DEPARTMENT OF MATHEMATICS

FACULTY

- Anne Dow, Ph.D., Chair, Associate Professor of Mathematics
- Catherine Gorini, Ph.D., Dean of Faculty, Professor of Mathematics
- Debra Levitsky, Ph.D., Assistant Professor of Mathematics
- David Streid, Ph.D., Assistant Professor of Mathematics
- Eric Hart, Ph.D., Adjunct Associate Professor of Mathematics and Mathematics Education
- Richard Weller, Ph.D., Adjunct Assistant Professor of Mathematics and Physics
- Anna Rivero, M.Sc., Instructor of Mathematics
- Johan Svenson, M.A., Adjunct Instructor of Mathematics and Physics
- John Price, Ph.D., Visiting Professor of Mathematics

INTRODUCTION

Mathematics is the exact study of abstract patterns and relationships. The objects that mathematicians study, such as numbers, operations, shapes, and relationships, are abstract and underlie all physical reality, but have no physical reality themselves, existing only in the consciousness of the mathematician. Thus, mathematicians study the functioning of intelligence itself.

In their work, mathematicians refer back to the principles of intelligence in their own consciousness and are able to discover the same principles of order and intelligence that govern all areas of life. Thus, mathematics is able to provide the basic language for all other sciences and has applications in every area of life.

Students who study mathematics at Maharishi University of Management learn to see the connections between the functioning of their own intelligence and mathematical knowledge. They acquire quantitative skills, problem-solving abilities, and clarity of thinking that provide a basis for success and leadership in technology-based careers. Graduates of the program in mathematics are prepared to enter a wide range of careers or continue their education with graduate or professional studies.

PROGRAMS OFFERED

B.S. in Mathematics

The Major in Mathematics provides a foundation in mathematics, plus electives in mathematics, computer science, biology, and/or physics. The program allows for flexibility in student goals by providing two tracks within the major.

MATHEMATICS TRACK

This track provides a strong foundation in mathematics that includes an introduction to real analysis and abstract algebra, plus a limited number of electives in mathematics, computer science, and/or physics.

- Students are prepared for a career in a technical area or in other professional and scientific areas.
- By judicious choice of electives and other courses, students may graduate prepared to undertake graduate study in mathematics, in computer science, in business, or in other professional and scientific areas.
- By careful selection of additional courses in computer science, students can graduate prepared to complete the Master of Science in Computer Science at Maharishi University of Management in one year.
- By also majoring in education, students can graduate prepared to teach mathematics in primary or secondary schools.

SCIENCES TRACK

This track allows students to include more science courses than the Mathematics Track. It provides students with basic mathematics and computer science and an opportunity to take further courses in mathematics, computer science, or applied areas of interest to the student.

- Students are prepared for a career in a technical area or, with careful attention to electives and other courses, for graduate study in computer science, business, and other professional or scientific areas.
- By careful selection of additional courses in both computer science and mathematics, students can graduate prepared to complete the Master of Science in Computer Science at Maharishi University of Management in one year.
- By also majoring in education, students can graduate prepared to teach mathematics in primary or secondary schools.
- Although it is possible to proceed to graduate study in mathematics through this degree, it is preferable to do so by following the Mathematics Track.

Minor in Mathematics

This minor is for students who wish to have knowledge of mathematics to support their study in computer science or any of the natural or applied sciences.

SPECIAL FEATURES

- Students gain an understanding of the parts of mathematics in relation to each other, to themselves, and to the overall body of mathematics. This integrated approach to mathematics is relevant, lively, interesting, and fulfilling for students.
- Even in their first courses, students begin to appreciate the full range of mathematics, from the deepest foundational levels to real-world applications in computer science, physics, engineering, business, and art.
- Students regularly use a computer laboratory to clarify principles and develop applications in many of their classes, including geometry, calculus, linear algebra, probability, and statistics.
- The mathematics department offers a friendly and nurturing environment for all students.
- All faculty are outstanding teachers. One has received an award for outstanding teaching from the Mathematical Association of America and another has attracted numerous National Science Foundation grants, including one to develop a model high school mathematics curriculum. The faculty organize annual mathematics festivals at the University that have attracted hundreds of high school students.
- Students regularly present their own research papers at the annual meeting of the Iowa Section of the Mathematical Association of America. Several students have received Outstanding Student Paper awards.
- Students participate in national and regional mathematics competitions. Two teams have received Honorable Mentions for their creativity and teamwork in the national Competition in Mathematical Modeling.
- The Math Club helps students sharpen their problem-solving abilities and encourages them to enter mathematical competitions.
- Research shows that educational techniques used at the University produce clearer, more orderly thinking, necessary for success in mathematics — and for later careers.

