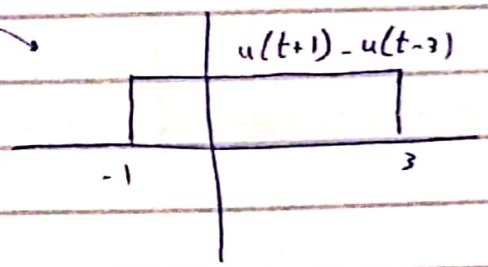
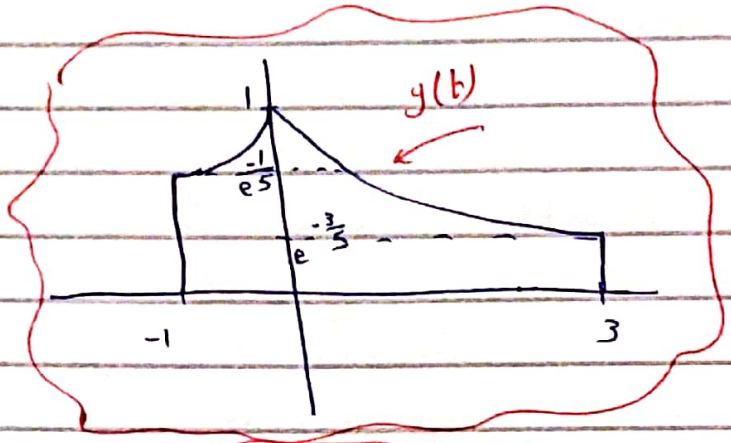
Youssef Victor
6668

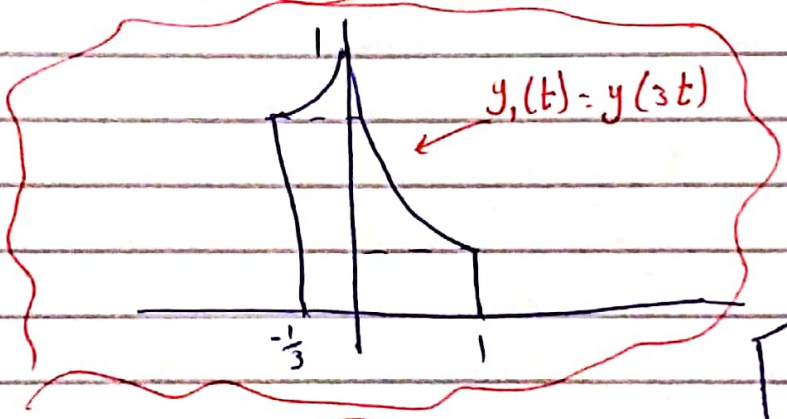
Part 1 - Handwritten Analysis

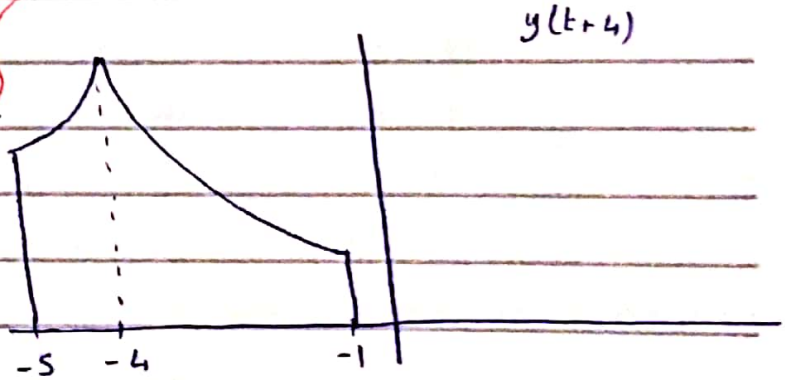
Q1:

