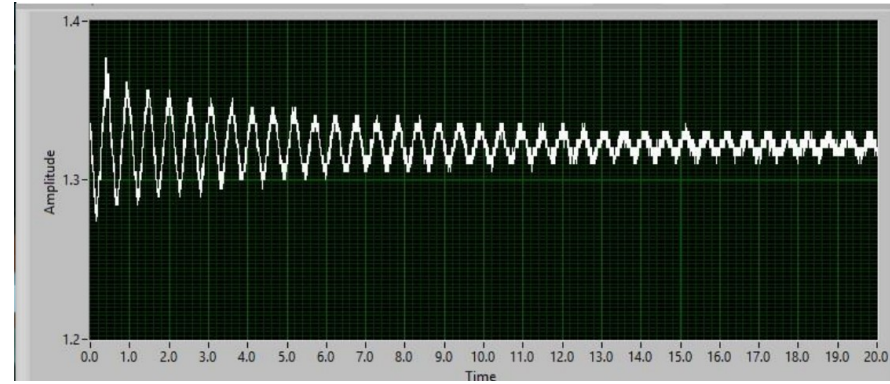# Lab 5: Signal Processing and Analysis
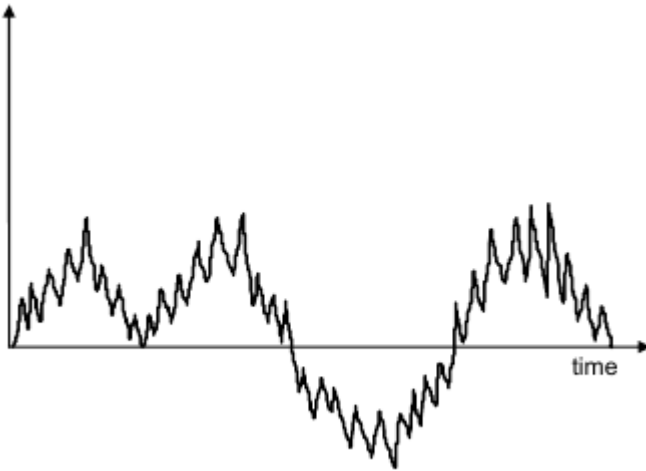

