



Teacher(s)	Jungers Raphaël ;Remacle Jean-François ;
Language :	French
Place of the course	Louvain-la-Neuve
Prerequisites	Basic training in numerical computation (LEPL1104 level) and linear algebra (LEPL1101 level)
Main themes	<p>The course is based on the solid mathematical foundations of matrix theory to develop algorithmic solutions to major current challenges involving calculations on/with matrices defined over a field (not over a ring).</p> <ul style="list-style-type: none"> # Review of linear algebra # Eigenvalue and singular decompositions # Application to the various versions of least squares (iterative ls, total ls) # Perron-Frobenius theory # Numerical solution of linear systems: iterative methods # QR factorization # Numerical solution of matrix problems with eigenvalues and eigenvectors
Learning outcomes	<p>At the end of this learning unit, the student is able to :</p> <p>In accordance with the AA framework, this course contributes to the development, acquisition, and assessment of the following learning outcomes:</p> <ul style="list-style-type: none"> # AA1.1, AA1.2, # AA2.1, AA2.4 # AA4.2, AA4.3 # AA5.1 <p>More specifically, at the end of the course, students will be able to:</p> <ul style="list-style-type: none"> # Master numerical linear algebra # Use matrix calculus tools to analyze the mathematical properties of various problems in applied mathematics, statistics, signal processing, imaging, and dynamical systems. # Analyze in depth various representative methods and algorithms for the numerical computer-based solution of significant classes of scientific or technical problems, in relation to the underlying themes of applied mathematics. # Implement methods in high-level software and verify its behavior on a practical problem. <p>Transversal learning outcomes:</p> <ul style="list-style-type: none"> # Work in a small team to solve a mathematical problem numerically.
Evaluation methods	<p>Students are assessed partly through an examination (written, or possibly oral depending on the circumstances) organized according to the procedures established by the EPL. The examination material corresponds to the content of the lectures and course materials, after possible removal of certain sections. In case of doubt following a written examination, the instructors reserve the right to summon the students concerned for an oral examination. The other part of the assessment is based on assignments, projects, and presentations completed during the semester. This grade earned during the semester is taken into account for both examination sessions.</p>
Teaching methods	<ul style="list-style-type: none"> • Class sessions will be held according to the schedule set by the EPL. • Assignments/projects will be completed individually or in groups. • Organizational details are specified each year in the course outline on Moodle. <p>Finally, some activities may be conducted remotely.</p>
Content	<p>After an introduction that reviews some basic concepts, we discuss the following topics:</p> <ol style="list-style-type: none"> 1. Review and additional information on eigenvalue theory 2. Singular value decomposition and applications: polar decomposition, angles between spaces, generalized inverse, projectors, least squares problem, regularization 3. Approximation and variational characterization: Courant-Fischer and Wielandt-Hoffmann theorems, value field, Gershgorin theorem 4. Matrices with positive elements: Perron-Frobenius theorem, stochastic matrices

	<p>5. Floating-point computation</p> <p>6. Stability, accuracy, and conditioning of algorithms</p> <p>7. Direct methods for solving systems of equations: LU, Choleski, pivoting, renumbering (RCMK), sparse storage, filling</p> <p>8. Krylov's iterative methods: Arnoldi iteration, conjugate gradients, GMRES, Lanczos.</p> <p>9. Eigenvalue calculation, QR algorithm</p>
Inline resources	<p>http://moodleucl.uclouvain.be/course/view.php?id=7969</p>
Bibliography	<p>Ouvrages de référence :</p> <p># G.H. Golub and C.F. Van Loan (1989). Matrix Computations, 2nd Ed, Johns Hopkins University Press, Baltimore.</p> <p># P. Lancaster and M. Tismenetsky (1985). The Theory of Matrices, 2nd Ed, Academic Press, New York</p> <p># Trefethen, L. N., & Bau III, D. Numerical linear algebra (Vol. 50). Siam.</p> <p># LINMA 2380 Course notes by R.J. et al</p>
Faculty or entity in charge	<p>MAP</p>

Programmes containing this learning unit (UE)				
Program title	Acronym	Credits	Prerequisite	Learning outcomes
Additionnal module in Mathematics	APPMATH	5		
Specialization track in Applied Mathematics	FILMAP	5		
Mineure Polytechnique	MINPOLY	5		