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Department of Electrical, Computer, & Biomedical Engineering
Faculty of Engineering & Architectural Science

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Instructor:	Dimitri Androutsos

Assignment/Lab Number:	3
Assignment/Lab Title:	Discrete-Time Fourier Series

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Student LAST Name	Student FIRST Name	Student Number	Section	Signature*
Fahmy	Ahmad	500913092	9	

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Appendix

A) Discrete Time Fourier Series (DTFS)

B) Inverse DTFS and Time Shifting

C) System Response

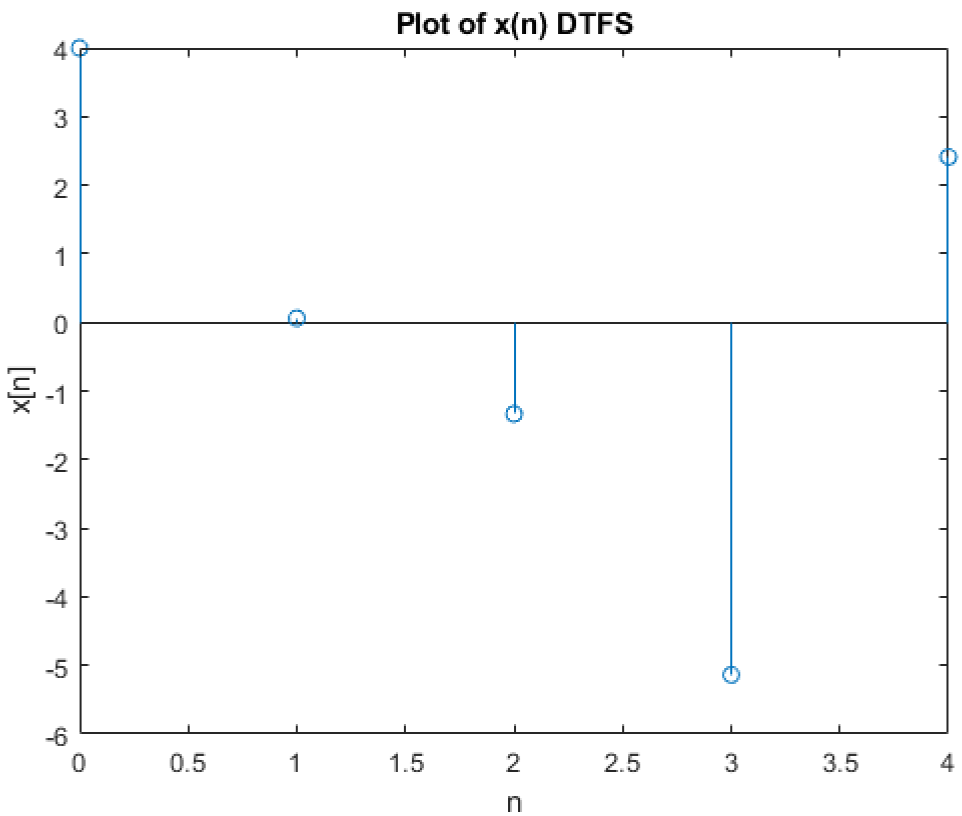
A) Discrete Time Fourier Series (DTFS)

