**Documentation:** (30 points)

In addition to submitting Parts 1 - 4 of the project in form of Jupyter notebooks, students need to submit a video presentation in which they describe their project outcomes. The presentation should cover the following topics:

* short description of DTMF signaling format (Nafiz)
* approaches investigated to decode DTMF signals, including successes or failures of the individual approaches (Dhruv)
* relevance of course topics to solve the project tasks (Dhruv)
* project management: responsibilities of each team member, original project timeline, adjustments (Luca)
* highlights and struggles (optional) (Nafiz)

Each team member must speak (state your name first) during the presentation. The entire presentation should last between 5-10 minutes. A link to the video needs to be submitted to Blackboard by the deadline.

**Dual-tone multi-frequency signaling** (**DTMF**) is a [telecommunication signaling](https://en.wikipedia.org/wiki/Signalling_(telecommunications)) system using the voice-frequency band over telephone lines between [telephone](https://en.wikipedia.org/wiki/Telephone) equipment and other communications devices and [switching centers](https://en.wikipedia.org/wiki/Automatic_telephone_exchange).[[](https://en.wikipedia.org/wiki/Dual-tone_multi-frequency_signaling#cite_note-Dodd1-1)The Touch-Tone system using a [telephone keypad](https://en.wikipedia.org/wiki/Telephone_keypad) gradually replaced the use of [rotary dial](https://en.wikipedia.org/wiki/Rotary_dial) and has become the industry standard for [landline](https://en.wikipedia.org/wiki/Landline) and mobile service.

DTMF works by assigning eight different audio frequencies to the rows and columns of the keypad. The columns on the keypad are assigned high-frequency signals, while the rows are assigned low-frequency signals.

When you press a key—which corresponds to a number or symbol—the phone generates a tone that simultaneously combines the high-frequency signal from the column that key is in with the low-frequency signal of the row it’s in. This unique signal pair is then transmitted over telephone wires to the local phone exchange, where the two signals are decoded to determine which numbers you are dialing. So when you press the “5” key on your phone’s keypad, for example, a combined signal tone of 1336 Hz and 770 Hz is sent to the phone company, which then knows that you’ve just pressed “5.” Once they receive the full number that you dialed, they can automatically route your call to it.

**Part – 1:**

* Determining the audio was a struggle for me
* I couldn't for the life of me download the audio file LMAO Idk why, but it never opened it
* It was difficult to judge the tones and it’s not possible to match the exact frequency I believe
* The audio was very small of 1s only
* Like I've added that understanding the sampling rate was difficult
* Is it only technical struggles or do team struggles count? Cuz I couldn't work on it due to other things for classes, so we could put that too
* For me, the highlight is ai learned to create an audio file
* Hmmm... Our quality check of the code each other had?
* We can reword this to "Being resourceful and doing research in order to overcome coding problems we did not know how to solve" LMAO
* We researched different sources to determine the sounds.

**Part – 2:**

* When we began having significant progress issues
* Attempting to save the signals into a CSV file created the biggest issue so far:
  1. When saving the individual points as 1 data frame cell, the compacted view when printing the data frame on CoCalc is what is saved when stored in the CSV cell.
  2. Instead of “[1, 2, 3, 4, 5, 6]”, it saves it as “[1, 2, 3, …, 6]”

**Part – 3:**

* We had the following ideas to decode the DTMF signals:
  1. 1. To identify the digit of the signal first plot the graph of the signal wave along the time. We calculate the time of the signal and then using F =1/T formula we determine the frequency of the signal. Finally, we match with the digit frequencies to find out the digit. This attempt did not work as calculating the time of the signal was impossible to do due to
  2. 2. To write a function where if we input the signal as a parameter it will return the frequency of the signal by going through the data frame for which we can make a for loop.
  3. 3. From the given equation in part 2, we will do a reverse calculation and subject the frequency. Then calculate the frequency of the signals by putting the values of phi, A and time(t) for the selected signal.
  4. 4. Idea was to get the lowest points in the graphs of signals per 0.01 seconds and finding the difference between them, theoretically getting the time passed between a full period of the wave to do f = 1/T. However, it did not to work as it gave frequencies in the 200 range instead of the desires 1400+ range.
  5. 5. To make use of the Fourier transform series. I had read about the Fourier transform series in my high school. The Fourier transform gives us insight into what frequencies make up a signal. I had learnt that we can use this technique to change the representation of a complex sinusoidal curve from its time domain to its frequency domain. So my plan is to see that if we can apply the Fourier transform formulae to the signals.

