School of Mathematical Sciences

☑ New ☐ Revised COURSE: COS-MATH-612 Numerical Linear Algebra

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>1-27-11</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>
<td></td>
<td></td>
</tr>
<tr>
<td>Writing Intensive</td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Honors</td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2.0 Course information:

Course Title: Numerical Linear Algebra
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:
☑ Semester Replacement (SR) to: parts of 1016-711 and 1016-712
☐ 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 apply matrix formulations in problem solving.
3.2 To develop canonical decompositions used in developing matrix-based algorithms.
3.3 To use existing software packages in solving matrix-based problems.

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

**COS-MATH-612 Numerical Linear Algebra**
This course covers numerical techniques for the solution of systems of linear equations, eigenvalue problems, singular-values and other decompositions, applications to least squares, boundary value problems, and additional topics at the discretion of the instructor. (COS-MATH-611 or permission of instructor) **Class 3, Credit 3 (S)**

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

5.1 Lloyd Trefethen and David Bau, *Numerical Linear Algebra*, SIAM, Philadelphia, PA.

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

6.1 Direct Methods for Solving Systems of Linear Equations
   6.1.1 Gaussian elimination and back-substitution
   6.1.2 Partial pivoting, complete pivoting, and stability
   6.1.3 LU and Choleski decompositions
      A. Error analysis
   6.1.4 Vector and matrix norms
   6.1.5 Conditioning, condition numbers, perturbation analysis, and residuals

6.2 Iterative Methods for Large Linear Systems
   6.2.1 Gauss-Jacobi and Gauss-Seidel
   6.2.2 SOR

6.3 Eigenvalues
6.3.1 Power method, inverse power method and shifts
6.3.2 Rayleigh quotient iteration
6.3.3 Orthogonal matrices and QR decomposition
6.3.4 QR algorithm
6.3.5 Hessenberg form
6.3.6 Singular value decomposition

6.4 Krylov Subspace Methods
6.4.1 Lanczos algorithm
6.4.2 Conjugate gradient method
6.4.3 Generalized minimal residual method
6.4.4 Preconditioning

6.5 Applications
6.5.1 Least squares, normal equations and pseudo-inverses*
6.5.2 Newton and quasi-Newton methods for systems of nonlinear equations*
6.5.3 Finite difference methods and differential equations*

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></td>
<td>Homework</td>
</tr>
<tr>
<td>7.1 Develop and apply direct methods for solving systems of linear equations</td>
<td>✓</td>
</tr>
<tr>
<td>7.2 Apply error analysis</td>
<td>✓</td>
</tr>
<tr>
<td>7.3 Develop and apply iterative methods for solving systems of linear equations</td>
<td>✓</td>
</tr>
<tr>
<td>7.4 Compute eigenvalues of a matrix</td>
<td>✓</td>
</tr>
<tr>
<td>7.5 Apply orthogonal matrices and QR decomposition</td>
<td>✓</td>
</tr>
</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