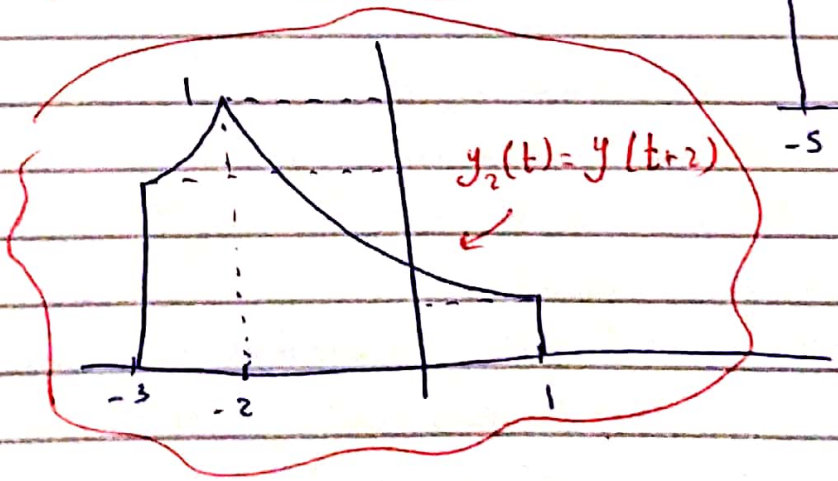
$$y(t) = e^{-\frac{|t|}{5}} \left(u(t+1) - u(t-3)\right)$$

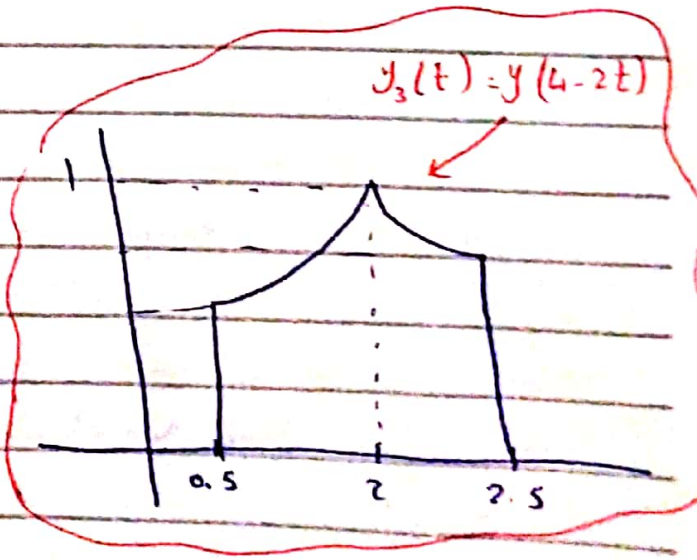












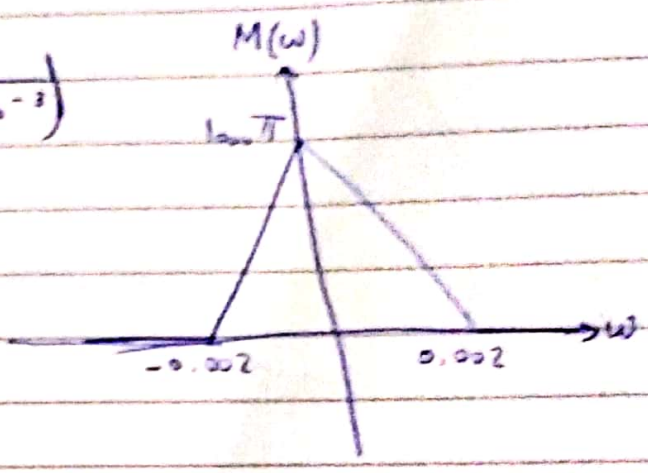
Question 2:

$m(t) = \text{sinc}^2(10^{-3}t)$

(a) $M(\omega) = \frac{3\pi}{10^{-3}} \Delta\left(\frac{\omega}{4 * 10^{-3}}\right)$

