Computer Assignment - 03 - Spring 2019

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Analysis and Synthesis

For the given periodic signals with the period T = 3, compute the Fourier coefficients and then reconstruct the original signal.

For each of the signals, plot the following:

1. The original and reconstructed signal on the same plot.
2. The Fourier coefficients; both the real and imaginary components vs the theoretical values.
3. Demonstrate the convergence of the reconstructed signal with respect to the original signal.

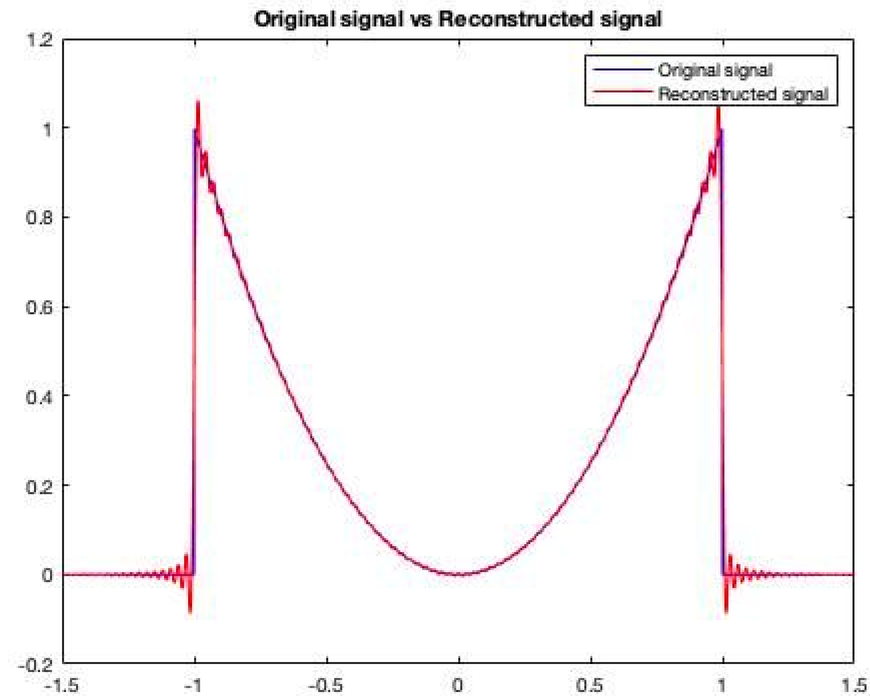
Signal: $x(t) = t^2$, $|t| < 1$

Solution:

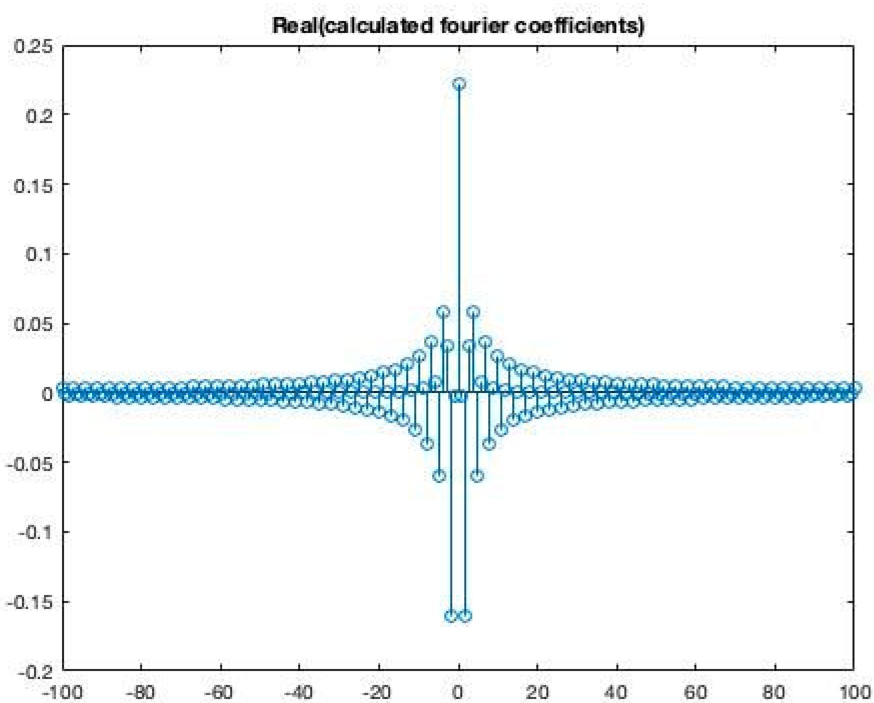
```
%function
function y = x(t)
    y = zeros(size(t));
    y(t>-1 & t<1) = t(t>-1 & t<1).^2;
end

T=3;
M=100;
w0 = 2*pi/T;
t = -(T/2):0.001:(T/2);
u = -M:M;
a = zeros(size((u)));

%calculating fourier coefficients
for k = 1:length(u)
    basis = exp(-1*1i*t*w0*u(k));
```

```
    a(k) = trapz(t,x(t).*basis)/T;
end
plot(t,x(t),'blue')
hold on

%re-construction
y = zeros(size(t));
for i = 1:length(t)
    for j = 1:length(u)
        y(i) = y(i)+(a(j)*exp(1i*u(j)*w0*t(i)));
    end
end

plot(t,real(y),'red')
hold off
legend('Original signal','Reconstructed signal');
title('Original signal vs Reconstructed signal');

%calculating theoretical fourier coefficients
theoretical_fourier_coefficients = zeros(size(u));
for k = 1:length(u)
    theoretical_fourier_coefficients(k) =
(2*(((u(k)*u(k)*w0*w0)-2)*sin(u(k)*w0)+2*u(k)*w0*cos(u(k)*w0))
)/(T*u(k)*u(k)*u(k)*w0*w0*w0);
end
theoretical_fourier_coefficients(101)=0.2219;
stem(u,real(a));
title('Real(calculated fourier coefficients)');
stem(u,real(theoretical_fourier_coefficients));
title('Real(theoretical fourier coefficients)');
stem(u,imag(a));
ylim([-0.2 0.2])
title('Imag(calculated fourier coefficients)');
```

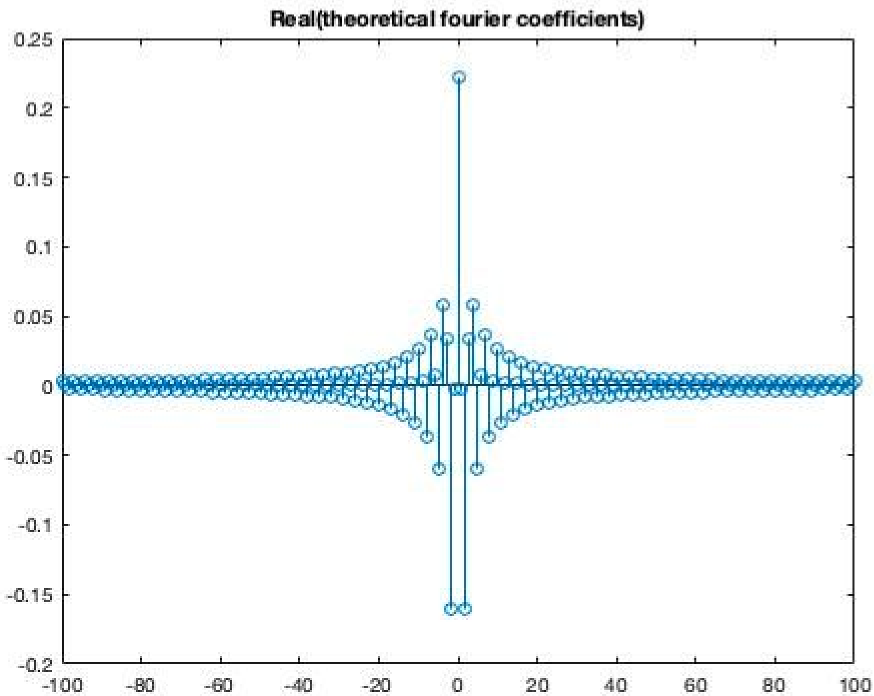
```
stem(u,imag(theoretical_fourier_coefficients));
title('Imag(theoretical fourier coefficients)');

%convergence
time_m = 1:100;
final_converge = zeros(size(time_m));
for i = 1:length(time_m)
    u = -i:i;
    a = zeros(size(u));
    for k = 1:length(u)
        basis = exp(-1*1i*t*w0*u(k));
        a(k) = trapz(t,x(t).*basis)/T;
    end
    y =zeros(size(t));
    for m = 1:length(t)
        for n = 1:length(u)
            y(m) = y(m)+(a(n)*exp(1i*u(n)*w0*t(m)));
        end
    end
    final_converge(i) = trapz(t,(abs(x(t)-y)).^2)/T;
end
stem(time_m,final_converge);
title('Converge of the signal')
```

