MATHEMATICS

FACULTY OF SCIENCE

UNIVERSITY OF ZARAGOZA

INDEX

INTRODUCTION

FACULTY OF SCIENCE

The Faculty of Science is located at the heart of Zaragoza city, in San Francisco Campus. It has a long history of excellence in teaching and research. The Faculty has a strong international profile and attracts students from Europe and around the world. With more than 1,000 ISI journal articles published per year, the Faculty is a leading research hub at the University of Zaragoza, ranked among the top 200 world-class universities for Natural Sciences & Mathematics (ARWU 2016).

Figures for the Faculty of Science:

- 1850 students
- 450 professors + 100 researchers + 100 support staff
- 40 classrooms + 20 teaching labs + 150 research labs + 9 computer classrooms

Undergraduate Degree Programs

- BSc in Biotechnology
- BSc in Chemistry
- BSc in Geology
- BSc in Mathematics
- BSc in Optics and Optometrics
- BSc in Physics

MSc Degree Programs

- MSc in Geology: Techniques and applications
- MSc in Industrial Chemistry
- MSc in Mathematical modelling and research, Statistics and Computation
- MSc in Molecular and Cellular Biology
- MSc in Quantitative Biotechnology (***in English***)
- Msc in Molecular Chemistry and Homogeneous Catalysis
- MSc in Physics and Physical technologies
- MSc in Nanostructured Materials and Nanotechnological Applications (***in English***)
- MSc Erasmus Mundus in Membranes Engineering (***in English***)

English-language friendly (ELF) modules

Three of our MScs are taught in English, while the rest of MScs and all the BScs are taught in Spanish. In 2018/19, six modules in the BSc in Mathematics will be taught in English. In the programs taught in Spanish, most of the modules are English-language friendly. This means that, in those modules, foreign students will have, upon request:

- Learning material in English.
- Office hours in English.
- Assessment (exams, homework...) in English.

In the list of modules for each program, see below, English-language friendly modules for 2018/2019 are marked with an ELF label. The list of ELF modules may change slightly by 2019/2020; a list for that year will be available some weeks before the start of the classes.

High level research: More than 1.000 research papers in JCR per year

The Faculty has been the seed of Research Institutes of the University of Zaragoza:

- BIFI: Institute of Biocomputation and Physics of Complex Systems
- ICMA: Aragon Materials Science Institute
- INA: Institute of Nanoscience of Aragon
- ISQCH: Institute of Chemical Synthesis and Homogeneous Catalysis
- IUCA: Environmental Science Institute of Aragon
- IUMA: Institute of Mathematics and Applications

Most professors/researchers in the Faculty of Science are members of these institutes.

BSc IN MATHEMATICS

Duration: 4 years full time. 60 ECTS per year.

Language: Spanish

Program aims:

The Bachelor's Degree in Mathematics aims to equip scientists with knowledge about the main concepts, methods and results of the various fields of Mathematics, and the main objectives are:

- To apply analytical, abstract and logical thinking in approaching and finding solutions to problems, in both academic and professional contexts.
- To participate in all the phases of problem-solving in scientific, technological or other areas requiring the use of mathematical tools: modeling, formulation, analysis, resolution and, where applicable, data processing.
- To effectively transmit knowledge, results and mathematical ideas.
- To recognize the presence of Mathematics in everyday life, through Nature, Science, Technology and Arts.
- To directly access to the labor market in jobs with medium / high responsibility.
- To continue specialized studies, both in mathematical and scientific or technological disciplines requiring mathematical knowledge

Structure:

Year 1. In the first year students must enrol in the following modules:

Module	ECTS	Semester
27000 - Linear algebra[ELF]	13.5	YL
27001 - Calculus I[ELF]	13.5	YL
27002 - General physics[ELF]	12.0	YL
27003 - Computer Science I[ELF]	9.0	S1
27004 - Numbers and Sets[ELF]	6.0	S1
27005 - Graphs and Combinatorics[ELF]	6.0	S2

