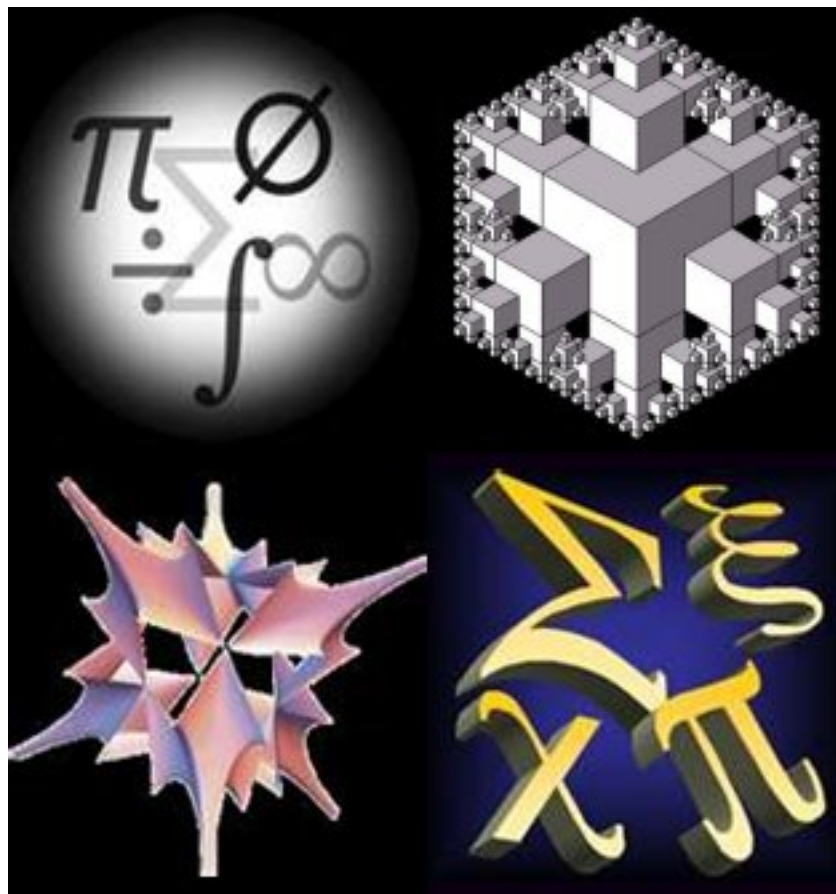


The University of Arizona
Undergraduate Programs
in the
Mathematical Sciences



2018–2019



UA SCIENCE

Mathematics

The information and requirements given here apply to the 2018–2019 catalog. For other catalog years, please consult the archive (<http://math.arizona.edu/academics/undergrads/requirements/majors/archive>).

This booklet describes the undergraduate degree programs in the Mathematical Sciences available for a student at The University of Arizona. It also contains information about facilities, activities, jobs, advising, and other services and activities supportive of these undergraduate programs, e.g., what they are, where to find them, whom to contact, and so on.

The contents of this booklet are a subset of the information available at the website <http://math.arizona.edu/academics/undergrads> and the latest version of this booklet, in PDF form, may be downloaded from that web address. You are presently looking at the booklet created on: May 23, 2018

This is a preliminary version of the handbook, including new information on the Statistics and Data Science major. Please see an advisor for the most up-to-date information.

To request an appointment with an advisor or ask a question, please use the contact forms in the upper right portion of the page at <http://mathcenter.math.arizona.edu>.

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Why study mathematical sciences?



In many disciplines, the history of the twentieth century tells of the introduction of more and more mathematical and statistical techniques. Mathematics has been established as a universal ingredient in the understanding of the world, and is the language used in conveying this understanding. Now, in the twenty-first century, higher mathematics and statistics are not just tools for physical scientists and engineers, but also of crucial importance in business, economics, social sciences, medicine, and many other fields. Many mathematicians still delight in the aesthetic appeal of their subject; however, it is ultimately the application of mathematics that makes it a critical element in modern civilization.

Statistics is a subfield of the mathematical sciences. Its applications to new technologies and big data are so numerous that it warrants its own major; however, to study statistics is essentially to study mathematics. When we refer to "mathematics" or "the mathematical sciences," statistics is included in those categories. Many students may find that their interests span courses from both the mathematics and

the statistics and data science programs, and we encourage you to study both! See policies regarding this on p. 13.

Why declare a math or statistics major?

Undergraduate training in mathematical sciences is an important step along many career paths. It is essential for those who intend to continue toward a graduate degree in mathematics, applied mathematics, statistics, or computer science. Admissions committees for graduate studies in astronomy, physics, engineering, economics, or finance often prefer students with undergraduate mathematics majors (together with the proper minor) over students who have majored in their own subject. Some University of Arizona mathematics graduates have also used their degree as the first step toward professional degrees in law, medicine, and even divinity.

The mathematics department offers majors in mathematics or in statistics and data science. These majors are not just a path toward graduate education. Mathematics training is training in general problem solving. Many employers recognize this fact; they also recognize that a bachelors degree in mathematics or statistics is proof of an ability and willingness to work hard. Many of our majors have found success by completing more than one major. Double majors in mathematics and science, mathematics and business, among others, prepare graduates with enhanced ability to compete well in the job market.

Mathematics and statistics majors are advised to develop both computing skills and communication skills during their time as a student. Computing skills are increasingly important in today's society. Experience using graphing calculators and standard mathematical software packages, programming experience, and experience using the internet are extremely useful. And in virtually any type of position, the need for good communication skills is paramount.

The Math Community at UA

Let us not forget one of the main reasons for becoming a mathematics or statistics major. It is fun! Our programs afford students plenty of time to link their mathematical interests to other intellectual endeavors. Students who combine mathematics, computer science, and another area will find themselves with many options when they graduate with an undergraduate degree.

The Department of Mathematics created the Math Center (see p.25) to ensure that our mathematics and statistics majors have a home base to turn to during

their undergraduate studies. One of our goals is to integrate the undergraduate mathematics and statistics majors into the intellectual life of this university and this nation. The working mathematician is involved in three areas: the creation of new mathematics, the application of mathematics to solve real-world problems, and the teaching of mathematics. Many of our undergraduate majors are able to perform these same activities during their undergraduate years through various research and teaching/tutoring opportunities and summer internship opportunities (see p. 32).

