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EE4820: Biomedical Signal Processing
Problem Set 1: Biomed Signals Overview and Matlab Refresher

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Due on Mon. Jan. 31

Learning objectives

- Biomedical signal applications
- Review of basic programming in MATLAB environment
- Fundamental MATLAB functions
- Fundementals of noise

1. MATLAB exercise
   - Start MATLAB
   - For each of the following commands, write the output that would be displayed in the command window if the command was executed:

   a) `x = 5; y = -4;`
      `x*y`

   b) `x = [-1 3; 2 -2; 4 -3]`

   c) `x(3, 1)`

   d) `-3*x`

   e) `y = [3 5 2; -1 2 -4]`

   f) (using the same x and y from parts `b` and `e`.

      `z = y*x`

   g) `z([1 3])`

   h) `z = [9:-2:1; -7:3:5]`

i) What happens if you type `z(3, 2)`?

h) Using the same z from part `h`, what is the output when you type:

`z'`

h) Write code to generate the figure shown in Fig. 1.

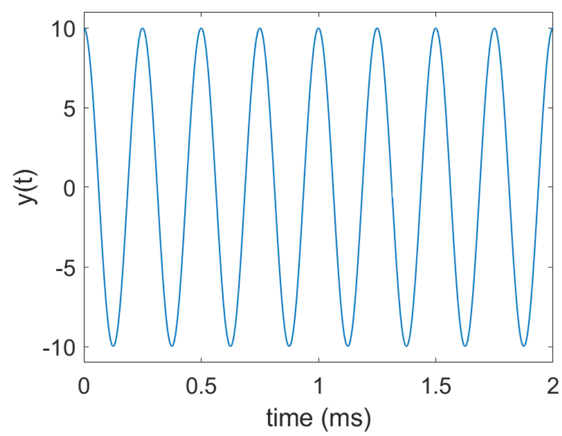


Figure 1:

2. ~~Semmlow P2.4~~

3. Determine the digital values for one period of a 5 Hz sine wave with an amplitude of 1V, offset by 1V, sampled at a rate of 25 samples per second. (The analog waveform ranges from 0 to 2V). Therefore, you should only need to convert 5 samples. Suppose the full scale analog voltage range is 3V, and you use a 6-bit A/D converter. Show your work.

a) `x = 5; y = -4;`
`x*y`

ans = -20

b) `x = [-1 3; 2 -2; 4 -3]`

x = -1 3
2 -2
4 -3

c) `x(3, 1)`

ans = 4

d) `-3*x`

ans = 3 -9
-6 6
-12 9

e) `y = [3 5 2; -1 2 -4]`

y = 3 5 2
-1 2 -4

f) (using the same x and y from parts `b` and `e`.

`z = y*x`

z = 15 -7
-11 5

g) `z([1 3])`

ans = 15 -7

h) `z = [9:-2:1; -7:3:5]`

$$z = \begin{matrix} 9 & 7 & 5 & 3 & 1 \\ -7 & -4 & -1 & 2 & 5 \end{matrix}$$

i) What happens if you type `z(3, 2)`?

Index in position 1 exceeds array bounds. Index must not exceed 2

h) Using the same z from part `h`, what is the output when you type:

`z'`

$$ans = \begin{matrix} 9 & -7 \\ 7 & -4 \\ 5 & -1 \\ 3 & 2 \\ 1 & 5 \end{matrix}$$

h) Write code to generate the figure shown in Fig. 1.

