Information Sheet
MATH464 Spring 2012
<u>Transform Methods for Scientists and Engineers</u>

Instructor: Radu Balan
Lectures: Tuesday, Thursday, 12:30pm-1:45pm, CSIC 4122.
Office Hours: Thursday, 2:00-3:00pm; in CSIC 4131
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MATH 464 is an introduction to transform methods used in science and engineering applications. Lectures cover topics including: Fourier transform, Fourier series, discrete and fast Fourier transform (DFT and FFT). Laplace transform. Poisson summation, and sampling. Optional Topics: Distributions and operational calculus, PDEs, Wavelet transform, Radon transform. Applications: Imaging, Speech Processing, PDEs of Mathematical Physics, Communications, Inverse Problems.
Prerequisite: MATH 246
Required Textbook: *A First Course in Fourier Analysis*, David W. Kammler, Cambridge University Press 2007
Additional Reading Materials:
Introduction to the Mathematics of Medical Imaging, Charles L. Epstein, SIAM 2008
Analysis, Elliott H. Lieb and Michael Loss, AMS 2001.
Harmonic Analysis and Applications, John J. Benedetto, CRC Press 1996

Grading. There will be one mid-term exam (100 points), homework assignments (for a total of 100 points), a project (100 points) and a final exam (200 points). Students are allowed one single-sided “cheat sheet” during the mid-term, and one double-sided “cheat sheet” during the final.
Exam dates: Mid-term (tentatively) on Thursday, March 15, 12:30pm-1.45pm. Final exam: Thursday, May 17, 1:30pm-3:30pm.
Homeworks. Homework must be submitted on the date assigned. Homework must be prepared without consulting any other person. You may however consult any written reference. In this case you should cite the reference. Results taken from the reference should be (re)stated to the notation used in the course. Explanations should be given in complete English sentences. Written work must be legible and clear.
Projects. Students may choose between two types of projects: a theory review of a topic connected to applied harmonic analysis; or a Matlab implementation of an application. In either case there will a 30-minute oral presentation with the instructor.
Academic Integrity. You are expected to adhere to the University’s Code of Academic Integrity, available on the University’s web site, at: https://www.shc.umd.edu
Students with Disabilities: If you have a documented disability and wish to discuss academic accommodations with me, please contact me as soon as possible.
Religious Observances. If you will be absent from class because of religious observances, please submit a list of the dates of your absences within a couple of days.

Syllabus
MATH 464 / Spring 2011
Transform Methods for Scientists and Engineers

Required Textbook: *A First Course in Fourier Analysis*, David W. Kammler, Cambridge University Press 2007

1. Introduction
   a. Sets, Functions, Continuity, Integrability
   b. Motivating Examples: Heat Equation, Image Processing

2. Fourier transform
   a. Definition for L^1 functions
   b. Plancherel Theorem. Extension to L^2
   c. Inversion formulae
   d. Algebraic and Analytic properties of Fourier transform
   e. Fourier Series
   f. Pointwise convergence results
   g. Fourier Transform for other spaces of functions.

3. Sampling Theory
   a. Bandlimited functions
   b. The Shannon-Kotel'nikov-Whittaker sampling formula
   c. Poisson Summation Formula
   d. Application: A/D Convertors

4. Windowed Fourier Transform
   a. Local information content: time and frequency localization
   b. Spectrograms and Short-Time Fourier Transforms
   c. Applications to Audio Signal Processing

~~5. Generalized Functions (Tempered Distributions)~~
   a. Test functions. Properties
   b. Tempered distributions: Fourier Transform and Differential Calculus

~~6. Applications to Partial Differential Equations~~
   a. Heat equation
   b. Wave equation
   c. Other equations

7. Wavelet Transform
   a. The Haar Example. Filterbank implementation
   b. Multiresolution Analysis (MRA) Wavelets
   c. Compactly supported wavelets: The Daubechies Class

8. Radon Transform and applications to signal processing