UNIVERSITÀ DEGLI STUDI DI BARI ALDO MORO

CONSIGLIO INTERCLASSE IN MATEMATICA

**COURSE OF STUDY** THREE-YEAR BACHELOR PROGRAMME IN MATHEMATICS

**ACADEMIC YEAR** 2023-2024

**ACADEMIC SUBJECT** NUMERICAL METHODS FOR COMPUTER GRAPHICS

| **General information** | |
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| Programme year | Third |
| Term | Second semester (February 26, 2024 – May 31, 2024) |
| European Credit Transfer and Accumulation System credits (ECTS) | 6 |
| SSD | MAT/08 – Numerical Analysis |
| Language | Italian |
| Mode of attendance | Not mandatory |

| **Lecturer** | |
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| Name and surname | Pierluigi Amodio |
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| Telephone | +39 080 544 2703 |
| Department and office | Department of Mathematics, room 2 fourth floor |
| Virtual meeting room | Microsoft Teams code tmg6ky4 |
| Web page | https://www.dm.uniba.it/it/members/amodio |
| Office hours | By appointment via email |

| **Work schedule** | Total | Lectures | Hands-on learning (recitations/laboratories) | Self-study |
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| **Hours** | 175 | 48 | 15 | 112 |
| **ECTS credits** | 7 | 6 | 1 | |

| **Learning objectives** | |
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| | Acquiring some knowledge about the main properties and issues related to the computer graphics. Acquiring basic knowledge about the development of 3D models in Matlab environment. |

| **Course prerequisites** | |
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| | The knowledge gained in the course Numerical Calculus I and II, basics of geometry and linear algebra. |

| **Syllabus** | |
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| Course contents | **0. IMAGE PROCESSING**<br>Representation of raster images on a computer. Main functions for the image processing (filters).<br>**1. PARAMETRIC REPRESENTATION**<br>Parametric representation of curves and surfaces. Analysis of strengths and weaknesses in computer graphics.<br>**2. POLYNOMIAL AND B-SPLINE CURVES**<br>Bernstein polynomials and Bézier curves. Main properties. De Casteljau algorithm. B-spline curves. De Boor algorithm. Derivative of polynomial Bézier curves and B-splines. Relation between regularity and multiplicity of |

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| | the knots. Degree elevation and knot insertion algorithms. Parametric interpolation.<br>**3. RATIONAL CURVES AND NURBS**<br>Rational curves and B-spline rational (NURBS) curves. Properties. Representation of conics and conic sections. NURBS functions.<br>**4. SURFACES**<br>Representation of free-form surfaces, surface of revolution, translation and rotation. Bilinear and ruled surfaces, general cylinders, swung surfaces.<br>**5. MATLAB IMPLEMENTATION**<br>Matlab implementation of all the proposed algorithms. |
| Reference books | • L. Piegl, W. Tiller, The NURBS book, Springer, 1997.<br>• F. Farin, Curves and Surfaces for Computer Aided Geometric Design, Academic Press, 1997.<br>• Lamberti, C. Dagnino, Elementi di matematica numerica per la grafica, Levrotto & Bella, 2008. |
| Additional course materials | |
| Repository | Handouts, notes, and Matlab codes supplied during the course lectures. |

| **Expected learning outcomes** | |
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| Knowledge and understanding | Understanding the power of computer graphics and the problems connected with the fulfillment of shapes by means of basic mathematical objects. |
| Applying knowledge and understanding | Acquiring skills in programming and testing of numerical codes for computer graphics. |
| Soft skills | *Making judgements*: Being able to detect a proper programming strategy to solve non-elementary problems in computer graphics. |
| | *Communication skills*: Being able to explain rigorously the basic theory of the numerical algorithms. |
| | *Learning skills*: Capability of studying and applying the techniques learned during the course to realize 3D models. |

| **Teaching methods** | |
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| | Lectures and exercise sessions in the Computer Centre. |

| **Assessment** | |
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| Assessment methods | The exam consists in the discussion of two projects (in Matlab) proposed and carried out in group or individually by the students and an oral exam to verify the knowledge of the theoretical notions. |
| Evaluation criteria | • *Knowledge and understanding*: Analysis of the presented numerical methods. Ability to compare methods solving the same problem, even in terms of computational efficiency.<br>• *Applying knowledge and understanding*: Discussion of the implemented codes and the executed examples; correct interpretation of the obtained solutions.<br>• *Making judgement*: Execution of algorithms and interpretation of the results obtained.<br>• *Communication skills*: Clearness, also in terms of used formalism, in the description and coding of the numerical techniques studied; ability to present effectively the numerical tests carried out.<br>• *Learning skills*: Numerical implementation and discussion of more difficult application problems than those presented during the lessons. |
| Grading policy | The final mark takes into account the assessment obtained by the student in the three parts: |

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| | • *Development of a code for curves*: Development of a main program to execute all the curve algorithms presented in the lessons.<br>• *Realization of a 3D object*: Computer implementation of a software that creates a 3D object and discussion of the techniques used.<br>• *Oral exam:* Discussion of algorithms and analytical properties of the numerical methods for curves and surfaces. |

| **Further information** | |
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