Masalah Syarat Batas / Pertemuan ke - 5 / Tugas

Makassar, 24 Maret 2021

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D. Latihan 2 (Hal 50)

A. Selesaikanlah soal-soal berikut!

2.) Fungsi f yang periodik dengan periode 8 ditentukan oleh $f(x) = x\,(x+4)$ dalam selang $-4 < x < 4$.
Tentukan deret Fourier $f(x)$.

<u>Penyelesaian</u>:

Diketahui: $f(x)$ periodik dengan periode $p = 8 = 2L$, maka $L = 4$.
selanjutnya akan dicari koefisien deret Fouriernya.

$$a_n = \frac{1}{L}\int_{-L}^{L}\left(f(x)\cdot\cos\frac{n\pi x}{4}\right)dx$$

$$a_0 = \frac{1}{4}\cdot\int_{-4}^{4}\left(x(x+4)\cdot\cos\frac{0\cdot\pi\cdot x}{4}\right)dx$$

$$a_0 = \frac{1}{4}\cdot\int_{-4}^{4}\left(x(x+4)\cdot\cos 0\right)dx$$

$$a_0 = \frac{1}{4}\cdot\int_{-4}^{4}\left(x(x+4)\cdot 1\right)dx$$

$$a_0 = \frac{1}{4}\cdot\int_{-4}^{4}\left(x^2+4x\right)dx$$

$$a_0 = \frac{1}{4}\cdot\left[\frac{1}{3}\cdot x^3 + 2\cdot x^2\right]_{-4}^{4}$$

$$a_0 = \frac{1}{4}\left[\left(\frac{1}{3}(4)^3 + 2(4)^2\right) - \left(\frac{1}{3}(-4)^3 + 2\cdot(-4)^2\right)\right]$$

$$a_0 = \frac{1}{4}\left[\left(\frac{1}{3}\cdot 64 + 2\cdot 16\right) - \left(\frac{1}{3}\cdot(-64) + 2\cdot 16\right)\right]$$

$$a_0 = \frac{1}{4}\left[\left(\frac{160}{3}\right) - \left(\frac{32}{3}\right)\right]$$

$$a_0 = \frac{1}{4}\left[\frac{128}{3}\right]$$

$$a_0 = \frac{32}{3}$$

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$$a_n = \frac{1}{L} \cdot \int_{-L}^{L} \left(f(x) \cdot \cos \frac{n\pi x}{L} \right) dx$$

$$= \frac{1}{4} \cdot \int_{-4}^{4} \left(x(x+4) \cdot \cos \frac{n\pi x}{4} \right) dx$$

$$= \frac{1}{4} \cdot \int_{-4}^{4} \left(x^2+4x \cdot \cos \frac{n\pi x}{4} \right) dx$$

= Misal $u = x^2+4x$ $\quad dv = \cos \frac{n\pi x}{4}\, dx$

$du = (2x+4)\, dx$

$$v = \int \left(\cos \frac{n\pi x}{4} \right) dx$$

$$v = \frac{1}{\frac{n\pi}{4}} \cdot \sin \left(\frac{n\pi}{4} x \right)$$

$$v = \frac{4}{n\pi} \cdot \sin \frac{n\pi x}{4}$$

$$\boxed{\int u\, dv = uv - \int v\, du}$$

$$= \frac{1}{4} \left(\left[(x^2+4x) \cdot \frac{4}{n\pi} \cdot \sin \frac{n\pi x}{4} \right] - \left[\int \left(\frac{4}{n\pi} \cdot \sin \frac{n\pi x}{4} \cdot (2x+4) \right) dx \right] \right)_{-4}^{4}$$

$$= \frac{1}{4} \left(\left[(x^2+4x) \cdot \frac{4}{n\pi} \cdot \sin \frac{n\pi x}{4} \right] - \left[\frac{4}{n\pi} \cdot \int \left(\sin \frac{n\pi x}{4} \cdot (2x+4) \right) dx \right] \right)_{-4}^{4}$$

