ECET 281 System Dynamics

Short description:
Students will be introduced to techniques of signal and system analysis. They will learn differential equations for circuit analysis, Laplace transforms for system analysis, transfer functions, Fourier series analysis of periodic sources, and Fourier transforms for the study of signal spectra and system frequency responses.

Learning outcomes:
Upon successful completion of this course a student will be able to:

- analyze first order circuits using differential equations;
- determine circuit transfer functions using Laplace transforms;
- calculate voltages and currents in a circuit using Laplace transforms;
- predict steady state behaviour for circuits with sinusoidal sources using phasors;
- compute voltages and currents for circuits with periodic sources using Fourier series;
- analyze the frequency content of a periodic signal using the Fourier series;
- analyze the frequency content of a non-periodic signal using the Fourier transform;
- determine the frequency response of a system.

Hours: 3/0/0

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Optional Text: Transform Circuit Analysis for Engineering and Technology (William D. Stanley)

Grading:	Online quizzes	5%
	Tests (3)	40%
	Final Exam	55%

Note: Problem sets will be assigned and solution sets will be posted. Problems will be discussed during class.

Important Dates:

Solution Set 1 posted	Thursday 27 September	(week 4)
Test 1	Thursday 4 October	(week 5)
Solution Set 2 posted	Thursday 1 November	(week 9)
Test 2	Thursday 8 November	(week 10)
Solution Set 3 posted	Thursday 22 November	(week 12)
Test 3	Thursday 29 November	(week 13)
Final Exam	10 – 18 December 2018	

Course outline:

1. Systems **1 hour**

- 1.1 Block diagrams
- 1.2 Linear stationary systems

2. Signals **2.5 hours**

- 2.1 Step, impulse and ramp functions
- 2.2 Time-shifted functions
- 2.3 Sinusoidal functions
- 2.4 Exponential functions
- 2.5 Shifted, delayed functions
- 2.6 Piecewise linear functions

Extra practice: Chapter 2: 3, 9, 21, 23, 27, 43, 53, 55, 61, 67
Chapter 3: 61, 63

3. Continuous time linear differential equations **5 hours**

- 3.1 Initial conditions for capacitors and inductors
- 3.2 Transient response
- 3.3 Steady state response
- 3.4 Complete circuit response
- 3.5 First and second order circuit examples

Extra practice: Chapter 4: 11, 13, 15, 17, 19, 21, 23, 29, 35, 37

4. Laplace transforms **4 hours**

- 4.1 Laplace transforms and inverse Laplace transforms
- 4.2 Laplace transform table
- 4.3 Properties of Laplace transforms
- 4.4 Inverse Laplace transforms

Extra practice: Chapter 5: 1 – 47 odd

5. Circuit analysis by Laplace transform[1] **4.5 hours**

- 5.1 Transformation of circuit differential equation
- 5.2 Circuit transformation with zero initial conditions
- 5.3 Modelling non-zero initial conditions
- 5.4 First and second order examples
- 5.5 Predicting circuit response

Extra practice: Chapter 6: 13, 15, 17, 19, 21, 23, 25, 29, 35, 37, 43, 49, 51

6. Transfer functions **6 hours**

- 6.1 Impulse response and convolution
- 6.2 Definition of transfer function
- 6.3 Computation of circuit transfer functions
- 6.4 Frequency response[2, 3]

6.5 Poles, zeros and stability

Extra practice: Chapter 7: 1, 3, 5, 21

7. Steady state AC analysis **2 hours**

7.1 Phasors
7.2 Impedance vectors
7.3 Circuit analysis for sinusoidal sources using phasors

Extra practice: Chapter 8: 1, 3

8. Fourier series **5 hours**

8.1 Fourier series definition
8.2 Periodic sources
8.3 Analysis of circuits with periodic sources using phasors[4]
8.4 Amplitude and phase spectra for periodic signals
8.5 Parseval's theorem[5]

Extra practice: Chapter 9: 1, 3, 5, 7

9. Fourier transforms **5 hours**

9.1 Definition
9.2 Relationship to Fourier series and Laplace transform
9.3 Frequency response for systems
9.4 Amplitude and phase spectra for non-periodic signals
9.5 Sampling theory
9.6 Relationship with discrete Fourier transform (DFT) and fast Fourier transform (FFT)[6]

Extra practice: Chapter 9: 11

Tests and review 7 hours
Total **42 hours**

Notes for instructors:

[1] This section should seek to present the methods of Laplace transforms for circuit analysis, for both zero and non-zero initial conditions, but it is not necessary to consider terribly complex circuits. Students will have been introduced to mesh and nodal analysis in ECET 140 Electronic Circuit Fundamentals, so these techniques may be used if desired.

[2] Presenting the connection between a transfer function derived using $\frac{1}{j\omega C}$ and $j\omega L$ and one derived using $\frac{1}{sC}$ and sL links the introduction to transfer functions the students received in ECET 140 Electronic Circuit Fundamentals with the new material in this course.

[3] That is, that the frequency response, which furnishes the magnitude and phase responses of a system, is really just the transfer function computed in the □ domain.

[4] Only the very simplest circuits need be considered here.

[5] The concepts behind Parseval's theorem are of greater importance than numerical verification.

[6] This topic is merely an introduction; DFTs and FFTs will be studied in greater detail in ECET 282 Digital Signal Processing.