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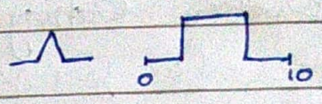
DAY 2 : Fourier Series and Gibbs Phenomena :

$$f(x) \cong \sum_{k=0}^{100} a_k \cos\left(k\frac{2\pi x}{L}\right) + b_k \sin\left(k\frac{2\pi x}{L}\right)$$



$$a_k = \langle f(x), \cos\left(k\frac{2\pi x}{L}\right) \rangle$$

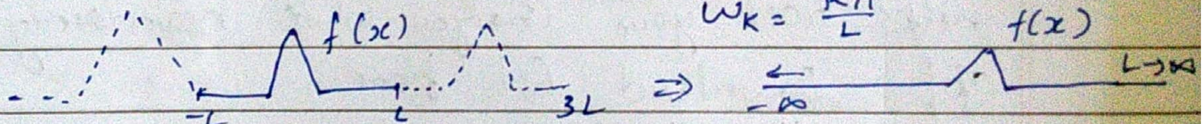
$$b_k = \langle f(x), \sin\left(k\frac{2\pi x}{L}\right) \rangle.$$

- Fourier Transform:

$$f(x) = \sum_{k=-\infty}^{\infty} c_k e^{ik\pi x/L}$$

$$c_k = \frac{1}{2\pi}\langle f(x), \psi_k \rangle = \frac{1}{2\pi}\int_{-L}^{L} f(x)\underbrace{e^{-ik\pi x/L}}_{\psi_k}dx$$

$$\omega_k = \frac{k\pi}{L}$$



$$\omega_L = \frac{k\pi}{L} = k\Delta\omega \Rightarrow \Delta\omega = \pi/L.$$

$$f(x) = \lim_{\substack{\Delta\omega\to 0\\ (L\to 0)}} \sum_{k=-\infty}^{\infty} \frac{\Delta\omega}{2\pi}\int_{-\pi/\Delta\omega}^{\pi/\Delta\omega} f(\xi)e^{-ik\Delta\omega\xi}d\xi\, e^{ik\Delta\omega x}$$

ξ - dummy variable.

$$= \int_{-\infty}^{\infty} \frac{1}{2\pi}\underbrace{\int_{-\infty}^{\infty} f(\xi)e^{-i\omega\xi}d\xi}_{f(\omega)}\, e^{i\omega x}d\omega$$

$$\boxed{\hat{f}(\omega) = F(f(x)) = \int_{-\infty}^{\infty} f(x)e^{-i\omega x}dx}$$

$$\boxed{f(x) = F^{-1}(\hat{f}(\omega)) = \frac{1}{2\pi}\int_{-\infty}^{\infty}\hat{f}(\omega)e^{i\omega x}d\omega}$$

Fourier transform.

Fourier transform & Derivative:

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$$F\left(\tfrac{d}{dx}f(x)\right) = \int_{-\infty}^{\infty} \underbrace{\frac{df}{dx}}_{dv} \underbrace{e^{-i\omega x}}_{u} dx$$

$$= \underbrace{\left[f(x)e^{-i\omega x}\right]_{-\infty}^{\infty}}_{uv=0} - \int_{-\infty}^{\infty} \underbrace{f(x)}_{v} \underbrace{(-i\omega e^{-i\omega x})}_{du} dv$$

$$= \underbrace{i\omega \int_{-\infty}^{\infty} f(x)e^{-i\omega x} dx}_{F(f(x))} = \underbrace{i\omega F(f(x))}_{F(df/dx)}$$

$$U_{tt} = CU_{xx} \quad (PDE) \xrightarrow{F} \boxed{\hat{U}_{tt} = -\omega^2 \hat{u} \quad (ODE)}$$

$$U(x,t) \xrightarrow{F} \hat{U}(\omega, t)$$

Fourier transform and Convolution Integrals:

$$(f*g) = \int_{-\infty}^{\infty} f(x-\xi)g(\xi)\,d\xi \quad \rightarrow (1)$$

$$F(f*g) = F(f)F(g) = \hat{f}\hat{g}$$

$$F^{-1}(\hat{f}\hat{g})(x) = \frac{1}{2\pi}\int_{-\infty}^{\infty} \hat{f}(\omega)\hat{g}(\omega)e^{i\omega x}\,d\omega$$

$$= \frac{1}{2\pi}\int_{-\infty}^{\infty} \hat{f}(\omega)\left(\int_{-\infty}^{\infty} g(y)e^{-i\omega y}dy\right)e^{i\omega x}\,d\omega$$

$$= \frac{1}{2\pi}\int_{-\infty}^{\infty}\int_{-\infty}^{\infty} \hat{f}(\omega)\,g(y)\,e^{i\omega(x-y)}\,d\omega\,dy$$

$$= \frac{1}{2\pi}\int_{-\infty}^{\infty} g(y) \underbrace{\int_{-\infty}^{\infty} \hat{f}(\omega)e^{i\omega(x-y)}\,d\omega}_{f(x-y)} dy$$

$$\boxed{(f*g) = \int_{-\infty}^{\infty} g(y)f(x-y)\,dy} \rightarrow (2)$$

$$\boxed{F^{-1}(\hat{f}\hat{g})(x) = f*g}$$

- Application of Z-transform:

Difference eq^n: $\Delta y_{n+1} + y_n = 2$

$\Delta y_{n+1} + \Delta^2 y_{n-1} = 1$

$\Delta f(x) = f(x+h) - f(x)$

$\Delta y_{n+1} = y_{n+2} - y_{n+1}$ & hence

$\Delta y_{n+1} + y_n = 2 \rightarrow (3) \Rightarrow y_{n+2} - y_{n+1} + y_n = 1$

$\Delta y_{n+1} + \Delta^2 y_{n-1} = 1$

$y_{n+2} - y_{n+1} + \Delta(\Delta y_{n-1}) = 1 \Rightarrow y_{n+2} - y_{n+1} + 2y_{n+1} - 2y_n + y_{n-1} = 1$

Now, $\Delta y_{n-1} = y_n - y_{n-1}$ $\qquad y_{n+2} - 2y_n + y_{n+1} = 1 \rightarrow (4)$

$\Delta(\Delta y_{n-1}) = \Delta(y_n - y_{n-1})$

$= \Delta y_n - \Delta y_{n-1}$

$= y_{n+1} - y_n - (y_n - y_{n-1})$

$= y_{n+1} - 2y_n + y_{n-1}$

(3) $\dfrac{(n+2) - n}{1} = 2 \qquad \dfrac{(n+2) - (n-1)}{1} = 3$

Properties $y_n = U_n + V_n$.

U_n = complementary function.

V_n = Partial function.

- **Phython:**

Graphical User Interfaces with Tkinter

→ Bookstore - it allows to store book information in database.

How to add entry in bookstore.

1. Import Tkinter or

```
1 from tkinter import*
2.
3. window=tk()
4
5. window = mainloop()
```

In O/T tk is not defined so TK.

b1 = Button(→ window, text = "Execute")

b1.grid() we have control on botton where we have to put column or row number

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→ Introduction to Tkinter.
→ Setting up a GUI with widgets.
→ Connecting GUI widgets with Callback Functions.

→ **Interacting with Databases:**

- Introduction to "Python with databases".

→ Python is able interact with many databases
MySQL, PostgrasSQL, Oracle, SQLITE

→ Connecting and Inserting Data to SQLITE via
Python ⓪ import sqlite3.

① Connect to a Database.
② Create a cursor object.
③ write an SQL query
④ commit changes.

→ Selecting, Inserting, deleting & uploading
SQLITE Records.

→ Introduction to postgoc SQL psycolog2.

→ Selecting, Inserting, deleting & uploading
PostgreSQL Records.
import pyswpg2