Careers in Mathematics and Statistics

There are few jobs with the title *Mathematician*. Mathematics majors may end up in a job with a title such as *Engineer* or *Analyst*. Career opportunities in the mathematical sciences fall into two broad categories, Educators and Practitioners:

Educators

University Professor

A Ph.D. degree in mathematics or statistics is required for this position. A university professor teaches courses, mentors students, and provides service to the institution and the community. A university professor can also be considered a practitioner to the extent that they conduct research and develop new knowledge in their field. A university professor may also engage in consulting activities.

College Teacher

College teachers may have a master's degree or a Ph.D., depending on the level and nature of the institution. Responsibilities may be exclusively instruction-related, as in the case of a community college, or may include some research.

High School or Middle School Teacher

Well-qualified mathematics teachers are in high demand. A bachelor's degree is the minimum requirement for teaching in secondary schools. State requirements for certification, which usually include courses in education, must also be met. The traditional areas of secondary school mathematics—algebra, geometry, and trigonometry—have been augmented in many schools by analytic geometry and calculus and other courses that are intended to meet diverse student needs. Newer curricula include computer programming, probability and statistics, linear algebra,

and applications. The prospective teacher who is familiar with these latter areas will have a competitive advantage.

Practitioners

Actuary

Actuaries are hired by insurance companies (life, health, casualty, etc.), pension plans, businesses, consulting firms (business and actuarial), and government agencies. To become an actuary (Associate or Fellow), one must pass a series of examinations administered by the Society of Actuaries. The initial exams are primarily mathematics, including probability and statistics, and can be taken while still an undergraduate student. Because actuarial science is a mixture of mathematics and business, the student should speak with an advisor about other course work needed to prepare for this career. Students who are interested in becoming actuaries will find additional information and suggestions on our Careers in Actuarial Science page (<http://math.arizona.edu/academics/undergrads/advising/actuary>).

Computational Scientist

A computational scientist is an applied mathematician who interprets problems arising from the physical sciences and engineering in mathematical form and develops mathematical solutions to these problems. Very large and sophisticated computers are used intensively. Potential employers include government laboratories, the chemical industry, and the biotech industry.

Operations Research Analyst

Also called management science analysts, operations research analysts help organizations coordinate activities and operate in the most efficient manner, by applying scientific methods and mathematical principles to organizational problems. Computers are used extensively in their work. Students interested in this career path should minor in Computer Engineering (COE) or Systems and Industrial Engineering (SIE).

Systems Engineer or Systems Analyst

A systems engineer or analyst usually has substantial course work in engineering or another technical field. This enables him/her to apply mathematical techniques to solve the problems unique to the industry of their employer. Students interested

in this career path should consider minoring in Systems and Industrial Engineering (SIE).

Scientific Writer/Communicator

The scientific publishing industry has a need for scientifically trained individuals for sales and editing. Excellent writing and oral communication skills are essential in this career field. Accurate and understandable technical writing is widely needed.

Software Engineer or Software Consultant

A software engineer generally designs and writes software that performs nonnumerical functions, such as graphics. A background in math and computer science is needed. Employers include consulting firms and large corporations which do their own software development. There is also room in this field for the entrepreneur or consultant.

Statistician

Statistics is both a very applied field and also a theoretical one. Many, but not all, statisticians are active in both applications and the development of new theory, but the greatest potential in terms of jobs is in applied statistics. Statisticians generally work with people in other fields, therefore communication skills are very important. Statistical applications nearly always include the analysis of data and hence some knowledge and experience in computing is very important. There are opportunities for statisticians in the government, in industry, business, medicine, and in academia.

Research Mathematician

In non-academic positions, research mathematicians conduct mathematical research in areas of interest to large corporations and various departments of government. These include the Department of Energy, various branches of the military, and security agencies. While the demand for non-academic research mathematicians has been shrinking in recent years, there still are positions available at national laboratories, the National Security Agency (NSA), and other government entities, as well as some large corporations. An advanced degree is usually required for these positions.

Data Scientist or Data Engineer

Data is collected constantly, from NASA's OSIRIS-REx spacecraft mapping the surface of the asteroid Bennu to your grocery store's loyalty card program. In many cases, the collections of data are too large to be handled by traditional means, or even to be stored on a single computer. The challenges inherent in working with and extracting meaning from big data ensure that skilled data scientists and engineers will continue to be in demand for the foreseeable future.

Undergraduate Degrees and Requirements

The mathematics and statistics majors are designed to meet many different needs. Our programs allow the student to choose a major and emphasis that best suit the individual's talents, interests, and career goals. A student may prepare for a variety of careers (see p.7) by selecting the appropriate major, emphasis, and minor. Students choosing a mathematics or statistics major can take advantage of the full range of mathematical resources available on campus.

The University offers two different degrees with a major in mathematics or statistics and data science, a Bachelor of Arts (B.A.) and a Bachelor of Science (B.S.).

Comparing the B.A. and the B.S.

As far as the mathematics or statistics coursework is concerned, the B.A. and B.S. are identical. The two degrees differ only in the following ways:

- Second language requirement (details below).
- Science/application course requirements (details below).

Math Department B.A. Requirements

- **Language Requirement:** Students must demonstrate *fourth semester proficiency* in a second language.
- The degree is not science-intensive. Students need to complete only the two Tier One NATS (170) and one Tier Two Natural Science courses, as specified in the University General Education requirements (<http://gened.arizona.edu/content/information-students>).

Math Department B.S. Requirements

- **Language Requirement:** Students must demonstrate *second semester proficiency* in a second language.
- **Laboratory Science Courses Requirement:** The degree is science-intensive and requires one of the following sequences of laboratory science courses:

- PHYS 141 & either 142 or 241
- PHYS 161H & either 162H or 261H
- CHEM 151 & 152
- CHEM 141 & 143 & 142 & 144
- CHEM 161 & 163 & 162 & 164
- MCB 181R & 181L & ECOL 182R & 182L
- PSIO 201 & 202
- GEOS 251 & either 302 or 304

Application Courses Requirement: (This requirement does not apply to the Mathematics Education Emphasis.) Students must complete at least six units of coursework that applies advanced mathematics or statistics to other academic fields.

