Faculty of Pure and Applied Sciences

DEPARTMENT OF MATHEMATICS AND STATISTICS

ACADEMIC FACULTY

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OBJECTIVES

The famous Platonic inscription "let no one ignorant of geometry enter" has been adopted, directly or indirectly, by all universities in the world and, appropriately, the Department of Mathematics and Statistics was one of the departments with which the University of Cyprus commenced its operation in 1992. The primary aim of the Department is the promotion, through scientific research and teaching, of the Mathematical Sciences.

The achievement of this aim is inextricably linked with the need to produce well-trained scientists who will contribute to the continuation of the cultural and economic progress of Cyprus. Because of the pivotal role of Mathematics and Statistics for Science, it is necessary to create a department of high calibre.

Important steps in achieving this ambition are the development of links with corresponding institutions abroad and the creation of high-level programmes of studies. The undergraduate programme started in September 1992.

The Department of Mathematics and Statistics offers two undergraduate degree programmes:

- Bachelor in Mathematics and Statistics
- Bachelor in Mathematics
  - Specialisation in Applied Mathematics
  - Specialisation in Pure Mathematics

PROGRAMME OF STUDY

The curriculum is divided into four levels and six groups. Level 101-199 corresponds mainly to courses of the first year of studies, level 201-299 corresponds mainly to courses of the second year of studies, level 301-399 corresponds mainly to courses of the third year of studies, and finally, level 401-499 corresponds mainly to courses of the fourth year of studies. Level 001-099 corresponds to service courses (see Table B) and are not open to Mathematics or Statistics majors (except MAS 007; see Degree Requirements).

The six groups into which the courses are divided correspond approximately to the following areas of Mathematics: Analysis, Algebra, Geometry, Probability/Statistics, Numerical Analysis and Applied Mathematics. The second digit of the course number determines the area of mathematics that the course belongs to. The characteristic digit (second digit of course number) of the six areas are 0 & 1, 2, 3, 5 & 6, 7 and 8, respectively, and they appear in table A.

DEGREE REQUIREMENTS

The degree in Mathematics or Mathematics and Statistics requires 240 ECTS obtained from the following courses:

1) Fifteen compulsory courses for all students (see Table A)

MAS 101 Calculus I
MAS 102 Calculus II
MAS 121 Linear Algebra I
MAS 122 Linear Algebra II
MAS 131 Basic Mathematics
MAS 191 Mathematics with Computers
MAS 202 Multivariate Integral Calculus
MAS 203 Ordinary Differential Equations
MAS 211 Multivariate Differential Calculus
MAS 261 Introduction to Probability
MAS 262 Introduction to Statistics
MAS 271 Numerical Analysis I
MAS 301 Real Analysis
MAS 302 Complex Analysis I
MAS 331 Classical Differential Geometry

2) Two courses from the following:

MAS 303 Partial Differential Equations
MAS 304 Functional Analysis
MAS 371 Numerical Analysis II

3) Course CS 031 Introduction to Programming (7 ECTS)

4) 15-25 ECTS must be elective courses from other departments.

These departments should be from three different faculties. Only one first-level foreign language course can be chosen as an "elective course".

5) Students are required to take two foreign language courses (in any language)

6) Nine courses according to the areas of specialisation:

(a) Specialisation: Degree in Mathematics and Statistics

MAS 350 Stochastic Processes
MAS 361 Probability Theory
MAS 362 Theory of Statistics
MAS 451 Linear Models I
MAS 452 Linear Models II
MAS 454 Nonparametric Statistics
MAS 455 Sampling Theory
MAS 456 Time Series
MAS 458 Statistical Data Analysis
MAS 459 Multivariate Analysis

MAS 466 Survival Analysis
MAS 468 Topics in Probability-Statistics I
MAS 469 Topics in Probability-Statistics II

The remaining two courses may be in any area of specialisation.

(b) Specialisation: Degree in Mathematics
• Pure Mathematics

PHY 111 General Physics I
MAS 321 Introduction to Algebra
MAS 433 Introduction to Algebraic Topology

The remaining six courses may be in any area of specialisation.

• Applied Mathematics

PHY 111 General Physics I
MAS 303 Partial Differential Equations
MAS 304 Functional Analysis
MAS 371 Numerical Analysis II

Selection of at least three courses from the list below:
(a) MAS 471 Numerical Solution of Ordinary Differential Equations
(b) MAS 472 Numerical Solution of Partial Differential Equations
(c) MAS 481 Applied Mathematical Analysis
(d) MAS 482 Classical Mechanics
(e) MAS 483 Fluid Mechanics

The remaining four courses may be in any area of specialisation.

Students choose their area of specialisation during the fall semester of their third year of studies. Students who wish to change their specialisation, must submit a written request to the Chairman of the Department before the beginning of the semester in which they wish this change to take effect.

At most two elective courses within the Department may be substituted, in exceptional cases and during the last year of studies, by graduate courses. In this case, a grade average of at least 8.5 in the departmental courses as well as the approval of the instructor and the academic advisor are required.

Students can complete their studies with more than 240 ECTS depending on the elective courses, within and out of the Department, that they choose to take.

Indicative programmes of study for the Degree in Mathematics with emphasis in Pure Mathematics, with emphasis in Applied Mathematics and for the Degree in Mathematics and Statistics are given in Tables C1, C2 and C3, respectively.

Two of the elective courses from other departments could be substituted by MAS 007 History of Mathematics (5 ECTS) and MAS 499 Independent Study (7 ECTS).

MINOR PROGRAMME OF STUDY

The requirements for the minor in Mathematics are the successful completion of eight courses which must include the courses: MAS 101, MAS 102, MAS 121, MAS 131, MAS 251 or MAS 252, MAS 271, MAS 007 and an additional course of 7 ECTS.

DESCRIPTION OF COURSES

MAS 101 Calculus I (8 ECTS)

Properties of real numbers. The basic properties of supA, infA. Sequences of real numbers, limits of sequences. Real valued functions, the inverse of a function, limits of functions, continuous functions, uniform continuity, the Intermediate Value Theorem, the Extreme Value Theory. Derivatives, graphs of functions, the Mean value theorem, L'Hopital's rule.