= Misal $u = 2x+4$ $\quad dv = \sin \frac{n\pi x}{4}\, dx$

$du = 2\, dx$

$$v = \int \sin \frac{n\pi x}{4}\, dx$$

$$v = \frac{1}{\frac{n\pi}{4}} \cdot \left(-\cos \frac{n\pi}{4} x \right)$$

$$v = -\frac{4}{n\pi} \cdot \cos \frac{n\pi x}{4}$$

Maka,

$$\int \left(\sin \frac{n\pi x}{4} \right) (2x+4)\, dx = \left[(2x+4) \left(-\frac{4}{n\pi} \cdot \cos \frac{n\pi x}{4} \right) \right] - \left[\int -\frac{4}{n\pi} \cos \frac{n\pi x}{4} \cdot 2\, dx \right]$$

$$= \left[(2x+4) \left(-\frac{4}{n\pi} \cdot \cos \frac{n\pi x}{4} \right) \right] - \left[-\frac{4}{n\pi} \int \cos \frac{n\pi x}{4} \cdot 2\, dx \right]$$

$$= \left[(2x+4) \left(-\frac{4}{n\pi} \cdot \cos \frac{n\pi x}{4} \right) \right] - \left[-\frac{8}{n\pi} \cdot \frac{1}{\frac{n\pi}{4}} \cdot \sin \frac{n\pi x}{4} \right]$$

$$= \left[(2x+4) \left(-\frac{4}{n\pi} \cdot \cos \frac{n\pi x}{4} \right) \right] - \left[-\frac{32}{(n\pi)^2} \cdot \sin \frac{n\pi x}{4} \right]$$

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Sehingga diperoleh,

$$= \frac{1}{4}\left(\left[(x^2+4x)\cdot\frac{4}{n\pi}\cdot\sin\frac{n\pi x}{4}\right]-\left[\frac{4}{n\pi}\cdot\int\left(\sin\frac{n\pi x}{4}\cdot(2x+4)\right)dx\right]\right)_{-4}^{4}$$

$$= \frac{1}{4}\left(\left[(x^2+4x)\cdot\frac{4}{n\pi}\cdot\sin\frac{n\pi x}{4}\right]-\left[\frac{4}{n\pi}\cdot\left(\left[(2x+4)\left(-\frac{4}{n\pi}\cdot\cos\frac{n\pi x}{4}\right)\right]-\left[-\frac{32}{(n\pi)^2}\cdot\sin\frac{n\pi x}{4}\right]\right)\right]\right)_{-4}^{4}$$

$$= \frac{1}{4}\left[\left(\left[(4^2+4(4))\cdot\frac{4}{n\pi}\cdot\sin\frac{n\pi 4}{4}\right]-\left[\frac{4}{n\pi}\cdot\left(\left[(2\cdot4+4)\left(-\frac{4}{n\pi}\cdot\cos\frac{n\pi\cdot4}{4}\right)\right]-\left[-\frac{32}{(n\pi)^2}\cdot\sin\frac{n\pi\cdot4}{4}\right]\right)\right]\right)\right.$$

$$\left.-\left(\left[((-4)^2+4(-4))\cdot\frac{4}{n\pi}\cdot\sin\frac{n\cdot\pi(-4)}{4}\right]-\left[\frac{4}{n\pi}\cdot\left(\left[(2\cdot(-4)+4)\left(-\frac{4}{n\pi}\cdot\cos\frac{n\cdot\pi(-4)}{4}\right)\right]-\left[-\frac{32}{(n\pi)^2}\cdot\sin\frac{n\pi(-4)}{4}\right]\right)\right]\right)\right]$$

$$= \frac{1}{4}\left[\left(\left[(32)\cdot\frac{4}{n\pi}\cdot(0)\right]-\left[\frac{4}{n\pi}\cdot\left(\left[(12)\left(-\frac{4}{n\pi}\cdot\cos n\pi\right)\right]-\left[-\frac{32}{(n\pi)^2}\cdot(0)\right]\right)\right]\right)\right.$$

$$\left.-\left(\left[(0)\cdot\frac{4}{n\pi}\cdot(0)\right]-\left[\frac{4}{n\pi}\cdot\left(\left[(-4)\cdot\left(-\frac{4}{n\pi}\cdot\cos -n\pi\right)\right]-\left[-\frac{32}{(n\pi)^2}\cdot(0)\right]\right)\right]\right)\right]$$