$= 10^3 \pi \Delta\left(\frac{\omega}{4 * 10^{-3}}\right)$

$= 1000\pi \Delta(250\omega)$

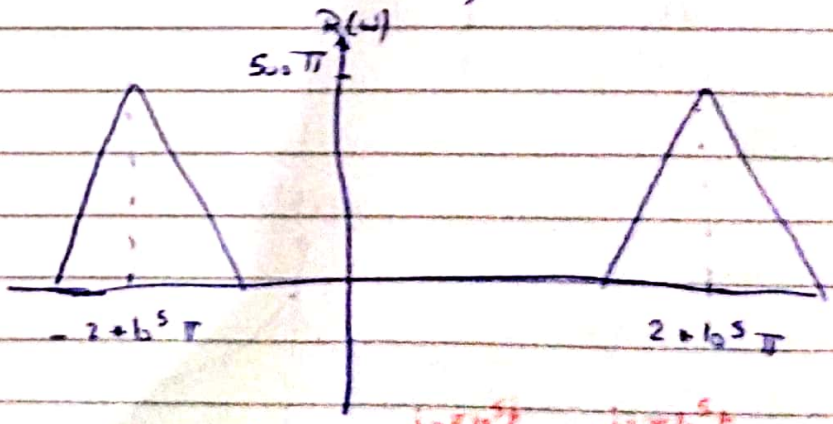


(b) $r(t) = m(t) \cdot \cos(2\pi 10^5 t)$

$r(t) = 1000\pi \Delta$

$r(t) = \text{sinc}^2(10^{-3}t) \cdot \cos(2\pi 10^5 t)$

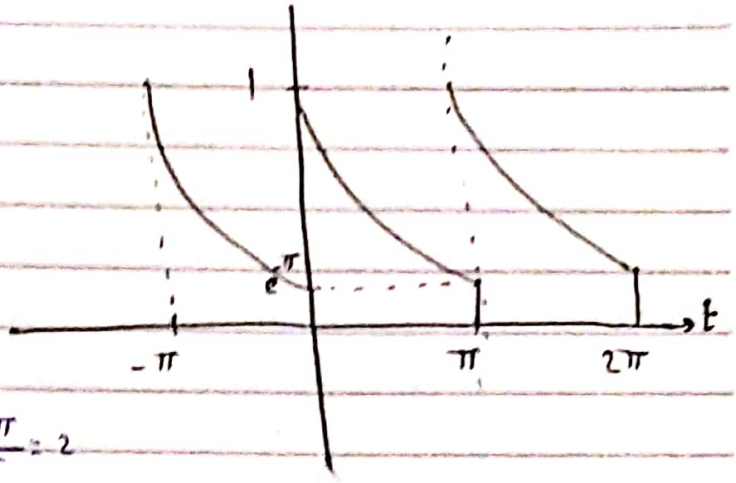
$R(\omega) = \frac{1}{2}\left(M(\omega - 2*10^5\pi) + M(\omega + 2*10^5\pi)\right)$



(c) Multiplying $m(t)$ by $\cos(2\pi 10^5 t)$, which is $\frac{e^{j2\pi 10^5 t} + e^{-j2\pi 10^5 t}}{2}$, caused the transform to be shifted in both left & right directions.

"Frequency shift property of Fourier Transform"

Q3



$$D_n = \frac{1}{T}\int_{T} x(t)\, e^{-jn\omega_0 t}\, dt$$

$$\omega_0 = 2\pi f = \frac{2\pi}{\pi} = 2$$

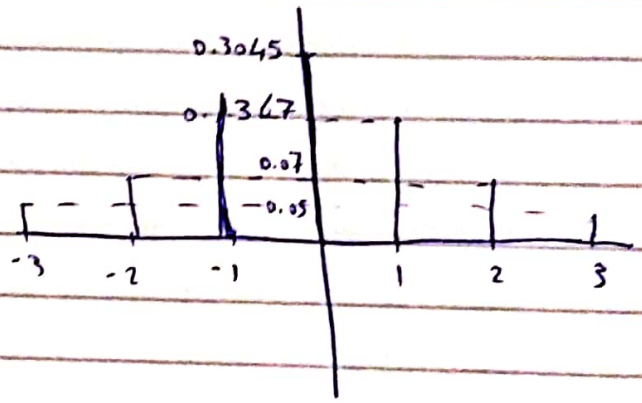
$$D_n = \frac{1}{\pi}\int_{0}^{\pi} e^{-t}\, e^{-2jnt}\, dt$$

