# University of Pretoria Yearbook 2020

# BScHons Mathematics and Mathematics Education Algebra and Analysis (02240183)

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| **Minimum duration of study** | 1 year |
| **Total credits** | 137 |
| **NQF level** | 08 |

## Programme information

The programme consists of seven honours modules (five modules of 15 credits each from the Department of Mathematics and Applied Mathematics and two modules of 16 credits each from the Department of Science, Mathematics and Technology Education) as well as the compulsory research project (30 credits). Elective modules should be selected according to the prerequisites of these modules.
Candidates are required to familiarise themselves with the General Regulations regarding the maximum period of registration and other requirements for honours degrees.

## Admission requirements

- An appropriate bachelor's degree
- At least a final grade point average of 60% at final-year level for all mathematics/applied mathematics modules
- Required that the candidate has completed the following modules with at least 60% each:
  - Real analysis at third-year level
  - Linear algebra at second-year level
- Complete preceding degree will be considered for selection.

## Promotion to next study year

The progress of all honours candidates is monitored biannually by the postgraduate coordinator/head of department. A candidate's study may be terminated if the progress is unsatisfactory or if the candidate is unable to finish his/her studies during the prescribed period.

## Pass with distinction

The BScHons degree is awarded with distinction to a candidate who obtains a weighted average of at least 75% in all the prescribed modules and a minimum of 65% in any one module.

# Curriculum: Final year

**Minimum credits: 137**

Select any two electives offered in the BScHons (Mathematics) or BScHons (Applied Mathematics) programmes, provided that the prerequisites are met with.

## Fundamental modules

### Project 795 (WTW 795)

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| **Module credits** | 30.00 |
| **Prerequisites** | No prerequisites. |
| **Language of tuition** | Module is presented in English |
| **Department** | Mathematics and Applied Mathematics |
| **Period of presentation** | Year |

**Module content**

Consult Department.

## Core modules

### Mathematics and mathematical literacy education 730 (MCE 730)

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|---|---|
| **Module credits** | 16.00 |
| **Service modules** | Faculty of Natural and Agricultural Sciences |
| **Prerequisites** | No prerequisites. |
| **Language of tuition** | Module is presented in English |
| **Department** | Science Mathematics and Technology Education |
| **Period of presentation** | Semester 1 or Semester 2 |

**Module content**

Perspectives in the teaching and learning of mathematics. This module will focus on contemporary issues in mathematics education such as: Types of mathematical knowledge in teacher education; learning theories in mathematics education; use of technology in the teaching of mathematics; classroom research; gender; language; culture (Ethno mathematics). Mathematics in context: prospects and challenges. This module also focuses on the role of mathematics in different contexts (including vocational and real life contexts): Nature of mathematics – mathematics as a human activity; rationale for learning mathematics; the theory of realistic mathematics education; content-driven and context-driven approach in mathematics; mathematical literacy; knowledge ‘transfer’: some challenges – school mathematics vs real world.

### Educational research methodology 745 (NMQ 745)

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|---|---|
| **Module credits** | 16.00 |
| **Language of tuition** | Module is presented in English |

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|---|---|
| **Department** | Science Mathematics and Technology Education |
| **Period of presentation** | Semester 1 |

**Module content**

The nature of educational enquiry: contexts of research, research ethics, truth, rationality, subjectivity and objectivity; Quantitative and qualitative modes of enquiry, research designs and data collection techniques. Various approaches to qualitative research including case study research, historical research, ethnographic research, and action research. Basic concepts and principles of quantitative research. Statistical techniques in the educational research process. Survey methodology and questionnaire design. Classification and graphical representation of data. Descriptive measures. Statistical inference. Data-processing procedures. Parametric versus non-parametric tests. Some test statistics (e.g. F-Test and T-test). Formulating a research methodology for a limited project.

