PH3120 – Computational Physics Laboratory 1
CPL106 – Fourier Transform
Lab Sheet

1. **Basics of Sinewave Signals**

   Answer the questions based on the properties of sinewave signals by considering the following function.

$$y(t) = A\sin(2\pi Ft + \phi)$$

   I. Define A, F, t and ϕ parameters.

   II. What is the relationship between the period of the sinewave (T) and F?

   III. What is the relationship between T and F?

   IV. Why high sampling rate is important in signal sampling?

   V. Assume that $A = 10$ cm, $F = 50$ Hz and $\phi = \frac{\pi}{2}$. Plot the signal with a sampling frequency of 10 Hz, 100 Hz and 1000Hz, 10000 Hz on the same graph. Comment on the results.

2. Discrete Fourier Transform (DFT)

   Answer the following questions based on the concepts of DFT.

   I. Explain the concept of time domain.

   II. Explain the concept of frequency domain and how it is related to the Fourier Transform.

   III. What is the difference between continuous Fourier transform and discrete Fourier transform?

      (a) How does the Fourier Transform convert **a discrete signal** from the time domain to the frequency domain? Provide an expression.

      (b) How does the Fourier Transform convert **a continues signal** from the time domain to the frequency domain? Provide an expression.

3. Fast Fourier Transform (FFT)

   I. Discuss the advantages of FFT over DFT.

   II. Two pure sine waves with different frequencies and amplitudes are superposed to form a resultant wave. Use the FFT algorithm in NumPy to determine the frequency components present in the resultant wave. Comment on the results.

Given:

- Sine wave 1: Frequency = 100 Hz, Amplitude = 2 V
- Sine wave 2: Frequency = 200 Hz, Amplitude = 1 V

III. A carrier signal of frequency 500 Hz is amplitude modulated by a modulating signal of frequency 50 Hz. Assume that the carrier wave has an amplitude of 5V, and modulating signal has an amplitude of 2V. Use the FFT in NumPy package to answer the following questions.

(a) Write the sinewave function for the carrier wave $(y_c(t))$.

(b) Write the sinewave function for the modulating signal (message signal) $(y_m(t))$.

(c) Write the wave function of modulated signal $(y(t))$.

(d) Plot $y_c(t), y_m(t)$ and $y(t)$ for t in [0,0.1].

(e) Use the FFT algorithm to determine the frequency components present in the modulated signal.

i. Plot the results from FFT and label each frequency component.

ii. What is the lowest frequency presented in the Fourier spectrum?

iii. What is the highest frequency presented in the Fourier spectrum?

iv. What is the band width based on the Fourier spectrum?

IV. Consider the following modulating signal.

$$y_m(t) = 10\sin(200\pi t) + 40\sin(100\pi t)$$

The carrier signal is given by $y_c(t) = 20\sin(400\pi t)$.

Use the FFT in NumPy package to answer the following questions.

(a) Write the wave function of modulated signal $(y(t))$.

(b) Plot $y_c(t), y_m(t)$ and $y(t)$ for t in [0,0.1].

(c) Use the FFT algorithm to determine the frequency components present in the modulated signal.

i. Plot the results from FFT and label each frequency component.

ii. What is the lowest frequency presented in the Fourier spectrum?

iii. What is the highest frequency presented in the Fourier spectrum?

iv. What is the band width based on the Fourier spectrum?