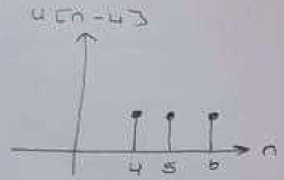
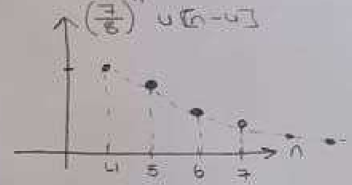
EE 321 Lab 2

1 - $h[n] = \left(\frac{7}{8}\right)^n u[n-4]$



$\Rightarrow$



* Is this system causal?

$$y[n] = x[n] * h[n] = \sum_{k=-\infty}^{\infty} x[k]\, h[n-k]$$

If the system is casual, to find $y[n_0]$ at a arbitrary instant n_0, the sections which $n > n_0$ for $x[n]$ are not needed.

All in all, in order to be causal, $h[n] = 0$ when $n < 0$ must be satisfied.

This can also be done with $h[n-k] = 0$ when $n < k$

To prove, $h[n-k] = \left(\frac{7}{8}\right)^{n-k} \cdot u[n-k-4]$

$u[n-k-4] = 0$ when $n-k-4 < 0$; for $n < k$

$\left(\frac{7}{8}\right)^{n-k} u[n-k-4] = 0$ $\Rightarrow$ Then, the system is CAUSAL!

* Is the system stable?

If the system is stable, then it should satisfy:

$$\sum_{n=-\infty}^{\infty} |h[n]| = \underline{\underline{\text{finite}}}$$ Then $$\sum_{-\infty}^{\infty} \left| \left(\frac{7}{8}\right)^n u[n-4] \right| = \sum_{n=4} \left(\frac{7}{8}\right)^n$$

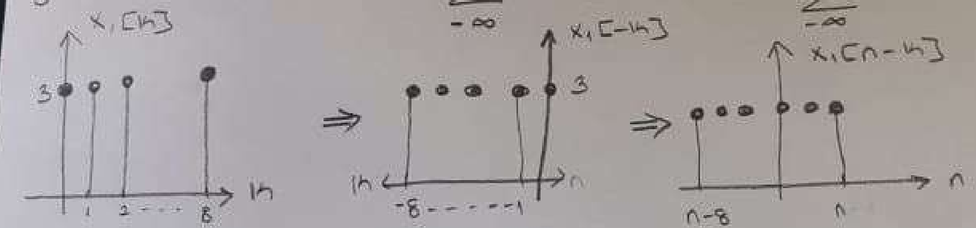
$$= \int_{n=0}^{\infty} \left(\frac{7}{8}\right)^n - \left(\frac{7}{8} + \frac{49}{64} + \left(\frac{7}{8}\right)^3 \right)$$

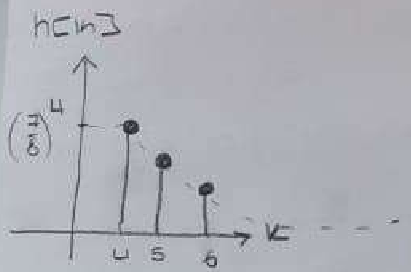
Then using geometric series property $\sum_{n=0}^{\infty} \left(\frac{7}{8}\right)^n = \frac{1}{1-\left(\frac{7}{8}\right)} = \underline{\underline{8}}$

Then, $8 - \underbrace{\left(\frac{7}{8} + \frac{49}{64} + \left(\frac{7}{8}\right)^3\right)}_{\text{finite}} < \infty$ and it is demonstrated that The system is STABLE.

a) $h[n] = (7/8)^n \, u[n-4]$ $\qquad x[n] = \begin{cases} 3 & \text{if } 0 \le n \le 8 \\ 0 & \text{else} \end{cases}$

$y_1[n] = x_1[n] * h[n] = \sum_{-\infty}^{\infty} x_1[k]\, h[n-k] = \sum_{-\infty}^{\infty} x_1[n-k].h[k]$





$$y_1[n] = \begin{cases} 0 & , \quad n < 4 \\ \sum_{k=4}^{n} 3\left(\frac{7}{8}\right)^k & 4 \le n < 12 \\ \sum_{k=n-8}^{n} 3\left(\frac{7}{8}\right)^k & 12 \le n \end{cases}$$

$y_1[n] = \sum_{k=4}^{n} 3\left(\frac{7}{8}\right)^k$ for $4 \le n < 12$ $\qquad y_1[n] = \sum_{k=n-8}^{n} 3\left(\frac{7}{8}\right)^k$ when $12 \le n$

$= \left(\frac{\left(\frac{7}{8}\right)^4 - \left(\frac{7}{8}\right)^{n+1}}{1-\frac{7}{8}}\right) \times 3 \qquad = 3\left(\frac{\left(\frac{7}{8}\right)^{n-8} - \left(\frac{7}{8}\right)^{n+1}}{1-\left(\frac{7}{8}\right)}\right)$

Then $y_1[n] = \begin{cases} 0 & \text{if } n < 4 \\ \left(\frac{\left(\frac{7}{8}\right)^4 - \left(\frac{7}{8}\right)^{n+1}}{1/8}\right) \times 3 & \text{if } 4 \le n \le 12 \\ \left(\frac{\left(\frac{7}{8}\right)^{n-8} - \left(\frac{7}{8}\right)^{n+1}}{1/8}\right) \times 3 & \text{if } n > 12 \end{cases}$

* Plot of analytical results and the Matlab code, plot can be found in Appendix 1A, 1B, 1C

b) $$x_2[n] = \begin{cases} 3 & \text{if } 0 \le n \le 4 \\ -3 & \text{if } 5 \le n \le 8 \\ -6 & \text{if } 9 \le n \le 13 \\ 0 & \text{else} \end{cases} , \quad y_2[n] = \sum_{k=-\infty}^{\infty} h[k]\, x[n-k]$$

We can see from the previous question that

$x_2[n] = x_1[n] - 2x_1[n-5]$ Then, $y_1[n] - 2y_1[n-5]$

As a result,

$$-2y_1[n-5] = \begin{cases} 0 & \text{if } n < 9 \\ -6 \cdot \dfrac{\left(\frac{7}{8}\right)^4 - \left(\frac{7}{8}\right)^{n-4}}{1/8} & \text{if } 9 \le n \le 17 \\ -6 \cdot \dfrac{\left(\frac{7}{8}\right)^{n-13} - \left(\frac{7}{8}\right)^{n-4}}{1/8} & \text{if } n > 17 \end{cases}$$

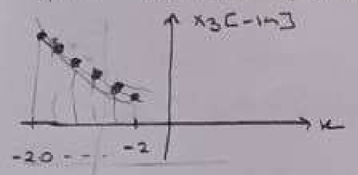
Then,

$$y_2[n] = y_1[n] - 2y_1[n-5] = \begin{cases} 0 & \text{for } n < 4 \\ 3 \times \left(\dfrac{\left(\frac{7}{8}\right)^4 - \left(\frac{7}{8}\right)^{n+1}}{1/8} \right) & \text{for } 4 \le n \le 9 \\ \dfrac{3\left(\frac{7}{8}\right)^4 - 3\left(\frac{7}{8}\right)^{n+1} - 6\left(\frac{7}{8}\right)^4 - 6\left(\frac{7}{8}\right)^{n-4}}{1/8} & \text{for } 9 \le n \le 12 \\ \dfrac{3\left(\frac{7}{8}\right)^{n-8} - 3\left(\frac{7}{8}\right)^{n+1} - 6\left(\frac{7}{8}\right)^4 + 6\left(\frac{7}{8}\right)^{n-4}}{1/8} & \text{for } 12 < n \le 17 \\ \dfrac{3\left(\frac{7}{8}\right)^{n-8} - 3\left(\frac{7}{8}\right)^{n+1} - 6\left(\frac{7}{8}\right)^{n-13} - 6\left(\frac{7}{8}\right)^{n-4}}{1/8} & \text{for } n > 17 \end{cases}$$

* The plot of analytically found result, the Matlab code and numerical result can be found in Appendix 2A, 2B, 2C.

c) $x_3[n] = \begin{cases} e^{j(1/3)n} & \text{if } 2 \le n \le 20 \\ 0 & \text{otherwise} \end{cases}$ $\qquad y_3[n] = \sum_{k=-\infty}^{\infty} h[k]\, x_3[n-k]$

The function can't be expressed in two axes but to find critical points, graph is below;



