School of Mathematical Sciences

☑ New ☐ Revised  COURSE: COS-MATH-781 Wavelets and Applications

1.0 Course Designations and Approvals:

<table>
<thead>
<tr>
<th>Required Course Approvals:</th>
<th>Approval Request Date</th>
<th>Approval Grant Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Academic Unit Curriculum Committee</td>
<td>10-20-10</td>
<td>10-27-10</td>
</tr>
<tr>
<td>College Curriculum Committee</td>
<td>11-01-10</td>
<td>9-27-11</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Optional Course Designations:</th>
<th>Yes</th>
<th>No</th>
<th>Approval Request Date</th>
<th>Approval Grant Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Education</td>
<td>☑</td>
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<tr>
<td>Writing Intensive</td>
<td>☑</td>
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<tr>
<td>Honors</td>
<td>☑</td>
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2.0 Course information:

Course Title: Wavelets and Applications
Credit Hours: 3
Prerequisite(s): COS-MATH-611 or permission of instructor
Co-requisite(s): None
Course proposed by: School of Mathematical Sciences
Effective date: Fall 2013

<table>
<thead>
<tr>
<th>Contact Hours</th>
<th>Maximum Students/section</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classroom</td>
<td>3</td>
</tr>
<tr>
<td>Lab</td>
<td></td>
</tr>
<tr>
<td>Workshop</td>
<td></td>
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<tr>
<td>Other (specify)</td>
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</table>

2.1 Course Conversion Designation: (Please check which applies to this course)

☑ Semester Equivalent (SE) to: 1016-812
☐ Semester Replacement (SR) to:
☐ New

2.2 Semester(s) offered:

☑ Fall ☐ Spring ☐ Summer

☑ Offered every other year only ☐ Other
2.3 Student Requirements:

Students required to take the course:
None

Students who might elect to take the course:
Graduate students and advanced undergraduate students in mathematics, physics, imaging science, or engineering

3.0 Goals of the course: (including rationale for the course, when appropriate)

3.1 To learn the mathematical theory underlying wavelet representations of functions.
3.2 To understand the construction of wavelet systems.
3.3 To learn various applications of wavelets to signal processing.

4.0 Course description: (as it will appear in the RIT Catalog, including pre- and co-requisites, semesters offered)

COS-MATH-781 Wavelets and Applications
A mathematical introduction to the theory and applications of orthogonal wavelets and their use in analyzing functions and function spaces. Topics include a brief survey of Fourier series representation of functions, Fourier transform and the Fast Fourier Transform (FFT) before proceeding to the Haar wavelet system, multiresolution analysis, decomposition and reconstruction of functions, Daubechies wavelet construction, and other wavelet systems. Applications such as data compression, noise reduction and image processing will be studied. (COS-MATH-611 or permission of instructor) Class 3, Credit 3 (F, alternate years)

5.0 Possible resources: (texts, references, computer packages, etc.)

5.1 Bogess, A. and Narcowich, F., A First Course in Wavelets with Fourier Analysis, Prentice Hall, Upper Saddle River, NJ
5.3 Pinsky, M., Introduction to Fourier Analysis and Wavelets, Brooks/Cole, Pacific Grove, CA

6.0 Topics: (outline) Topics with an asterisk(*) are at the instructor’s discretion, as time permits

6.1 Inner Product Spaces
   6.1.1 The Spaces $L^2$ and $\ell^2$
   6.1.2 Orthogonality and orthogonal projections
   6.1.3 Linear operators and their adjoints
6.2 Fourier Series and Fourier Transforms
   6.2.1 Convergence theorems
   6.2.2 Fourier transforms
   6.2.3 Discrete Fourier transform
   6.2.4 Fast Fourier transform
6.3 Haar Wavelet System
6.3.1 Haar scaling function and wavelets
6.3.2 Haar decomposition and reconstruction
6.3.3 Filters
6.4 Multiresolution Framework
6.4.1 Definitions and scaling relation
6.4.2 Multiresolution analysis
6.4.3 Discrete wavelet transform
6.4.4 General decomposition and reconstruction
6.5 Wavelet Design
6.5.1 Shannon, Meyer and other wavelets
6.5.2 Daubechies’ construction
6.6 Applications
6.6.1 Noise reduction
6.6.2 Signal compression
6.6.3 Image enhancement

7.0 Intended learning outcomes and associated assessment methods of those outcomes: Assessment methods with an asterisk(∗) are at the instructor’s discretion

<table>
<thead>
<tr>
<th>Learning Outcomes</th>
<th>Assessment Methods</th>
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<tbody>
<tr>
<td></td>
<td>Homework</td>
</tr>
<tr>
<td>7.1 Analyze function spaces, orthogonality and convergence</td>
<td>✓</td>
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<tr>
<td>7.2 Compute orthogonal projections</td>
<td>✓</td>
</tr>
<tr>
<td>7.3 Compute Fourier series and transforms</td>
<td>✓</td>
</tr>
<tr>
<td>7.4 Implement the Fast Fourier Transform</td>
<td>✓</td>
</tr>
<tr>
<td>7.5 Analyze scaling functions, wavelets and filters</td>
<td>✓</td>
</tr>
<tr>
<td>7.6 Compute function decomposition and reconstruction</td>
<td>✓</td>
</tr>
<tr>
<td>7.7 Analyze multiresolution analysis</td>
<td>✓</td>
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<tr>
<td>7.8 Analyze principles of wavelet design</td>
<td>✓</td>
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<tr>
<td>7.9 Apply wavelets to real problems</td>
<td>✓</td>
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8.0 Program goals supported by this course:
8.1 To develop an understanding of the mathematical framework that supports engineering, science, and mathematics.

8.2 To develop critical and analytical thinking.

8.3 To develop an appropriate level of mathematical literacy and competency.

8.4 To provide an acquaintance with mathematical notation used to express physical and natural laws.

9.0 General education learning outcomes and/or goals supported by this course: Not applicable

10.0 Other relevant information: (such as special classroom, studio, or lab needs, special scheduling, media requirements, etc.)

Software: Mathematica, MATLAB