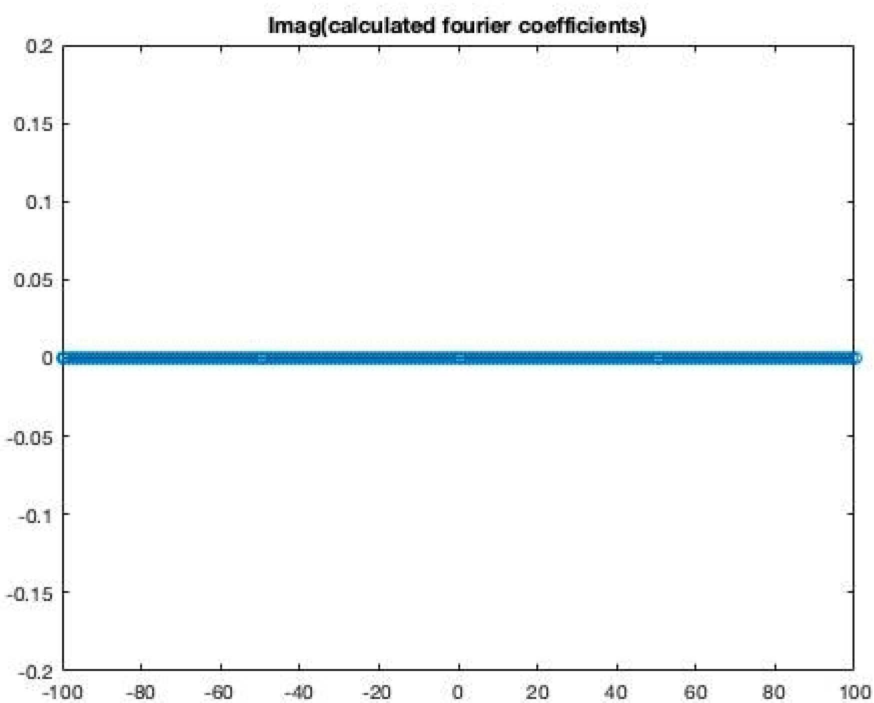


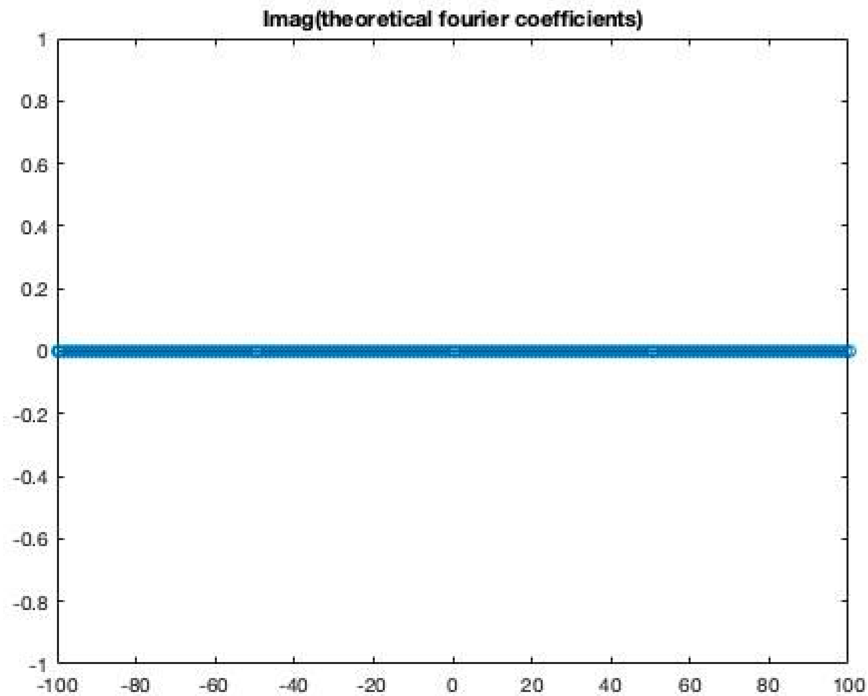
Original signal vs Reconstructed signal
Original signal
Reconstructed signal
1.2
1
0.8
0.6
0.4
0.2
0
-0.2
-1.5
-1
-0.5
0
0.5
1
1.5

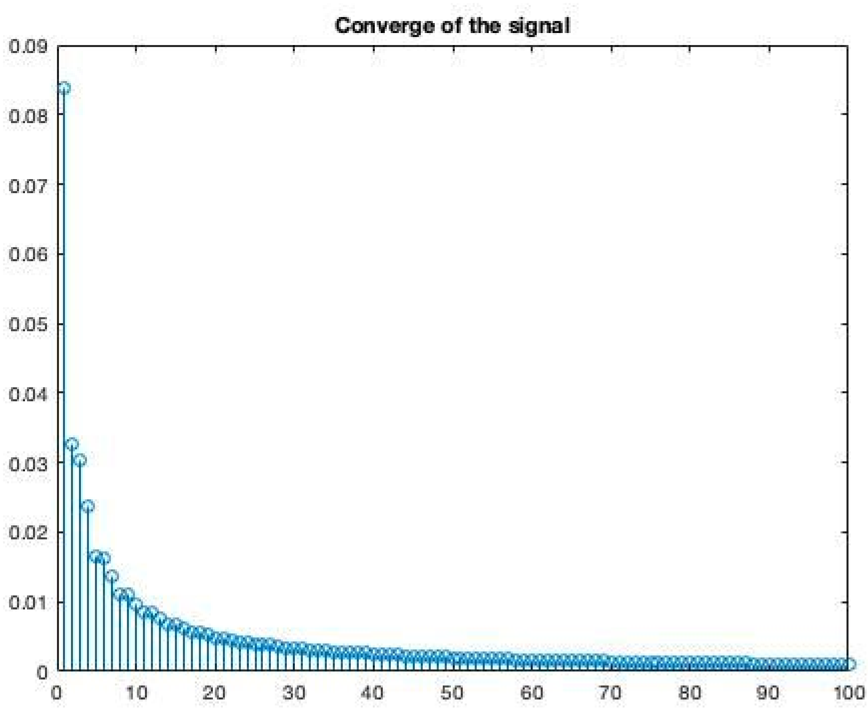


Real(calculated fourier coefficients)
0.25
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-100
-80
-60
-40
-20
0
20
40
60
80
100


Real(theoretical fourier coefficients)
0.25
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-100
-80
-60
-40
-20
0
20
40
60
80
100


Imag(calculated fourier coefficients)
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-100
-80
-60
-40
-20
0
20
40
60
80
100


Imag(theoretical fourier coefficients)
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
-100 -80 -60 -40 -20 0 20 40 60 80 100


Converge of the signal
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0 10 20 30 40 50 60 70 80 90 100

$$a_k = I = \frac{1}{3}\int_{-1}^{1} t^2 e^{-jk\omega t}\,dt$$

$$I = \frac{1}{3}\left[\int_{-1}^{1} t^2 e^{-jk\omega t}\,dt\right] = \frac{1}{3}\left[\left. t^2 \frac{e^{-jk\omega t}}{-jk\omega}\right|_{-1}^{1} - \int_{-1}^{1} \frac{2t\, e^{-jk\omega t}}{-jk\omega}\,dt\right]$$

Let $I_1 = \int_{-1}^{1} 2t\, e^{-jk\omega t}\,dt$

$$I_1 = 2\left[\left.\frac{t e^{-jk\omega t}}{-jk\omega}\right|_{-1}^{1} - \left.\frac{e^{-jk\omega t}}{(jk\omega)^2}\right|_{-1}^{1}\right] = 2\left[\frac{e^{-jk\omega} + e^{jk\omega}}{-jk\omega} - \frac{e^{-jk\omega} - e^{jk\omega}}{(jk\omega)^2}\right]$$

$$= 2\left[\frac{2\cos k\omega}{-jk\omega} + \frac{2j\sin k\omega}{(-1)(k\omega)^2}\right]$$

So

$$I = \frac{1}{3}\left[\left(\frac{e^{-jk\omega} - e^{jk\omega}}{-jk\omega}\right) - \frac{j4\cos k\omega}{(-j)(k\omega)^2} + \frac{4j\sin k\omega}{(k\omega)^2(k\omega)(-j)}\right]$$

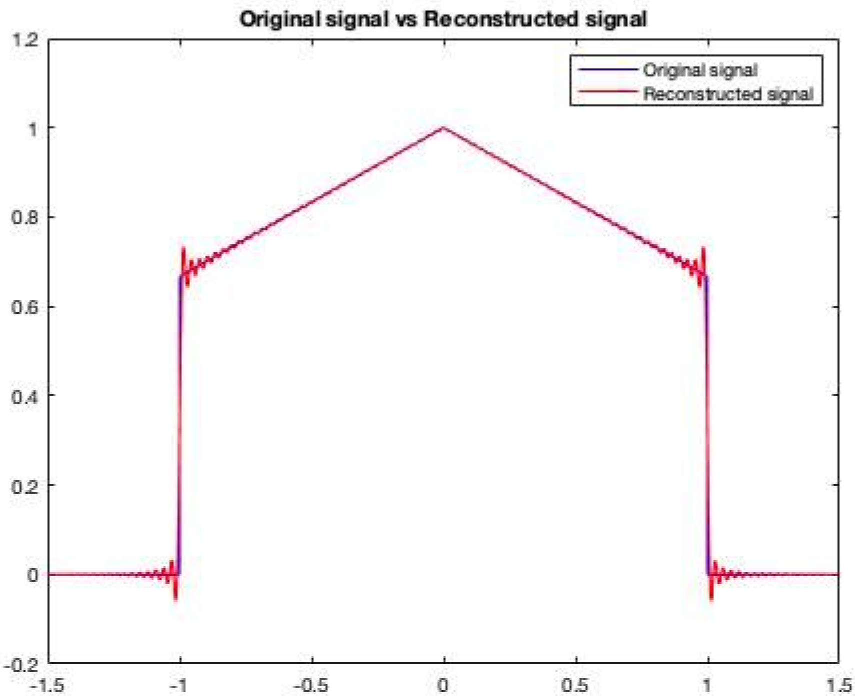
$$I = \frac{1}{3}\left[\frac{-2j\sin k\omega}{-jk\omega} + \frac{4\cos k\omega}{k^2\omega^2} + \frac{(-4)\sin k\omega}{(k\omega)^3}\right]$$

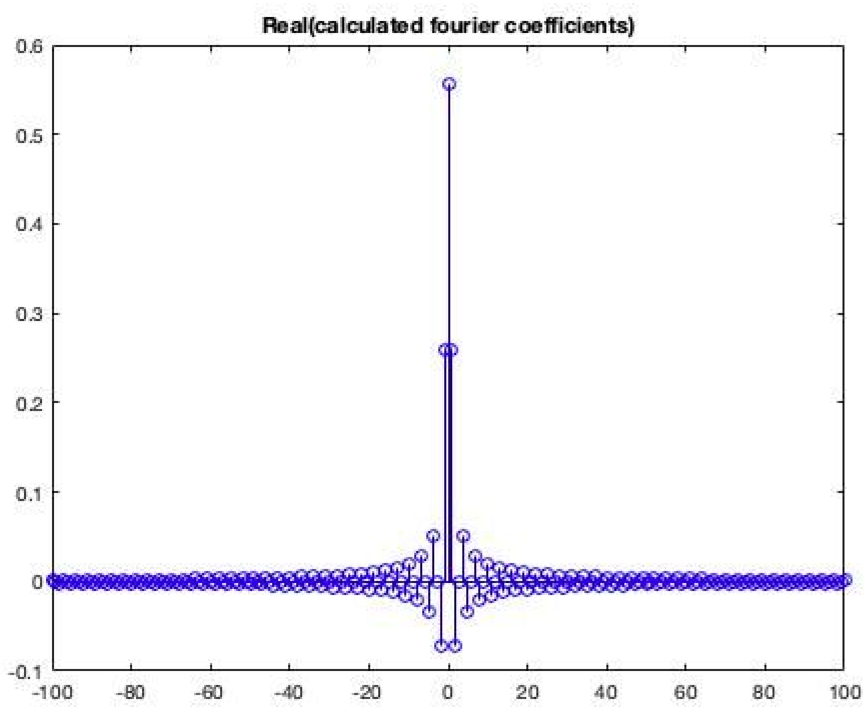
$$I = \frac{2}{3}\left[\frac{(k^2\omega^2 - 2)\sin(k\omega) + 2k\omega\cos(k\omega)}{k^3\omega^3}\right]$$

