UNIVERSIDAD DE MURCIA

FACULTY OF MATHEMATICS

# Numerical Linear Algebra

## Syllabus

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| **Course code:** | 1586 |
| **Number of ECTS credits:** | 6 |
| **Semester:** | 2nd (February-June) |
| **Prerequisites:** | None |
| **Recommended components:** | Linear Algebra (1569)<br>Affine and Euclidean Geometries (1575)<br>Linear Algebra and Geometry extension (1580)<br>Object oriented programming (1577)<br>Several variables functions I (1578)<br>Numerical calculus in one variable (1581) |
| **Language of instruction:** | Spanish (students are allowed to ask questions and write homeworks and exams in English) |

## Course description

This is the second course in the subject Numerical Methods. The target of this subject is the study of the mathematical basis and to implement numerical algorithms to solve problems from the scientific world on a computational platform. In this course we work on numerical methods to solve systems of linear equations, find eigenvalues and eigenvectors of matrix and their applications to approximation problems and to solve systems with non linear equations.

## Learning outcomes and competences

After completion of this course you will:

1. know the basic techniques in numerical linear algebra and their implementation throughout algorithms in the computers, you also will be able to use the formalisms and exactitud of maths to design, analyze and verify these algorithms.
2. be able to find numerical approximations to system of linear equations using direct methods and iterative methods, and compare between them in concrete problems.
3. solve overdetermined systems and apply them to minimum square approximation problems.
4. give several approximations of the eigenvalues and eigenvectors of a matrix.
5. solve some systems of non linear equations.

## Course contents

I. Introduction and some complements of matrix analysis.

Linear systems, matrix and linear maps. Examples of problems with models that need methods of numerical linear algebra. Subordinated matrix norms. Analysis of error, complexity and conditioning in linear problems.

II. Direct methods to solve linear systems.

Systems that are easy to solve. LU factorization and Gauss Method, approximations of the determinant and inverse matrix. QR factorization, House holder method. Diagonally dominant matrices. Symmetric matrix, the Choleski method. Overdetermined linear systems. Normal equations. Examples.

III. Iterative methods to solve linear systems.

Convergence of iterative methods. Jacobi, Gauss-Seidel and over-relaxation methods. The particular case with diagonally dominant matrix and the tridiagonal matrix. The conjugate gradient method.

IV. Methods to approximate eigenvalues and eigen vectors.

The Greschgorin theorem. Power iteration and inverse iteration methods. The Jacobi method for the symmetric case. Householder and QR methods.

V. Non linear equations systems.

Fixed point iterates, accelerated Gauss-Seidel iterates. Gradient descent method. Newton iterates to solve non linear systems. Quasi-Newton methods.

## References

### Main texts

1. Burden R. y Faires J. D. *Análisis Numérico (7a ed.)*, Thomson, Madrid, 2002

2. Allaire G. and Kaber S. M. *Numerical Linear Algebra*, Texts in Applied Mathematics 55, Springer. DOI: 10.1007/978-0-387-68918-0, 2008

3. Kincaid D. y Cheney W. *Análisis Numérico. Las Matemáticas del Cálculo Científico*, Addison-Wesley Sudamericana, Wilmington, 1994

### Supplementary references

1. Atkinson K.E. *An introduction to Numerical Analysis (2a ed.)*, John Wiley & Sons, Nueva York, 1989.

2. Aubanell A., Benseny A. y Delshams A. *Útiles básicos de Cálculo Numérico (3a ed.)*, Labor, Barcelona, 1993

3. Aula Virtual UM (Universidad de Murcia): Notas de clase, guías didácticas, hojas de problemas, prácticas ...

4. Ciarlet P.G. *Introduction a l'analyse numérique matricielle et a l'optimisation*, Masson París.1990.

5. Ciarlet P.G. Miara B. y Thomas J.M. *Exercices d'analyse numérique matricielle et d'optimisation avec solutions*, Masson París 1995

6. García Merayo F. y Nevot Luna A. *Análisis Numérico. Más de 300 ejercicios resueltos y comentados*, Paraninfo, Madrid, 1993

7. Hammerlin G. and Hoffmann K. H. *Numerical Mathematics*, Springer-Verlag, Nueva York, 1991

8. Lenguaje de programación JAVA, Oracle-Sun Inc. (de libre distribución sin fines comerciales)

9. NetBeans, sponsored by Oracle. (editor y compilador de JAVA de libre distribución sin fines comerciales)