Information Sheet
MATH416 Spring 2016
Applied Harmonic Analysis: Introduction to Signal Processing

Instructor: Radu Balan
Lectures: Tuesday, Thursday, 11:00am-12:15pm, CSIC 4122.
Office Hours: Thursday, 12:30-1:30pm; in CSIC 4131
Contact Information: Email **rvbalan@math.umd.edu** , Math Building, Room 2308, x55492 / CSCAMM , Room 4131 , x51217

MATH 416 is an introduction to applied harmonic analysis. MATH 416 introduces the mathematical concepts arising in signal analysis from the applied harmonic analysis point of view. Topics include: applied linear algebra, Fourier series, discrete Fourier transform, Fourier transform, Shannon Sampling Theorem, Wavelet transform, wavelet bases, multiresolution analysis, and discrete wavelet transform.

Prerequisite: Minimum grade of C- in MATH 141; and 1 course with a minimum grade of C- from (MATH240, MATH461, MATH341); and familiarity with MATLAB is required.
Required Textbook: *Mathematics for Multimedia*, Mladen V. Wickerhauser, Birkhauser 2010 (2nd Edition); available online for free for UMD students
Additional Reading Materials:
A First Course in Fourier Analysis, David Kammler, Cambridge University Press 2007.
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 two mid-term tests (100 points each), homework assignments (for a total of 100 points), and a final exam (200 points - cumulative). Students are allowed one formula sheet during each test, and two formula sheets during the final exam. The cut-off for course letter grades will not be higher than 90% (A), 80%(B), 70%(C) and 60% (D). Canvas is used to aggregate total scores.
Exam dates: TBD. Final exam: Thursday, May 12, 8:00am-10:00am.
Review Sessions. There will be two optional review sessions before tests, and one final review before the final exam. Dates: TBD.
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.
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 416 / Spring 2016
Applied Harmonic Analysis: An Introduction to Signal Processing

Required Textbook: *Mathematics for Multimedia*, Mladen V. Wickerhauser, Birkhauser 2010

1. Introduction
    a. Sets, Numbers, Functions, Continuity, Integrability.

2. Linear Analysis
    a. Vector Spaces, norms, scalar products, Banach and Hilbert spaces.
    b. Linear Transformations: Matrix algebra, adjoints and projections, linear independence and invertibility; linear systems.

3. Time and Frequency
    a. Fourier Analysis: Fourier series, Fourier transform, localization (windowed Fourier transform)
    b. Discrete Fourier Analysis: DFT, Discrete sine and cosine transforms

4. Sampling and Estimation Theory
    a. Lagrange interpolation
    b. Bandlimited functions, Shannon's Formula
    c. Basic estimation theory

5. Scale and Resolution
    a. Wavelet Analysis: The affine group, the continuous wavelet transform
    b. Discrete Wavelet transform: Multiresolution Analysis (MRA), filterbanks, (optional) lifting

6. (Optional)
    a. Uncertainty principles in harmonic analysis and estimation theory (Heisenberg uncertainty; CRLB)
    b. Source coding examples
    c. Signal processing examples