MAS 102 Calculus II (8 ECTS)

Riemann integral, integrability of continuous, monotone functions. The fundamental theorem of calculus. Areas of regions in the plane, volumes of solids of revolution. The indefinite integral, integration by parts, integration by change of variables, integration of rational functions. Taylor's formula. Infinite series, tests of convergence, absolutely convergent series, conditionally convergent series, Leibniz's Theorem, product of series.

MAS 121 Linear Algebra I (8 ECTS)

Numbers, equivalence relations. Groups, Examples (symmetric, cyclic, dihedral). Isomorphism. Rings and Fields. Examples. Vector spaces, basis, dimension. Linear maps. Matrices and linear maps. Rank, change of basis matrix. Determinant. Linear systems.

MAS 122 Linear Algebra II (8 ECTS)

Polynomial Ring. Eigenvalues, eigenvectors. Diagonalisation and applications. Theorem of Cayley – Hamilton, minimal polynomial. Generalised eigenspaces, nilpotent endomorphisms, Jordan canonical form. Inner product spaces (Gram – Schmidt). Orthogonal, self dual endomorphisms. Bilinear, quadratic forms.

MAS 131 Basic Mathematics (8 ECTS)

Methods and applications of differentiation. Methods of integration and applications. Improper Integrals. Power series. Fourier series. Elements of analytic geometry on the place and in space. Functions and surfaces. Polar coordinates. Partial derivatives and Lagrange multipliers. Multiple integration and Jacobien.

MAS 191 Mathematics with Computers (8 ECTS)

Preliminaries: Basic Matlab commands. Matlab as a programming language. Real and complex numbers, vectors, matrices. Representation of numbers, vectors and matrices. Simple Matlab programmes. Matrices: General notions. Matrix operations with Matlab. Computation of determinants and inverses. Eigenvalues

and Eigenvectors: General notions of Eigenvalues and Eigenvectors. Computation of them with Matlab. Special emphasis on the complex case. Diagonal table matrices. Plots with Matlab: Simple plot, two- and three- dimensional plots. Special plots: Phase planes, contour plots, flows. Linear on OPES. Special topics on differential equations. Multivariate calculus. Fast Fourier Transform.

MAS 201 - Multivariate Differential Calculus (8 ECTS)

Spaces with norm (examples, n- dimensional Euclidean space, equivalent norms, Cauchy – Schwarz inequality). Open, closed sets, limits, continuity. Compactness (Theorem of Heine – Borel, Bolzano – Weierstrass). Vector valued functions of one real variable. Partial derivates. Total differential. Mean value theorem, Taylor's Theorem. Implicit and inverse function theorems. Lagrange multipliers.

MAS 202 Multivariate Integral Calculus (8 ECTS)

Integration of continuous functions with compact support. Transformation theorem. Integrable functions and sets, properties. Volumes. Theorem of Fubini. Convergence theorems. Transformation Theorem, applications. Parameterised surfaces, partition of unity. Surface and curve – integrals. Differential forms. Theorem of Stokes, applications.

MAS 203 Ordinary Differential Equations (8 ECTS)

Basic notions. Solution techniques for first-order equations and physical applications. Theorems of Existence and Uniqueness. Linear systems and exponential of matrices. Higher order linear equations. Method of power series: Smooth and singular solutions. Smooth dependence of solutions on parameters.

MAS 223 Number Theory (7 ECTS)

Divisibility theory in the integers. The Euclidean algorithm. Primes and their distribution. The fundamental theorem of arithmetic. The theory of consequences. Fermat´ s little theorem. The quadratic reciprocity law. Perfect numbers. Representation of integers as sums of squares. Fibonacci numbers. Continued fractions. Pell´ s equation.

MAS 261 Introduction to Probability (8 ECTS)

Probability, random variables, distribution functions, independence, expected value, moment generating functions, random rectors, conditional distribution, conditional expected value, laws of large numbers, central limit theorem.

MAS 262 Introduction to Statistics (8 ECTS)

Statistics. Sufficiency and completeness. Exponential families of distributions. Unbiasedness, unbiased estimators. Cramer – Rao inequality. Method of moments, maximum likelihood estimators, confidence intervals, hypothesis testing.

MAS 271 Numerical Analysis I (8 ECTS)

Propagation and estimation of errors: Floating-point arithmetic - Rounding error analysis - Loss of significance - Stability and condition of problems and algorithms - The symbolism - Richardson extrapolation. The solution of nonlinear equations: Fixed-point iteration - Order of convergence and asymptotic error constant - The Newton and the secant methods - Multiple roots - Always convergent methods (the bisection and the regula falsi methods) - Aitken´s acceleration process. Solution of linear systems: Direct methods (Gauss elimination and LU-decomposition) - The need for partial pivoting and for scaling - Cholesky´s method for symmetric and positive definite systems - The computation of the determinant and the inverse of an nxn matrix - the least squares method for over-determined systems. Interpolation and quadrature: Lagrange interpolation (Existence and uniqueness - Cardinal and Newton representations of the interpolating polynomial - The error of the interpolating polynomial) - Hermite interpolation (Existence and uniqueness - Cardinal representation of the interpolating polynomial - The error of the interpolating polynomial) - Newton-Cotes quadrature rules - The precision of a quadrature rule - Detailed description and analysis of the trapezoidal and the Simpson rules - Composite rules.

MAS 301 Real Analysis (8 ECTS)

The real number system R, the least upper bound property and its consequences. Countable and uncountable sets. The Cantor ternary set. Introductory theory of metric spaces. The metric spaces R and R^n. Compact sets. Heine – Borel Theorem, Bolzano – Weierstrass Theorem. Sequences of real numbers, limit superior and inferior of a sequence. Cauchy sequences, series of real numbers. Complete metric spaces, Cantor intersection Theorem, the fixed point Theorem and applications. Continuous functions. Topological characterisation of continuity. Continuity and compactness. Uniform continuity, Lipschitz functions. Sequences and series of functions. Pointwise convergence, uniform convergence. Uniform convergence and continuity, uniform convergence and integration, uniform convergence and differentiation. The space C ([a,b]), the topology of uniform convergence.

