Satılmış Furkan Kahraman
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27/09/2023
Report 1

EE 321 Lab 1

Part 1

a)

```
a =

    3.2000    4.8571   -6.0000   24.0000
```

Figure 1 – a = [3.2 34/7 -6 24]

```
a =

    3.2000
    4.8571
   -6.0000
   24.0000
```

Figure 2 – `a = [3.2; 34/7; -6; 24]`

b) At part b, the result is not shown at the command window. But a and b are given the same values at part a.

c)

```
tic
a = [3.2 34/7 -6 24]
toc
```

Figure 3 – Code without ";"

Elapsed time is 0.000250 seconds.

```
tic
a = [3.2; 34/7; -6; 24]
toc
```

Figure 4 – Code with ";"

Elapsed time is 0.000228 seconds.

When the time is important too, semicolon figure should be used to reduce time and increase time efficiency.

d) ERROR: Incorrect dimensions for matrix multiplication. Check that the number of columns in the first matrix matches the number of rows in the second matrix. To operate on each element of the matrix individually, use TIMES (.*) for elementwise multiplication.

Because of the dimensions of matrices are not eligible for matrix multiplication.

e) Then type c=a.*b, this operation is only multiplication of elements of matrices sequential elements. It does not imply. And c = b.*a does not change the result because arrangement does not affect result.

f)

```
c =

  -2.4361e+03
```

Figure 5 – The result of matrix multiplication

With this code, MATLAB has done matrix multiplication and give a 1x1 matrix which is the result.

g)

```
c =

   1.0e+03 *

    0.0186    0.0154    0.0160   -0.3264
    0.0282    0.0233    0.0243   -0.4954
   -0.0348   -0.0288   -0.0300    0.6120
    0.1392    0.1152    0.1200   -2.4480
```

Figure 6 – The result of matrix multiplication

With this code, MATLAB has done matrix multiplication and give a 4x4 matrix which is the result.

h) A = [1:0.01:2]
This code generates every number between 1 and 2, with 0.01 intervals.

i)Elapsed time is 0.000363 seconds.

j)

```
a = []
for i=1:101
    a(i) = 0.99+0.01*i
end
a
```

Figure 7 – a with for loop

Elapsed time is 0.008763 seconds.

k)

```
a = zeros(1,101)
for i=1:101
    a(i) = 0.99+0.01*i
end
a
```

Figure 8 – allocated memory

Elapsed time is 0.015141 seconds.

First method is much faster.

l) MATLAB sequentially assigns the values in the vector to the function and returns the value.

m) plot(x) uses variable in it as an x-axis and plotted the same graph with plot (t, x). Instead in plot (x, t), variables are changed the axes.

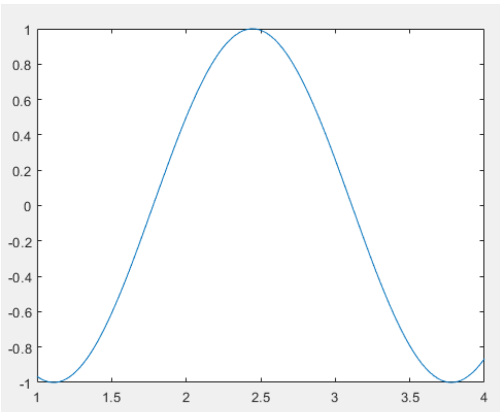

Figure 9 – plot(t,x)

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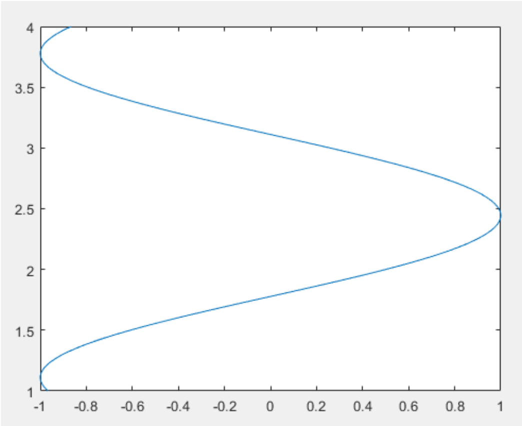

