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 Matlab.

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Tentative Outline:

- Lesson 1 - *Wednesday 23th June 2021 - 3h*:

  - Introduction to numerical methods;
  - Solution of Ordinary Differential Equations;
  - Solution of System of Ordinary Differential Equations

- Lesson 2 - *Thursday 24th June 2021 - 3h*:

  - Solution of Elliptic Equations

- Lesson 3 - *Wednesday 30th June 2021 - 3h*:

  - Iterative Solution of Linear Systems

- Lesson 4 - *Thursday 1st July 2021 - 3h*:

  - Solution of Parabolic Equations - 1D case

- Lesson 5 - *Wednesday 7th July 2021 - 3h*:

  - Solution of Parabolic Equations - 2D case

- Lesson 6 - *Thursday 8th July 2021 - 3h*:

  - Solution of Hyperbolic Equations - 1D case

- Lesson 7 - *Wednesday 14th July 2021 - 3h*:

  - Solution of Hyperbolic Equations - 2D case

- Lesson 8 - *Thursday 15th July 2021 - 3h*:

  - Basics of Computational Fluid-Dynamics - 1D and 2D cases