MAS 302 Complex Analysis I (8 ECTS)

Complex numbers, Basic complex functions, Cauchy- Riemann equations, holomorphic functions, harmonic functions. (Exponential, trigonometric and logarithmic functions). Contontintegration, Cauchy's theorem, Cauchy's integral formula. Morera's theorem, Liouville's theorem, the fundamental theorem of algebra. The Maximum modulus theorem. Taylor series, Laurent series, calculus of residues. Conformal mapping, linear fractional transformation.

MAS 303 Partial Differential Equations (7 ECTS)

Separation of variables – Fourier series. First order Partial Differential Equations. Nonlinear first order Partial Differential Equations. Linear second order Partial Differential Equations. Elliptic, Parabolic and Hyperbolic Partial Differential Equations.

MAS 304 Functional Analysis (7 ECTS)

Metric spaces: Examples and elements of the theory of metric spaces. Banach spaces: Norm, dimension and compactness, bounded operators, linear functionals, dual space, the spaces lp, $1 \leq p \leq \infty$, Hilbert spaces: Inner products, orthogonal sums, orthonormal bases, the Riesz representation theorem, the adjoint operator, self – adjoint, unitary and normal operators. Fundamental theorems for Banach spaces: the Hahn–Banach theorem, reflexive spaces, the uniform boundedness theorem, weak and strong convergence, the open mapping and closed

graph theorems. Applications: The fixed point theorem and its applications to the theory of linear, integral and differential equations, applications to the theory of approximation.

MAS 321 Introduction to Algebra (7 ECTS)

Basic properties of groups. Cayley's theorem. Subgroup and Lagrange's theorem. Normal subgroups and factor groups. First isomorphism theorem. Group actions. Basic properties of rings. Ideals. R – modules over principal ideal domain and the fundamental theorem of finitely generated abelian groups.

MAS 331 Classical Differential Geometry (8 ECTS)

Curves in Rn (length, orientation, parameterisation). Curves in R2 (normal field, curvature, Frenet equations). Curves in R3 (curvature, torsion, Frenet equations). Surfaces in R3: Parameterisation, tangent space, first and second fundamental form, Curvature, geometric interpretation of curvature, examples. Inner geometry of surfaces (local isometry, Christoffel symbols, Theorema Egregium, vector fields, parallel transport, geodesics). Theorem of Gauss – Bonnet.

MAS 350 Stochastic Processes (7 ECTS)

Basic concepts, continuous and discrete time Markov processes, birth and death processes, Poisson processes, introduction to martingales, Brownian motion.

MAS 361 Probability Theory (8 ECTS)

Measure spaces and σ-algebras, stochastic independence, measurable functions and random variable, distribution functions, Lebesque integral and mean value, convergence of sequences of random variables, laws of large numbers, characteristic function, central limit theorem, conditional probability, conditional mean value.

MAS 362 Statistical Theory (7 ECTS)

Stochastic convergence, asymptotic properties of moment estimators and maximum likelihood estimators, asymptotic normality and efficiency, hypothesis testing, asymptotic properties and efficiency of tests.

MAS 371 Numerical Analysis II (7 ECTS)

Preliminaries: Basic definitions and theorems of Linear Algebra – Lagrange and Hermite interpolation – Newton-Cotes quadrature rules. Vector and matrix norms: Basic definitions and properties – Induced matrix norms – Perturbed linear systems (perturbation analysis) – Condition of linear systems – Iterative refinement. Methods for eigenproblems: The Gershgorin theorems – The Rayleigh quotient – The power and inverse iteration methods – Similarity transformation methods (Givens and Householder for symmetric matrices – Basic forms of the LR and the QR algorithms) – Sturm sequence property for the eigenvalues of symmetric tri-diagonal matrices. Iterative methods for linear systems: General iterative methods – The methods of Jacobi, Gauss-Seidel and SOR – Convergence theorems – Asymptotic rate of convergence – Introduction to the theory for the optimum SOR relaxation parameter. Orthogonal polynomials and Gauss quadrature rules: Zeros of orthogonal polynomials – Three-term recurrence relation – Legendre, Chebyshev, Laguerre, Hermite and Jacobi polynomials – Gauss quadrature rules (Legendre, Chebyshev, Laguerre, Hermite and Jacobi.)

MAS 401 Measure Theory and Integration (7 ECTS)

General revision: Sets, orderings, cardinality, metric spaces. Measures: Algebras and σ- algebras, additive and σ- additive measures, outer measures, Borel measures on the real line. Integration: measurable functions, integration of positive functions, integration of complex valued functions, modes of convergence, product measures, the n – dimensional Lebesgue integral, integration in polar coordinates, signed measures, the Radon – Nikodym theorem, complex measures, differentiation on Euclidean space, functions of bounded variation. L^P Spaces: The basic theory, the dual of L^P , the useful inequalities, the distribution function, weak – L^P spaces, interpolation.

MAS 402 Complex Analysis II (7 ECTS)

Compactness and convergence in the space of analytic functions. The space of meromorphic functions. Riemann mapping theorem. Weierstrass factorisation theorem. Analytic continuation (Schwarz reflection principle, Monodromy theorem). Entire functions. Elements of Geometric theory.

MAS403-Ordinary Differential Equations II

Asymptotic behaviour of nonlinear systems of ODEs: Stability. Perturbation Theory of systems of ODEs which possess periodic solutions. Perturbations of two-dimensional autonomous systems. Poincaré-Bendixson theory.

MAS 418 Introduction to Fourier Analysis (7 ECTS)

Inner products, Hilbert spaces, orthogonal systems, completeness, periodic functions, trigonometric polynomials, Fourier series, pointwise convergence, the Dirichlet theorem, Gibb's phenomenon, Parseval theorem, Cesàro and Abel summability, the Fejer and Poisson theorems, the Riemann – Lebesgue Lemma, convergence of special trigonometric series, the local Riemann theorem. Differentiation and integration of Fourier series, Fourier transform, Plancherd's formula, convolution, applications to Partial Differential Equations.

MAS 419 Topics in Analysis (7 ECTS)

Topics from real analysis, complex analysis, harmonic analysis or differential equations.