$$= \frac{1}{4}\left[\left([0]-\left[\frac{4}{n\pi}\cdot\left(\left[(12)\cdot\left(-\frac{4}{n\pi}\cdot\cos n\pi\right)\right]\right)\right]\right)-\left([0]-\left[\frac{4}{n\pi}\cdot\left(\left[(-4)\cdot\left(-\frac{4}{n\pi}\cdot\cos n\pi\right)\right]\right)\right]\right)\right]$$

$$= \frac{1}{4}\left[\left(\frac{-48}{n\pi}\cdot\frac{-4}{n\pi}\cdot\cos n\pi\right)-\left(\frac{16}{n\pi}\cdot\frac{-4}{n\pi}\cdot\cos n\pi\right)\right]$$

$$= \frac{1}{4}\left[\left(\frac{192}{(n\pi)^2}\cdot\cos n\pi\right)+\left(\frac{64}{(n\pi)^2}\cdot\cos n\pi\right)\right]$$

$$a_n = \frac{1}{4}\left[\cos n\pi\cdot\left(\frac{192+64}{(n\pi)^2}\right)\right]$$

$$a_n = \cos n\pi\cdot\left(\frac{256}{(n\pi)^2}\right)\cdot\frac{1}{4}$$

$$a_n = (\cos n\pi)\cdot\left(\frac{64}{(n\pi)^2}\right)$$

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$$b_n = \frac{1}{L} \cdot \int_{-L}^{L} \left(f(x) \cdot \sin \frac{n\pi x}{L} \right) dx$$

$$= \frac{1}{4} \cdot \int_{-4}^{4} \left(x(x+4) \cdot \sin \frac{n\pi x}{4} \right) dx$$

$$= \frac{1}{4} \cdot \int_{-4}^{4} \left(x^2+4x \cdot \sin \frac{n\pi x}{4} \right) dx$$

= Miss $u = x^2+4x$ $\quad dV = \sin \frac{n\pi x}{4}\, dx$

$du = (2x+4)\, dx$ $\quad V = \int \sin \frac{n\pi x}{4}\, dx$

$$V = \frac{1}{\frac{n\pi}{4}} \cdot \left(-\cos \frac{n\pi x}{4} \right)$$

$$V = -\frac{4}{n\pi} \cdot \cos \frac{n\pi x}{4}$$

$\boxed{\int u\, dv = uv - \int v\, du}$

$$= \frac{1}{4} \cdot \left(\left[(x^2+4x) \cdot \left(-\frac{4}{n\pi} \cdot \cos \frac{n\pi x}{4} \right) \right] - \left[\int \left(-\frac{4}{n\pi} \cdot \cos \frac{n\pi x}{4} \cdot (2x+4) \right) dx \right] \right)_{-4}^{4}$$

$$= \frac{1}{4} \cdot \left(\left[(x^2+4x) \cdot \left(-\frac{4}{n\pi} \cdot \cos \frac{n\pi x}{4} \right) \right] - \left[-\frac{4}{n\pi} \cdot \int \left(\cos \frac{n\pi x}{4} \cdot (2x+4) \right) dx \right] \right)_{-4}^{4}$$

= Miss $u = 2x+4$ $\quad dV = \cos \frac{n\pi x}{4}\, dx$

$du = 2\, dx$ $\quad V = \int \cos \frac{n\pi x}{4}\, dx$

$$V = \frac{1}{\frac{n\pi}{4}} \cdot \sin \frac{n\pi x}{4}$$

$$V = \frac{4}{n\pi} \cdot \sin \frac{n\pi x}{4}$$

Maka,

$$\int \left(\cos \frac{n\pi x}{4} \right) \cdot (2x+4)\, dx = \left[(2x+4) \cdot \left(\frac{4}{n\pi} \cdot \sin \frac{n\pi x}{4} \right) \right] - \left[\int \frac{4}{n\pi} \cdot \sin \frac{n\pi x}{4} \cdot 2\, dx \right]$$

$$= \left[(2x+4) \cdot \frac{4}{n\pi} \cdot \sin \frac{n\pi x}{4} \right] - \left[\frac{8}{n\pi} \cdot \int \sin \frac{n\pi x}{4} \right]$$

