Signals and Systems (ELEC ENG 3TP3)
Term I 2017-2018

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Teaching Assistants:
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Class Schedule:
Lectures: Tue., Thu., Fri. 8:30-9:20pm, Room: MDCL 1105
Tutorial: Mon. 12:30-13:20, Room: LRW B1007
Lab: None. There might be bonus MATLAB assignments.

Course Text:
[Lathi] B. P. Lathi, Linear Systems and Signals, Second Edition, Oxford University Press, 2005.

Alternative Text:
[Kamen] Edward Kamen and Bonnie Heck, Fundamentals of Signals and Systems Using the Web and MATLAB, Third Edition, Prentice Hall, 2007.

Additional Resources:
1. MATLAB Primer
2. Online signals & systems demonstration from John Hopkins University
3. Online MATLAB for systems tutorial from Carnegie-Mellon University
4. OCTAVE: A free MATLAB clone

Course Objectives:
To discover the fundamental principles of representing signals and linear systems in the time and frequency domains, and to use these principles in the analysis and design of linear control and communication systems.

Upon completion of this course, students should be able to

· model simple electrical, mechanical and discrete systems with differential or difference equations.

· represent standard signals in terms of time domain or frequency domain form using Fourier series, Fourier transform, Laplace transform, or z-transform, as appropriate.

· construct the input-output relationship for a range of linear systems and solve for the output given certain classes of inputs such as impulse, step, sinusoidal, exponential, etc.

· describe the frequency domain characterization of signals and system performance and interpret signal/system behavior in terms of frequency content/response.

· decompose periodic signals using Fourier series and construct the output of a linear system when the decomposed signal is applied to it.

· explain the fundamental concepts of filtering and be able to design simple filters to modify frequency content of given signals.

· use the Laplace transform to construct transient and steady state response of continuous systems to standard signals and understand system characteristics through s-domain parameters.

· use the z-transform to construct transient and steady state response of discrete systems to standard signals and understand system characteristics through z-domain parameters.

· relate discrete-time and continuous-time systems through the properties of sampling and discretization.

· describe the relationships between the frequency domain, the time domain and the uses of Fourier, Laplace and z- techniques to assist in analysis and design.

· analyze and design simple linear systems using MATLAB.

Tentative Outline:

1. **Introduction** (1 hour)
   What are signals and systems? Examples from control and robotics, communications, remote sensing, biomedical, audio-visual entertainment.
2. **Elementary Signals and Basic Operations** (2 hours)
   Continuous-time and discrete-time; Periodic and non-periodic
   Shifting and scaling
   Sinusoidal signals; Complex exponentials; Impulse functions
   Block diagrams
   System properties: Stability, memory, causality, invertibility, time invariance, linearity
   Book sections: 1.1-1.8
3. **Time Domain Representations of Linear Time-Invariant Systems** (6 hours)
   Convolution discrete-time and continuous-time; impulse response
   Stability and causality
   Frequency response
   Differential and difference equations
   Book sections: 2.1-2.4, 2.6-2.8,3.1-3.8, 3.10
4. **Fourier Representations of Signals** (5 hours)
   Definitions: Discrete-time Fourier Series, Fourier Series, Discrete-time Fourier Transform, Fourier Transform,
   Properties: Symmetries, time-shift properties, convolution, modulation, Parseval, duality,

time-bandwidth product
Book sections: 6.1-6.4, 7.1-7.6

5. **Applications of Fourier Representations** (4 hours)
   Frequency response revisited, including differential/difference equations
   Relationships between Fourier representations;
   Basic concepts of filtering and filter design; Decibel measures
   Case Study: A simplified DSB-SC transmission system
   Sampling and ideal reconstruction of continuous-time signals; practical reconstruction;
   Approximating the Fourier Transform using a Discrete-time Fourier Series of the sampled signal;
   Book sections: 6.1-6.4, 7.1-7.6
6. **Laplace Transform** (4 hours)
   Review of Laplace Transform: Definition, properties, poles and zeros
   Region of convergence, inversion;
   Application to systems analysis: Causality, stability, system inversion,
   Relationships to differential equations and Fourier Transforms;
   Fourier Transform from poles and zeros; Time domain response from poles and zeros.
   Book sections: 4.1-4.9
7. **z-Transform** (4 hours)
   Complementary treatment to that for the Laplace transform
   Book sections: 5.1-5.4
8. **Applications to Feedback Systems** (9 hours)
   Basic concepts of feedback
   Open and closed loop control
   Review of transient response of first and second-order systems; Reduced-order models
   Stability: Root Locus; Nyquist Criterion; Bode Diagram;
   Relative stability: Gain and phase margins; Damping ratio
   Simple control system design; Proportional, integral, derivative, phase lag, phase lead
   Book sections: Covered in the sections on Laplace/Z/Fourier transforms.
9. **Epilogue** (1 hour)
   Characteristics of physical signals
   Characteristics of physical systems: Time-variation; Non-linearities;

Total Lectures: 39 (including reviews and discussions)
Note: The course outline is subject to change. Material from the texts will be supplemented with additional class notes.

Grading:
Final exam (2.5 hrs): 50%
Midterm: 30% (max of two 50-minute midterms; no makeup midterms; Oct. 20 and Nov. 17).
Assignments and pop-up quizzes: 20% (there may be bonus programming assignments)
Late penalty for projects and assignments: 10% per day.

Others:
Standard McMaster calculator and one "cheat-sheet" (letter-size; both sides; handwritten only; no worked examples) will be allowed for mid-term and final exams.

Policy Reminders:
The Faculty of Engineering is concerned with ensuring an environment that is free of all adverse discrimination. If there is a problem, that cannot be resolved by discussion among the persons concerned, individuals are reminded that they should contact the Department Chair, the Sexual Harassment Officer or the Human Rights Consultant, as soon as possible.

Students are reminded that they should read and comply with the Statement on Academic Ethics and the Senate Resolutions on Academic Dishonesty as found in the Senate Policy Statements distributed at registration and available in the Senate Office.

Academic dishonesty consists of misrepresentation by deception or by other fraudulent means and can result in serious consequences, e.g. the grade of zero on an assignment, loss of credit with a notation on the transcript (notation reads: "Grade of F assigned for academic dishonesty"), and/or suspension or expulsion from the university. It is your responsibility to understand what constitutes academic dishonesty. For information on the various kinds of academic dishonesty please refer to the Academic Integrity Policy, specifically Appendix 3.

The instructor and university reserve the right to modify elements of the course during the term. The university may change the dates and deadlines for any or all courses in extreme circumstances. If either type of modification becomes necessary, reasonable notice and communication with the students will be given with explanation and the opportunity to comment on changes. It is the responsibility of the student to check their McMaster email and course websites weekly during the term and to note any changes.

Last updated: September 5, 2017.