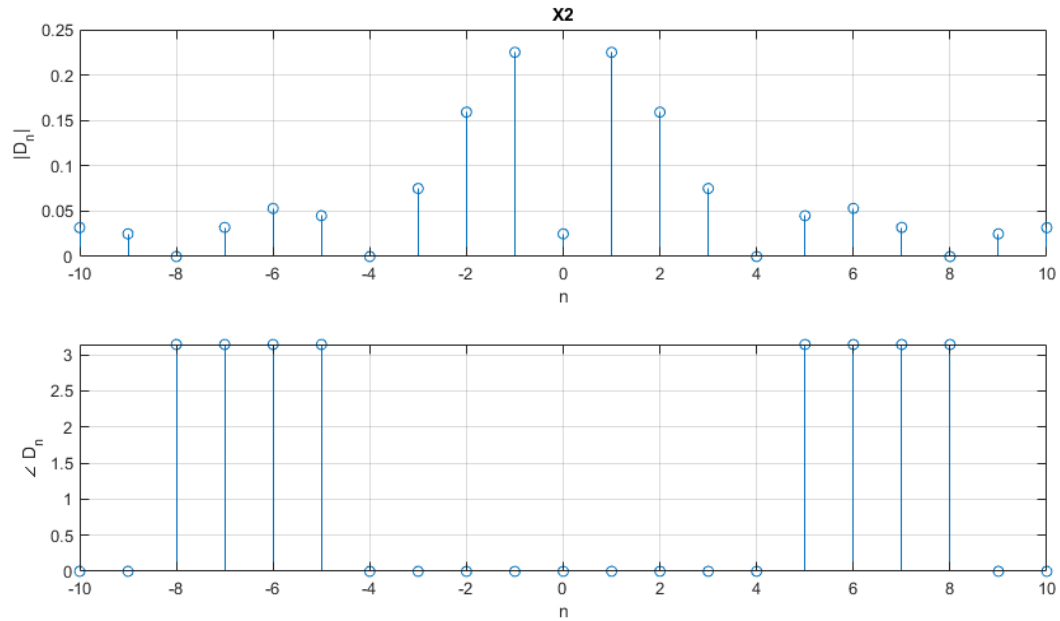
n=(-10:10);
D_n = n;
for i=min(n):1:max(n)
if i==0
D_n((i+abs(min(n))+1))=0.05;
else
D_n((i+abs(min(n))+1))=(sin((i*pi)/2))./(i*pi);
end
end
subplot (2,1,1);
stem(n,abs(D_n));
title ('X2');
xlabel ('n'); ylabel ('|D_n|');
grid;
subplot(2,1,2);
stem(n,angle(D_n));
xlabel('n');
ylabel('\angle D_n');
grid;

```



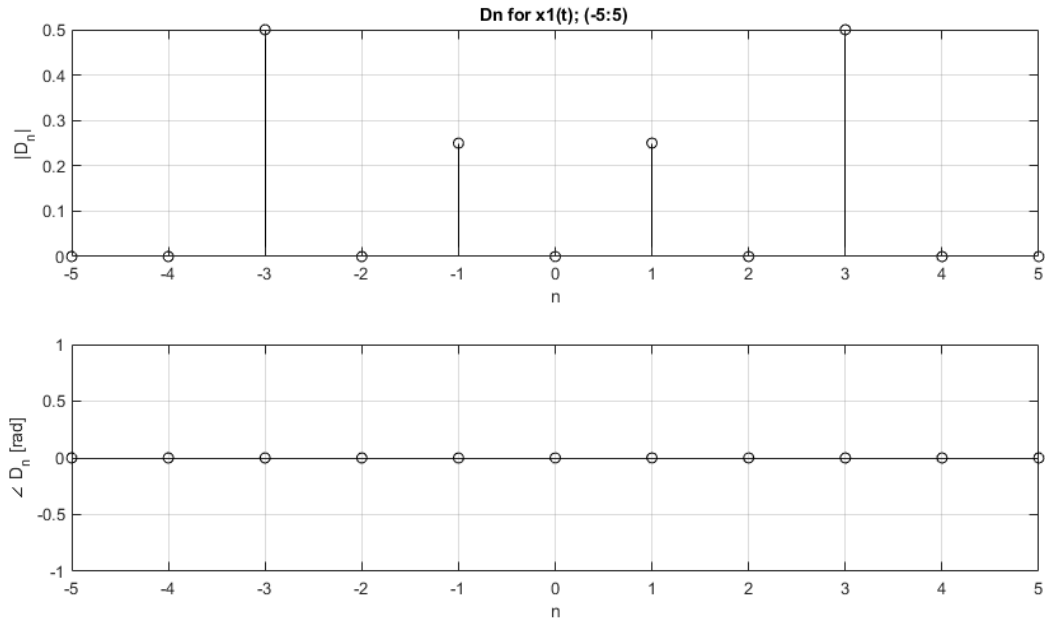
## A.3 (x3)

```
n=(-10:10);
D_n = n;
for i=min(n):1:max(n)
if i==0
D_n((i+abs(min(n))+1))=0.025;
else
D_n((i+abs(min(n))+1))=(sin((i*pi)/4))./(i*pi);
end
end
subplot (2,1,1);
stem(n,abs(D_n));
title ('x2');
xlabel ('n'); ylabel ('|D_n|');
grid;
subplot(2,1,2);
stem(n,angle(D_n));
xlabel('n');
ylabel('\angle D_n');
grid;
```



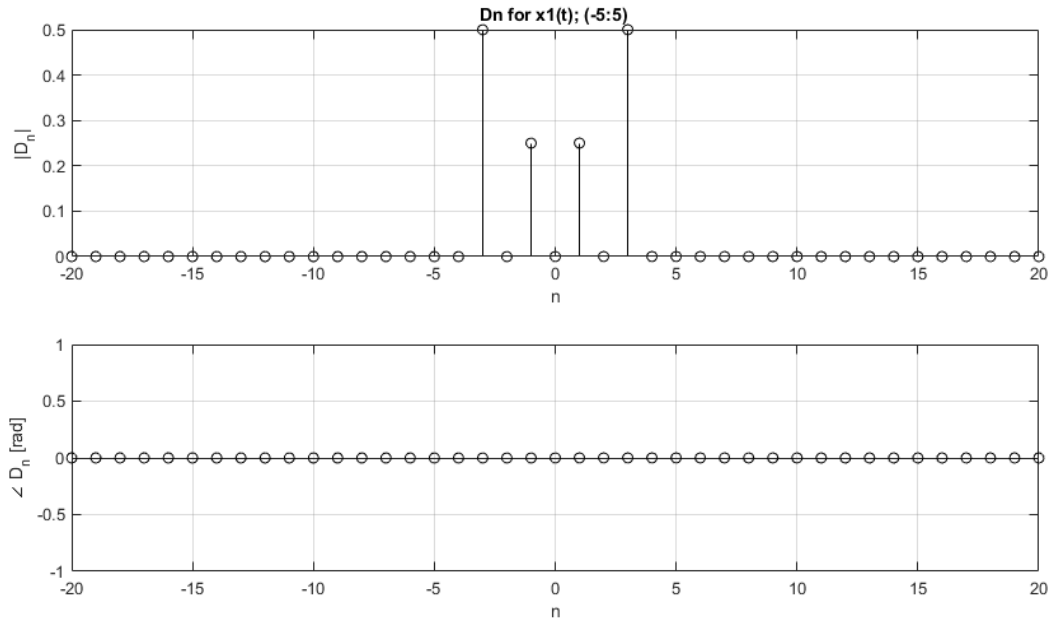
## A.4 (x1a)

```
n = (-5:5);
D_n = (n==1).*(1/4)+(n==-1).*(1/4)+(n==3).*(1/2)+(n==-3).*(1/2);
subplot(2,1,1);
stem(n,abs(D_n), 'k');
xlabel('n');
ylabel('|D_n|');
title('Dn for x1(t); (-5:5) ');
grid;
subplot(2,1,2);
stem(n,angle(D_n), 'k');
xlabel('n');
ylabel('\angle D_n [rad]');
grid;
```



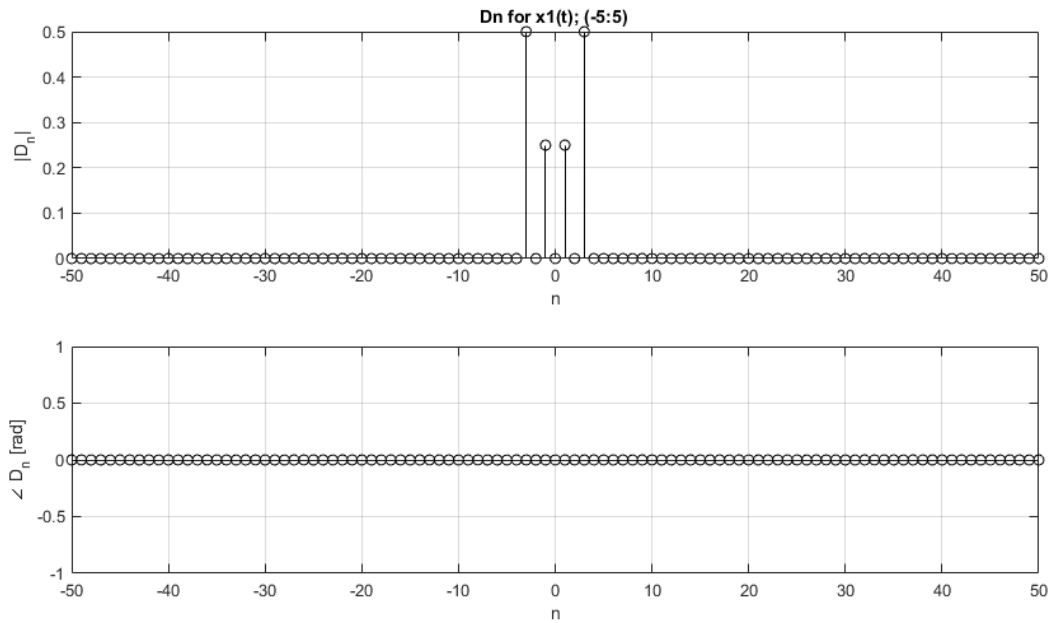
## A.4 (x1b)

