School of Mathematical Sciences

New Revised COURSE: COS-MATH-711 Advanced Methods in Scientific Computing

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>1-27-10</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>
<td></td>
<td></td>
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<tr>
<td>Writing Intensive</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Honors</td>
<td>✓</td>
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</table>

2.0 Course information:

Course Title: Advanced Methods in Scientific Computing
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>
</tr>
<tr>
<td>Other (specify)</td>
<td></td>
</tr>
</tbody>
</table>

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

- ✓ Semester Equivalent (SE) to: 1016-713
- □ 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:
Applied and Computational Mathematics graduate students in the Scientific Computing concentration

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 implement advanced numerical methods and apply them to a variety of problems in science and engineering.

3.2 To apply advanced numerical methods to a variety of problems in science and engineering.

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

COS-MATH-711 Advanced Methods in Scientific Computing
This course examines the use of discrete Fourier transforms, simulation methods, optimization techniques, and number theory algorithms that are employed in modern scientific computing. (COS-MATH-611 or permission of instructor) Class 3, Credit 3 (F)

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


5.2 M. H. Kalos and P. A. Whitlock, Monte Carlo Methods, Wiley, Hoboken, NJ

5.3 V. Chvatal, Linear Programming, W. H. Freeman, New York, NY


5.5 N. Madras, Lectures on Monte Carlo Methods, American Mathematical Society, Providence, RI


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

6.1 Discrete Fourier Transform and Applications
   6.1.1 Introduction to Fourier analysis and orthogonal functions
   6.1.2 The physical and graphical interpretation of modes
   6.1.3 Fast Fourier transforms
   6.1.4 Applications

6.2 Monte Carlo Methods
   6.2.1 Review of probability: random variables, densities, moments, independence
6.2.2 Pseudo random numbers
6.2.3 Generating random variables
6.2.4 Applications

6.3 Optimization
6.3.1 Linear programming
6.3.2 Integer programming
6.3.3 Levenberg-Marquardt method
6.3.4 Nelder-Mead method
6.3.5 Simulated annealing
6.3.6 Applications

6.4 Basic Number Theoretic Methods
6.4.1 Extended Euclidean algorithm for finding the greatest common divisor
6.4.2 Modular exponentiation
6.4.3 Continued fractions based methods
6.4.4 Sieving (Eratosthenes and quadratic)
6.4.5 Factoring (classical techniques - include probabilistic algorithm)

7.0 Intended learning outcomes and associated assessment methods of those outcomes:

<table>
<thead>
<tr>
<th>Learning Outcomes</th>
<th>Assessment Methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.1 Implement computational methods</td>
<td>✓</td>
</tr>
<tr>
<td>7.2 Use the algorithms to solve applied problems</td>
<td>✓</td>
</tr>
<tr>
<td>7.3 Compare the results obtained using different computation schemes</td>
<td>✓</td>
</tr>
<tr>
<td>7.4 Determine the range of applicability of the methods</td>
<td>✓</td>
</tr>
<tr>
<td>7.5 Evaluate the efficiency of the methods</td>
<td>✓</td>
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</tbody>
</table>

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.)

None