

Assignment 2

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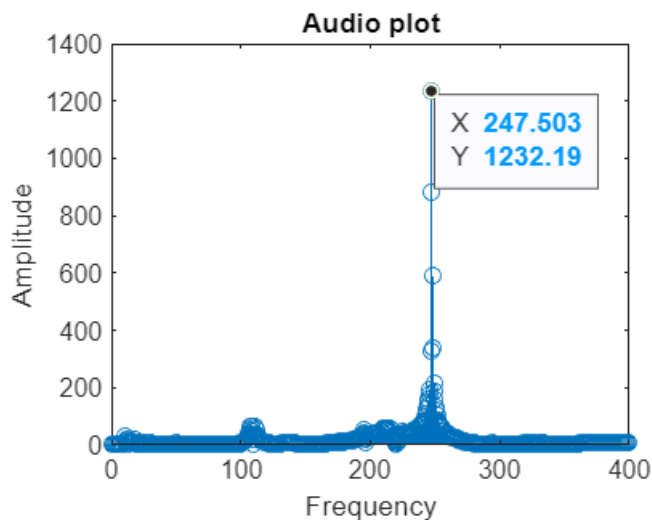
Vladislav Serafimov

Frequency analysis

```
[y, fs] = audioread("week2_unknown_guitar_string.wav");  
yf = fft(y);  
stem(linspace(0,44100, length(abs(yf))) ,abs(yf))
```

We limit the frequency range to 400 because the high E string of the guitar is tuned to ~329 Hz

```
xlim([0, 400])  
title("Audio plot")  
xlabel("Frequency")  
ylabel("Amplitude")
```



figure

From the plot we can deduce that the frequency is 247,503 Hz, meaning that an open B string is being played.

Z transform

1.

Using the z-transform $X(z) = \sum x[n].z^{-n}$ of $x[n] = \{0, 1, 2, 3, 2, 7\}$ we can calculate

$$X(z) = x[1]z^{-1} + x[2]z^{-2} + x[3]z^{-3} + x[4]z^{-4} + x[5]z^{-5}$$

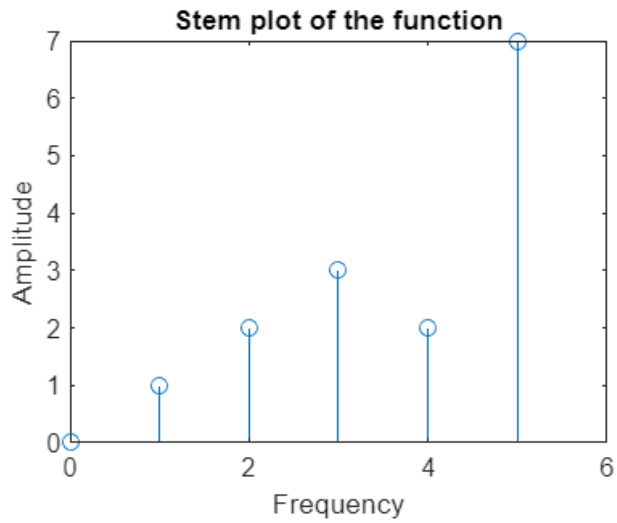
$$= z^{-1}(1 + 2z^{-1} + 3z^{-2} + 2z^{-3} + 7z^{-4})$$

```
clear  
xn = [0, 1, 2, 3, 2, 7];  
stem(0:5,xn)
```

```

title("Stem plot of the function")
xlim([0, 6])
xlabel("Frequency")
ylabel("Amplitude")

```



figure

2.