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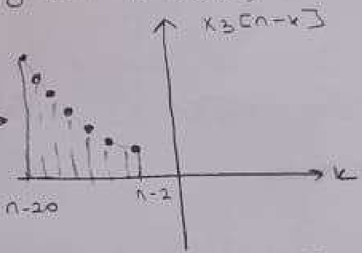
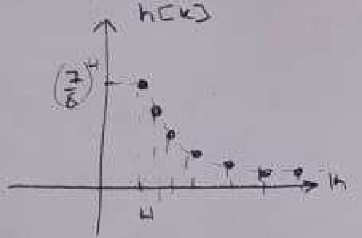




$$x[n] * h[n] = y_3[n] = \begin{cases} 0 & \text{for } n<6 \\ \sum_{k=4}^{n-2} \left(\frac{7}{8}\right)^k \left(e^{j/3}\right)^{n-k} & 6 \le n < 24 \\ \sum_{k=n-20}^{n-2} \left(\frac{7}{8}\right)^k \left(e^{j/3}\right)^{n-k} & \text{for } 24 \le n \end{cases}$$

From $\sum_{k=0}^{n} (p)^k = \frac{1-p^{n+1}}{1-p}$

$$y_3[n] = \begin{cases} 0 & \text{if } n<6 \\ \dfrac{\left(e^{j/3}\right)^n \left(\left(\frac{7}{8}\right)e^{-j/3}\right)^4 - \left(\frac{7}{8}e^{-j/3}\right)^{n-1}}{1 - \frac{7}{8}e^{-j/3}} & \text{if } 6 \le n < 24 \\ \dfrac{\left(e^{j/3}\right)^n \left(\frac{7}{8}e^{-j/3}\right)^{n-20} - \left(\frac{7}{8}e^{-j/3}\right)^{n-1}}{1 - \frac{7}{8}e^{-j/3}} & \text{if } n \ge 24 \end{cases}$$

* Plot of analytically result, Matlab code, numerically founded result plot can be seen in Appendix 3A, 3B and 3C

d) $x_4[n] = \begin{cases} -3\sin((1/3)n) & \text{if } 2 \le n \le 20 \\ 0 & \text{otherwise} \end{cases}$

As a hint $x_4[n] = -3\,\mathrm{Im}[x_3[n]]$ is given. And since this system is LTI, it can be understood that

$y_3[n] = T[x_3[n]]$, $T[-3\,\mathrm{Im}\{x_3[n]\}] = -3\,\mathrm{Im}\{y_3[n]\}$

Then

$$y_4[n] = \begin{cases} 0 & \text{if } n<6 \\ -3\,\mathrm{Im}\left\{ \dfrac{(e^{j1/3})^n\left(\left(\frac{7}{8}\right)e^{-j1/3}\right)^4 - \left(\left(\frac{7}{8}\right)e^{-j1/3}\right)^{n-1}}{1-\frac{7}{8}e^{-j1/3}} \right\} & \text{if } 6 \le n < 24 \\ -3\,\mathrm{Im}\left\{ \dfrac{(e^{j1/3})^n\left(\left(\frac{7}{8}\right)e^{-j1/3}\right)^{n-20} - \left(\frac{7}{8}e^{-j1/3}\right)^{n-1}}{1-\frac{7}{8}e^{-j1/3}} \right\} & \text{if } n \ge 24 \end{cases}$$

* Plot of analytically founded result, Matlab code, numerically founded result plot can be seen in Appendix 4a, 4b, 4c.

e) $x_5[n] = \begin{cases} 2\cos[(1/3)n] & \text{if } 2 \le n \le 20 \\ 0 & \text{else} \end{cases}$

$$y_5[n] = \begin{cases} 0 & \text{if } n<6 \\ 2\,\mathrm{Re}\left\{ \dfrac{(e^{j1/3})^n\left(\left(\frac{7}{8}e^{-j1/3}\right)^4 - \left(\left(\frac{7}{8}\right)e^{-j1/3}\right)^{n-1}\right)}{1-\frac{7}{8}e^{-j1/3}} \right\} & \text{if } 6 \le n < 24 \\ 2\,\mathrm{Re}\left\{ \dfrac{(e^{j1/3})^n\left(\left(\frac{7}{8}\right)e^{-j1/3}\right)^{n-20} - \left(\frac{7}{8}e^{-j1/3}\right)^{n-1}}{1-\frac{7}{8}e^{-j1/3}} \right\} & \text{if } n \ge 24 \end{cases}$$

* Plot of analytically founded results. Matlab code, numerical result can be seen in 5a, 5b, 5c

f) $x_6[n] = x_1[n] + 2\gamma\, x_2[n]$

Since this is a LTI system, we can use linearity properties

$x_6[n] = x_1[n] + 2\gamma x_2[n]$

$$y_6[n] = \sum_{k=-\infty}^{\infty} x_6[k]\, h[n-k] = \sum_{k=-\infty}^{\infty} \left(x_1[k] + 2\gamma x_2[k] \right) h[n-k]$$

$$= \sum_{k=-\infty}^{\infty} x_1[k]\, h[n-k] + 2\gamma \sum_{k=-\infty}^{\infty} x_2[k]\, h[n-k] = y_1[n] + 2\gamma y_2[n]$$

$$y_1[n] = \begin{cases} 0 & \text{if } n<4 \\ 24\left(\left(\frac{7}{8}\right)^4 - \left(\frac{7}{8}\right)^{n-1} \right) & \text{if } 4 \le n \le 12 \\ 24\left(\left(\frac{7}{8}\right)^{n-8} - \left(\frac{7}{8}\right)^{n+1} \right) & \text{if } n > 12 \end{cases}$$

$$2\gamma y_2[n] = \begin{cases} 0 & \text{for } n<4 \\ 48\gamma\left(\left(\frac{7}{8}\right)^4 - \left(\frac{7}{8}\right)^{n+1} \right) & \text{for } 4 \le n < 9 \\ 16\gamma\left(3\left(\frac{7}{8}\right)^4 - 3\left(\frac{7}{8}\right)^{n+1} - 6\left(\frac{7}{8}\right)^4 + 6\left(\frac{7}{8}\right)^{n-4} \right) & \text{for } 9 \le n < 12 \\ 16\gamma\left(3\left(\frac{7}{8}\right)^{n-8} - 3\left(\frac{7}{8}\right)^{n+1} - 6\left(\frac{7}{8}\right)^4 + 6\left(\frac{7}{8}\right)^{n-4} \right) & \text{for } 12 < n \le 17 \\ 16\gamma\left(3\left(\frac{7}{8}\right)^{n-8} - 3\left(\frac{7}{8}\right)^{n+1} - 6\left(\frac{7}{8}\right)^{n-13} + 6\left(\frac{7}{8}\right)^{n-4} \right) & \text{for } n > 17 \end{cases}$$

$y_1[n] + 2\gamma y_2[n] = y_6[n]$

$$y_6[n] = \begin{cases} 0 & \text{if } n<4 \\ (24+48\gamma)\left(\left(\frac{7}{8}\right)^4 - \left(\frac{7}{8}\right)^{n+1} \right) & \text{if } 4 \le n < 9 \\ (24+48\gamma)\left(\left(\frac{7}{8}\right)^4 - \left(\frac{7}{8}\right)^{n+1} \right) + 48\gamma\left(-2\left(\frac{7}{8}\right)^4 + 2\left(\frac{7}{8}\right)^{n-4} \right) & \text{if } 9 < n \le 12 \\ 24\left(\left(\frac{7}{8}\right)^{n-8} - \left(\frac{7}{8}\right)^{n+1} \right) + 48\gamma\left(\left(\frac{7}{8}\right)^{n-8} - \left(\frac{7}{8}\right)^{n+1} - 2\left(\frac{7}{8}\right)^4 + 2\left(\frac{7}{8}\right)^{n-4} \right) & \text{if } 12 < n \le 17 \\ 24\left(\left(\frac{7}{8}\right)^{n-8} - \left(\frac{7}{8}\right)^{n+1} \right) + 48\gamma\left(\left(\frac{7}{8}\right)^{n-8} - \left(\frac{7}{8}\right)^{n+1} - 2\left(\frac{7}{8}\right)^{n+3} + 2\left(\frac{7}{8}\right)^{n-4} \right) & \text{if } n > 17 \end{cases}$$

* The plot of analyticaly founded result, Matlab code and numerical result can be seen in Appendix 6a, 6b, 6c.