Salil S. Kulkarni

Data Acquisition Systems Components

Digital
Counter / Timer
Sensors
Motors
Relays

Physical System	Transducer Sennsor	Signal Conditioning	A / D Converter	Computer

00101011
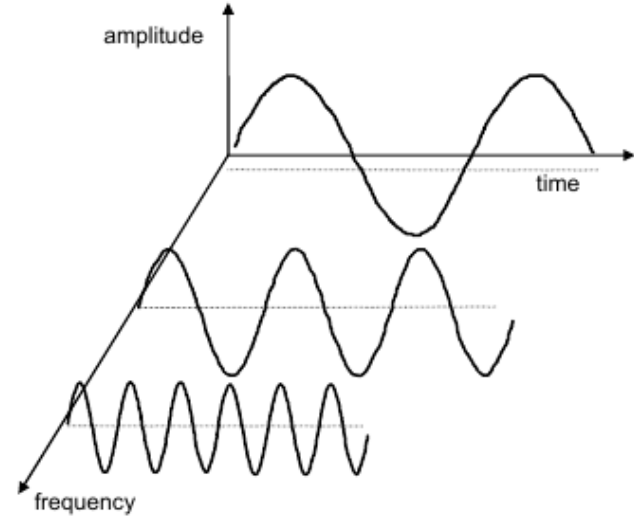00111011
10100000
101010

IQSdirectory.com
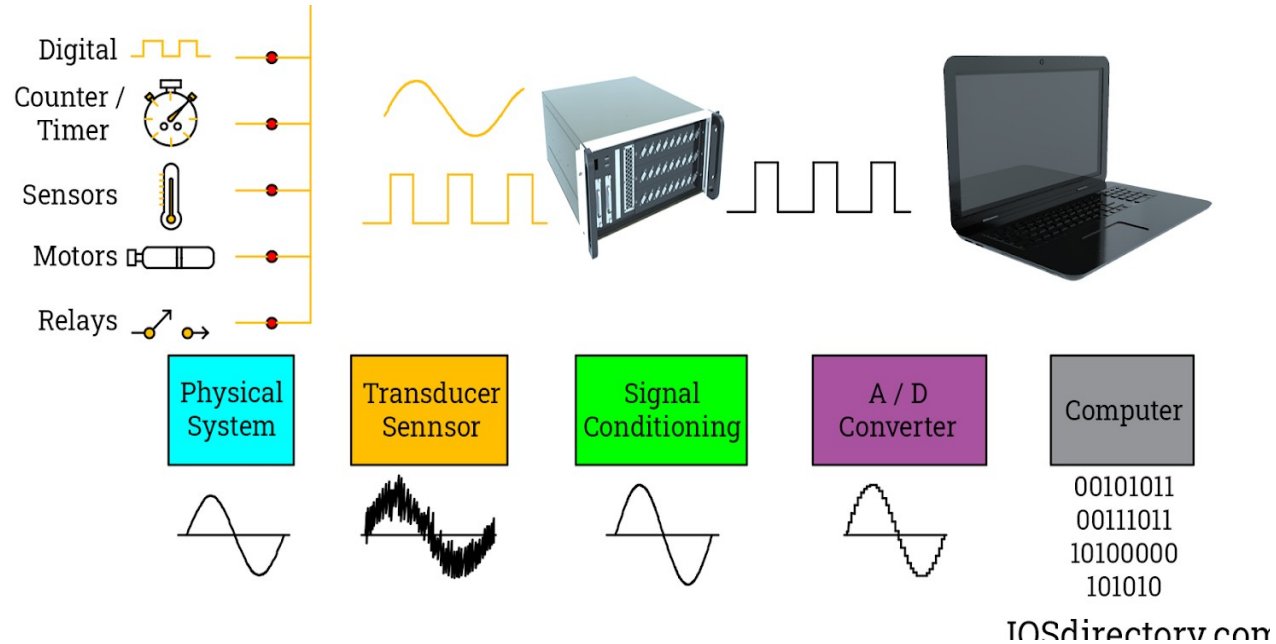
Basics of Signal Processing

- Typical analog time varying signal from a sensor

Composite signal



Signal components

- Objective of signal processing is to extract informartion from the signal
  – e.g. frequency content, respective amplitudes, etc

Dennis H. Shreve, Signal processing for effective vibration analysis, IRD Mechanalysis, Inc, Columbus, Ohio, November 1995

Fast Fourier Transform (FFT)