$$D_n = \frac{1}{\pi}\int_{0}^{\pi} e^{-t(1+j2n)}\, dt$$

$$= \frac{1}{\pi}\cdot\frac{1}{-(1+j2n)}\cdot\left[e^{-t(1+j2n)}\right]_{0}^{\pi}$$

$$D_n = \frac{-1}{\pi+j2\pi n}\left(e^{-\pi-j2\pi n} - 1\right)$$

Magnitude



$$D_0 = \frac{-1}{\pi}\left(e^{-\pi} - 1\right) = 0.30455$$

$$D_{-3} = 0.0082 + j\,0.0494 = 0.05 \angle 1.41$$

$$D_{-2} = 0.0179 + j\,0.0717 = 0.074 \angle 1.326$$

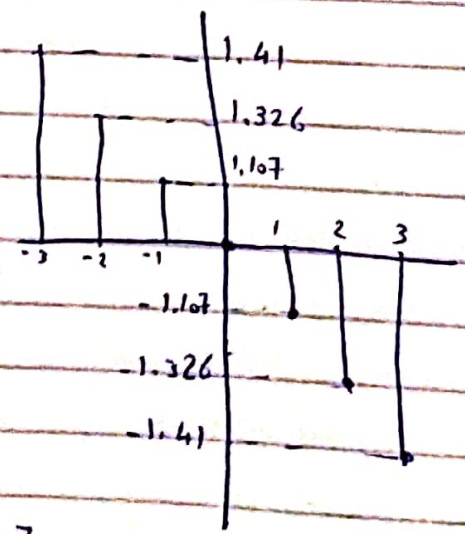
$$D_{-1} = 0.0609 + j\,0.1218 = 0.13617 \angle 1.107$$

$$D_1 = 0.0609 - j\,0.1218 = 0.13617 \angle -1.107$$

$$D_2 = 0.0179 - j\,0.0717 = 0.074 \angle -1.326$$

$$D_3 = 0.0082 - j\,0.0494 = 0.05 \angle -1.41$$

Angle



MATLAB final project - part 1

Table of Contents


```
%% generate_samples helper function
% Generates a samples vector between min and max inputs with the specified
% frequency. The length of the output vector is (max - min) * frequency.
function f = generate_samples(min, max, frequency)
    if min >= max
        throw(MException('"max" must be greater than "min"'));
    end
    if frequency <= 0
        throw(MException('"frequency" must be positive'));
    end
    f = linspace(min, max, (max - min) * frequency);
end
```

