MATHEMATICAL SCIENCES (MA)

MA 105 Mathematical Foundations for Business   (3 credits)
Pre-Req: Students starting Fall 2025 or later must demonstrate competency through the ALEKS PPL Placement Assessment. https://www.bentley.edu/offices/student-success/mathplacement
This course presents concepts of three mathematical modeling topics (linear programming, mathematics of finance and probability) that are of particular relevance to business applications. Linear Programming can be helpful in allocating limited resources among various activities. Mathematics of Finance introduces the mathematical methods used in evaluating financial instruments such as loans and bonds. Probability aids in understanding the impact of uncertainty of future events on decision-making. Effective communication of results will be emphasized.

Typically Offered: Fall and Spring

MA 105L Mathematical Foundations for Business with Lab   (3 credits)
Pre-Req: Students starting Fall 2025 or later must demonstrate competency through the ALEKS PPL Placement Assessment. https://www.bentley.edu/offices/student-success/mathplacement
This course presents concepts of three mathematical modeling topics (linear programming, mathematics of finance and probability) that are of particular relevance to business applications. Linear Programming can be helpful in allocating limited resources among various activities. Mathematics of Finance introduces the mathematical methods used in evaluating financial instruments such as loans and bonds. Probability aids in understanding the impact of uncertainty of future events on decision-making. Effective communication of results will be emphasized.

Typically Offered: Fall and Spring

MA 107 Applied Calculus for Business   (3 credits)
Pre-Req: Students starting Fall 2025 or later must demonstrate competency through the ALEKS PPL Placement Assessment. https://www.bentley.edu/offices/student-success/mathplacement
The course presents concepts of differential and integral calculus, introduces functions as simple mathematical models, and develops students' quantitative reasoning skills. Specific emphasis will be placed on the understanding of as well as the use of tools relevant to solving problems in business and economics. Topics include derivatives, indefinite and definite integrals and applications to marginal profit/revenue/cost, optimization, continuous income streams and consumer's/producer's surplus.

Typically Offered: Fall and Spring

MA 107L Applied Calculus for Business with Lab   (3 credits)
Pre-Req: Students starting Fall 2025 or later must demonstrate competency through the ALEKS PPL Placement Assessment. https://www.bentley.edu/offices/student-success/mathplacement
The course presents concepts of differential and integral calculus, introduces functions as simple mathematical models, and develops students' quantitative reasoning skills. Specific emphasis will be placed on the understanding of as well as the use of tools relevant to solving problems in business and economics. Topics include derivatives, indefinite and definite integrals and applications to marginal profit/revenue/cost, optimization, continuous income streams and consumer's/producer's surplus.

Typically Offered: Fall and Spring

MA 131 Calculus I   (3 credits)
Pre-Req: Students starting Fall 2025 or later must demonstrate competency through the ALEKS PPL Placement Assessment. https://www.bentley.edu/offices/student-success/mathplacement
This course presents a thorough treatment of differential calculus that assumes a solid foundation in algebra and trigonometry. Topics include limits and continuity; the differentiation of single-variable functions; implicit and logarithmic differentiation; curve sketching; optimization; and applications to business, economics, and the social and natural sciences.

Typically Offered: Fall and Spring

MA 131L Calculus I with Lab   (3 credits)
Pre-Req: Students starting Fall 2025 or later must demonstrate competency through the ALEKS PPL Placement Assessment. https://www.bentley.edu/offices/student-success/mathplacement
This course presents a thorough treatment of differential calculus that assumes a solid foundation in algebra and trigonometry. Topics include limits and continuity; the differentiation of single-variable functions; implicit and logarithmic differentiation; curve sketching; optimization; and applications to business, economics, and the social and natural sciences.

Typically Offered: Fall and Spring

MA 139 Calculus II   (3 credits)
Pre-Req: MA 131 or MA 131L
This course is a continuation of MA 131. It presents a thorough treatment of integral calculus. Topics include integrating single-variable functions, including indefinite, definite and improper integrals by substitution, parts and partial fraction expansion; an introduction to ordinary differential equations; and applications to probability, business, economics, and the social and natural sciences.