MAS 422 Introduction to Coding Theory (7 ECTS)

Introduction to finite fields. Vector spaces over finite fields. Linear codes. Encoding and decoding with a linear code. Syndrome decoding. Hamming codes. Cyclic codes.

MAS 424 Theory of Rings and Modules (7 ECTS)

Rings and ideals. Homomorphism theorems. Unique factorisation domains and principal ideal domains. Factor rings. Prime and maximal ideals. R-modules and homomorphisms. Finitely generated R-modules. Noetherian rings.

MAS 425 Theory of Groups (7 ECTS)

Generators and relations. Homomorphism theorems. Direct and semidirect products. Group actions. Sylow theorems and p – groups. Simple groups. Composition series and the Jordan – Hölder theorem. Soluble and nilpotent groups.

MAS 426 Galois Theory (7 ECTS)

Polynomial rings, irreducible polynomials. Field extensions and splitting fields. Automorphisms and fixed fields. Normal extensions and Galois extensions. The fundamental theorem of Galois theory. Solution by radicals.

MAS 427 Group Representation Theory (7 ECTS)

Representations. FG - modules, FG - submodules, FG - homomorphisms. Maschkeãs Theorem and Schurãs Lemma. Irreducible modules. The group algebra, the centre of the group algebra. Characters, relation between characters and representations.

MAS 429 Topics in Algebra (7 ECTS)

Topics from Algebra.

MAS 431 Introduction to Differentiable Manifolds (7 ECTS)

Manifolds, Tangent space. Partition of unity. Theorem of Sard. Vector fields, flows. Frobenius Theorem. Differenital forms. Theorem of Stokes. De Rham Theorem.

MAS 432 Introduction to Riemannian Geometry (7 ECTS)

Riemannian manifolds. Geodesics, exponential map, normal coordinates. Gauss lemma. Theorem of Hopf – Rinow. Curvature. Jacobi fields. Theorem of Bonnet – Myers, Synge – Weinstein and Hadamard – Cartan.

MAS 433 Introduction to Algebraic Topology (7 ECTS)

Topological spaces. Continuous functions. Separation Axioms. Compact, connected sets. Homotopy, Fundamental group, covering spaces. Introduction to Homology.

MAS 434 Algebraic Topology (7 ECTS)

Homology theory and applications. Cohomology. Universal coefficient theorem. Products. Kuenneth formula. Thom isomorphism. Poincare duality.

MAS 439 Topics in Geometry (7 ECTS)

Topics from differential geometry, algebraic geometry and algebraic topology.

MAS 451 Linear Models I (7 ECTS)

The Simple Linear Regression Model: Estimation, Confidence Intervals, Hypothesis Testing. The Multiple Linear Regression Model: Estimation, Confidence Intervals, Hypothesis Testing. Model Adequacy and Model Selection. Polynomial Regression.

MAS 452 Linear Models II (7 ECTS)

Analysis of variance with one or more fixed-effects, Analysis of variance with one or more random-effects, Analysis of covariance, Generalised linear models: estimation in (for example) logistic or logarithmic regression, asymptotic properties.

MAS 454 Nonparametric Statistics (7 ECTS)

Order statistics and their distributions. Sign tests, rank tests, confidence intervals, tolerance regions. Rank correlation coefficient and tests, linear regression. Kolmogorov-Smirnov tests, Lilliefors test. Contingency tables, X2 tests for goodness of fit, independence and homogeneity.

MAS 455 Sampling Theory (7 ECTS)

Survey design. Simple random sampling, stratified, systematic, cluster and multi-stage sampling. Mean and variance estimation, ratio estimators, regression estimators. Determination of optimum sample size. Sampling errors.

MAS 456 Time Series (7 ECTS)

Stationary processes, second order moments. ARMA and ARIMA processes. Maximum likelihood estimation, least squares estimators, Yule-Walker estimators. Prediction of stationary processes. Introduction to model selection.

MAS 458 Statistical Data Analysis (7 ECTS)

Exploratory statistics. Linear models and applications. Analysis of variance, classification analysis, data structure analysis, exploratory methods. Generalised linear models. Nonlinear models, robust methods, experimental design methods. Statistical computing methods and software. Biometric, econometric and other applications.

MAS 459 Multivariate Analysis (7 ECTS)

Multivariate Normal distribution, estimation of the mean vector and the covariance matrix, maximum likelihood estimation. Correlation coefficient, partial correlation coefficient and their distribution. T2- statistic and its distribution, T2- tests. Distribution of the sample covariance matrix, Wishart distribution, Principal components, canonical correlations, cluster and discriminant analysis. Introduction to multivariate analysis of variance: parameter estimation and tests.

MAS 466 Survival Analysis (7 ECTS)

Censored data, truncated data. Survival function and hazard function. Nonparametric estimation of the survival function and the hazard function. Parametric models for the hazard function. Counting processes and martingales. Semiparametric Cox model. Tests for one or more populations, tests of class – K.

MAS 468 Topics in Probability-Statistics I (7 ECTS)

Topics from probability and statistics.

MAS 469 Topics in Probability-Statistics II (7 ECTS)

Topics from statistics and probability.

MAS 471 Numerical Solution of Ordinary Differential Equations (7 ECTS)

Numerical solution of ordinary differential equations: Linear multistep methods-theory and applications, Runge-Kutta methods, first order systems and stiffness, two-point boundary value problems.

MAS 472 Numerical Solution of Partial Differential Equations(7 ECTS)

First and second order hyperbolic PDEs, the method of characteristics, finite difference techniques, the finite element

method. Parabolic PDEs, methods for the solution of the one- and two-dimensional heat equation. Elliptic PDEs, finite difference methods for Poisson's equation.

MAS 473 Finite Element Methods (7 ECTS)

Variational formulation of boundary value problems. Galerkin Method. Basis functions and discretisation. Stiffness matrix and methods of solving linear systems. Error estimates. Collocation method, least squares method, and Rayleigh-Ritz method. Finite element methods for parabolic equations.

MAS 481 Applied Mathematical Analysis (7 ECTS)

Calculus of variations. Laplace transform. Fourier analysis. Special functions. Integral equations. Asymptotic analysis.

