



Department of Chemical & Materials Engineering

## CHE 573: Signal Processing for Chemical Engineers 2014 Winter Term

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### Course Time Schedule:

Lecture M W F 10:00–10:50 in ETLC E2-009  
Lab time: F 14:00–16:50 will have 2~3 labs. Lab room will be announced.

**Teaching Assistant:** Jing Zhang ([jzhang7@ualberta.ca](mailto:jzhang7@ualberta.ca))

**Grader:**

**Office Hours:** M 11:00–12:00 in ECERF 7-017 (Jinfeng Liu)

### Course webpage

All handouts, assignments and other pertinent information will be posted on UofA's eclass portal for this course: <https://eclass.srv.ualberta.ca/portal/> Other important announcements and information will also appear on this webpage.

### Course Objectives

The main objective of this course is to introduce commonly used powerful *information processing techniques*, namely, **temporal** and **spectral** analysis via (1) **correlation analysis**, (2) **Fourier transforms** (spectral analysis) and (3) **filtering methods** (including filter design) for practical data analysis. The focus of this course is on discrete-time signals. A systematic development of the theoretical background will be supplemented with suitable applications to real-life data. The course will also provide the student with a hands-on experience in applying these tools to real-life data from the process industry.

The preliminary part of this course provides an introduction to the theory of sampling, discrete-time systems and convolution. Notions of frequency in continuous-time and discrete-time domains will be provided with suitable examples. MATLAB® will be the primary software platform for this course.

### Who will find this course useful?

This course is aimed at students at the undergraduate and graduate levels. This course is particularly useful to all individuals currently studying/working (or intend to take up employment) in disciplines such as engineering/ medicine/ sciences/ business with particular interests in data analysis. Engineering students will also find it useful to obtain a basic knowledge of Digital Signal Processing (DSP) for future and current research projects in areas such as control theory, process monitoring, *etc.* A practical engineer can

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directly employ the techniques taught in this course to analyze process data with applications to controller performance assessment, plant-wide oscillation detection, time-delay estimation, etc.

### Course Contents

Topics to be covered will include some or all the following. (The required lecture hours given are approximate):

	Topic	Sub-topics	Duration
<i>Part I:</i> Introduction & Fundamentals (12 lectures)	Introduction	Course objectives; Introduction to digital signal processing.	1 Lecture
	Signals	Fundamental definitions; Introduction to CT and DT signals; Frequencies in CT and DT signals; Unit sample and unit step signals.	2~3 Lectures
	Sampling	Introduction to sampling; Concept of Aliasing; Sampling Theorem; Data preprocessing – outlier detection.	2~3 Lectures
	Systems	DT systems – CT systems to DT systems; Linearity, causality, stability, time invariant; Representation of DT systems – input/output, impulse; Convolution sum; FIR, IIR systems.	3~4 Lectures
	$z$ -Transform	Definition & properties of $z$ -transform; Inverse $z$ -transform; Transfer functions; Poles and zeros; Applications of $z$ -transform to LTI systems; Relationship between $s$ -transform and $z$ -transform.	2~3 Lectures

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<p><i>Part II:</i> Correlation Analysis in the Time Domain (8 lectures)</p>	<p>Power signals</p>	<p>Auto-correlation, auto-covariance; Auto-correlation functions (ACF); Partial autocorrelation function (PACF); Applications of ACF, PACF - periodic signal detection, disturbance model (MA, AR, ARMA) identification; Cross-correlation functions (CCF); Applications of CCF – process delay detection, impulse response identification.</p>	<p>8 Lectures</p>
<p>Part III: Frequency Domain Analysis (16 lectures)</p>	<p>Fourier series &amp; transforms for signals</p>	<p>Introduction to spectrum; Fourier series for periodic signals; Power spectrum; Magnitude &amp; phase spectra; Applications of power spectrum; Fourier transforms for aperiodic signals.</p>	<p>9 Lectures</p>
	<p>Frequency response of DT systems</p>	<p>Frequency response function; Response to periodic &amp; aperiodic signals.</p>	<p>3 Lectures</p>
	<p>Filters</p>	<p>Introduction to filtering; Low-, high- and band-pass filters; MA, EWMA filter; Design of filters.</p>	<p>4 Lectures</p>

### Text book

A text book is not required for this course. The lecture notes and class handouts should suffice. For supplementary reading, the following books are recommended.

