New Revised COURSE: COS-MATH-712 Numerical Methods for Partial Differential Equations

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>1-25-11</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>
<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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2.0 Course information:

Course Title: Numerical Methods for Partial Differential Equations
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>
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</table>

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

✓ Semester Equivalent (SE) to: 1016-811
☐ 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 introduce the modern theory and techniques of numerical methods for partial differential equations.

3.2 To analyze the errors produced in the numerical solution of partial differential equations.

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

**COS-MATH-712 Numerical Methods for Partial Differential Equations**
This is an advanced course in numerical methods that introduces students to computational techniques for solving partial differential equations, especially those arising in applications. Topics include: finite difference methods for hyperbolic, parabolic, and elliptic partial differential equations, consistency, stability and convergence of finite difference schemes. (COS-MATH-611 or permission of instructor) **Class 3, Credit 3 (F)**

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


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

6.1 Parabolic Partial Differential Equations
   6.1.1 Explicit methods: Lax-Friedrichs and Forward-Time Centered Space
   6.1.2 Implicit methods: Crank-Nicolson and Backward-Time Centered Space
   6.1.3 Von Neumann analysis

6.2 Hyperbolic Partial Differential Equations
   6.2.1 Explicit methods: Forward-Time Centered-Space, Forward-Time Backward-Space, Lax-Wendroff
   6.2.2 Implicit methods: Crank-Nicolson
   6.2.3 Stability theory, Courant-Friedrichs-Lewy condition
   6.2.4 Group velocity, phase velocity, dispersion, dissipation
6.2.5 Method of characteristics
6.2.6 Weak solutions and shocks
6.2.7 Shock-capturing schemes

6.3 Elliptic Partial Differential Equations and Finite Difference Schemes in 2D and 3D
6.3.1 Stencils
6.3.2 Jacobi, Gauss-Seidel and Successive Over-Relaxation
6.3.3 Mesh generation for complex geometries

6.4 Galerkin and Spectral Methods*

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

<table>
<thead>
<tr>
<th>Learning Outcomes</th>
<th>Assessment Methods</th>
</tr>
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<tbody>
<tr>
<td>7.1 Explain numerical algorithms for partial differential equations</td>
<td>✓ ✓ ✓ ✓</td>
</tr>
<tr>
<td>7.2 Implement numerical algorithms for partial differential equations</td>
<td>✓ ✓ ✓ ✓</td>
</tr>
<tr>
<td>7.3 Identify when to use a specific numerical technique</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