MAS 482 Classical Mechanics (7 ECTS)

Newton's Laws. Central Forces. Moving Coordinate Systems. Systems of Particles. Motion of Rigid Bodies. Language's Equations.

MAS 483 Fluid Mechanics (7 ECTS)

Coordinate systems. Vector and tensor calculus. Surfaces and integral theorems. Conservation laws. Narier-Strokes equations. Partial differential equations and methods of solution. Flows with analytical solution. Flow Potential Theory and related problems.

MAS 484 Introduction to Mathematical Modelling (7 ECTS)

This course emphasises the role of mathematical modelling as a tool for learning and appreciating mathematical techniques. Applications are drawn from diverse areas such as discrete dynamical systems, graphs and networks, linear programming, transportation. Extensive use of computer software is made throughout the course.

MAS 497, MAS 498 Mathematical Problem Solving Techniques(4 ECTS)

This course is geared toward undergraduate students interested in mathematical problem solving. It will also prepare students who plan to participate in mathematical Olympiads. The emphasis is on problem solving techniques, creative thought and exposition skills. A variety of solving techniques will be introduced followed by a number of examples and problems. The problems will cover various areas of mathematics such as algebra, analysis, combinatorics, number theory, geometry, etc. This is an elective course, but it will be taken into serious consideration (or will be mandatory) in the selection of students representing the Department in international mathematical competitions.

MAS 499 Independent Study (7 ECTS)

An independent study with sufficient elements of initiative and novelty under the guidance of a faculty member.

Courses offered to other departments

MAS 001 Mathematics I (6 ECTS)

Functions, Limits, Continuity, Differentiation, Applications of differentiation, Integration, Applications of integration, Logarithmic and exponential functions.

MAS 002 Mathematics II (6 ECTS)

Techniques of integration, Improper integral, Sequences, Infinite series, Power series, Partial Derivatives, Differential equations, Linear systems, Matrices, Determinants, Vector spaces, Eigenvalues and Eigenvectors, Linear transformations.

MAS 004 Introductory Mathematics for Physics I (8 ECTS)

Functions, Limits, Continuity, Differentiation, Applications of differentiation, Integration, Logarithm and exponential functions, Techniques of integration, Applications of integration, Improper integral, Sequences, Infinite series, Power series, Complex numbers.

MAS 005 Introductory Mathematics for Physics II (7.5 ECTS)

Vectors, Vector-valued functions, Partial Derivatives, Linear systems, Matrices, Determinants, Vector spaces, Inner product spaces, Eigenvalues and Eigenvectors, Linear transformations.

MAS 006 Complex Analysis for Physics Majors (7.5 ECTS)

Complex numbers, Basic complex functions, Cauchy - Riemann equations, holomorphic functions, harmonic functions. (Exponential, trigonometric and logarithmic functions). Contontintegration, Cauchy's theorem, Cauchy's integral formula. Morera's theorem, Liouville's theorem, the fundamental theorem of algebra. The Maximum modulus theorem. Taylor series, Laurent series, calculus of residues. Conformal mapping, linear fractional transformation. Applications to physical problems.

MAS 007 History of Mathematics (5 ECTS)

Variable topics from ancient Greek mathematics, the Middle Ages and the modern era.

MAS 014 Introductory Mathematics I (6 ECTS)

Functions, Limits, Continuity, Differentiation, Applications of differentiation, Integration, Logarithmic and exponential functions, Techniques of integration, Applications of integration, Improper integral, Sequences, Infinite series, Power series, Complex numbers.

MAS 015 Introductory Mathematics II (6 ECTS)

Vectors, Vector-valued functions, Partial Derivatives, Linear systems, Matrices, Determinants, Vector spaces, Inner product spaces, Eigenvalues and Eigenvectors, Linear transformations.

MAS 016 Linear Algebra for Computer Science (8 ECTS)

Linear Spaces. Linear independence. Base and Dimension. Matrices and determinants. Linear systems and Gaussian elimination. Matrix inversion. Linear Operators, range and null space. Eigenvalues and Eigenvectors. Diagonalization.

MAS 017 Calculus for Computer Science

The real numbers. Sequences: Convergent sequences, Cauchy sequences, the Cauchy criterion. Limit Theorems, Monotone convergence theorem. Subsequences, limit numbers, upper and lower limits. Series, series of nonnegative terms, the root and ratio tests. Functions of a real variable. Limits of functions. Continuous functions. Differentiation. Properties of the derivative, the mean value theorem, L´ Hopital´s rule, Taylor´s theorem. Newton´s method of approximation. The Riemann integral. The fundamental theorem of Calculus. Integration by parts, substitution theorems. Indefinite integrals. Approximate integration. The trapezoidal rule, the midpoint rule, Simpson´s rule. Several applications of calculus.

MAS 021 Calculus I (6 ECTS)

Basic review: Numbers, absolute values and inequalities, functions, one-to-one functions, function inverse. Coordinate geometry. Limits and rates of change: Definition of the limits and functions. Continuity. Tangent of a function and rate of change. Derivatives: The derivative. Differentiation formulas and function derivatives. Higher derivatives. Derivatives as rates of change (Velocity and Applications of Derivatives and Curve Sketching: Mean value theorem. Maximum, minimum and points of infection. Horizontal and vertical asymptotes. Applied maximum and minimum problems. L'Hopital's rule. Acceleration). Chain rule. Differential and Newton's approximation. Integration: Area and define integral. Anti- derivatives and fundamental theorem of integral calculus. Indefinite integrals. Evaluation of Integrals. Estimates of definite integrals and numerical integration. Applications of Integrals: Using tables of integrals. Area between curves. Volume by parallel cross-section and the shell method. Improper integrals. Moments and centres of mass. Average value of a function.

