



DEPARTMENT OF MATHEMATICS
AND APPLIED MATHEMATICS

STUDY GUIDE
2023-2024

Programme of Postgraduate Studies
Mathematics and Education

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STUDY GUIDE

1. The Department of Mathematics and Applied Mathematics

The Department of Mathematics and Applied Mathematics was created in June 2013 by the merge of the Department of Mathematics (founded in 1977) and the Department of Applied Mathematics (founded in 1999). It is both the oldest and the youngest department of the University of Crete and the largest of the Faculty of Science and Technology.

The **Department of Mathematics** admitted students for the first time in the academic year 1977-1978 and together with the Department of Philology were the first departments to operate at the University of Crete. The Department created a long tradition of excellent university teaching accompanied by significant research results in the mathematical science. From its early years of operation it made its mark on the map of higher education. It established a flexible programme of undergraduate studies and was the first of all the Departments of Mathematics in Greece to operate, as early as in 1984, an organised Postgraduate Studies Programme leading to the acquisition of an M.Sc. degree or even a PhD dissertation. The Department has pioneered the implementation of international practices, such as the organisation, in the year 2000, of its external evaluation.

The **Department of Applied Mathematics** was founded by members of the Department of Mathematics, in 1999, with the aim of developing the applications of Mathematics in Greece. It attracted accomplished and dynamic young researchers from Europe and America and soon developed excellent education and research in applied Mathematics. It secured important competitive research projects and activities and introduced innovative ways of teaching and innovative courses in the programme of studies.

The unified Department continues the excellent academic tradition of the two Departments, as demonstrated in their external evaluations by H.A.H.E. (Hellenic Authority of Higher Education). The quality of teaching is comparable to that of many world-leading Universities, where almost all staff have studied and worked. Faculty members are active in research, have developed international collaborations and publish their research in high-impact journals.

2. Postgraduate Programme “Mathematics and Education”

The Postgraduate Programme of Studies (M.Sc.) entitled “Mathematics and Education” has started to operate in the academic year 2024-2025. The aim of the MSc is Mathematics and Education is to promote a high-level postgraduate education and knowledge, in areas of Mathematics related to Education (mainly secondary education), as well as in Mathematics Education. Graduates of the M.Sc. enhance their understanding of concepts and methodology at both theoretical and applied levels. They acquire a knowledge base to meet the needs of academic research and the labour market. The skills acquired relate to the development of critical thinking, problem solving, creativity, communication and cooperation.

Learning outcomes

Upon completion of the M.Sc. graduates will have knowledge and skills related to:

- awareness of how mathematical topics are related to mathematics in the school curriculum
- an advanced perspective on areas of undergraduate mathematics that relate to education

- the identification of different theoretical approaches to the teaching and learning of mathematics and how these can be used in teaching practice
- discernment and critically examination of research methodologies in Mathematics Education
- communication of research results in Mathematics and Mathematics Education to an audience
- familiarity with the use of new technologies in presentations and teaching practice
- critical reading of the literature in areas such as School Mathematics, Mathematics Education, Psychology and Pedagogy

Graduates awarded the M.Sc. in “Mathematics and Education”, are expected to have high training and specialisation in Mathematics relevant to education and in Mathematics Education. They are capable of continuing to further studies aiming at a doctoral degree, or they can get employed as executives in public and private education, in educational organizations, public services, private enterprises, and organisations (managers and supervisors of departments and offices, principals in secondary, and primary schools, executives at the Institute of Educational Policy, in central and regional services of the Ministry of Education, Research and Religious Affairs, etc.). In addition, graduates can work as trainers in Schools, Centres, or Institutes for the training of educators and to undertake the work of School Advisors. The program offers postgraduate studies of international level and trains scientific personnel who seek opportunities abroad for similar studies, research, and occupation.

3. Criteria for the selection of students

A. The postgraduate programme accepts graduates of Departments of Natural Sciences, Engineering Schools, Economics Schools, and Education Sciences Schools of domestic Universities and equivalent recognised institutions abroad, as well as graduates of other University Departments and former Technological Educational Institutes (T.E.I.) in relevant fields, as described in each announcement. If the candidates’ academic transcript does not demonstrate sufficient knowledge of Mathematics, the Evaluation Committee may request successful completion of undergraduate courses from the Department before enrollment in the M.Sc. program.