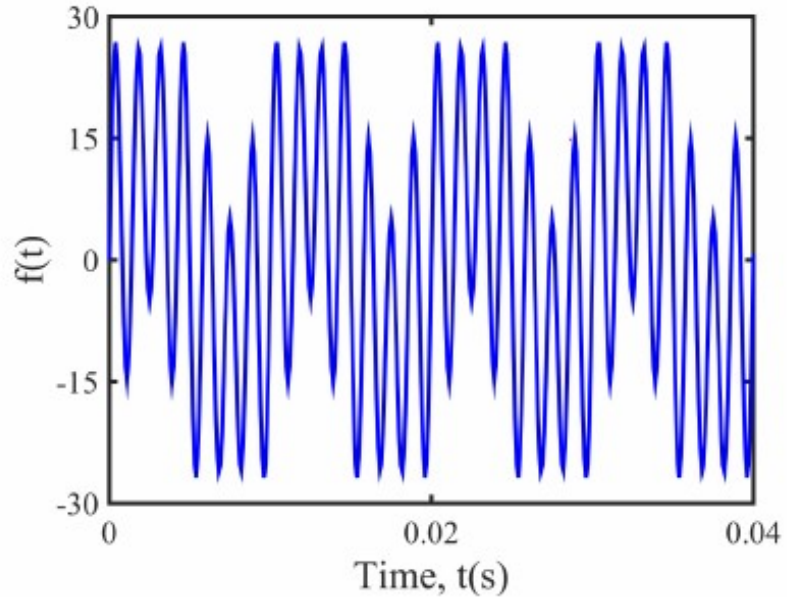FFT efficiently computes the discrete fourier transform of a given signal
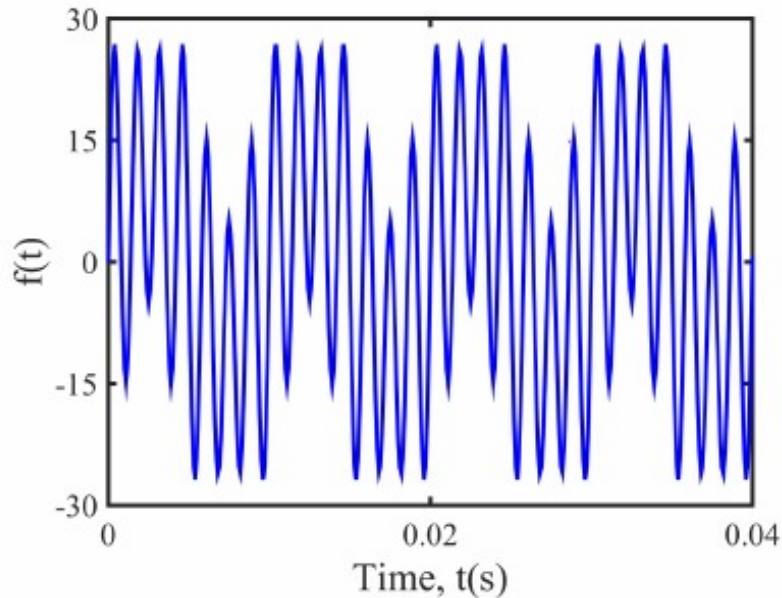
$$f(t) = 10\sin(2\pi 100t) + 5\sin(2\pi 500t) + 20\sin(2\pi 700t)$$
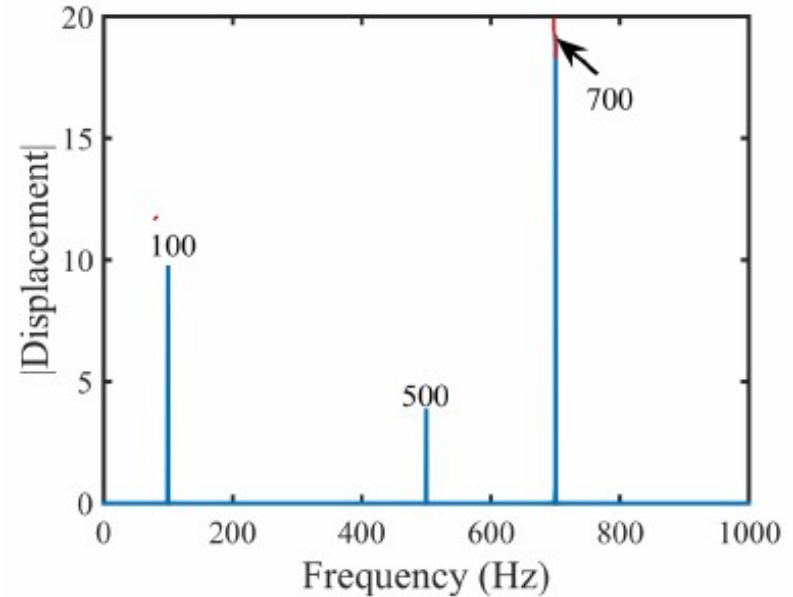
J. W. Cooley and J.W.Tukey. An algorithm for the machine calculation of complex Fourier series, Mathematics of Computation, pp.297-301, Vol. 19, April 1965.

