Feel free to do one of the following tasks as your final project. I personally prefer the engineering task although it needs to have access to a function generator. In my view, you become familiar with many practical points while doing the engineering task.

ENGINEERING TASK

Task 1

Make a simple oscilloscope by feeding a signal to your laptop via its microphone jack and displaying the captured signal on its monitor. Note that I personally do not take any responsibility for any possible damage to your laptop!

(a) Write a MATLAB/Python code to display the captured signal online. Feed your oscilloscope with sine, triangle, and square waves and observe the results.

(b) Is there any limitation on the maximum amplitude and frequency of your oscilloscope?

(c) Prepare a short report and describe your work concisely. Use suitable figures or equations to better describe different parts of your code and to make your report more readable and understandable. Take a short video of yourself demonstrating the performance of your oscilloscope.

(d) ***Bonus!*** *Create a GUI for your oscilloscope such that useful information like frequency, amplitude, and so on are reported alongside the captured wave.*

(e) ***Bonus!*** *Write your report in LaTeX.*

SOFTWARE TASK

Task 2

Assume that the integral-differential equations of a single-input LTI circuit is given as

$$\boldsymbol{AY} = \boldsymbol{W}$$

Task 2 continued on next page...

, where A is an $n \times n$ matrix whose elements are a multiple of $\{D, D^{-1}, 1\}$ with D denoting the D-operator. Further, Y is an $n \times 1$ vector denoting some circuit variables including the desired signal $y(t)$ residing in the $N \in \{1, \cdots n\}$th entry of the vector. Finally, W is an $n \times 1$ vector whose $M \in \{1, \cdots n\}$ element is $w(t)$, the input waveform of the circuit.

(a) Develop a MATLAB/Python function named "analyzer" that receives $\mathbf{A}$, $\mathbf{Y}$, and $\mathbf{W}$ along with any required input arguments such as N, M, and $w(t)$ and returns the differential equation relating $y(t)$ to $w(t)$.

(b) Extend your code to return the impulse response curve of $y(t)$.

(c) Extend your code to return the frequency response curves of $y(t)$.

(d) Prepare a short report and describe your work concisely. Use suitable figures to better describe the developed codes and to make your report more readable and understandable.

*(e) **Bonus!** Extend your work such that the minimal differential equation of $y(t)$ is obtained, that is, the lowest-order differential equation governing $y(t)$. Feel free to search to know more about the minimal differential equation.*

*(f) **Bonus!** Write your report in LaTeX.*