$V_{p\text{-}p} = 20V$

$V_m = 10V$

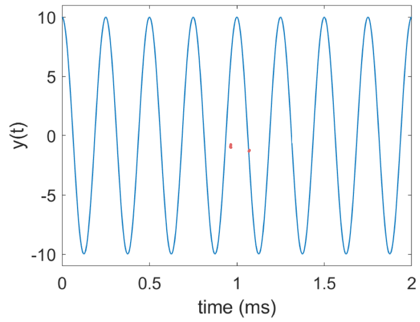
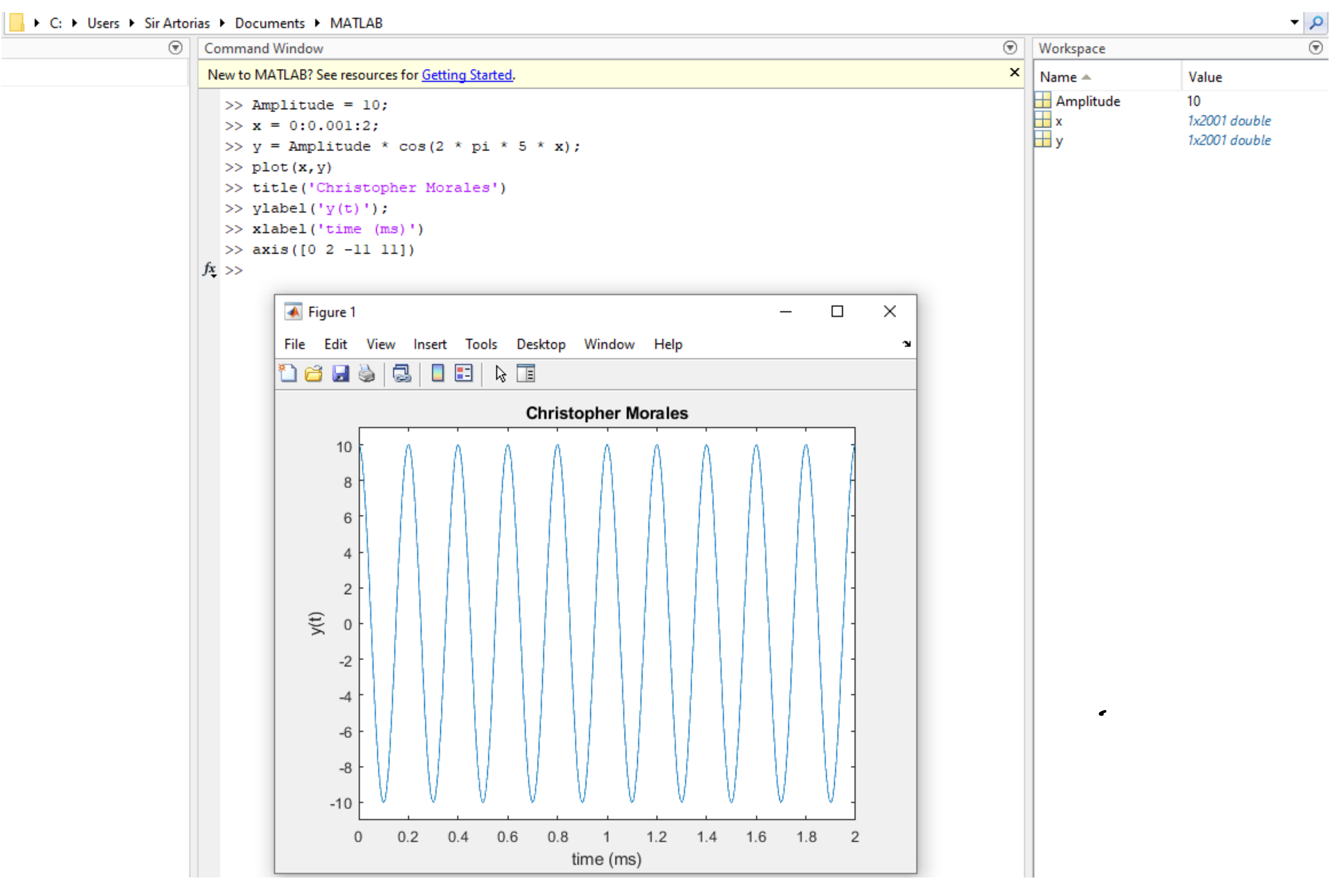
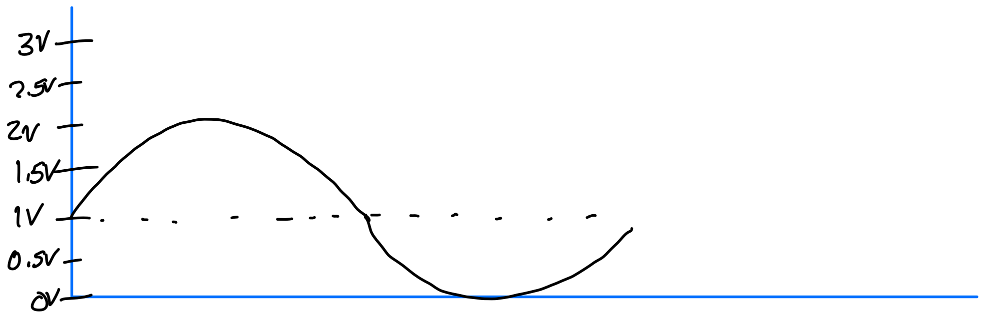


Figure 1:

Answer:



3. Determine the digital values for one period of a 5 Hz sine wave with an amplitude of 1V, offset by 1V, sampled at a rate of 25 samples per second. (The analog waveform ranges from 0 to 2V). Therefore, you should only need to convert 5 samples. Suppose the full scale analog voltage range is 3V, and you use a 6-bit A/D converter. Show your work.



