EE256 ASSIGNMENT 2

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Subject Name: Signals and Systems

Q1)

1. When defining the impulse function $\delta(t)$ or Dirac delta function, the specific shape of the signal used to approximate it is not crucial. The impulse function is a theoretical construct representing an infinitely narrow pulse at a specific point in time. Consider the following cases:

   (a) The triangular pulse

   $$\Lambda_\Delta(t) = \frac{1}{\Delta}\left(1 - \frac{|t|}{\Delta}\right)(u(t+\Delta) - u(t-\Delta))$$

   Carefully plot it using MATLAB, compute its area, and find its limit as $\Delta \to 0$. What do you obtain in the limit?

   (b) Consider the signal

   $$S_\Delta(t) = \frac{\sin\left(\frac{\pi t}{\Delta}\right)}{\pi t}$$

   Use the properties of the sinc signal $S = \sin(\pi t)/(\pi t)$ to express $S_\Delta(t)$ in terms of S(t). Then find its area, and the limit as $\Delta(t) \to 0$. Use symbolic MATLAB to show that for decreasing values of $\Delta(t) \to 0$, $S_\Delta(t)$ becomes like the impulse signal.

A1)A)

```
d=0.1
t=linspace(-3,3,10000);
triangular_pulse= (1/d)*(1-(abs(t)/d)).*(heaviside(t+d)-heaviside(t-d));

plot(t,triangular_pulse)
xlabel('time','FontSize',15,'Color',[0.15 0.15 0.15])
ylabel('pulse','FontSize',15,'Color',[0.45,0.45,0.45])

area= trapz(t,triangular_pulse);
disp(area)

%we can conclude that-

% the area is 1 for the given impulse
% as the value of d tends to 0, the triangle becomes more thin and the
% height inc such that  the area remains constant i.e 1
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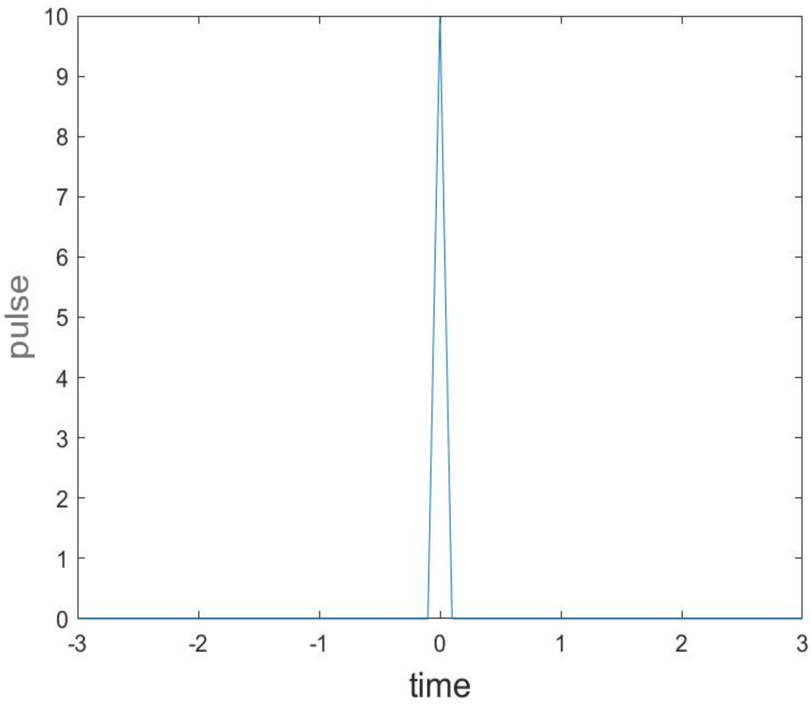
% hence the value of limit at t=0 of the function for a specific value of d
% is not constant and keeps changing

% for d=0
%at t=0
d=sym("d")
t=0
triangular_pulse= (1/d)*(1-(abs(t)/d)).*(heaviside(t+d)-heaviside(t-d));

limit(triangular_pulse,d,0)
```



A1)B)

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sinc_func = @(x) sin(pi * x) / (pi * x);
S_t = @(t) sinc_func(t);
Delta = 0.1;
S_delta_t = @(t) sinc_func(t / Delta) * S_t(t);

t_values = linspace(-10, 10, 1000);
figure;
```

```
subplot(2,1,1);
plot(t_values, arrayfun(S_t, t_values));
title('S(t)');

subplot(2,1,2);
plot(t_values, arrayfun(S_delta_t, t_values));
title(['S_\Delta(t) for \Delta = ' num2str(Delta)]);