```
n = (-20:20);
D_n = (n==1).*(1/4)+(n==-1).*(1/4)+(n==3).*(1/2)+(n==-3).*(1/2);
subplot(2,1,1);
stem(n,abs(D_n), 'k');
xlabel('n');
ylabel('|D_n|');
title('Dn for x1(t); (-5:5) ');
grid;
subplot(2,1,2);
stem(n,angle(D_n), 'k');
xlabel('n');
ylabel('\angle D_n [rad]');
grid;
```



## A.4 (x1c)

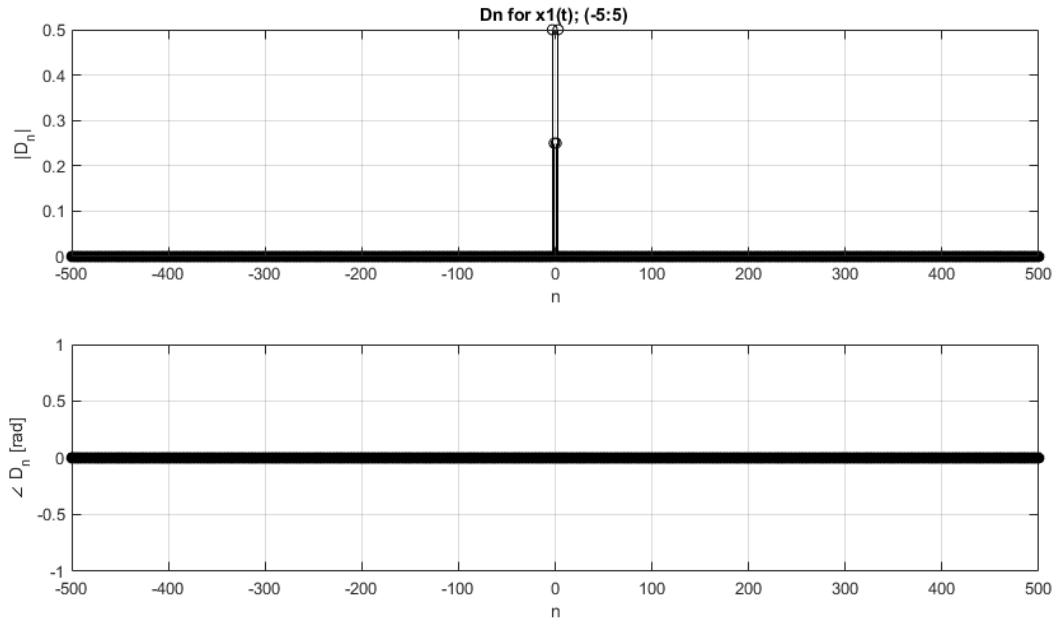
```
n = (-50:50);
D_n = (n==1).*(1/4)+(n==-1).*(1/4)+(n==3).*(1/2)+(n==-3).*(1/2);
subplot(2,1,1);
stem(n,abs(D_n), 'k');
xlabel('n');
ylabel('|D_n|');
title('Dn for x1(t); (-5:5) ');
grid;
subplot(2,1,2);
stem(n,angle(D_n), 'k');
xlabel('n');
ylabel('\angle D_n [rad]');
grid;
```



## A.4 (x1d)

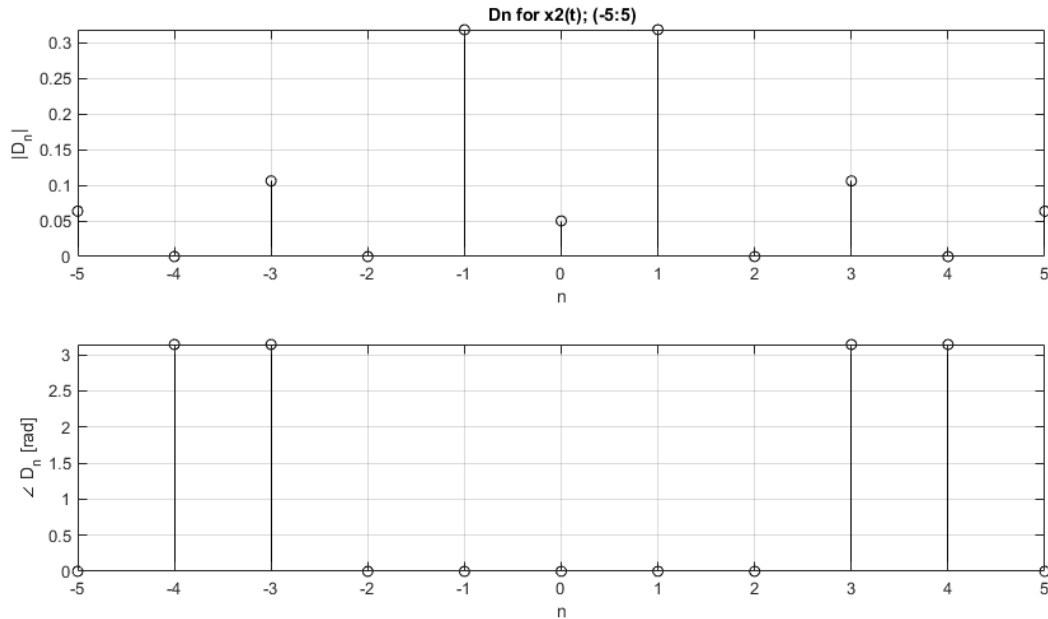
```
n = (-500:500);
D_n = (n==1).*(1/4)+(n==-1).*(1/4)+(n==3).*(1/2)+(n==-3).*(1/2);
subplot(2,1,1);
stem(n,abs(D_n), 'k');
xlabel('n');
ylabel('|D_n|');
title('Dn for x1(t); (-5:5) ');
grid;
subplot(2,1,2);
stem(n,angle(D_n), 'k');
xlabel('n');
ylabel('\angle D_n [rad]');
grid;
```





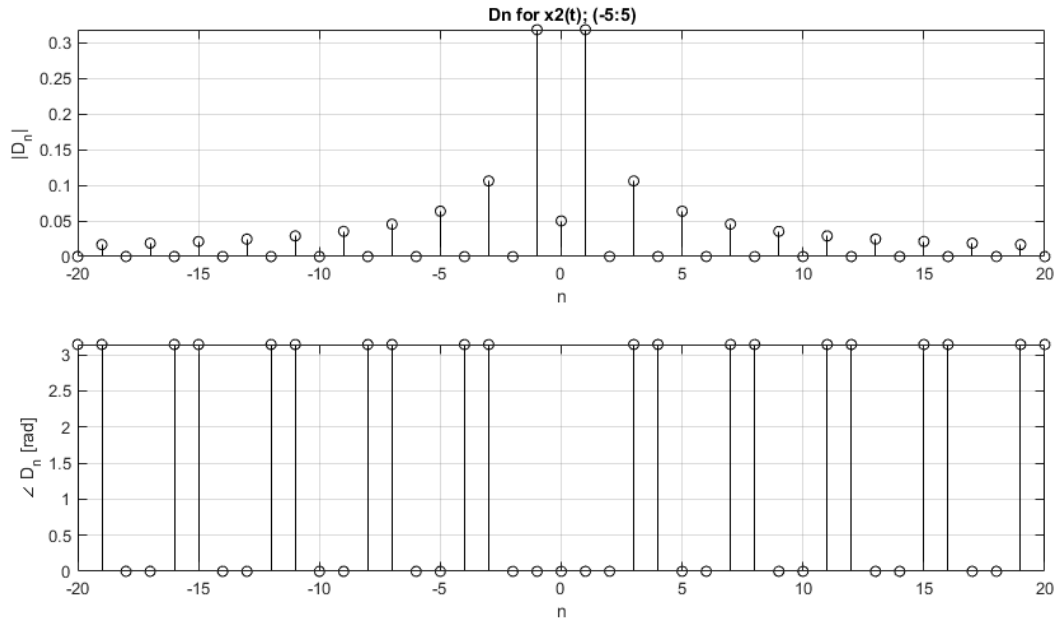
## A.4 (x2a)

