July 2025 CSE 220
Online on CFT
Subsection: C1+C2
Time: 30 minutes + 5 minutes(submission)

Consider this signal:

$$x(t) = Square(t) + Triangle(t)$$

For this signal,

i. Shift the phase of the signal by $2\pi f_0 t$, where $f_0 = 10$ unit.

ii. Compress the time axis of this signal by $a = 10$ unit.

We can consider, $y(t) = modified\ x(t)$

Now, find the CFT of $x(t)$ and $y(t)$. From the CFTs, describe the effect of (i) and (ii). For this, define the time axis as $t \in [-5, 5]$ using at least 2000 samples.

Numerical Verification :

- Plot $|Y(f)|$ and $1/|a| * |X((f-f_0)/a)|$
- Also plot $\angle Y(f)$ and $\angle X((f-f_0)/a)$
- Verify if $|Y(f)| = 1/|a| * |X((f-f_0)/a)|$ and $\angle Y(f) = \angle X((f-f_0)/a)$

Use a frequency axis covering $f \in [-10, 10]$ with at least 1000 samples.

Error Analysis :

- $MSE_{magnitude} = 1/N * \sum (|Y(f)| - (1/|a| * |X((f-f_0)/a)|))^2$
- $MSE_{phase} = 1/N * \sum (\angle Y(f) - \angle X((f-f_0)/a))^2$

If the procedure is performed correctly, both MSE values should fall within the acceptable tolerance range.

Instructions :

- All things must be implemented using the OOP framework. Do not handle anything manually.
- You are NOT allowed to use `np.fft` or any built-in Fourier transform function.
- You must use `np.trapz()` or `np.trapezoid()` for numerical integration.
- Submit a single Python file named: `StudentID.py`