Part 1 - Fundamental Period & Fundamental Frequency

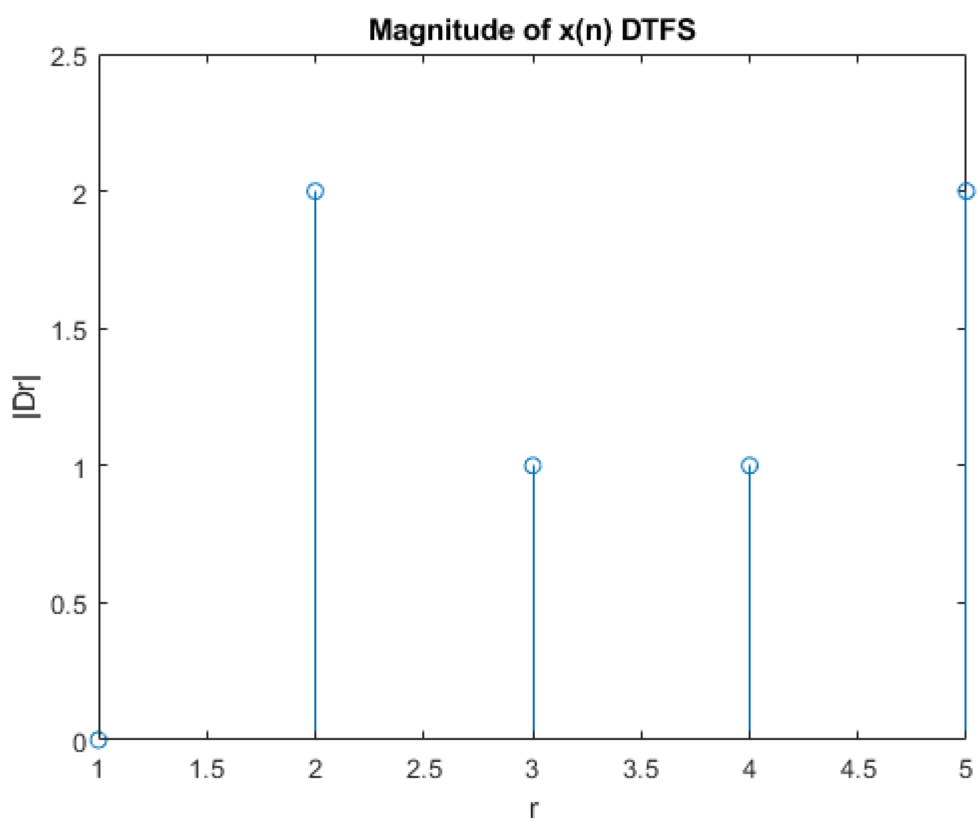
```
clc
clear
n = 0:20;
x = 4*cos(2.4*pi*n)+2*sin(3.2*pi*n);
mN1 = (2.4*pi)/(2*pi);
mN2 = (3.2*pi)/(2*pi);
%m/N1 = 6/5
%m/N2 = 8/5
N0 = 5;
Om0 = 2*pi/N0;
```

Part 2 - DTFS

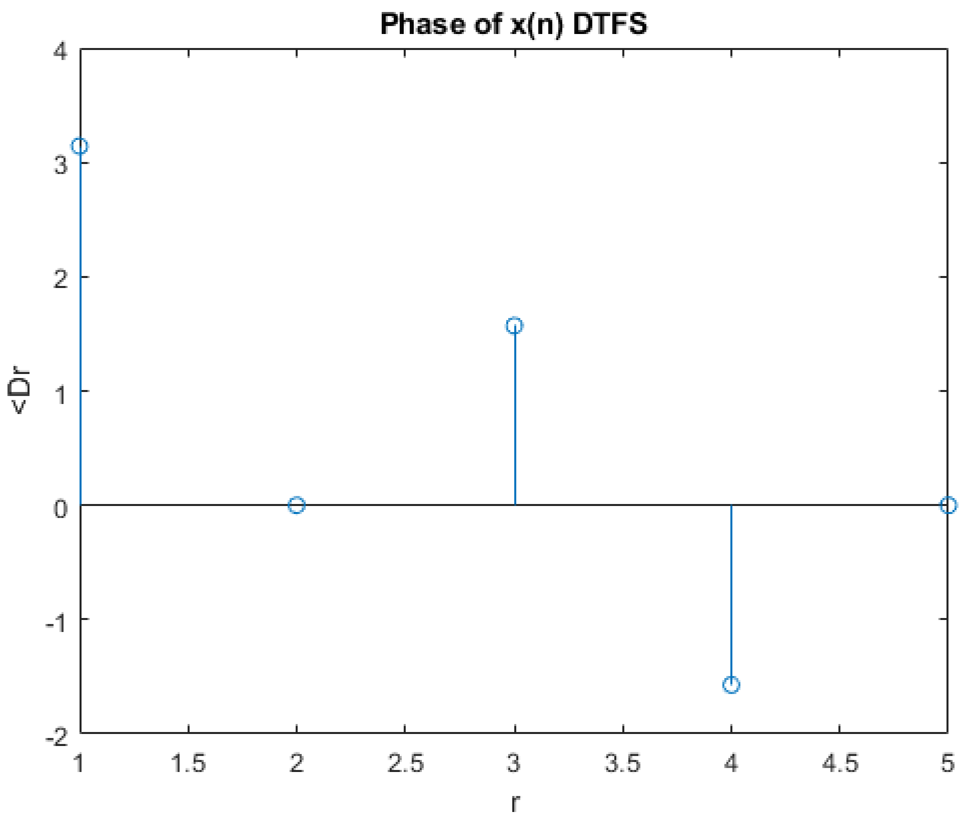
```
n = 0:N0-1;
x = 4*cos(2.4*pi*n)+2*sin(3.2*pi*n);
for(r = 0:N0-1)
    Dr(r+1)=(sum(x.*exp(-1i.*r.*n.*Om0)))/N0;
end

figure;
stem(n, x);
title('Plot of x(n) DTFS')
xlabel('n')
ylabel('x[n]')

figure;
stem(abs(Dr));
title('Magnitude of x(n) DTFS')
xlabel('r')
ylabel('|Dr|')

figure;
stem(angle(Dr));
title('Phase of x(n) DTFS')
xlabel('r')
ylabel('<Dr')
```



