**EE 401** **Transform Theory for Engineers** **Fall 2011**
**Jenkins**

**Course Syllabus (Draft)**
v0.9, 4/28/2011

## Course description

This course covers theory and techniques of transforms in engineering. Topics covered include: complex variables, analytic functions, series, contour integration and residue theory; orthogonal basis-function representation of signals; Laplace transform; Fourier transform; discrete-time signals and sampling theory; Z transform; depending on time available and student interest, discrete versions of Fourier transform. Properties, mathematical techniques, and applications will be discussed.

The relative emphasis of the various topics covered will be adapted to the interest level of the students taking the class. Similarly, application areas that are chosen will depend on student interest.

## Prerequisites

Knowledge of signals and systems, differential equations, complex variables and functions, and some transforms; at the level of EE 301 and MATH 445.

## Course meeting time and location

Lecture: Mon., Wed., 3:30-4:50 PM; OHE 120
Discussion: Fri., 11:00 – 11:50 AM, OHE 120

The course is also offered over the Distance Education Network.

## Course Texts

Required text: A. D. Poularikas and S. Seely, *Signals and Systems*, Second Edition (Krieger Publishing Co., Malabar, Florida, 1994)

Supplemental texts: It is helpful to most students to have a text on complex variables, because Poularikas and Seely's treatment is very brief on this subject. If you don't already have a good book on the topic, I recommend either one of the following:

J. W. Brown and R. V. Churchill, *Complex Variables and Applications*, Eighth Edition (McGraw-Hill, New York, 2009)

E. B. Saff and A. D. Snider, *Fundamentals of Complex Analysis with Applications to Engineering and Science*, Third Edition (Prentice Hall, Pearson Education, Inc., Upper Saddle River, Hew Jersey 2003)

1. Course introduction and overview

2. Complex variables, functions, and integration, including:

   - Differentiability; analytic functions; singularities
   - Series and convergence
   - Analytic continuation and uniqueness
   - Poles and residues; Laurent expansion
   - Contour integration; Cauchy's theorems; Cauchy principal value
   - Branch points and branch cuts, and integrals around them
   - *Applications may be selected from these or other applications of interest: potential functions, fluid or temperature flow, inverse Laplace integrals and Fourier integrals, boundary value problems

3. Introduction to transforms; orthogonal representation of signals (orthogonality, completeness, Parseval's theorem, and approximate representations). Application to image representation*.

4. Laplace transforms (existence, convergence, properties, inversion techniques) and applications (including linear systems, circuit analysis*, ordinary and partial differential equations, system stability).

5. Spectral analysis of signals, including Fourier transforms (existence, properties, inversion), system applications, modulation, and multidimensional Fourier transform. Applications to signal processing*, electromagnetism*, and/or optics*.

6. Bandlimited functions, sampling, and aliasing.

7. Discrete-time signals and systems, including discrete impulse response, convolution, and difference equations.

8. Z transforms, including properties, convergence, inversion techniques, application examples*, and relation to Fourier and Laplace transforms.

9. Discrete versions of Fourier transform: discrete-time Fourier transform (DTFT), discrete Fourier transform (DFT), including properties and relation to Fourier transform*.

* Depending on student interest and time available.

**Topics:**

1. Complex variables, functions, and series; contour integration; analytic functions and uniqueness.
2. Continuous-time transforms, including general theory, Laplace and Fourier transforms.
3. Sampling and discrete-time transforms, including Z transform and some discrete variants of Fourier transform.
4. Mathematical foundation and tools, including the use of complex variables and integration in all topics of the course.
5. Application of transform techniques to solve problems.

**Course Objectives:** To provide the student with a solid mathematical foundation in complex variables and common engineering transforms, including intuition in their use, and tools and techniques for applying them to a variety of problems.

**Course Outcomes:** Upon completion of the course, the student will be able to:

1. Determine over what domain a complex function is analytic by using a variety of tools.
2. Expand complex functions into power series, and assess region of convergence.
3. Evaluate contour integrals in the complex plane.
4. Understand the underlying representations of linear transforms, based on complete, orthogonal basis sets.
5. Perform forward and inverse Laplace transforms, with or without tables, by a variety of techniques.
6. Apply Laplace transform techniques to a variety of problems, including ordinary and partial differential equations, and system stability.
7. Understand and apply Fourier transform methods to one-dimensional and multi-dimensional problems.
8. Understand bandlimited functions, sampling, and aliasing.
9. Perform forward and inverse Z transforms, with or without tables, by a variety of techniques.
10. Apply Z transform techniques to a variety of problems, including difference equations and discrete-time system stability.
11. Understand the relationships between Laplace transform, Fourier transform, Z transform, and discrete Fourier transform.
12. Understand the relationships between various discrete versions of the Fourier transform.

## Course logistics and grading

### Course Materials (daily lecture notes, handouts, and homeworks)

These materials will be available for downloading from the web. "Daily lecture notes" are notes the professor writes out during lecture, and will be posted on the web site within 24 hours after each class. Video archives of the lectures will also be posted. The web site for EE 401 materials is easily reachable from the main DEN page: **http://den.usc.edu**. Click on "log in". You will need a DEN account, which is automatically set up for you if you are registered for this class. You will need Adobe Acrobat Reader to view the files.

### Grading (tentative)

| | | |
|---|---|---|
| **Homeworks** | (throughout the semester) | 20% |
| **Midterm exam** | (Day and time TBA) | 40% |
| **Final exam** | (Monday, 12/12/2011, 2:00 – 4:00 PM Pacific Time) | 40% |

### Policy on Academic Integrity

All students are expected to abide by the USC student conduct code, as well as apply common sense as to what behavior is reasonable and fair to other students. Violations will be dealt with in accordance with university guidelines.

In this class, collaboration on techniques for solving homework assignment problems is allowed, and can be helpful; however, each student is expected to work out and write up his or her own solution. Use of other solutions to homework problems, from any source including other students, before the worked-out homework is turned in, is not permitted. Of course, collaboration on exams is not permitted.

More information can be found in the Scampus:
**http://web-app.usc.edu/scampus/university-student-conduct-code/**

## Contact information

### Course Contact Information

| | |
|---|---|
| **Instructor:** | Prof. B. Keith Jenkins |
| Office: | EEB 404A |
| Phone: | 213-740-4149 |
| Fax: | 213-740-6618 |
| Email: | jenkins@sipi.usc.edu [Please include "EE 401" in the subject line] |
| Office hours: | TBA |

| | |
|---|---|
| **T. A.:** | TBA |
| Office: | |
| Phone: | |
| Fax: | |
| Email: | |
| Office hours: | |

---------

### Distance Education Network (DEN) Program Contact Information

Main web page: [http://den.usc.edu](http://den.usc.edu)

Complete contact information is available from this web page. A few contacts are listed below for your convenience:

| | | |
|---|---|---|
| General technical problems (online services, webcasts, software) | webclass@usc.edu | 213-821-1321 |
| General administrative problems | denadmin@usc.edu | 213-740-4488 |
| Master Control (studio classrooms) (Class broadcasting, classroom telephones, recording issues) | networkcontrol@den.usc.edu | 213-740-0130 |
| Exams and proctoring: | denexam@usc.edu | 213-821-3136 |
| Homework submissions, records, and delivery (remote students): | | |
| Charlene Stephens | denhw@usc.edu | 213-740-9356 |
| Fax submission | | 213-740-9121 |
| Fax submission (alt. number) | | 213-740-8591 |