The number of students admitted in the M.Sc. programme per year is set at a maximum of sixteen (16) and a minimum of five (5). The call for admissions is posted on the Program's and Institution's website and is announced to other Higher Education Institutions in the country. The call includes the criteria and the procedure for the selection of candidates, the deadline for submitting applications and the method of submission, as well as the contact information of the administrative support service of the Programme.

B. Submission of Applications

The documents that must be submitted to the Postgraduate Studies Secretariat of the Department of Mathematics and Applied Mathematics are:

- Application for admission to the Postgraduate Program.
- Curriculum Vitae.
- Transcript of records.
- Copies of English language diplomas or other certificates, as specified in the respective announcement.
- Two (2) to three (3) recommendation letters from individuals who are personally familiar with the candidate's academic progress in undergraduate studies or professional activity relevant to the subject of the M.Sc. program.
- Any other supplementary qualifications that may be considered necessary by the candidates (e.g., additional academic degrees, scholarships (IKY), performance in exams (e.g., GRE, TOEFL), or academic competitions (Mathematical Society Competition, etc.).
- Brief description of the candidate's scientific interests.
- Copy of diploma or official certificate of completion of studies, if available. If the application is accepted, a prerequisite for enrollment in the M.Sc. program is the submission of a copy of the undergraduate degree certificate. If the undergraduate degree comes from an institution abroad, it should have been

assessed and recognised by the Interdisciplinary Organization for Recognition of Academic Titles & Information (D.O.A.T.A.P.), and this procedure is conducted by the M.Sc. Secretariat in accordance with the provisions of law 4957/2022.

- For enrollment in the M.Sc. program, it is necessary to submit, if required by law, certified copies of the above-mentioned documents.

C. Method of Submission

Applications, recommendation letters, and relevant documents are submitted electronically through the University's website.

Personal data is collected based on General Data Protection Regulation 2016/679 and remain available to the University of Crete for the duration of the studies of the students and even after their graduation for any future reference. During the period in which personal data remains available to the University, individuals have the right to access, correct, update, restrict processing in accordance with the terms of the General Data Protection Regulation 2016/679 (EU).

D. Process and Selection Criteria

The examination of applications is conducted by a committee appointed annually by the Department Assembly and consists of faculty members of the Department. The selection criteria considered are:

1. Overall performance of the candidate in courses,
2. Grades in courses relevant to the subject of the M.Sc. program,
3. Interview and/or written examinations,
4. University and Department where the candidate studied,
5. Any significant achievements during undergraduate studies,
6. Performance in any undergraduate thesis or postgraduate thesis,
7. Recommendation letters,
8. Proficiency in English or a second foreign language in addition to English,
9. Any other qualifications presented by the candidate in their application.
10. Other information or quantification the candidate may provide in their application.

E. Providing equal opportunities

The Department aims to provide equal opportunities in education and training. It ensures equal opportunities in the admission and completion of postgraduate studies without discrimination based on gender, color, nationality, religion, or personal status, in accordance with Greek legislation.

4. Duration of studies, extensions and suspensions

The duration of studies for the award of the Master's Degree is set at twelve (12) months, [paragraph 3, article 1, under the heading F5/89656/B3/13-8-2007 ministerial decision (B'1466)]. As the Postgraduate Program primarily targets active teachers, the format of the program that aligns with the needs of a large part of the students is an intensive annual program, during which they can utilise the school-holiday period to complete their thesis. The annual duration of the program also ensures the structure of the Master's Program with the writing of the thesis or the report of the Educational Activity after the evaluation of the courses of the spring semester. Extension and/or suspension of studies (up to one year each) may be granted by decision of the relevant bodies based on the reasons requested by the students according to the current legislation. There is the possibility of part-time attendance for working students, or in exceptional cases, for non-working students, upon decision of the relevant bodies, the maximum duration of which is two (2) calendar years.

5. Course Recognition

Upon application by the interested student and recommendation by the Coordinating Committee, the Department may recognise certain postgraduate courses for fulfilling the requirements of the postgraduate program of studies. This is done by determining the equivalent ECTS weight according to the applicable regulations. These courses must have been attended by the student at a university during their undergraduate or postgraduate studies. The total number of ECTS credits that can be recognised in this way cannot exceed 20 ECTS credits.

6. Master's Thesis

The completion of a master's thesis is not mandatory. Students who choose to undertake a thesis select their topic from the subject area of the postgraduate program. The thesis is carried out under the supervision and guidance of a supervisor and is examined by an Examination Committee. The thesis can be written in Greek or English and must include an abstract in the language of writing and an extensive summary in the other language.

