# Neural data analysis - Session 2

Fourier transforms, spectral analysis

# Why Fourier?

- A lot of biological data (EEG, circadian rhythms, speech, birdsong, etc.) is oscillatory
- The frequency of these oscillations is often of interest
- Fourier analysis provides a way of identifying the frequencies of the oscillations present in a signal

# Math review – complex numbers

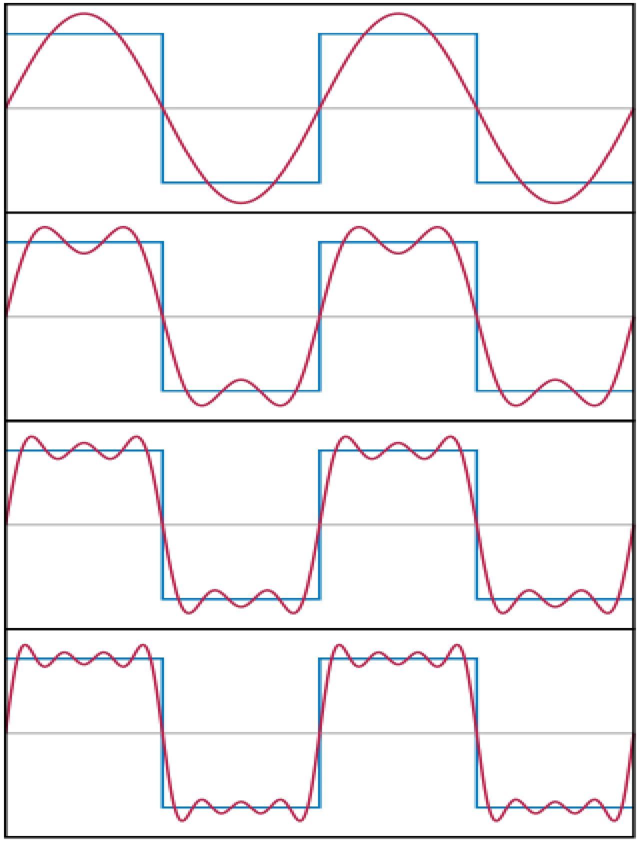
# Waves - terminology

# Fourier series - intuition

- Can represent any periodic function as a sum of sine and cosine functions with different frequencies

$$f(x) = \sum_{n=-\infty}^{\infty} c_n e^{inx}.$$

$$c_n = \frac{1}{2\pi} \int_{-\pi}^{\pi} f(x) e^{-inx} \, dx.$$



# Fourier transforms

- Coefficients in the Fourier series give the "amount" of a particular frequency in the signal
- From this, one can derive a more general expression describing the frequency content in an arbitrary (non-periodic) signal

# Formal definition

FT of f(x):

$$\hat{f}(\xi) = \int_{-\infty}^{\infty} f(x)\, e^{-2\pi i x \xi}\, dx,$$

Inverse transform:

$$f(x) = \int_{-\infty}^{\infty} \hat{f}(\xi)\, e^{2\pi i x \xi}\, d\xi,$$

Note: Conventions vary widely!!

# Discrete Fourier transform

- Fourier transform of a discrete time signal (this is what matlab does)

# FFT in Matlab

- Fast algorithm for computing the DFT

# Power Spectrum

# Exercise – sine waves buried in noise

# Stationarity, ergodicity

- FT assumes that a signal is stationary – that it's frequency content does not change over time
- A related concept is that of ergodicity – that the ensemble average is equivalent to the time average

# Windows and the STFT

- Many biological signals are distinctly non-stationary
- Can apply a sliding window to the original signal and compute a new Fourier transform for each window
- Get something called a spectrogram

# Exercise – zebra finch song

# Exercise 2 – EEG data