BILKENT UNIVERSITY
ELECTRICAL AND ELECTRONICS ENGINEERING
EE321-02 LAB2 REPORT

17/10/2024

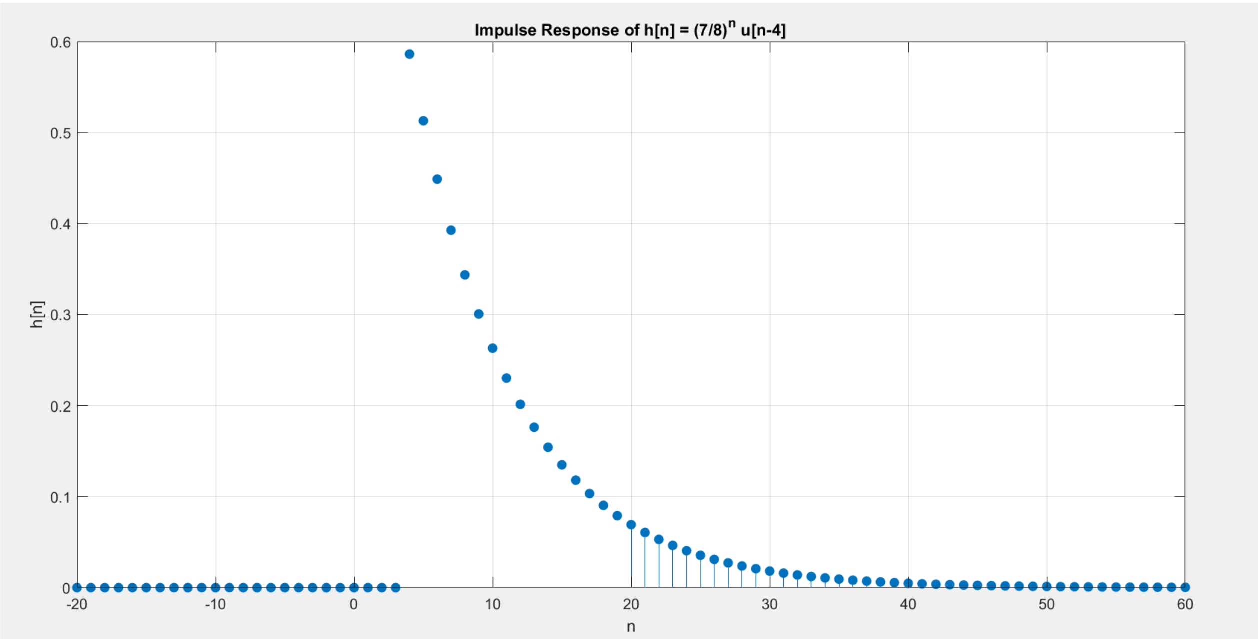
NEHİR DEMİRLİ-22203611

INTRODUCTION:

This lab consists of 6 distinct input signals. Then according to the given h[n], we calculated the different outputs of the system for different input signals.

Q1: The impulse response of a discrete linear time invariant system is h[n] = (7/8)nu[n − 4]. Plot this impulse response.

Here is the plot for the continuous equation which is used to calculate the discrete impulse response of the system.

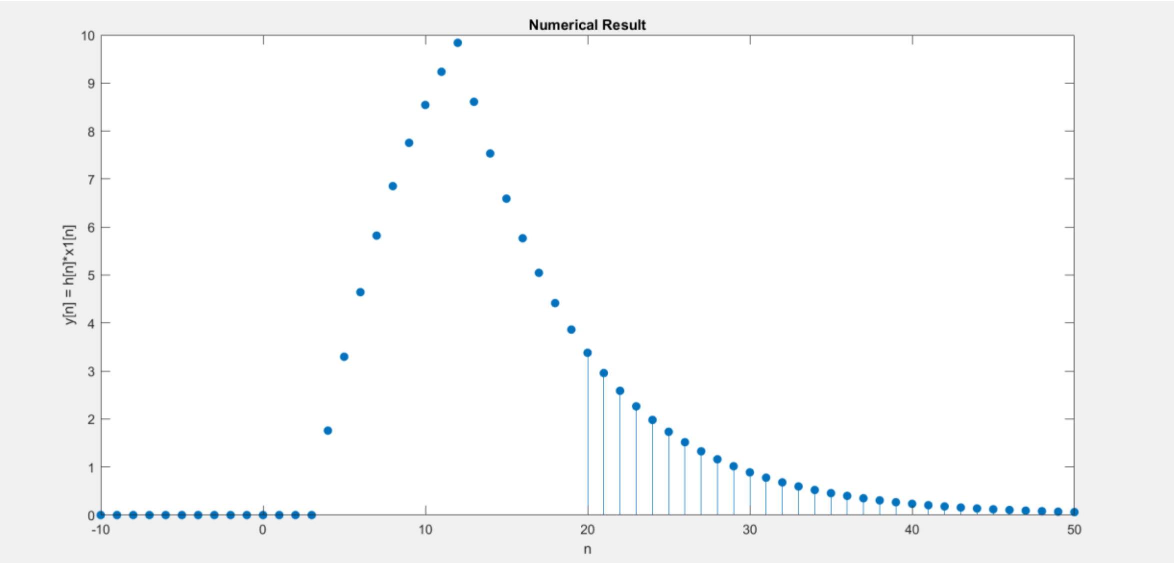


[Figure 1: The plot of the h[n]]

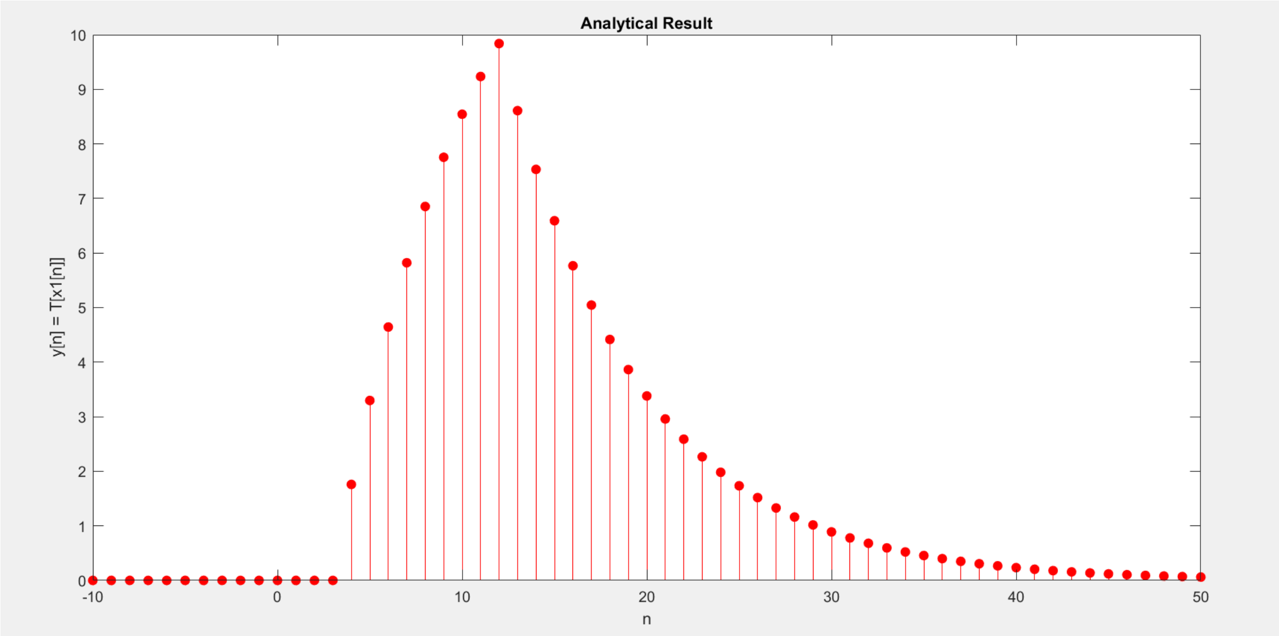
```
n = -20:60;
h_n = (7/8).^(n).*(n >= 4);
figure;
stem(n, h_n, 'filled');
xlabel('n');
ylabel('h[n]');
title('Impulse Response of h[n] = (7/8)^n u[n-4]');
grid on;
```

The code of h[n]