Function: $x(t) = 4t - 4te^{-3t}$

a)

$$x(0) = -4$$

$$x(1) = 4 - 4e^{-3} \approx 3,8$$

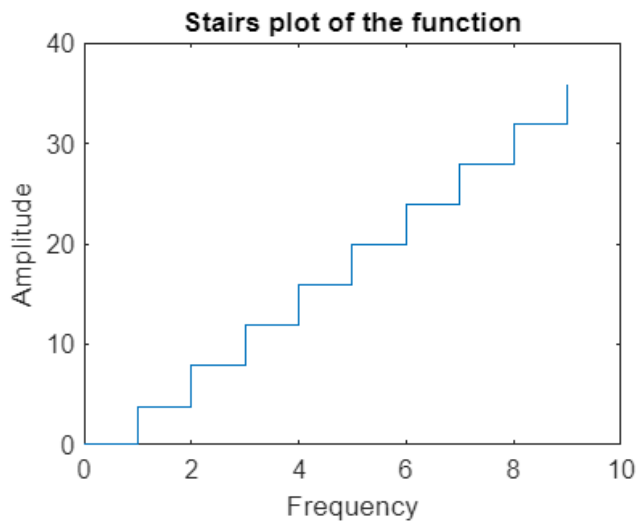
$$x(2) = 8 - 8e^{-6} \approx 7,96$$

$$x(3) = 12 - 12e^{-9} \approx 11,99$$

```

clear
t = 0:9;
xt = 4*t - 4.*t.*exp(-3.*t);
stairs(t, xt)
title("Stairs plot of the function")
xlabel("Frequency")
ylabel("Amplitude")

```



figure

b)

$$X(z) \approx -4 + 3,8z^{-1} + 7,96z^{-2} + 11,99z^{-3}$$

3.

a)

$$x(t) = 3\sin(4t) + 4\cos(4t)$$

$$X(z) \approx 4 - 4,885z^{-1} + 2,386z^{-2} + 1,766z^{-3}$$

```
clear
syms t [1 4];
xt = 3.*sin(4.*t) + 4.*cos(4.*t);
ztrans(simplify(xt))
```

ans =

$$\left(\frac{3z \sin(4)}{\sigma_1} + \frac{4z(z - \cos(4))}{\sigma_1} \right) \frac{z(4 \cos(4t_2) + 3 \sin(4t_2))}{z-1} \frac{z(4 \cos(4t_3) + 3 \sin(4t_3))}{z-1} \frac{z(4 \cos(4t_4) + 3 \sin(4t_4))}{z-1}$$

where

$$\sigma_1 = z^2 - 2 \cos(4)z + 1$$

b)

$$x(k) = 7,4^k$$

$$X(z) \approx 1 + 7,4z^{-1} + 54,76z^{-2} + 405,224z^{-3}$$

```
clear
```

```
syms k [1 4];
xk = 7.4.^k;
ztrans(simplify(xk))
```

ans =

$$\left(\frac{z}{z - \frac{37}{5}} \frac{\left(\frac{37}{5}\right)^{k_2} z}{z - 1} \frac{\left(\frac{37}{5}\right)^{k_3} z}{z - 1} \frac{\left(\frac{37}{5}\right)^{k_4} z}{z - 1} \right)$$

c)

$$x(k) = 7k \cdot 7^{k-1} = k7^k$$

$$X(z) \approx 7z^{-1} + 98z^{-2} + 1029z^{-3}$$

```
clear
syms k [1 4];
xk = k.*7.^k;
ztrans(simplify(xk))
```

ans =

$$\left(\frac{7z}{(z-7)^2} \frac{7^{k_2} k_2 z}{z-1} \frac{7^{k_3} k_3 z}{z-1} \frac{7^{k_4} k_4 z}{z-1} \right)$$

4.

$$H(s) = \frac{2s+1}{(s+1)(s+2)} = \frac{A}{s+1} + \frac{B}{s+2} = \frac{s(A+B) + 1(2A+B)}{(s+1)(s+2)}$$

Then $2s+1 = s(A+B) + (2A+B)$ giving us $A = -1; B = 3$

$$H(s) = \frac{-1}{s+1} + \frac{3}{s+2}$$

```
s = tf('s');
H1 = [2 1];
```

Lower part is $s(s+1)(s+2) = s^3 + 3s^2 + 2s$

```
H2 = [1 3 2 0];
[r, p, k] = residue(H1, H2);
r
```

```
r = 3x1
-1.5000
1.0000
0.5000
```

```
p
```

```
p = 3x1
-2
```

-1
0