Plot of x(n) DTFS
x[n]
n



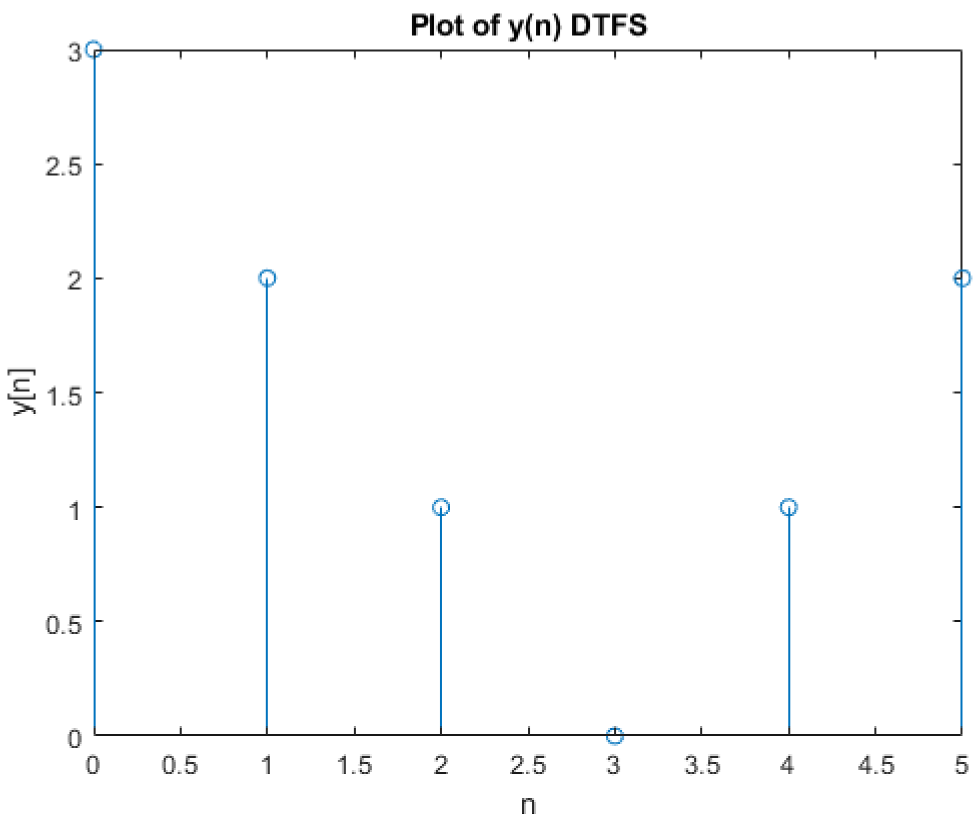
Magnitude of x(n) DTFS
|Dr|
r

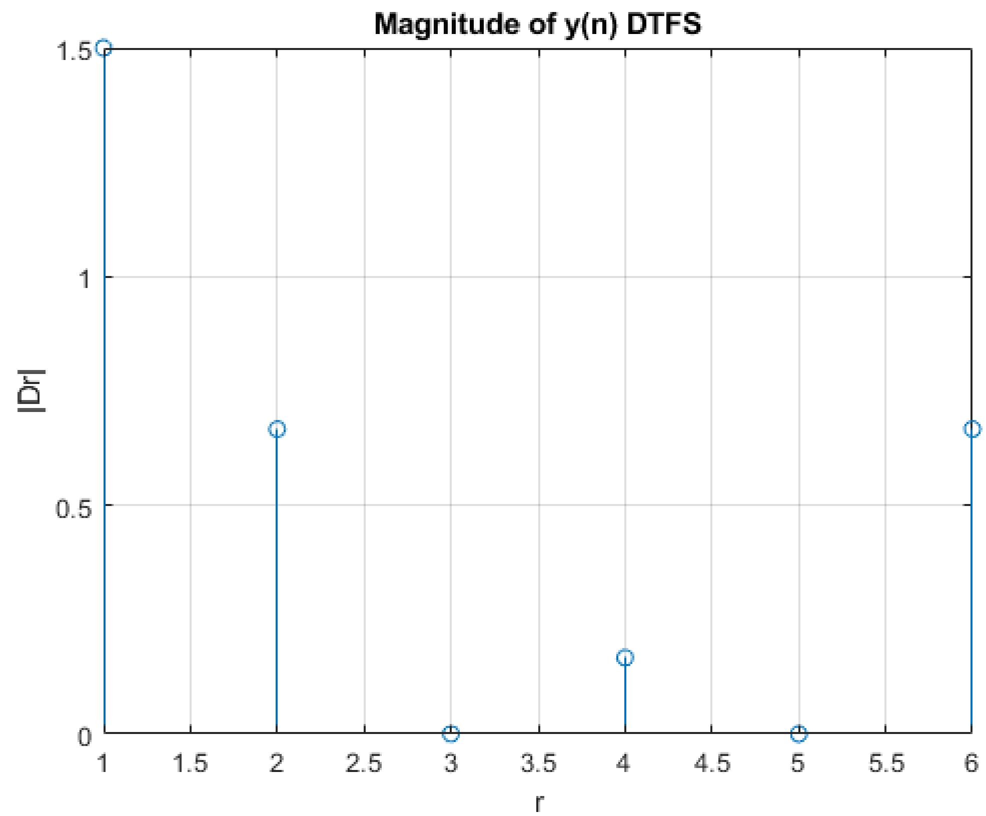


Part 3 - P1 and P2 with Lab3 Manual Figure 1

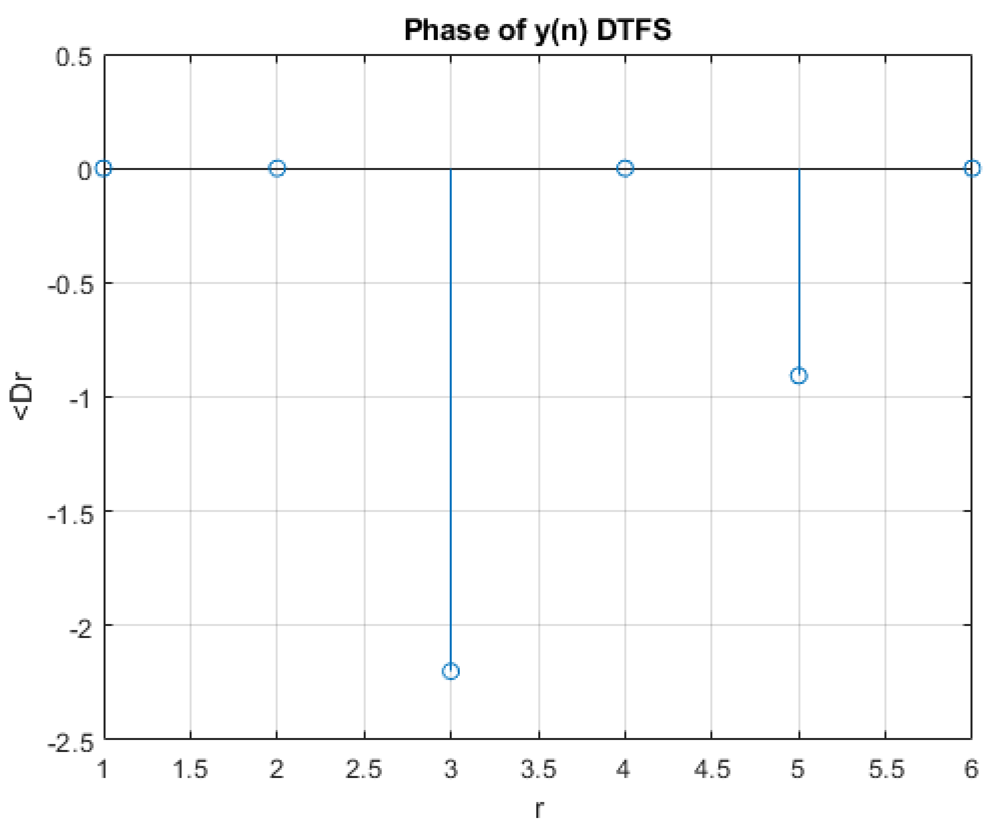
```
clc
clear
N0 = 6;
Om0 = 2*pi/N0;

n = 0:N0-1;
y = [3 2 1 0 1 2];
for(r = 0:N0-1)
   Dr(r+1)=(sum(y.*exp(-1i.*r.*n.*Om0)))/N0;
end

figure;
stem(n, y);
title('Plot of y(n) DTFS')
xlabel('n')
ylabel('y[n]')

figure;
stem(abs(Dr));
title('Magnitude of y(n) DTFS')
```

```
xlabel('r')
ylabel('|Dr|')
grid on

figure;
stem(angle(Dr));
title('Phase of y(n) DTFS')
xlabel('r')
ylabel('<Dr')
grid on
```