S1: Semester 1. Mid-September to mid-January
S2: Semester 2. Beginning-February to end-May
YL: Year-long. Mid-September to end-May
[ELF]: English-language friendly module (see first page)

Year 2. In the second year students must enrol in the following modules:

Module	ECTS	Semester
27006 - Calculus II[ELF]	15.0	YL
27007 - Numerical Analysis I[ELF]	9.0	YL

27008 - General Topology[ELF]	9.0	YL
27009 - Ordinary Differential Equations[ELF]	9.0	YL
27010 - Linear Geometry (in English)	6.0	S1
27011 - Algebraic Structures (in English)	6.0	S2
27012 - Introduction to Probability and Statistics[ELF]	6.0	S2

Year 3. In the third year students must enrol in the following modules:

Module	ECTS	Semester
27013 - Geometry of Curves and Surfaces[ELF]	10.5	YL
27014 - Complex Analysis (in English)	9.0	YL
27015 - Numerical Analysis II	9.0	YL
27016 - Probability (in English)	6.0	S1
27017 - Galois Theory (in English)	6.0	S1
27018 - Operations Research (in English)	6.0	S1
27019 - Mathematical Statistics[ELF]	7.5	S2
27020 - Partial Differential Equations[ELF]	6.0	S2

Year 4. In the fourth year students must enrol in the following modules:

Module	ECTS	Semester
27021 - Lebesgue Integral[ELF]	6.0	S1
27022 - Mathematical Modelling[ELF]	6.0	S1
27023 – Undergraduate Dissertation* [ELF]	10.0	S2

In this fourth year they must also select six modules from the list of optional modules:

Module	ECTS	Semester
27024 - Computer Science II[ELF]	6.0	S1
27027 - Stochastic Optimisation[ELF]	6.0	S1
27031 - Dynamical Systems[ELF]	6.0	S2
27033 - Regression Methods[ELF]	6.0	S1
27034 - Functional Analysis[ELF]	6.0	S1
27037 - Mathematical Astronomy[ELF]	6.0	S1
27039 - History of Mathematics[ELF]	6.0	S1
27041 - Differentiable Manifolds[ELF]	6.0	S1
27043 - Algebraic Curves[ELF]	6.0	S1
27025 - Database Systems I[ELF]	6.0	S2
27029 - Numerical Simulation in Ordinary Differential Equations[ELF]	6.0	S2
27030 - Numerical Treatment of Partial Differential Equations[ELF]	6.0	**

27032 - Probability Theory[ELF]	6.0	S2
27035 - Fourier Analysis[ELF]	6.0	S2
27038 - Celestial Mechanics[ELF]	6.0	S2
27040 - Topolgy of Surfaces[ELF]	6.0	S2
27045 - Applied and Computational Algebra[ELF]	6.0	S2
27026 - Database Systems II[ELF]	6.0	**
27028 - Game Theory[ELF]	6.0	**
27036 - Foundations of Mathematical Analysis[ELF]	6.0	**
27042 - Riemannian Geometry[ELF]	6.0	**
27044 - Representation Theory[ELF]	6.0	**

Not all the optional modules are available every year. A list of the available modules for the following year (starting in September) is published in June. The modules with ** in the Semester column are not being offered in 2018/2019.

*Undergraduate Dissertation

The Undergraduate Dissertation (UD) is a 250 hours project on any of the modules of the Degree. It is undertaken during the second semester of the 4th year. Student are supervised by a professor who defines the objectives of the project and guides them along the work. The students must write a report and make a public defense of it. The following list includes of some examples of UDs performed in the last years.

- Group theory. Decision problems and applications in cryptography.
- Stochastic models in Medicine. Survival analysis.
- Numerical simulation of tumor growth.
- Logistic regression. Application to studies of prostate cancer
- Identification of explosives through parametrization of plane curves
- Banach algebras and integral transformations.
- Ramsey's theory for graphs.
- Magnetic fields on surfaces.
- Numerical simulation in Finance.
- Mathematical modelling of diseases.
- Symplectic formulation of quantum mechanics.
- Mathematical models of neurons.
- Transportation problems and the fixed-load transportation problem.
- Statistical inference based on MCMC.
- The spectral theorem of bounded normal operators.
- Numerical methods applied to fluid mechanics.
- Sums of squares.
- Applications of P-matrices to mathematical models.
- The prime number theorem.
- Dynamical systems with symmetry.
- Interacting systems. The voter model.