$V_m = 1V$

$W = 2\pi f = 2\pi(\frac{1}{T})$

$$W_0 = 2\pi f = 2\pi\left(\frac{1}{T}\right) = \frac{2\pi}{25} =$$

$$V(t) = V_m \overset{\cos}{\sin}(W_0 t + \theta) + D = \sin\left(\frac{2\pi}{25} t\right) + 1$$

$2^6 = 64$ bits, possible values

$$\Delta q = \text{quantization step} = \frac{V_{max} - V_{min}}{2^n - 1} = \frac{3V - 0V}{2^6 - 1} = \frac{3V}{64 - 1} = \frac{3}{63} = \frac{1}{21}$$

Analog Value: 0V, 0.5V, 1V, 1.5V, 2V

$$\text{Digital Value} = \left[\frac{0V}{\frac{1}{21}}\right] = 0 \rightarrow 0b0000$$

$$\text{Digital Value} = \left[\frac{\frac{1}{2}}{\frac{1}{21}}\right] = \frac{21}{2} = 10.5 \rightarrow 0b1010.1$$

$(10)_{10} = (?)_2$

$$\begin{array}{r} 10 \\ -8 \\ \hline 2 \\ -2 \\ \hline 0 \end{array}$$

$$\frac{0}{2^4}\ \frac{1}{2^3}\ \frac{0}{2^2}\ \frac{1}{2^1}\ \frac{0}{2^0}$$

$(10)_{10} = (1010)_2$

$(0.5)_{10} = (?)_2 \rightarrow (0.5)_{10} = (1)_2$

$0.5 \times 2 = 1$

$$\text{Digital Value} = \left[\frac{1V}{\frac{1}{21}}\right] = 21 \longrightarrow \text{0b 10101}$$

$(21)_{10} = (?)_2$ $\quad$ $(21)_{10} = (10101)_2$

$$\begin{array}{r} 21 \\ -16 \\ \hline 5 \\ -4 \\ \hline 1 \\ -1 \\ \hline 0 \end{array}$$

$$\frac{0}{2^5}\ \frac{1}{2^4}\ \frac{0}{2^3}\ \frac{1}{2^2}\ \frac{0}{2^1}\ \frac{1}{2^0}$$

$$\text{Digital Value} = \left[\frac{\frac{3}{2}}{\frac{1}{21}}\right] = \frac{63}{2} \approx 31.5 \longrightarrow \text{0b 1111.1}$$

$(31)_{10} = (?)_2 \rightarrow (31)_{10} = (1111)$

$$\begin{array}{r} 31 \\ -16 \\ \hline 15 \\ -8 \\ \hline 7 \\ -4 \\ \hline 3 \\ -2 \\ \hline 1 \\ -1 \\ \hline 0 \end{array}$$

$$\frac{0}{2^5}\ \frac{1}{2^4}\ \frac{1}{2^3}\ \frac{1}{2^2}\ \frac{1}{2^1}\ \frac{1}{2^0}$$

$(0.5)_{10} = (?)_2 \rightarrow (0.5)_{10} = (1)_2$

$0.5 \cdot 2 = 1$

Digital Value $= \left[\dfrac{2V}{\frac{1}{21}} \right] = 42 \rightarrow$ 0b101010

$(42)_{10} = (?)_2 \qquad (42)_{10} = (101010)_2$

$$\begin{array}{r} 42 \\ -32 \\ \hline 10 \\ -8 \\ \hline 2 \\ -2 \\ \hline 0 \end{array}$$

$\dfrac{0}{2^6}\ \dfrac{1}{2^5}\ \dfrac{0}{2^4}\ \dfrac{1}{2^3}\ \dfrac{0}{2^2}\ \dfrac{1}{2^1}\ \dfrac{0}{2^0}$