Magnitude of y(n) DTFS
|Dr|
r
1.5
1
0.5
0
1
1.5
2
2.5
3
3.5
4
4.5
5
5.5
6

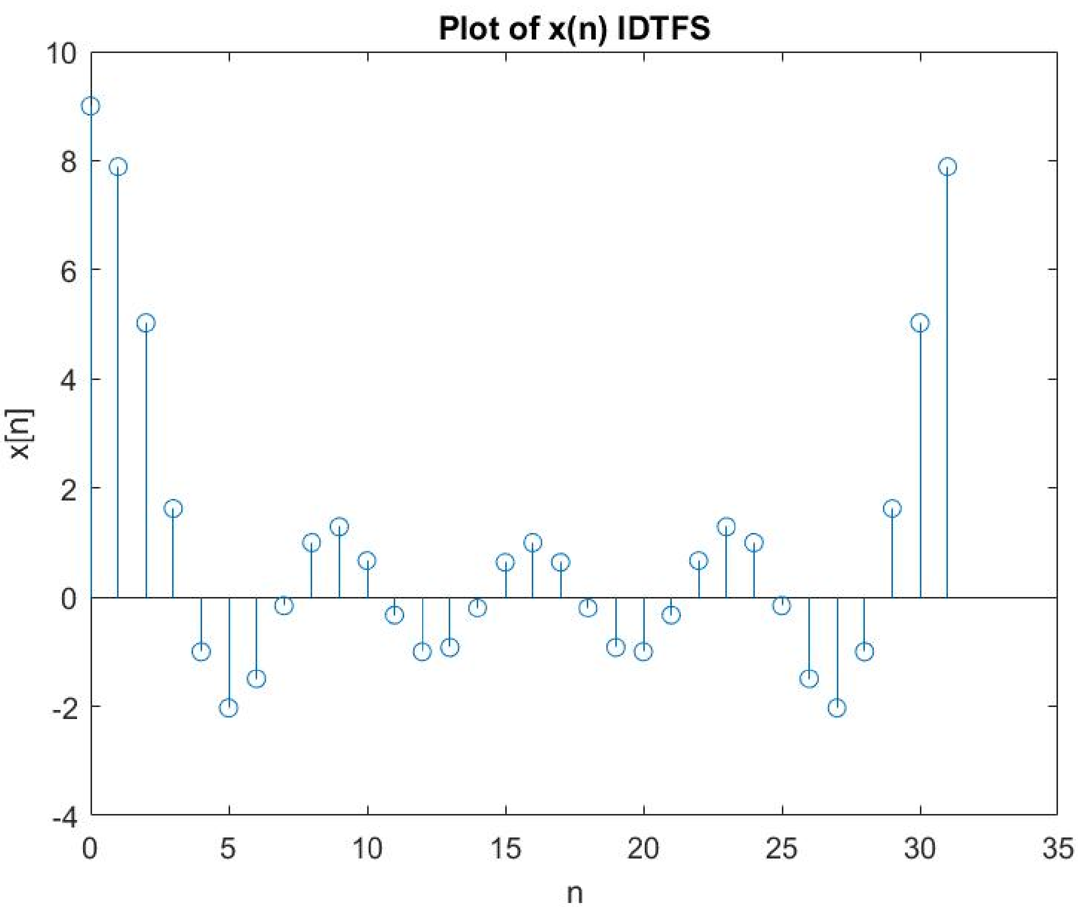


Phase of y(n) DTFS
<Dr
r
0.5
0
-0.5
-1
-1.5
-2
-2.5
1
1.5
2
2.5
3
3.5
4
4.5
5
5.5
6

B) Inverse DTFS and Time Shifting Property