The Coordinating Committee, upon the student's request, which includes the proposed title of the thesis, the proposed supervisor(s), and an attached summary of the proposed work, appoints the supervisor. For the evaluation and approval of the thesis, the Coordinating Committee forms a three-member Examination Committee. The supervisor is one of the three members, and all members must have the necessary qualifications according to the applicable regulations. Additionally, at least one member of the Examination Committee must be a faculty member of the Department in a related field.

The period from the approval of the thesis by the Coordinating Committee to its examination cannot be less than three months. The postgraduate student submits the thesis text to the members of the Examination Committee at least 15 days before the examination date. To be approved, the student must defend the thesis in public. The examination is oral and public, following this procedure: The student presents their work, followed by questions from the Committee members and then from the audience.

The Examination Committee members provide comments on the content of the thesis to the student, who must take these comments into account when finalising the text. Depending on the nature and extent of modifications or improvements, the Committee members may request to review the thesis text again or authorise the supervisor to give the final approval. The Committee members approve the final text and sign the evaluation report.

Finally, the postgraduate student submits two signed copies of the thesis: one to the Graduate Studies Office of the Department and one to the University Library. If the thesis has been financially supported by a scholarship, a third copy must be submitted to the Graduate Studies Office for delivery to the scholarship-granting organization. Additionally, the student submits the final thesis text in electronic form and a printed poster to the Graduate Studies Office. The theses are recorded in the University of Crete's Digital Library and posted on the Department's website.

7. Auxiliary teaching duties

Auxiliary teaching duties include all the various tasks (usually overseeing laboratories or teaching tutorials) assigned by the Department within the framework of conducting courses, examinations, and all educational processes.

8. Evaluation of Students

Each year, an evaluation of the performance of students is conducted by the Program's Coordinating Committee. If, by the end of two semesters, a full-time student has not successfully passed at least three (3) courses, their performance is considered unsatisfactory. In the case of unsatisfactory performance, the Coordinating Committee may recommend to the Steering Committee the student's dismissal.

The evaluation of student performance is the responsibility of the instructor of each course, in accordance with the applicable regulations. The grading scale for successful performance, in descending order, is: A+, A, A-, B+, B, B-, C+, C, C-. For unsatisfactory performance: D. Alternative methods will be applied for the evaluation of students with disabilities and special educational needs.

9. Evaluation of Teaching

The evaluation of postgraduate courses and instructors by postgraduate students is conducted through the completion of questionnaires in an electronic form.

10. Language of Instruction

The language of instruction for courses is Greek, and it may be English in cases where the course is attended by postgraduate students whose native language is not Greek. The language for writing the postgraduate thesis can be either Greek or English.

11. Academic Advisor

For each postgraduate student admitted to the M.Sc., the Department appoints an academic advisor, who is a member of the Department's faculty. The role of the academic advisor is to assist the postgraduate student in adjusting to the M.Sc., in course selection and in any academic issues that may arise during the postgraduate studies. In the case of a postgraduate thesis, after the appointment of a Supervisor by the Board, he/she assumes the role of academic advisor from then on.

12. Completion of Part of Studies through the ERASMUS Program

Students of the postgraduate programs of the Department of Mathematics and Applied Mathematics have the opportunity to complete part of their studies abroad to attend courses through the ERASMUS Program. Attendance of courses can take place at a selected higher education institution with which the University has established a bilateral agreement, and which the interested student can find on the Department's website. Each mobility occurs in one of the 30 European countries for a period of 3-6 months with full recognition of the mobility period. In the case of mobility for studies, students must enroll in courses that correspond to the postgraduate program's curriculum, thus allowing them to earn up to 30 ECTS per semester. On the Department's website, interested students can find a description of the relevant procedure and the selection and ranking criteria.

13. Student Welfare

The Student Welfare Office supports and promotes initiatives that assist students, foster their intellectual growth, and support their personal development. It also helps them explore and experience various aspects of student life.

Students at the University of Crete have the possibility to apply for free meals at the student restaurants. The selection of students is made on the recommendation of the relevant Committee, according to the current legislation, the financial resources of the University of Crete, and the students' ranking.

Students who are not eligible for free meals can dine at the student restaurants by paying approximately €3 per meal or using 7-day and 15-day meal cards priced at €14.25 and €30.50, respectively, which include breakfast, lunch and dinner, and which are provided by the restaurants.

