MASTER 'S PROGRAMME
**APPLIED MATHEMATICS - IN ENGLISH**

1ST YEAR OF STUDY, 1ST SEMESTER

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| COURSE TITLE | **SCIENTIFIC CALCULUS** |
| COURSE CODE | **MA1CSt** |
| COURSE TYPE | full attendance/tutorial |
| COURSE LEVEL | 2nd cycle (master's degree) |
| YEAR OF STUDY, SEMESTER | 1st year of study, 1st semester |
| NUMBER OF ECTS CREDITS | **7** |
| NUMBER OF HOURS PER WEEK | 4 (2 lecture hours + 2 seminar/laboratory hours) |
| NAME OF LECTURE HOLDER | Dr. Ghiba Ionel-Dumitrel |
| NAME OF SEMINAR HOLDER | Dr. Ghiba Ionel-Dumitrel |
| PREREQUISITES | Curriculum : Mathematical Analysis, Linear Algebra<br>Competencies: operation with basic notions of mathematical analysis and linear algebra; basic knowledge of computer programming would be helpful<br>Language: advanced level of English |

## A GENERAL AND COURSE-SPECIFIC COMPETENCES

**General competences**:

- ✓ Having a responsible attitude towards scientific research and teaching, being able to fully develop the personal potential in the professional career, respecting the principles of a rigorous and efficient work in order to fulfill complex tasks, respecting the ethical norms and principles in the professional activity
- ✓ Being able to make a selection of information resources and to use them efficiently

**Course-specific competences**:

- ✓ Manipulating notions, methods and mathematical models, specific techniques in scientific calculus and applications
- ✓ Being able to construct and apply mathematical methods for analysing and simulating some processes
- ✓ Being able to develop, analyse and test algorithms and specific programming languages; being able to use them for solving problems in applied mathematics

## B LEARNING OUTCOMES

- ✓ Students will use knowledge gained from previous courses taken (linear algebra, mathematical analysis, numerical analysis, optimization) in order to find and/or approximate the solutions of certain real problems, to obtain numerical algorithms, and to implement them in Matlab. They will be able to generalize the results, when practice will demand
- ✓ After successfully completing this course, the students will be able to:
  - ✧ Explain the basic methods used during the semester
  - ✧ Describe the analytical methods of solving the studied problems
  - ✧ Use the studied numerical algorithms and the basic optimization techniques
  - ✧ Analyse the solutions of the specific studied problems
  - ✧ Use Matlab as a calculus tool

## C LECTURE CONTENT

1. Short presentation of the topics. Linear Programming with Matlab: the setup, formulating the problem and a graphical solution, discussion and applications
2. Linear Algebra - a constructive approach: Jordan exchange, linear independence, matrix inversion
3. The Simplex Method: example and discussion, vertices, the phases of the algorithm, finite

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| | termination<br>4. Linear Programs in nonstandard form - transforming constraints and variables<br>5. Global and local optima for unconstrained optimization, classification of matrices<br>6. Second order optimality conditions, quadratic functions<br>7. Least squares: “solution” of overdeterminated systems, data fitting<br>8. Regularized least squares, denoising<br>9. The gradient method<br>10. The condition number, diagonal scaling<br>11. The Gauss-Newton method, convergence analysis of the gradient method<br>12. Quadratic Programming: basic existence result, KKT conditions |
| D | **RECOMMENDED READING FOR LECTURES** |
| | 1. W. Gander, M.J. Gander, F. Kwok. Scientific computing- An introduction using Maple and MATLAB. Vol. 11. Springer Science & Business, 2014.<br>2. M. Ferris, C. Michael, O. L. Mangasarian, S.J. Wright. Linear programming with MATLAB. Vol. 7. SIAM, 2007.<br>3. A. Beck, Introduction to nonlinear optimization-Theory, Algorithms, and Applications with MATLAB, SIAM, 2014. |
| E | **SEMINAR CONTENT** |
| | 1. Short presentation of the topics. Linear Programming with Matlab: the setup, formulating the problem and a graphical solution, discussion and applications<br>2. Linear Algebra - a constructive approach: Jordan exchange, linear independence, matrix inversion<br>3. The Simplex Method: example and discussion, vertices, the phases of the algorithm, finite termination<br>4. Linear Programs in nonstandard form - transforming constraints and variables<br>5. Global and local optima for unconstrained optimization, classification of matrices<br>6. Second order optimality conditions, quadratic functions<br>7. Least squares: “solution” of overdeterminated systems, data fitting<br>8. Regularized least squares, denoising<br>9. The gradient method<br>10. The condition number, diagonal scaling<br>11. The Gauss-Newton method, convergence analysis of the gradient method<br>12. Quadratic Programming: basic existence result, KKT conditions |
| F | **RECOMMENDED READING FOR SEMINARS** |
| | 1. W. Gander, M.J. Gander, F. Kwok. Scientific computing- An introduction using Maple and MATLAB. Vol. 11. Springer Science & Business, 2014.<br>2. M. Ferris, C. Michael, O. L. Mangasarian, S.J. Wright. Linear programming with MATLAB. Vol. 7. SIAM, 2007.<br>3. A. Beck, Introduction to nonlinear optimization-Theory, Algorithms, and Applications with MATLAB, SIAM, 2014. |
| G | **EDUCATION STYLE** |

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| LEARNING AND TEACHING METHODS | Lectures: lecture, dialogue, proof<br><br>Seminars/laboratory: exercises, dialogue, PC simulations |
| ASSESSMENT METHODS | Course: weight in the final grade 40% (written examination)<br>Seminar/laboratory: weight in the final grade 60% (written examination)<br>Minimal requirements:<br>1. Knowledge and correct use of fundamental concepts, results and algorithms<br>2. Application of analytical and numerical methods for solving some optimization problems<br>3. Minimum grade 5 |
| LANGUAGE OF INSTRUCTION | English |