$$= \left[(2x+4) \cdot \frac{4}{n\pi} \cdot \sin \frac{n\pi x}{4} \right] - \left[\frac{8}{n\pi} \cdot \frac{1}{\frac{n\pi}{4}} \cdot \left(-\cos \frac{n\pi x}{4} \right) \right]$$

$$= \left[(2x+4) \cdot \frac{4}{n\pi} \cdot \sin \frac{n\pi x}{4} \right] + \left[\frac{32}{(n\pi)^2} \cdot \cos \frac{n\pi x}{4} \right]$$

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Sehingga diperoleh,

$$= \frac{1}{4} \cdot \left(\left[(x^2+4x) \cdot \left(-\frac{4}{n\pi} \cdot \cos\frac{n\pi x}{4}\right) \right] - \left[-\frac{4}{n\pi} \cdot \int \left(\cos\frac{n\pi x}{4} \cdot (2x+4) \right) dx \right] \right)_{-4}^{4}$$

$$= \frac{1}{4} \cdot \left(\left[(x^2+4x) \cdot \left(-\frac{4}{n\pi} \cdot \cos\frac{n\pi x}{4}\right) \right] + \left[\frac{4}{n\pi} \cdot \left(\left[(2x+4) \cdot \frac{4}{n\pi} \cdot \sin\frac{n\pi x}{4} \right] + \left[\frac{32}{(n\pi)^2} \cdot \cos\frac{n\pi x}{4} \right] \right) \right] \right)_{-4}^{4}$$

$$= \frac{1}{4} \left[\left(\left[(4^2+4\cdot 4) \cdot \left(-\frac{4}{n\pi} \cdot \cos\frac{n\pi\cdot 4}{4}\right) \right] + \left[\frac{4}{n\pi} \cdot \left(\left[(2\cdot 4+4) \cdot \frac{4}{n\pi} \cdot \sin\frac{n\pi\cdot 4}{4} \right] + \left[\frac{32}{(n\pi)^2} \cdot \cos\frac{n\pi\cdot 4}{4} \right] \right) \right] \right) \right.$$

$$\left. - \left(\left[((-4)^2+4\cdot(-4)) \cdot \left(-\frac{4}{n\pi} \cdot \cos\frac{n\pi\cdot(-4)}{4}\right) \right] + \left[\frac{4}{n\pi} \cdot \left(\left[2\cdot(-4)+4) \cdot \frac{4}{n\pi} \cdot \sin\frac{n\pi\cdot(-4)}{4} \right] + \left[\frac{32}{(n\pi)^2} \cdot \cos\frac{n\pi\,(-4)}{4} \right] \right) \right] \right) \right]$$

$$= \frac{1}{4} \cdot \left[\left(\left[(32) \cdot \left(-\frac{4}{n\pi} \cdot \cos n\pi\right) \right] + \left[\frac{4}{n\pi} \cdot \left(\left[(12) \cdot \frac{4}{n\pi} \cdot (0) \right] + \left[\frac{32}{(n\pi)^2} \cdot \cos n\pi \right] \right) \right] \right) \right.$$

$$\left. - \left(\left[(0) \cdot \left(-\frac{4}{n\pi} \cdot \cos -n\pi\right) \right] + \left[\frac{4}{n\pi} \cdot \left(\left[(-4) \cdot \frac{4}{n\pi} \cdot (0) \right] + \left[\frac{32}{(n\pi)^2} \cdot \cos -n\pi \right] \right) \right] \right) \right]$$

$$= \frac{1}{4} \cdot \left[\left(\left[-\frac{128}{n\pi} \cdot \cos n\pi \right] + \left[\frac{4}{n\pi} \cdot \left([0] + \left[\frac{32}{(n\pi)^2} \cdot \cos n\pi \right] \right) \right] \right) \right.$$

$$\left. - \left([0] + \left[\frac{4}{n\pi} \left([0] + \left[\frac{32}{(n\pi)^2} \cdot \cos n\pi \right] \right) \right] \right) \right]$$