A) Numerical Result



B) Analytical Result

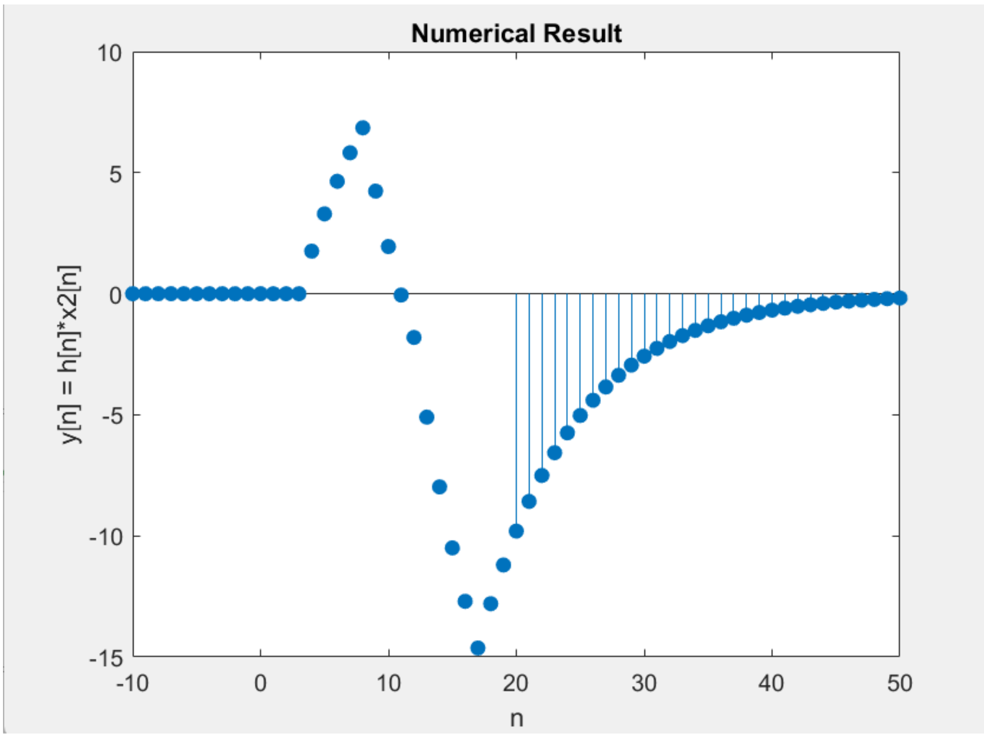


C) The code

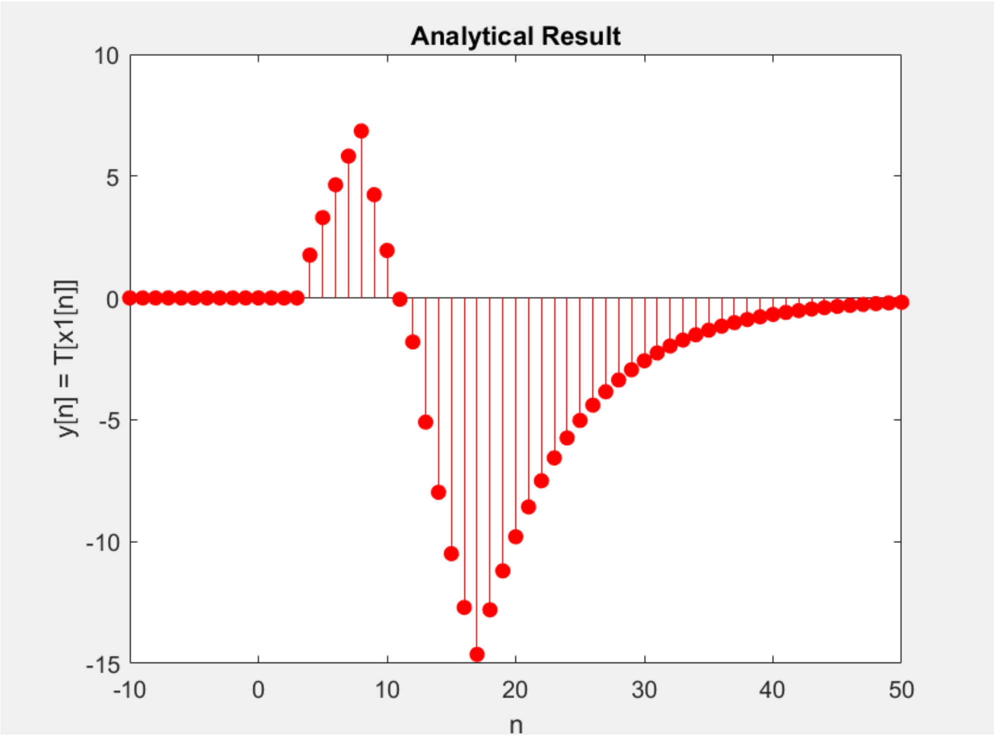
```
% Numerical Result of q1
l = 100;
n = -l:l;
uh = zeros(size(n));
uh(n >= 4) = 1;
h = (7/8).^n .* uh;

r = -l/2:l/2;
x1 = zeros(size(r));
x1((r >= 0) & (r <= 8)) = 3;

y1 = zeros(size(r));
for k = 1:length(r)  % Convolution loop

    y1 = y1 + h(r - r(k) + l + 1) .* x1(k);
end

% Plot the Numerical Result
figure;
stem(-10:50, y1(41:101), 'filled');  % Plot the result from index 41 to 101
xlabel('n');
ylabel('y[n] = h[n]*x1[n]');
title('Numerical Result for y1[n]');

% Analytic Result plot
n = -10:100;
y1_2 = zeros(size(n));  % Initialize the analytical result
y1_2((n >= 4) & (n <= 12)) = 24 * ((7/8).^4 - (7/8).^(5:13));  % For n in [4,12]
y1_2(n > 12) = 24 * ((7/8).^4 - (7/8).^(13:101));  % For n > 12

% Plot the Analytic Result
figure;
stem(-10:50, y1_2(1:61), 'filled', 'r');
xlabel('n');
ylabel('y[n] = T[x1[n]]');
title('Analytical Result');
```

Q2:

A) Numerical Result



B) Analytical Result



C.1) Numerical Part

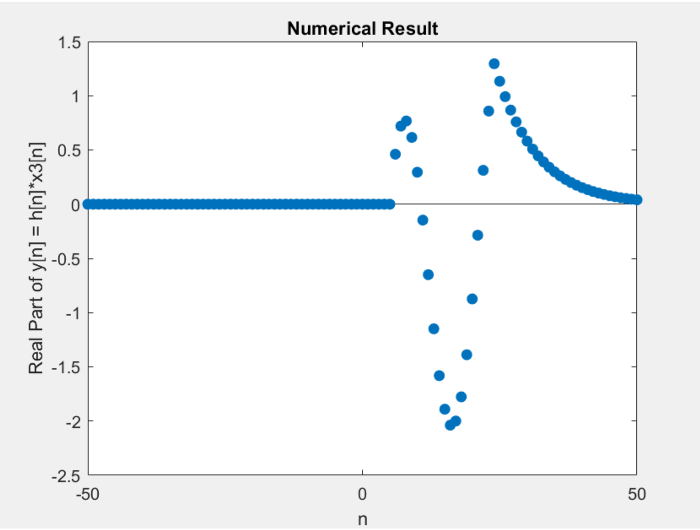
```
% Numerical Result of q1
l = 100;  % Length parameter
n = -l:l;  % Define range of n

% Define h[n]
uh = zeros(size(n));
uh(n >= 4) = 1;  % Step function uh[n] is 1 for n >= 4
h = (7/8).^n .* uh;  % h[n] = (7/8)^n * uh[n]

% Define x2[n]
r = -l/2:l/2;  % Range for r
x2 = zeros(size(r));  % Initialize x2
x2((r >= 0) & (r <= 4)) = 3;  % Set x2 for 0 <= r <= 4
x2((r >= 5) & (r <= 8)) = -3;  % Set x2 for 5 <= r <= 8
x2((r >= 9) & (r <= 13)) = -6;  % Set x2 for 9 <= r <= 13

% Initialize y2[n]
y2 = zeros(size(r));

% Find indices where x2 is non-zero
k_indices = find(x2);

% Perform convolution
for idx = 1:length(k_indices)
    k = k_indices(idx);
    x2_k = x2(k);
    shift = r - r(k);
    h_indices = shift + l + 1;

    % Make sure indices are within valid range
    valid_indices = (h_indices >= 1) & (h_indices <= length(h));

    % Compute the convolution sum
    y2(valid_indices) = y2(valid_indices) + h(h_indices(valid_indices)) * x2_k;
end

% Plot Numerical Result
figure;  % Open a new figure window
stem(-10:50, y2(41:101), 'filled');
xlabel('n');
ylabel('y[n] = h[n]*x2[n]');
title('Numerical Result for y2[n]');
```