For more information, please visit the website: <https://www.merimna.uoc.gr/index.php/el/>

14. University Gym

Since 2007, the University of Crete campus in Voutes, located in the city of Heraklion, has been home to a comprehensive sports center. This facility includes an indoor gymnasium with a seating capacity of 1,080 and a 25-meter indoor swimming pool with five lanes. Additionally, the University of Crete owns a full-size football field with artificial turf in the area of Agios Ioannis Knossos.

For more information, please visit the website: <https://unisport.uoc.gr/>

15. Transportation from the City of Heraklion to the Voutes University Campus

By Bus: There are regular bus services operated by the Heraklion Urban KTEL connecting various neighborhoods of the city to the Voutes University Campus.

By Car: The Voutes University Campus is located 8.5 kilometers southwest of the city center. To get there, head towards the Heraklion-Moires National Road and before completing the first kilometer, turn right at the traffic light after Estavromenos. There are signs directing you to the university from there.

By Taxi: For taxi information, you can visit the following websites:

<https://candiataxi.gr/>

<https://www.cretataxi.com/>

For more information, you can visit the university's websites:

<https://www.uoc.gr/university/traf/traf.html>

<https://visit.uoc.gr/xartes/>

16. Accessibility

Externally, there are special access routes for individuals with disabilities (PWD) to all buildings on the Voutes University Campus of the University of Crete.

Internally, aside from vertical transportation via common elevators, the Mathematics building features external access to lecture amphitheaters and dedicated spaces for PWD within the amphitheaters. Additionally, computer facilities have reserved desks for PWD, available on the upper level of the teaching amphitheaters.

There is direct accessibility to all classrooms of the Department. Automatic door opening is also available.

17. People

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REGULATIONS OF THE POSTGRADUATE PROGRAM "MATHEMATICS AND EDUCATION"

Program Requirements

A typical postgraduate course consists of 13 weeks of instruction, with a minimum of three (3) teaching hours per week. Classes are rescheduled by the instructors as necessary, with the corresponding announcements made by the administration office. For courses worth 10 ECTS, the total activity hours are estimated at two hundred and fifty (250) per course. A typical postgraduate course includes four (4) teaching hours per week, twelve (12) study hours per week, and forty-two (42) hours for exams (finals and midterms) and/or assignments, including preparation time.

The educational process of the postgraduate program is organised in-person. It is possible to offer one course per semester in a hybrid format: four intensive lecture periods during the semester, with online presentations for the remaining time.

Typically, the teaching of the program's courses is conducted in-person. It is possible that part of a course or an entire course is offered via synchronous distance learning; however, the credit hours corresponding to these cannot exceed twenty-five percent (25%) of the total ECTS credits of the postgraduate program.

Requirements for Obtaining the Master's Degree

The total number of ECTS credits required for the award of the M.Sc. is 75. To obtain the M.Sc., students must attend and successfully complete at least five (5) courses and complete a thesis, or attend and successfully complete at least six (6) courses. Students are required to successfully complete the Compulsory Courses and at least one course from each of Groups A, B, and C. Regular attendance throughout the duration of the studies is mandatory, as is the presentation of a lecture in the Z58 Seminar on Mathematics Education, which is credited with 3 ECTS at the end of the studies.

Detailed Study Program

(a) The program of courses consists of Compulsory Courses or Seminars, and Elective Courses, which are divided into three groups. The student is required to successfully complete the compulsory courses and at least one course from each group of Elective Courses. In addition to the postgraduate courses, students of the Postgraduate Program may participate in educational activities as part of their studies, fulfilling the corresponding obligations. Indicatively, the program is structured as follows:

1st Semester		
COURSES		ECTS
Mathematics Education 1		10
Elective Course		10
Elective Course		10
TOTAL		30
2nd Semester		
Elective Course		10
Elective Course		10
Elective Course	Start of Thesis	10
TOTAL		30
SUMMER PERIOD		
Elective Course or Educational Activities	Writing and Presentation of Thesis	12
Seminar on Mathematics Education		3
TOTAL		15
TOTAL PROGRAM		75

(b) The table below presents a list of Compulsory Courses and Elective Courses for the M.Sc. program. Elective Courses are categorized into Groups A, B, and C. Compulsory Courses belong to Group COMP. This list may be expanded by decision of the Department Assembly. It is adjusted and specified for each Academic Year by decision of the Department Assembly.

