MECA2120 Introduction to finite element methods.

[30h+30h exercises] 5 credits

This course is taught in the 1st semester

Teacher(s): Vincent Legat
Language: French
Level: Second cycle

Aims

The aim of this lecture is to introduce students to the principles and practice of Finite Element analysis. The analysis of complex static and dynamic problems involves, in essence, three steps:
- Selection of a mathematical model.
- Computation of a numercila solution of the model.
- Interpretation of the predicted response.

Main themes

The objective of this course is to teach the student the theory and practical use of modern finite element methods for the solution of static problems.
On completion of the course the student should
- have a basic understanding of FE analysis and what can be achieved through its use,
- be able to select an element type, materials, loading and boundary conditions,
- be aware of the limitations and potential errors of FE modelling,
- have a basic knowledge of how to interpret results provided by FE analysis,
- be able to operate a standard FE analysis packages,
- be aware of the range of applications of FE analysis.

Content and teaching methods

Nowadays, finite element methods are used successfully for the analysis of very complex problems in various areas of engineering. A finite element analysis is now frequently imperative to reach a safe and cost-effective design. However, the appropriate and efficient use of finite element procedures is only possible if the basic assumptions employed in the mathematical model, the numerical FE discretisation and the computer implementation are known.
The content of the course is as follows :
- Boundary values problem in Continuum Mechanics,
- Variational and discrete formulation for elliptic problems : element types and their derivation, assembly of stiffness matrices, loading and boundary condition considerations.
- Linear elasticity, basic modelling of trusses and frames.
- Mathematical theory of the best approximation : error estimations, modelling accuracy, efficient adaptive meshing techniques, convergence.
- Mixed problems : Stokes equation and incompressible elasticity
- Advection diffusion problems : Petrov-Galerkin and Discontinuous Galerkin formulations.
- Resolution of large sparse systems : direct and iterative solvers, parallel issues.

Other information (prerequisite, evaluation (assessment methods), course materials recommended readings, ...)

- V. Legat, Introduction aux elements finis (lecture notes, 2004)
- C. Johnson, Numerical Solution of Partial Differential Equations by the Finite Element Method, Cambridge University Press, (1987)
- T. J. R. Hughes, The Finite Element Method, Prentice Hall, (1987).
- O. C. Zienkiewicz, R. L. Taylor, The Finite Element Method (volumes 1 & 2), Prentice Hall, (1989).
- G. Strang, G. j. Fix, An Analysis of the Finite Element Method, Prentice Hall, (1977).
- P. G. Ciarlet, The Finite Element Method for Elliptic Problems, North Holland / American, (1978).
- A. George, J. W. Liu, Computer Solution of Large Sparse Positive Definite Systems, Prentice Hall, (1981).

More information and grading policy is available on the web-site http://www.mema.ucl.ac.be/~vl/teaching/meca2120/
Students will use MATLAB to explore the basic principles of the finite element method.
Commercial codes are also presented and could be used.

Other credits in programs

ELEC23	Troisième année du programme conduisant au grade d'ingénieur civil électricien	(5 credits)	
ELME23/M	Troisième année du programme conduisant au grade d'ingénieur civil électro-mécanicien (mécatronique)	(5 credits)	
FSA3DA	Diplôme d'études approfondies en sciences appliquées	(5 credits)	
GC21	Première année du programme conduisant au grade d'ingénieur civil des constructions	(5 credits)	Mandatory
GC22	Deuxième année du programme conduisant au grade d'ingénieur civil des constructions	(5 credits)	Mandatory
GC23	Troisième année du programme conduisant au grade d'ingénieur civil des constructions	(5 credits)	
INCH23	Troisième année du programme conduisant au grade d'ingénieur civil chimiste	(5 credits)	
MAP22	Deuxième année du programme conduisant au grade d'ingénieur civil en mathématiques appliquées	(5 credits)	
MAP23	Troisième année du programme conduisant au grade d'ingénieur civil en mathématiques appliquées	(5 credits)	
MATR22	Deuxième année du programme conduisant au grade d'ingénieur civil en science des matériaux	(5 credits)	
MECA21	Première année du programme conduisant au grade d'ingénieur civil mécanicien	(5 credits)	
MECA22	Deuxième année du programme conduisant au grade d'ingénieur civil mécanicien	(5 credits)	Mandatory
MECA23	Troisième année du programme conduisant au grade d'ingénieur civil mécanicien	(5 credits)	