CS-330 Assignment 1
Introduction:
GNU Radio, Sampling, Nyquist frequency, Aliasing

Hard Deadline: 03 November 2025

Assinged: 23 October 2025

General Information

For each assignment some code examples with complete working flowgraphs or blocks are provided, but in some cases there might be some missing elements.
For every assignment you should provide screenshots of the execution of the flowgraph in your report! 📷

Exercise 1

The goal of this exercise is to help you become familiar with the Nyquist frequency.
Open the *lab1_1.grc*, using the **GNU Radio Companion** and execute the flowgraph.

1. Are the signals provided going to be transmitted properly without loss of information and why?
2. Perform the proper modifications to produce visually smoother signals, **without** changing the frequency of the signals. Compare the CPU usage between the previous run and the new one and *report* your findings. 📷
3. Which is the minimum possible sampling rate that you can use at the flowgraph and why?
4. Does the parameter *Sample Rate* of the *Throttle* block affect the signal? If your answer is "no", what does this parameter actually affect?

Exercise 2

The second exercise explores signal properties in the frequency domain. It will help you become familiar with the spectrum analysis graphical tool of GNU Radio and learn some basic properties of the Fourier Transform. Copy the flowgraph of the previous exercise as *lab1_2.grc*.

1. Drop the Time Sink and insert a Frequency Sink. At the **Spectrum Width** option select **Half**.
2. Instead of fixed parameters for the frequency and amplitude of the signals, use QT widgets to dynamically and graphically change their values. Which are the minimum and maximum values allowed?
3. Set the frequency of both signal A and B at 5 kHz.
   (a) What do you observe about the spectrum of signal A+B compared to the spectrum of signal A and B respectively?
   (b) Why is the spectrum of signal A and signal B the same regardless of the fact that the first is a cosine and the second a sine?

   (c) Change signal B to be a cosine. What is the difference between the Relative Gain of signal A+B and the Relative Gain of signal A, in the spectrum? Use mathematics to prove what you found.
   Hint: Zoom in on the spectrum and use the mouse pointer to find the amplitude of the signals.

4. Set the frequency of signal A to 440 Hz and the frequency of signal B to 441 Hz, and their amplitude to 0.5. Make both signals A and B cosines. Add an **Audio Sink** and a **Time Sink** (with a large number of points, 3-4 times the sampling rate) at the output of the Add block.

   (a) What do you notice about the generated sound? This phenomenon is called beating, the resulting sound/signal is a beat and is the result of adding two signals whose frequencies have a small difference.

   (b) Does the frequency of the beat have any relation to the frequencies of the composing signals? Verify your observations with a mathematical proof or by observing the time interval between subsequent zeros (0) in the amplitude of the beat on the Time Sink. In the later case, verify your observation by using various frequencies for the signals and reporting accordingly.

Exercise 3

This exercise will help you understand the notion of signal phase and what happens when two signals are transmitted concurrently. Open the *lab1_3.grc* file. The flowgraph included is incomplete and you should perform some modifications.

1. Without adding any other block, try to produce a zeroed signal for the A+B signal. **You are not allowed to alter the signal sources parameters or the sampling rate.** 📷

2. Which is the value that you used for the parameter of the delay block? Why and how did you choose this value? Show all your calculations.
   Hint: The desired outcome might not happen within the first period of the signal.

Exercise 4

The goal of this exercise is to present the insights of sampling, aliasing and filtering.

Open the *lab1_4.grc* file. The flowgraph provides a signal source block that operates on a sampling rate of 32 kHz. This signal is plotted using the Frequency Sink block of GNU Radio. In order to emulate properly a downsampled signal, the flowgraph utilizes the *Keep 1 in M* block which drops out 2 of every 3 samples and keeps only the first (down-sampling/decimation by a factor of 3). The resulting signal is also plotted together in the same Frequency Sink block.

1. Use the slider to change the frequency. What do you observe?

2. Which is the frequency range of the down-sampled signal? Why?

3. **Before** the down-sampling (keep 1 in M block), insert a proper filter block in order to cutoff the undesired aliasing effect. GNU Radio provides a variety of filter blocks under the category *Filters*. *Report* the type of the filter you chose, the parameters you applied, and the reasoning.

4. What is f_{alias} frequency and how does it affect our signal in the frequency domain? Is there a way to calculate it?

About Submission

The submission of the Assignments will be done through the course's e-learn webpage. If needed, more info will be sent to the list prior to the deadline.

You should provide a report as a **single pdf file**, containing your comments, screenshots or anything that you believe will be helpful for your grading. Also include any .grc files that you have created or changed.

About Oral Examination

All students who have submitted their exercises are requested to attend the oral exam session, in order to present their solutions. A short quiz will also take place during that time. You will need to choose a timeslot for the oral exam using Doodle. More details will be sent to you via email.

Attention

- Each student will only be examined during the timeslot chosen.
- During this session both the Assignments 1 and 2 will be examined.
- Both the timely submission and the oral exam session will contribute to the grading of the assignment.