```
n=(-5:5);
D_n = n;
for i=min(n):1:max(n)
if i==0
D_n((i+abs(min(n))+1))=0.05;
else
D_n((i+abs(min(n))+1))=(sin((i*pi)/2))./(i*pi);
end
end
subplot(2,1,1);
stem(n,abs(D_n), 'k');
xlabel('n');
ylabel('|D_n|');
title('Dn for x2(t); (-5:5)');
grid;
subplot(2,1,2);
stem(n,angle(D_n), 'k');
xlabel('n');
ylabel('\angle D_n [rad]');
grid;
```



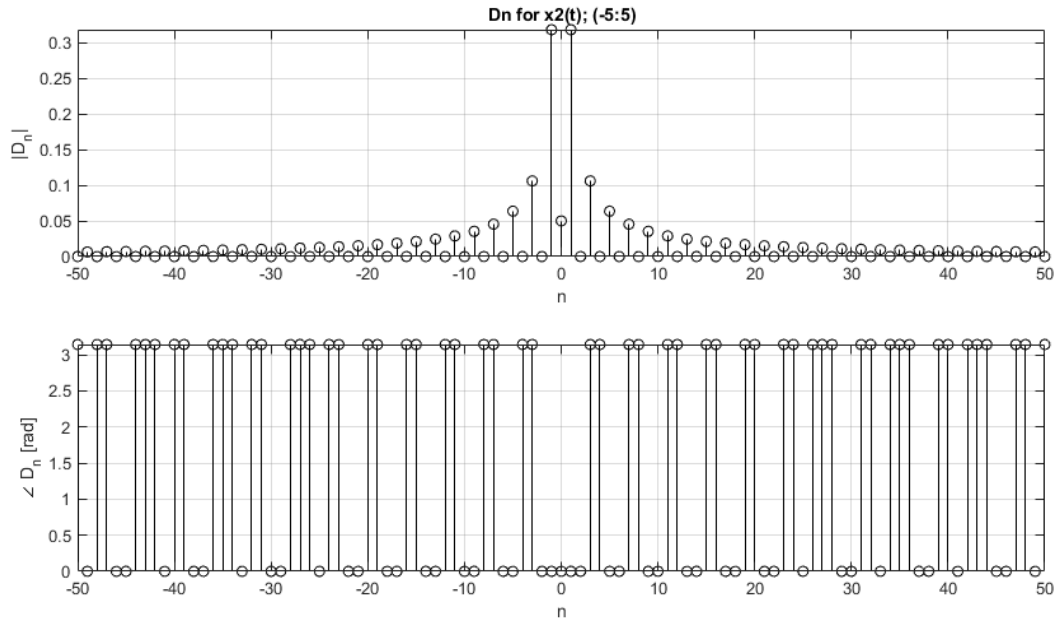
## A.4 (x2b)

```
n=(-20:20);
D_n = n;
for i=min(n):1:max(n)
if i==0
D_n((i+abs(min(n))+1))=0.05;
else
D_n((i+abs(min(n))+1))=(sin((i*pi)/2))./(i*pi);
end
end
subplot(2,1,1);
stem(n,abs(D_n), 'k');
xlabel('n');
ylabel('|D_n|');
title('Dn for x2(t); (-5:5)');
grid;
subplot(2,1,2);
stem(n,angle(D_n), 'k');
xlabel('n');
ylabel('\angle D_n [rad]');
grid;
```



## A.4 (x2c)

```
n=(-50:50);
D_n = n;
for i=min(n):1:max(n)
if i==0
D_n((i+abs(min(n))+1))=0.05;
else
D_n((i+abs(min(n))+1))=(sin((i*pi)/2))./(i*pi);
end
end
subplot(2,1,1);
stem(n,abs(D_n), 'k');
xlabel('n');
ylabel('|D_n|');
title('Dn for x2(t); (-5:5)');
grid;
subplot(2,1,2);
stem(n,angle(D_n), 'k');
xlabel('n');
ylabel('\angle D_n [rad]');
grid;
```



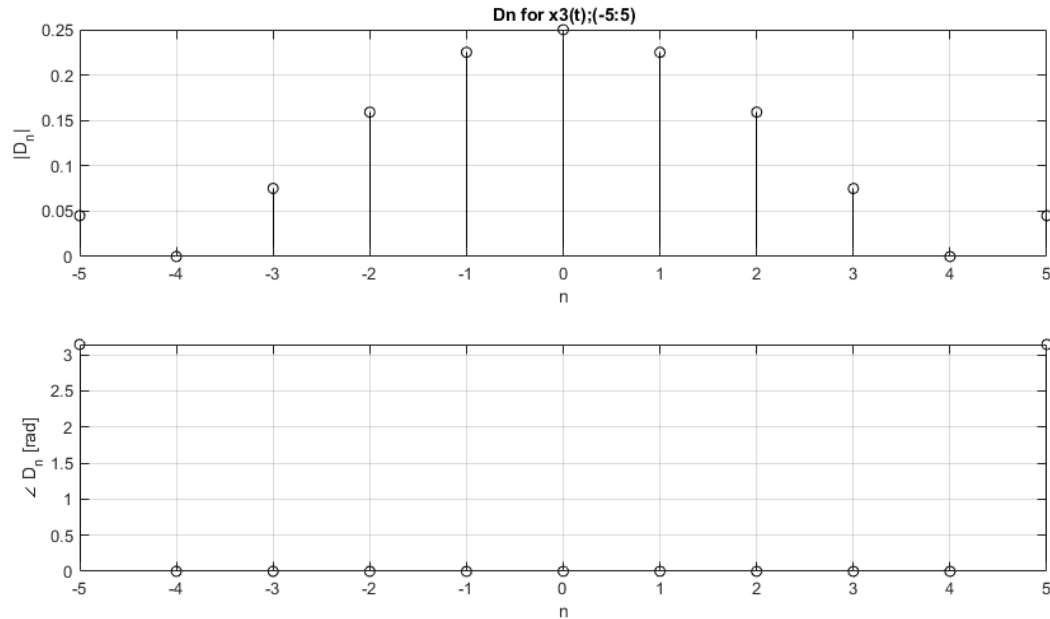
## A.4 (x2d)

```
n=(-500:500);
D_n = n;
for i=min(n):1:max(n)
if i==0
D_n((i+abs(min(n))+1))=0.05;
else
D_n((i+abs(min(n))+1))=(sin((i*pi)/2))./(i*pi);
end
end
subplot(2,1,1);
stem(n,abs(D_n), 'k');
xlabel('n');
ylabel('|D_n|');
title('Dn for x2(t); (-5:5)');
grid;
subplot(2,1,2);
stem(n,angle(D_n), 'k');
xlabel('n');
ylabel('\angle D_n [rad]');
grid;
clf;
```

---

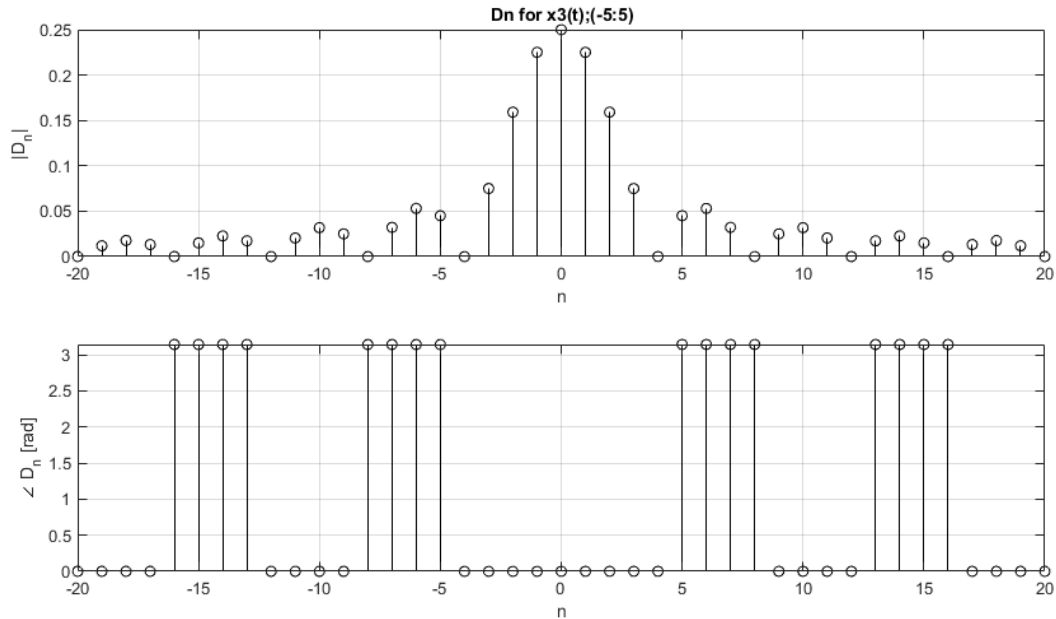
## A.4 (x3a)