MAS 022 Calculus II (6 ECTS)

Integration and Applications (Review): Continued from MAS 021. Techniques of Integration. Integration by parts. Partial fractions. Powers and products of sines and cosines. Trigonometric powers. Integrals involving $\sqrt{a2 \pm x2}$ and $\sqrt{x2 \pm a2}$. Rational expressions in sin x and cos x. Sequent and series: Convergence of a series, the integral and comparison tests. Absolute and conditional convergence. Alternative series. Power series. Taylor and Maclaurin series. Polar Coordinates: Area in polar coordinates. Parametric equations. Arc length and speed on a curve. Area of a surface of revolution. Vectors: Algebra of vectors. Vectors in space. Dot product and cross product of vectors. Lines and planes. Partial Derivatives: Functions of several variables. Graphs of equations and level curves. Partial derivatives. Tangent planes and differentials. The Chain rule. Directional derivatives, gradients, divergence and curl. Critical points and extrema.

MAS 023 Linear Algebra and Topics in Multivariable Calculus (6 ECTS)

Multiple Integrals: Double and triple integrals. Double integrals over rectangles and more general regions. Integrals in cylindrical, spherical and polar coordinates. Applications: surface areas, average and centroids. Line and surface integrals: Line integrals. Fundamental theorem of line integrals. Green's and Stoke's Theorems. Divergence theorem. Linear Algebra: Solution of systems of linear equations. Gaussian elimination. Linear independence, basis and dimension. Matrix inversion and pseudo-inverse. Orthogonality: Inner products and projections. Orthogonal bases and orthogonal matrices and the Gram-Schmidt Orthogonalisation. Determinants: Properties of determinants. Formulas for determinants. Applications of determinants. Eigenvalues and Eigenvectors: Characteristic equation and evaluation of Eigenvalues and eigenvectors. Matrix diagonalisation. Applications. Similarity transformations and triangular forms.

MAS 024 Ordinary Differential Equations (6 ECTS)

First Order Differential Equations: Solutions to first order linear and non-linear equations. Separable equations, exact equations, homogeneous equation. Applications Second Order Differential Equations: Fundamental solutions of homogeneous equations. The non-homogeneous problem. Methods of undetermined coefficients and variations of parameters. Series solutions. Applications in electrical networks. Systems of First Order Linear Equations: Homogeneous linear systems with constant coefficients. Complex Eigenvalues. Repeated Eigenvalues. Non-homogenous linear systems. Partial Differential Equation: Separation of variables and Fourier Series. Non- Linear Differential Equation and Stability Analysis: Phase planes and stability. Liapunov's Method.

MAS 031 Calculus I (5 ECTS)

The real number system. Sequences of real numbers, limits. Functions of a real variable; Limits of functions. Continuous functions. Differentiation and applications. Riemann integrability, the fundamental theorem of calculus. Series. Taylor's Theorem, power series.

MAS 032 Linear Algebra (5 ECTS)

Vector spaces. Bases and dimension. Matrices and determinants. Linear systems and Gauss elimination method. Inverse matrix. Rank. Linear maps, image and kernel. Eigenvalues and eigenvectors. Diagonalisation.

MAS 033 Engineering Mathematics (5 ECTS)

First order ordinary differential equations. Separable and exact equations. Integrating factor. Second order differential equations. Methods of undetermined coefficients and variation of parameters. Series solutions. Functions of several variables. Partial derivatives. Chain rule. Directional derivative and gradient. Extrema of functions of two variables. Lagrange multipliers. Vector functions. Divergence and curl. Double and triple integrals. Line and surface integrals. Introduction to partial differential equations. Separation of variables. Heat equation.

MAS 034 Probability and Statistics for Engineers (5 ECTS)

Descriptive statistics. Measures of central tendency and dispersion. Probability. Random variables. Distribution function. Distribution. Independence. Mean. Covariance. Moment generating functions. Convergence of sequences of random variables. Limit Theorems. Laws of large numbers. Exponential families of distributions. Estimation: Point estimation, sufficiency, and completeness. Confidence interval for the mean, variance, difference of the means, ratio of variances and proportions. Testing Hypothesis: Null hypothesis - Alternative hypothesis,

Type I and II errors. Testing for the mean for small and large samples, testing for the difference of the means. Testing for the variance and the ratio of variances, Testing for proportions. Simple linear regression, analysis of variance.

MAS 041 Calculus I for MME (6 ECTS)

Same description as MAS 031

MAS 042 Linear Algebra for MME (6 ECTS)

Same description as MAS 032

MAS 043 Engineering Mathematics for MME (6 ECTS)

Same description as MAS 033

MAS 044 Probability and Statistics for Engineers (6 ECTS)

Same description as MAS 034

MAS 051 Statistical Methods (5 ECTS)

Descriptive statistics, probability, Binomial distribution, Normal distribution, sampling, confidence intervals, hypothesis testing, correlation, regression analysis, Introduction to analysis of variance.

MAS 055 Introduction to Probability and Statistics (5 ECTS)

Probability. Random variables. Probability density function. Distributions. Independence. Expectation. Moment generating functions. Convergence of random variables. Limit theorems. Point estimation (sufficiency, completeness), confidence intervals, Exponential families of distributions. Statistical hypotheses, X2 tests. Simple linear regression, analysis of variance.

MAS 061 Statistical Analysis I (6 ECTS)

Descriptive statistics, probability models. Random variables, expected value, sampling, Central Limit Theorem. Estimation, confidence intervals, hypothesis testing. Introduction to regression analysis.

MAS 062 Statistical Analysis II (6 ECTS)

Regression analysis. Analysis of qualitative data. X2 tests. Analysis of variance. Nonparametrics. Time Series. Decision Theory.

MAS 066 Biostatistics

Population distributions, samples, frequency distributions, descriptive statistics, histograms, pies, numerical statistics, mean, mode, median, variation, range, percentiles, variance, standard deviation, coefficient of variation. Estimation, point estimates, confidence intervals for the mean (large and small samples), confidence intervals for the variation (large and small samples), confidence intervals for the difference between two means (paired – unpaired), confidence intervals for the ratio of the variances of two normal distributed populations. Hypothesis testing, statistical significance, null hypothesis – alternative hypothesis, error of the first (a) and second kind (b), test for the mean (large and small samples), test for the difference between two means (large and small samples), paired significance testing, significance testing for the variation, comparing the variation of two populations. Analysis of variance (anova). Non – parametric tests, test of homogeneity, the sign test, the Kolmogorov-Smirnov test, rank sum test, Wilcoxon test, Mann-Whithey test, Kruskal-Wallis test. Qualitative variables, nominal – ordinal, comparison of a sample ration with a given one, paired and unpaired comparison of the rations between two samples, chi-square analysis (X2), comparison of rations between «s» samples with «k» categories.