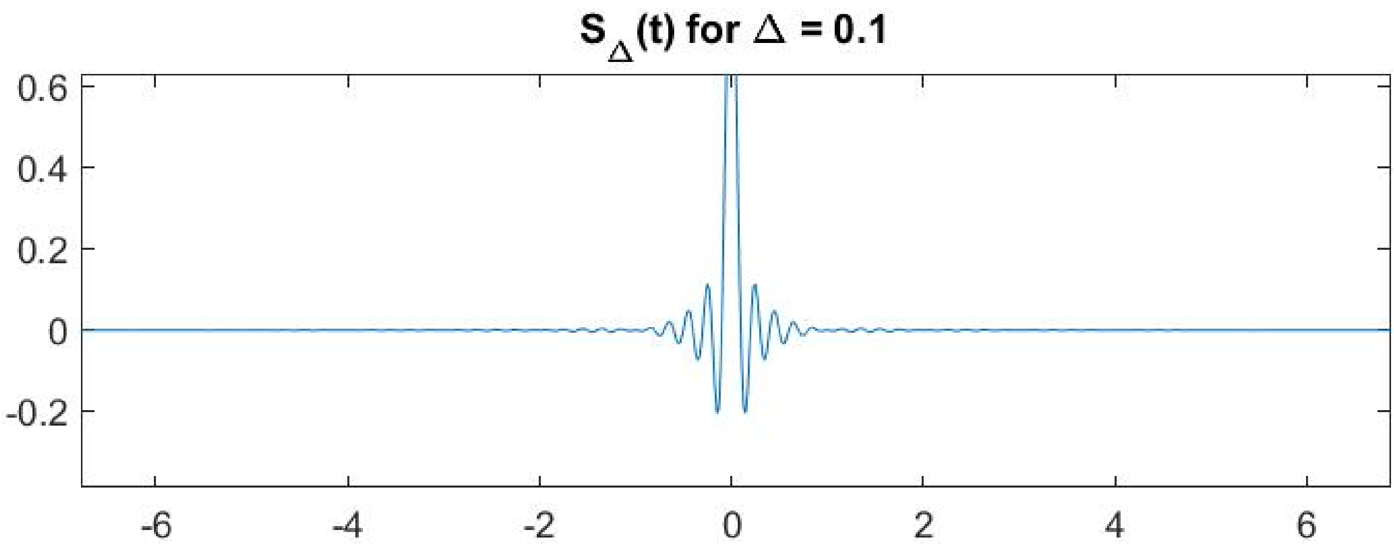
area_under_curve = trapz(t_values, arrayfun(S_delta_t, t_values));

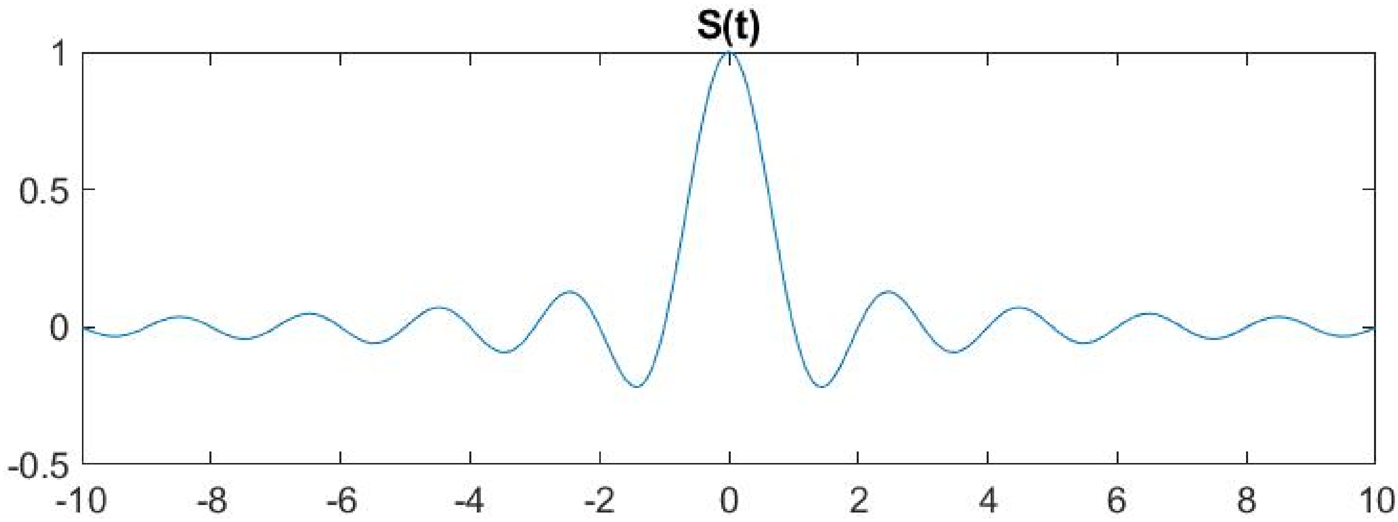
disp(['Area under the curve for \Delta = ' num2str(Delta) ': ' num2str(area_under_curve)]);