For **mathematics majors**, these courses must have a pre- or co-requisite of at least Calculus I (MATH 122B or higher). Choose from the following:

ABE 201, 284, 428, 481A; ASTR 250; ATMO 421C, 436A, 469A, 469B; BIOC 462A, 462B, 463A, 466; BME 481B; CE 214; CHEE 201, 201L, 202, 301A, 481A, 481B; CHEM 161, 162, 325, 326, 404A, 480A, 480B, 481; CSC 345, 422, 433, 436, 437, 445, 453, 460, 477; CSCV 345; ECE 381A, 429; ECOL 302, 447, 496N; ECON 332, 361; ENGR 211C, 211P; ENVS 420, 470; GEOG 463; GEOS 322, 356, 419, 432, 434A, 440, 469, 479; HWRS 421, 431, 460A; ISTA 352, 421; MCB 315, 480; MSE 345, 404, 415; OPTI 201R, 303; PHYS 140, 141, 142, 143, 151, 152, 161H, 162H, 240, 241, 251, 261H; PSIO 303, 472; PTYS 407; SIE 250, 265; WSM 460A; or courses approved by your academic advisor.

For **statistics and data science majors**, these courses must have a pre- or co-requisite of a statistics course or at least Calculus I (MATH 122B or higher). Choose from the following:

ABE 201, 284, 423, 428; ACBS 313; AME 472; ASTR 250; BIOC 462A, 462B, 466; BME 481B; CE 214; CHEM 161, 162, 325, 326, 404A, 480A, 480B; CSC 345, 422, 433, 436, 437, 445, 453, 460, 477; CSCV 345; ECE 381A, 429; ECOL 302, 447; ECON 332, 361; ENGR 211C; ENVS 420, 470; EPID 479; GEOG 463; GEOS 322, 356, 419, 432, 434A, 440, 469, 479; ISTA 321, 350, 421, 450; MCB 315, 416A, 480; MSE 345, 404, 415; NSCS 344; OPTI 201R; PHYS 140, 141, 142, 143, 161H, 162H, 240, 241, 261H; PSIO 303, 472; PTYS 407; RAM 456A; RNR 417, 473; SIE 250, 265, 422, 496; SOC 476; WFSC 444; WSM 460A; or courses approved by your academic advisor.

Note: B.S. students may satisfy both the Laboratory Science Courses Requirement and the Application Courses Requirement by completing one of the Physics sequences. Some courses may require a major or minor in the subject area and/or additional prerequisites to enroll. Check the course catalog for details.

Double Degrees

Students pursuing a second major that has a degree title different from that of the first major are technically double degree students. Additional requirements may apply to double degree students that do not pertain to double major students (students with two majors that have exactly the same degree title). See an advisor for detailed information about these additional requirements.

Departmental Double Dipping Policies

In choosing your combination of majors and minors, keep in mind the following restrictions on double-dipping within the Mathematics Department's programs:

- A **double major or degree** in mathematics and statistics and data science is possible, with the requirement that students complete at least **21 unique units** in each major; because of the way the majors are structured, this means that students will take 7 unique upper-division courses in each major. If you anticipate overlapping courses, speak with your faculty advisor about making substitutions or changing your emphasis to avoid this.
- A **major in mathematics with a minor in statistics and data science, or vice versa**, is possible, with the requirement that students complete at least **6 unique upper-division units** in the minor. A statistics and data science major may not use courses with probability or statistics in the title as upper-division coursework in the math minor.
- For students with a major in the mathematics department, the minor requirement can only be filled by **minors outside the department**. For example, a statistics major with a mathematics minor would need a second minor to fulfill this requirement.

B.A./B.S. in Statistics and Data Science

The information and requirements given here apply to the 2018–2019 catalog. For other catalog years, please consult the archive (<http://math.arizona.edu/academics/undergrads/requirements/majors/archive>).

Statistics and Data Science Major Required Courses

The following courses are required for all Statistics and Data Science (SDS) majors:

- MATH 122A AND MATH 122B⁽¹⁾ or MATH 125 — Calculus I
- MATH 129 — Calculus II
- MATH 223 — Vector Calculus
- MATH 313 — Introduction to Linear Algebra⁽²⁾
- MATH 363 — Introduction to Statistics⁽³⁾
- DATA 375 — Introduction to Statistical Computing⁽⁴⁾
- MATH 464 — Theory of Probability⁽⁵⁾
- MATH 466 — Theory of Statistics
- DATA 467 — Introduction to Applied Linear Models⁽⁶⁾
- DATA 465 — Introduction to Data Science⁽⁷⁾
- One upper-division statistics major elective. See next page for options.

⁽¹⁾ MATH 122A and MATH 122B are a single-semester sequence of courses that cover Calculus I.

⁽²⁾ MATH 310 (Applied Linear Algebra) will also fill this requirement; however, it has a prerequisite of MATH 254, which does not count towards the statistics and data science major. MATH 313 replaces MATH 215, which is no longer offered. Students who completed MATH 215 prior to fall 2015 or who have transfer credit equivalent to MATH 215 will still fulfill this requirement, though they will not earn upper-division credit for the course.

⁽³⁾ This course is currently offered as MATH 363 as of Fall 2018, but may be available as DATA 363 in future, pending approval.

⁽⁴⁾ DATA 375 will be offered for the first time in Spring 2019; thereafter it will be offered every fall and spring semester. The course number and prefix are provisional.

⁽⁵⁾ Students who have completed MATH 313 and MATH 363 AND are declared statistics and data science majors can request to be manually enrolled in MATH 464 for the 2018-19 and 2019-20 academic years, bypassing the MATH 323 prerequisite. Once there are enough statistics majors to support independent courses, we will open new versions with the appropriate prerequisites.

⁽⁶⁾ DATA 467 will be offered for the first time in Fall 2019; thereafter it will be offered every fall semester. The course number and prefix are provisional.

⁽⁷⁾ DATA 465 will be offered for the first time in Spring 2020; thereafter it will be offered every spring semester. The course number and prefix are provisional.