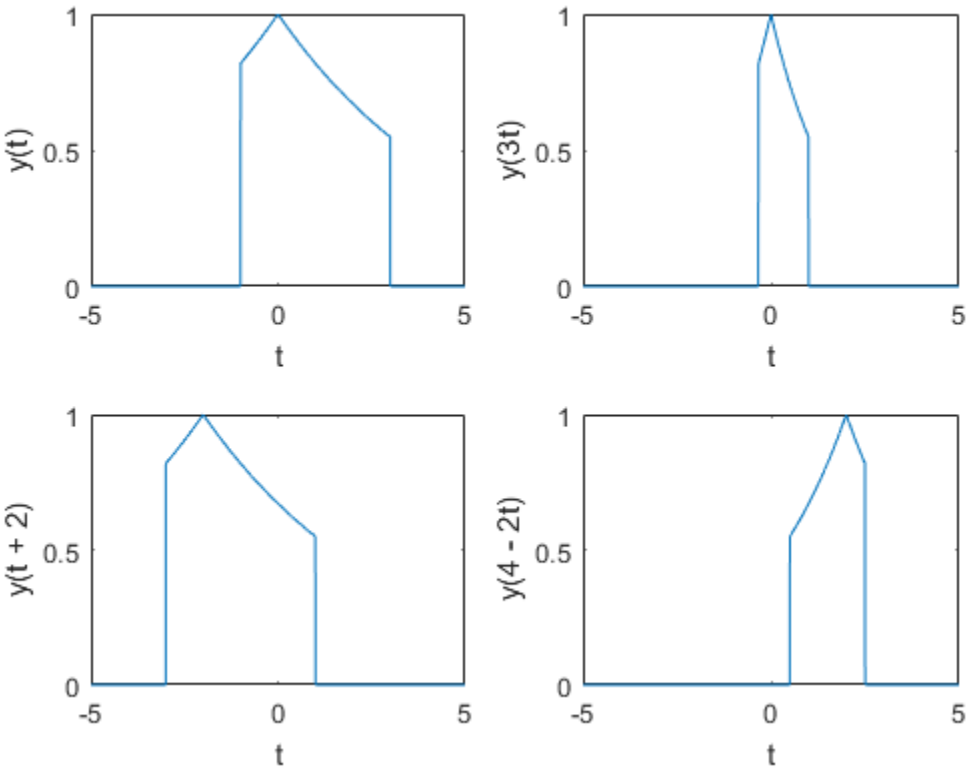
Question 1

```
sampling_freq = 200;
timeSamples = generate_samples(-5, 5, sampling_freq);
syms t;
y_func = exp(abs(t) / -5) * (heaviside(t + 1) - heaviside(t - 3));

y = subs(y_func, timeSamples); % y(t)
y1 = subs(y_func, 3 * timeSamples); % y(3t)
y2 = subs(y_func, timeSamples + 2); % y(t + 2)
y3 = subs(y_func, 4 - 2 * timeSamples); % y(4 - 2t)

figure('Name', 'Question 1', 'NumberTitle', 'off');
subplot(2, 2, 1);
plot(timeSamples, y);
xlabel('t');
ylabel('y(t)');
subplot(2, 2, 2);
plot(timeSamples, y1);
xlabel('t');
ylabel('y(3t)');
subplot(2, 2, 3);
plot(timeSamples, y2);
xlabel('t');
ylabel('y(t + 2)');
```

```
subplot(2, 2, 4);
plot(timeSamples, y3);
xlabel('t');
ylabel('y(4 - 2t)');
```