Figure 10 – plot (x, t)

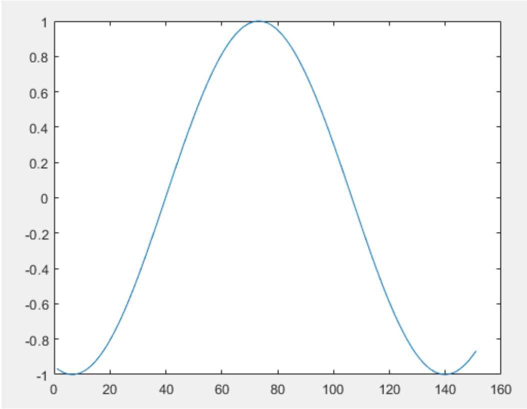

Figure 11 – plot(x)

n) Plot (t, x, '-+') plots the graph with a line and put the plus sign on each point.

Plot (t, x, '+') plots the graph without a line and just plus sign on each point.

o) 26 points are included in the array of t.

p) t = linspace(0,4,151) will generate the same output.

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q)

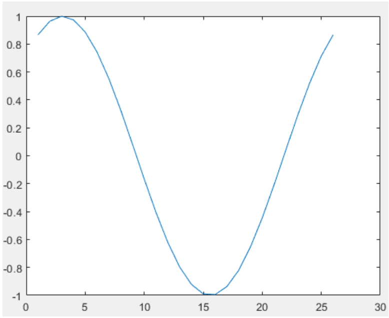

Figure 12 - x=sin(2*pi*t+pi/3)

s) This time 101 points are added into the time points.

v)

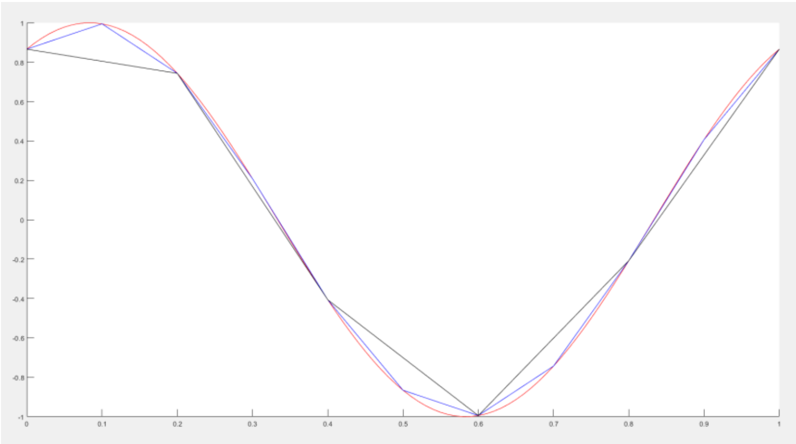

Figure 13 – Sine function implementations

If the sine function has more discretized point in time domain the results are more likely to resemble an analogue continuous signal.

w) Plot command filled the space between the points with linear lines.

x) Stem command is used to show discretize points on the graph. But plot command returns a continuous wave.

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Part 2

a) Both sound() and soundsc() are eligible to listen to discrete version of the signal in Matlab.

Pitch of the sound has increased as frequency is increased.

x2(t)'s sound resembles to piano because it is decaying when it is produced. x1(t)'s sound resembles to flute because it's magnitude is constant from start to end.