Code	Title of Course	ECTS	Group
Group A: Mathematics			
Z11	Analysis	10	A
Z12	Real Analysis	10	A
Z13	Complex Analysis	10	A
Z15	Algebra	10	A
Z16	Number Theory	10	A
Z17	Group Theory and Symmetry	10	A
Z18	Logic and Set Theory	10	A
Z21	Geometry – Euclidean and Non-Euclidean	10	A
Z22	Differential Geometry	10	A
Z23	Topology: Surfaces and Knots	10	A
Z25	Differential Equations	10	A
Z26	Modeling	10	A

Z27	Probability and Statistics	10	A
Z31	History of Mathematics until the 5 th century B.C.	10	A
Z32	History of Mathematics until the 6 th century B.C.	10	A
Z35	Philosophy of Mathematics	10	A
Z37.x	Study Course in Mathematics for Education	6 – 10 *	
Z39.x	Topics in Mathematics for Education	6 – 10 *	A
	Group B: Mathematics Education Courses		
Z51	Mathematics Education 1	10	COMP
Z52	Teaching of Calculus	10	B
Z53	Teaching of Arithmetic and Algebra	10	B
Z54	Teaching of Geometry	10	B
Z55	Teaching of Mathematics Using Technology	10	B
Z56	Mathematics Education 2	10	B
Z57.x	Study Course in Mathematics Education	6 – 10 *	
Z58	Seminar in Mathematics Education	3	COMP
Z59.x	Topics in Mathematics Education	6 – 10 *	B
	Group C: Education Science Courses		
Z60	Education Science	10	Γ
Z61	Cognitive Psychology	10	Γ
Z62	Developmental Psychology	10	Γ
Z65	Research Methodology in Education Sciences	10	Γ
Z67.x	Study Course in Education Sciences	6 – 10 *	
Z69.x	Topics in Education Sciences	6 – 10 *	Γ
	Other Educational Activities		
Z81	Start of Thesis	10	
Z82	Writing and Presentation of Thesis	7	
Z85	Teaching Assistant Duties	2	
Z86	Educational Activity	2 – 10 *	

- The teaching hours and ECTS credits of the courses Topics in Mathematics for Education, Topics in Mathematics Education, and Topics in Education Science, Educational Activity, and the corresponding Study Courses are determined according to the content of each course. For example, the course Z86 Educational Activity may include a small-scale research study, development of educational materials, outreach activities, science communication activities, etc. By decision of the Department Assembly, the course list may include: (i) postgraduate courses from other M.Sc. programs of the University of Crete, provided that they have relevant or complementary content to equivalent courses of the present M.Sc. program, (ii) postgraduate courses offered by either a domestic or an international university, within the framework of cultural exchange programs (e.g., Erasmus), where the student can participate, (iii) postgraduate-level courses that the student can attend as part of a school or series of lectures, for which ECTS credits are awarded. Below the courses offered in the Master's Program are described:

Course Description

(Detailed descriptions are provided [here](#))

Z11 Analysis

Real numbers. Real functions. Monotonic functions, continuity of monotonic functions, indefinite integrals of monotonic functions, differences of monotonic functions. Differentiability of monotonic functions. Subsets of \mathbb{R} . Behavior of random functions. Continuity. Continuous functions. Darboux continuous functions. Semi-continuous functions. Continuity and Riemann integrability. Differentiation. The example of Katznelson and Stromberg. The set $A(\mathbb{I})$. The fundamental theorem of Calculus. The Cantor set. The Cantor function.

Z12 Real Analysis

Measures and outer measures, Lebesgue measure and more generally Borel measures, measurable functions, Lusin's theorem, integration, Lebesgue and Lebesgue-Stieltjes integrals, product measure and multiple integrals, Tonelli and Fubini theorems, convergences (pointwise, mean, in measure, almost uniform), signed and complex measures, Hahn, Jordan, and Lebesgue decompositions (absolutely continuous and singular measures), Hardy-Littlewood maximal function, Lebesgue differentiation theorem, Radon-Nikodym derivative, L_p spaces and their duality.

Z13 Complex Analysis

Topology of the complex plane, extended complex plane. Limits and continuity of functions, series of numbers and functions. Derivative and holomorphy, Cauchy-Riemann equations. Special functions. Contour integrals. Cauchy's theorem. Cauchy's integral formula. Cauchy estimates, Liouville's theorem, the fundamental theorem of algebra. Maximum modulus principle, open mapping principle, winding number, homotopy. Chains and cycles (of curves), homology. Residue theorem, (computations of integrals), meromorphic functions, argument principle, Rouché's theorem. Riemann mapping theorem, conformal automorphisms of the disk and the upper half-plane.