## Functional analysis 710 (WTW 710)

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|---|---|
| **Module credits** | 15.00 |
| **Prerequisites** | Real analysis on third-year level |
| **Contact time** | 2 lectures per week |
| **Language of tuition** | Module is presented in English |
| **Department** | Mathematics and Applied Mathematics |
| **Period of presentation** | Semester 1 |

**Module content**

An introduction to the basic mathematical objects of linear functional analysis will be presented. These include metric spaces, Hilbert spaces and Banach spaces. Subspaces, linear operators and functionals will be discussed in detail. The fundamental theorems for normed spaces: The Hahn-Banach theorem, Banach-Steinhaus theorem, open mapping theorem and closed graph theorem. Hilbert space theory: Riesz' theorem, the basics of projections and orthonormal sets.

## Axiomatic set theory and mathematical logic 724 (WTW 724)

| | |
|---|---|
| **Module credits** | 15.00 |
| **Contact time** | 1 lecture per week |
| **Language of tuition** | Module is presented in English |
| **Department** | Mathematics and Applied Mathematics |
| **Period of presentation** | Semester 1 |

**Module content**

Axiomatic set theory, ordinals, transfinite induction and recursion, ordinal arithmetic, the axiom of choice, cardinal arithmetic, the continuum hypothesis. Propositional and first order logic. The completeness and compactness theorems. Decidability, Gödel’s incompleteness theorems.

## Algebra 731 (WTW 731)

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|---|---|
| **Module credits** | 15.00 |

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|---|---|
| **Prerequisites** | Algebra on third-year level |
| **Contact time** | 2 lectures per week |
| **Language of tuition** | Module is presented in English |
| **Department** | Mathematics and Applied Mathematics |
| **Period of presentation** | Semester 1 |

**Module content**

The following topics will be covered: Galois theory and solving equations by radicals, introduction to the theory of R-modules, direct sums and products, projectivity and injectivity, finitely generated modules over Euclidean domains, primary factorisation, applications to Jordan and rational canonical forms of matrices.

### Measure theory and probability 734 (WTW 734)

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|---|---|
| **Module credits** | 15.00 |
| **Prerequisites** | Real analysis on third-year level |
| **Contact time** | 2 lectures per week |
| **Language of tuition** | Module is presented in English |
| **Department** | Mathematics and Applied Mathematics |
| **Period of presentation** | Semester 1 |

**Module content**

Measure and integration theory: The Caratheodory extension procedure for measures defined on a ring, measurable functions, integration with respect to a measure on a σ-ring, in particular the Lebesgue integral, convergence theorems and Fubini's theorem.
Probability theory: Measure theoretic modelling, random variables, expectation values and independence, the Borel-Cantelli lemmas, the law of large numbers. $L^1$-theory, $L^2$-theory and the geometry of Hilbert space, Fourier series and the Fourier transform as an operator on $L^2$, applications of Fourier analysis to random walks, the central limit theorem.

## Elective modules

### Special topics 727 (WTW 727)

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|---|---|
| **Module credits** | 15.00 |
| **Prerequisites** | As required by specific topical content. |
| **Contact time** | 1 lecture per week |
| **Language of tuition** | Module is presented in English |
| **Department** | Mathematics and Applied Mathematics |
| **Period of presentation** | Semester 2 |

**Module content**

A selection of special topics will be presented that reflects the expertise of researchers in the Department. The presentation of a specific topic is contingent on student numbers. Consult the website of the Department of Mathematics and Applied Mathematics for more details.

## Main principles of analysis in application 735 (WTW 735)

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|---|---|
| **Module credits** | 15.00 |
| **Prerequisites** | Calculus at 2nd-year level (eg WTW 218) and one 3rd-year level module on analysis or applications of analysis (eg WTW 310, WTW 382, WTW 383 or WTW 386) |
| **Contact time** | 2 lectures per week |
| **Language of tuition** | Module is presented in English |
| **Department** | Mathematics and Applied Mathematics |
| **Period of presentation** | Semester 1 |

**Module content**

Study of main principles of analysis in the context of their applications to modelling, differential equations and numerical computation. Specific principles to be considered are those related to mathematical biology, continuum mechanics and mathematical physics as presented in the modules WTW 772, WTW 787 and WTW 776, respectively.