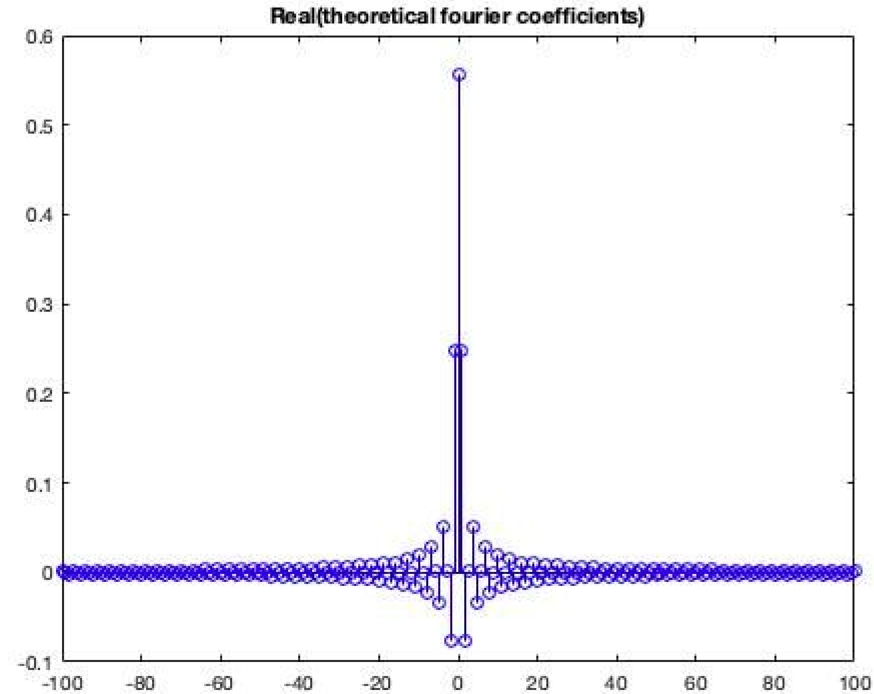
Signal: x(t) = 1-|t|/3 , |t| < 1
Solution:

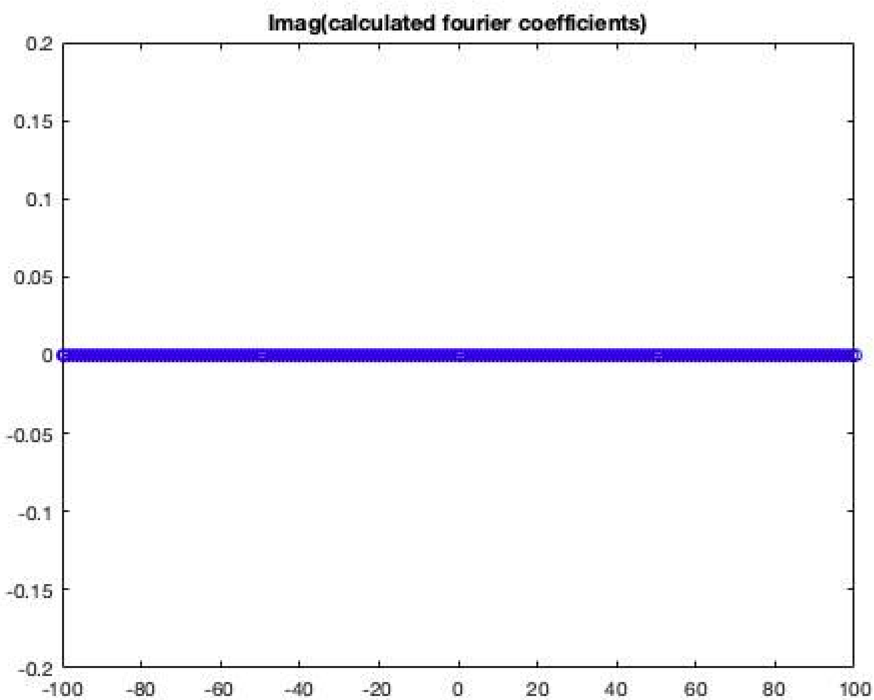
```
function y = x(t)
        y = zeros(size(t));
        y(t>-1 & t<1) = 1-(abs(t(t>-1 & t<1))/3);
end

T=3;
M=100;
w0 = 2*pi/T;
t = -(T/2):0.001:(T/2);
u = -M:M;
a = zeros(size((u)));
for k = 1:length(u)
   basis = exp(-1*1i*t*w0*u(k));
   a(k) = trapz(t,x(t).*basis)/T;
end
plot(t,x(t),'blue')
hold on

y = zeros(size(t));
for i = 1:length(t)
   for j = 1:length(u)
      y(i) = y(i)+(a(j)*exp(1i*u(j)*w0*t(i)));
   end
end
plot(t,real(y),'red')
hold off
legend('Original signal','Reconstructed signal');
title('Original signal vs Reconstructed signal');
theoretical_fourier_coefficients = zeros(size(u));
for k = 1:length(u)
```

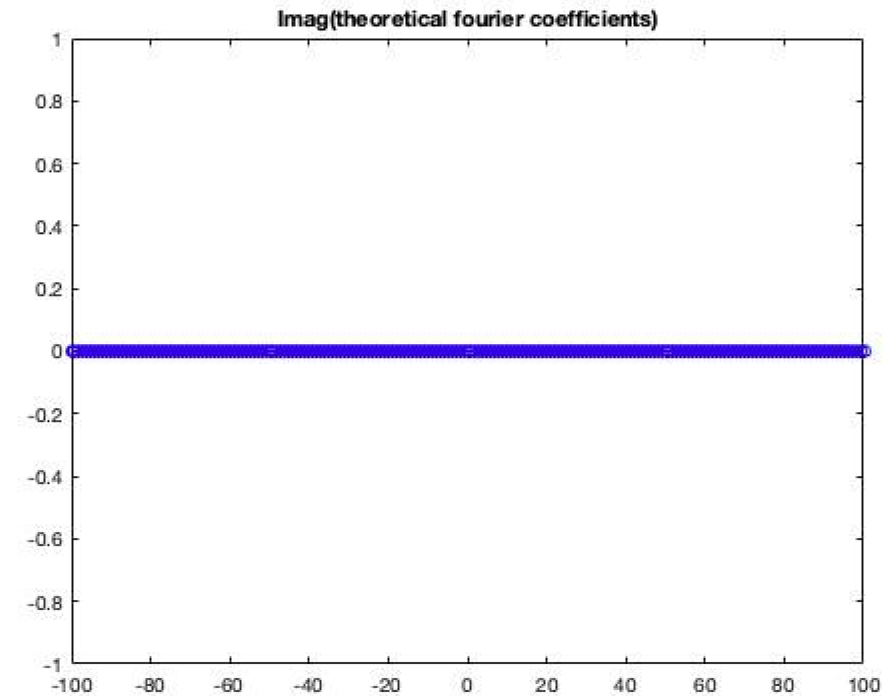
```
    theoretical_fourier_coefficients(k) =
(((4/3)*(sin(u(k)*w0)/(u(k)*w0))) +
((1/3)*(2-2*cos(u(k)*w0))/(u(k)*u(k)*w0*w0)))/T;
end
theoretical_fourier_coefficients(101)=0.5553;
stem(u,real(a),'blue');
title('Real(calculated fourier coefficients)');
stem(u,real(theoretical_fourier_coefficients),'blue');
title('Real(theoretical fourier coefficients)');
stem(u,imag(a),'blue');
ylim([-0.2 0.2])
title('Imag(calculated fourier coefficients)');
stem(u,imag(theoretical_fourier_coefficients),'blue');
title('Imag(theoretical fourier coefficients)');
time_m = 1:100;
final_converge = zeros(size(time_m));
for i = 1:length(time_m)
    u = -i:i;
    a = zeros(size(u));
    for k = 1:length(u)
        basis = exp(-1*1i*t*w0*u(k));
        a(k) = trapz(t,x(t).*basis)/T;
    end
    y =zeros(size(t));
    for m = 1:length(t)
        for n = 1:length(u)
            y(m) = y(m)+(a(n)*exp(1i*u(n)*w0*t(m)));
        end
    end
    final_converge(i) = trapz(t,(abs(x(t)-y)).^2)/T;
end
stem(time_m,final_converge);
title('Converge of the signal')
```

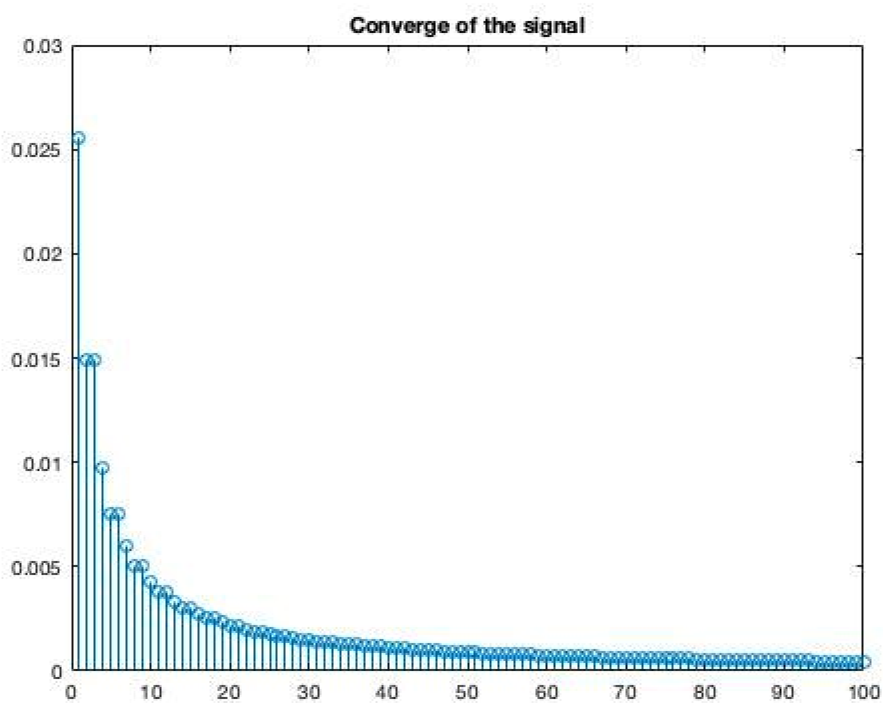

Original signal vs Reconstructed signal
Original signal
Reconstructed signal
1.2
1
0.8
0.6
0.4
0.2
0
-0.2
-1.5
-1
-0.5
0
0.5
1
1.5


Real(calculated fourier coefficients)
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
-100
-80
-60
-40
-20
0
20
40
60
80
100


Real(theoretical fourier coefficients)
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
-100
-80
-60
-40
-20
0
20
40
60
80
100


Imag(calculated fourier coefficients)
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-100
-80
-60
-40
-20
0
20
40
60
80
100


Imag(theoretical fourier coefficients)
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
-100
-80
-60
-40
-20
0
20
40
60
80
100


Converge of the signal
0.03
0.025
0.02
0.015
0.01
0.005
0
0
10
20
30
40
50
60
70
80
90
100

$$a_k = I = \frac{1}{3}\int_{-1}^{1} 1 - \frac{|t|}{3} \times e^{-jk\omega t}\,dt$$

$$I = \frac{1}{3}\int_{-1}^{0}\left(1+\frac{t}{3}\right)e^{-jk\omega t}\,dt + \int_{0}^{1}\left(1-\frac{t}{3}\right)e^{-jk\omega t}\,dt$$

$$= \frac{1}{3}\int_{-1}^{1} e^{-jk\omega t}\,dt + \frac{1}{3}\int_{-1}^{0} t\, e^{-jk\omega t} + \frac{-1}{3}\int_{0}^{1} e^{-jk\omega t} \times t\,dt$$

$$= \frac{e^{-jk\omega t}}{-jk\omega}\Big|_{-1}^{1} + \frac{1}{3}\left(t\,\frac{e^{-jk\omega t}}{-jk\omega}\Big|_{-1}^{1} - \frac{e^{-jk\omega t}}{(jk\omega)^2}\right)_{-1}^{0}$$

$$-\frac{1}{3}\left(t\,\frac{e^{-jk\omega t}}{-jk\omega}\Big|_{-1}^{1} - \frac{e^{-jk\omega t}}{(jk\omega)^2}\right)_{0}^{1}$$

$$= \frac{1}{3}\left[\frac{4}{3}\,\frac{\sin k\omega}{k\omega} + \frac{1}{3}\,\frac{(2-2\cos k\omega)}{k^2\omega^2}\right]$$