DEPARTMENTAL REQUIREMENTS

Entrance Requirements for the Bachelor of Science Degree in Mathematics and the Minor in Mathematics

Before entering the Major in Mathematics or the Minor in Mathematics, students must successfully complete Functions and Graphs 2 (MATH 162) and College Composition 2 (WTG 192).

Graduation Requirements for the Bachelor of Science Degree in Mathematics

To graduate with a B.S. in Mathematics, students must successfully complete all requirements for the bachelor's degree. (Please refer to "Degree Requirements" in "Academic Policies.")

As part of the requirements for the B.S. in Mathematics, all students must complete 52 credits of required courses as follows:

28 credits of required courses:

- MATH 200 The Mathematics of Infinity
- MATH 272 Discrete Mathematics
- MATH 281 Calculus 1
- MATH 282 Calculus 2
- MATH 283 Calculus 3
- MATH 286 Linear Algebra 1
- MATH 351 Probability

Students in the Mathematics Track must also complete:

8 credits of required courses:

MATH 423 Real Analysis 1
MATH 431 Algebra 1

Plus

8 credits of mathematics courses numbered 267 or higher

Plus

8 credits of electives chosen from the following:

- any mathematics course numbered 267 or higher,
- any physics course numbered 210 or higher,
- any computer science course numbered 200 or higher,
- MGT 314.

In addition, in their final year, students in the Mathematics Track are required to

• Take the Educational Testing Service Major Field Test in Mathematics and submit their results to the Department of Mathematics.

Students in the Sciences Track must also complete:

4 credits of required courses:

• CS 201 Computer Programming 1

plus

8 credits of computer science courses numbered 203 or higher

plus 12 credits of electives chosen from the following courses:

• any mathematics course numbered 267 or higher,
• any physics course numbered 210 or higher
• any computer science course numbered 203 or higher
• any chemistry course numbered 201 or higher
• any biology course numbered 260 or higher

In addition, in their final year, students in the Sciences Track are required to:

• Take an assessment test to be chosen by the Department of Mathematics, and to submit the results to the Department of Mathematics. Students, who have taken the general Graduate Record Examination (GRE) for entry into graduate school or for other purposes, may satisfy this requirement by simply submitting their GRE results to the Department of Mathematics. Students not taking the GRE will need to consult the Department of Mathematics to determine an appropriate test.

Students in both tracks are required in their senior year to:

- Complete a Senior Project, either in place of the required project for a higher-level mathematics course, or by including the course MATH 490 Senior Project in their 52 credits of required courses, or both. See below under MATH 490 Senior Project for a description of this project.
- Make their Senior Project into a poster for submission for presentation at the annual Knowledge Celebration in June of the year of completing the Major in Mathematics.

Master of science in computer science

Students completing the Sciences Track of the Mathematics Major with courses in computer science are eligible to continue on to Maharishi University of Management's Master of Science in Computer Science and may be able to complete it in one year.

Students enrolling in the Sciences Track of the Major in Mathematics, who intend to pursue this avenue, are advised to study carefully the "Entrance Requirements for the Master of Science Degree in Computer Science" given in the section of this catalog called "Department of Computer Science." It is strongly recommended that these students complete all these requirements as part of their undergraduate program, in addition to the requirements for the Sciences Track of the Major in Mathematics. These students should also consult the Department of Computer Science regarding their best choice of computer science courses during their undergraduate program, so that they can complete the Master of Science in Computer Science in one year.

Graduation Requirements for the Minor in Mathematics

To graduate with a minor in mathematics, students must successfully complete 20 credits of mathematics courses numbered 267 or higher.