Statistics and Data Science Major Elective Courses

The SDS major requires one upper-division elective course. The current courses that will be accepted towards this requirement are listed below. More course options will be added as the program grows; see your academic advisor for details.

- MATH 367 — Statistical Methods in Sports Analytics^(*)
- MATH 462 — Financial Math
- MATH 468 — Applied Stochastic Processes
- SIE 440 — Survey of Optimization Methods

^(*) *This course is currently offered as MATH 367 as of Fall 2018, but may be available as DATA 367 in future, pending approval.*

Supporting Computer Science Requirement

All SDS majors are required to complete a computer programming course, regardless of the degree selected. Choose one course:

- CSC 110 — Introduction to Computer Programming I
- ISTA 130 — Computational Thinking and Doing

Minor Requirement

All SDS majors are required to complete a minor in any subject outside of the math department.

For an example of how to order your coursework to heed prerequisites and meet all degree requirements, please consult the sample 4-year plans (<http://math.arizona.edu/academics/undergrads/advising/handouts>). You will develop an individualized plan in consultation with your faculty advisor. Students planning to enroll in three MATH courses in a single semester are advised to talk to their math faculty advisor before finalizing their schedule. The Math Department requires that students enrolling in four or more MATH courses for a single term obtain permission from their math faculty advisor. Note that special courses like Supplemental Instruction, Workshops, Teaching Assistantship enrollment, and Pedagogy courses for the Secondary Math Education Program are not counted toward this limit.

B.A./B.S. in Mathematics

The information and requirements given here apply to the 2018–2019 catalog. For other catalog years, please consult the archive (<http://math.arizona.edu/academics/undergrads/requirements/majors/archive>).

Math Major Emphases

Both the Bachelor of Arts (B.A.) and the Bachelor of Science (B.S.) in Mathematics require a core of basic courses (listed on p. 17) followed by additional courses specific to one of seven possible emphases:

- **Applied Mathematics Emphasis:** This emphasis is for students who intend to enter the job market upon graduation, but may also be appropriate for students who plan to go on to graduate school in a field of science or engineering. (see p. 18)
- **Comprehensive Emphasis:** This emphasis prepares students for graduate study in mathematics, applied mathematics, or most scientific fields. (see p. 19)
- **Probability and Statistics Emphasis:** This emphasis is for students considering a career as an actuary or statistician, as well as for students wanting to attend graduate school in statistics. (see p. 20)
- **Mathematics Education Emphasis:** This emphasis prepares students for teaching mathematics at the secondary school level. The emphasis has two main components: a set of courses in mathematics, and a set of courses in teaching and learning mathematics in secondary schools. (see p. 21)
- **Computer Science Emphasis:** This emphasis is for students interested in applications of computers to mathematical problems, including math majors who plan to attend graduate school in computer science. (see p. 22)
- **Economics or Business Emphasis:** This emphasis is for students with a particular interest in business applications of mathematics, especially those preparing for graduate school in economics or finance. (see p. 23)
- **Life Sciences Emphasis:** This emphasis is for students considering a career in medicine, as well as for students wanting to attend graduate school in the biological sciences. (see p. 24)

Each emphasis requires at least 15 units of 400-level mathematics course work, and each emphasis, except Mathematics Education, requires the student to complete a minor outside of the Math Department. Courses in minors must be distinct from those in the major.

The complete official requirements for each emphasis are given in the *University Catalog* in the form of an *Academic Advisement Report (ADVIP)*. Below we cover the portion of the requirements specific to the mathematics major. It is important for students to consult with their academic advisor about their choice and order of courses, as well as which additional courses would strengthen their degree program.

Supporting Computer Science Requirement

All math majors are required to complete a computer programming course, regardless of the degree and emphasis selected. Choose one course:⁽¹⁾

- CSC 110 — Introduction to Computer Programming I
- ISTA 130 — Computational Thinking and Doing

Core Courses

All seven emphases for the B.A./B.S. require the following core courses, which should ideally be completed by the end of the sophomore year.

- MATH 122A AND MATH 122B ⁽²⁾ or MATH 125 — Calculus I
- MATH 129 — Calculus II
- MATH 223 — Vector Calculus
- MATH 313 — Introduction to Linear Algebra ⁽³⁾
- MATH 323 — Formal Mathematical Reasoning and Writing ⁽⁴⁾
- MATH 355 — Analysis of Ordinary Differential Equations ⁽⁵⁾

⁽¹⁾ Either CSC 110 or ISTA 130 is recommended for most students. Other courses that can be used to satisfy the programming requirement are: CSC 127A, CSC 227, ECE 175, MIS 301, MSE 350, and PHYS 305. These latter courses may require prior programming experience, additional prerequisites and/or a major or minor declared in another subject.

⁽²⁾ MATH 122A and MATH 122B are a single-semester sequence of courses that cover Calculus I.

⁽³⁾ MATH 313 replaces MATH 215, which is no longer offered. Students who completed MATH 215 prior to fall 2015 or who have transfer credit equivalent to MATH 215 will still fulfill this requirement, though they will not earn upper-division credit for the course.

⁽⁴⁾ MATH 323 is a writing-emphasis course that is the foundation for many of the advanced courses taken by any math major. It is prerequisite for more theoretical 400-level courses in the major. Students who do not do well in MATH 323 should speak to an advisor about their choice of major/emphasis. MATH 396L, the Wildcat Proofs Workshop, is a 1 unit supplemental instruction course intended to give students additional practice and guidance in learning proof writing techniques. The course is optional, but recommended!

⁽⁵⁾ MATH 355 is the differential equations course that all mathematics majors are expected to take. This course emphasizes the ideas of dynamical systems and makes use of a more sophisticated approach to differential equations. MATH 254 is a differential equations course that is aimed at engineering and science majors. Students with an additional major in engineering or science may ask their math faculty advisors for permission to substitute MATH 254 course for MATH 355 if a scheduling issue arises.

Applied Mathematics Emphasis

A minor in any subject outside of the math department is required with this emphasis.