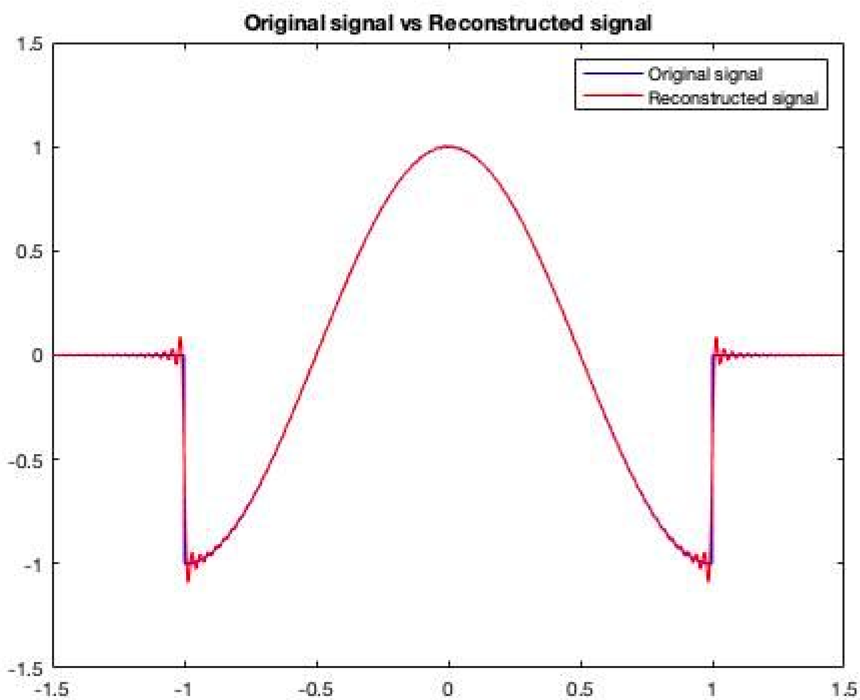
Signal: x(t) = cos(pi*t) , |t| < 1

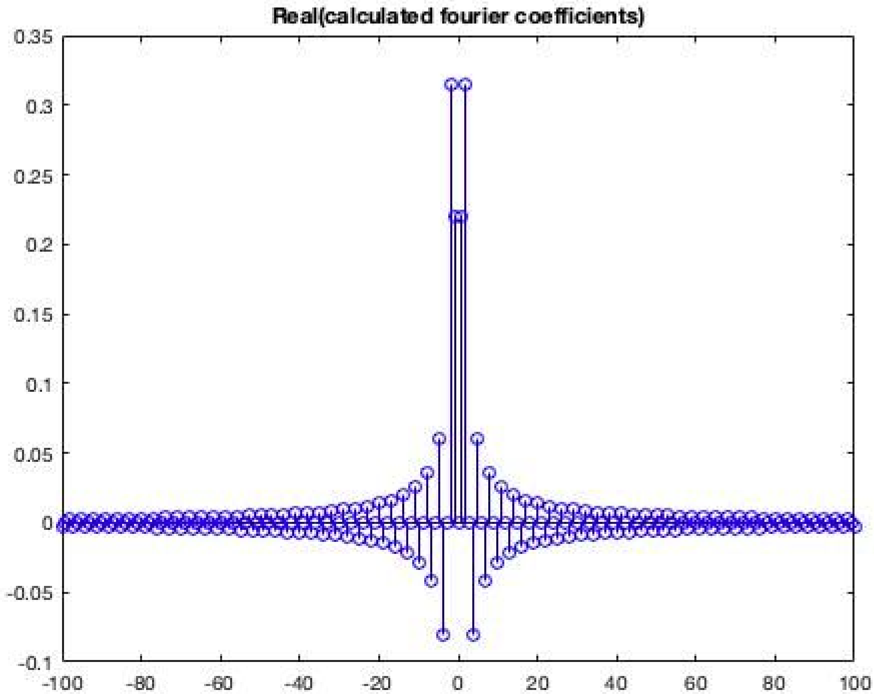
Solution:

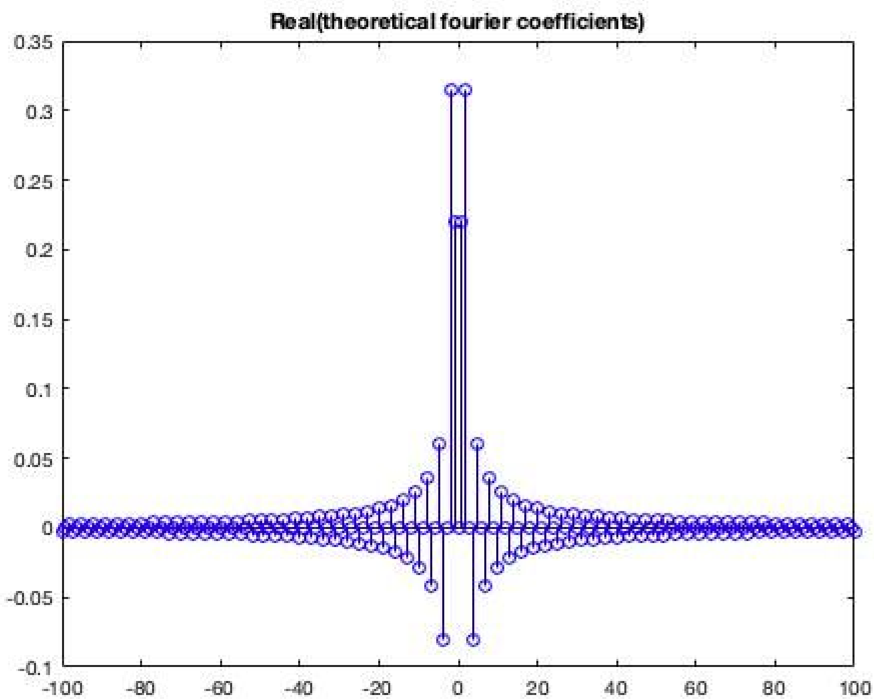
```
function y = x(t)
   y = zeros(size(t));
   y(t>-1 & t<1) = cos(pi*t(t>-1 & t<1));
end

T=3;
M=100;
w0 = 2*pi/T;
t = -(T/2):0.001:(T/2);
u = -M:M;
a = zeros(size((u)));
for k = 1:length(u)
   basis = exp(-1*1i*t*w0*u(k));
   a(k) = trapz(t,x(t).*basis)/T;
end
```

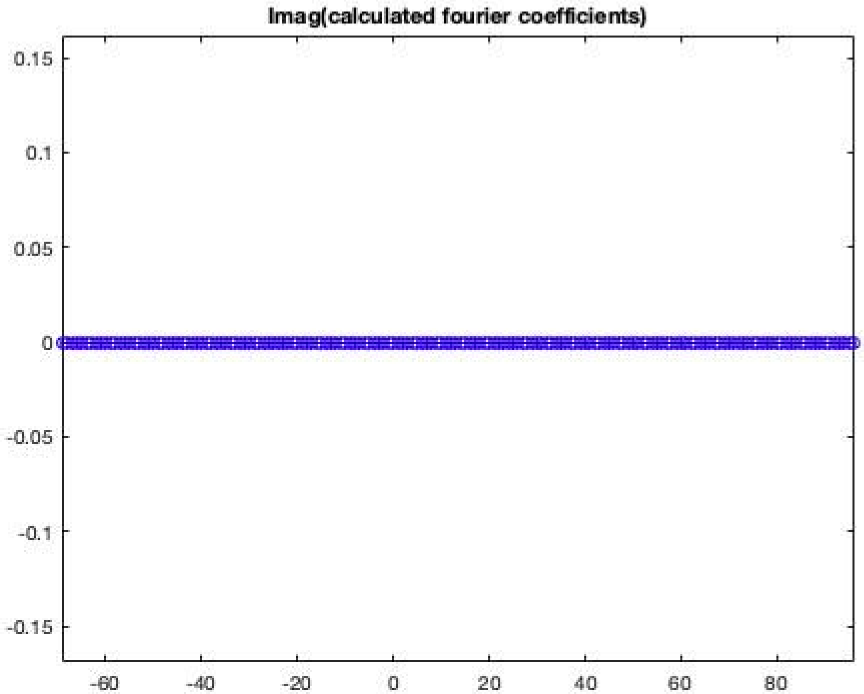
```
plot(t,x(t),'blue')
hold on

y = zeros(size(t));
for i = 1:length(t)
   for j = 1:length(u)
      y(i) = y(i)+(a(j)*exp(1i*u(j)*w0*t(i)));
   end
end
plot(t,real(y),'red')
hold off
legend('Original signal','Reconstructed signal');
title('Original signal vs Reconstructed signal');
theoretical_fourier_coefficients = zeros(size(u));
for k = 1:length(u)
   theoretical_fourier_coefficients(k) =
(2*u(k)*w0*sin(u(k)*w0))/((T)*((pi*pi)-(u(k)*u(k)*w0*w0)));
end
stem(u,real(a),'blue');
title('Real(calculated fourier coefficients)');
stem(u,real(theoretical_fourier_coefficients),'blue');
title('Real(theoretical fourier coefficients)');
stem(u,imag(a),'blue');
ylim([-0.2 0.2])
title('Imag(calculated fourier coefficients)');
stem(u,imag(theoretical_fourier_coefficients),'blue');
title('Imag(theoretical fourier coefficients)');

time_m = 1:100;
final_converge = zeros(size(time_m));
for i = 1:length(time_m)
   u = -i:i;
   a = zeros(size(u));
```