Teacher Licensure with an Endorsement in Elementary or Secondary Mathematics

Students aiming for Iowa teacher licensure with an endorsement in elementary or secondary mathematics should consult the M.U.M. Education Department early in their planning.

Mathematics Placement and Mathematics Requirements for All Students

Maharishi University of Management has a second-year distribution requirement in mathematics and many majors have mathematical prerequisites or requirements. During the first few weeks after arrival, all undergraduate students are placed at a particular level of mathematics, based on transfer credit for a course numbered Math 162 or above or taking a placement test in mathematics. Students may not enroll for any mathematics course until placement is completed. For a more complete description of the placement program in mathematics, please see "Mathematics Placement Policies" and "General Education Requirements" in the subsection "Bachelors Degree Requirements" of the section "Academic Policies" in this Catalog.
(www.mum.edu/pdf/catalog/academicpolicies.pdf)

MATH 148 Infinity: From the Empty Set to the Boundless Universe of All Sets — Exploring the Full Range of Mathematics and Seeing Its Source in Your Self
Mathematics takes place in the imagination, in consciousness, unlimited either by finite measuring instruments, by the senses, or even by the feelings. At the same time, mathematics has strict criteria for right knowledge. The power of mathematics lies in bringing infinity out into the finite and making it useful in everyday life — from deciding which bank offers the best return on money, to medical imaging, to designing textiles, to creating a work of art, to putting a man on the moon.

In this course, students explore many different ways in which mathematics expresses, emerges from, and uses infinity and its self-interacting dynamics. They look at the foundation of mathematics in the infinitary processes of set theory, the universe of sets, different sizes of infinity, the continuum and its limit process, sequences and series, infinite replication, and applications of infinity in many areas of life. (2 credits)

MATH 151 Basic Mathematics: Locating the Basis of Mathematics in the Self-Interacting Dynamics of Consciousness
Arithmetic is the study of patterns, relations, and operations on numbers. Topics include the arithmetic of integers, fractions, decimal fractions, ratios, and percents, with an emphasis on applications. (4 credits)

MATH 152 Elementary Algebra: Using Variables to Manage All Possible Numbers at the Same Time and Solve Practical Problems
The infinitely flexible language of algebra is used to quantify and model mathematical patterns and relationships. Topics include operations on algebraic expressions, linear equations, the coordinate plane, inequalities, factoring, and simple quadratic equations. (4 credits) *Prerequisite:* Math 151

MATH 153 Intermediate Algebra: Using Variables to Manage All Possible Numbers at the Same Time and Solve Practical Problems
This course extends Elementary Algebra to develop further algebraic models. Topics include polynomials, rational and radical expressions, quadratic equations, and graphing in the coordinate plane. (4 credits) *Prerequisite:* MATH 152

MATH 161 Functions and Graphs 1: Name and Form — Locating the Patterns of Orderliness That Connect a Function with Its Graph and Describe Numerical Relationships

MATH 162 Functions and Graphs 2: Name and Form — Learning to Relate the Shape of a Graph to Its Corresponding Function

A mathematical function quantifies the relationship between two related quantities and can be used to model change. Functions and their graphs are essential to all branches of mathematics and their applications. (4 credits each)

Topics 1: domain and range, average rate of change, graphs, functions (linear, exponential, logarithmic, and quadratic), and applications. *Prerequisite:* MATH 153

Topics 2: trigonometry, algebra of functions, compositions and inverses of functions, functions (trigonometric, power, polynomial, and rational), and applications. *Prerequisite:* MATH 161

MATH 170 Mathematics for Sustainable Living: Knowledge is for Action

This course is designed especially for students entering the major in Sustainable Living who do not have the basic algebraic prerequisites for that major. Topics are drawn from college algebra, geometry, functions, and graphs, and these topics are related to problems in Sustainable Living such as landscaping, heat loss, solar and wind energy, and water management. (4 credits) *Prerequisite:* MATH 152, WTG 192

MATH 200 The Mathematics of Infinity

The course provides a gentle introduction to the modern history of mathematical infinity through the theory of large cardinals (infinities so large they can't be proven to exist). Students will explore the different levels of infinity, examine for themselves a few of the enormous large cardinals, and discover how Maharishi's Vedic Mathematics suggests a solution to a modern-day problem about the mathematical infinite – a solution that is the subject of recently published research. The main prerequisite is a willingness to explore the nature of the Infinite and to learn a new kind of mathematics in the process. (4 credits)