```
n=(-5:5);
D_n = n;
for i=min(n):1:max(n)
if i==0
D_n((i+abs(min(n))+1))=0.25;
else
D_n((i+abs(min(n))+1))=(sin((i*pi)/4))./(i*pi);
end
end
subplot(2,1,1);
stem(n,abs(D_n), 'k');
xlabel('n');
ylabel('|D_n|');
title('Dn for x3(t);(-5:5)');
grid;
subplot(2,1,2);
stem(n,angle(D_n), 'k');
xlabel('n');
ylabel('\angle D_n [rad]');
grid;
```



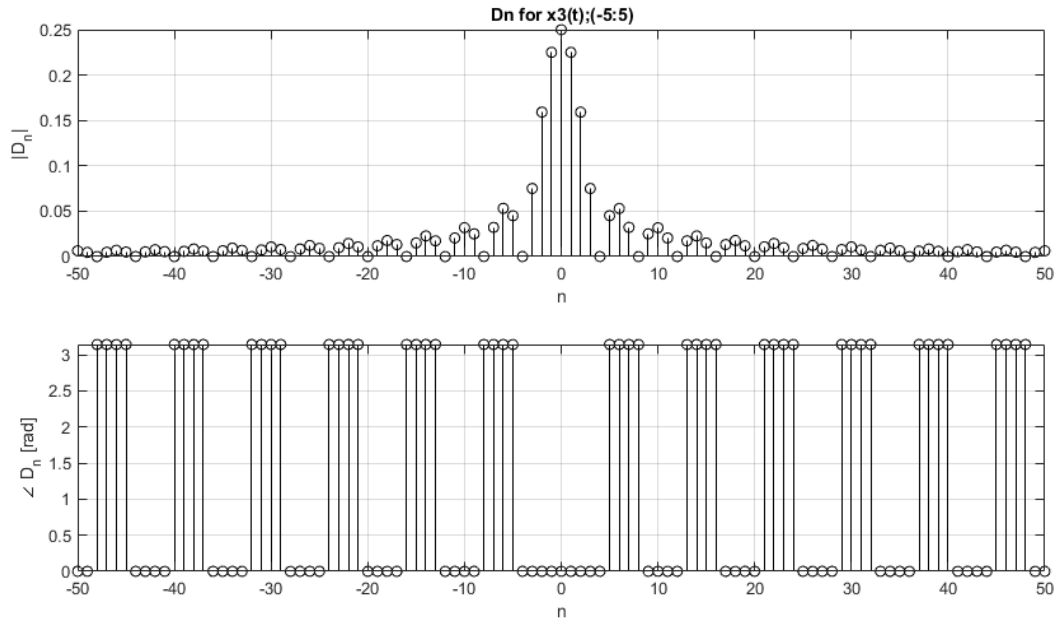
## A.4 (x3b)

```
n=(-20:20);
D_n = n;
for i=min(n):1:max(n)
if i==0
D_n((i+abs(min(n))+1))=0.25;
else
D_n((i+abs(min(n))+1))=(sin((i*pi)/4))./(i*pi);
end
end
subplot(2,1,1);
stem(n,abs(D_n), 'k');
xlabel('n');
ylabel('|D_n|');
title('Dn for x3(t);(-5:5)');
grid;
subplot(2,1,2);
stem(n,angle(D_n), 'k');
xlabel('n');
ylabel('\angle D_n [rad]');
grid;
```



## A.4 (x3c)

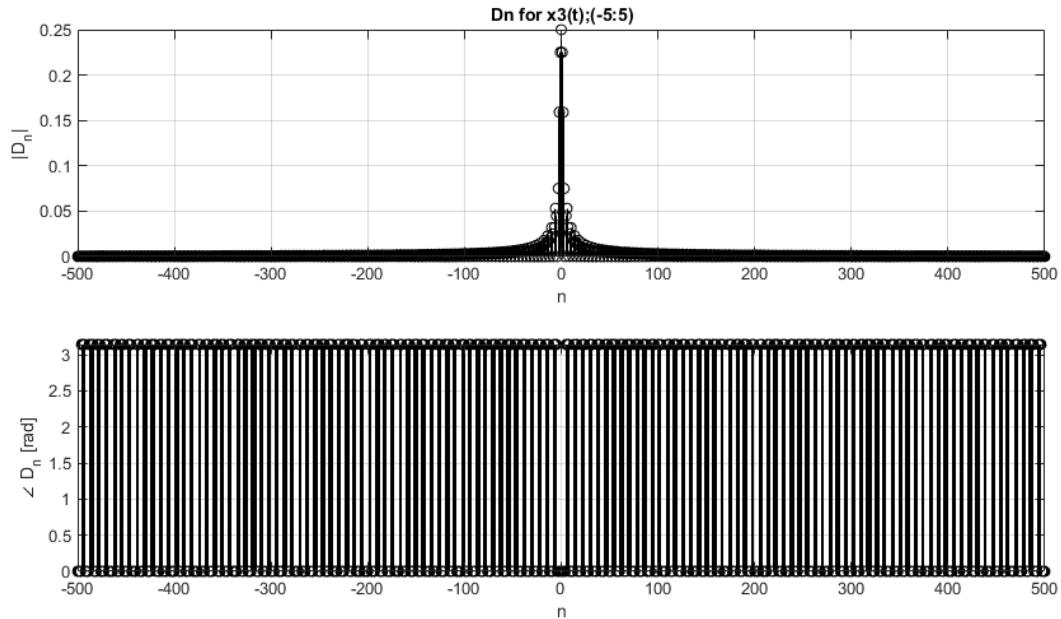
```
n=(-50:50);
D_n = n;
for i=min(n):1:max(n)
if i==0
D_n((i+abs(min(n))+1))=0.25;
else
D_n((i+abs(min(n))+1))=(sin((i*pi)/4))./(i*pi);
end
end
subplot(2,1,1);
stem(n,abs(D_n), 'k');
xlabel('n');
ylabel('|D_n|');
title('Dn for x3(t);(-5:5)');
grid;
subplot(2,1,2);
stem(n,angle(D_n), 'k');
xlabel('n');
ylabel('\angle D_n [rad]');
grid;
```



## A.4 (x3d)

```
n=(-500:500);
D_n = n;
for i=min(n):1:max(n)
if i==0
D_n((i+abs(min(n))+1))=0.25;
else
D_n((i+abs(min(n))+1))=(sin((i*pi)/4))./(i*pi);
end
end
subplot(2,1,1);
stem(n,abs(D_n), 'k');
xlabel('n');
ylabel('|D_n|');
title('Dn for x3(t);(-5:5)');
grid;
subplot(2,1,2);
stem(n,angle(D_n), 'k');
xlabel('n');
ylabel('\angle D_n [rad]');
grid;
```





## A5 (x1)

```
t = -300:1:300;
x = 0;
for n = -5:5
    D_n = 0;
    if (n==3 || n==-3)
        D_n=(1/2);
    end
    if (n==1 || n==-1)
        D_n=(1/4);
    end
    x=x+D_n.*(exp(sqrt(-1)*n*(pi/10)*t));
end
```

## A5 (x2)

```
D_n=[-50:50];
nleftlim = -50;
nrightlim = 50;
x = 50+1;
if n == 0,
    D_n(x) = 0.5;
else
    D_n(n-nleftlim+1) = (sin(n.*pi*0.5)./(n.*pi));
end
n = [nleftlim:nrightlim];
W0 = pi/10; t = -300:300;
s = 300+1;
b=length(t);
```

---