Z15 Algebra

The course aims to provide insight into fundamental areas of modern algebra and to connect basic algebraic concepts with teaching. Theory of polynomials in one and several variables. Group theory. Symmetry. Field theory, algebraic extensions of fields. Galois theory, fundamental theorem of Galois theory. Constructible numbers.

Z16 Number Theory

Integers and rational numbers. Arithmetic functions. Euler's and Möbius' functions. Linear congruences. Algebraic congruences. Primitive roots. Indices. Legendre's and Jacobi's symbols. Fibonacci numbers. Lucas sequences. Continued fractions. Pell's equation. Introduction to the theory of quadratic forms. Applications of Number Theory in factorization and cryptography.

Z17 Group Theory and Symmetry Groups

Symmetries of regular polygons. Group representations. Isometries of the Euclidean plane. Geometric types of isometries. Structure and representations of the group of isometries of the Euclidean plane. Stabilizers and transitivity. Subgroups of the group of isometries of the plane. Discontinuous groups. Symmetries of bands. Regular tessellations of the Euclidean plane. Triangle groups. Regular polyhedra in Euclidean space.

Z18 Logic and Set Theory

Propositional Logic, truth tables, logical consequence, tautologies, formal proofs, the Completeness Theorem and Compactness Theorem for Propositional Logic. Predicate Logic, first-order languages, interpretations (models), interpretation of types and propositions, formal proofs. Completeness and Compactness Theorems in Predicate Logic. Recursive functions. The intuitive notion of "set," Zermelo-Fraenkel axioms, power sets, construction of natural numbers, ordinal numbers and their arithmetic, transfinite induction, cardinals, Axiom of Choice, Axiom of Continuum.

Z21 Geometry – Euclidean and Non-Euclidean

Study of Euclidean, Parabolic, Projective, and Hyperbolic Geometry, mainly in two dimensions, with emphasis on transformations that preserve the distinctive characteristics of each geometry. Transformations of Euclidean Geometry. The homoparallel plane and its transformations. Ceva's and Menelaus' Theorems. The projective plane and its transformations. Desargues' Theorem, Pappus' Theorem. Double ratio. The hyperbolic plane. Möbius transformations. Invariant sets. Hyperbolic distance. Hyperbolic triangles. Inversive geometry. Geometric inversion in a circle.

Z22 Differential Geometry

Differentiable curves. Curve reparameterization. Curvature and torsion of a curve. The Frenet frame. Surfaces. Differentiable maps on surfaces. The tangent plane and the differential of a map. The first fundamental form. The shape operator and the second fundamental form. Normal curvature, principal curvatures, and their geometric interpretation. Umbilical points. Gaussian curvature. Isometries. Inner distance and internal properties of surfaces. Gauss's Theorema Egregium. Geodesics. Length minimization. Geodesics in spherical and hyperbolic geometry. Brief mention of: Differentiable Manifolds, differentiable maps. The tangent space and the tangent bundle. Submanifolds. Vector fields. Riemannian metrics. Geodesics and normal charts on Riemannian manifolds.

Z23 Topology: Surfaces and Knots

Introduction to Topology: Topological space. Continuous maps. Homeomorphisms. Hausdorff property. Compactness. Connectedness. Quotient space. Homotopy: Homotopic maps. Homotopy type. Fundamental group: Construction of the fundamental group. Examples and applications. Free groups and free products. Seifert-Van Kampen theorem. Covering spaces: Basic concepts and examples. Elements of Knot Theory: Definitions. Knot isotopy. Invariants. Jones polynomial. Alternating knots. Applications in Chemistry and Biology. Surfaces. Orientability. Triangulation. Fundamental group of surfaces. Classification of surfaces.

Z25 Ordinary Differential Equations

Local existence of solutions (Picard-Lindelöf and Peano). Uniqueness of solutions. Smooth dependence of solutions on data - parameters. Linear systems: Fundamental solutions, constant and non-constant coefficients, asymptotic behavior of solutions. Asymptotic behavior of nonlinear equations. Stability and instability of solutions. Linearization. Lyapunov-like functions for stability analysis. Poincaré - Bendixson, existence of periodic solutions. Elements of bifurcation theory in one and two dimensions. Phase diagrams for autonomous systems.

Z26 Modeling

Definition of Mathematical Modeling. Methodology for approaching a real-world problem: understanding the described situation, constructing a mathematical model, working on the mathematical model, interpreting the results in the real environment, and evaluating the outcome. Examples of teaching units on modeling using Geometry. Examples of teaching units on modeling using Algebra. Examples of teaching units on modeling using Analysis. Developing skills for successful modeling. Use of software for problem modeling. Theoretical approaches related to the introduction of modeling in Mathematics Education.

