



Advanced Engineering Analysis  
*Introduction to Finite Difference Analysis*  
Daniele Chiappini

The aim of this course is to provide the basis for the finite difference analysis. This powerful tool may be adopted for a large number of engineering problems. The course is structured so to give to attendants a general overview of the methods which may be used while facing up with a differential equation (both ordinary and partial). More specifically the first part of the course is addressed to the definition of the discrete forms of derivatives which are most commonly used in applications. After, the Ordinary Differential Equations (ODE's) have analysed with referring both to Boundary Values Problems as well as to Initial Values Problems. ODE's have solved in case of system of equations as well, and the way to pass from a high order equation to a system of first order ones is presented as well. Thus, the focus moves towards the numerical solution of Partial Differential Equations (PDE's) both at steady state and during transients. Particular attention has addressed to the distinction between explicit and implicit methods with defining to stability conditions when needed. Finally some basics on Computational Fluid-Dynamics will be provided with showing one of the possible approaches to solve the Navier-Stokes equations.

The course is organized in 8 lessons (expected duration 3h). The first part is purely theoretical, while within the second one some applications will be developed. It is warmly suggested to have at least one laptop every two students. Most probably exercises will be developed in Octave.

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## Tentative Outline:

- Lesson 1 - *Tuesday December the 12th 2017 - 15:00-18:00:*
  - Introduction to numerical methods;
  - Solution of Ordinary Differential Equations;
  - Solution of System of Ordinary Differential Equations
- Lesson 2 - *Thursday December the 14th 2017 - 15:00-18:00:*
  - Solution of Elliptic Equations
- Lesson 3 - *Tuesday December the 19th 2017 - 15:00-18:00:*
  - Iterative Solution of Linear Systems
- Lesson 4 - *Thursday December the 21st 2017 - 15:00-18:00:*
  - Solution of Parabolic Equations - 1D case
- Lesson 5 - *Monday January the 08th 2018 - 15:00-18:00:*
  - Solution of Parabolic Equations - 2D case
- Lesson 6 - *Thursday January the 11th 2018 - 15:00-18:00:*
  - Solution of Hyperbolic Equations - 1D case
- Lesson 7 - *Monday January the 15th 2018 - 15:00-18:00:*
  - Solution of Hyperbolic Equations - 2D case
- Lesson 8 - *Thursday January the 18th 2018 - 15:00-18:00:*
  - Basics of Computational Fluid-Dynamics - 1D and 2D cases