MATH 205 Maharishi Vedic Mathematics: Mathematical Structure and the Transcendental Source of Natural Law

This course studies the mathematics of Veda, as explained by Maharishi. Topics include mathematical models of the self-referral structure of the Veda, mathematics as the intellectual expression of the structure of pure knowledge, mathematics in the Vedic Literature, and examination of the principles of modern mathematics in the light of Maharishi Vedic Science. (2–4 credits) *Prerequisite:* WTG 192

MATH 266 Geometry for the Artist: Applying Abstractions of Shape and Form to Create Beautiful Concrete Images
Geometry, the study of shape and form, is an essential tool for the visual artist. Topics in this course include symmetry, Euclidean and non-Euclidean geometry, perspective and projective geometry, and fractals. Materials fee: $10 (4 credits)

MATH 267 Geometry: From Point to Infinity — Using Properties of Shape and Form to Handle Visual and Spatial Data
Geometry gives an understanding of shape, form, and structure that has many applications in mathematics, science, and technology. In-depth study of Euclidean and non-Euclidean geometries and their applications. (4 credits) *Prerequisite:* MATH 162

MATH 272 Discrete Mathematics: Unified Approaches to Managing Discrete Phenomena in Computer Science and Other Disciplines
Discrete mathematics, the study of finite processes and discrete phenomena, is essential for computer science. Topics include logic and sets, relations and functions, vertex-edge graphs, recursion, and combinatorics. (4 credits) *Prerequisite:* MATH 162, WTG 192

MATH 281 Calculus 1: Derivatives as the Mathematics of Transcending, Used to Handle Changing Quantities
MATH 282 Calculus 2: Integrals as the Mathematics of Unification, Used to Handle Wholeness
MATH 283 Calculus 3: Unified Management of Change in All Possible Directions
Calculus, one of the most useful areas of mathematics, is the study of continuous change. It provides the language and concepts used by modern science to quantify the laws of nature and the numerical techniques through which this knowledge is applied to enrich daily life. Using the mathematics computer laboratory, students gain a clear understanding of the fundamental principles of calculus and how they are applied in real-world situations. (4 credits each)
Topics Calculus 1: limits, continuity, derivatives, applications of derivatives, integrals, and the fundamental theorem of calculus. *Prerequisite:* MATH 162, WTG 192
Topics Calculus 2: techniques of integration, further applications of derivatives, and applications of integration. *Prerequisite:* MATH 281
Topics Calculus 3: infinite series, functions of several variables and their derivatives, gradient, directional derivatives, vector-valued functions and their derivatives, the Jacobian matrix, and chain rule. *Prerequisite:* MATH 286

MATH 286 Linear Algebra 1: Linearity as the Simplest Form of a Quantitative Relationship
Linear algebra studies linearity, the simplest form of quantitative relationship, and provides a basis for the study of many areas of pure and applied mathematics, as well as

key applications in the physical, biological, and social sciences. Topics include systems of linear equations, vectors, vector equations, matrices, determinants, vector spaces, bases, and linear transformations. (4 credits) *Prerequisite:* MATH 282

MATH 304 Calculus 4: Locating Silence within Dynamism
This course extends the calculus of a function of a single real variable to functions of several real variables. Topics include maxima and minima, curvilinear coordinates, line integrals, multiple integrals, change of variables, gradient fields, surface integrals, and the theorems of Green, Stokes, and Gauss. (4 credits) *Prerequisite:* MATH 283

MATH 307 Linear Algebra 2: Unified Approaches to Linear Transformations
This course deepens and extends many of the topics covered in Linear Algebra 1; additional topics include the Cayley-Hamilton theorem, Jordan canonical form, inner-product spaces, orthogonality, and spectral theory. (4 credits) *Prerequisite:* MATH 286