C.2) Analytical Part

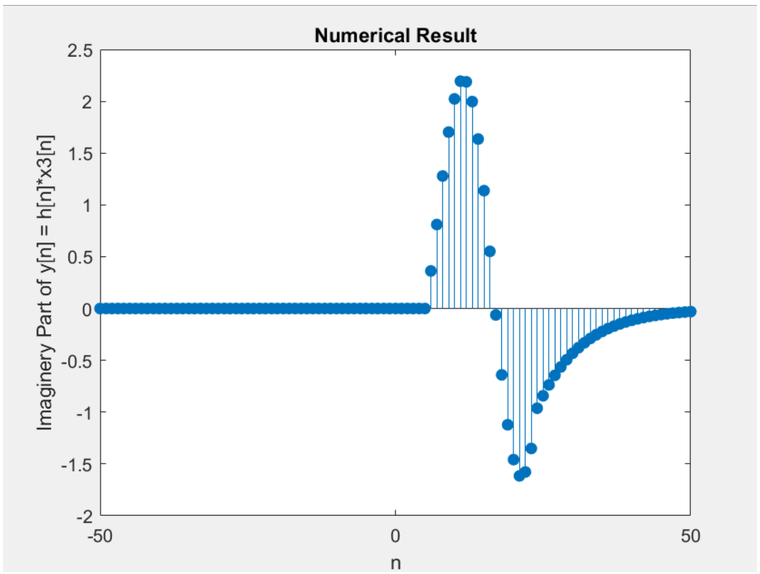
```
% Analytic Result
n = -10:100;
y2_2 = zeros(size(n));

% Define the analytic result piece by piece
y2_2((n >= 4) & (n <= 9)) = 24 * ((7/8).^4 - (7/8).^(5:10));
y2_2((n >= 9) & (n <= 12)) = 24 * ((7/8).^4 - (7/8).^(10:13)) - 48 * ((7/8).^4 - (7/8).^(5:8));
y2_2((n >= 12) & (n <= 17)) = 24 * ((7/8).^(4:9) - (7/8).^(13:18)) - 48 * ((7/8).^4 - (7/8).^(8:13));
y2_2(n >= 17) = 24 * ((7/8).^(9:92) - (7/8).^(18:101)) - 48 * ((7/8).^(4:87) - (7/8).^(13:96));

% Plot Analytic Result
figure;  % Open another figure window
stem((-10:50), y2_2(1:61), 'filled', 'r');
xlabel('n');
ylabel('y[n] = T[x1[n]]');
title('Analytical Result for y2[n]');
```

Q3)

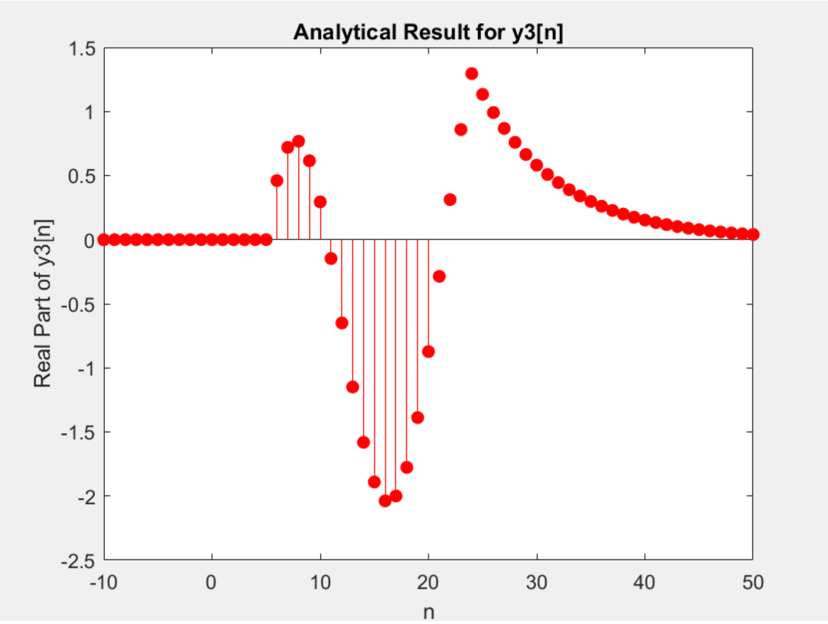
A.1) Numerical Real Part



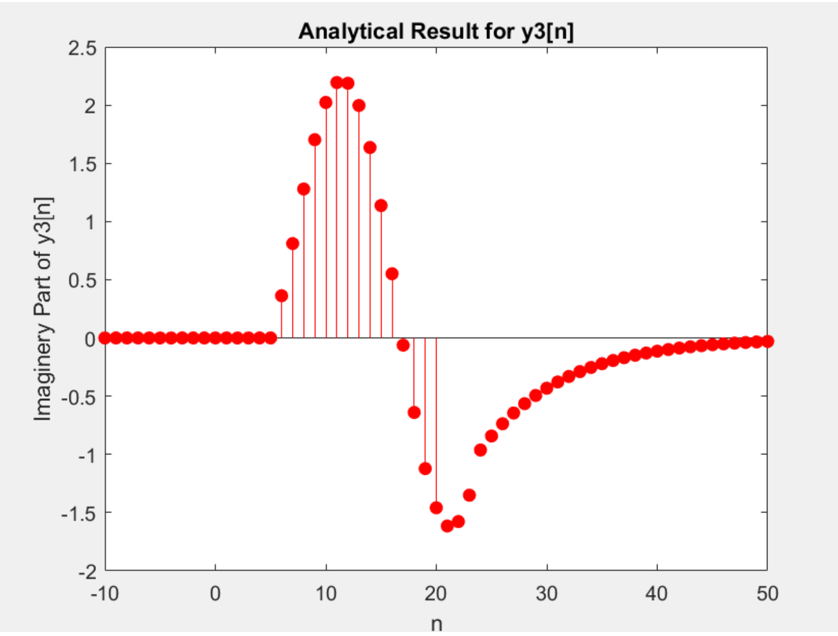
A.2) Numerical Imaginary Part



B.1) Analytical Real Part



B.2) Analytical Imaginary Part



C.1) The Code of Numerical part

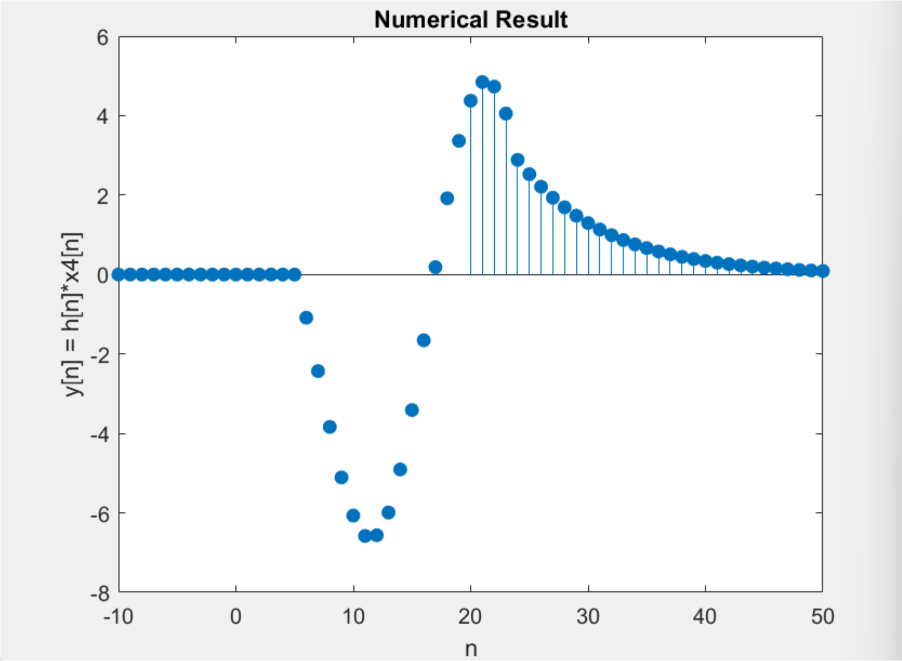
```
% Sayısal Sonuç
L = 100;
m = -L:1:L;
uh_m = zeros(size(m));
uh_m(m >= 4) = 1;
h_m = (7/8).^m .* uh_m;
t = (-L/2):1:(L/2);
x_signal = zeros(size(t));
x_signal((t <= 20) & (t >= 2)) = exp((2:20) .* 1/3 * 1i);
y_signal = zeros(size(t));

% Konvolüsyon döngüsü
for k = -(L/2):(L/2)
    temp = h_m(t - k + L + 1) .* x_signal(k + (L/2) + 1);
    y_signal = y_signal + temp;
end

% Sayısal Sonucun Gösterimi
figure;  % Yeni bir grafik penceresi aç
stem(t, real(y_signal), 'filled');
xlabel('n');
ylabel('Real Part of y[n] = h[n]*x3[n]');
title('Numerical Result');

figure;
stem(t, imag(y_signal), 'filled');
xlabel('n');
ylabel('Imaginery Part of y[n] = h[n]*x3[n]');
title('Numerical Result');
```