- Core Courses (listed on p. 17)
- MATH 422 — Advanced Applied Mathematics
- One of the following three sequences:
 1. MATH 454 — Ordinary Differential Equations and Stability Theory
 2. MATH 456 — Applied Partial Differential Equations

or

1. MATH 464 — Theory of Probability
2. MATH 466 — Theory of Statistics

or

1. MATH 475A — Mathematical Principles of Numerical Analysis
2. MATH 475B — Mathematical Principles of Numerical Analysis

- MATH 485 — Mathematical Modeling ^(*)
- A 5th 400-level MATH course, to be selected with approval from your math faculty advisor. You may choose from the pre-approved list: MATH 413, 424, 454, 456, 464, 468, 475A, 488. If you prefer to select another course, you may do so ONLY if approved by your math faculty advisor.

() Students should plan to take MATH 485 in their final spring semester (it is only offered in spring semesters). In addition to more typical prerequisites, MATH 485 requires completion of at least one 400-level MATH course (422, 454, 456, 464, or 475A). Prerequisites also include linear algebra (313), differential equations (254 or 355), and a programming course.*

For an example of how to order your coursework to heed prerequisites and meet all degree requirements, please consult the sample 4-year plans (<http://math.arizona.edu/academics/undergrads/advising/handouts>). You will develop an individualized plan in consultation with your faculty advisor. Students planning to enroll in three MATH courses in a single semester are advised to talk to their math faculty advisor before finalizing their schedule. The Math Department requires that students enrolling in four or more MATH courses for a single term obtain permission from their math faculty advisor. Note that special courses like Supplemental Instruction, Workshops, Teaching Assistantship enrollment, and Pedagogy courses for the Secondary Math Education Program are not counted toward this limit.

Comprehensive Emphasis

This emphasis covers the minimum requirements for admission to most graduate programs in mathematics or applied mathematics. We have separate information on selecting the appropriate emphasis and courses to prepare for various types of graduate programs (see <http://math.arizona.edu/academics/undergrads/grad-prep>). Students selecting the comprehensive emphasis should consult with a Mathematics Department faculty advisor in choosing additional course work to ensure that they are prepared for the graduate school of their choice. A minor in any subject outside of the math department is required with this emphasis.

- Core Courses (listed on p. 17)
- MATH 413 — Linear Algebra
- MATH 424 — Theory of Complex Variables
- MATH 425A — Real Analysis of One Variable
- MATH 425B — Real Analysis of Several Variables
- One of the following two pairs:
 1. MATH 415A — Introduction to Abstract Algebra
 2. MATH 415B — Second Course in Abstract Algebra

or

1. MATH 454 — Ordinary Differential Equations and Stability Theory
2. MATH 456 — Applied Partial Differential Equations

Students completing this emphasis are expected to be proficient in proof writing before beginning most of the 400-level courses above. It is recommended that students who do not earn an A or B in MATH 323 speak with an advisor about their selected math major emphasis before enrolling in proof-intensive 400-level courses.

For an example of how to order your coursework to heed prerequisites and meet all degree requirements, please consult the sample 4-year plans (<http://math.arizona.edu/academics/undergrads/advising/handouts>). You will develop an individualized plan in consultation with your faculty advisor. Students planning to enroll in three MATH courses in a single semester are advised to talk to their math faculty advisor before finalizing their schedule. The Math Department requires that students enrolling in four or more MATH courses for a single term obtain permission from their math faculty advisor. Note that special courses like Supplemental Instruction, Workshops, Teaching Assistantship enrollment, and Pedagogy courses for the Secondary Math Education Program are not counted toward this limit.

Probability and Statistics Emphasis

A minor in any subject outside of the math department is required with this emphasis. The math major with probability and statistics emphasis differs from the SDS major in that it gives more theoretical background. Students who wish to attend graduate school in statistics, economics, or another related field are advised to choose this option instead of (or in addition to) the SDS major.

In association with the Graduate Interdisciplinary Program in Statistics, we offer an Accelerated Master's Program in Statistics. See <http://math.arizona.edu/academics/undergrads/requirements/stats> for information.

- Core Courses (listed on p. 17)
- MATH 425A — Real Analysis of One Variable
- MATH 464 — Theory of Probability
- MATH 466 — Theory of Statistics
- One of the following two courses:
 - MATH 468 — Applied Stochastic Processes
 - MATH 413 — Linear Algebra
- A 5th 400-level MATH course, to be selected with approval from your math faculty advisor. You may choose from the pre-approved list: MATH 413, 422, 425B, 454, 456, 462, 468, 485. If you prefer to select another course, you may do so ONLY if approved by your math faculty advisor.

Students completing this emphasis are expected to be proficient in proof writing before beginning their 400-level course work. It is recommended that students who do not earn an A or B in MATH 323 speak with an advisor about their selected math major emphasis before enrolling in 400-level courses.

For an example of how to order your coursework to heed prerequisites and meet all degree requirements, please consult the sample 4-year plans (<http://math.arizona.edu/academics/undergrads/advising/handouts>). You will develop an individualized plan in consultation with your faculty advisor. Students planning to enroll in three MATH courses in a single semester are advised to talk to their math faculty advisor before finalizing their schedule. The Math Department requires that students enrolling in four or more MATH courses for a single term obtain permission from their math faculty advisor. Note that special courses like Supplemental Instruction, Workshops, Teaching Assistantship enrollment, and Pedagogy courses for the Secondary Math Education Program are not counted toward this limit.

Mathematics Education Emphasis

This emphasis is for students preparing to teach mathematics at the secondary school level. This emphasis does not require a minor. See the Secondary Math Education Program (SMEP) website (<http://smep.math.arizona.edu/>) for additional information.

The Noyce Interns and Noyce Scholars programs offer experience and funding to students interested in learning more about the teaching profession; see the SMEP website for details and to apply.