Delta_values = logspace(-5, 0, 100);
limit_values = arrayfun(@(delta) S_delta_t(0), Delta_values);

figure;
loglog(Delta_values, limit_values);
title('Limit as \Delta approaches 0');
xlabel('\Delta');
ylabel('S_\Delta(0)');

% As Delta approaches 0, S_delta(t) becomes like the impulse signal
```





Now we see that as delta becomes small, the graph tends to become like impulse

A2)

A2) $h(t) = \frac{1}{\pi t}$

$F(h(t)) = H(\omega) = -j\,sgn(\omega)$

$\therefore y(t) = h(t) \times x(t) = \int_{-\infty}^{\infty} \frac{x(t)}{\pi(t-\tau)}\, d\tau$

$\therefore y(\omega) = H(\omega) \cdot x(\omega)$

$= (-j\,sgn(\omega) \cdot (x(\omega))$

The above convolution shows that the phase is shifted by -90° due to the presence of (-j) comp.

A3)

A = 1;

T = 1;

fs = 1000;

```
duration = 5*T;

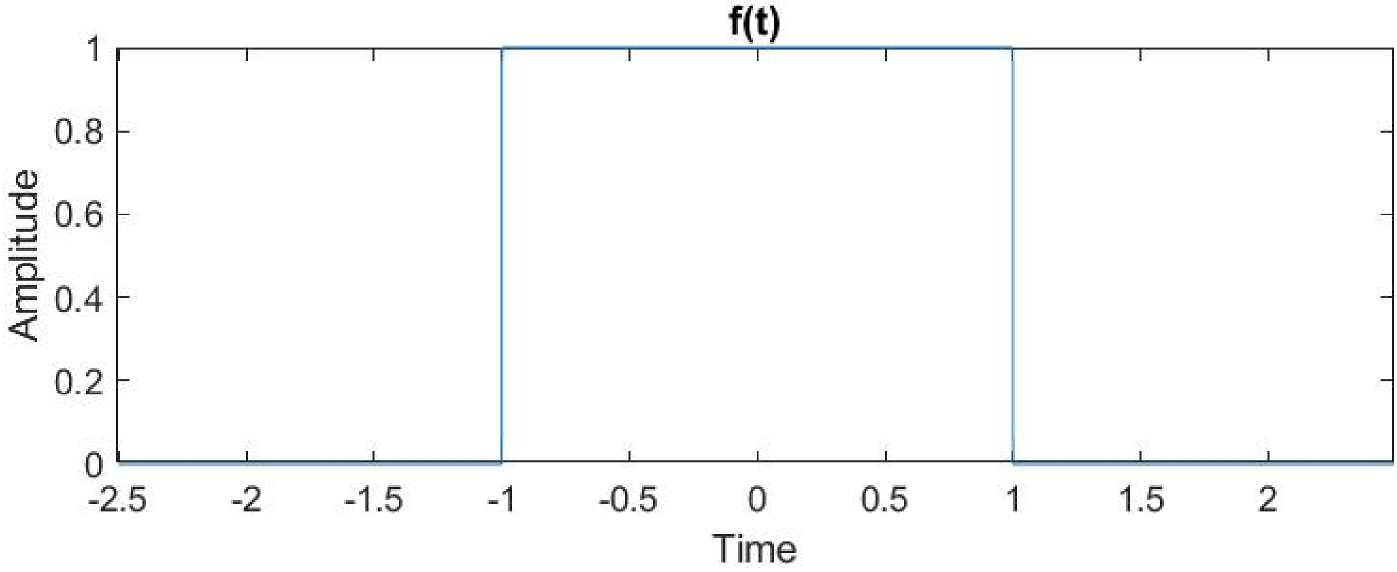
t = linspace(-duration/2, duration/2, fs*duration);
f_t = A * (heaviside(t + T) - heaviside(t - T));
omega = linspace(-pi/T, pi/T, length(t));
F_f = fftshift(fft(f_t));