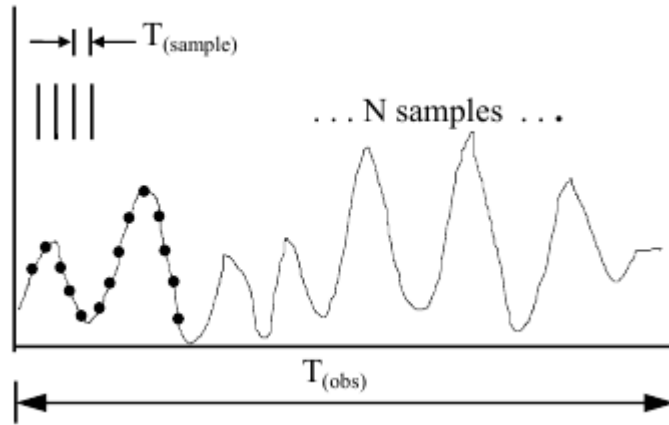One of the top 10 algorithms of the 20th century

Signal Processing Basics

- Observation time

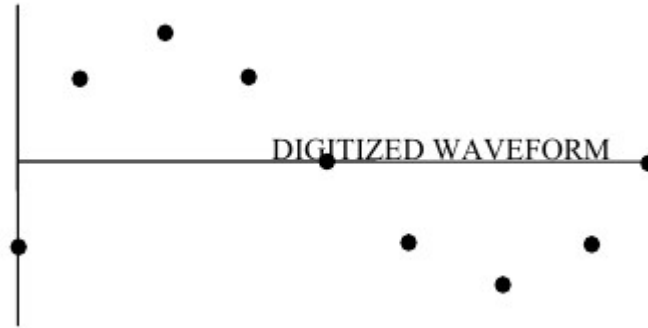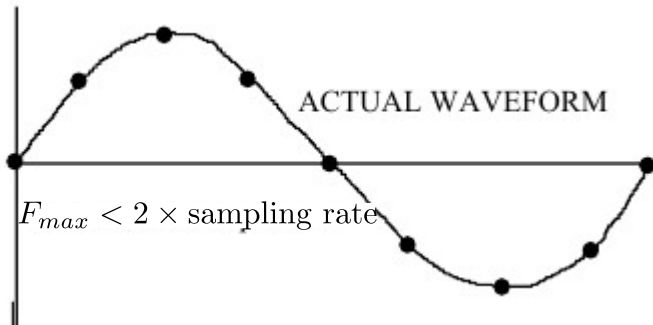- Sampling rate

- Windowing function

Signal Processing Basics

- Observation time

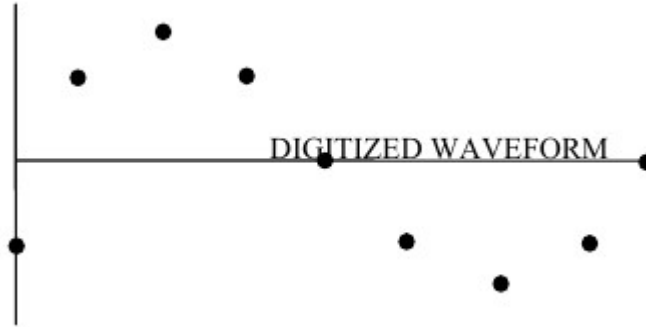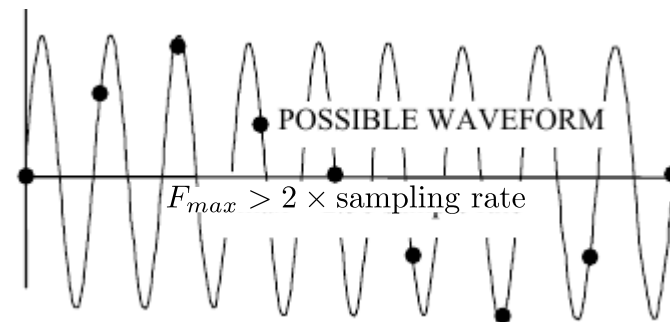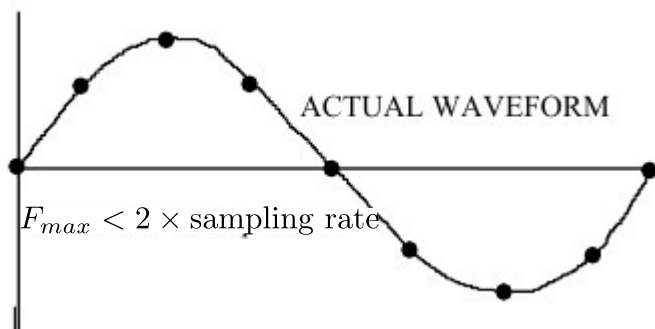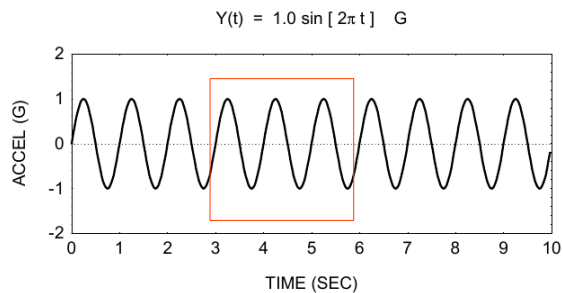# Signal Processing Basics