- Core Courses (listed on p. 17)
- Courses in Mathematics:
 - MATH 315 — Introduction to Number Theory and Modern Algebra
 - MATH 330 — Topics in Geometry
 - MATH 361 — Elements of Statistics using Calculus
 - MATH 404 — History of Mathematics
 - MATH 407 — Synthesis of Mathematical Concepts
- Courses in Teaching and Learning Mathematics (Pedagogy):
 - MATH 205 — Teaching Secondary Mathematics
 - EDP 301 — Educational Psychology and Child and Adolescent Development
 - SERP 400 — Survey of Exceptional Students
 - TLS 416 — An Introduction to Structured English Immersion
 - TLS 435 — Content Area Literacy in a Multicultural School
 - MATH 406A — Curriculum and Assessment in Secondary School Mathematics
 - MATH 406B — Methods of Teaching Mathematics in Secondary Schools
 - MATH 494C — Student Teaching
- Constitution Requirement for AZ certification — complete one: POL 210 or equivalent; AEPA Constitution exam
- GPA requirements:
 - GPA ≥ 2.5 in MATH 122A&B/125, 129, 223
 - Pedagogy GPA ≥ 2.5
 - Major GPA and Cumulative UA GPA ≥ 2.0

For an example of how to order your coursework to heed prerequisites and meet all degree requirements, please consult the sample 4-year plans (<http://math.arizona.edu/academics/undergrads/advising/handouts>). You will develop an individualized plan in consultation with your faculty advisor. Students planning to enroll in three MATH courses in a single semester are advised to talk to their math faculty advisor before finalizing their schedule. The Math Department requires that students enrolling in four or more MATH courses for a single term obtain permission from their math faculty advisor. Note that special courses like Supplemental Instruction, Workshops, Teaching Assistantship enrollment, and Pedagogy courses for the Secondary Math Education Program are not counted toward this limit.

Computer Science Emphasis

A minor in computer science (<https://www.cs.arizona.edu/minor-cs>) is required with this emphasis.

- Core Courses (listed on p. 17)
- One of the following three sequences:
 1. MATH 415A — Introduction to Abstract Algebra
 2. MATH 415B — Second Course in Abstract Algebra

or

1. MATH 464 — Theory of Probability
2. MATH 466 — Theory of Statistics

or

1. MATH 475A — Mathematical Principles of Numerical Analysis
2. MATH 475B — Mathematical Principles of Numerical Analysis

- Two of the following six courses:
 - MATH 413 — Linear Algebra
 - MATH 443 — Theory of Graphs and Networks
 - MATH 445 — Introduction to Cryptography
 - MATH 446 — Theory of Numbers
 - MATH 447 — Combinatorial Mathematics
 - CSC 473 — Automata, Grammars and Languages ^(*)
- A 5th 400-level MATH course, to be selected with approval from your math faculty advisor. You may choose from the pre-approved list: MATH 401A, 401B, 402, 413, 415A, 443, 445, 446, 447, 464, 468, 475A, 485, CSC 473. If you prefer to select another course, you may do so ONLY if approved by your math faculty advisor.

^(*) *Students minoring in computer science may not double-dip courses with their math major. Students with a double major in C.S. and math may be able to double-dip additional courses between the two majors, within reasonable limits. Consult with advisors from both majors when planning your coursework to avoid graduation delays.*

For an example of how to order your coursework to heed prerequisites and meet all degree requirements, please consult the sample 4-year plans (<http://math.arizona.edu/academics/undergrads/advising/handouts>). You will develop an individualized plan in consultation with your faculty advisor. Students planning to enroll in three MATH courses in a single semester are advised to talk to their math faculty advisor before finalizing their schedule. The Math Department requires that students enrolling in four or more MATH courses for a single term obtain permission from their math faculty advisor. Note that special courses like Supplemental Instruction, Workshops, Teaching Assistantship enrollment, and Pedagogy courses for the Secondary Math Education Program are not counted toward this limit.

Economics or Business Emphasis

This emphasis requires one of the following minors:

- an Economics Minor (<http://econ.arizona.edu/undergraduate/minors.asp>), or
- a Business Administration Minor (<http://ugrad.eller.arizona.edu/academics/minors/business.asp>), or
- a Finance Minor (<http://www.ugrad.eller.arizona.edu/academics/minors/finance.asp>), or
- a Thematic Minor (<http://registrar.arizona.edu/academics/thematic-minors>) emphasizing courses from two or more disciplines/subject areas such as Economics, Business, and Finance.

The minor should be chosen in consultation with an advisor.

- Core Courses (listed on p. 17)
- MATH 425A — Real Analysis of One Variable
- MATH 464 — Theory of Probability
- Two of the following four courses:
 - MATH 413 — Linear Algebra
 - MATH 425B — Real Analysis of Several Variables
 - MATH 466 — Theory of Statistics
 - MATH 468 — Applied Stochastic Processes
- A 5th 400-level MATH course, to be selected with approval from your math faculty advisor. You may choose from the pre-approved list: MATH 413, 422, 425B, 432, 454, 456, 462, 466, 468, 485. If you prefer to select another course, you may do so ONLY if approved by your math faculty advisor.

Students completing this emphasis are expected to be proficient in proof writing before beginning their 400-level course work. It is recommended that students who do not earn an A or B in MATH 323 speak with an advisor about their selected math major emphasis before enrolling in 400-level courses.

For an example of how to order your coursework to heed prerequisites and meet all degree requirements, please consult the sample 4-year plans (<http://math.arizona.edu/academics/undergrads/advising/handouts>). You will develop an individualized plan in consultation with your faculty advisor. Students planning to enroll in three MATH courses in a single semester are advised to talk to their math faculty advisor before finalizing their schedule. The Math Department requires that students enrolling in four or more MATH courses for a single term obtain permission from their math faculty advisor. Note that special courses like Supplemental Instruction, Workshops, Teaching Assistantship enrollment, and Pedagogy courses for the Secondary Math Education Program are not counted toward this limit.

Life Sciences Emphasis

A minor in the biological sciences is required for this emphasis. Possibilities include Astrobiology, Biochemistry, Biology, Biosystems Engineering, Ecology & Evolutionary Biology, Environmental Sciences, Molecular & Cellular Biology, Physiology, Physiological Sciences, and Pre-Health Professions, or a thematic minor (<http://registrar.arizona.edu/academics/thematic-minors>) with a life sciences emphasis. A second major in a life science area may also be used to fulfill the minor requirement.