TABLE A: COURSES FOR STUDENTS OF MATHEMATICS AND STATISTICS

	ECTS	Pure Mathematics	Applied Mathematics	Statistics
MAS 101 Calculus I	8	▲	▲	▲
MAS 102 Calculus II	8	▲	▲	▲
MAS 121 Linear Algebra I	8	▲	▲	▲
MAS 122 Linear Algebra II	8	▲	▲	▲
MAS 131 Basic Mathematics	8	▲	▲	▲
MAS 191 Mathematics with Computers	8	▲	▲	▲
MAS 201 Multivariate Differential Calculus	8	▲	▲	▲
MAS 202 Multivariate Integral Calculus	8	▲	▲	▲
MAS 203 Ordinary Differential Equations I	8	▲	▲	▲
MAS 223 Number Theory	7	▲	▲	▲
MAS 261 Introduction to Probability	8	▲	▲	▲
MAS 262 Introduction to Statistics	8	▲	▲	▲
MAS 271 Numerical Analysis I	8	▲	▲	▲
MAS 301 Real Analysis	8	▲	▲	▲
MAS 302 Complex Analysis I	8	▲	▲	▲
MAS 303 Partial Differential Equations	7	+	▲	+
MAS 304 Functional Analysis	7	+	▲	+
MAS 321 Introduction to Algebra	7	▲		
MAS 331 Classical Differential Geometry	8	▲	▲	▲
MAS 350 Stochastic Processes	7			▲
MAS 361 Probability Theory	8			▲
MAS 362 Theory of Statistics	7			▲
MAS 371 Numerical Analysis II	7	+	▲	+
MAS 401 Measure Theory and Integration	7			
MAS 402 Complex Analysis II	7			
MAS 403 Ordinary Differential Equations II	7			
MAS 418 Introduction to Fourier Analysis	7			
MAS 419 Topics in Analysis	7			
MAS 422 Introduction to Coding Theory	7			
MAS 424 Theory of Rings and Modules	7			
MAS 425 Theory of Groups	7			
MAS 426 Group Representation Theory	7			
MAS 427 Galois Theory	7			
MAS 429 Topics in Algebra	7			
MAS 431 Introduction to Differentiable Manifolds	7			
MAS 432 Introduction to Riemannian Geometry	7			
MAS 433 Introduction to Algebraic Topology	7	▲		
MAS 434 Algebraic Topology	7			
MAS 439 Topics in Geometry	7			
MAS 451 Linear Models I	7			▲
MAS 452 Linear Models II	7			▲
MAS 454 Nonparametric Statistics	7			▪
MAS 455 Sampling Theory	7			▪
MAS 456 Time Series	7			▪
MAS 458 Statistical Data Analysis	7			▪
MAS 459 Multivariate Analysis	7			▪
MAS 466 Survival Analysis	7			▪
MAS 468 Topics in Probability-Statistics I	7			▪
MAS 469 Topics in Probability-Statistics II	7			▪
MAS 471 Numerical Solution of Ordinary Differential Equations	7		●	
MAS 472 Numerical Solution of Partial Differential Equations	7		●	
MAS 473 Finite Element Method	7			
MAS 481 Applied Mathematical Analysis	7		●	
MAS 482 Classical Mechanics	7		●	
MAS 483 Fluid Mechanics	7		●	
MAS 484 Introduction to Mathematical Modelling	7			
MAS 497/498 Mathematical Problem Solving Techniques	7	▸	▸	▸
MAS 499 Independent Study	7	▸	▸	▸

▲ = Compulsory Courses / ● = At least three out of five courses are to be selected / ▪ = two out of six courses are to be selected / + = two out of three courses are to be selected / ▸= It can replace an elective course from other departments.

Note: Courses with no symbols are considered free electives within the Department.

TABLE B: COURSES FOR OTHER DEPARTMENTS

		Department	ECTS
MAS 001	Mathematics I	ECO, PBA. BIO	6
MAS 002	Mathematics II	PBA	6
MAS 004	Introductory Mathematics for Physics I	PHY	8
MAS 005	Introductory Mathematics for Physics II	PHY	7,5
MAS 006	Complex Analysis for Physics Majors	PHY	7,5
MAS 007	History of Mathematics	MAS, EDU, «E»*	5
MAS 014	Introductory Mathematics I	CHE	6
MAS 015	Introductory Mathematics II	CHE	6
MAS 016	Linear Algebra for Computer Science	CS	7,5
MAS 017	Calculus Algebra for Computer Science	CS	7,5
MAS 021	Calculus I	ECE	6
MAS 022	Calculus II	ECE	6
MAS 023	Linear Algebra and Topics in Multivariate Calculus	ECE	6
MAS 024	Ordinary Differential Equations	ECE	6
MAS 031	Calculus I	CEE	5
MAS 032	Linear Algebra	CEE	5
MAS 033	Engineering Mathematics	CEE	5
MAS 034	Probability and Statistics for Engineers	CEE	5
MAS 041	Calculus I for MME	MME	6
MAS 042	Linear Algebra for MME	MME	6
MAS 043	Engineering Mathematics for MME	MME	6
MAS 044	Probability and Statistics for Engineers	MME	6
MAS 051	Statistical Methods	EDU, SPS, PSY	5
MAS 055	Introduction to Probability and Statistics	CS	5
MAS 061	Statistical Analysis I	ECO, PBA	6
MAS 062	Statistical Analysis II	PBA	6
MAS 066	Biostatistics	BIO	6

Note: *«E» = Free Elective Course

TABLE C1: INDICATIVE PROGRAMME OF STUDIES – PURE MATHEMATICS

1st semester

	ECTS
MAS 101 Calculus I	8
MAS 131 Basic Mathematics	8
MAS 121 Linear Algebra I	8
Foreign Language Course I	5
TOTAL:	**29**

2nd semester

MAS 102 Calculus II	8
MAS 122 Linear Algebra II	8
CS 031 Introduction to Programming	7
MAS 191 Mathematics with Computers	8
TOTAL:	**31**