MSc IN MATHEMATICAL MODELLING AND RESEARCH, STATISTICS AND COMPUTING

Duration: 1 year full time. 60 ECTS.

Language: Spanish.

Program aims:

The objective of this Master's Degree program is to train researchers and professionals in Mathematics and its applications and equip them with high technical and scientific skills, knowledge and practical experience in the applications of Mathematics, Statistics and in the use of Computer Science in R&D&I. Students will be capable of joining competitive research teams and developing their own research activity in all fields where Mathematics are involved. They will also have a suitable training to enroll in a PhD program. Moreover, they will be capable of understanding, modeling, and solving problems arising in business, engineering and other sciences, and developing software applications for the numerical simulation of real life problems.

Structure:

The Master is a joint program involving 5 universities: University of Basque Country, University of La Rioja, Public University of Navarre, University of Oviedo, University of La Laguna and University of Zaragoza. Modules in the first semester (October-December) are taught at the University of Basque Country and modules in the second semester (February-March) are taught at University of Zaragoza. There are also two/three modules taught in April at one of the other universities, depending on the year. The list of modules in each semester may vary from year to year. Two modules are taught online.

All modules in the Master except the Master's Dissertation are optional. Students must select 8 modules from the following list:

Module	ECTS	Semester
69251 - Databases and object-oriented programming[ELF]	6.0	S1 (UBC)
69252 - Partial differential equations[ELF]	6.0	S1 (UBC)
69253 - Statistical modeling[ELF]	6.0	S1 (UBC)
69255 - Numerical methods in physics and engineering[ELF]	6.0	S1 (UBC)
69264 - Groups and representations[ELF]	6.0	S1 (UBC)
69256 - Time series[ELF]	6.0	S1 (UBC)
69257 - Control theory[ELF]	6.0	S1 (UBC)
69258 - Optimization techniques[ELF]	6.0	S1 (UBC)
69259 - Bio-inspired algorithms and evolutionary computation techniques[ELF]	6.0	S2 (UZ)
69254 - Mathematical models in logistics[ELF]	6.0	S2 (UZ)
69261 - Nonlinear dynamics and applications[ELF]	6.0	S2 (UR)

69262 - Computer-aided geometric design[ELF]	6.0	S2 (UZ)
69265 - Introduction to data mining[ELF]	6.0	S2 (UZ)
69267 - Stochastic processes and probability[ELF]	6.0	S2 (UZ)
69268 - Scientific programming and computational algebra[ELF]	6.0	S2 (UR-UZ)
69269 - Algebraic topology[ELF]	6.0	S2 (UZ)
69263 - Geometry of manifolds[ELF]	6.0	S2 (UZ)
69250 - Functional and Fourier analysis[ELF]	6.0	S2 (UR)
69266 - Signal processing and image[ELF]	6.0	OL
69260 - Encoding and cryptography [ELF]	6.0	OL

S1 (UBC): Semester 1. October to December. University of Basque Country
S2 (UZ): Semester 2. February-March. University of Zaragoza
S2 (ULL): Semester 2. April. University of La Rioja
OL: Online module

This table is applicable for the academic year 2018/19. Semesters, as well as the university where they are taught, may change for some modules in 2019/20. A table for the academic year 2019/20 will be available in January, 2019.