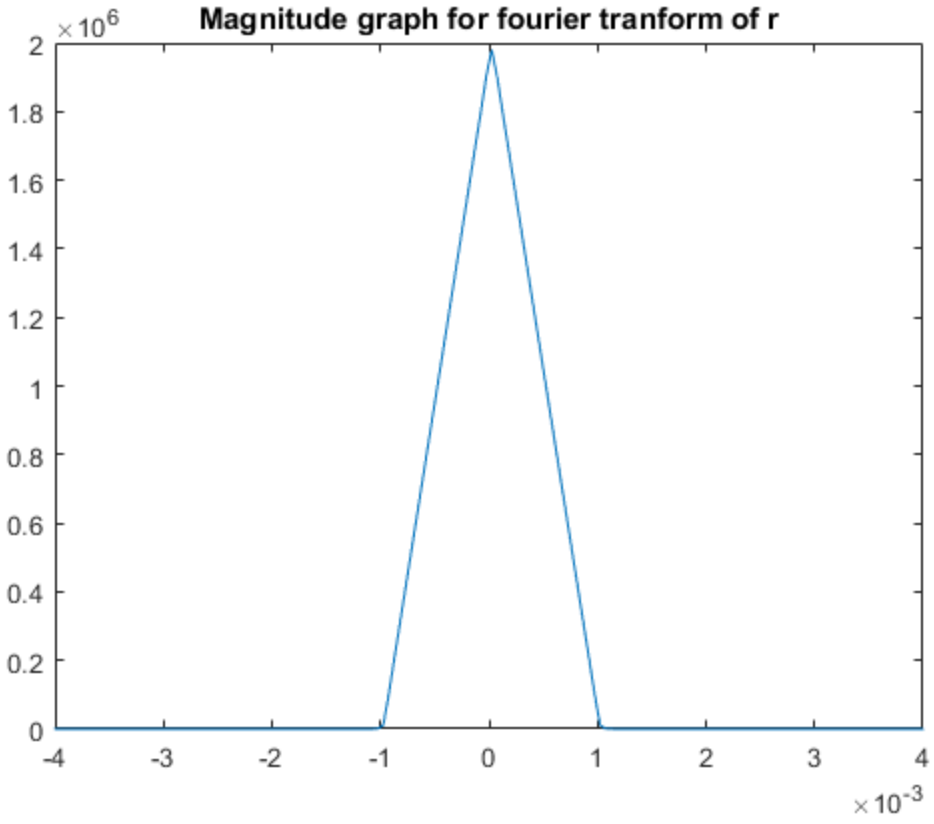
Question 2

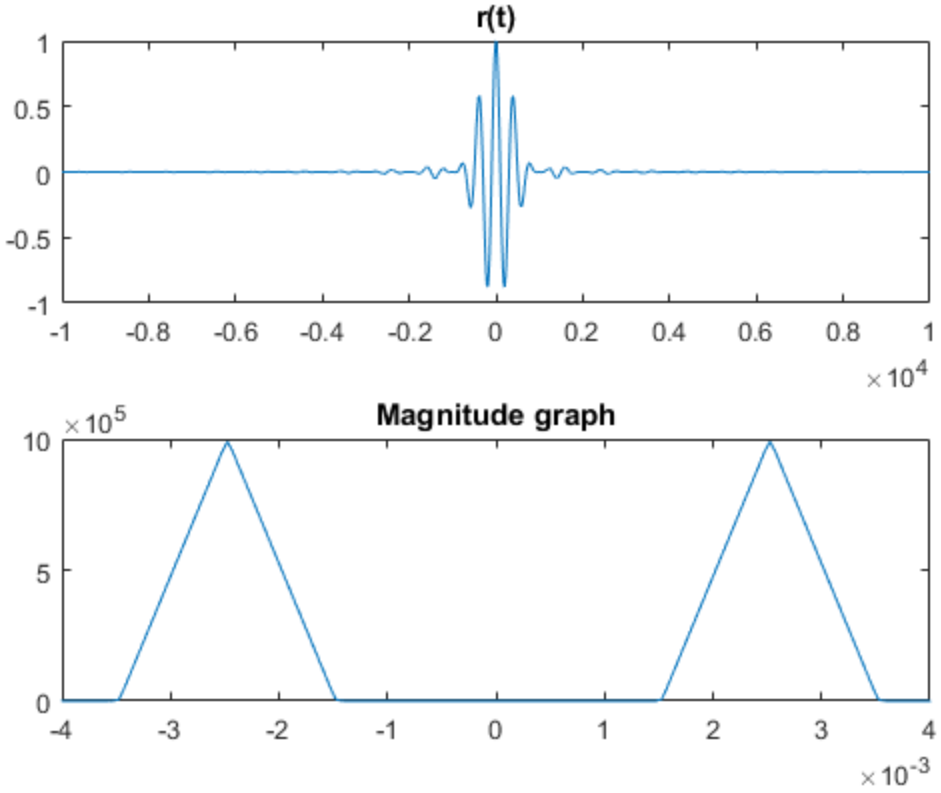
This will take sometime to run (a few minutes on my machine).

```
sampling_freq = 2000; % It must be much higher to satisfy nyquist
 criterion, but it hangs on my machine.
timeSamples = generate_samples(-10000, 10000, sampling_freq);
m = sinc(0.001 * timeSamples) .^ 2;
M = fftshift(fft(m));
F = linspace(-sampling_freq / 2, sampling_freq / 2,
 length(timeSamples));
figure('Name', 'Question 2 - a - F.T. of (sinc(10^-3 *
 t))^2', 'NumberTitle', 'off');
plot(F, abs(M));
xlim([-0.004 0.004]);
title('Magnitude graph for fourier tranform of r');

r = m .* cos(2 * pi * 100000 * timeSamples);
figure('Name', 'Question 2 - b', 'NumberTitle', 'off');
subplot(2, 1, 1);
plot(timeSamples, r);
```

```
title('r(t)');
R = fftshift(fft(r));
subplot(2, 1, 2);
plot(F, abs(R));
xlim([-0.004 0.004]);
title('Magnitude graph');
```





