Subject:	Advanced Numerical Methods	**Code**	93.75
Credits:	6	**Total hours:**	102
Department	of Exact and Natural Sciences	**Year:**	2022

Course: Civil Engineering, Computer Science Engineering, Bioengineering, Mechanical Engineering

Curriculum: M22, BIO 22, C23, S10 A - Rev18, S10-Rev23, S10 - Rev18

Subject presentation:

The subject is taught in the fourth year of the Computer Science Engineering course and belongs to the Department of Mathematics. To a certain extent, this subject is a continuation of the subject Numerical Methods (93.07). The aim of both courses is to provide a solid foundation in different numerical calculation algorithms that are useful for future computer science engineers. It also deals with mathematical concepts, such as series and Fourier transform or eigenvalues and singular value decomposition, which are not covered in other subjects.

93.75 is a correlative subject of Image Analysis and Processing (72.52). The mathematical concepts mentioned above are applied in the field of image processing.

Advanced Numerical Methods is also correlated with Machine Learning (72.75) and Introduction to Computational Neuroscience (72.88). In these subjects some of the concepts of linear algebra, eigenvalues and singular value decomposition (with application to principal component analysis, e.g.) seen in 93.75 can be applied.

Finally, the basic concepts of pseudo-random number generation can be related to fundamental problems in cryptography and computer security.

Learning objectives:

1. Understand the basic concepts of the contents of the subject.
2. To know some applications of the contents to the area of computer science engineering.
3. To be able to gain insight into the use of the contents in various engineering applications.

Contents:

No.	Description
1	**Concepts of Linear Algebra** Normed vector space with an inner product. Orthogonality. Gram-Schmidt method.
2	**Eigenvalues and eigenvectors** Diagonalization. Application to solving systems of linear difference equations. Numerical methods for finding eigenvalues: Powers, QR. Decomposition into singular values; application to the least squares problem. Principal component analysis (PCA).
3	**Harmonic Analysis** Periodic functions. Fourier series. Fourier Transform (FFT). Application of the Fourier transform to ordinary differential equations. Sampling of continuous signals. Discrete-Time Fourier Transform (DTFT). Applications of DTFT to difference equations. Discrete Fourier Transform (DFT). Fast Fourier Transform (FFT).
4	**Partial derivative equations** Finite difference methods. Multigrid methods.
5	**Pseudo-random number generation** Characteristics. Examples.

Laboratory assignments:

No.	Description
1	**Not applicable** No practical laboratory work in this subject.

Required bibliography:

No.	Description
1	J. H. Mathews and K. D. Fink, Numerical Methods with MATLAB. 3rd Ed. Spain: Prentice Hall, 2000. 3rd. Ed. Spain: Prentice Hall, 2000.
2	R. E. Ziemer, W. H. Tranter y D. R. Fannin, Signals and systems: continuous and discrete. 4th. Ed. Upper Saddle River, N.J., EE.UU.: Pearson, 1998.

Additional bibliography:

No.	Description
1	G. Strang, Computational Science and Engineering. Wellesley, MA, EE.UU.: Wellesley-Cambridge Press, 2007.
2	G. Strang, Introduction to Linear Algebra. 4th. Ed. Wellesley, MA, EE.UU.: Wellesley-Cambridge Press, 2009.
3	G. H. Golub y C. F. Van Loan, Matrix computations. 3rd. Ed. Baltimore, MD, EE.UU.: The Johns Hopkins University Press, 1996.
4	Quarteroni, R. Sacco y F. Saleri, Numerical Mathematics. 2nd. Ed. New York, NY, EE.UU.: Springer Verlag, 2007.

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