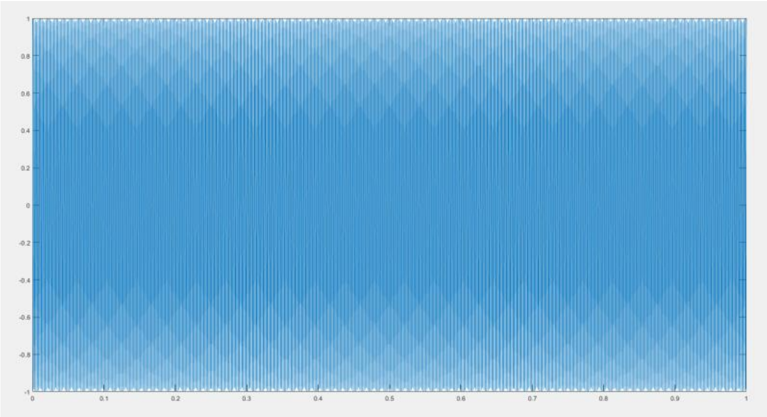

Figure 14 – 440 Hz Frequency

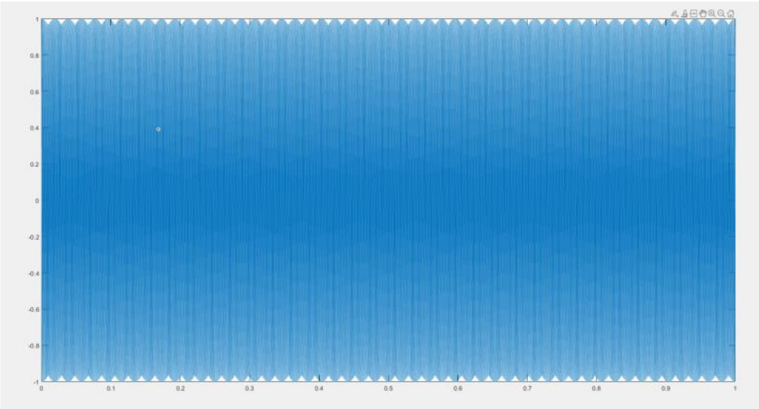

Figure 15 – 687 Hz Frequency

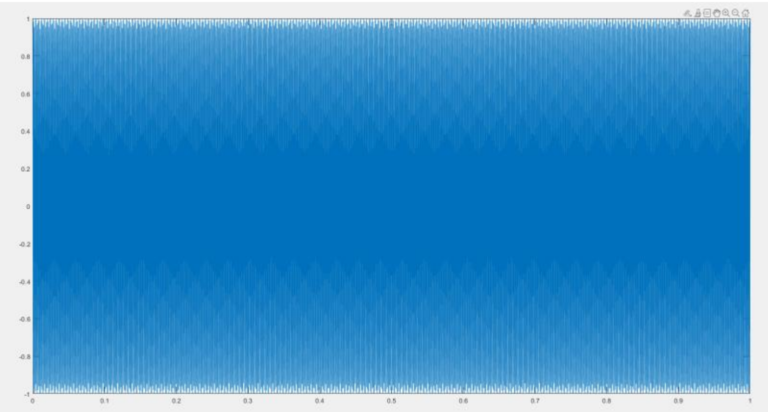

Figure 16 – 883 Hz Frequency

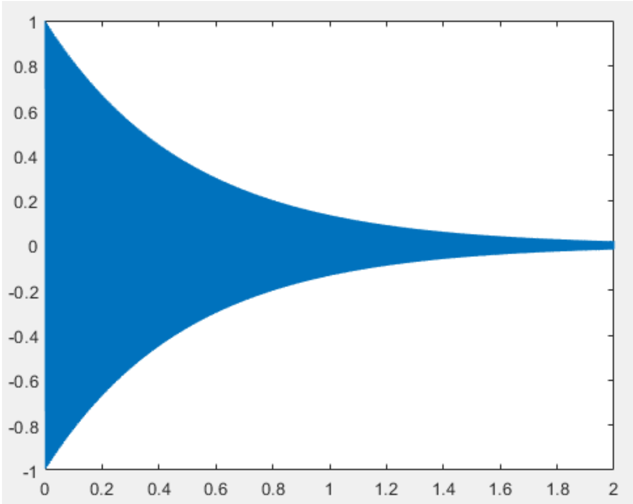

Figure 17- a =2

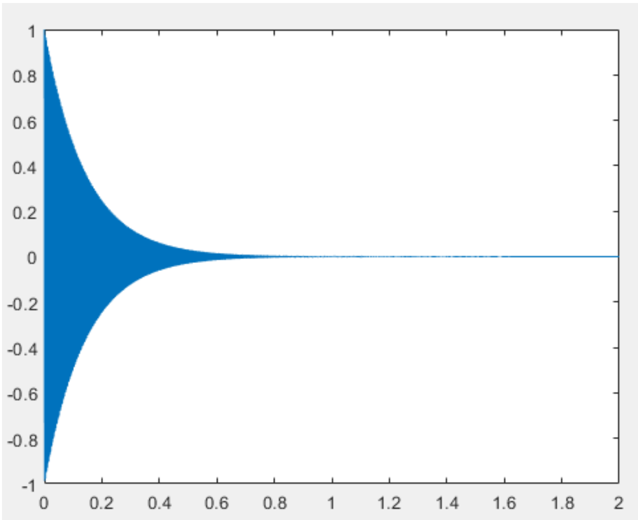

Figure 18 – a = 7

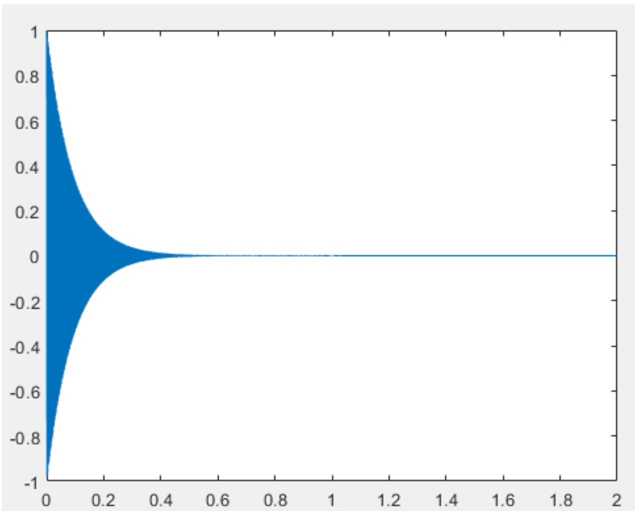

Figure 19 – a = 1

As a is increased, the audible part of the sound is decreasing. The magnitude of the voice signal decays faster.

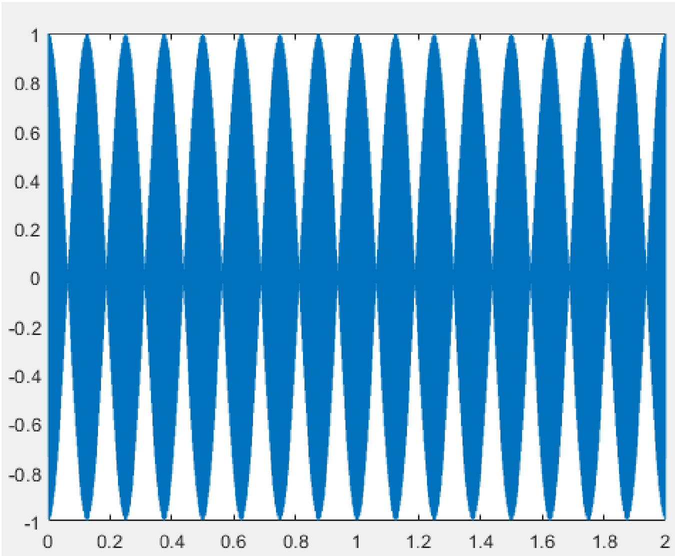

Figure 20 – f0 = 440 Hz, f1= 4 Hz

The low frequency part of the sound added depth and vibrancy to the sound.

$$\cos a * \cos b = \frac{1}{2}(\cos(a+b) + \cos(a-b))$$

Eq. 1 - Cosine multiplication identity

```
t=[0:1/8192:1];

f0 = 880;

f1 = 220;

x3 = cos(2*pi*f0*t) .* cos(2*pi*f1*t);

sound(x3)
```

Figure 21 - Multiplication of frequencies

```
f0 = 880;

f1 = 220;

f2 = 1100

f3 = 660

x2 = cos(2*pi*f2*t)

x1 = cos(2*pi*f3*t)

sound(x1)

sound(x2)
```

Figure 22 – Two different frequencies

The multiplication of 880 and 220 Hz has the same sound with summation 1100 and 660 Hz.