3rd semester

MAS 201 Multivariate Differential Calculus	8
MAS 261 Introduction to Probability	8
MAS 271 Numerical Analysis I	8
Foreign Language Course II	5
TOTAL:	**29**

4th semester

MAS 202 Multivariate Integral Calculus	8
MAS 203 Ordinary Differential Equations	8
MAS 262 Introduction to Statistics	8
MAS XX* Elective course within the Department	7
TOTAL:	**31**

5th semester

MAS 301 Real Analysis	8
Elective Course I** (e.g. MAS 303 Partial Differential Equations)	7
MAS 321 Introduction to Algebra	7
PHY 111 General Physics I	8
TOTAL:	**30**

6th semester

	ECTS
MAS 302 Complex Analysis I	8
MAS 331 Classical Differential Geometry	8
MAS XX* Elective course within the Department	7
Elective Course II** (e.g. MAS 304 Functional Analysis)	7
TOTAL:	**30**

7th semester

MAS 433 Introduction to Algebraic Topology	7
MAS XX* Elective course within the Department	7
Elective course from other departments	5
Elective course from other departments	5
Elective course from other departments	5
TOTAL:	**29**

8th semester

MAS XX* Elective course within the Department	7
MAS XX* Elective course within the Department	7
MAS XX* Elective course within the Department	7
Elective course from other departments	5
Elective course from other departments	5
TOTAL:	**31**

Note:

* MAS XX = Elective course within the Department

** Selection of at least two courses from the list below:

(a) MAS 304 Functional Analysis

(b) MAS 303 Partial Differential Equations

(c) MAS 371 Numerical Analysis II

TABLE C2: INDICATIVE PROGRAMME OF STUDIES – APPLIED MATHEMATICS

1st semester

	ECTS
MAS 101 Calculus I	8
MAS 131 Basic Mathematics	8
MAS 121 Linear Algebra I	8
Foreign Language Course I	5
TOTAL:	**29**

2nd semester

MAS 102 Calculus II	8
MAS 122 Linear Algebra II	8
CS 031 Introduction to Programming	7
MAS 191 Mathematics with Computers	8
TOTAL:	**31**

3rd semester

MAS 201 Multivariate Differential Calculus	8
MAS 251 Probability I	8
MAS 271 Numerical Analysis I	8
Foreign Language Course II	5
TOTAL:	**29**

4th semester

MAS 202 Multivariate Integral Calculus	8
MAS 203 Ordinary Differential Equations	8
MAS 252 Statistics I	8
MAS XX* Elective course within the Department	7
TOTAL:	**31**

5th semester

	ECTS
MAS 301 Real Analysis	8
MAS 303 Partial Differential Equations	7
MAS 371 Numerical Analysis II	7
PHY 111 General Physics I	8
TOTAL:	**29**

6th semester

MAS 302 Complex Analysis I	8
MAS 331 Classical Differential Geometry	8
MAS **	7
MAS XX* Free elective within the Department	7
TOTAL:	**29**

7th semester

MAS **	7
MAS 304 Functional Analysis	7
Elective course from other departments	5
Elective course from other departments	5
Elective course from other departments	5
TOTAL:	**29**

8th semester

MAS **	7
MAS XX* Elective course within the Department	7
MAS XX* Elective course within the Department	7
Elective course from other departments	5
Elective course from other departments	5
TOTAL:	**31**

Note:

* MAS XX = Elective course within the Department

** MAS = Selection of at least three courses from the list below:

(a) MAS 471 Numerical Solution of Ordinary Differential Equations
(b) MAS 472 Numerical Solution of Partial Differential Equations
(c) MAS 481 Applied Mathematical Analysis
(d) MAS 482 Classical Mechanics
(e) MAS 483 Fluid Mechanics

TABLE C3: INDICATIVE PROGRAMME OF STUDIES – STATISTICS

	ECTS
1st semester	
MAS 101 Calculus I	8
MAS 131 Basic Mathematics	8
MAS 121 Linear Algebra I	8
Foreign Language Course I	5
TOTAL:	**29**
2nd semester	
MAS 102 Calculus II	8
MAS 122 Linear Algebra II	8
CS 031 Introduction to Programming	7
MAS 191 Mathematics with Computers	8
TOTAL:	**31**
3rd semester	
MAS 201 Multivariate Differential Calculus	8
MAS 251 Probability I	8
MAS 271 Numerical Analysis I	8
Foreign Language Course II	5
TOTAL:	**29**
4th semester	
MAS 202 Multivariate Integral Calculus	8
MAS 203 Ordinary Differential Equations	8
MAS 252 Statistics I	8
MAS XX* Elective course within the Department	7
TOTAL:	**31**

	ECTS
5th semester	
MAS 301 Real Analysis	8
MAS 361 Theory of Probability	8
MAS 362 Theory of Statistics	7
Elective Course I**	7
TOTAL:	**30**
6th semester	
MAS 302 Complex Analysis I	8
MAS 331 Classical Differential Geometry	8
MAS 350 Stohastic Processes	7
MAS XX* Elective course within the Department	7
TOTAL:	**30**
7th semester	
MAS 451 Linear Models I	7
MAS XX*	7
Elective course from other departments	5
Elective course from other departments	5
Elective course from other departments	5
TOTAL:	**29**
8th semester	
MAS 452 Linear Models II	7
MAS (Stat)***	7
Elective Course II**	7
Elective course from other departments	5
Elective course from other departments	5
TOTAL:	**31**

Note:

* MAS XX = Elective course within the Department

** Selection of at least two courses from the list below:

(a) MAS 303 Partial Differential Equations
(b) MAS 304 Functional Analysis
(c) MAS 371 Numerical Analysis II

*** MAS (Stat) *** = Selection from the list below:

(a) MAS 454 Nonparametric Statistics
(b) MAS 455 Sampling Theory
(c) MAS 456 Time Series
(d) MAS 458 Statistical Data Analysis
(e) MAS 459 Multivariate Analysis
(f) MAS 466 Survival Analysis
(g) MAS 468 Topics in Probability-Statistics I
(h) MAS 469 Topics in Probability-Statistics II