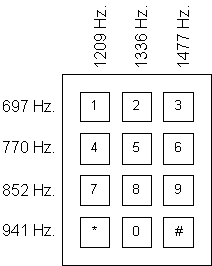
**Part – 4:**

**Script Notes**

(Add your personal thoughts if you want to)

**Description of DTMF Signalling Format:**

The DTMF signalling format is the number pad system that replaced the old rotary dials in telephones. They consist of having the following layout:



Clicking on one of the buttons created a combination of the frequencies placed alongside the top and left hand side of the image to create a unique frequency that could be transmitted through cable and decoded by the telephone provider to connect them to the desired phone.

**Approaches Investigated to Decode DTMF Signals:**

1. To identify the digit of the signal first plot the graph of the signal wave along the time. We calculate the time of the signal and then using F =1/T formula we determine the frequency of the signal. Finally, we match with the digit frequencies to find out the digit. This attempt did not work as calculating the time of the signal was impossible to do due to the random phase shift.
2. To write a function where if we input the signal as a parameter it will return the frequency of the signal by going through the data frame for which we can make a for loop. This attempt did not work as it was extremely inefficient and there were too many unknown variables.
3. From the given equation in part 2, we will do a reverse calculation and subject the frequency. Then calculate the frequency of the signals by putting the values of phi, A and time(t) for the selected signal. This attempt did not work as the only way to work backwards with the equation was to consider the randomly selected phase shift, which introduces another unknown variable and is impossible to know.
4. Idea was to get the lowest points in the graphs of signals per 0.01 seconds and finding the difference between them, theoretically getting the time passed between a full period of the wave to do f = 1/T. However, it did not to work as it gave frequencies in the 200 range instead of the desires 1400+ range. This attempt did not work as the minimum values could vary greatly due to the random phase shift.
5. To make use of the Fourier transform series. I had read about the Fourier transform series in my high school. The Fourier transform gives us insight into what frequencies make up a signal. I had learnt that we can use this technique to change the representation of a complex sinusoidal curve from its time domain to its frequency domain. So my plan is to see that if we can apply the Fourier transform formulae to the signals. This approach did work.

**Relevance of Course Topics:**

* Pandas: Creating data frames to save and manipulate data
* NumPy library: Aids solving mathematical and complex tasks
* Indexing: Picking specific values from the data frames
* Exporting and importing files
* Loops: Aids functions in the creation of repeatable work
* Matplotlib graphing: Visualizing our data
* Functions: Making our workload repeatable

**Project Management:**

* Team roles:
  + Team Leader: Dhruv Maniar
  + Quality Assurance: Nafiz Imtiaz, Luca Scutari
* Due to projects from our other classes, we began working later than other groups, but we had a plan to make up for it as we had mostly the entire thanksgiving break free to work on the project.
* Originally, we wanted to have all the programming portions of the project done by the Friday before the deadline (December 4th) to have the weekend to calmly create the video. However, our problems with part 2 and 3 caused us to have to delay this until the very last day of the deadline.

**Highlights and struggles (Optional):**

* Highlights:
  + Learning how to create audio files
  + Our group dynamic. We worked well as a group, checking each other’s work constantly
  + Our resourcefulness in solving our own issues by doing research or revisiting topics discussed in class
* Struggles:
  + Part 1:
    - Luca had issues with downloading the audio file
    - Due to other projects and class work, some of us could not work on this part at points
  + Part 2:
    - Attempting to save the signals to a CSV file
  + Part 3:
    - Decoding the signal
    - Reorganizing the 8000 columns
    - Not knowing if we could change the array in task 5
  + Part 4:
    - Separating the individual signals in the 7 second audios