- Core Courses (listed on p. 17)
- MATH 422 — Advanced Applied Mathematics
- One of the following two courses:
 - MATH 454 — Ordinary Differential Equations and Stability Theory
 - MATH 456 — Applied Partial Differential Equations
- MATH 464 — Theory of Probability
- One of the following two courses:
 - MATH 466 — Theory of Statistics
 - MATH 468 — Applied Stochastic Processes
- MATH 485 — Mathematical Modeling ^(*)

^(*) *Students should plan to take MATH 485 in their final spring semester (it is only offered in spring semesters). In addition to more typical prerequisites, MATH 485 requires completion of at least one 400-level MATH course (422, 454, 456, 464, or 475A). Prerequisites also include linear algebra (313), differential equations (254 or 355), and a programming course.*

For an example of how to order your coursework to heed prerequisites and meet all degree requirements, please consult the sample 4-year plans (<http://math.arizona.edu/academics/undergrads/advising/handouts>). You will develop an individualized plan in consultation with your faculty advisor. Students planning to enroll in three MATH courses in a single semester are advised to talk to their math faculty advisor before finalizing their schedule. The Math Department requires that students enrolling in four or more MATH courses for a single term obtain permission from their math faculty advisor. Note that special courses like Supplemental Instruction, Workshops, Teaching Assistantship enrollment, and Pedagogy courses for the Secondary Math Education Program are not counted toward this limit.

Advising, Activities, and Events

The Math Center

The Math Center supports our undergraduate mathematical sciences degree programs. The Math Center provides advising to math and statistics majors and minors on course selection and program requirements. Additionally, we organize events for undergraduates and provide facilities for undergraduate activities including the MathCats student club.

Be sure to watch for a weekly news email from the Math Center (mcenter@math.arizona.edu) that will announce these and other events that may be of interest to you, as well as important academic announcements that you need to be aware of. It may be helpful to add the Math Center email address to your contacts to ensure these messages do not end up in your junk folder. Weekly messages are also archived on our Facebook page (<https://www.facebook.com/UAmathmajors>).

Faculty Advisors

To help you create a course of study best suited to your talents, interests, and goals, faculty members from the Mathematics Department have volunteered to act as advisors for math and statistics majors.

The Math Center sends a special notification twice per year to make sure every math or statistics major is aware of their faculty advisor assignment, current GPAs, academic level, and other information pertinent to priority registration. Watch for messages around the end of September and end of February.

As students progress in their major, they are assigned faculty advisors based on the major or emphasis that has been selected. Your advisor will then - and each term thereafter - discuss your educational plans with you and help you set up a program of study. They can provide more helpful information regarding the content and difficulty level of the specialized 400-level courses that you will be taking. For students who have selected a math major emphasis that has a flexible fifth 400-level course, the course selection must be approved by the faculty advisor. They will also be the one to verify that your math or statistics major is complete when it comes time to graduate.

Your faculty advisor is also a source of information about careers and/or grad-

uate school, and may know of research and internship opportunities within the University and across the country.

College of Science Advising Office

The College of Science Advising Office is also available to assist math and statistics majors. Some of the issues they assist with include: starting (and ending) degree checks, possible granting of the Dean's permission to withdraw from a course after the deadline, assistance with university petitions, or if an urgent matter arises and the Math Center Advising Staff are not available. The College of Science Advising Office is located in the Gould-Simpson Building room 1017. If your primary major is not in the mathematics department, please consult with your primary college's advising office for assistance with these issues.

Online Knowledge Base

The Math Department has created a knowledge base with answers to many commonly asked advising questions: <http://mathcenter.math.arizona.edu>. If your question isn't answered here, the links at the top right may be used to submit questions or request appointments (a response from mcenter@math.arizona.edu can usually be expected within about one business day - sometimes much faster).

Events Calendar

The Math Center maintains a calendar of events of interest to undergraduate math or statistics majors. Some of these events are put on *specifically for mathematical sciences majors* – some of them are even organized or sponsored by the Math Center itself. But we also list other events that we believe to be of special interest to our majors. The current listing is on the Math Center Events webpage (<http://math.arizona.edu/events/ugrads>). If you have an event that may be of interest to other undergraduates, feel free to submit it to mathcenter@math.arizona.edu for possible inclusion in the calendar.

The MathCats Club

MathCats is the undergraduate club for students of all majors who are interested in mathematics. It provides opportunities for students to get to know each other,

share experiences, have fun, and help each other succeed. <http://math.arizona.edu/academics/undergrads/activities/mathcats>

Putnam Competition

The first Saturday in December, some UA undergraduate students participate in the William Lowell Putnam Mathematical Competition (<http://math.scu.edu/putnam/>), a national contest sponsored by the Mathematical Association of America (MAA). The competition consists of two 3-hour sessions, during each of which each student individually attempts to solve six problems. The exam is designed to test originality and creativity in mathematical thinking. The MAA maintains a list of top participants (<http://maa.org/awards/putnam.html>) from past competitions.

Problem–Solving Laboratory

The *UA Mathematics Problem–Solving Laboratory* meets informally once a week to ponder challenging mathematical problems and learn important techniques for solving them. A knowledge of calculus is necessary for some problems, but many problems require only insight and ingenuity.

All UA undergraduate students are welcome to participate. It is also possible to register for the seminar as a one-credit pass-fail course, MATH 294A. For more information, including the meeting place and time for the current semester, see the schedule of classes (<http://schedule.arizona.edu>).

Undergraduate Research Seminar

The *UA Mathematics Undergraduate Research Seminar*, MATH 396C is an exciting opportunity to introduce undergraduates to research and careers in the mathematical sciences. Several different faculty members will present 1-2 lectures each on research topics/projects in which undergraduates can become involved. The lectures will be given by experts covering computational, mathematical, physical and engineering aspects of the subject accessible to an undergraduate audience. Speakers will expose the role of the mathematical sciences in the work they do.

The seminar is open to all undergraduates who have completed a course in linear algebra (MATH 313) or vector calculus (MATH 223). MATH 396C carries one unit of upper-division elective credit, and is generally offered each fall semester. This course may not be used to fulfill degree requirements for any major or minor.

Students considering writing an honors thesis in math or statistics are encouraged to enroll in the research seminar prior to or during the term in which they will plan their honors thesis.