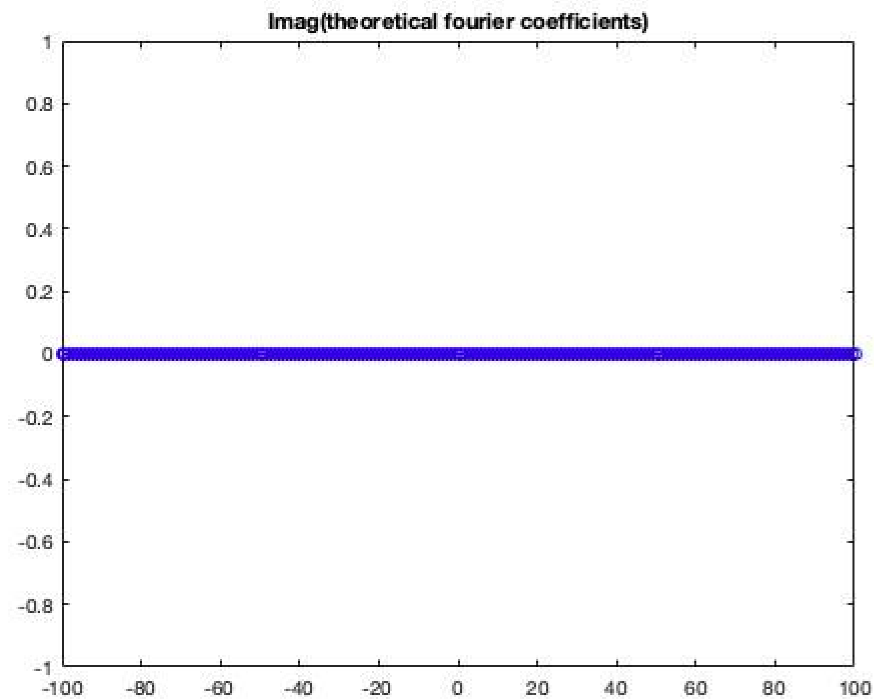
```
    for k = 1:length(u)
        basis = exp(-1*1i*t*w0*u(k));
        a(k) = trapz(t,x(t).*basis)/T;
    end
    y =zeros(size(t));
    for m = 1:length(t)
        for n = 1:length(u)
            y(m) = y(m)+(a(n)*exp(1i*u(n)*w0*t(m)));
        end
    end
    final_converge(i) = trapz(t,(abs(x(t)-y)).^2)/T;
end
stem(time_m,final_converge,'blue');
title('Converge of the signal')
```

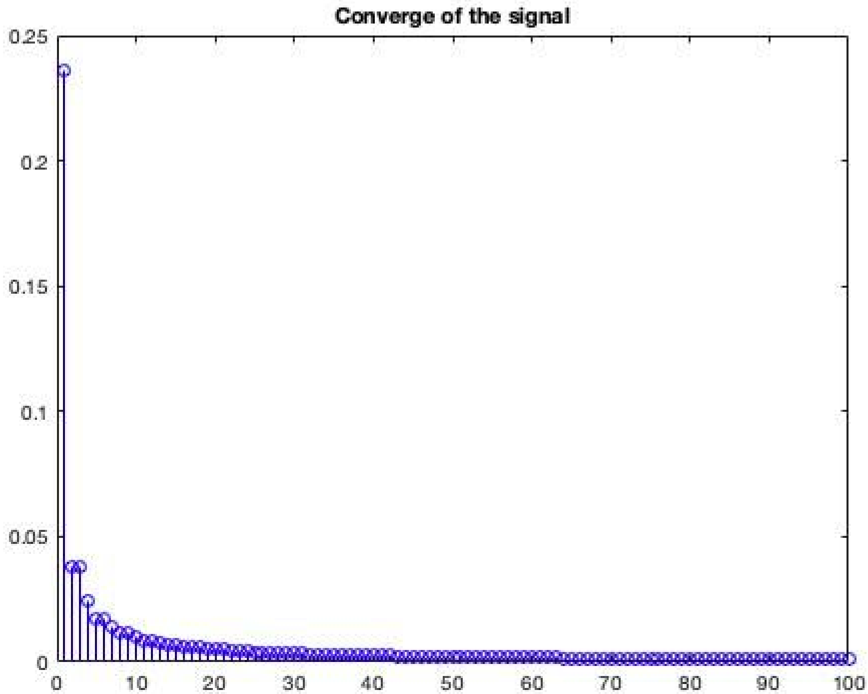



Real(calculated fourier coefficients)
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-100
-80
-60
-40
-20
0
20
40
60
80
100


Real(theoretical fourier coefficients)
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-100
-80
-60
-40
-20
0
20
40
60
80
100


Imag(calculated fourier coefficients)
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-60
-40
-20
0
20
40
60
80


Imag(theoretical fourier coefficients)
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
-100
-80
-60
-40
-20
0
20
40
60
80
100



$$a_k = \frac{1}{3}\int_{-1}^{1} \cos(\pi t)\, e^{-jk\omega_0 t}\, dt = \frac{1}{3}\int \cos(\pi t)\, e^{-jk\omega_0 t}\, dt$$

$$= \frac{1}{6}\int_{-1}^{1}\left[e^{-jt\left(\frac{3\pi + 2k\pi}{3}\right)} + e^{jt\,\frac{\pi - 2k\pi}{3}} \right] dt$$

$$= \frac{1}{6}\left| \frac{e^{-jt\,\frac{\pi}{3}(2k+3)}}{-j\,\frac{\pi}{3}(2k+3)} + \frac{e^{jt\,\frac{\pi}{3}(3-2k)}}{j\,\frac{\pi}{3}(3-2k)} \right|_{-1}^{1}$$

$$= \frac{1}{6}\left[\frac{-e^{-j\frac{\pi}{3}(2k+3)} + e^{j\frac{\pi}{3}(2k+3)}}{j\left(\frac{\pi}{3}\right)(2k+3)} \right] +$$

$$\frac{1}{6}\left[\frac{e^{j\frac{\pi}{3}(3-2k)} - e^{-j\frac{\pi}{3}(3-2k)}}{j\left(\frac{\pi}{3}\right)(3-2k)} \right]$$

$$= \frac{\sin \frac{\pi}{3}(2k+3)}{\pi(2k+3)} + \frac{\sin\left(\frac{\pi}{3}(3-2k)\right)}{\pi(3-2k)}$$

$$= \frac{2k\omega \sin k\omega}{3(\pi^2 - k^2\omega^2)} \quad \text{as } \omega = \frac{2\pi}{3}$$

Fourier Transform

For the given aperiodic signals, compute the Fourier transform and then the inverse Fourier Transform.

For each of the signals, plot the following:

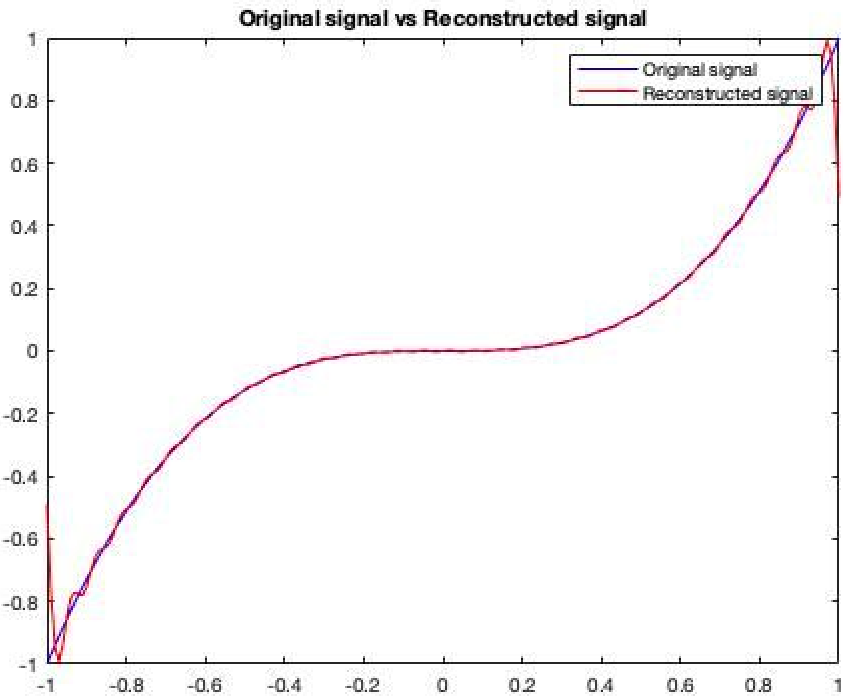
1. The original and reconstructed signal on the same plot.
2. The Fourier transform both the real and imaginary components vs the theoretical values.

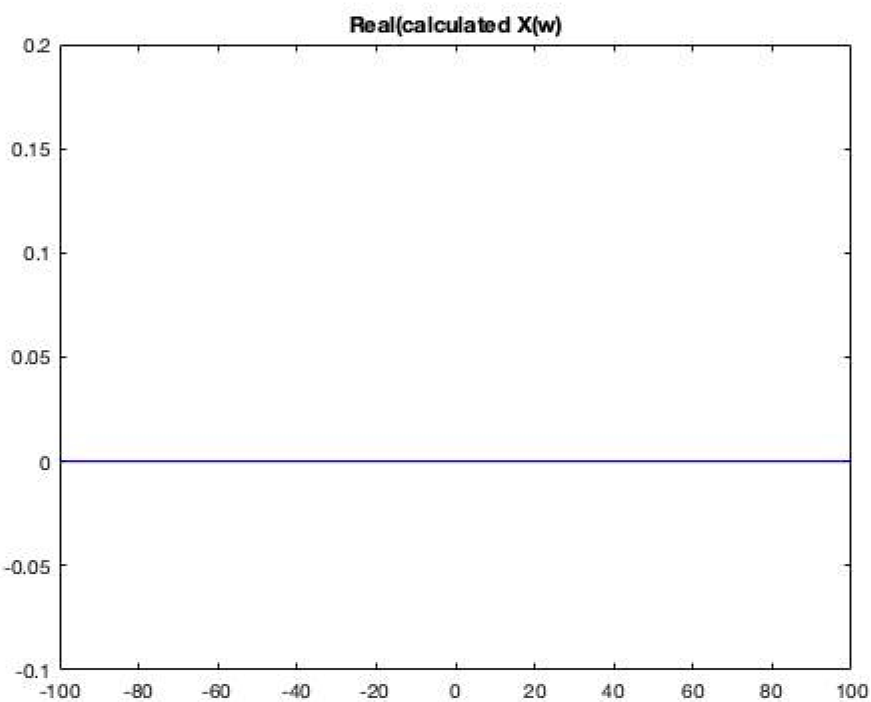
Signal: $x(t) = t^3$, $|t| < 1$

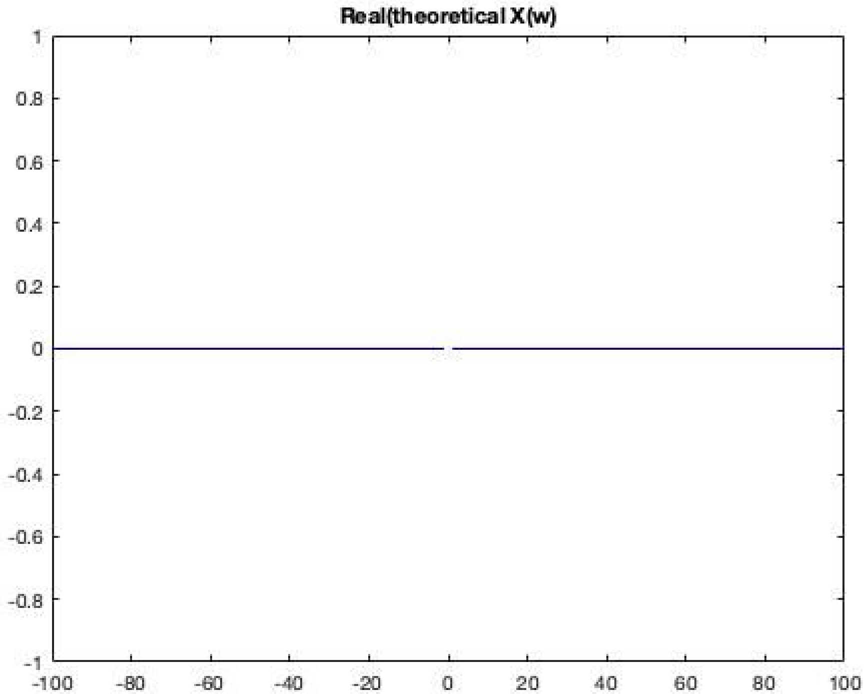
Solution:

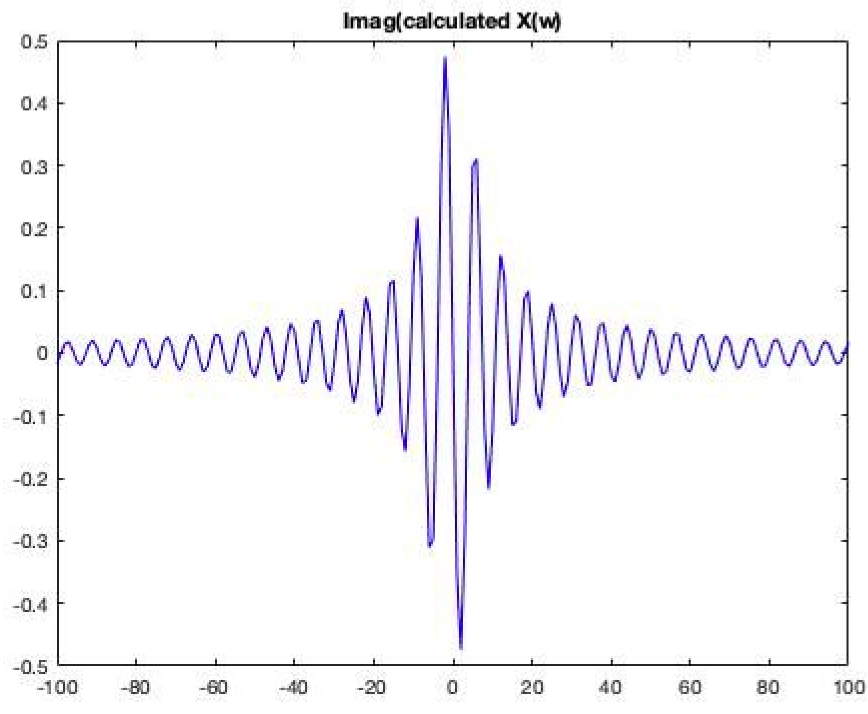
```
t = -1:0.01:1;
w0 = -100:100;
x = t.^3;
a =zeros(size(w0));

for i = 1:length(w0)
   basis = exp(-1i*w0(i)*t);
   a(i) = trapz(t,x.*basis);
end

theoretical_x_w = zeros(size(w0));
for i = 1:length(w0)
   w = w0(i);
```

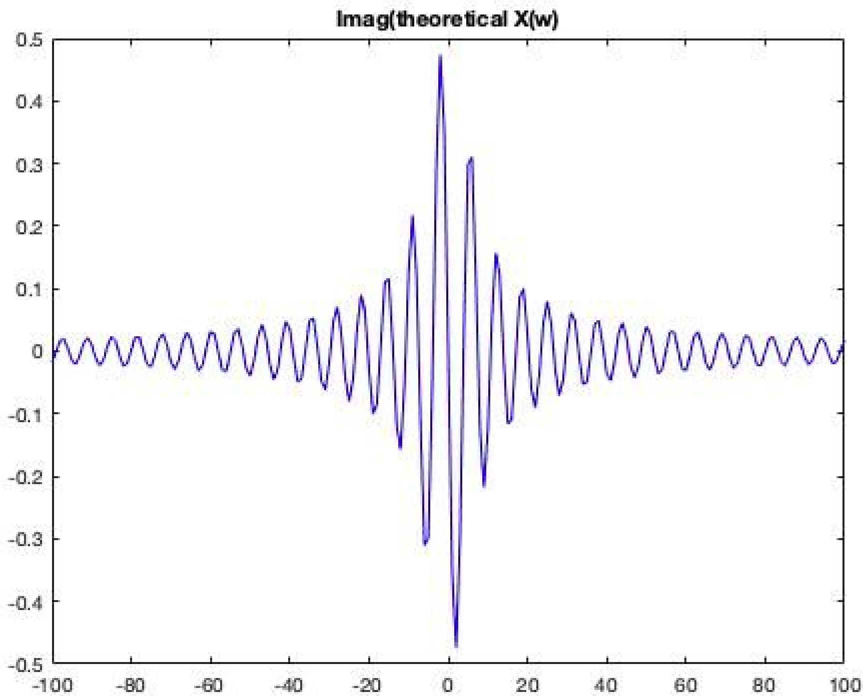
```
    theoretical_x_w(i) = ((2*1i*cos(w))/w) -
((6*1i*sin(w))/(w*w))-((12*1i*cos(w))/(w*w*w))+((12*1i*sin(w))/(
w*w*w*w));
end
theoretical_x_w(101)=0;
plot(w0,real(a));
title('Real(calculated X(w)');
ylim([-0.1 0.2])
plot(w0,real(theoretical_x_w));
title('Real(theoretical X(w)');
plot(w0,imag(a));
title('Imag(calculated X(w)');
plot(w0,imag(theoretical_x_w));
title('Imag(theoretical X(w)');
inverse_a = zeros(size(t));
for i = 1:length(t)
    basis = exp(1i*w0*t(i));
    inverse_a(i) = (trapz(w0,basis.*a))/(2*pi);
end

plot(t,x,'blue');
hold on;
plot(t,real(inverse_a),'red');
hold off;
legend('Original signal','Reconstructed signal')
title('Original signal vs Reconstructed signal')
```


Original signal vs Reconstructed signal
Original signal
Reconstructed signal
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1


Real(calculated X(w)
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-100
-80
-60
-40
-20
0
20
40
60
80
100


Real(theoretical X(w)
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
-100 -80 -60 -40 -20 0 20 40 60 80 100


Imag(calculated X(w)
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
-100 -80 -60 -40 -20 0 20 40 60 80 100



$x(t) = t^3 \qquad |t| < 1$

$X(\omega) = \int_{-\infty}^{\infty} x(t)\, e^{-j\omega t}\, dt = \int_{-\infty}^{\infty} t^3 e^{-j\omega t}\, dt$

$= \frac{t^3 e^{-j\omega t}}{-j\omega}\Big|_{-1}^{1} - \int_{-1}^{1} \frac{3t^2 e^{-j\omega t}}{-j\omega}\, dt \Big] \Rightarrow$

$= \frac{e^{-j\omega} + e^{j\omega}}{-j\omega} + \frac{3}{j\omega}\, \frac{t^2 e^{-j\omega t}}{-j\omega}\Big|_{-1}^{1} - \int_{-1}^{1} 2\frac{t\, e^{-j\omega t}}{-j\omega}\, dt$

$= \frac{2\cos\omega}{-j\omega} + \frac{3}{j^2\omega^2}\left(e^{-j\omega} - e^{j\omega}\right) + \frac{6}{j^2\omega^2} \int_{-1}^{1} t\, e^{-j\omega t}\, dt$

$= \frac{2j\cos\omega}{\omega} + \frac{3}{\omega^2}\left(-2j\sin\omega\right) - \frac{6}{\omega^2}\, \frac{t\, e^{-j\omega t}}{-j\omega}\Big|_{-1}^{1} - \int_{-1}^{1} \frac{e^{-j\omega t}}{-j\omega}\, dt$

$= \frac{2j\cos\omega}{\omega} - \frac{6j\sin\omega}{\omega^2} - \frac{12j\cos\omega}{\omega^3} + \frac{6}{-j\omega^3} \cdot \frac{e^{-j\omega t}}{(-j\omega)}\Big|_{-1}^{1}$

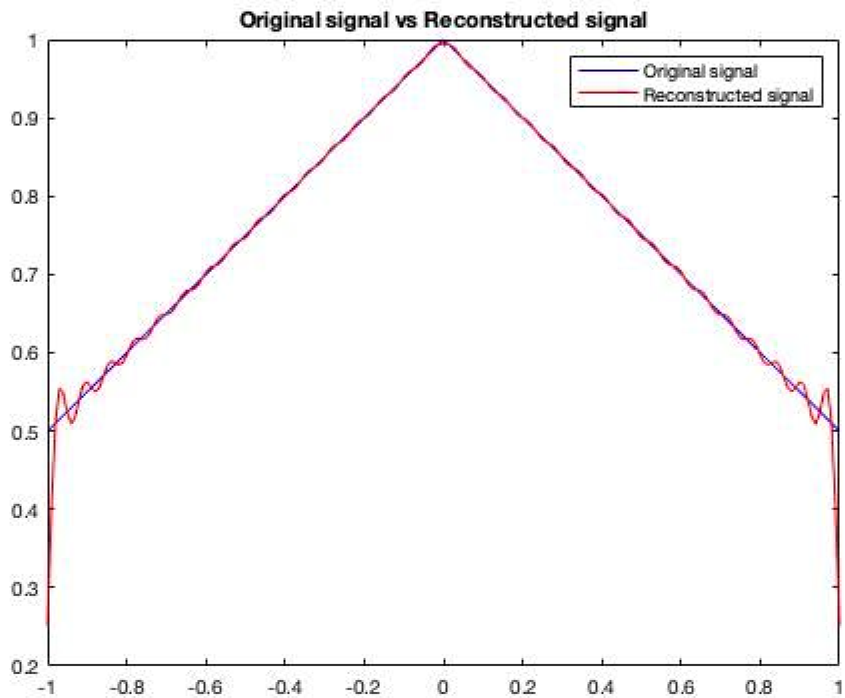
$= \frac{2j\cos\omega}{\omega} - \frac{6j\sin\omega}{\omega^2} - \frac{12j\cos\omega}{\omega^3} - \frac{6}{\omega^4}\left(-2j\sin\omega\right)$