- Sampling Rate

DIGITIZED WAVEFORM

Signal Processing Basics

- Sampling Rate

DIGITIZED WAVEFORM

ACTUAL WAVEFORM

$F_{max} < 2 \times$ sampling rate

Dennis H. Shreve, Signal processing for effective vibration analysis, IRD Mechanalysis, Inc, Columbus, Ohio, November 1995

Signal Processing Basics

- Sampling Rate

DIGITIZED WAVEFORM

ACTUAL WAVEFORM

$F_{max} < 2 \times \text{sampling rate}$

POSSIBLE WAVEFORM

$F_{max} > 2 \times \text{sampling rate}$

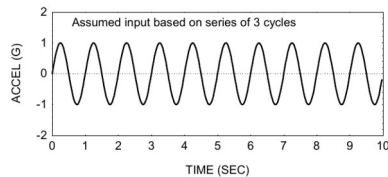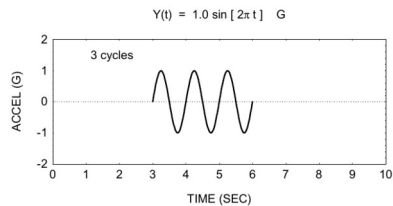Dennis H. Shreve, Signal processing for effective vibration analysis, IRD Mechanalysis, Inc, Columbus, Ohio, November 1995

Signal Processing Basics

- Windowing Function

$Y(t) = 1.0 \sin[2\pi t]$ G
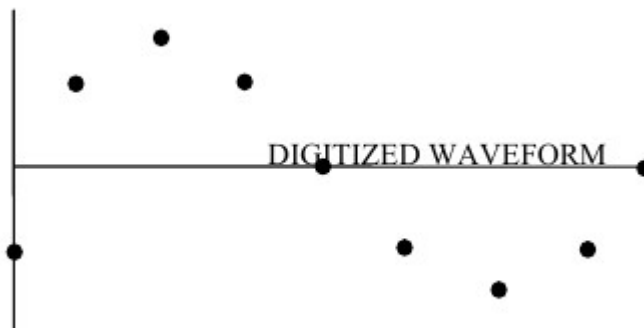
Actual Signal