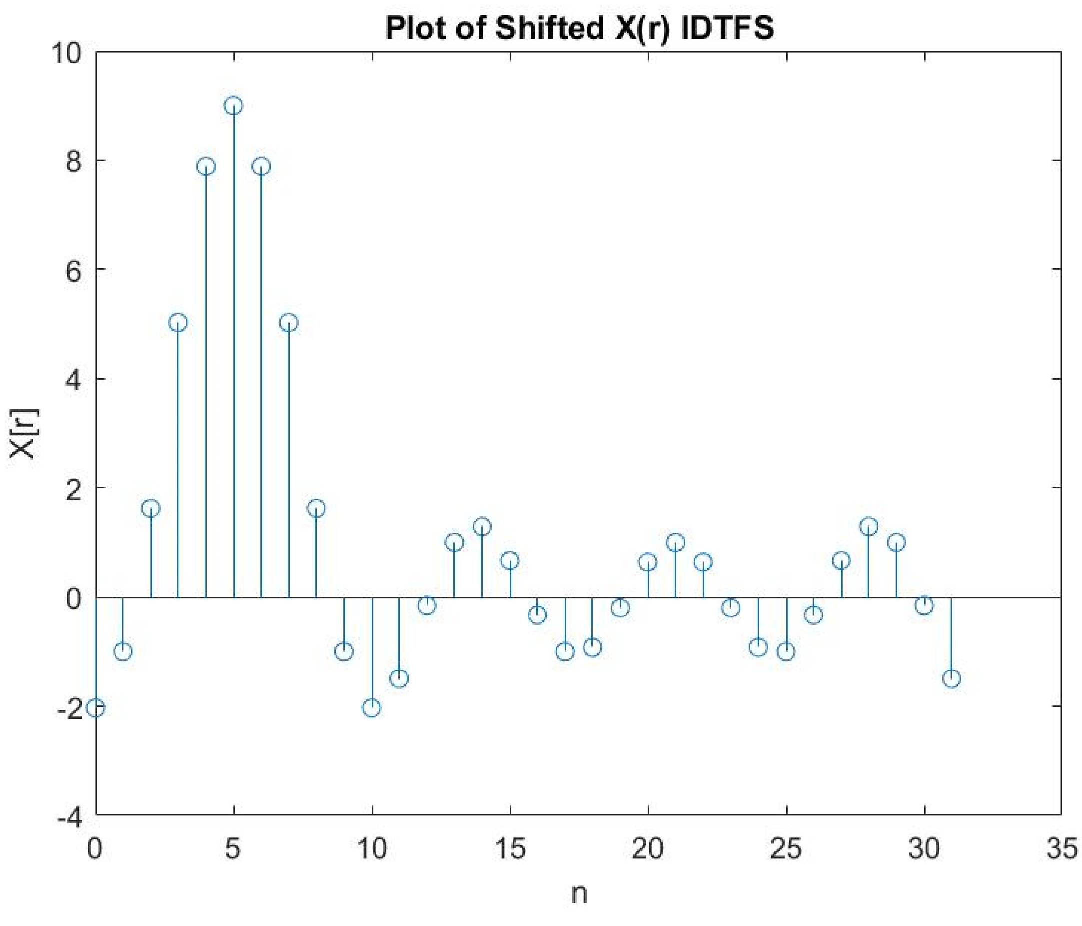
Part 1 - Inverse DTFS

```
clc
clear
N0 = 32;
Om0 = 2*pi/N0;
n = 0:N0-1;

xr = [ones(1,5) zeros(1,23) ones(1,4)];
x = ifft(xr).*N0;

figure;
stem(n, x);
title('Plot of x(n) IDTFS')
xlabel('n')
ylabel('x[n]')
```