C.2) The code of Analytical Part

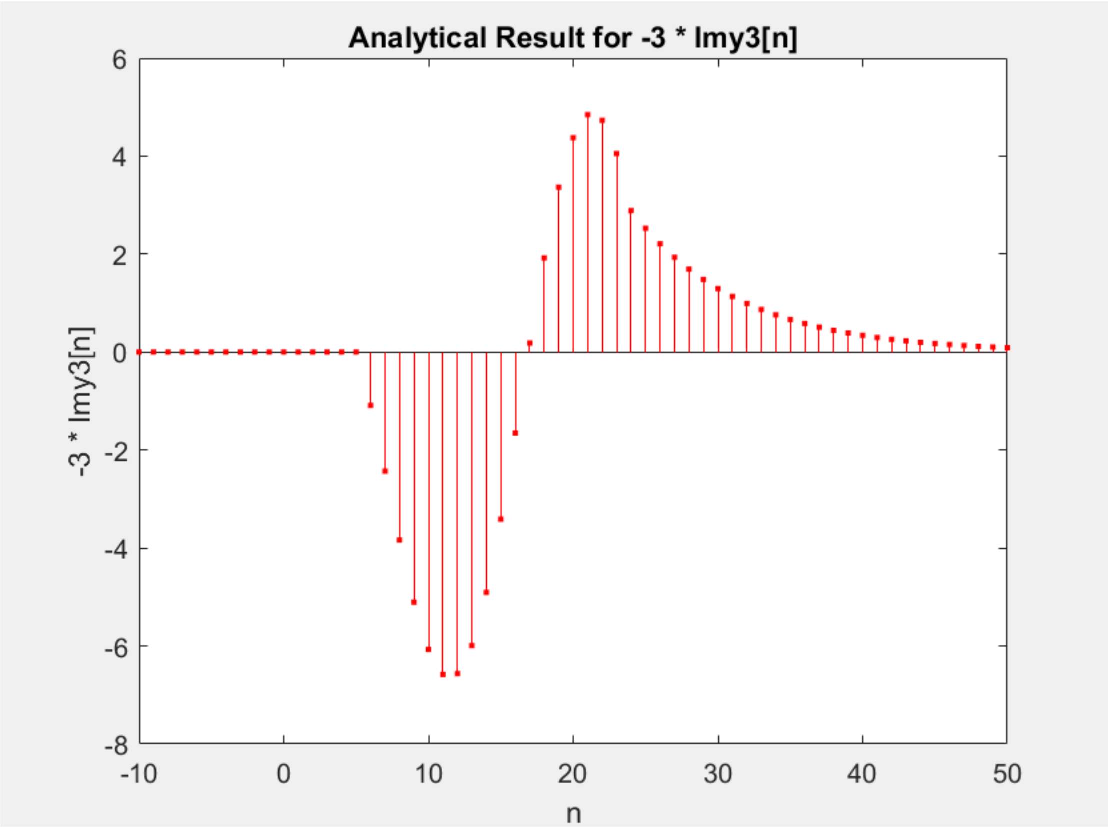
```
% Parametreler
m_range = -10:100;
y_analytic = zeros(size(m_range));  % Analitik sonuç sinyali
i_comp = sqrt(-1);  % Kompleks sayı i (veya j)

% Farklı m aralıkları için analitik sonuç
y_analytic((m_range >= 6) & (m_range <= 24)) = ...
    (exp(i_comp / 3) .^ m_range((m_range >= 6) & (m_range <= 24))) .* ...
    (((7/8) * exp(-i_comp / 3))^4 - ((7/8) * exp(-i_comp / 3)) .^ (m_range((m_range >= 6) & (m_range <= 24)) - 1)) ...
    / (1 - (7/8) * exp(-i_comp / 3));

y_analytic((m_range >= 24)) = ...
    (exp(i_comp / 3) .^ m_range((m_range >= 24))) .* ...
    (((7/8) * exp(-i_comp / 3)) .^ (m_range((m_range >= 24)) - 20) - ((7/8) * exp(-i_comp / 3)) .^ (m_range((m_range >= 24)) - 1)) ...
    / (1 - (7/8) * exp(-i_comp / 3));

% Gerçek Kısmın Gösterimi
figure;
stem((-10:50), real(y_analytic(1:61)), 'filled', 'r');
xlabel('n');
ylabel('Real Part of y3[n]');
title('Analytical Result for y3[n]');

% Sanal Kısmın Gösterimi
figure;
stem((-10:50), imag(y_analytic(1:61)), 'filled', 'r');
xlabel('n');
ylabel('Imaginery Part of y3[n]');
title('Analytical Result for y3[n]');
```

Q4:

A) Numerical Result



B) Analytical Result:



C.1) The code of Numerical part

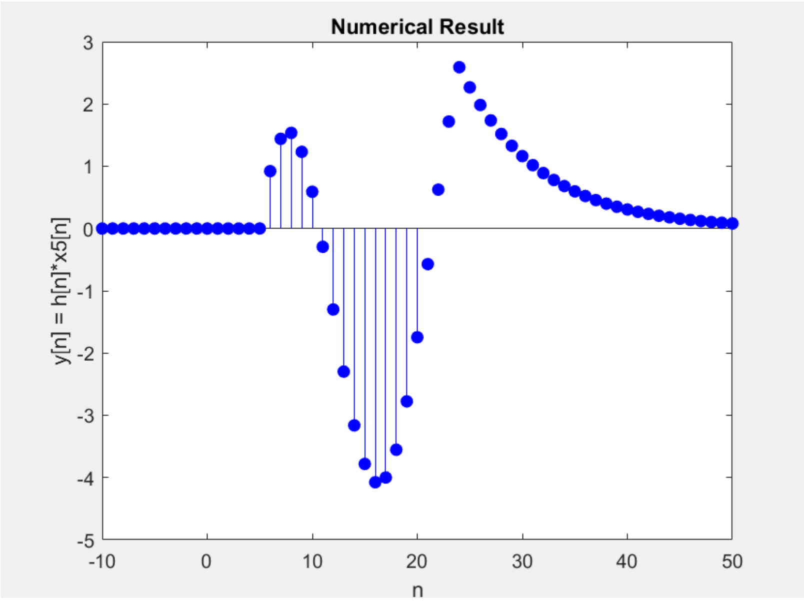
```
% Sayısal Sonuç
size_l = 100;
index = -size_l:1:size_l;
step_function = zeros(size(index));
step_function(index >= 4) = 1;
filter_response = (7/8).^index .* step_function;
range_vals = (-size_l/2):1:(size_l/2);
input_signal = zeros(size(range_vals));
input_signal((range_vals <= 20) & (range_vals >= 2)) = exp((2:20) .* 1/3 * 1i);
output_signal = zeros(size(range_vals));

% Konvolüsyon işlemi
for shift = -(size_l/2):(size_l/2)
    temp_mult = filter_response(range_vals - shift + size_l + 1) .* input_signal(shift + (size_l/2) + 1);
    output_signal = output_signal + temp_mult;
end

% Sayısal Sonucun Gösterimi
figure;  % Yeni bir grafik penceresi aç
stem(range_vals, real(output_signal), 'filled');
xlabel('n');
ylabel('Real Part of y[n] = h[n]*x3[n]');
title('Numerical Result');

figure;
stem(range_vals, imag(output_signal), 'filled');
xlabel('n');
ylabel('Imaginery Part of y[n] = h[n]*x3[n]');
title('Numerical Result');
```