Z27 Probability and Statistics

Historical evolution of the concepts of uncertainty and probability. Mathematical foundation of Probability Theory. Basic principles of combinatorics and application in probability calculations. Conditional probability, independence, law of total probability, and Bayes' theorem. Random variables and distributions: Discrete and continuous random variables, mean, variance, moments, moment-generating function. Special distributions and applications: Binomial, Geometric, Poisson, etc. Descriptive statistics: graphical and numerical methods for data description. Basic principles of estimation: maximum likelihood estimators, moment estimators, confidence intervals. Hypothesis testing: Formulation of hypotheses, types of errors, test statistic, decision rules. Linear regression and analysis of variance: Assumptions of linear models, least squares estimators, applications in statistical research.

Z31 History of Mathematics until the 5th Century BC

Egyptian and Babylonian Mathematics. Greek Mathematics. Thales, Pythagoras, the famous problems of ancient Greek mathematicians. Theaetetus, Eudoxus. Euclid's Elements. Hellenistic mathematics after Euclid. Apollonius. Archimedes. Summary of the history of mathematics after the Hellenistic period. Diophantus, Ptolemy, Pappus, Proclus.

Z32 History of Mathematics after the 6th Century AD

Brief overview of mathematics in China and India. Arabic mathematics and the Western Middle Ages. Mathematics during the Renaissance, especially with Cardano, Tartaglia, and Ferrari. The beginning of modern mathematics: Vieta, Napier, Briggs, Galileo, Kepler, Cavalieri. Special study of the time of Fermat and Descartes. Various topics at the discretion of the instructor about the forerunners of Calculus, Newton and Leibniz, the mathematicians of the time of Bernoulli, and Euler, Lagrange, Gauss, Cauchy, etc.

Z35 Philosophy of Mathematics

Mathematics, science, philosophy: why does the question of a philosophy of mathematics arise? The Conceptual Notation of Gottlob Frege. Axiomatization in arithmetic, geometry, and set theory. The concept of a formal/standardized system. The "historical" schools of the Foundations of Mathematics: Frege, Russell, Hilbert, Brouwer, etc. The restructuring of the philosophical problems of mathematics from 1930 onwards. Mathematical realism or mathematical Platonism. Indispensability arguments by Quine and others. Contemporary perspectives on the philosophical problems of mathematics.

Z37.x Course Study in Mathematics Education

The content of the course can be determined by the instructor in relation to the needs of the students of the postgraduate program.

Z39.x Topics in Mathematics for Education

The content of the course can be determined by the instructor in relation to the needs of the students of the postgraduate program.

Z51 Mathematics Education I

Behaviorism, Constructivism, teaching contract, Theory of Didactical Situations. Vygotsky, zone of proximal development, play. Contextualised learning, types of uncertainty, negotiation, intersubjectivity, meaning construction. Classroom practice. Proof, deductive reasoning, argumentation, Lakatos, generic examples. Problem-solving, heuristics, realistic mathematics education, intuition. Mathematical literacy, creativity, talent,

and high ability in mathematics. Historical evolution of algebra and epistemological issues. Activity theory. Representations of mathematics in society.

Z52 Teaching of Calculus

The concept and importance of representation, changing representations, connecting representations. Signifier, signified, mathematical object. Concept image and concept definition. Teaching Knowledge. Teaching and learning of real numbers, infinity, functions, limit, continuity, derivative, integral. Content analysis of school textbooks. Storytelling and mathematical problem posing. Study of research papers and teaching issues for secondary and tertiary education.

Z53 Teaching of Arithmetic and Algebra

The role of algebra in mathematics education. Development of algebraic thinking and teaching approaches to algebra concepts. The transition from arithmetic to algebra, the nature of algebra. The concept of variable and functional relations. Function as mapping and covariation. Designing activities for teaching algebra in secondary education. Modeling realistic situations. Proof in algebra and teaching approaches.

Z54 Teaching of Geometry

Euclidean Geometry in education. The three models of Geometry. Levels of geometric thinking. The importance of definitions in Geometry. Theory of representations in teaching Geometry. Euclid's Elements. Historical development of the concept of plane. Hilbert's axioms for Euclidean Geometry. The parallel postulate. Non-Euclidean Geometry. Modern branches of Geometry and their applications, and their place in education. Teaching and learning proof within the context of "authentic mathematics." Teaching and learning geometric constructions. The use of Dynamic Geometry software. The position of Geometry in curriculum frameworks.