```
x = zeros(1,b);
for t=-300:300
for n=nleftlim:nrightlim
x(t+s) = x(t+s) + real(D_n(n-nleftlim+1).*exp(n.*1i*W0*t));
end
end
```

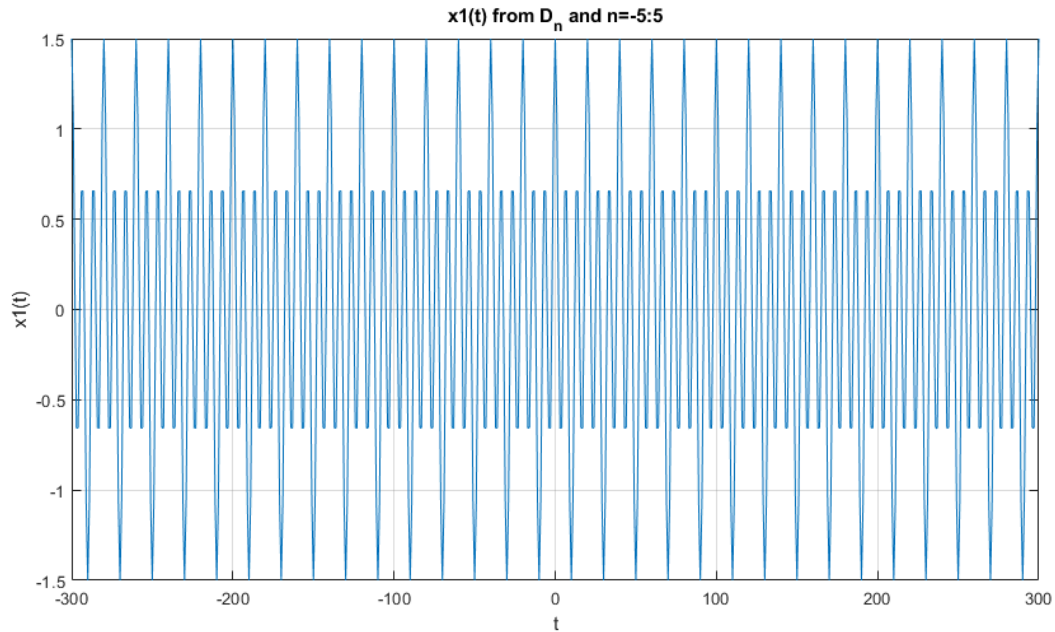
## A5 (x3)

```
D_n=[-500:500];
nleftlim = -500; nrightlim = 500; x = 500+1;
if n == 0,
D_n(x) = 0.5;
else
D_n(n-nleftlim+1) = (sin(n.*pi*0.25)./(n.*pi));
end
n = [nleftlim:nrightlim];
W0 = pi/20; t = -300:300;
s = 300+1;
b=length(t);
x = zeros(1,b);
for t=-300:300
for n=nleftlim:nrightlim
x(t+s) = x(t+s) + real(D_n(n-nleftlim+1).*exp(n.*1i*W0*t));
end
end
```

## A6 (x1a)

```
clf;
t = -300:1:300;
x = 0;
for n = -5:5
D_n = 0;
if (n==3 || n==-3)
D_n=(1/2);
end
if (n==1 || n==-1)
D_n=(1/4);
end
x=x+D_n.*(exp(sqrt(-1)*n*(pi/10)*t));
end
plot(t,x);
xlabel('t');
ylabel('x1(t)');
title('x1(t) from D_n and n=-5:5');
grid;
```

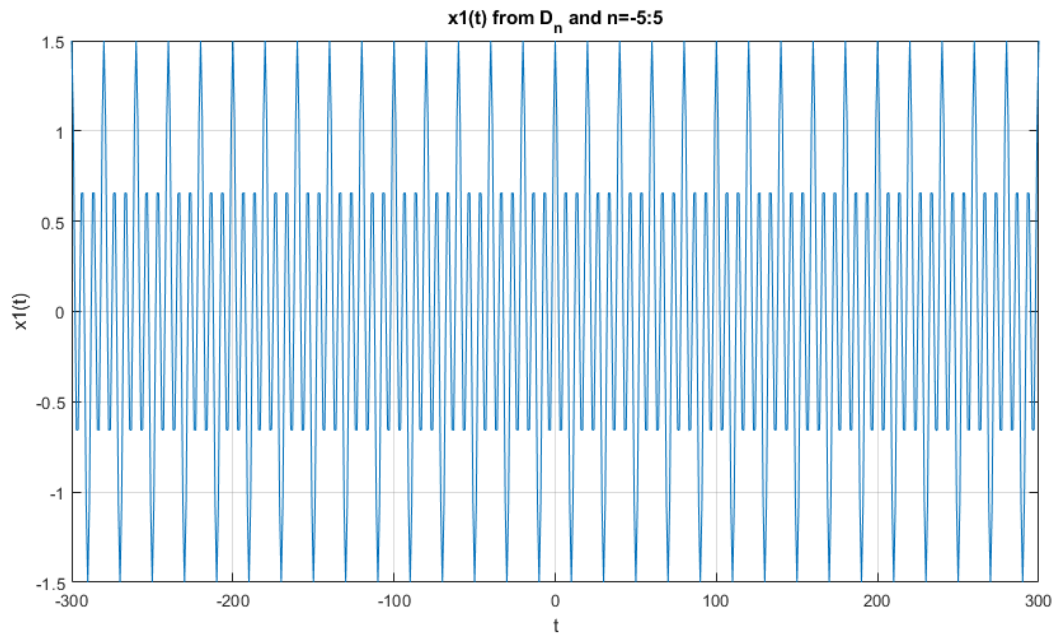
*Warning: Imaginary parts of complex X and/or Y arguments ignored.*



## A6 (x1b)

```
t = -300:1:300;
x = 0;
for n = -20:20
    D_n = 0;
    if (n==3 || n==-3)
        D_n=(1/2);
    end
    if (n==1 || n==-1)
        D_n=(1/4);
    end
    x=x+D_n.*(exp(sqrt(-1)*n*(pi/10)*t));
end
plot(t,x);
xlabel('t');
ylabel('x1(t)');
title('x1(t) from D_n and n=-5:5');
grid;
```

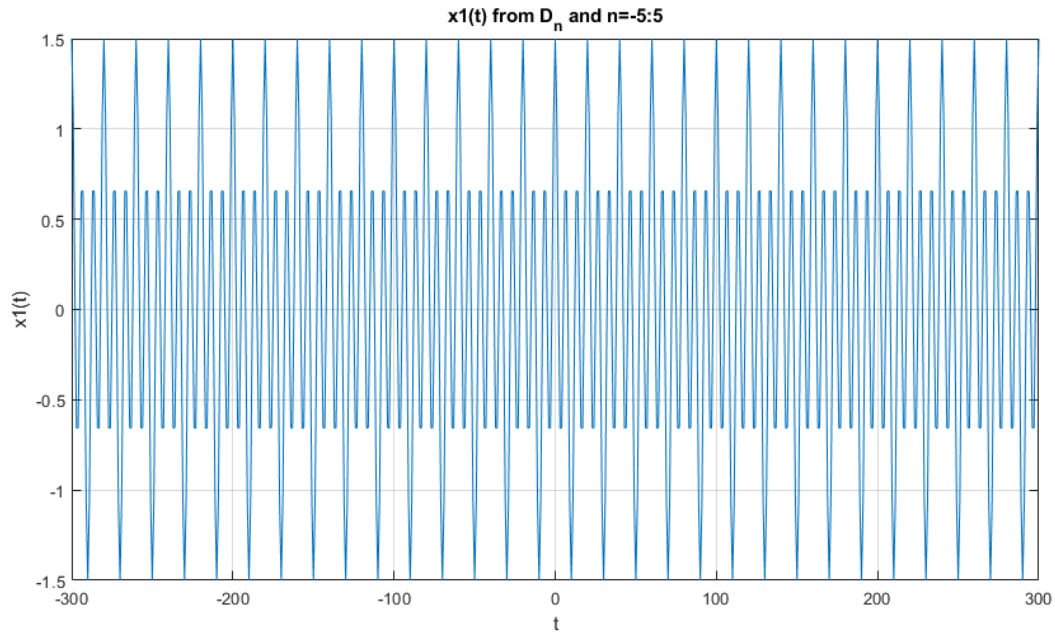
*Warning: Imaginary parts of complex X and/or Y arguments ignored.*



## A6 (x1c)

```
t = -300:1:300;
x = 0;
for n = -50:50
    D_n = 0;
    if (n==3 || n==-3)
        D_n=(1/2);
    end
    if (n==1 || n==-1)
        D_n=(1/4);
    end
    x=x+D_n.*(exp(sqrt(-1)*n*(pi/10)*t));
end
plot(t,x);
xlabel('t');
ylabel('x1(t)');
title('x1(t) from D_n and n=-5:5');
grid;
```

*Warning: Imaginary parts of complex X and/or Y arguments ignored.*



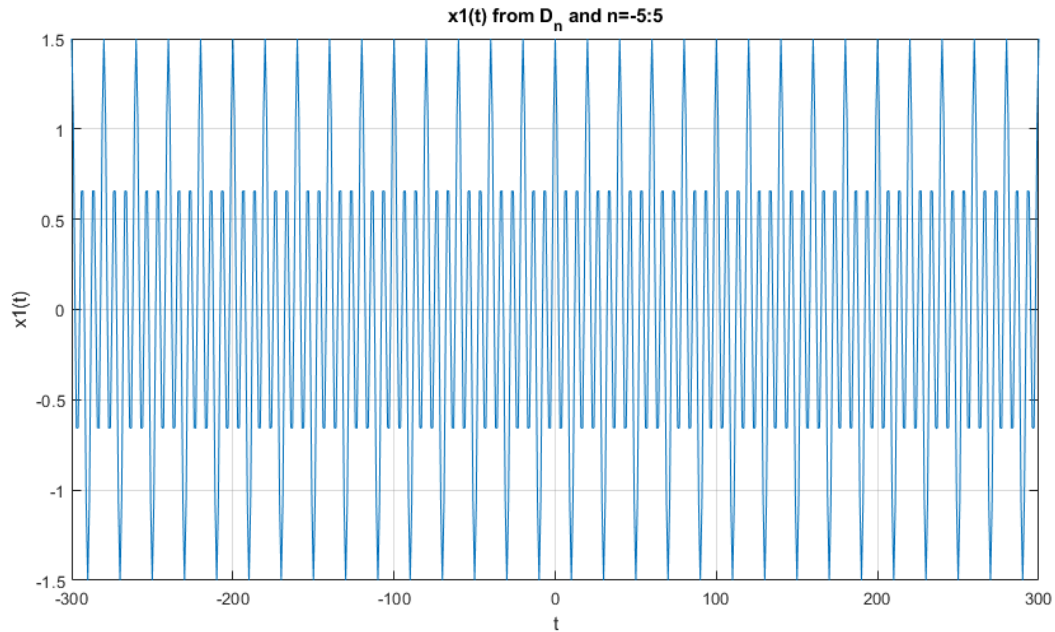
## A6 (x1d)

