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Assignment - 3
Report

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Q1

$$x[n] = \begin{cases} 1 & -N_1 \le n \le N_1 \\ 0 & N_1 < |n| \le \frac{N-1}{2} \end{cases}$$

$N_1 = 2$

$$a_k = \frac{1}{N} \sum_{\langle N \rangle} x[n] \cdot e^{j\frac{2\pi n}{N}k}$$

$x[n]$ takes value 1 from only $-N_1$ to N_1, $N_1 = 2$

$$\Rightarrow a_k = \frac{1}{N} \sum_{n=-N_1}^{N_1} x[n] \cdot e^{-j\frac{2\pi n}{N}k}$$

$$\Rightarrow a_k = \frac{1}{N} \left(e^{-j\frac{4\pi}{N}k} + e^{j\frac{4\pi}{N}k} + e^{-j\frac{2\pi}{N}k} + e^{j\frac{2\pi}{N}k} + 1 \right)$$

$$\Rightarrow \boxed{a_k = \frac{1}{N} \left(2\cos\left(\frac{2\pi k}{N}\right) + 2\cos\left(\frac{4\pi k}{N}\right) + 1 \right)}$$

Inference : $x[n]$ has only real coefficients

Q2

$f(x) = x + \pi \qquad -\pi \le x \le \pi$

$f(x + 2\pi) = f(x)$

Thus, Time period = 2π

The graph is plotted from -3π to 3π (3 periods)

The fourier representation, which is discrete is plotted from -10 to 10 (roughly the same interval)

$$a_k = \frac{1}{T} \int_T f(t) \cdot e^{-jk(2\pi/T)t} \, dt$$

$$= \frac{1}{2\pi} \int_{-\pi}^{\pi} (t + \pi) \, e^{-jkt} \, dt$$

for $K = 0$,

$$a_0 = \frac{1}{2\pi} \int_{-\pi}^{\pi} (t + \pi) \, dt$$

$$\Rightarrow \boxed{a_0 = \pi}$$

for $K \neq 0$

$$a_K = j \left(\frac{\cos K\pi}{K} \right)$$ (after solving integral by parts)

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$$\therefore \quad a_k = \begin{cases} \pi & , k = 0 \\ \dfrac{(-1)^k}{k} \cdot j & k \neq 0 \end{cases}$$

Inference : The fourier series will be ~~rea~~ zero on all points except $k=0$ on real axis while it will be zero only on $k=0$ on imaginary axis.

In other words, coefficient is real only for $k=0$ while all other coefficients are imaginary with alternating signs and decreasing magnitude