Assignment 2

Stephen Cruz Wright

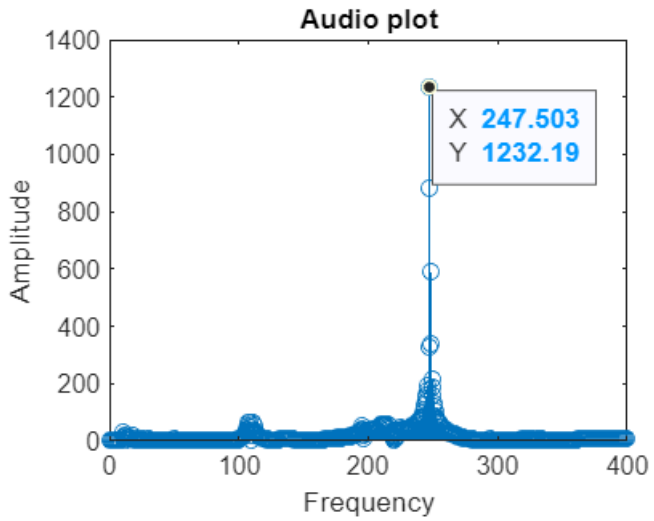
Vladislav Serafimov

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.

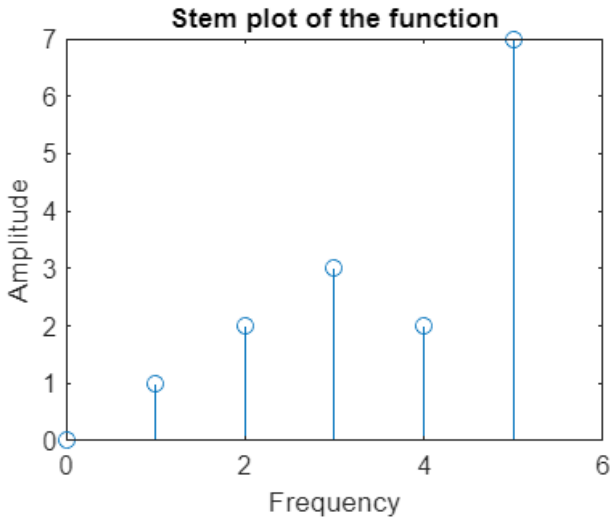
Using the z-transform $X(z) = \sum x[n].z^{-n}$ of $x[n] = \{0, 1, 2, 3, 2, 7\}$ we can calculate

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

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

```
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)

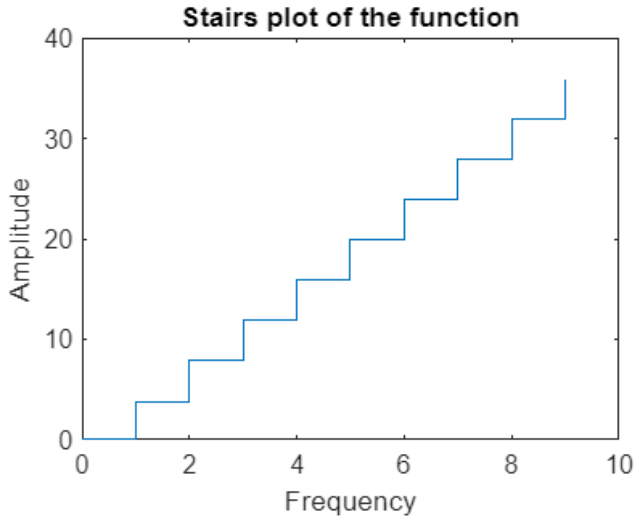
$x(0) = -4$

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

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

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

```
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)

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

$$X(z) = \frac{1}{z^2 - 2zcos(4T) + 1}(3zsin(4T) + 4(z - zcos(4T)))$$

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

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

```
ans =
```

$$\frac{3\,z\,\sin(4)}{z^2 - 2\cos(4)\,z + 1} + \frac{4\,z\,\left(z - \cos(4)\right)}{z^2 - 2\cos(4)\,z + 1}$$

b)

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

$$X(z) = \frac{z}{z - 7,4}$$

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

```
clear
```

```
syms k;
xk = 7.4.^k;
ztrans(simplify(xk))
```

```
ans =
```

$$\frac{z}{z-\frac{37}{5}}$$

c)

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

$$X(z) = \frac{7z}{(z-7)^2}$$

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

```
clear
syms k;
xk = k.*7.^k;
ztrans(simplify(xk))
```

```
ans =
```

$$\frac{7\,z}{(z-7)^2}$$

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 = 3×1
   -1.5000
    1.0000
    0.5000
```

```
p
```

```
p = 3×1
```

```
-2
-1
 0
```