Typically Offered: Fall and Spring

MA 139L Calculus II with Lab   (3 credits)
Pre-Req: MA 131 or MA 131L
This course is a continuation of MA 131. It presents a thorough treatment of integral calculus. Topics include integrating single-variable functions, including indefinite, definite and improper integrals by substitution, parts and partial fraction expansion; an introduction to ordinary differential equations; and applications to probability, business, economics, and the social and natural sciences.

Typically Offered: Fall

MA 205 Chaos, Fractals and Dynamics   (3 credits)
Pre-Req: MA 107, MA 107L, MA 123, MA 123L, MA 131, or MA 131L
This course introduces basic concepts of dynamical systems through lectures, slides, films and computer experimentation. Students predict system behavior based on mathematical calculations and on observation of computer results (no computer programming experience is necessary). Topics include iteration of functions, Julia sets, Mandelbrot sets, chaos and fractals.

Typically Offered: Once a year

MA 214 Intermediate Applied Statistics   (3 credits)
Pre-Req: GB 213 or ST 113
Context and Perspectives: Scientific Inquiry
Statisticians have assumed larger and more important roles in the modern world as corporate problems become more complex. Feedback from statisticians is used by managers at all levels, especially as data sets become larger. In MA214, you will be asked to conduct hypothesis tests on multiple populations, learn to analyze variance, see applications of multiple regression and analyze contingency tables. The statistical functions in EXCEL will be complemented by a higher-level statistical package. The course will focus on applications drawn from the primary business disciplines.

Typically Offered: Fall and Spring

MA 215 Mathematics of Sports   (3 credits)
Pre-Req : GB 213 or ST113
Mathematics and sports will help students understand how analytic ideas can aid in understanding athletic competitions and improving individual and team performances. The mathematical topics will include some with a statistical component (expectations, probability and risk/reward judgments) and some with a deterministic bent (optimization, ranking and validation). A variety of software packages will be used to demonstrate the many ways that a mathematical point of view can inform participants and fans alike.

Typically Offered: Other

MA 223 Linear Models for Business Decision-Making   (3 credits)
Pre-Req: Three credits of math
This course is an introduction to linear optimization models as they apply to problems in business and economics. The potential and limitations of various models are discussed. Emphasis is placed on developing models from written descriptions and interpreting model solutions, typically computer-generated. Specific topics include linear and integer programming models.

Typically Offered: Every two or more years

MA 225 Probability Models for Business Decision-Making   (3 credits)
Pre-Req: GB 213 or ST 113
This course is an introduction to probabilistic models as they apply to management, economic and business administration problems. The potential and limitations of various models are discussed. Emphasis is placed on developing models from written descriptions and interpreting model solutions, typically computer-generated. Specific topics include an introduction to basic probability, decision analysis, queuing models and simulation.

Typically Offered: Every two or more years

MA 233 Calculus III   (3 credits)
Pre-Req: MA 139 or MA 139L
This course includes such topics as sequences and series (including geometric and Taylor series); multivariable differential and integral calculus; vector calculus; and applications to business, economics, and the social and natural sciences.

Typically Offered: Fall and Spring

MA 235 Differential Equations   (3 credits)
Pre-Req: MA 139 or MA 139L
This is an introductory course in ordinary differential equations with application to the social and natural sciences. First-order differential equations, second-order linear equations with constant coefficients and first-order linear systems are examined. The emphasis is on formulation of equations (modeling), analytical and graphical solution techniques and interpretation of solutions (prediction). Solution techniques include the methods of integrating factors, undetermined coefficients and variation of parameters. Linear first-order and second-order difference equations with applications are also introduced. Computer experiments are carried out in MATLAB and PHASER.

Typically Offered: Once a year

MA 239 Linear Algebra   (3 credits)
Pre-Req: MA 139 or MA 139L
This course includes topics on matrices, determinants, systems of linear equations and Gaussian elimination, vector spaces, linear independence, inner products, orthonormal bases, Gram-Schmidt process, QR-Factorization, the least-squares method, eigenvalues and eigenvectors. Applications to social and natural sciences as well as the connection with other mathematical disciplines is discussed.

Typically Offered: Fall

MA 243 Discrete Probability   (3 credits)
Pre-Req: Three credits of math
This course relates to problems of a probabilistic nature in business, economics, management science and the social sciences. It includes such topics as set notation, permutations, combinations, mutually exclusive and independent events, conditional probability, Bayes' Theorem, expectation and dispersion, Markov chains and decision-making.This course introduces the common discrete distributions: binomial, hypergeometric, geometric, negative binomial and Poisson. Simulation may be used where appropriate.

