# Spectral Analysis with MATLAB

* Spectral Analysis
  + Estimating power consumption of the frequency components of a signal
  + Applications:
    - Astronomy
    - Automotive parts
      * Ford Motor compay develops and Deploys Sound-Quality Metrics with MATLAB
    - Multimedia
    - Bio-Medical
* Spectral Analysis using Fourier Transform -fft
  + To convert Time domain signal to frequency domain, we use fft function
  + fft: Fast Fourier Transform; Output: Magnitude (Strength of frequency components) and phase (How these frequency components Align with Time) Response
* Challenges
  + Using Fourier Transform required domain knowledge:
    - Complex output for real valued input
    - Compute magnitude and phase info
    - Positive and negative frequency components
    - Signal power info is unavailable
* Pwelch function to perform power spectral density analysis in matlab
  + Pwelch plots signal power density as a function of frequency using Welch’s method
  + Ideal when you have little info about the spectral content of the signal
  + Plots one-sided PSD of the signal: don’t need to worry about the +ve and -ve sides (by default)
* Improving Spectral Resolution with Signal Windows
  + Windowing: process of shaping a signal before the PSD is computed
  + Window parameters (size / type of window) used to improve spectral estimation
    - Longer window segments result in greater frequency resolution
  + Choice (type/length) of window depends on the application
* Data with missing values:
  + Pwelch doesn’t work well when the input set has some missing data
  + Interpolating missing data samples alters the spectrum
  + Use plomb function for spectral analysis of signals with missing data
* Spectrogram: what if I want both Frequency & Time??
  + Provides a time-frequency representation of a signal
  + Plots the frequency variations as a function of time with the power at any instant represented using a color
  + Useful when you want to determine when (at what time instant) certain frequencies occurs (order of frequencies)
  + Eg, which buttons were pressed during the calling of a number, each button pressed has 2 tones attached to it
* Summary:
  + Spectral Analysis is widely used technique to estimate power content of frequencies in a signal
  + Using fft for spectral analysis requires domain knowledge
  + Spectral Analysis made easy (pwelch, plomb, spectrogram\_
  + Other Spectral Analysis tools also available in Signal Processing Toolbox

Webinar URL: <https://in.mathworks.com/solutions/dsp.html>

Dataset File: <https://in.mathworks.com/matlabcentral/fileexchange/47976-spectral-analysis-webinar-code-zip>

For Data Tables Manipulation & Viewing: <https://in.mathworks.com/videos/introducing-tables-and-categorical-arrays-79924.html>

Annexure:

**Welch's method** (also called the periodogram **method**) for estimating power spectra is carried out by dividing the time signal into successive blocks, forming the periodogram for each block, and averaging.