

Selected Topics in CFD - list 10

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1

Implement the Fast Fourier Transform (FFT) and its inverse (IFFT) from scratch. Verify your implementation by demonstrating the following:

- $\mathcal{F}^{-1}\{\mathcal{F}\{x\}\} = x$ (accounting for numerical precision).
- The implementation exhibits linearithmic complexity, i.e., $O(N \log N)$.

2

Solve the following one-dimensional Poisson equation:

$$\frac{d^2 u}{dx^2} = f(x)$$

where $x \in [0, 2\pi)$ and the source term is defined as:

$$f(x) = \sin(x) + \cos(3x) - \sin(4x)$$

Assume periodic boundary conditions and a zero-mean constraint, such that:

$$\int_0^{2\pi} u(x) \, dx = 0$$