Typically Offered: Fall and Spring

MA 250 Data Visualization   (3 credits)
Pre-Req: MA 214 or MK 340 or EC 483
This course covers the principles and practices of data visualization and storytelling with statistical graphics. Building on foundational statistics knowledge, students will learn how to construct clear and effective visualizations that highlight key insights from techniques like hypothesis testing, linear modeling, and multivariate analysis. A significant focus is placed on detecting misleading or confusing displays, improving integrity of visuals, communicating compelling narratives, and the ethical representation of data.

Typically Offered: Once a year

MA 252 Regression Analysis   (3 credits)
Pre-Req: (MA 131 or MA131L) and MA 214.
This course focuses on the statistical concepts that form the basis for advanced topics in regression analysis, notably the construction of multiple regression models, time-series models and an analysis of the residuals. Students apply these concepts to large, multi-dimensional data sets using advanced software such as SAS or SPSS, and gain experience in becoming more informed decision-makers through the interpretation of the software results. Emphasis is also placed on being able to communicate the statistical results to a general audience.

Typically Offered: Fall and Spring

MA 255 Design of Experiments   (3 credits)
Pre-Req: MA 252
Context and Perspectives: Scientific Inquiry
The course addresses the design and analysis of experiments, with a focus on management applications. The differences, advantages and disadvantages of various designs are discussed with a special emphasis on factorial and fractional factorial designs. These popular designs allow for two or more factors to be systematically and simultaneously varied while the experimenter tries to determine not only the (main) effect of each factor, but also how the level of one factor influences the impact of another factor (aka interaction). Students will extend the long history of successes of the (fractional) factorial design into the field of management inquiry. Specific applications will stress cost savings and policy making; multiple examples will be drawn from the marketing disciplines.

Typically Offered: Fall and Spring

MA 263 Continuous Probability for Risk Management   (3 credits)
Pre-Req: (GB 213 or ST 113) and MA 139
This course focuses on concepts and techniques of continuous probability and their applications to risk management in insurance and finance. Among other topics, the most commonly used single- and multi-variable continuous probability distributions are addressed. Concepts are illustrated with a large number of applied risk management problems.

Typically Offered: Fall

MA 267 Discrete Mathematics   (3 credits)
Pre-Req: Three credits of Math
In contrast to the continuous real number line from calculus, "discrete" mathematical structures are made up of distinct, separate parts. The instructor chooses a few topics to cover from the many available discrete mathematics topics, including mathematical language and syntax, proofs and logic, circuits, cryptography, graphs (i.e., relationships among people, agencies, machines, and more.), number theory, combinations and permutations, and similar topics. The relationship of mathematics to computer science features prominently.

Typically Offered: Every two or more years

MA 280 Selected Topics in the Mathematical Sciences   (3 credits)
This course examines a particular area of mathematics or its applications. It may include such topics as the use of mathematical models in environmental science, the history of mathematics, elementary measure theory or financial mathematics. The topic will be announced prior to registration.

Typically Offered: As needed

MA 298 Experimental Math Course   (3 credits)
Experimental courses explore curriculum development, with specific content intended for evolution into a permanent course. Students may repeat experimental courses with a different topic for credit.
Typically Offered: As needed

MA 299 Experimental Courses in Math   (3 credits)
Experimental courses explore curriculum development, with specific content intended for evolution into a permanent course. Students may repeat experimental courses with a different topic for credit.

Typically Offered: As needed

MA 307 The Mathematics of Computer Graphics   (3 credits)
Pre-Req: Three credits of Math
This course introduces mathematics for analyzing and describing images and scenes. Manipulations of two- and three-dimensional figures and spaces are analyzed using geometry, vectors, matrices and polynomials. A significant aspect of the course involves using these mathematical methods to generate images and animations that are both attractive and informative.