omega_interval = linspace(-pi/T, pi/T, fs);
energy_in_interval = sum(abs(F_f(omega >= -pi/T & omega <= pi/T)).^2);
total_energy = sum(abs(F_f).^2);
=percentage_energy = (energy_in_interval / total_energy) * 100;

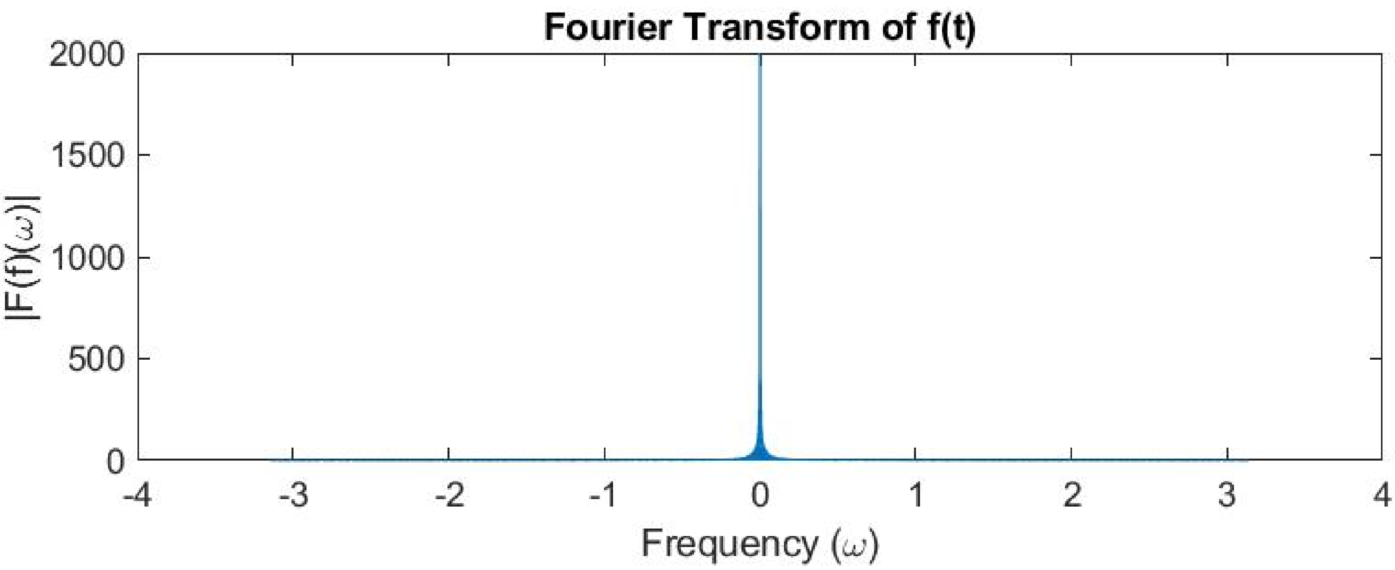
disp(['Total energy of f(t): ', num2str(total_energy)])
disp(['Energy in the specified interval: ', num2str(energy_in_interval)])
disp(['Percentage of energy in the specified interval: ', num2str(percentage_energy), '%'])
figure;


subplot(2, 1, 1);
plot(t, f_t);
title('f(t)');
xlabel('Time');
ylabel('Amplitude');

subplot(2, 1, 2);
plot(omega, abs(F_f));
title('Fourier Transform of f(t)');
xlabel('Frequency (\omega)');
ylabel('|F(f)(\omega)|');
```



Total energy of f(t): 10000000



Energy in the specified interval: 10000000
Percentage of energy in the specified interval: 100%