MATH 308 Ordinary Differential Equations: Describing Evolving Systems and Predicting Their Future
The most concise mathematical expression that describes a continuously changing physical system is a differential equation, which uses derivatives to quantify all possible states of an evolving system in one equation. Topics include first-order differential equations, second-order linear differential equations, power-series solutions, Laplace transforms, numerical methods of solution, and systems of differential equations. (4 credits) *Prerequisite:* MATH 283

MATH 310 Mathematical Problem Solving: Systematic Techniques for Using Mathematics to Solve Problems
Problem solving is a fundamental — and exciting — part of mathematics. In this course, students develop and practice many methods and techniques of mathematical problem solving. (4 credits) *Prerequisite:* MATH 282

MATH 315 Special Topics in Mathematics
In this course students investigate a specialized area of mathematics in depth. Topics will vary. (4 credits — may be repeated) *Prerequisite:* consent of the instructor

MATH 318 Complex Analysis: Transcending the Real Numbers to a Simpler and More Unified Numbering System
Complex analysis is one of the great achievements of modern mathematics, providing an extension of the real number line to a two-dimensional plane of numbers with surprising applications throughout most areas of mathematics. Topics include analytic functions, Cauchy-Riemann equations, contour integration, Cauchy's Theorem and integral

formulas, power series, residue theorem, and conformal mappings. (4 credits) *Prerequisite:* MATH 304

MATH 351 Probability: Locating Orderly Patterns in Random Events to Predict Future Outcomes
Probability provides precise descriptions of the laws underlying random events, with applications in quantum physics, statistics, computer science, and control theory. Topics include permutations and combinations, conditional probability, random variables, discrete and continuous distributions, expectation, and the central limit theorem. (4 credits) *Prerequisite:* MATH 282

MATH 353 Probability and Statistics 1: Methods for Deriving Dependable Knowledge from Incomplete Information
Probability provides precise mathematical descriptions of the laws underlying random events, and statistics uses this mathematical theory to make inferences from empirical data and assess their reliability. Topics include probability, random variables, probability distributions, mean and standard deviation, central limit theorem, tests of hypotheses, linear regression, and correlation. (4 credits) *Prerequisite:* MATH 161, WTG 192

MATH 354 Probability and Statistics 2: Methods for Deriving Dependable Knowledge from Incomplete Information
The topics of Probability and Statistics 1 are studied more deeply, with emphasis on their mathematical foundations. (4 credits) *Prerequisites:* MATH 353 and MATH 283

MATH 370 Mathematical Logic: Mathematical Criteria for Establishing Accurate Forms of Knowledge
Mathematical logic is the mathematical description of the structure and function of the symbolic language of mathematics. This course develops a rigorous symbolic language, suitable for expressing all mathematical concepts, demonstrates the soundness and completeness of the language, and shows the inherent limitations of such formal systems indicated by Gödel's Incompleteness Theorems. (4 credits) *Prerequisite:* consent of the instructor

MATH 399 Directed Study
(variable credits) *Prerequisite:* consent of the department faculty

MATH 401 Practicum in Teaching College Mathematics: Knowledge Is Structured in Consciousness
Under the direction of a senior faculty member, students prepare and give lectures, lead tutorial sessions, and write and grade quizzes and exams for a college-level mathematics course. (4 credits) *Prerequisite:* consent of the instructor

MATH 402 Undergraduate Research in Mathematics
This course provides an opportunity for students to do original research under the supervision of a faculty member. (1 credit) *Prerequisite:* consent of the instructor

MATH 410 Seminar in Applied Mathematics 1: Knowledge Is for Action
MATH 411 Seminar in Applied Mathematics 2: Knowledge Is for Action
In these courses, students apply the theoretical knowledge they have gained in previous mathematics courses to an applied problem taken from a real-life situation in business or industry. Problems differ from year to year. (4 credits each — may be repeated) *Prerequisite:* consent of the instructor

MATH 420 Numerical Analysis: Using Abstract Mathematical Principles to Design Accurate and Efficient Numerical Methods for Solving Problems
Scientific and engineering applications of computers require advanced numerical techniques of manipulating and solving complex systems of equations with great efficiency and minimum error. Topics include numerical solutions of systems of linear equations, curve fitting, interpolation, numerical integration, solution of algebraic equations, and error analysis. (4 credits) *Prerequisite:* MATH 282