C.2) The code of Analytic part

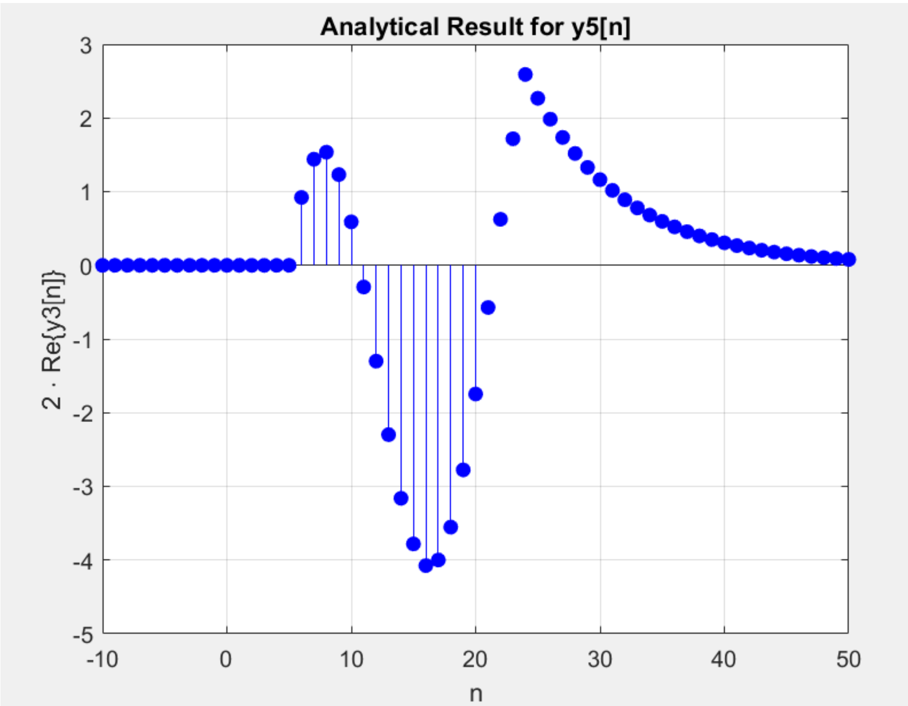
```
% Parametreler
num_range = -10:100;
analytic_result = zeros(size(num_range));  % Analitik sonuç sinyali
complex_unit = sqrt(-1);  % Kompleks sayı i

% Farklı num_range aralıkları için analitik sonuç
analytic_result((num_range >= 6) & (num_range <= 24)) = ...
    (exp(complex_unit / 3) .^ num_range((num_range >= 6) & (num_range <= 24))) .* ...
    (((7/8) * exp(-complex_unit / 3))^4 - ((7/8) * exp(-complex_unit / 3)) .^ (num_range((num_range >= 6) & (num_range <= 24)) - 1)) ...
    / (1 - (7/8) * exp(-complex_unit / 3));

analytic_result((num_range >= 24)) = ...
    (exp(complex_unit / 3) .^ num_range((num_range >= 24))) .* ...
    (((7/8) * exp(-complex_unit / 3)) .^ (num_range((num_range >= 24)) - 20) - ((7/8) * exp(-complex_unit / 3)) .^ (num_range((num_range >= 24)) - 1)) ...
    / (1 - (7/8) * exp(-complex_unit / 3));

% Gerçek Kısmın Gösterimi
figure;
stem((-10:50), real(analytic_result(1:61)), 'filled', 'r');
xlabel('n');
ylabel('Real Part of y3[n]');
title('Analytical Result for y3[n]');
```

Q5:

A) Numerical Result



B) Analytical Result



C.1) The code of Numerical part

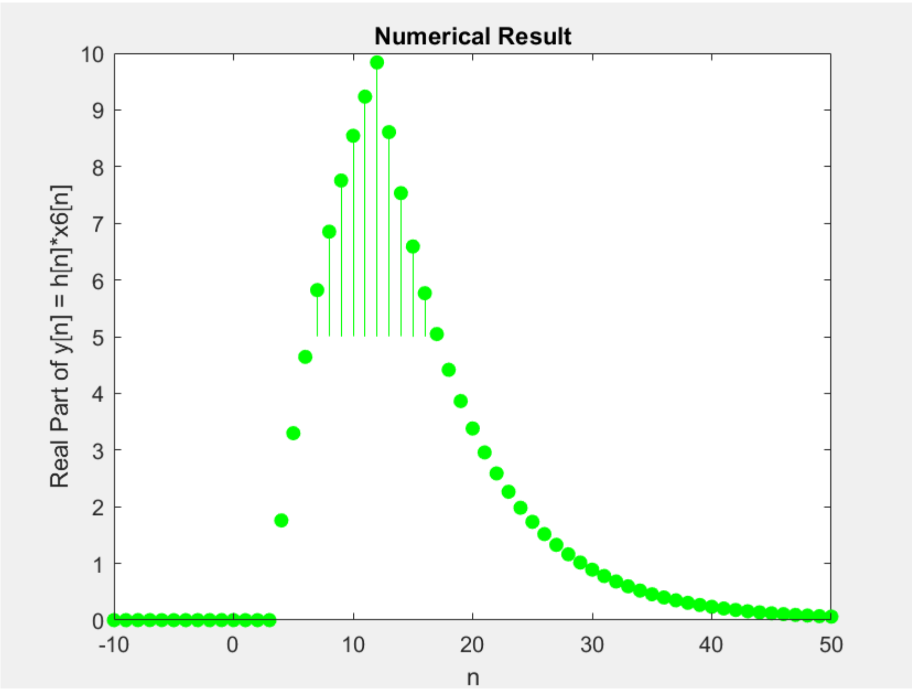
```
% Başlangıç ayarları
L = 100;
N = -L:L;

% Step ve h fonksiyonu
step_h = zeros(size(N));
step_h(N >= 4) = 1;
h_filter = (7/8).^N .* step_h;

% r ve x_sinyal
r_vals = -L/2:L/2;
x_sinyal = zeros(size(r_vals));
x_sinyal((r_vals >= 2) & (r_vals <= 20)) = 2 * cos((2:20) * 1/3);

% Y_sinyal
Y_sinyal = zeros(size(r_vals));

% Konvolüsyon işlemi
k_vals = find(x_sinyal);

for idx = 1:length(k_vals)
    k_pos = k_vals(idx);
    x_val = x_sinyal(k_pos);
    shift_vals = r_vals - r_vals(k_pos);
    h_shifted_vals = shift_vals + L + 1;

    valid_idx = (h_shifted_vals >= 1) & (h_shifted_vals <= length(h_filter));
    Y_sinyal(valid_idx) = Y_sinyal(valid_idx) + h_filter(h_shifted_vals(valid_idx)) * x_val;
end

% Sayısal Sonuç Plotlama
figure;
stem(-10:50, Y_sinyal(41:101), 'filled', 'b');
xlabel('n');
ylabel('y[n] = h[n]*x_sinyal[n]');
title('Numerical Result');
```

C.2) The code for Analytical part

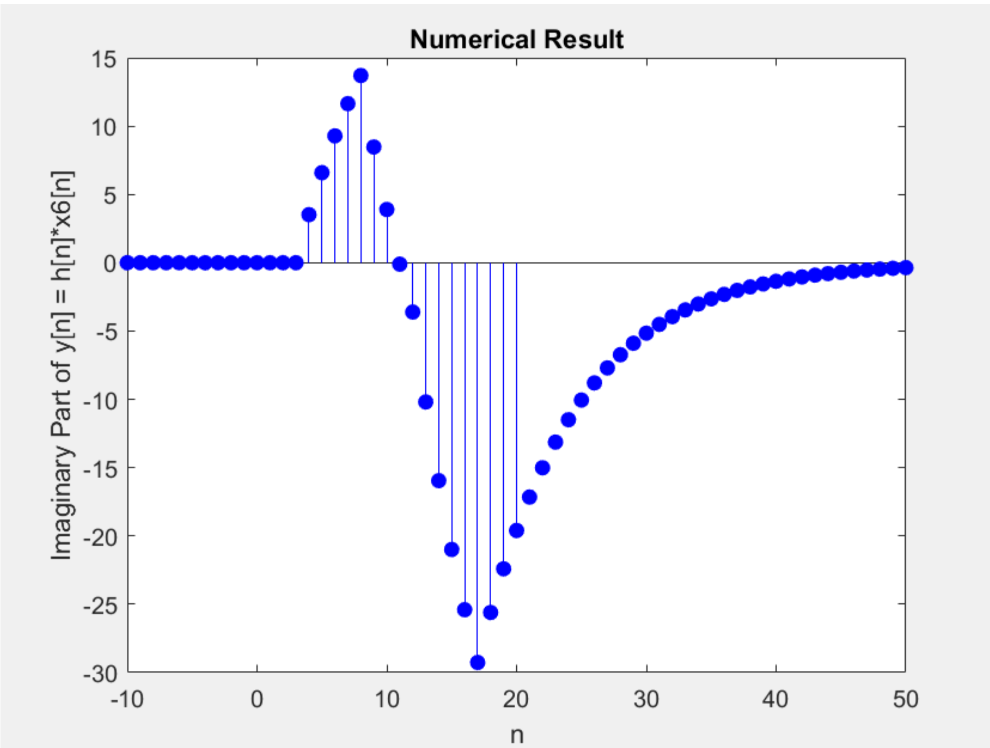
```
% Analitik sonuç hesaplama
ind_1 = (n_vals >= 6) & (n_vals <= 24);
y_analytic(ind_1) = (exp(j_val/3).^n_vals(ind_1)) .* ...
    (((7/8) * exp(-j_val/3)).^4 - ((7/8) * exp(-j_val/3)).^(n_vals(ind_1) - 1)) ...
    / (1 - (7/8) * exp(-j_val/3));

ind_2 = (n_vals > 24);
y_analytic(ind_2) = (exp(j_val/3).^n_vals(ind_2)) .* ...
    (((7/8) * exp(-j_val/3)).^(n_vals(ind_2) - 20) - ((7/8) * exp(-j_val/3)).^(n_vals(ind_2) - 1)) ...
    / (1 - (7/8) * exp(-j_val/3));

% Re{y_analytic[n]} sinyalini hesapla
y_real = 2 * real(y_analytic);

% Sonucu çizdir
figure;
stem((-10:50), y_real(1:61), 'filled', 'b');
xlabel('n');
ylabel('2 * Re{y_analytic[n]}');
title('Analytical Result for y5[n]');
grid on;
```

