Course details

Course staff

- **Instructor**: Prof. Oleg Michailovich (olegm@uwaterloo.ca, EIT 4127, ext. 38247)
- **TA**: TBD

Office hours

- **Instructor**: Monday @ 11:00 AM - 12:00 PM
- **TA**: TBD

Course website

- [www.ece.uwaterloo.ca/~ece413](http://www.ece.uwaterloo.ca/~ece413)
Marking scheme

- Bi-weekly home assignments (5 assignments × 5%): 25%
- Midterm exam: 25%
- Final exam: 50%
Course outline

1 Discrete-time signals and systems
   - Properties of linear time-invariant systems
   - Convolution description of linear time-invariant systems
   - Analytical and numerical evaluation of convolution
   - Linear constant-coefficient difference equations
   - Real-time implementation of FIR filters

2 The $z$-transform
   - The $z$-transform and its inverse
   - Properties of the $z$-transform
   - System function of LTI systems
   - Pole-zero locations and time-domain behaviour
   - The one-sided $z$-transform

3 Fourier representation of signals
   - Sinusoidal signals and their properties
   - Fourier representation of continuous-time signals
   - Fourier representation of discrete-time signals
   - Summary of Fourier series and Fourier transforms
   - Properties of the discrete-time Fourier transform
Transform analysis of LTI systems
- Response of LTI systems in the frequency domain
- Distortion of signals passing through LTI systems
- Frequency response for rational system functions
- Dependence of frequency response on poles and zeros
- Relationship between magnitude and phase responses
- Invertibility and minimum-phase systems
- All-pass systems

Sampling of continuous-time signals
- Ideal periodic sampling of continuous-time signals
- Reconstruction of a band-limited signal from its samples
- The effect of undersampling: aliasing
- Discrete-time processing of continuous-time signals
- Practical sampling and reconstruction
- Sampling of bandpass signals
The Discrete Fourier Transform

- Computational Fourier analysis
- The Discrete Fourier Transform (DFT)
- Sampling the Discrete-Time Fourier Transform
- Properties of the Discrete Fourier Transform
- Linear convolution using the DFT
- Fourier analysis of signals using the DFT

Computation of the Discrete Fourier Transform

- Direct computation of the Discrete Fourier Transform
- Decimation-in-time FFT algorithms
- Decimation-in-frequency FFT algorithms
- Generalizations and additional FFT algorithms
- Practical considerations
Design of FIR filters
- FIR filters with linear phase
- Design of FIR filters by windowing and frequency sampling
- Chebyshev polynomials and minimax approximation
- Equiripple optimum Chebyshev FIR filter design
- Design of some special FIR filters

Design of IIR filters
- Introduction to IIR filter design
- Design of continuous-time lowpass filters
- Transformation of continuous-time filters to discrete-time filters
- Design examples for lowpass IIR filters
- Frequency transformations of lowpass filters
Course outline (continued)

10 **Multirate signal processing**
   - Sampling rate conversion
   - Implementation of multirate systems
   - Filter design for multirate systems
   - Two-channel filter banks
   - Multichannel filter banks

11 **Random signal processing**
   - Spectral analysis of stationary processes
   - Optimum linear filters
   - Linear prediction and all-pole signal modelling

12 **Signal estimation and detection**
   - Statistical estimation
   - Maximum likelihood and Bayesian estimation
   - Hypothesis testing
   - Applications
Questions?