$$= \frac{1}{4} \cdot \left[\left(\left[-\frac{128}{n\pi} \cdot \cos n\pi \right] + \left[\frac{128}{(n\pi)^3} \cdot \cos n\pi \right] \right) - \left(\frac{128}{(n\pi)^3} \cdot \cos n\pi \right) \right]$$

$$= \frac{1}{4} \cdot \left[\left(\cos n\pi \cdot \left(-\frac{128}{n\pi} + \frac{128}{(n\pi)^3} \right) \right) - \left(\frac{128}{(n\pi)^3} \cdot \cos n\pi \right) \right]$$

$$b_n = \frac{1}{4} \cdot \left[(\cos n\pi) \left(\left(\frac{-128}{n\pi} + \frac{128}{(n\pi)^3} \right) - \left(\frac{128}{(n\pi)^3} \right) \right) \right] \quad //$$

$$b_n = \frac{1}{4} \left[(\cos n\pi) \cdot \left(-\frac{128}{n\pi} \right) \right]$$

$$b_n = \frac{-32}{n\pi} \cdot \cos n\pi$$

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$$f(x) = \frac{1}{2} \cdot a_0 + \sum_{n=1}^{\infty} \left[a_n \cdot \cos\left(n \cdot \frac{2\pi}{p} \cdot x\right) + b_n \cdot \sin\left(n \cdot \frac{2\pi}{p} \cdot x\right) \right]$$

$$f(x) = \frac{1}{2} \cdot \left(\frac{32}{3}\right) + \sum_{n=1}^{\infty} \left[(\cos n\pi)\left(\frac{64}{(n\pi)^2}\right) \cdot \cos\left(n \cdot \frac{2\pi}{4} \cdot x\right) + \left(-\frac{32}{n\pi}\right) \cdot (\cos n\pi) \cdot \sin\left(n \cdot \frac{2\pi}{4} \cdot x\right) \right]$$

$$f(x) = \frac{16}{3} + \sum_{n=1}^{\infty} \left[(\cos n\pi)\left(\frac{64}{(n\pi)^2}\right) \cdot \cos\left(n \cdot \frac{2\pi}{4} x\right) + (\cos n\pi)\left(-\frac{32}{n\pi}\right) \cdot \sin\left(n \cdot \frac{2\pi}{4} \cdot x\right) \right] //$$

Kita peroleh deret fourier f(x) yg periodanya 8.

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B. Pilihlah salah satu jawaban yang menurut Anda paling tepat! (Hal. 51)

1.) Fungsi f yang periodik dengan periode 2π ditentukan oleh $f(x) = x(\pi - x)$ dalam selang $0 < x < \pi$. Deret sinus Fourier $f(x)$ adalah:

a. $f(x) = \frac{4}{\pi} \cdot \sum (\cos n\pi - 1) \cdot \sin nx$

b. $f(x) = \frac{-4}{\pi^2} \cdot \sum (\cos n\pi - 1) \cdot \frac{\sin nx}{n^2}$

c. $f(x) = -\frac{4}{\pi} \cdot \sum (\cos n\pi - 1) \cdot \frac{\sin nx}{n^3}$

d. $f(x) = \frac{2}{\pi} \cdot \sum \frac{\sin nx}{n}$

Penyelesaian:

Karena ditanyakan deret sinus Fourier $f(x)$, maka dapat dibentuk fungsi $F(x)$ yang memenuhi:

$$F(x) = f(x) = x(\pi - x) \quad \text{dalam selang } 0 < x < \pi$$
$$F(x) = -f(-x) = -(-x(\pi - (-x))) = x(\pi + x) \quad \text{dalam selang } -\pi < x < 0$$

Karena $F(x)$ fungsi ganjil, maka $a_n = a_0 = 0$.

