1051-716 Fourier Methods for Imaging

http://www.cis.rit.edu/class/simg716/ (open website, no password necessary; NOT part the RIT "MyCourses" system; includes links to the recorded lectures and notes from each class)

Instructor:

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Office Hours TBD, and by appointment

Meeting Rooms/Times: Quarter 20091: MW, 10:00AM - 11:50AM, Room 76-1275

NOTE: I am expecting to take an important imaging trip to Egypt from 14-25 September. We will deal with this either by scheduling makeup classes (most likely) or having a substitute lecturer. Though the interruption to the class is not ideal, these dates were very difficult to schedule given the constraints at the site.

Prerequisites:

Calculus – any additional experience with Matrix Algebra, Linear Algebra and Complex Analysis is useful.

Details:

Homework will be assigned, and is to be handed in **on time** (adjustments will be considered **in advance** except in case of unforeseeable emergency). Scores for assignments handed in late will be penalized heavily and homework will not be accepted after solutions have been posted. Problems (or some subset thereof) will be graded and solutions to all problems will be handed out as quickly as possible after the homework is due.

Homework – 30% (Assignments usually given Monday, usually due 1 week later at start of class.)
Midterm Exam (closed book, closed notes, 2 hours, anticipated date: W, 8 October) – 30 %
Final Exam (cumulative, closed book, closed notes, 2 hours, W 12 November, room TBA) – 40%

Most students find this to be challenging material, and it is *essential* to attain some level of mastery of Fourier theory (also called *linear systems theory*) if you plan to work in any area of imaging. Fourier transforms appear in many (if not all) aspects of imaging, especially to describe and/or predict the behavior of optical imaging systems and to filter digital or analog images. If you are not very familiar with the subject (and even if you are), you should expect to devote a significant amount of time to the subject outside of class. A rule of thumb for academic classes is that you will spend 2-3 hours outside of class *per hour* of class time, hence 8-12 hours per week outside of class. You should use this material as a springboard to your specific subject of interest. It would be wise to plan to do outside reading on the subject throughout the term.

RIT is (still) on the quarter schedule, and time FLIES by (particularly for offsite students!). If you are having problems learning the material, ***DON'T WAIT***; ASK for help ***EARLY*** – in class and/or out of class. Though I keep my office door closed, PLEASE knock. If I am not doing something urgent, I will set aside time to help – working with students individually or in small groups is the most enjoyable part of my job.

My philosophy on exams is that they test *understanding* of material, which is the ability to assimilate concepts and synthesize useful results for applications. This is *not* the same as the ability to parrot discussions of concepts or replicate the solutions to homework problems. In other words, you need to know how to *apply* the material in the course. Be forewarned, my exams seem to have a reputation among students, and I make no apologies.

Grading:

I reserve the right for some flexibility, but the approximate mapping of numerical to letter grades is:

Numerical Score	Letter Grade
88 - 100	A
76.0 - 87.9	B
68.0 - 75.9	C
60.0 - 67.9	D
< 60	F

Note that the histogram bins are a bit wider for higher scores. Also be aware that students with fellowships must maintain an average of "B" or better (GPA 3.0+) to maintain their support (all the more reason to ask questions early rather than late) and that ALL graduate students must maintain this GPA to remain in good standing for graduation.

A word of warning: one pet peeve is the student who asks no questions, in class or otherwise, until just before some deadline (homework due or exam), at which time all questions suddenly are *urgent*. My advice is to your homework and exam studying early so that you can ask questions in time to have an positive impact on your understanding..

Online Students: You MUST have a document page scanner and software to convert the scanned files to PDF (e.g., Adobe *Acrobat*, which is more than the free *Acrobat Reader*). These are for converting homework to PDF format. DO NOT plan to submit homework by FAX machines – the image quality is often very poor and it is sent to the department FAX machine, so delivery is not guaranteed. MAKE SURE that your submissions are readable before e-mailing them to me. The online material is transmitted simultaneously with the onsite class. I plan to give the lectures using the video scanner/projector, so the online and onsite students see and hear the same material simultaneously. The notes I write during the are then scanned (alas, not in color), converted to pdf, and uploaded to the course website (usually within an hour of the end of class). A warning: unless I get a teaching assistant who can sit in during the class to monitor the offsite students, it will be difficult to respond to questions from online students since I often cannot monitor the website while presenting the material. You may find it more useful to ask questions offline before or after the class.

Course Material:

This course introduces mathematical formalisms for describing imaging systems, with emphasis on systems with responses constrained to be linear in dynamic range and independent of spatial location in the scene. In other words, the course develops mathematical models of imaging systems and applies them to problems relevant to imaging.

Text materials:

Linear Mathematics with Applications to Imaging, Roger Easton, to be published someday (perhaps)

Bound copies (in two volumes) are available in the RIT bookstore at the cost of printing. Many other books are available that touch on aspects of mathematical models of imaging systems and parameters *Foundations of Image Science* (Barrett and Myers) includes much of the same material at a more theoretical level. For now, text materials consist of my *text Linear Systems with Applications to Imaging* and other (optional) books that contain material applicable to both courses in this sequence:

1. *Foundations of Image Science*, H.H. Barrett and K.D. Myers, Wiley-Interscience, 2004, ISBN 978-0471153009, Catalog number TK8315 .B37 2004.
2. *Linear Systems, Fourier Transforms, and Optics*, Jack D.Gaskill, Wiley, 1978, ISBN 978-0471292883, QC355.2.G37 *(inspiration for some homework problems)*
3. *Fourier Analysis and Imaging*, R.N. Bracewell, Prentice-Hall, 2004, ISBN 978-0306481871. (An earlier version, *Two-Dimensional Imaging*, is in the RIT Library, TA1637.B73).

Unfortunately, only the first of these gives sufficient consideration to the derivation and application of discrete (sampled) systems. This subject is covered to some extent in my book and other resources are listed in the bibliography at http://www.cis.rit.edu/class/simg716/Bibliography_716-20091.pdf

Some material on the subject is available on the internet, but I very seriously doubt that anyone can master Fourier methods without becoming familiar (and spending time) with other books. You should locate the shelves in the library where this material is concentrated (TA, TK, QC) and USE the books you find there.

Signals:

For some specific applications in 1-D linear systems, my program for PCs ("***SIGNALS***") may be useful. It was written with the intent of being easy to use and may be downloaded from *ftp://ftp.cis.rit.edu/software/sgnls554.zip*

The user manual also is available online at:

http://www.cis.rit.edu/resources/software/sig_manual/index.html

The program runs quite well in DOSBox, which is available for many platforms from http://www.dosbox.com/

SignalShow:

The new Java counterpart of ***Signals***, called ***SignalShow***, which was written as a Senior Project by Juliet Bernstein, illustrates both 1-D and 2-D examples of Fourier mathematics and imaging. The beta releases for the three primary computing platforms (Windows, Macintosh OSX, and Linux) are available online at http://www.signalshow.com/. This site includes links to help videos that are posted on YouTube. You may find this program very helpful in your quest to visualize the concepts in this course, as well as in 1051-718 "Digital Imaging Mathematics," and in 1051-733 "Optics for Imaging."