Part 2 - Time Shifting

```
clc
clear
N0 = 32;
Om0 = 2*pi/N0;
n = 0:N0-1;

xr = [ones(1,5) zeros(1,23) ones(1,4)];
X = xr.*exp(-1i.*5.*n.*Om0);
X = ifft(X)*N0;

figure;
stem(n, X);
title('Plot of Shifted X(r) IDTFS')
xlabel('n')
ylabel('X[r]')
```



The result in part 2 differs from x[n] in part 1 by being shifted 5 units to the right due to the multiplication by $e^{-j5\Omega_0 r}$ in the frequency domain.

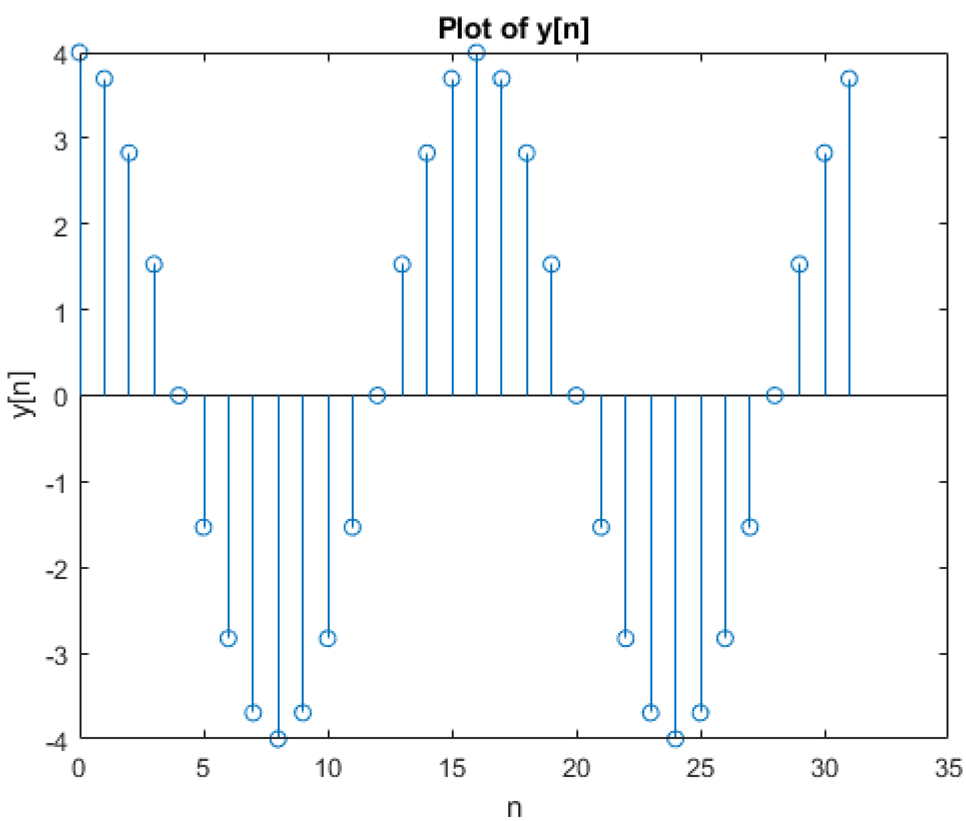
C) System Response

Part 1 - Plot of H[r] for Lab3 Figure 3 with Respect to Ω_0

```
clc
clear
N0 = 32;
Om0 = 2*pi/N0;
r = 0:N0-1;

Hr = [ones(1,5) zeros(1, 23) ones(1,4)];

figure;
stem(Om0.*r, Hr);
title('H[r] for Lab3 Figure 3 with Respect to Omega')
xlabel('r')
ylabel('H[r]')
```