Q6:

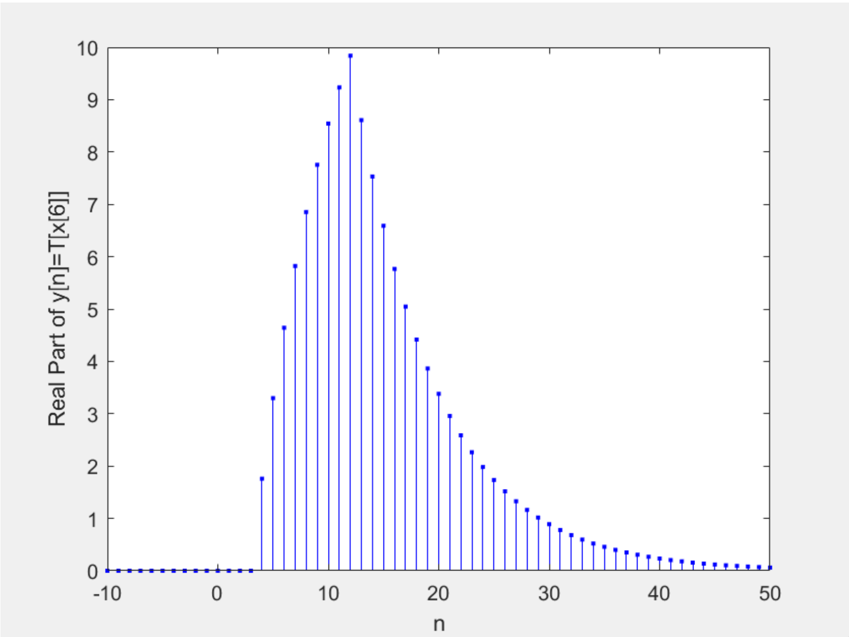
A.1)Numerical Solution Real part



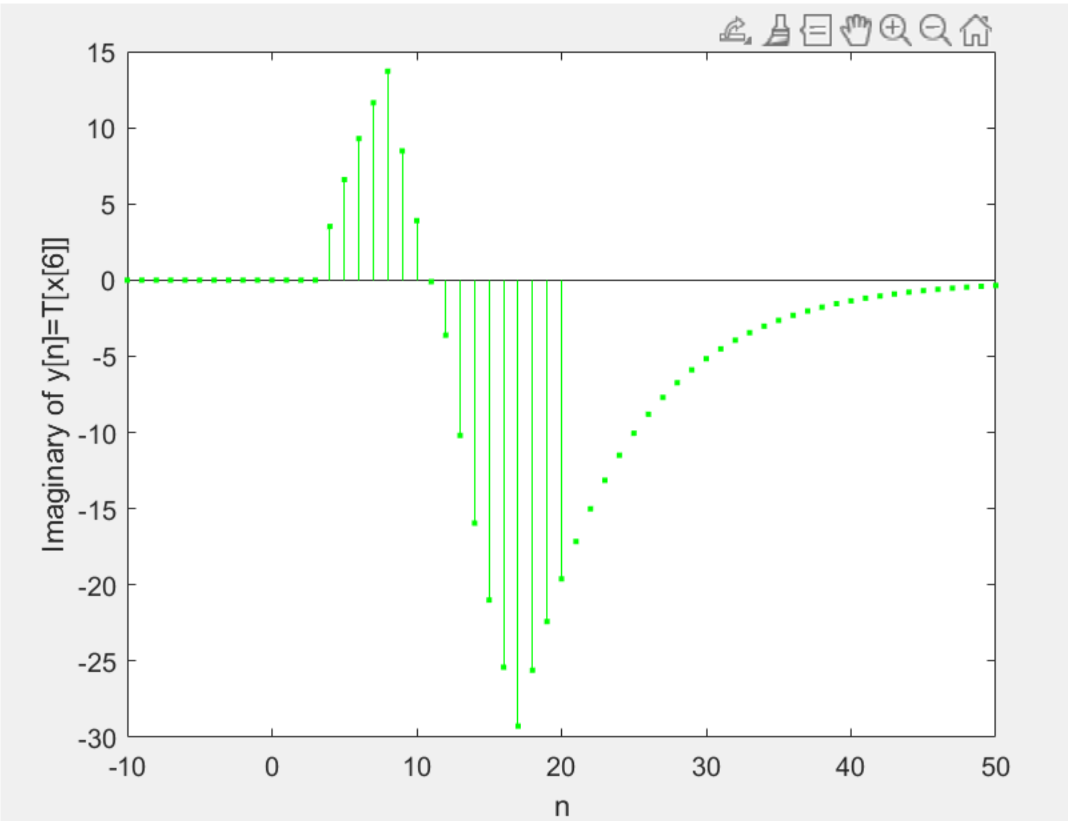
A.2) Numerical Solution Imaginary Part



B.1)Analytical Solution Real part



B.2) Analytical Solution Imaginary part



C.1) The code of Numerical part

```
% Sayısal Sonuç
L = 100;
N = -L:1:L;
unit_h = zeros(size(N));
unit_h(N >= 4) = 1;
h_signal = (7/8).^N .* unit_h;
range_r = (-L/2):1:(L/2);

x_comp1 = zeros(size(range_r));
x_comp1((range_r <= 8) & (range_r >= 0)) = 3;

x_comp2 = zeros(size(range_r));
x_comp2((range_r <= 4) & (range_r >= 0)) = 3;
x_comp2((range_r <= 8) & (range_r >= 5)) = -3;
x_comp2((range_r <= 13) & (range_r >= 9)) = -6;

y_out = zeros(size(range_r));
complex_signal = x_comp1 + 2*1i*x_comp2;

for idx = -(L/2):(L/2)
    shifted_h = h_signal(range_r - idx + L + 1) .* complex_signal(idx + (L/2) + 1);
    y_out = y_out + shifted_h;
end

% Sayısal Sonucu Plotlama
figure;
stem(-10:50, real(y_out(41:101)), 'filled', 'g');
xlabel('n');
ylabel('Gerçek Parça y[n] = h[n]*x6[n]');
title('Sayısal Sonuç');

figure;
stem(-10:50, imag(y_out(41:101)), 'filled', 'b');
xlabel('n');
ylabel('Sanal Parça y[n] = h[n]*x6[n]');
title('Sayısal Sonuç');
```

C.2) The code for Analytical part

```
% Analitik Sonuç
n_vals = -10:100;
y_real_part = zeros(size(n_vals));
y_real_part((n_vals >= 4) & (n_vals <= 12)) = 24 * ((7/8).^4 - (7/8).^(5:13));
y_real_part(n_vals >= 12) = 24 * ((7/8).^(4:92) - (7/8).^(13:101));

n_vals = -10:100;
y_imag_part = zeros(size(n_vals));
y_imag_part((n_vals >= 4) & (n_vals <= 9)) = 24 * ((7/8).^4 - (7/8).^(5:10));
y_imag_part((n_vals >= 9) & (n_vals <= 12)) = 24 * ((7/8).^4 - (7/8).^(10:13)) - 48 * ((7/8).^4 - (7/8).^(5:8));
y_imag_part((n_vals >= 12) & (n_vals <= 17)) = 24 * ((7/8).^(4:9) - (7/8).^(13:18)) - 48 * ((7/8).^4 - (7/8).^(8:13));
y_imag_part(n_vals >= 17) = 24 * ((7/8).^(9:92) - (7/8).^(18:101)) - 48 * ((7/8).^(4:87) - (7/8).^(13:96));

% Analitik Sonucu Plotlama
figure;
stem(-10:50, y_real_part(1:61), 'filled', '.b');
xlabel('n');
ylabel('Gerçek Parça y[n] = T[x[6]]');

figure;
stem(-10:50, 2*y_imag_part(1:61), 'filled', '.g');
xlabel('n');
ylabel('Sanal Parça y[n] = T[x[6]]');
```

CONCLUSION:

This lab consisted of six parts with input signals. The lab manual provided the impulse response for the machine we worked with. Then we estimated the system's various outputs for distinct input signals for both numerical and analytical part.