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Contents

1 Prerequisite Mathematics

A few prerequisite mathematics will be discussed here in anticipation of their requirements in the subsequent sections after this section.

1.1 Dirac Delta Function

Dirac Delta function, $\delta(t)$, has the following property:

$$\delta(t) = \begin{cases} \infty, & \text{if } t = 0 \\ 0, & \text{otherwise} \end{cases} \tag{1.1}$$

$$1 = \int_{-\infty}^{\infty} \delta(t) dt \tag{1.2}$$

The following integral is also a Dirac Delta function:

$$\delta(t) = \int_{-\infty}^{\infty} e^{2\pi i f t} df \tag{1.3}$$

The above relations will be used throughout the discussion of this article.

2 Fourier Transform

Fourier transform is a mathematical transformation, in the context of my discussion, that maps one function in time domain into another function in frequency domain. There are two types of FT, Fourier transform in short: continuous and discrete. Discrete FT is of great importance in many modern data processing application as modern computers are digital, meaning they perform computation in discrete manner. I'll discuss a continous case first before moving onto the discrete case.

2.1 Continuous Fourier Transform

Consider a continuous function of t, $x(t)$. The continuous FT of x is as follows:

$$\mathcal{F}_t[x] = \int_{-\infty}^{\infty} x(t) e^{-2\pi i f t} dt$$
$$= X(f) \tag{2.1}$$

$X(f)$ is also continuous in f. You can also perform inverse FT on X, which is:

$$\mathcal{F}_f[X] = \int_{-\infty}^{\infty} X(f) e^{2\pi i f t} df$$
$$= \int_{-\infty}^{\infty} \int_{-\infty}^{\infty} x(\tau) e^{-2\pi i f \tau} d\tau \ e^{2\pi i f t} df$$
$$= \int_{-\infty}^{\infty} x(\tau) \int_{-\infty}^{\infty} e^{2\pi i f (t-\tau)} df d\tau$$
$$= \int_{-\infty}^{\infty} x(\tau) \delta(t - \tau) d\tau$$
$$= x(t) \tag{2.2}$$

where I used (1.3)

1. Let's see if the pdf automatically reloads after building a modified pdf. Please write your lab number at the top right corner of this quiz as well as your signature. On the back of this quiz, please write your name.

   For questions 2 and 3, consider the following quantity called standard deviation of x:

$$\sigma_x = \sqrt{\frac{1}{N-1} \sum_{i=1}^{N} (x_i - \bar{x})^2} \tag{2.3}$$

   where $x_1, x_2, \ldots, x_N$ are the values of x for N measurements. Suppose you made the measurement of x five times and obtained the results 56, 57, 56, 58, 57 (for convenience, any units were omitted).

2. (16 pts) Calculate σ_x. Show all your work.

3. (8 pts) Report your final result x_{exp} appropriately.

4. (8 pts) Briefly describe what we are doing for today's experiment.

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