Selanjutnya akan dicari nilai b_n.

next

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b.
$$b_n = \frac{2}{\pi} \cdot \int_0^{\pi} f(x) \cdot \sin nx \; dx$$

$$= \frac{2}{\pi} \cdot \int_0^{\pi} (x(\pi - x)) \cdot \sin nx \cdot dx$$

$$= \frac{2}{\pi} \cdot \int_0^{\pi} (x\pi - x^2) \cdot \sin nx \cdot dx$$

$= \frac{2}{\pi} \cdot$ Miss $u = x\pi - x^2$ $\qquad dV = \sin nx \; dx$

$du = (\pi - 2x) \; dx$ $\qquad V = \int \sin nx \; dx$

$V = \frac{1}{n} \cdot (-\cos nx)$

$V = -\frac{1}{n} \cdot \cos nx$

$$= \frac{2}{\pi} \cdot \left[(x\pi - x^2)\left(-\frac{1}{n} \cdot \cos nx\right) - \left(\int -\frac{1}{n} \cdot \cos nx \cdot (\pi - 2x)\, dx\right) \right]_0^{\pi}$$

$$= \frac{2}{\pi} \cdot \left[(x\pi - x^2)\left(-\frac{1}{n} \cdot \cos nx\right) + \left(\frac{1}{n} \cdot \int \cos nx \cdot (\pi - 2x) \cdot dx\right) \right]_0^{\pi}$$

$=$ Miss $u = \pi - 2x$ $\qquad dV = \cos nx \; dx$

$du = -2 \; dx$ $\qquad V = \int \cos nx \; dx$

$du = -2 \; dx$ $\qquad V = \frac{1}{n} \cdot \sin nx$

$$= \frac{2}{\pi} \cdot \left[(x\pi - x^2)\left(-\frac{1}{n} \cdot \cos nx\right) + \left(\frac{1}{n} \cdot \left((\pi - 2x) \cdot \frac{1}{n} \cdot \sin nx - \int \frac{1}{n} \cdot \sin nx \cdot -2\, dx\right)\right) \right]_0^{\pi}$$

$$= \frac{2}{\pi} \cdot \left[(x\pi - x^2)\left(-\frac{1}{n} \cdot \cos nx\right) + \left(\frac{1}{n}\left(\frac{\pi - 2x}{n} \cdot \sin nx + \frac{2}{n} \cdot \frac{1}{n} \cdot (-\cos nx)\right)\right) \right]_0^{\pi}$$

$$= \frac{2}{\pi} \cdot \left[(x\pi - x^2)\left(-\frac{1}{n} \cdot \cos nx\right) + \left(\frac{1}{n}\left(\frac{\pi - 2x}{n} \cdot \sin nx - \frac{2 \cdot \cos nx}{n^2}\right)\right) \right]_0^{\pi}$$

$$= \frac{2}{\pi} \cdot \left(\left[(\pi \cdot \pi - \pi^2)\left(-\frac{1}{n} \cdot \cos n\pi\right) + \left(\frac{1}{n}\left(\frac{\pi - 2\pi}{n} \cdot \sin n\pi - \frac{2 \cdot \cos n\pi}{n^2}\right)\right) \right] - \left[0 - \frac{2}{n^3} \right] \right)$$

$$= \frac{2}{\pi} \left(\left[(0) + \left(\frac{1}{n}\left(-\frac{\pi}{n} \cdot \sin n\pi - \frac{2 \cdot \cos n\pi}{n^2}\right)\right) \right] + \left[\frac{2}{n^3} \right] \right)$$

$$= \frac{2}{\pi} \cdot \left(\left[-\frac{2 \cdot \cos n\pi}{n^3} \right] + \left[\frac{2}{n^3} \right] \right)$$

$$b_n = \frac{4}{\pi n^3} (1 - \cos n\pi)$$

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$\therefore$ Deret Sinus Fourier $f(x)$ adalah

$$f(x) = \frac{1}{2} \cdot a_0 + \sum_{n=1}^{\infty} (a_n \cdot \cos nx + b_n \cdot \sin nx)$$

$$= \frac{1}{2} \cdot (0) + \sum_{n=1}^{\infty} \left((0) \cdot \cos nx + \left(\frac{4}{\pi n^3} \cdot (1 - \cos n\pi) \right) \cdot \sin nx \right)$$

$$= \frac{4}{\pi} \sum_{n=1}^{\infty} (1 - \cos n\pi) \cdot \frac{\sin nx}{n^3}$$

$$= -\frac{4}{\pi} \sum_{n=1}^{\infty} (\cos n\pi - 1) \cdot \frac{\sin nx}{n^3}$$

//

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