```

t = -300:1:300;
x = 0;
for n = -500:500
    D_n = 0;
    if (n==3 || n== -3)
        D_n=(1/2);
    end
    if (n==1 || n== -1)
        D_n=(1/4);
    end
    x=x+D_n.*(exp(sqrt(-1)*n*(pi/10)*t));
end
plot(t,x);
xlabel('t');
ylabel('x1(t)');
title('x1(t) from D_n and n=-5:5');
grid;

```

*Warning: Imaginary parts of complex X and/or Y arguments ignored.*

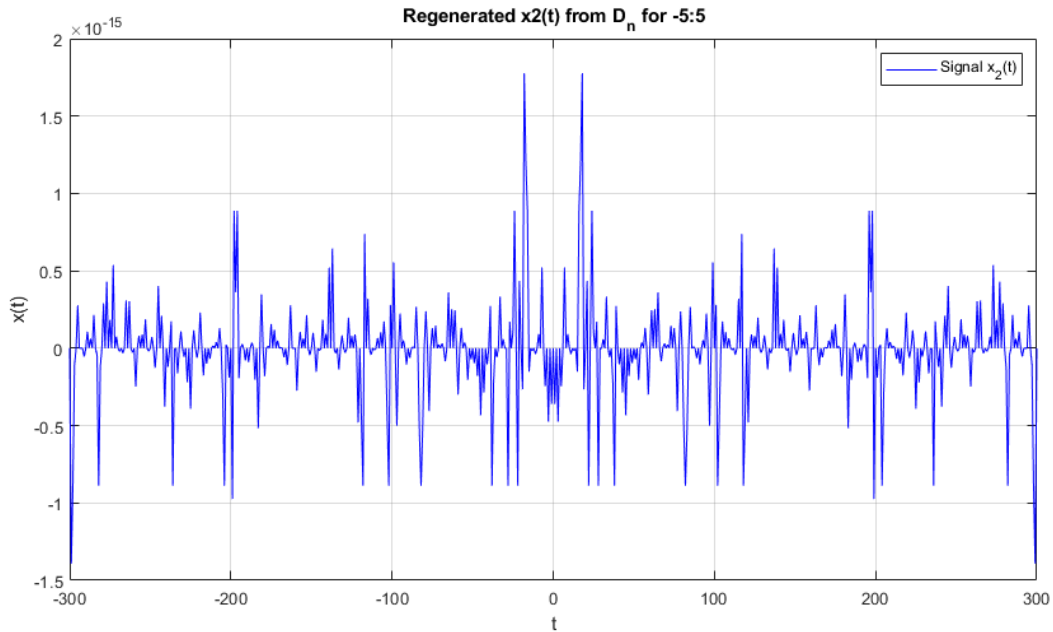


## A6 (x2a)

```

D_n=[-5:5]; nleftlim = -5;
nrightlim = 5;
x = 5+1;
if n == 0,
D_n(x) = 0.05;
else
D_n(n-nleftlim+1) = (sin(n.*pi*0.5)./(n.*pi));
end
n = [nleftlim:nrightlim];
W0 = pi/10;
t = -300:300;
s = 300+1;
b=length(t);
x = zeros(1,b);
for t=-300:300
for n=nleftlim:nrightlim
x(t+s) = x(t+s) + real(D_n(n-nleftlim+1).*exp(n.*1i*W0*t));
end
end
t=-300:300;
plot(t,real(x), 'b');
ylabel('x(t)');
xlabel('t');
title('Regenerated x2(t) from D_n for -5:5');
legend('Signal x_2(t)');
grid;

```

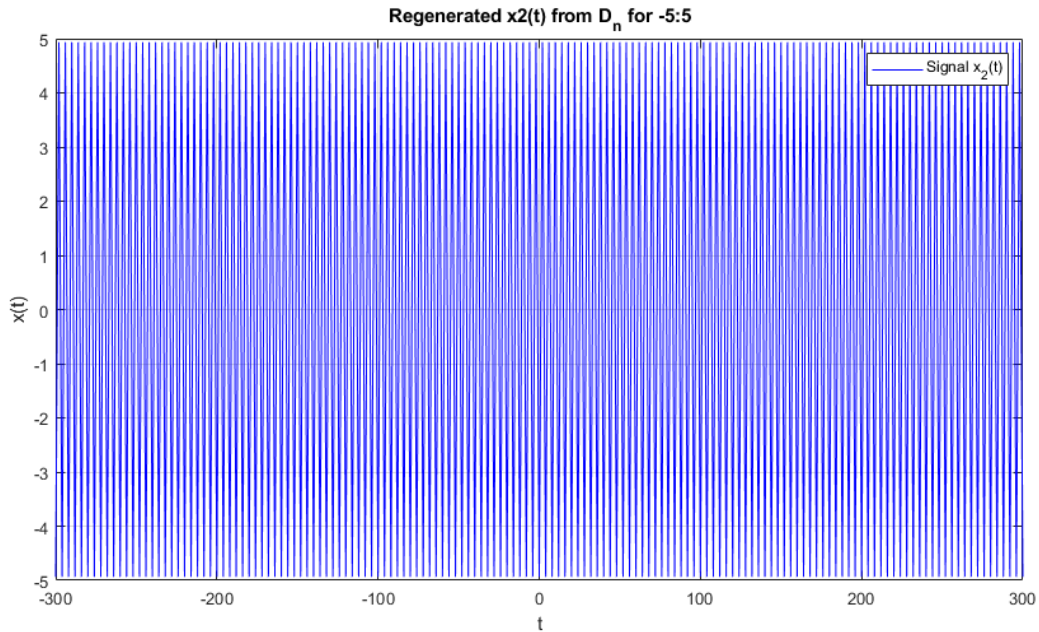


## A6 (x2b)

```

D_n=[-20:20]; nleftlim = -20;
nrightlim = 20;
x = 20+1;
if n == 0,
D_n(x) = 0.05;
else
D_n(n-nleftlim+1) = (sin(n.*pi*0.5)./(n.*pi));
end
n = [nleftlim:nrightlim];
W0 = pi/10;
t = -300:300;
s = 300+1;
b=length(t);
x = zeros(1,b);
for t=-300:300
for n=nleftlim:nrightlim
x(t+s) = x(t+s) + real(D_n(n-nleftlim+1).*exp(n.*1i*W0*t));
end
end
t=-300:300;
plot(t,real(x), 'b');
ylabel('x(t)');
xlabel('t');
title('Regenerated x2(t) from D_n for -5:5');
legend('Signal x_2(t)');
grid;

```



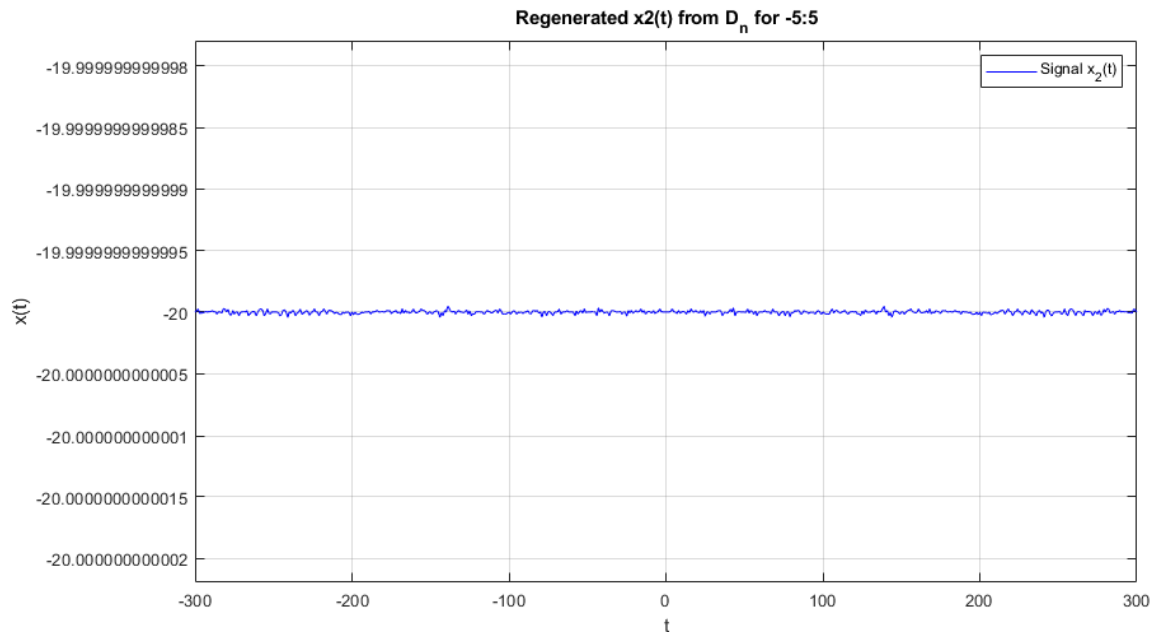
## A6 (x2c)

