Numerical methods

Course code: ANM1		ECTS Credits: 5	
Department	: MFA/ ET	**Lectures**	: 7h30
Lecturers	: A. Benselama; G.Lehnasch, F.Virot	**Tutorials**	: 7h30
Year of study	: 1st year	**Laboratory sessions**	: 15h00
Semester	: 1st semester	**Project**	: 9h00
Assessment method(s)	: 1 written test, 1 practical work test, 1 project	**Home works**	:
		Total hours	: 39h00
Language of instruction	: English		
Type of course	: Compulsory		

Objective: get an overview of resolution methods for partial differential equations that model mechanical problems (in fluid mechanics, heat transfer and structural calculation, for instance)

Prerequisites: basic numerical analysis: numerical integration and derivation; resolution of ordinary differential equations; programing language: FORTRAN, C or C++

Content:

1. Introduction to computational physics

2. Classification of Partial Differential Equation
- Generic examples: Poisson, heat, wave equations
- Classification by characteristics: hyperbolicity, parabolicity and ellipticity

3. An overview of solution strategies
- Equations to be solved
- The general form of the conservative equations: the transport equation
- Lax(-Richtmyer) theorem

4. Space and time discretization
- Nodal approximation of functions
- Weighted residual methods (WRM)
- Finite Difference Method: consistance, accuracy and energy conservation
- Finite Element Method–Galerkin method and skewing
- Finite Volume Method
- Time discretization: finite-difference-like and quadrature methods
- Stability: matrix spectrum and von Neumann analyses

5. Equations of motion
- two-dimensional problem of an incompressible flow
- Domain discretization: collocation and staggered grid schemes
- Velocity-pressure coupling methods: pressure correction and pressure equation techniques

6. Boundary Element method
- Adjoining problem and Green identities
- the reciprocity relation
- discretization

Recommended reading:

Roache, P.J., Fundamentals of computational fluid dynamics, Hermosa Pub, 1998Hirsch, C., Numerical computation of internal and external flows, volume 1: Fundamentals of numerical discretization, John Wiley and Sons, Ltd., 1988 Patankar, S. V., Numerical heat transfer and fluid flow, Hemisphere, 1980 Strang, G. and Fix, G., An analysis of the finite element method, Prentice Hall, 1973 Tannehill, J. C. *et al.*, Computational fluid mechanics and heat transfer, Taylor and Francis, 1997

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