Signal Processing Basics

- Windowing Function

Actual Signal
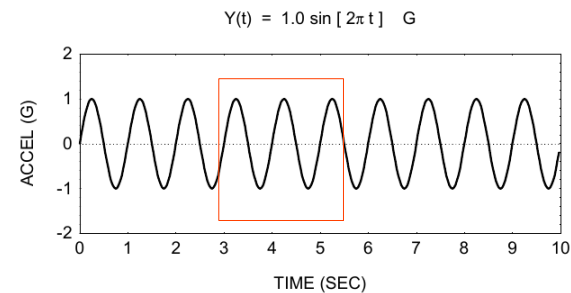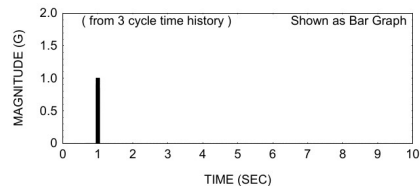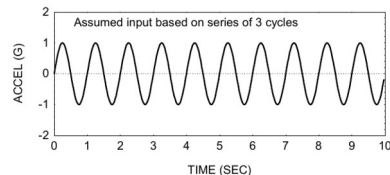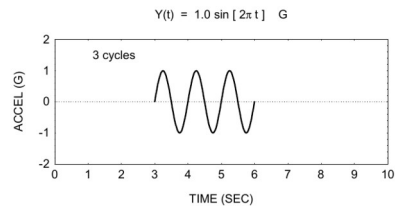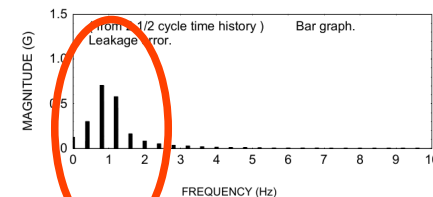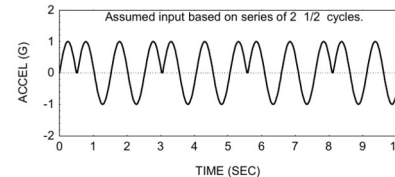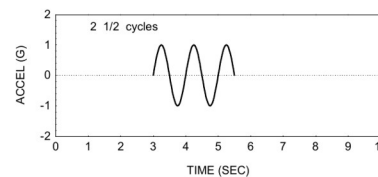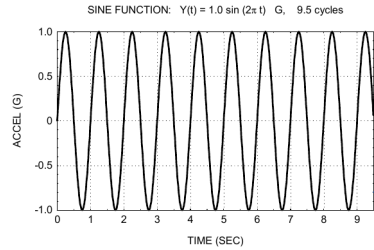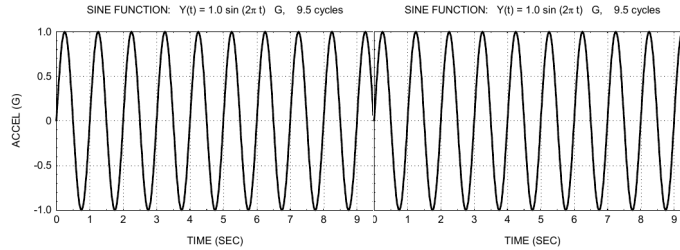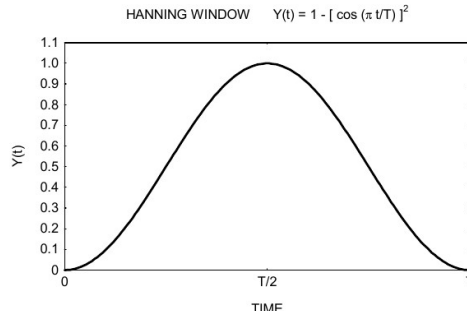
Actual Signal

Leakage error

Signal Processing Basics

- Windowing – actual signal is multiplied by a windowing function so that the sampled waveform appears continuous and periodic
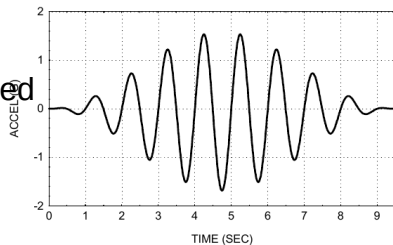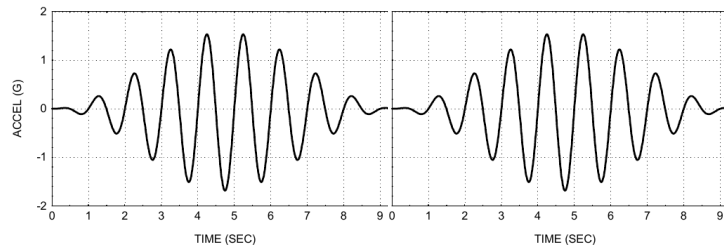