Master's Dissertation[ELF]

The Master's Dissertation (MD) is a 300 hour compulsory project on any of the modules of the Degree. It is undertaken during the second semester. There are two types of Master's Dissertation that the student can take depending on his/her interests. The first type is a research project. The second type consists on solving a problem posed by a company or institution. Students are supervised by a professor who defines the specific objectives of the Project and guides him/her along the work. Student must write a report and make a public defense of it. The following list includes some examples of MDs performed in the last years:

- CUDA implementation of the solution of a system of linear equations arising in an hp- finite element code.
- New canonical variables for the analytical integration of the equatorial problem of the artificial satellite.
- Factorization of Vandermonde matrices and Newton's formula.
- Comparison and development of anti-spam filters based on data mining.
- Supervised learning techniques in Alzheimer's disease.
- Tools for the orbital design of a satellite constellation.
- Artin groups.
- Delta-records in random sequences with trend.
- Application of evolutionary models for the analysis of social and cultural changes in communication networks.
- Lie algebroids and their applications to the interpolation of differential manifolds.
- Extreme value analysis with nonhomogeneous Poisson processes.
- Modelling the severity of heat waves.
- Medical images registration.
- Quantitative analysis and treatment of images for the characterizaton of crystalline structures in micrographs of electron microscopy with atomic resolution.

RESEARCH GROUPS IN MATHEMATICS

- **Algebra**. Director: Javier Otal
- **Geometry**. Director: María Teresa Lozano
- **Numerical methods in partial differential equations and integrals**. Director: Francisco Lisbona
- **Stochastic models**. Director: Gerardo Sanz
- **Mathematical physics**. Director: Eduardo Martínez
- **Optimization and simulation**. Director: Herminia Calvete
- **Mathematical analysis and applications**. Director: Jesús Bastero
- **Numerical analysis and applications**. Director: Juan Manuel Peña
- **Celestial Mechanics**. Director: Antonio Elipe

LIST OF SELECTED PUBLICATIONS (2014)

S.S. Abhyankar and E. Artal. Analytic theory of curvettes and dicriticals. Revista Matemática Complutense 27 (2014), 461-499.

J.A. Adell, J. Bustamante and J.M. Quesada. Polynomial operators for one-sided Lp-approximation to Riemann integrable functions. Journal of Inequalities and Applications. (2014), 2014:494.

I. Alberto, C.A. Coello and P.M. Mateo. A comparative study of variation operators used for evolutionary multi-objective optimization. Information Sciences 273 (2014), 33-48

M. Alfaro, A Peña, T. Pérez and M.L. Rezola. On linearly related orthogonal polynomials in several variables. Numerical algorithms, 66 (2014), 525-553.

L.C. de Andrés, M.Fernández, S.Ivanov, J.Santisteban, L.Ugarte and D. Vassilev. Quaternionic Kähler and Spin(7) metrics arising from quaternionic contact Einstein structures. Annali de Matematica Pura ed Applicata 193 (2014), 261-290.

E. Artal, J.I. Cogolludo-Agustín and A. Libgober. Depth of cohomology support loci for quasi-projective varieties via orbifold pencils. Revista Matemática Iberoamericana 30 (2014), 373-404

E. Artal, J.I. Cogolludo-Agustín and J. Ortigas-Galindo. Kummer covers and braid monodromy. Journal of the Institute of Mathematics of Jussieu. 13 (2014), 633-670

F.G. Badía and C. Sangüesa. Log-concavity for Bernstein-type operators using stochastic orders. Journal of Mathematical Analysis and Applications 413 (2014), 953-962.

F.G. Badía, C. Sangüesa and J.H. Cha. Stochastic comparison of multivariate conditionally dependent mixtures. Journal of Multivariate Analysis 129 (2014), 82-94

A. Ballester-Bolinches, L. A. Kurdachenko, J. Otal and T. Pedraza. Groups whose primary subgroups are normal sensitive. Monashefte fürMathematik. 175 (2014), 175-185.

A. Barreras and J.M. Peña. Accurate and efficient LDU decompositions of almost diagonally dominant Z-matrices. BIT 54 (2014), 343-356

A. Barreras and J.M. Peña. On the extension of some total positivity inequalities. Linear Algebra and its Applications (2014), 153-167.

