

**Prefix, Number and Name of Course:** ACM 631 Eigenvalue Problems

**Credit Hours:** 1

**In Class Instructional Hours:** 1    **Labs:** 0    **Field Work:** 0

**Catalog Description:**

*Prerequisite:* MAT 202 OR equivalent

Numerical algorithms for eigenvalue problems, matrix factorization, matrices, vectors, eigenvalues, eigenvectors, eigenspaces, eigenvalue algorithms.

**Reasons for Addition or Revision:**

To create a one-semester-hour core module for the graduate Professional Applied and Computational Mathematics program where students will study numerical methods and algorithms for eigenvalue problems arising from quantum mechanics, finance, molecular physics, quantum chemistry, geology and glaciology, image and signal processing, and many other areas.

<b>Student Learning Outcomes:</b> Students will:	<b>Content References:</b>	<b>Assessment:</b>
1. learn techniques to form orthonormal bases.	I	Group work in class, individual homework assignments, exams.
2. solve eigenvalue problem.	I, II, III, V	Group work in class, individual homework assignments, exams, and computer projects.
3. utilize computer software for diverse practical settings.	I-IV	Group computer projects.

**Course Content:**

- I. Inner product spaces
  - A. Inner products
  - B. Angle and orthogonality
  - C. Orthonormal bases
  - D. Orthogonal matrices
  
- II. Eigenvalues problem
  - A. Eigenvalues and eigenvectors
  - B. Diagonalization
  - C. Orthogonal diagonalization

- III. Eigenvalue algorithms
  - A. Power iteration
  - B. Inverse iteration
  - C. QR algorithm
  - D. Divide-and-conquer algorithm
- IV. Selected applications
  - A. Chaos
  - B. Molecular orbitals
  - C. Geology and glaciology
  - D. Stress tensor
  - E. Genetics
- V. Use of numerical analysis software

**Resources:**

Scholarships in the Field:

Allaire, G. and Craig, A. (translator), *Numerical Analysis and Optimization: An Introduction to Mathematical Modeling and Numerical Simulation*, Oxford Press, 2007.

Atkinson, K. and Han, W., *Elementary Numerical Analysis*, John Wiley & Sons Inc, 2003.

Atkinson, K. E., *Elementary Numerical Analysis*, John Wiley & Sons, New York, 1993.

Burden, R. L. and Faires, J. D., *Numerical Analysis*, Boston, MA: PWS-Kent, 1989.

Curtis, F. G. and Wheatley, P. O., *Applied Numerical Analysis*, Addison-Wesley, 2008.

Gilat, A., *MATLAB: An Introduction with Applications* (2<sup>nd</sup> ed.). John Wiley & Sons, 2004.

Griffiths, D. V. and Smith, I. M., *Numerical Methods for Engineers*, CRC Press, 2006.

Golub, G. H. and Van Loan, F. C., *Matrix Computations*, Baltimore, MD: Johns Hopkins University Press, 1983, 1989.

Higham, N. J., *Accuracy and Stability of Numerical Algorithms* (2<sup>nd</sup> ed.), SIAM, 2002.

Leader, J. J., *Numerical Analysis and Scientific Computation*, Addison Wesley, 2004.

Liu, J. P., *Focus on Numerical Analysis*, Nova Science Pun Inc., 2006.

Mathews, J. H., *Numerical Methods for Computer Science, Engineering and Mathematics*, Prentice Hall, New Jersey, 1987.

Richard, L. B. and Faires, J. D., *Numerical Analysis*, Thomson Brook/Cole, 2005.

Press, W. H., et al., *Numerical Recipes: The Art of Scientific Computing*, New York, NY: Cambridge University Press, 1986.

Sewell, G., *The Numerical Solution of Ordinary and Partial Differential Equations*, New York, NY: Academic Press, 1988.

Smith, W. A., *Elementary Numerical Analysis*, Prentice-Hall, New Jersey, 1986.

Steinberg, D. I., *Computational Matrix Algebra*, McGraw-Hill, New York, 1974.

Wilkinson, J. H., *The Algebraic Eigenvalue Problem*, New York, NY: Oxford University Press, 1965, 1988.

#### Periodicals:

*Electronic Journal of Boundary Elements*

*Electronic Transactions on Numerical Analysis*

*IMA Journal of Numerical Analysis*

*International Journal of Numerical Analysis and Modeling: International Journal for Numerical Methods in Engineering Advance in Numerical Analysis – An Open Access*

*Journal Journal of Numerical Analysis, Industrial and Applied Mathematics ESAIM: Mathematics Modeling and Numerical Analysis*

*Journal of Online Mathematics and its Applications*

*SIAM Journal on Numerical Analysis*

#### Electronic and/or Audiovisual Resources:

Eigenvalue Problems: Theory, Algorithms and Application

([http://www.cs.utk.edu/~ward/talks/research\\_intro/index.htm](http://www.cs.utk.edu/~ward/talks/research_intro/index.htm)).

Introduction to Numerical Analysis for Engineering

(<http://ocw.mit.edu/OcwWeb/Mechanical-Engineering/2-993JSpring-2005/CourseHome/>).

Numericalmathematics.com (<http://www.numericalmathematics.com>).

Numerical analysis DMOZ category ([http://www.dmoz.org/Science/Math/Numerical\\_Analysis/](http://www.dmoz.org/Science/Math/Numerical_Analysis/)).

Numerical Analysis Project (<http://math.fullerton.edu/mathews/numerical.html>).

Numerical Computing Resources on the Internet

(<http://www.indiana.edu/~statmath/bysubject/numerics.html>).

Numerical Methods Resources

(<http://www.onesmartclick.com/engineering/numerical-methods.html>).

Numerical-methods.com (<http://www.numerical-methods.com>).

Numerical Methods – Online Course (<http://www.math.jct.ac.il/~naiman/nm/>).

Numerical Recipes: The Art of Scientific Computing (third edition) ([www.nr.com](http://www.nr.com)).

Scientific computing FAQ (<http://mathcom.com/corpdir/techinfo.mdir/index.html>).