MATH 423 Real Analysis 1: Locating the Finest Impulses of Dynamism within the Continuum of Real Numbers
MATH 424 Real Analysis 2: Developing a Conceptual Foundation for Calculus
Analysis is the mathematically rigorous development of calculus based on the theory of infinite sets. The analysis sequence begins with the application of the infinitary methods of set theory to construct the uncountable continuum of real numbers and unfold its topological structure, and then shows how the basic principles of calculus can be logically unfolded from this set-theoretic understanding of the continuum. (4 credits each)
Topics 1: infinite sets, completeness, numerical sequences and series, open sets, closed sets, compact sets, connected sets, and continuous functions. *Prerequisite:* MATH 283
Topics 2: properties of continuous functions, differentiation, mean value theorem, Riemann integral. *Prerequisite:* MATH 423

MATH 431 Algebra 1: Algebraic Operations as the Self-Interacting Dynamics of a Mathematical System
MATH 432 Algebra 2: The Integration and Interaction of Two Algebraic Operations on a Mathematical System
Algebra is the study of the structures given to sets of elements by operations or relations as well as the structure-preserving transformations between these sets. (4 credits each)

Topics Algebra 1: groups and subgroups, quotient groups, group homomorphisms, direct sum, kernel, image, Noether isomorphism theorems, and the structure of finitely generated abelian groups. *Prerequisite:* MATH 286
Topics Algebra 2: rings, integral domains, fields, principal ideal domains, unique factorization domains, modules and submodules, tensor products, and exact sequences. *Prerequisite:* MATH 431

MATH 434 Set Theory: Mathematics Unfolding the Path to the Unified Field — the Most Fundamental Field of Natural Law
Set theory provides a unified foundation for the diverse theories of modern mathematics based upon the single concept of a set. Topics include axioms of set theory, ordinals, transfinite induction, the universe of sets, cardinal arithmetic, large cardinals, and independence results. (4 credits) *Prerequisite:* MATH 370

MATH 436 Foundations of Mathematics: The Unified Field as the Basis of All of Mathematics and All Laws of Nature
This course introduces recent developments that have provided important new insights into the structure of the foundations of mathematics. Topics covered in the course vary from year to year. (4 credits) *Prerequisite:* MATH 370

MATH 460 Topics in Set Theory
Topics vary from year to year and may include large cardinals and elementary embeddings; applications of set theory to topology and analysis; applications of set theory to algebra; introduction to the theory of forcing; Gödel's constructible universe; descriptive set theory. (4 credits) *Prerequisite:* consent of instructor

MATH 466 Topology: Relation between Point and Infinity
Topology shows how all mathematical aspects of shape, structure, and form can be expressed in terms of set theory. Students study topologies and their properties of separation, connectedness and compactness, topological mappings, and the fundamental group of a topological space. (4 credits) *Prerequisites:* MATH 423 and 431

MATH 485 Theory of Computation: The Laws That Govern the Self-Interacting Dynamics of Numbers and Their Application
Students focus on formal abstract models of computation and capabilities of abstract machines in relation to their increasing ability to recognize more general classes of formal languages. Topics include formal grammars, finite-state machines, equivalence of finite-state machines, right-linear and left-linear grammars, pushdown automata, context-free languages, Turing machines, unsolvable problems, and recursive functions. (4 credits) *Prerequisite:* MATH 272

MATH 490: Senior Project: Integration of All Knowledge in the Self
Students write a substantial paper unifying the knowledge gained from the courses taken during their major and relating this knowledge to deep principles from Maharishi Vedic Science. This paper may take the form of: 1) An integrated summary of main ideas from the courses taken during their major, addressing themes and questions to be provided by the Department of Mathematics, or 2) A paper written in accord with the guidelines for submissions for the Raja Raam Award and submitted for that award (see description elsewhere in this Catalog), or 3) A report of research conducted by the student on a mathematical topic or problem chosen in conjunction with the Department of Mathematics. In all of these cases, the paper will be made by the student into a poster for submission for presentation at the annual Knowledge Celebration in June of the year of completion of the major. (4 credits) *Prerequisite:* consent of the instructor

MATH 499 Directed Study
(variable credits) *Prerequisite:* consent of the department faculty