UCLouvain

lfsab1104

2017

Numerical methods

5 credits	30.0 h + 30.0 h	Q1

Teacher(s)	Legat Vincent ;
Language :	French
Place of the course	Louvain-la-Neuve
Prerequisites	LFSAB1101 and LFSAB1102 or equivalents *The prerequisite(s) for this Teaching Unit (Unité d'enseignement – UE) for the programmes/courses that offer this Teaching Unit are specified at the end of this sheet.*
Main themes	This course is intended as an introduction to techniques for carrying out numerical computation on computers, historically one of the fundamental disciplines of computer science. It may be considered to be a preparatory course for a course in numerical analysis. While mathematical in nature, emphasis is also given to programming techniques and style, and techniques for numerical methods. Laboratory exercises will be carried out using the MATLAB system; experience with this package is not assumed. The course serves three main goals: • the understanding of basic numerical techniques with the underlying mathematical notions, • the hability to interpret the reliability of numerical results, • the programming skills to implement simple numerical algorithms.
Aims	**Contribution of the course to the program objectives** Regarding the learning outcomes of the program of Bachelor in Engineering, this course contributes to the development and the acquisition of the following learning outcomes: • LO 1.1, 1.2 • LO 2.2, 2.3, 2.4, 2.6, 2.7 • LO 3.1, 3.2, 3.3 • LO 4.1, 4.4 **Specific learning outcomes of the course** At the end of the lecture, the student must be able to: 1 • identify physical reality, mathematical model and numerical solution • understand the numerical methods in terms of accuracy, convergence and stability, • select a numerical methods taking into account accuracy and cost requirements, • implement a numerical method in computer software, • interpret and to validate the computed results, which may lead to further refinement of the mathematical model The goal is to cover a wide range of numerical methods to obtain an approximate solution of problems of physics where an exact solution is not available. A broad knowledge is often decisive to choose the right method when developing a new code. A strong emphasis is put on the problem based learning where the participants analyze data, derive, implement, document and execute their own models. Finally, the analytical and the numerical approaches are presented as complementary tools. - - - - *The contribution of this Teaching Unit to the development and command of the skills and learning outcomes of the programme(s) can be accessed at the end of this sheet, in the section entitled "Programmes/courses offering this Teaching Unit".*
Evaluation methods	Written examination about the theory, exercises and problems inspired from the course (90% of the final grade) - Homeworks (10%) A written test is organized during the semester. This test contributes for 1/3 to the final grade provided that its grade is higher than the one of the final examination.
Teaching methods	Lectures in auditorium, supervised exercise and problem sessions, and unsupervised assignments. Real-life examples using numerical methods Use of MATLAB software
Content	This course presents a broad overview of numerical methods, using calculus, algebra and computing science. The student must become aware of the relevant issues in selecting appropriate method and software and using them wisely, in terms of computational cost, numerical accuracy, complexity and stability. To make the presentation concrete and appealing, the programming environment MATLAB is adopted as a faithful companion. Topics include:

	• Error analysis: modelling error, truncation error, convergence and approximation order, floating point number representation (IEEE754). • Approximation and interpolation: Lagrange polynomials, spline functions, NURBS, orthogonal polynomials, error estimators. • Numerical integration and differentiation: backward and centered finite difference, midpoint, trapezoidal and Simpson formula, adaptive techniques. • Ordinary Differential Equations (ODE): Taylor and Runge Kutta methods, predictor-corrector methods, stability on unbounded intervals and perturbation analysis. • Linear equations: factorization methods and iterative techniques, complexity, computation of eigenvalues. • Nonlinear equations: bisection and Newton methods, optimisation applications. • Partial Differential Equations (PDE): boundary value problems (Laplace, heat equation, waves equation), approximation by finite differences. Although numerous concrete applications, the student will acquire a working knowledge in numerical methods using a problem based learning environment;
Inline resources	http://perso.uclouvain.be/vincent.legat/teaching/fsab1104.php
Bibliography	**Notes de cours** • V Legat, MATHEMATIQUES ET METHODES NUMERIQUES...ou les aspects facetieux du calcul sur un ordinateur (copyright V. Legat, 2015) • V. Legat, énoncés et solutions des exercices (copyright V. Legat, 2015) Les notes de cours sont disponibles ici : http://perso.uclouvain.be/vincent.legat/teaching/fsab1104.php **Bibliographie** • Charles F. Van Loan, Introduction to Scientic Computing, Second Edition, Prentice Hall, Upper Saddle River, ISBN 0-13949157-0 (1999). • Jacques Rappaz, Marco Picasso, Introduction a l'analyse numerique, Presses polytechniques et universitaires romandes, Lausanne, ISBN 2-88074363-X (2000). • 'Andre Fortin, Analyse numerique pour ingenieurs, Seconde Edition, Presses internationales polytechniques, Montreal, ISBN 2-55300936-4 (2001). • 'William L. Briggs, Van Emden Henson, Steve F. McCormick, A Multigrid Tutorial,Second Edition, SIAM, Philadelphia, ISBN 0-89871462-1 (2000). • 'Brigitte Lucquin, Olivier Pironneau, Introduction to Scientic Computing, John Wiley &Sons, New York, ISBN 0-47197266-X (1998). • Alfio Quarteroni, Fausto Saleri, Scientic Computing with MATLAB, Springer-Verlag, Berlin, ISBN 3-35044363-0 (2003). • Desmond J. Higham, Nicholas J. Higham Matlab Guide, Society for Industrial and Applied Mathematics (SIAM), Philadelphia, ISBN 0-89871469-9 (2000). • Michael T. Heath Scientic Computing : an Introduction Survey, McGraw Hill, New-York,ISBN 0-07-115336-5 (1997). • K. E. Atkinson, An Introduction to Numerical Analysis, Second Edition, John Wiley & Sons,New York (1989). • S. D. Conte, C. de Boor, Elementary Numerical Analysis, An Algorithmic Approach, Third Edition, McGraw-Hill Book Company, New York (1980). • B.M. Irons, N.G. Shrive, Numerical Methods in Engineering and Applied Sciences : numbers are fun, Second Edition, John Wiley and Sons (1987). • John H. Mathews, Numerical Methods for Mathematics, Science and Engineering, Second Edition, • Prentice Hall, Englewood Clis, ISBN 0-13624990-6 (1992). W. H. Press, S. A. Teukolsky, W. T. Vetterling, B. P. Flannery Numerical Recipes in C: The Art of Scientic Computing, Second Edition, Cambridge University Press, Cambridge (1994).
Faculty or entity in charge	BTCI

Programmes containing this learning unit (UE)				
Program title	Acronym	Credits	Prerequisite	Aims
Bachelor in Engineering	FSA1BA	5	LFSAB1101 AND LFSAB1102	
Master [120] in Physics	PHYS2M	5		
Bachelor in Engineering : Architecture	ARCH1BA	5	LFSAB1101A AND LFSAB1102	
Additionnal module in Statistics and data science	LSTAT100P	5		