R. Barrio, F. Blesa and S. Serrano. Unbounded dynamics in dissipative flows: Rossler model, Chaos: An Interdisciplinary Journal of Nonlinear Science 24 (2014), 024407.

R. Barrio, M.A. Martínez, S. Serrano and A. Shilnikov. Macro-and micro-chaotic structures in the Hindmarsh-Rose model of bursting neurons. Chaos: An Interdisciplinary Journal of Nonlinear Science.24 (2014), 023128.

R. Barrio and M. Rodríguez. Systematic Computer Assisted Proofs of periodic orbits of Hamiltonian systems, Communications in Nonlinear Science and Numerical Simulation 19 (2014), 2660-2675.

D. Beltita and J. E. Galé, Linear connections for reproducing kernels on vector bundles, Mathematische Zeitschrift 277 (2014), 29-62.

S. Benayadi and A. Elduque. Classification of quadratic Lie algebras of low dimension. Journal of Mathematical Physics. 55 (2014), 081703.

F. Blesa, J.M. Seoane, R. Barrio and M.A.F. Sanjuán, Effects of periodic forcing in chaotic scattering, Physical Review E 89 (2014), 042909.

H.I. Calvete, C. Galé and J.A. Iranzo. Planning of a decentralized distribution network using bilevel optimization. Omega 49 (2014), 30-41

S. Campos-Orozco and J. E. Galé, Continuous Sheffer families II. Journal of Mathematical Analysis and Applications 412 (2014), 381-390.

J.F. Cariñena, I. Gheorghiu, E. Martínez and P. Santos. Conformal Killing vector fields and a virial theorem. Journal of Physics A 47 (2014), 465206.

J.F. Cariñena, J. Grabowski, J. de Lucas and C. Sardón. Dirac--Lie systems and Schwarzian equations. Journal of Differential Equations 257 (2014), 2303.

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A. Castelo, A. Mendioroz, R. Celorrio and A. Salazar. Characterization and spatial resolution of cracks using lock-in vibrothermography. NDT & E International 66 (2014), 815.

R. Celorrio, A.J. Omella, A. Mendioroz, A. Oleaga and A. Salazar. Advances in crack characterization by lock-in infrared thermography. International Journal of Thermophysics (2014), 1-6.

R. Celorrio, A.J. Omella, N.W. Pech-May, A. Oleaga, A. Mendioroz and A. Salazar. Vertical cracks characterization using lock-in thermography. II. Finite cracks. Measurement Science and Technology 25 (2014), 115602.

C. Clavero and J.L. Gracia, An improved uniformly convergent scheme in space for 1D parabolic reaction--diffusion coupled systems. Applied Mathematics and Computation 243 (2014), 57-73.

J.I. Cogolludo-Agustín, J. Martín-Morales and J. Ortigas-Galindo. Local invariants on quotient singularities and a genus formula for weighted plane curves. International Mathematics Research Notices 13 (2014), 3559-3581.

R. Delgado, F.J. López and G. Sanz. Necessary and sufficient conditions for strong comparability of multicomponent systems. Discrete Event Dynamical Systems 24 (2014), 1-14.

J. Delgado and J.M. Peña. Fast and accurate algorithms for Jacobi-Stirling matrices. Applied Mathematics and Computation 236 (2014), 253-259

W. Dicks and C. Martínez-Pérez. On isomorphisms of Brin-Thompson-Higman groups. Israel Journal of Mathematics. 199 (2014), 189-218.

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M. Fernández, S. Ivanov, L. Ugarte and D. Vassilev. Non-Kaehler heterotic string solutions with non-zero fluxes and non-constant dilaton. Journal of High Energy Physics 06 (2014), 073.

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J.M. Franco, I. Gómez and L. Rández. Optimization of explicit two-step hybrid methods for solving orbital and oscillatory problems. Computer Physics Communications 185 (2014), 2527-2537.

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M. García-Esnaola and J.M. Peña. Error bounds for linear complementarity problems of Nekrasov matrices. Numerical Algorithms 67 (2014), 655-667.

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