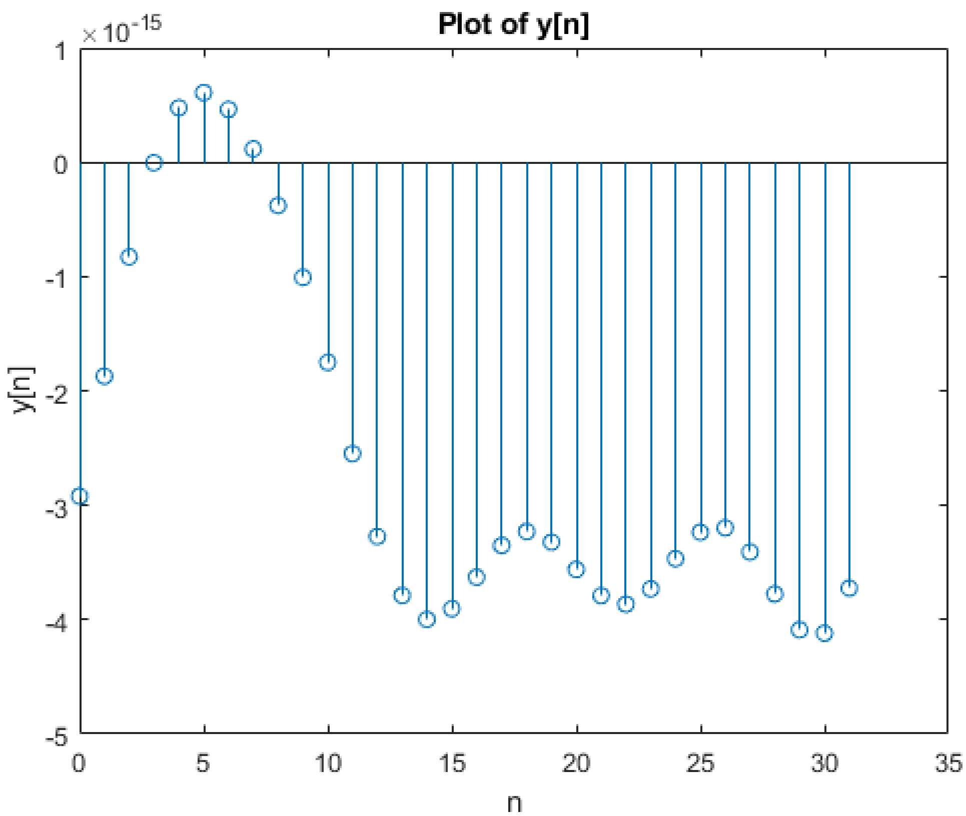
Part 2 - Plot of System Response for Lab3 Figure 3 with input $x_1[n]$

```
clc
clear
N0 = 32;
Om0 = 2*pi/N0;
r = 0:N0-1;

Hr = [ones(1,5) zeros(1, 23) ones(1,4)];
x = 4*cos(pi*r/8);
X = fft(x);

Y = X.*Hr;
y = ifft(Y);

figure;
stem(r, y);
title('Plot of y[n]')
xlabel('n')
ylabel('y[n]')
```



Part 3 - Plot of System Response for Lab3 Figure 3 with input $x_2[n]$

```
clc
clear
N0 = 32;
Om0 = 2*pi/N0;
r = 0:N0-1;

Hr = [ones(1,5) zeros(1, 23) ones(1,4)];
x = 4*cos(pi*r/2);
X = fft(x);

Y = X.*Hr;
y = ifft(Y);

figure;
stem(r, y);
title('Plot of y[n]')
xlabel('n')
ylabel('y[n]')
```



Part 4 – Result 1 and 2 Comparison

The results in Part 1 and 2 are different because $x_1[n]$ had a period of 16 units, whereas the period for $x_2[n]$ had a period of 4 units. The Fourier transform of $x_1[n]$ and $x_2[n]$ creates delta functions at 2 and 30, as well as 8 and 24, respectively. This means $x_1[n]$ falls within the range of H[r] but $x_2[n]$ does not resulting in the system responses above.