```

D_n=[-50:50]; nleftlim = -50;
nrightlim = 50;
x = 50+1;
if n == 0,
D_n(x) = 0.05;
else
D_n(n-nleftlim+1) = (sin(n.*pi*0.5)./(n.*pi));
end
n = [nleftlim:nrightlim];
W0 = pi/10;
t = -300:300;
s = 300+1;
b=length(t);
x = zeros(1,b);
for t=-300:300
for n=nleftlim:nrightlim
x(t+s) = x(t+s) + real(D_n(n-nleftlim+1).*exp(n.*1i*W0*t));
end
end
t=-300:300;
plot(t,real(x), 'b');
ylabel('x(t)');
xlabel('t');
title('Regenerated x2(t) from D_n for -5:5');
legend('Signal x_2(t)');
grid;

```



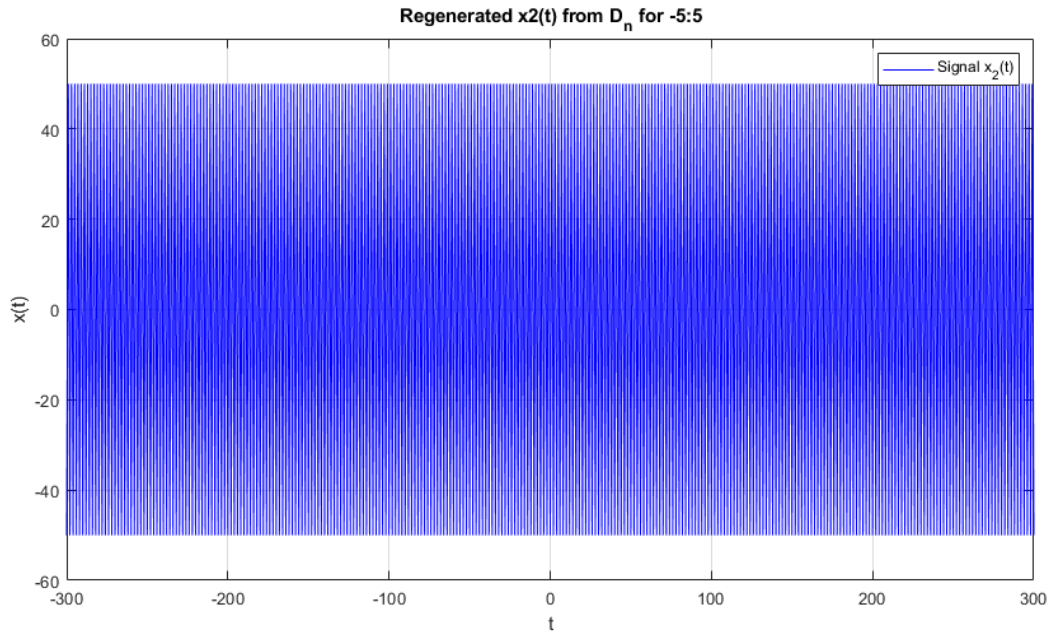


## A6 (x2d)

```

D_n=[-500:500]; nleftlim = -500;
nrightlim = 500;
x = 500+1;
if n == 0,
D_n(x) = 0.05;
else
D_n(n-nleftlim+1) = (sin(n.*pi*0.5)./(n.*pi));
end
n = [nleftlim:nrightlim];
W0 = pi/10;
t = -300:300;
s = 300+1;
b=length(t);
x = zeros(1,b);
for t=-300:300
for n=nleftlim:nrightlim
x(t+s) = x(t+s) + real(D_n(n-nleftlim+1).*exp(n.*1i*W0*t));
end
end
t=-300:300;
plot(t,real(x), 'b');
ylabel('x(t)');
xlabel('t');
title('Regenerated x2(t) from D_n for -5:5');
legend('Signal x_2(t)');
grid;

```

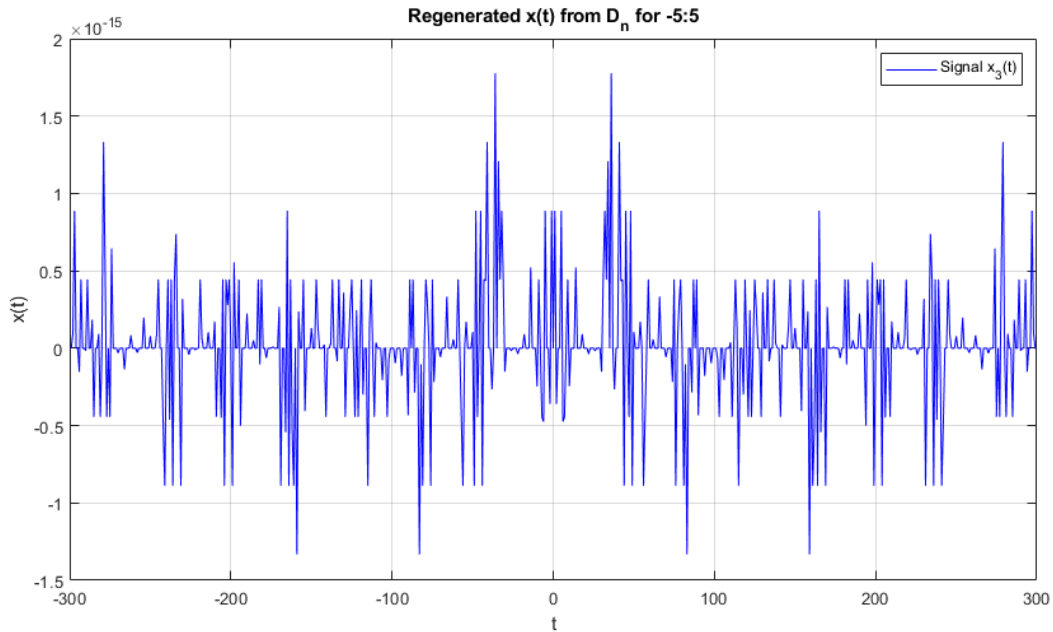


## A6 (x3a)

```

D_n=[-5:5];
nleftlim = -5;
nrightlim = 5;
x = 5+1;
if n == 0,
D_n(x) = 0.025;
else
D_n(n-nleftlim+1) = (sin(n.*pi*0.25)./(n.*pi));
end
n = [nleftlim:nrightlim];
W0 = pi/20;
t = -300:300;
s = 300+1;
b=length(t);
x = zeros(1,b);
for t=-300:300
for n=nleftlim:nrightlim
x(t+s) = x(t+s) + real(D_n(n-nleftlim+1).*exp(n.*1i*W0*t));
end
end
t=-300:300;
plot(t,real(x), 'b');
ylabel('x(t)');
xlabel('t');
title('Regenerated x(t) from D_n for -5:5');
legend('Signal x_3(t)');
grid;

```

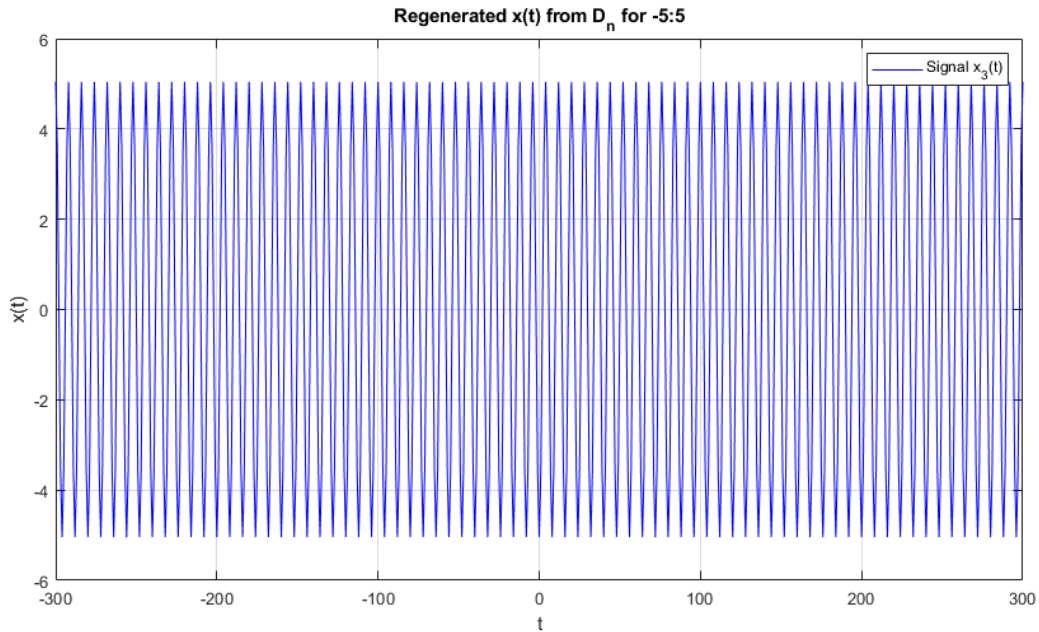


## A6 (x3b)