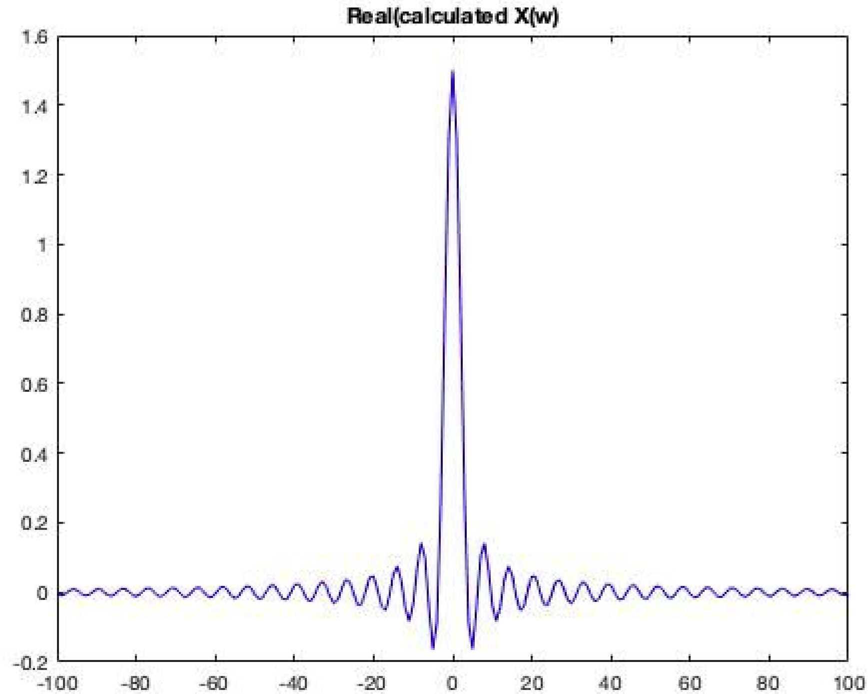
$= \frac{2j\cos\omega}{\omega} - \frac{6j\sin\omega}{\omega^2} - \frac{12j\cos\omega}{\omega^3} + \frac{12j\sin\omega}{\omega^4}$ Ans

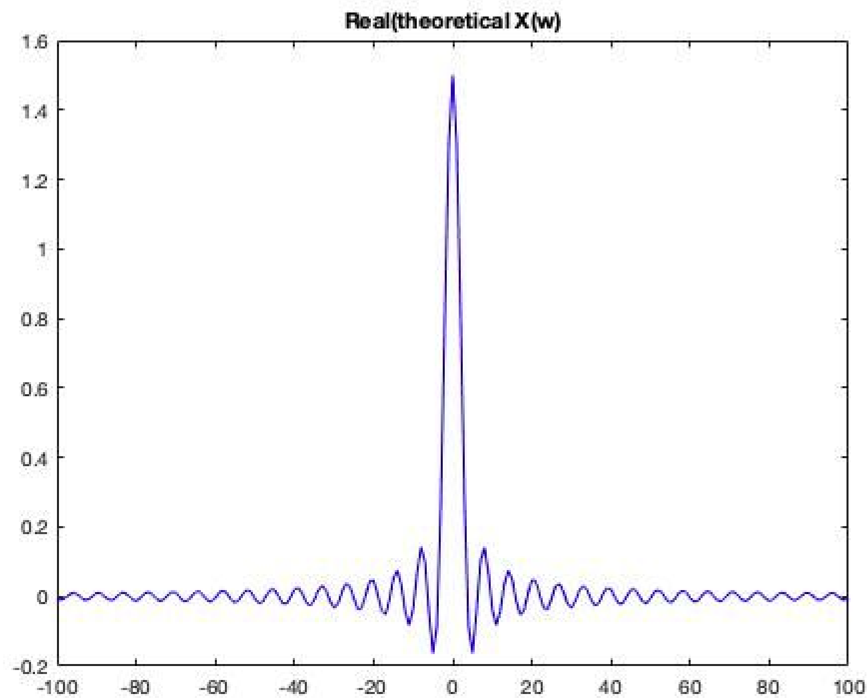
Signal: x(t) = 1-|t|/2 , |t| < 1
Solution:

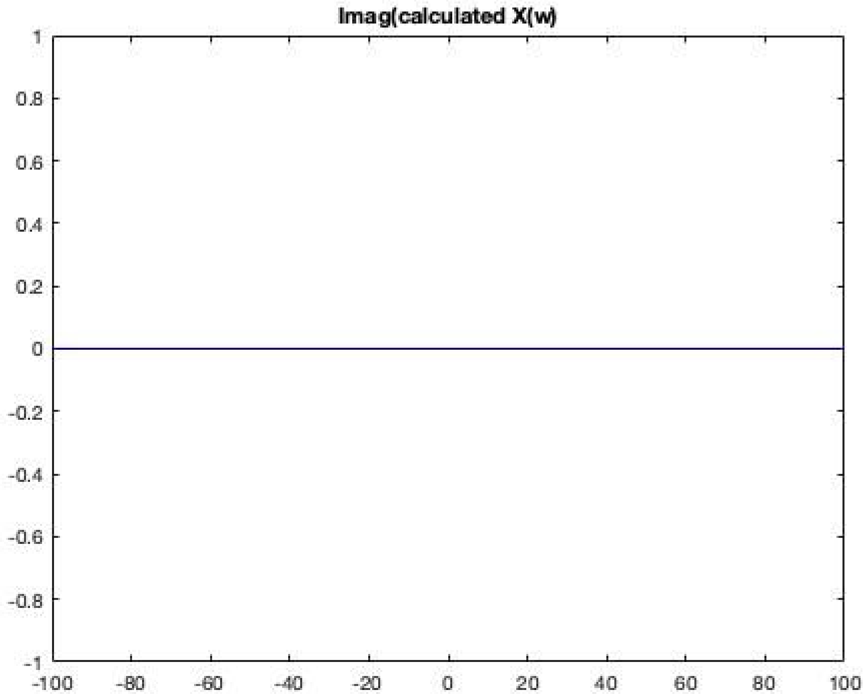
```
t = -1:0.01:1;
w0 = -100:100;
x = 1-((abs(t))/2);
a =zeros(size(w0));
for i = 1:length(w0)
   basis = exp(-1i*w0(i)*t);
   a(i) = trapz(t,x.*basis);
end
theoretical_x_w = zeros(size(w0));
for i = 1:length(w0)
   w = w0(i);
   theoretical_x_w(i) = (((sin(w)/(w))) +
((1/2)*(2-2*cos(w))/(w*w)));
end
theoretical_x_w(101)=1.5;
plot(w0,real(a),'blue');
title('Real(calculated X(w)');
plot(w0,real(theoretical_x_w),'blue');
title('Real(theoretical X(w)');
plot(w0,imag(a),'blue');
title('Imag(calculated X(w)');
ylim([-1 1])
plot(w0,imag(theoretical_x_w),'blue');
title('Imag(theoretical X(w)');
inverse_a = zeros(size(t));
for i = 1:length(t)
   basis = exp(1i*w0*t(i));
   inverse_a(i) = (trapz(w0,basis.*a))/(2*pi);
end
plot(t,x,'blue');
hold on;
```

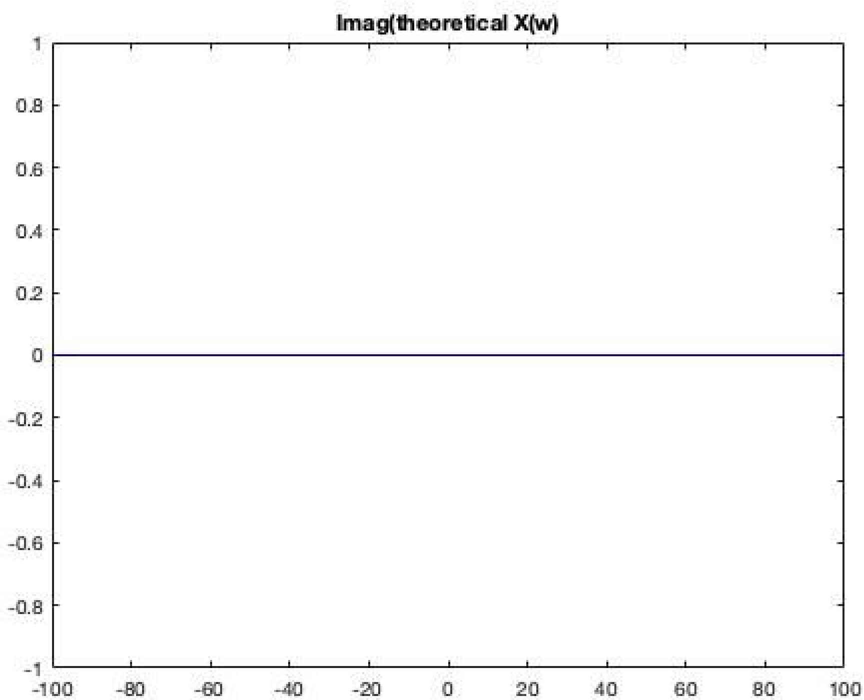
```
plot(t,real(inverse_a),'red');
hold off;
legend('Original signal','Reconstructed signal')
title('Original signal vs Reconstructed signal')
```




Real(calculated X(w)
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
-0.2
-100
-80
-60
-40
-20
0
20
40
60
80
100


Real(theoretical X(w)
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
-0.2
-100
-80
-60
-40
-20
0
20
40
60
80
100


Imag(calculated X(w)
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
-100
-80
-60
-40
-20
0
20
40
60
80
100


Imag(theoretical X(w)
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
-100
-80
-60
-40
-20
0
20
40
60
80
100

$$X(\omega) = \int_{-1}^{1} x(t)\, e^{-j\omega t}\, dt \qquad x(t) = 1 - \frac{|t|}{2}$$

$$= \int_{-1}^{0} \left(1 + \frac{t}{2}\right) e^{-j\omega t} dt + \int_{0}^{1} \left(1 - \frac{t}{2}\right) e^{-j\omega t}\, dt$$

$k = 1$

$$= \int_{-1}^{1} e^{-jkt}\, dt + \frac{1}{2} \int_{-1}^{0} t\, e^{-j\omega t}\, dt + -\frac{1}{2} \int_{0}^{1} e^{-jk\omega t}\, dt \times 1$$

$$= \frac{e^{-jk\omega t}}{-jk\omega}\Big|_{-1}^{1} + \frac{1}{2}\left(\frac{t\, e^{-jk\omega t}}{-jk\omega}\Big|_{-1}^{0} - \frac{e^{-j\omega t}}{(j\omega)^2}\Big|_{-1}^{0} \right)$$

$$-\frac{1}{2}\left(\frac{t\, e^{-j\omega t}}{-j\omega}\Big|_{0}^{1} - \frac{e^{-j\omega t}}{(j\omega)^2}\Big|_{0}^{1} \right)$$