Actual Signal

X

Modulated Signal
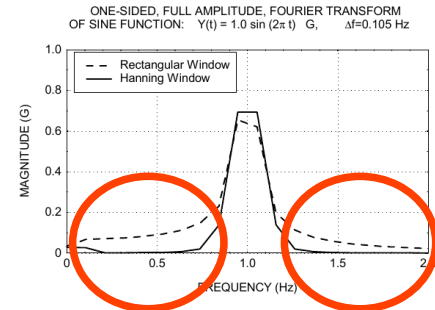
Signal Processing Basics

- Types of Windowing Functions

Hann window · Welch window · Tukey window (α = 0.5)
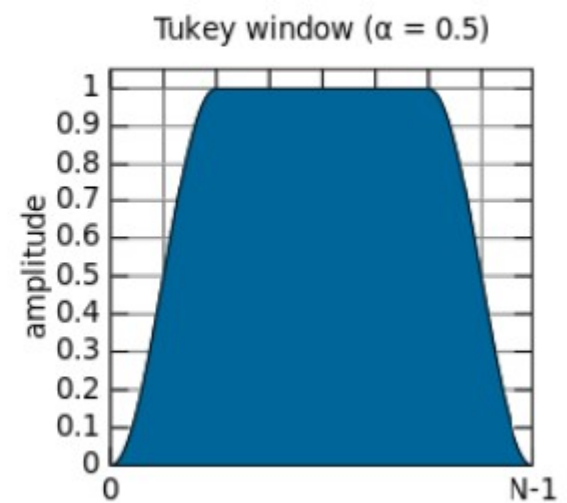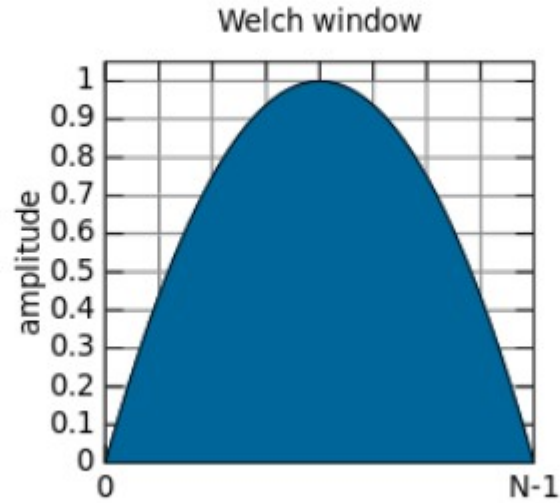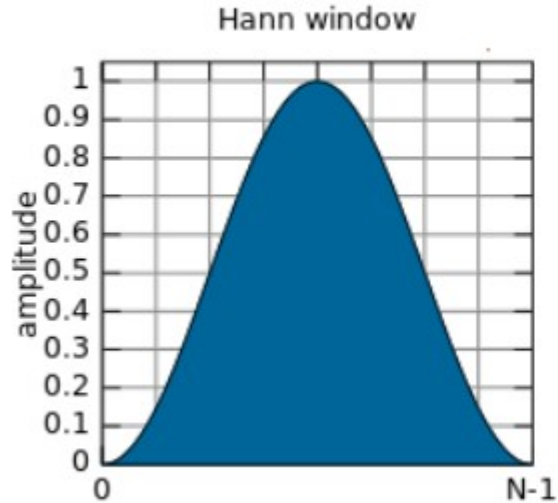
During the Lab

Part A

- Recreate the signal using the data (sheet 1) for your group using different sampling rates (ideal rate 20 times the max frequency) – sample at frequencies equal to and lower than the ideal sampling rate
- Analyse the data by using different observation times and study its effect on the FFT
- Analyse the data by using different windowing functions and study their effect on the FFT

Part B

- Use the data (sheet 2) for your group
- Analyse the data by performing FFT analysis (use multiple windowing functions)