Typically Offered: Other

MA 309 Game Theory   (3 credits)
Pre-Req: Six credits of math or [(MA 107 or MA 123 or MA 123L or MA 131 or MA 131L) and ST 113].
Game theory is the study of strategic behavior of rational actors who are aware of the interdependence of their actions. Course topics include the extensive form tree representation and the key concepts of strategy space and strategy profile. The normal form game representation is developed and illustrated with classical games such as the Prisoner's dilemma and Hawk-Dove. The discrete probability model is developed and applied to the concepts of player beliefs and mixed strategies. Solution concepts for games such as dominance and iterated dominance, best response curves, Nash equilibrium and security strategies are developed and compared. Additional topics may also be included, such as evolutionary games and fair division strategies.

MA 310 Actuarial Topics in Probability and Risk Management   (3 credits)
Pre-Req: MA 263
This is an advanced course focused on further developing fundamental tools in discrete and continuous probability necessary for the analysis and solution of risk management problems. Significant time is spent examining complex problems and determining which mathematical technique(s) to apply. Success in mastering the techniques presented requires a substantial commitment to independent study. Students doing well in this course should be prepared to take the Society of Actuaries Exam P (Probability) or Casualty Actuarial Society Exam 1.

Typically Offered: Spring

MA 315 Mathematical Modeling with VBA in Excel   (3 credits)
Pre-Req: MA 214
While Microsoft Excel is not an ideal analytics tool, it is ubiquitous in business contexts, making it often the best platform to share work with colleagues and clients. This is particularly true when creating an automated analysis and sharing it with nontechnical users, who need a familiar interface. Consequently, we cover in this course ways to create and automate various analytical techniques in the programming language VBA (Visual BASIC for Applications) that is built into Microsoft Excel. We will focus on using it for mathematical modeling, automating analyses, and creating user interfaces inside of Excel for sharing an automated analysis tool with a nontechnical user.

Typically Offered: Once a year

MA 335 Financial Calculus and Derivative Pricing   (3 credits)
Pre-Req: MA 139 and ST 113/GB 213
This course provides an introduction to the basic mathematical concepts underlying the famous Black-Scholes-Merton option pricing formula and the associated financial market model, including model limitations and alternatives. Selected topics from ordinary differential equations, probability theory and statistics are used to develop and analyze the economic concepts. Hedging strategies and portfolio sensitivity parameters associated with options are also developed and discussed.

Typically Offered: Spring

MA 343 The Mathematics of Discrete Options Pricing   (3 credits)
Pre-Req: Six credits of math
This course is devoted to basic principles and techniques of no-arbitrage discrete derivative pricing. Using elementary probability and linear algebra, the binomial option pricing model is developed. No-arbitrage option pricing and hedging are addressed using binomial trees. Real-market data is used to explore the computational aspects of options pricing. The course should be of interest to strong math students who would like to see how fundamental mathematics is applied to a significant area of finance and to strong finance and economics students who would like to better understand the concepts behind the standard options pricing models.

Typically Offered: Fall

MA 346 Data Science   (3 credits)
Pre-Req: (GB 213 or ST 113) and CS 230
Context and Perspectives: Scientific Inquiry
Working with and finding value in data has become essential to many enterprises, and individuals with the skills to do so are in great demand in industry. The required skill set includes the technical programming skills to access, process and analyze a large variety of data sets, and the ability to interpret and communicate these results to others. Anyone with these abilities will provide benefit to their organization regardless of their position. This course presents the essentials of this skill set.

Typically Offered: Fall and Spring

MA 347 Data Mining   (3 credits)
Pre-Req: MA 252
Context and Perspectives: Scientific Inquiry
This course will introduce participants to the most popular data-mining techniques, with an emphasis on getting a general understanding of how the method works, how to perform the analysis using suitable available software, and how to interpret the results in a business context. Topics will include linear regression models, logistic regression models, association rules analysis (also known as market basket analysis), cluster analysis, k-nearest neighbors, decision tree analysis, and Naïve Bayes. Additional techniques may be introduced if time allows.

Typically Offered: Fall and Spring

MA 352 Mathematical Statistics   (3 credits)
Pre-Req: MA 233 and MA 263
This course covers calculus-based mathematical statistics intended for upper-level undergraduate students in the mathematical sciences. The goal is to provide a solid foundation in theoretical statistical inference, which includes the theoretical aspects of estimation theory and hypothesis testing procedures. Upon completion of this course, students are expected to understand and apply basic concepts in mathematical statistics. In particular, students will study concepts in distributions and convergence, moment methods, estimations and test of statistical hypothesis.