```

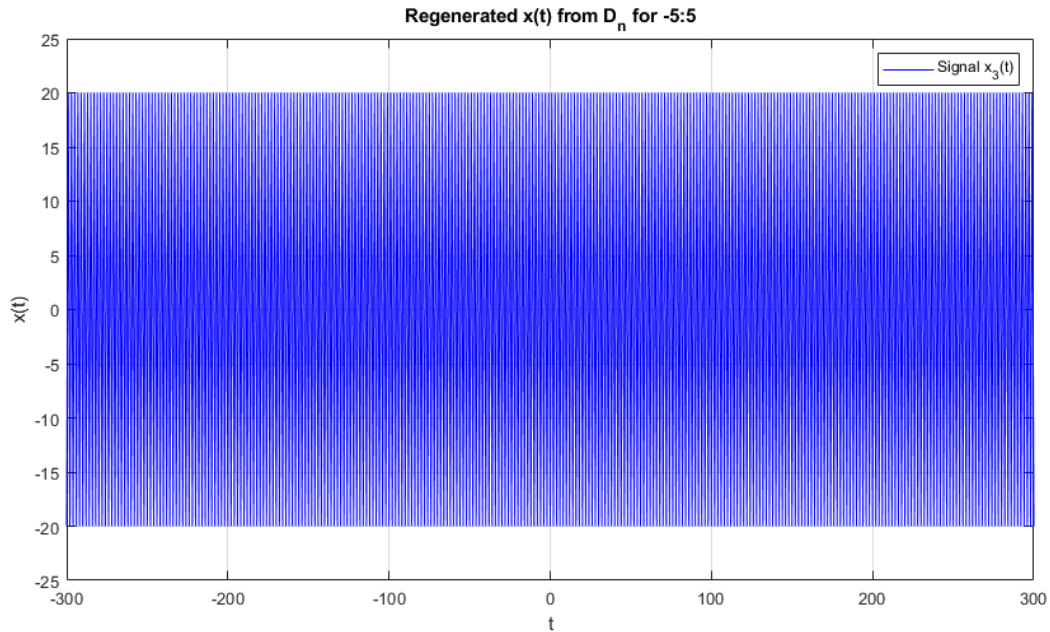
D_n=[-20:20];
nleftlim = -20;
nrightlim = 20;
x = 20+1;
if n == 0,
D_n(x) = 0.025;
else
D_n(n-nleftlim+1) = (sin(n.*pi*0.25)./(n.*pi));
end
n = [nleftlim:nrightlim];
W0 = pi/20;
t = -300:300;
s = 300+1;
b=length(t);
x = zeros(1,b);
for t=-300:300
for n=nleftlim:nrightlim
x(t+s) = x(t+s) + real(D_n(n-nleftlim+1).*exp(n.*1i*W0*t));
end
end
t=-300:300;
plot(t,real(x), 'b');
ylabel('x(t)');
xlabel('t');
title('Regenerated x(t) from D_n for -5:5');
legend('Signal x_3(t)');
grid;

```



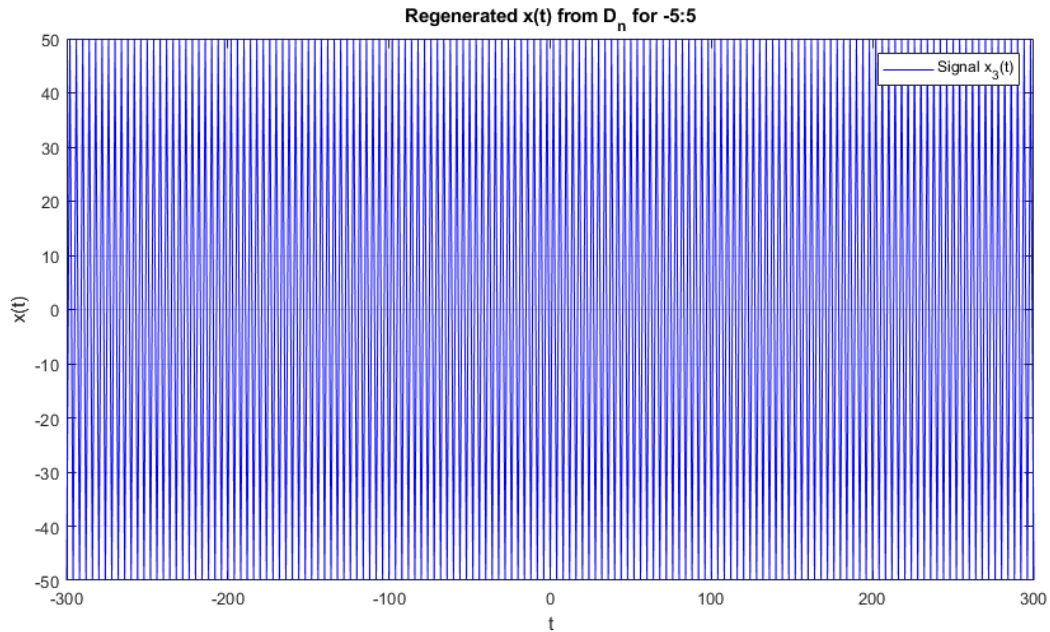
## A6 (x3c)

```
D_n=[-50:50];
nleftlim = -50;
nrightlim = 50;
x = 50+1;
if n == 0,
D_n(x) = 0.025;
else
D_n(n-nleftlim+1) = (sin(n.*pi*0.25)./(n.*pi));
end
n = [nleftlim:nrightlim];
W0 = pi/20;
t = -300:300;
s = 300+1;
b=length(t);
x = zeros(1,b);
for t=-300:300
for n=nleftlim:nrightlim
x(t+s) = x(t+s) + real(D_n(n-nleftlim+1).*exp(n.*1i*W0*t));
end
end
t=-300:300;
plot(t,real(x), 'b');
ylabel('x(t)');
xlabel('t');
title('Regenerated x(t) from D_n for -5:5');
legend('Signal x_3(t)');
grid;
```



## A6 (x3d)

```
D_n=[-500:500];
nleftlim = -500;
nrightlim = 500;
x = 500+1;
if n == 0,
D_n(x) = 0.025;
else
D_n(n-nleftlim+1) = (sin(n.*pi*0.25)./(n.*pi));
end
n = [nleftlim:nrightlim];
W0 = pi/20;
t = -300:300;
s = 300+1;
b=length(t);
x = zeros(1,b);
for t=-300:300
for n=nleftlim:nrightlim
x(t+s) = x(t+s) + real(D_n(n-nleftlim+1).*exp(n.*1i*W0*t));
end
end
t=-300:300;
plot(t,real(x), 'b');
ylabel('x(t)');
xlabel('t');
title('Regenerated x(t) from D_n for -5:5');
legend('Signal x_3(t)');
grid;
```



## B1

```
% From A.1 and A.2 ;
% wo for x1(t) : pi/10
% wo for x2(t) : pi/10
% wo for x3(t) : pi/20
```

## B2

```
% The difference between the fourier coefficients of x1 and x2 is
% that from  $n = (-\infty:\infty)$ , for x2, there are infinite coefficients and
% for x1, there will always be only 4 coefficients.
```

## B3

```
% The fourier coefficients are similar except for x3, the sin function
% is dilated by  $4\pi$  and for x2 the sine function is dilated by  $\pi/2$ 
```

## B4

```
% For x2,  $D_0$  is  $1/2$  and since x4 is just x2 shifted down by  $1/2$ ,  $D_0$  for
% x4 is 0
```

## B5

```
% x1 would not change since there are distinct numbers
% for x2 and x3 the higher the value of  $n$ , the more accurate
% the functions become
```

---

## B6

```
% for x2 and x3, you would need n to be from (-inf:inf) to reconstruct the  
% functions properly
```

## B7

```
% storing the coeffecients would not work as x(t) is arbitrary, so we don't  
% know how many coeffecients are there
```

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