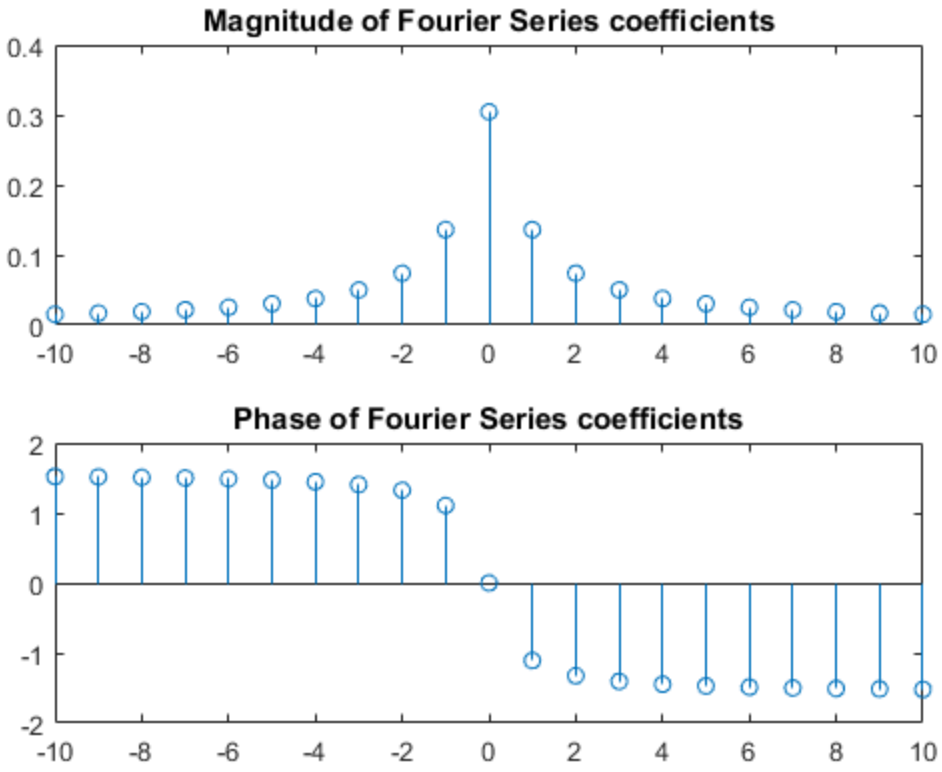
Question 3

a

```
syms t n;
Fn = (1 / pi) * int(exp(-t) * exp(-1i * n * 2 * pi * (1 / pi) * t), t,
 0, pi);
n = -10:10;
coefficients = eval(subs(Fn, n));
```

b

```
figure('Name', 'Question 3', 'NumberTitle', 'off');
subplot(2, 1, 1);
stem(n, abs(coefficients));
title('Magnitude of Fourier Series coefficients');
subplot(2, 1, 2);
stem(n, angle(coefficients));
title('Phase of Fourier Series coefficients');
```



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