Part 3

$$x(t)=\cos(2*\pi*\emptyset(t))$$

Eqn. 2

$$f_{ins} = \frac{d\emptyset}{dt}$$

Eqn. 3

So, the α = a/2

$$x4(t) = \cos(2\pi*(a/2)*t^2)$$

$$\emptyset(t) = (a/2)*t^2$$

$$f_{ins} = \frac{d\emptyset}{dt} = a*t$$

The alpha number is generated by random.org was 1611. With this selection I got a sound which its frequency range is from 0 to 1611 Hz. So the sound's pitch is increasing linearly along I hear it.

```
t = [0:1/8192:1];

f0 = 1611*t

x1 = cos(2*pi*f0.*t)

sound(x1)
```

Figure 23 – MATLAB code for x4(t)

For $x5(t) = \cos(2\pi(-500t^2+1600t))$, the frequency is $(-500t^2+1600t)$ and rate of the change of the frequency is the derivative of this frequency which equals to (-1000t + 1600) Hz/s.

At t0 = 0, f = 1600 Hz

At t0 = 1, f = 600 Hz

At t0 = 2, f = 400 Hz

I heard that frequency has started from high pitch and it decays the pitch of sound it stops and it starts increasing again.

Part 4

$x(t) = \cos(2\pi\alpha t + \varphi)$,

When $\varphi = 0$, the sound frequency is still and starting point is determined by cosine term.

When $\varphi = \pi/4$, the sound frequency is still same but starting point has changed.

When $\varphi = \pi/2$, the sound frequency is still same but starting point has changed.

When $\varphi = 3\pi/4$, the sound frequency is still same but starting point has changed.

When $\varphi = \pi$, the sound frequency is still same but starting point has changed.

So, the sound has not changed as we shifted the signal.

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Part 5

At part 5, it is expected to show that summation of two cosine wave is equal to another cosine wave and to determine the parameters of sum cosine wave.

$$A_1 \cdot \cos(2\pi . f_o . t + \phi_1) + A_2 \cdot \cos(2\pi . f_o . t + \phi_2) = \sqrt{\left(A_1 \cdot \cos(\phi_1) + A_2 \cdot \cos(\phi_2)\right)^2 + \left(A_1 \cdot \sin(\phi_1) + A_2 \cdot \sin(\phi_2)\right)^2} \cdot \cos\left(2\pi f_o t + \tan^{-1}\left(\frac{A_1 \cdot \sin\phi_1 + A_2 \cdot \sin\phi_2}{A_1 \cdot \cos\phi_1 + A_2 \cdot \cos\phi_2}\right)\right)$$

let $\tan^{-1}\left(\frac{A_1 \cdot \sin\phi_1 + A_2 \cdot \sin\phi_2}{A_1 \cdot \cos\phi_1 + A_2 \cdot \cos\phi_2}\right) = \phi_3$

so the summation equals to,

$$= \underbrace{\sqrt{\left(A_1 \cdot \cos(\phi_1) + A_2 \cdot \cos(\phi_2)\right)^2 + \left(A_1 \cdot \sin(\phi_1) + A_2 \cdot \sin(\phi_2)\right)^2}}_{\overset{\shortparallel}{A_3}} \cdot \cos(2\pi f_o t + \phi_3)$$

$$A_3 = \sqrt{A_1^2 \cdot \cos(\phi_1)^2 + 2 . A_1 A_2 \cdot \cos\phi_1 \cos\phi_2 + A_2^2 \cdot \cos(\phi_2)^2 + A_1^2 \cdot \sin\phi_1^2 + 2 . A_1 . A_2 \sin\phi_1 \sin\phi_2 + A_2^2 \cdot \sin\phi_2^2}$$

$$A_3 = \sqrt{A_1^2 + A_2^2 + 2 A_1 A_2 . (\cos\phi_1 \cdot \cos\phi_2 + \sin\phi_1 \cdot \sin\phi_2)} = \sqrt{A_1^2 + A_2^2 + 2 . A_1 A_2 \cdot \cos(\phi_1 - \phi_2)}$$

if $\phi_1 - \phi_2 = 0$, $A_3 = A_1 + A_2$ and it is the max value

if $\phi_1 - \phi_2 = \pi$, $A_3 = A_1 - A_2$ and $A_3 \geqslant 0$ so the min value is equal to 0

Figure 24 – The proof

A3 has the maximum value when there is no phase difference between waves and A3 = A1 + A2

A3 has the minimum value when there is π phase difference between waves and min value is zero.