UCLouvain

lepl1110

2024

Finished elements

5.00 credits	30.0 h + 30.0 h	Q2

Teacher(s)	. SOMEBODY ;Legat Vincent ;Remacle Jean-François ;
Language :	French
Place of the course	Louvain-la-Neuve
Prerequisites	This course assumes that you have acquired the basic notions in numerical simulation, in particular the mastery of basic numerical methods and their underlying principles (stability, precision, convergence, etc.) as well as an introduction to the resolution of differential equations (PDE) by finite differences as taught in the LEPL1104 courses.
Main themes	The general objective of the course is the introduction of the finite element method to solve problems that arise in the various engineering disciplines: electromagnetism, structural and fluid mechanics, biomedical applications... The applications will therefore concern all engineering disciplines. The content of the course consists mainly of three aspects: - the basic concepts of the finite element technique; - introduction to the mathematical basis of finite elements: calculus of variations; - the effective and complete implementation of a problem in a compiled language: C.
Learning outcomes	**At the end of this learning unit, the student is able to :** 1 At the end of this course, students will be able to: - subsequently become knowledgeable users of finite element digital simulation computer tools in the various engineering disciplines; - become aware of the digital problems that may arise during this use. In particular, the accent is placed on the analysis of the criteria which make it possible to choose the most suitable method and to estimate the validity of the results produced by the computer; - choose a method taking into account precision and complexity requirements; - understand the finite element method; - create a small C program implementing the complete resolution of a problem by the finite element method in the various engineering disciplines; - certify and validate the result of the simulation thus obtained. With regard to the AA reference of the program "Bachelor in Engineering Sciences, orientation civil engineer", this course contributes to the development, acquisition and evaluation of the following learning outcomes: - AA 1.1, 1.2 -AA 2.2, 2.3, 2.4, 2.6, 2.7 -AA 3.1, 3.2, 3.3 - AA 4.1, 4.4

Evaluation methods	The final grade for the course will be obtained on the basis of the homework, the project and the written exam.
	In June and September, an exam will be organized to replace the exam grade.
	It is not possible to submit a new version of the homework and project at the end of the deadline: failure to submit the project therefore drastically reduces the chances of passing the course in the second session.
	More precisely, the final grade for the course will be obtained from the continuous assessment and the certificate assessment defined as follows:
	• **Continuous assessment**
	A = Average of marks obtained for homework
	• **Certificate evaluation**
	B = Examination (compulsory) organized during the year
	C = Project, report and interview (compulsory)
	More precisely, the final grade will be deducted from the following formula:
	`Grade = max((A+B+C)/3,(B+C)/2) if (B+C)/2 >= 10`
	`Score = (B+C)/2 if (B+C)/2 < 10`

Content	How to numerically solve the partial differential equations that appear in the different engineering disciplines? Scientific computing is a process which makes it possible to obtain an approximate solution for these problems. This course aims to introduce the principle and implementation of one of the most popular methods: finite elements.

	The course presents a general methodology and a unified approach which gradually leads from elementary examples to the major applications of the method. The approach emphasizes the multidisciplinary aspect between algebraic calculation, mathematical analysis and computer implementation. - Interpolation of a function on an unstructured mesh; - Finite elements for elliptic equations: weak and discrete formulations, fundamental data structures; - Best approximation theory: introduction to the theory of distributions, Sobolev spaces, Lax'Milgram's theorem, Céa's lemma, a priori and a posteriori error estimates; - Generation of meshes: Delaunay triangulation, introduction to numerical geometry; - Finite elements for advection'diffusion problems: Petrov'Galerkin methods; - Techniques for solving large linear systems generated by the method: band solvers, frontal technique and conjugate gradient method; - Dynamic and modal analysis. The proposed approach will be largely transversal for all disciplines using generic and varied examples. The interest of all students will be stimulated during the completion of the final program that they will achieve. Depending on their sensitivity, each student will be able to further develop one or the other theme: the emphasis may therefore be on the general architecture of the implementation, on the optimization code performance, on the analysis of the numerical properties of the implemented method, on the graphical visualization of the results or on separate applications. For example, the final application could be the simulation of electromagnetism, the propagation of acoustic waves, the propagation of a tsunami or the vibration of a structure composed of metal lattices... A possible interaction with the disciplinary projects given during the same semester could also be considered.
Inline resources	https://perso.uclouvain.be/vincent.legat/zouLab/epl1110.php
Faculty or entity in charge	EPL

Programmes containing this learning unit (UE)				
Program title	Acronym	Credits	Prerequisite	Learning outcomes
Additionnal module in Mathematics	APPMATH	5		
Bachelor in Engineering	FSA1BA	5		
Master [120] in Architecture and Engineering	ARCH2M	5		
Master [120] in Physics	PHYS2M	5		