Typically Offered: Every two or more years

MA 357 Mathematical Theory of Interest   (3 credits)
Pre-Req: MA 139 or MA 139L
The theory of interest addresses the critical financial question of determining the value of a stream of cash flows. This is a problem-solving intensive course aimed at preparing the highly motivated student for the Society of Actuaries Exam FM. Emphasis is placed on learning efficient and effective techniques for solving interest theory problems.

Typically Offered: Spring

MA 374 Fundamentals of Short-Term Actuarial Mathematics   (3 credits)
Pre-Req: MA 310
This course introduces fundamental topics of actuarial mathematics for short-term coverages that are applicable for health, life, and property/casualty insurance. We will focus on modeling techniques, such as frequency, severity, coverage modifications, and aggregate models, as well as the principles of ratemaking and reserving. This course will cover most of the short-term modeling topics on the Society of Actuaries Exam FAM and the Casualty Actuarial Society Exam MAS-I.

Typically Offered: Every two or more years

MA 375 Fundamentals of Long-Term Actuarial Mathematics   (3 credits)
Pre-Req: MA 310 and MA 357
This course introduces fundamental topics of actuarial mathematics for long-term coverages. We will examine survival models, contingent payment models (present value random variables, premium, and policy valuation) and their applications to insurance and other financial risks. This course will cover most of the long-term modeling topics on the Society of Actuaries Exam FAM.

Typically Offered: Every two or more years

MA 376 Advanced Long Term Actuarial Mathematics   (3 credits)
Pre-req: MA 375
This course further develops knowledge and mastery of fundamental actuarial mathematics, focused on long-term insurance, health, and annuity contracts. We begin with survival models for multiple state contingent cash flows and use them to calculate premiums and policy values for long-term coverages. Then we consider joint life insurance and annuity contracts and their profit metrics. Finally, we explore how retirement benefits are accrued, valued, and funded. This course is designed to help a motivated student prepare for the Society of Actuaries (SOA) ALTAM examination.

Typically Offered: Every two or more years

MA 380 Introduction to Generalized Linear Models and Survival Analysis in Business   (3 credits)
Pre-Req: MA 252.
Context and Perspectives: Scientific Inquiry
The course is designed for students interested in analyzing data with advanced regression modeling. It introduces generalized linear models (GLMs) and survival analysis with a focus on business applications. It includes GLMs with various linking functions: logistic models, Poisson models, and others. It particularly emphasizes the applications of these functions in real world data analysis and includes the use of professional statistical packages. Survival analysis is an important method for analyzing hazard and survival time in areas such as health care, finance, marketing and management. The course will focus on applications of survival models and the interpretation of simple survival models using Kaplan-Meier curves.

Typically Offered: Fall and Spring

MA 398 Experimental Course in Actuarial Ratemaking and Reserving   (3 credits)
Pre-Req: MA 214 and MA 263
This course introduces basic ratemaking and reserving practices and techniques. These techniques are fundamental to a well-rounded actuarial education and should be of interest to all actuarial students. Both ratemaking and reserving are key actuarial responsibilities and this course will offer a hands-on/project based approach to learning the techniques and understanding the impact on insurer profitability. The concepts and skills we develop are particularly relevant to short term coverages as is typically found in health and property and casualty contracts. We will analyze data, build models in Excel, update them as new data becomes available, and make recommendations to management.

Typically Offered: Once a year

MA 399 Experimental Course in MA   (3 credits)
Experimental courses explore curriculum development, with specific content intended for evolution into a permanent course. Topics may be offered twice before it becomes a permanent course. Students may repeat experimental courses with a different topic for credit.
Typically Offered: As needed

MA 401 Directed Study in Mathematical Sciences   (3 credits)
This course permits superior students to study special topics. (May be repeated for credit.)

Typically Offered: As needed

MA 402 Seminar in Mathematical Sciences   (3 credits)
Pre-Req: Three credits of math
This course permits small-group study of selected topics by advanced students. (May be repeated for credit.)

Typically Offered: As needed

MA 421 Internship in Mathematical Sciences   (3 credits)
An internship provides students with an opportunity to gain on-the-job experience and apply principles and issues raised in the academic discipline to a work environment. The student is required to attend pre-internship workshops sponsored by the Center for Career Services, meet regularly with a faculty advisor, and develop a final paper or special project.

Typically Offered: As needed