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DEPARTMENT OF INDUSTRIAL ENGINEERING

PhD Course in Mechanics and Advanced Engineering Sciences (DIMSAI)

Wolfram Mathematica: an introduction to symbolic computation, data manipulation and numerical analysis for engineers

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1 Learning outcomes

The present course aims to introduce the student to the software *Mathematica*, developed by *Wolfram Research*. This software is particular interesting for his built-in libraries that can be useful for several areas of technical computing. In the present course we will focus mainly on symbolic computation, data manipulation and numerical analysis. The students will acquire a basic knowledge of the software and learn how use it to solve problems concerning their own research field.

2 Program

1. Introduction to numerical computations
   (a) Arithmetic operations
   (b) Exact and approximative results
   (c) Logarithmic, exponential, factorial and roots
   (d) Circular trigonometric functions
   (e) Hyperbolic trigonometric functions
   (f) Inverse trigonometric functions
   (g) Arbitrary-precision computations
   (h) Rounding integer divisions
   (i) Complex numbers
   (j) Relational operators and logic functions
   (k) Test functions applied to numerical values

(l) Numerical types and numerical sets

2. Developing computations

   (a) Using results from previous calculations
   (b) Information about functions and operators
   (c) Assigning values to variables
   (d) Introduction to lists
   (e) Extracting and modifying elements from unidimensional lists
   (f) Introduction to contexts
   (g) Introduction to strings
   (h) Manipulating numbers
   (i) Formatting numbers
   (j) Some statistic functions
   (k) Generating random values
   (l) Messages
   (m) Alternative forms

3. Introduction to symbolic computations

   (a) Representing symbolic expressions
   (b) Introduction to rules
   (c) Other rule applications
   (d) Manipulating algebraic expressions
   (e) Manipulating trigonometric expressions
   (f) Simplifying expressions
   (g) Other manipulations in expressions
   (h) Controlling the results exibition
   (i) Extracting parts from expressions
   (j) Representing equations and inequations
   (k) Solution of algebraic equations
   (l) Introduction to linear algebra

4. Lists and data manipulation

   (a) Building one-dimensional lists
   (b) Building multidimensional lists
   (c) Forms of lists exibition
   (d) Assignments with lists

(e) Information about lists
(f) Extracting elements from lists
(g) Insertion, exclusion and modification of lists elements
(h) Combining and rearranging lists
(i) Gathering elements
(j) List structure manipulation

5. Introduction to programming

(a) Introduction to models
(b) Definition of functions
(c) Functions of multiple variables
(d) Composite models and correspondence with models
(e) Options to functions
(f) Modifying title and distributing to arguments
(g) Pure functions
(h) Functions with sequential evaluations and local variables
(i) Repetitive operations: iterations
(j) Other forms of assignments
(k) Flux control
(l) Following executions
(m) Input and output data

6. Graphics and visualization

(a) Two-dimensional graphics
(b) Options
(c) Re-exibiting and combining graphics
(d) Graphic of fields (isolines)
(e) Three-dimensional graphics
(f) Graphics from list of data
(g) Curves and parametric surfaces
(h) Representing geometric figures
(i) Animations and interactivity

7. Integral and differential calculus and numerical computations

(a) Limits and derivatives
(b) Integration
(c) Summation, products and power series
(d) Differential equations
(e) Numerical solution of algebraic equations
(f) Interpolation of numerical data

3 Dates

- 20/01/2025: 14:00-16:00
- 23/01/2025: 14:00-16:00
- 24/01/2025: 14:00-16:00
- 27/01/2025: 14:00-16:00
- 29/01/2025: 14:00-16:00
- 31/01/2025: 14:00-16:00

4 Assessment

The exam consists of using the *Mathematica* environment to define, to solve and to present the results of some physical problem of the student's interest. The choice of the specific problem must be agreed with the professor.

5 Teaching mode

Lessons will be held in presence or, if necessary, in a hybrid modality. The lessons will be entirely in the *Mathematica* environment. It is necessary for the students to install *Mathematica* in their own computer (UniBo has a campus license for *Mathematica*).