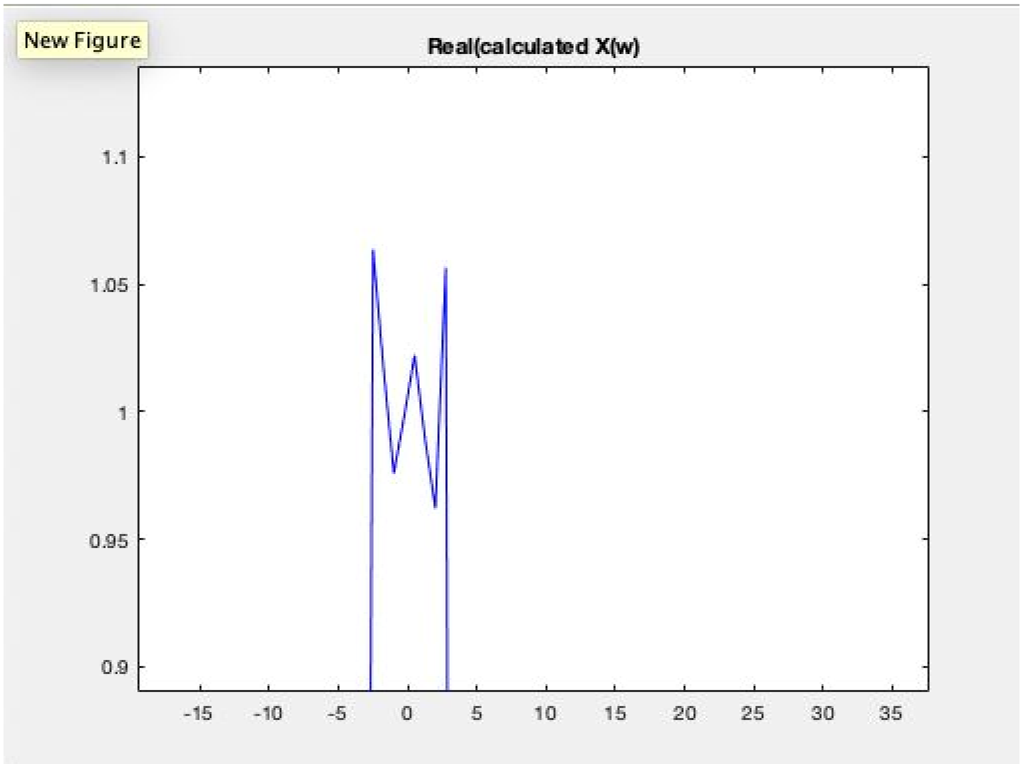
$k = 1$

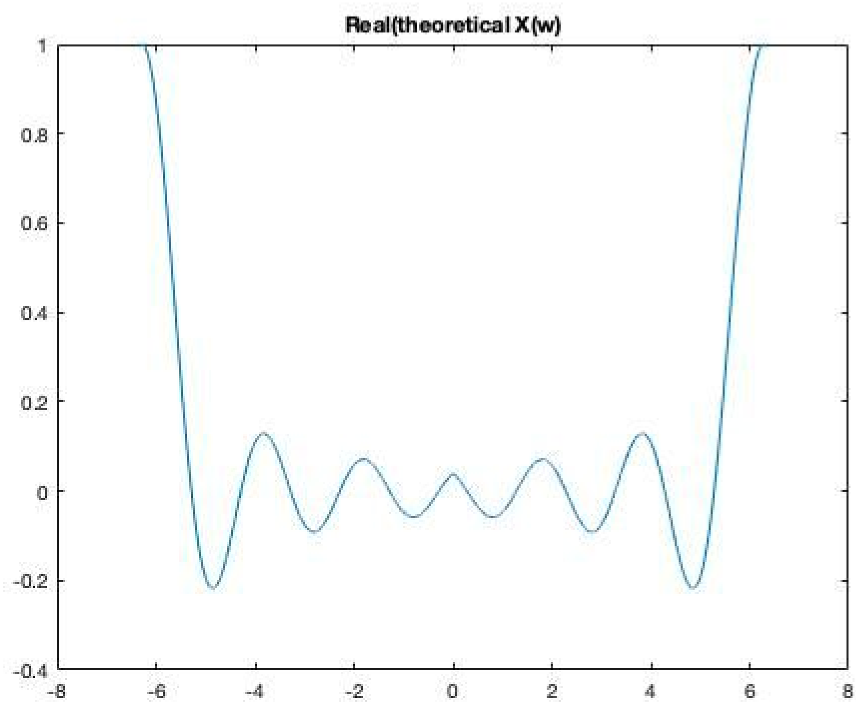
$$= \frac{\sin k\omega}{\omega} + \frac{1 - \cos\omega}{\omega^2}$$

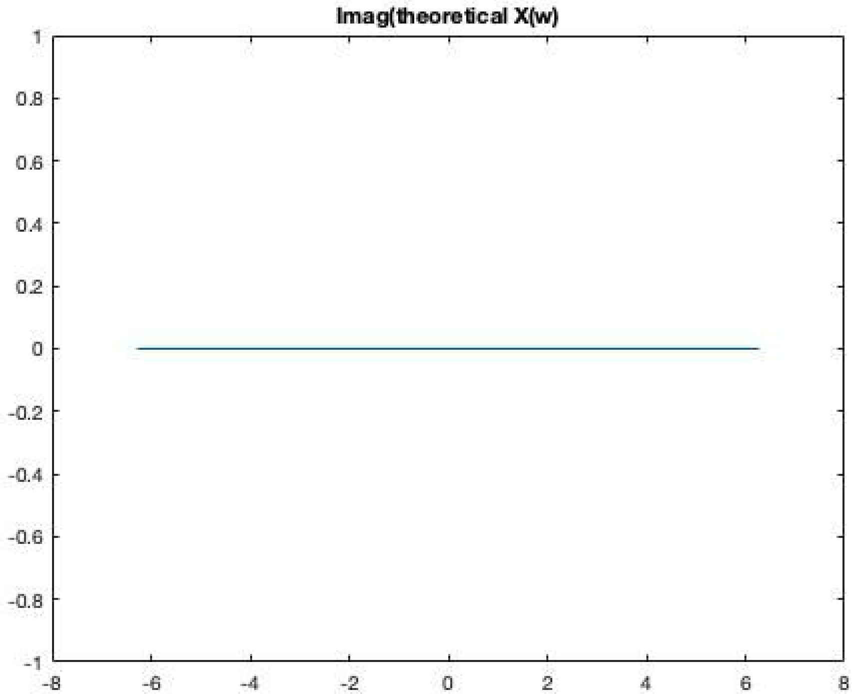
$$= \frac{\sin\omega}{\omega} + \frac{1 - \cos\omega}{\omega^2}$$

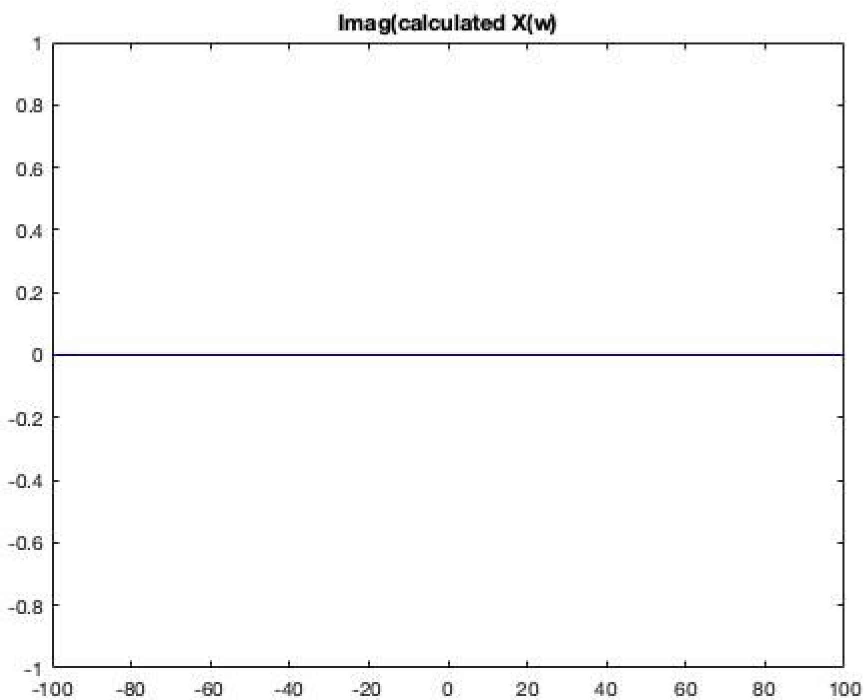
Signal: x(t) = sinc(t) , |t| < 2*pi
Solution:

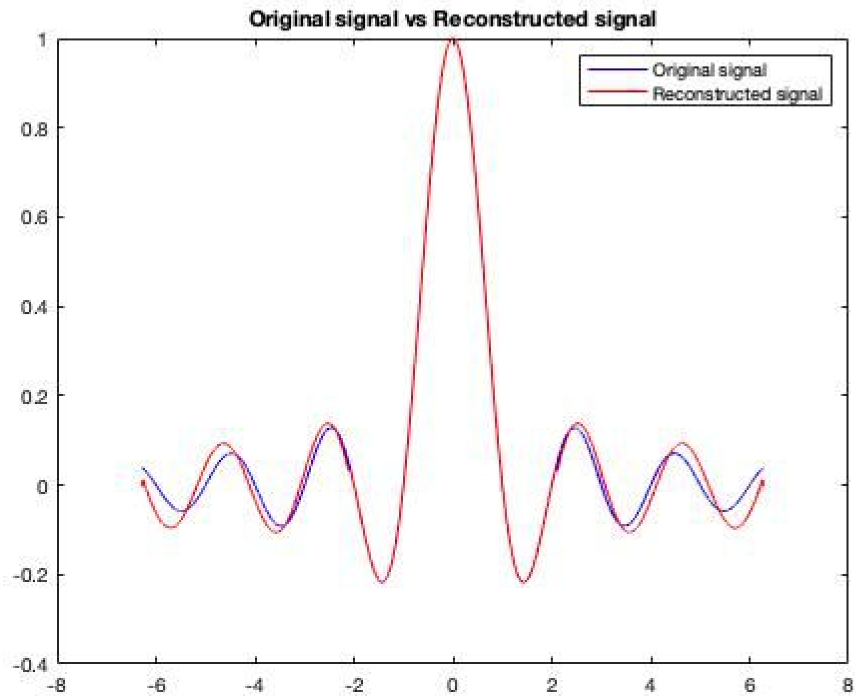
```
t = -2*pi:0.001:2*pi;
w0 = -100:0.75:100;
x = sinc(t);
a =zeros(size(w0));
for i = 1:length(w0)
   basis = exp(-1i*w0(i)*t);
   a(i) = trapz(t,x.*basis);
end
plot(t,real(fftshift(x)));
title('Real(theoretical X(w)');
plot(t,imag(fftshift(x)));
title('Imag(theoretical X(w)');
plot(w0,real(a),'blue');
title('Real(calculated X(w)');

plot(w0,imag(a),'blue');
title('Imag(calculated X(w)');
ylim([-1 1])
inverse_a = zeros(size(t));
for i = 1:length(t)
   basis = exp(1i*w0*t(i));
   inverse_a(i) = (trapz(w0,basis.*a))/(2*pi);
end
plot(t,x,'blue');
hold on;
plot(t,real(inverse_a),'red');
hold off;
legend('Original signal','Reconstructed signal')
title('Original signal vs Reconstructed signal')
```


New Figure
Real(calculated X(w)
1.1
1.05
1
0.95
0.9
-15
-10
-5
0
5
10
15
20
25
30
35


Real(theoretical X(w)
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-8
-6
-4
-2
0
2
4
6
8


Imag(theoretical X(w)
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
-8
-6
-4
-2
0
2
4
6
8


Imag(calculated X(w)
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
-100
-80
-60
-40
-20
0
20
40
60
80
100


Original signal vs Reconstructed signal
Original signal
Reconstructed signal
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-8
-6
-4
-2
0
2
4
6
8

Thank You!!