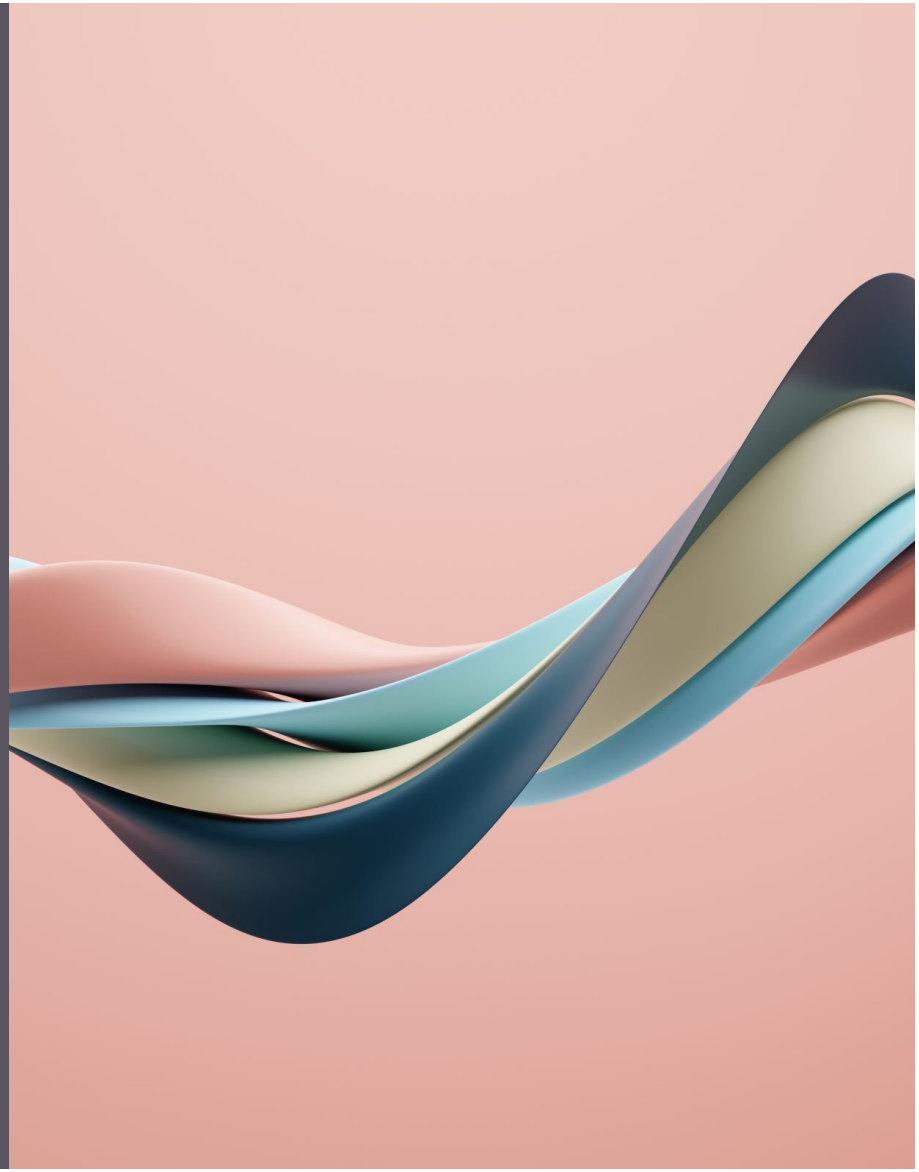
FOURIER ANALYSIS

How the energy of a signal is distributed as a function of frequency



Fourier frequency analysis decomposes complex signals into constituent sine/cosine waves, essential for signal processing, engineering, and data analysis. Major applications include filtering noise, compressing data (JPEG, MP3), enhancing images in medical scans (MRI/CT), analyzing vibrations, interpreting seismic data, and designing communication systems like OFDM.

Key Applications of Fourier Analysis

- **Signal and Image Processing:**
  - **Filtering & Audio Processing:** Removing noise, enhancing specific frequency bands (equalization), and compressing audio data.
  - **Image Compression & Enhancement:** Used in JPEG compression and image filtering (low-pass for smoothing, high-pass for edge detection).
  - **Radar and Sonar:** Target detection, velocity estimation, and clutter suppression.

- **Engineering and Physical Sciences:**
  - **Vibration Analysis:** Monitoring machinery health and diagnosing faults by analyzing spectral components.
  - **Structural Engineering:** Analyzing resonance frequencies in buildings and bridges to prevent failures.
  - **Circuit Analysis:** Analyzing electrical systems and signal responses in Quora.

- **Medical and Scientific Imaging:**
  - **Medical Imaging:** Reconstructing images from raw sensor data in MRI and CT scans.
  - **Biomedical Signal Processing:** Analyzing EEG, ECG, and EMG data to extract frequency-domain features.
  - **Astronomy:** Enhancing images and removing atmospheric distortion.

- **Data Analysis and Specialized Fields:**
  - **Geophysics:** Analyzing seismic waves to locate oil reserves.
  - **Finance:** Analyzing market stock volatility by examining price signal changes.
  - **Communications:** Modulating and demodulating signals, such as in OFDM.
  - **Quantum Physics:** Breaking down wavefunctions to understand quantum mechanics.

Types of Fourier Techniques

- **Fourier Series:** Used for periodic signals.
- **Fourier Transform:** Used for non-periodic, continuous signals.
- **Fast Fourier Transform (FFT):** An efficient algorithm for digital signal processing, including averaging methods like exponential averaging.