# MATH 5330

## Computational Methods of Linear Algebra

### Spring 2017
### The University of Texas at El Paso

**Xianyi Zeng, Instructor**

This course focuses on several fundamental topics in computational methods of linear algebra: solutions to systems of linear equations, linear least squares problems, the eigenvalue problems, and linear programming.

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| Course number: | MATH 5330 |
| Course title: | Computational Methods of Linear Algebra |
| Credit hours: | 3 |
| Term: | Spring 2017 |
| Time & location: | 18:00–19:20pm TR, Old Main 201 |
| Prerequisites: | MATH 3323 or equivalent and working knowledge of a high-level programming language |
| Course fee: | None |
| Instructor: | Xianyi Zeng |
| | Office location: Bell Hall 202<br>Office phone: 915-747-6759<br>Email: xzeng@utep.edu<br>Website: http://utminers.utep.edu/xzeng/homepage |
| Course website: | http://utminers.utep.edu/xzeng/2017spring_math5330 |
| Office hours: | 14:00pm – 15:00pm Tuesday, 11:00am – 12:00pm Friday, or by appointment |
| Textbook: | Granville Sewell, *Computational Methods of Linear Algebra*, 3rd Edition, World Scientific Publishing Company 2014 |
| Other references: | Gene H. Golub and Charles F. Van Loan, *Matrix Computations*<br>Yousef Saad, *Iterative Methods for Sparse Linear Systems*<br>David G. Luenberger and Yinyu Ye, *Linear and Nonlinear Programming* |

## Course objectives

This course begin with an introduction to basic concepts of matrix analysis including special matrices and vector/matrix norms. Then it will cover four basic problems in numerical linear algebra:

- The first one covers numerical methods for linear systems. The topics include both factorization-based methods and iterative methods, sparse systems, and error analysis.
- The second problem is the linear least squares problem; emphasize will be given to the usage of robust Householder transformations.
- The third subject involves numerical methods for the eigenvalue problem for both symmetric and general matrices and the singular value decomposition.
- The last problem is a brief introduction to linear programming, which covers the simplex method and the dual problem, etc.

## Grading

Your grade for the course will be based on the following:

- 30% homework.
- 20% midterm exam 1 (introduction, linear system).
- 20% midterm exam 2 (least squares problem, the eigenvalue problems).
- 30% final exam (comprehensive, but with emphasis on materials after midterm exam 2).

## Final exam schedule

Thursday, May 11, 2017. 7:00pm – 9:45pm.

## Homework policy

Late homework will be not accepted under any circumstances. However, among all your homework scores, the lowest **two** will not contribute to your final grade. All homework sets are individual work, you should not collaborate in their completion.

## Attendance policy

This is a challenging course and attendance is essential for success. Please try not to be absent unless absolutely necessary.

## Accommodations for students with disabilities

If you have a disability and need classroom accommodations, please contact The Center for Accommodations and Support Services (CASS) at 747-5148, or by email to cass@utep.edu, or visit their office located in UTEP Union East, Room 106. For additional information, please visit the CASS website at `http://www.sa.utep.edu/cass`.

## Academic honesty policy

Make sure you understand the UTEP academic honesty policy. Students are encouraged to share ideas, but you must do your own homework and you must write your own code for the projects (you may copy code that is on the course website). If homework or program code is suspected of being duplicated or copied, you will receive an incomplete for the assignment, and your case will be referred to the Dean of Students for adjudication. If the instructor has reason to believe that you have cheated on a quiz or exam, your case will be referred to the Dean of Students for adjudication.

## Course format and participation

The course is composed of lectures and after-lecture office hours. There will be no lab session on programming skills. The students, however, should be able to work with at least either Matlab of C/C++ in order to complete the homework.

## Military statement

If you are a military student with the potential of being called to military service and/or training during the course of the semester, you are encouraged to contact as soon as possible.

## Course drop deadline

**March 30** is the university fall drop/withdrawal deadline. After this date no dropping is allowed.

## Course topics

1. Introduction
    - Special matrices
    - Vector and matrix norms
    - The computational complexity
2. Solutions of linear systems
    - Gaussian elimination and LU decomposition
    - Sparse matrices
    - Estimates of roundoff errors
    - Iterative methods
    - The Krylov-subspace methods
3. Linear least squares problems
    - Orthogonal reduction
    - Householder transformations
4. The eigenvalue problems
    - Symmetric matrices
    - General matrices
    - The power and inverse power methods
    - The generalized eigenvalue problem
    - The singular value decomposition (SVD)
5. Linear programming
    - The simplex method
    - The dual problem

## Course schedule

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| Week 01 (01/17–01/20) | Preliminaries. The Gaussian elimination and LU decomposition. |
| Week 02 (01/23–01/27) | Roundoff error analysis. Sparse systems. Iterative methods. |
| Week 03 (01/30–02/03) | The conjugate gradient method. The Krylov-subspace methods. |
| Week 04 (02/06–02/10) | GMRES, BiCGSTAB, preconditioners. |
| Week 05 (02/13–02/17) | Midterm exam 1. |
| Week 06 (02/20–02/24) | Linear squares problems. Orthogonal reduction. |
| Week 07 (02/27–03/03) | Householder transformation. Revisit GMRES. |
| Week 08 (03/06–03/10) | The Jacobi method. The QR decomposition. |
| Week 09 (03/13–03/17) | Spring break. |
| Week 10 (03/20–03/24) | Iterative methods. The generalized eigenvalue problem. |
| Week 11 (03/27–03/31) | The singular value decomposition. |
| Week 12 (04/03–04/07) | Midterm exam 2. |
| Week 13 (04/10–04/14) | Introduction to linear programming. |
| Week 14 (04/17–04/21) | The simplex method. |
| Week 15 (04/24–04/28) | The dual problem. |
| Week 16 (05/01–05/05) | Final exam review. |
| Week 17 (05/08–05/12) | Final exam (05/11). |