## Mathematical optimisation 750 (WTW 750)

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|---|---|
| **Module credits** | 15.00 |
| **Prerequisites** | Multivariate Calculus on 2nd-year level; Linear Algebra on 2nd-year level |
| **Contact time** | 2 lectures per week |
| **Language of tuition** | Module is presented in English |
| **Department** | Mathematics and Applied Mathematics |
| **Period of presentation** | Semester 1 |

**Module content**

Classical optimisation:  Necessary and sufficient conditions for local minima.  Equality constraints and Lagrange multipliers.  Inequality constraints and the Kuhn-Tucker conditions.  Application of saddle point theorems to the solutions of the dual problem.  One-dimensional search techniques.  Gradient methods for unconstrained optimisation.  Quadratically terminating search algorithms.  The conjugate gradient method.  Fletcher-Reeves.  Second order variable metric methods:  DFP and BFCS.  Boundary following and penalty function methods for constrained problems.  Modern multiplier methods and sequential quadratic programming methods.  Practical design optimisation project.

## Finite element method 763 (WTW 763)

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| **Module credits** | 15.00 |
| **Prerequisites** | WTW 733 is strongly recommended |

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| **Contact time** | 2 lectures per week |
| **Language of tuition** | Module is presented in English |
| **Department** | Mathematics and Applied Mathematics |
| **Period of presentation** | Semester 2 |

**Module content**

An analysis as well as an implementation (including computer programs) of methods is covered. Introduction to the theory of Sobolev spaces. Variational and weak formulation of elliptic, parabolic, hyperbolic and eigenvalue problems. Finite element approximation of problems in variational form, interpolation theory in Sobolev spaces, convergence and error estimates.

## Stochastic calculus 764 (WTW 764)

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|---|---|
| **Module credits** | 15.00 |
| **Prerequisites** | WTW 734 or WTW 735 |
| **Contact time** | 2 lectures per week |
| **Language of tuition** | Module is presented in English |
| **Department** | Mathematics and Applied Mathematics |
| **Period of presentation** | Semester 2 |

**Module content**

Mathematical modelling of Random walk. Conditional expectation and Martingales. Brownian motion and other Lévy processes. Stochastic integration. Ito's Lemma. Stochastic differential equations. Application to finance.

## Mathematical methods and models 772 (WTW 772)

| | |
|---|---|
| **Module credits** | 15.00 |
| **Prerequisites** | No prerequisites. |
| **Contact time** | 2 lectures per week |
| **Language of tuition** | Module is presented in English |
| **Department** | Mathematics and Applied Mathematics |
| **Period of presentation** | Semester 2 |

**Module content**

This module aims at using advanced undergraduate mathematics and rigorously applying mathematical methods to concrete problems in various areas of natural science and engineering.
The module will be taught by several lecturers from UP, industry and public sector. The content of the module may vary from year to year and is determined by relevant focus areas within the Department. The list of areas from which topics to be covered will be selected, includes: Systems of differential equations; dynamical systems; discrete structures; Fourier analysis; methods of optimisation; numerical methods; mathematical models in biology, finance, physics, etc.

## Partial differential equations of mathematical physics 776 (WTW 776)

| | |
|---|---|
| **Module credits** | 15.00 |
| **Prerequisites** | WTW 710 or WTW 735 |
| **Contact time** | 2 lectures per week |
| **Language of tuition** | Module is presented in English |
| **Department** | Mathematics and Applied Mathematics |
| **Period of presentation** | Semester 2 |

**Module content**

Field-theoretic and material models of mathematical physics. The Friedrichs-Sobolev spaces. Energy methods and Hilbert spaces, weak solutions – existence and uniqueness. Separation of variables, Laplace transform, eigenvalue problems and eigenfunction expansions. The regularity theorems for elliptic forms (without proofs) and their applications. Weak solutions for the heat/diffusion and related equations.

The information published here is subject to change and may be amended after the publication of this information. The General Regulations (G Regulations) apply to all faculties of the University of Pretoria. It is expected of students to familiarise themselves well with these regulations as well as with the information contained in the General Rules section. Ignorance concerning these regulations and rules will not be accepted as an excuse for any transgression.