- J.G. Proakis and D.G. Manolakis, *Digital Signal Processing: Principles, Algorithms and Applications*, 4th edition, Prentice Hall, 2007.
- Sanjit Mitra. *Digital Signal Processing: A Computer-Based Approach, 2e with DSP Laboratory using MATLAB*, McGraw-Hill Higher Education, 2001.
- A.V. Oppenheim and R.W. Schaffer. *Digital Signal Processing*, Prentice Hall, Eaglewood Cliffs, NJ, 1998.
- There is a lot of material on the web as well as demo toolboxes in Matlab.

### Prerequisites

CHE 358 Process Data Analysis; CHE 446 Process Dynamics and Control

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### Assignments

There will be five (more or less) assignments in this course.

### Software

The software platform for this course is MATLAB and the associated toolboxes. MATLAB is a popular scientific computation and visualization software package that closely incorporates the theory taught in this course. The Signal Processing Toolbox along with the MATLAB contains the necessary tools for the analysis and design of control systems. It is highly recommended that students familiarize themselves with the basic functionalities of MATLAB as the text and the course frequently refer to MATLAB codes for implementation purposes.

The best way to learn MATLAB is by going through some of the popular tutorials first and then trying it out for oneself. A good site that contains links to a few educational web sites is: [http://www.mathworks.com/academia/student\\_center/tutorials/launchpad.html](http://www.mathworks.com/academia/student_center/tutorials/launchpad.html)

MATLAB is available on all departmental Unix workstations as well as several PC labs. You may want to consider buying the Student Edition of MATLAB for Windows XP, available in the U of A Bookstore, for your own PC; this software will be useful later for several other courses.

*MATLAB is a registered trademark of the Mathworks Inc.*

### Computer Labs

The objective of the computer labs is to enable the students to apply the concepts learnt in the classroom to computer-aided data analysis. This exercise allows the student to (1) obtain more insights into the theory and (2) obtain an experience of combining the theory with powerful tools that MATLAB and the associated toolboxes offer for data processing.

Several labs will be carried out and the exact time schedules will be announced later. The venue for the labs will be announced in the class room and on the web page. Handouts will be given at the beginning of each lab. The students are expected to go through the handout carefully prior to performing the lab work. The lab reports should be stapled or contained in a standard lab book.

### Examinations and Grading

Assignments	25%	
Midterm exam	30%	(28 February, 2014 during regular class time)
Final exam	45%	(23 April 2013 at 9 AM)

The conversion of the percentage grade into a final grade will be performed using a combination of relative and absolute measures taking into account the quality of work submitted and University policy on the distribution of grades. Grades are unofficial until confirmed by Faculty Council or its representative. Re-examination requests for a missed midterm examination will not be entertained. The weight for any deferred midterm exam will be carried onto the final exam. All examinations are closed book and closed notes; calculators are required. Policy regarding the use of calculators will be declared. Formulae sheets, if required, will be provided with each examination.

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### **Penalty for late assignments**

Unless you have an acceptable excuse, there will be a penalty on late assignments (including lab reports) according to the following rules:

- Late by 24 hours or less, the grade will be reduced by 25%
- Late by more than 24 hours, a zero grade will be assigned

### **Plagiarism, Cheating, Misrepresentation of Facts and Participation in an Offence:**

The University of Alberta is committed to the highest standards of academic integrity and honesty. Students are expected to be familiar with these standards regarding academic honesty and to uphold the policies of the University in this respect. Students are particularly urged to familiarize themselves with the provisions of the Code of Student Behaviour (online at <http://www.governance.ualberta.ca/en/CodesofConductandResidenceCommunityStandards/CodeofStudentBehaviour.aspx>) and avoid any behaviour which could potentially result in suspicions of cheating, plagiarism, misrepresentation of facts and/or participation in an offence. Academic dishonesty is a serious offence and can result in suspension or expulsion from the University.

The following behaviours constitute academic misconduct in this course (in addition to those specified on the Code):

1. Looking at another student's exam during a midterm or final.
2. Copying any part of an assignment or lab report from another student, or from an assignment or lab report from previous offerings for CHE573.
3. Permitting any other class member to copy any part of your assignment or project report.
4. Presenting laboratory data from any other student or former student of CHE573 as your own.
5. Using a programmable calculator in the exams.
6. Accessing the eclass during exams.