Z55 Teaching Mathematics Using Technology

Digital technologies for mathematics: Computer Algebra Systems, Dynamic Geometry Systems. Designing activities using digital tools, the concept of exploratory activities, connecting representations and mathematical concepts. Instrumental genesis, dragging modalities, semiotic mediation, resources. The classroom and digital technologies, classroom orchestration, the role of the teacher. The knowledge and support of the teacher (TPACK). Pedagogical reflections and trends of the 21st century.

Z56 Mathematics Education II

Positivism and critiques. The political and social turns in mathematics education. Teaching practice and knowledge. Structuralism and poststructuralism. Theory of Discourse and genealogy. Discourse analysis. Commognition. Inclusion, equity, identity. Utilising research in teaching practice. Study and discussion of research topics related to algebra, geometry, analysis, probability, and statistics in secondary and tertiary education.

Z57.x Study Course in Mathematics Education

The content of the course can be determined by the instructor in relation to the needs of the students.

Z58 Seminar on Mathematics Education

Regular and active attendance to talks in Mathematics and Education throughout the duration of the studies. Presentation of an hourly lecture on a topic related to research in Mathematics Education.

Z59.x Topics in Mathematics Education

The content of the course can be determined by the instructor in relation to the needs of the students of the Postgraduate Program.

Z60 Pedagogy

The aims of the school. Pedagogical, social, and economic functions of the school. Contemporary theories of education and the role of the teacher. Contemporary theories of learning. Elements of organisation and planning of teaching, aspects of evaluating teaching practices and students. Psychopedagogical problems. Issues of intercultural education. Technology and education. Education and social reproduction. The contemporary school and humanistic education.

Z61 Cognitive Psychology

Architecture of the cognitive system, principles governing its operation. Representation and organisation of knowledge. Theories of knowledge reorganisation. Brain structure underlying cognitive functions. Perception and Language. Attention and Performance (performing multiple cognitive tasks). Memory: structure, function, models, memory dysfunctions. Learning and Long-Term Memory. Knowledge in semantic memory (concepts and concept formation). Problem-solving (strategies, past experience, insight). Judgment, decision making, and reasoning. Learning, Emotion, and Motivation. Interaction of cognitive processes with emotions.

Z62 Developmental Psychology

Basic theories of development: Sigmund Freud and Eric Erikson. The prenatal environment. The biopsychomotor, cognitive, and linguistic development of infants. The course of affective development. Attachment evolution and types. Cognitive and linguistic development in early childhood. Gender role identity. Cognitive and psychosocial development in school-age and adolescent years.

Z65 Research Methodology in Educational Sciences

Overview of research literature. Referencing styles. Research topic, research problem, and research questions. Sampling. Research designs: Survey, educational experiment, ethnography, case study, action research, grounded theory, mixed methods. Criteria for research quality. Quantitative data collection. Qualitative data collection. Quantitative data analysis. Contemporary methodological approaches to qualitative data analysis. Interpretation in qualitative data analysis. Research ethics. Writing literature reviews and research proposals.

Z67.x Study Course in Educational Sciences

The content of the course can be determined by the instructor in relation to the needs of the students of the Postgraduate Program.

Z69.x Topics in Educational Sciences

The content of the course can be determined by the instructor in relation to the needs of the students of the Postgraduate Program.

Z81 Start of Thesis

Selection of the topic for the thesis, within the thematic area of the subject of the Postgraduate Program. Writing a proposal for approval to start the work, which includes the proposed title of the thesis, the proposed supervisor(s), and an abstract of the proposed work. Work under the supervision and guidance of the supervisor.

Z82 Writing and Presentation of Thesis

This involves the writing of the thesis. For the thesis to be approved, the student must defend it before the Examination Committee. The examination of the thesis is oral and in public according to the following procedure: The student presents their work. This is followed by questions from members of the Examination Committee and then from the audience. Members of the Examination Committee may submit any comments on the content of the work to the student, who must take into account the Committee's comments in shaping the final text. The final text of the thesis is in electronic format and is accompanied by a printed poster.

Z85 Teaching Assistant Duties

Teaching duties include all individual tasks (usually supervision of laboratories or tutoring) assigned by the Department within the framework of conducting courses, examinations, and all educational procedures.

Z86 Educational Activity

The activity may include small-scale research, writing educational materials, outreach activities, and science communication activities in mathematics according to the needs of the students of the Postgraduate Program and the availability of instructors.