For further information about the seminar, please contact the current URA program coordinator: ura@math.arizona.edu

Mathematical Sciences Colloquia

The School of Mathematical Sciences organizes various colloquia, seminars, and other talks throughout each semester. Whenever such an event is specifically aimed at undergraduate majors, it is well-publicized and listed on our calendar. However, in general, the colloquia series are always aimed at a wide audience, and undergraduates should consider attending these talks. <http://math.arizona.edu/outreach/lectures>

Undergraduate Colloquium

On selected afternoons during each semester, the math department organizes hour-long programs designed especially for undergraduate students. Sometimes it is a talk on a mathematical topic by a faculty member or visitor. Sometimes the speaker is a math or statistics undergraduate student. Some talks concern an area of mathematics, while other talks are on practical matters such as careers, graduate school, and selecting upper-division math courses.

Mathematics / Applied Mathematics / Statistics Colloquia

At least twice a week, talks are presented by distinguished mathematicians from the University of Arizona and other institutions around the world. Coffee, tea, and cookies are usually served beforehand. These events provide an opportunity to rub shoulders with faculty members and to see famous mathematicians in action.

TRIPODS Seminars

TRIPODS is a set of research groups dedicated to developing theoretical foundations in data sciences. They hold weekly talks on relevant projects and research, which are often accessible to undergraduates. Pizza is usually served. These talks can give students an idea of the most recent research being conducted in interdisciplinary data sciences. See <http://tripods.arizona.edu> for more information.

Math Instruction Colloquium

This is a colloquium for anyone interested in mathematics education, which includes mathematics undergraduates, graduate students, post-docs, faculty, and local school teachers. Techniques, strategies, and course content in the teaching of mathematics are discussed by participants and by leading educators invited from the outside.

Graduate Student Colloquium

The math department graduate students organize a weekly colloquium, often on topics accessible to undergraduate students. The speakers are usually graduate students presenting aspects of their own research. The atmosphere is generally rather informal.

Applied Mathematics Brown Bag Colloquium

The graduate students in the Interdisciplinary Program in Applied Mathematics organize a weekly colloquium, often on topics accessible to undergraduate students. The speakers are usually graduate students presenting aspects of their own research. The atmosphere is generally rather informal.

Opportunities for Mathematical Sciences Majors

100% Engagement at the University of Arizona is an initiative intended to broaden the experiences of undergraduates. Engagement experiences are not only resume builders, but also aid in forming and clarifying future goals. Learn more at <http://ose.arizona.edu/students>.

Department-level Opportunities

See <http://math.arizona.edu/academics/undergrads/opportunities> for details.

Undergraduate Research

Our Undergraduate Research Assistant (URA) program provides opportunities to earn money or credit while engaging in research. You might furthermore have an opportunity to present your research at a conference such as SUnMaRC (<http://sunmarc.org/>).

Undergraduate Teaching Opportunities

Our Undergraduate Teaching Assistant (UTA) programs provide opportunities to earn money or credit while engaging in teaching-related activities.

The brand new Noyce Interns and Noyce Scholars programs offer experience to students interested in learning more about the teaching profession.

Tutoring Jobs

The Center for Recruitment and Retention of Mathematics Teachers (<http://crr.math.arizona.edu/>) offers an opportunity to observe dynamic teaching, attend tutor preparation classes for a credit, and tutor middle and high school students for pay. Other locations on campus that offer tutoring services might also have job opportunities. For a current listing, see the math department tutoring page (<http://math.arizona.edu/academics/tutoring>).

Honors

The University of Arizona Honors College <https://honors.arizona.edu/> administers an honors program where students can graduate with honors in a major or minor field. Graduating with honors requires acceptance to the Honors College, a minimum number of units of honors course work, and successful completion of an honors thesis.

Honors Course Work: 30 units of honors course work are usually required; consult an Honors Student Success Counselor for more information.

The Math Department offers a few honors courses/sections that count toward a mathematics or statistics major, usually at the 100- and 200-level. These honors math courses are available to select highly motivated students with strong mathematical backgrounds. Acceptance to the UA Honors College is not a requirement. Eligibility is determined based on what type of student you are: current UA students may be nominated by the instructor of their current math class; new incoming Freshmen who start at UA in Fall semester may be eligible based on math placement. If you are a new incoming Freshman for Fall semester and would like to know more, please see the math placement advisors at your new student orientation, or contact placement@math.arizona.edu

In higher-level math courses, students may choose to contract for honors. Juniors and Seniors in the Honors College may also (with appropriate approvals) take 500-level graduate courses for undergraduate honors credit. Non-honors Seniors with strong GPAs may also be able to take 500-level courses. Talk to your advisor for more information.

Honors Thesis: Students considering an honors thesis in mathematics or statistics should consult with the Math Center early on for suggestions to find a project idea and help connect with a faculty member to supervise your research. Taking MATH 396C in a fall semester can be a good way to find a thesis topic and mentor.

University-level Opportunities

There exist many research-related and teaching-related opportunities on the UA campus. This section lists some of the more prominent of such activities.

The University of Arizona Office of Undergraduate Research website (<http://ur.arizona.edu/>) can help you find research opportunities around the U of A, and will help you connect with projects in your area of interest.

Undergraduate Biology Research Program

To learn more, please visit the Undergraduate Biology Research Program website (<http://ubrp.arizona.edu/>).

UA NASA Space Grant Program

To learn more, please visit the NASA Space Grant Program website (<http://spacegrant.arizona.edu/opportunities/internships/>).

UA Summer Research Institute

This program, although run by the UA Graduate College, offers opportunities for undergraduate students. To learn more, please visit the Summer Research Institute website (<http://grad.arizona.edu/sri/>).

Teaching Teams Program

The primary goal of the Teaching Teams Program (TTP) is to improve learning on the campus of the University of Arizona. They do this through the creation of a Teaching Team which includes Instructors, Graduate Teaching Assistants (GTAs), and student peer assistants. These student peer assistants are called Preceptors. To learn more about becoming a Preceptor, see the Teaching Teams Program website (<https://teachingteams.arizona.edu/about>).

UA Career Services

Besides offering job placement help for current UA students and alumni, UA Career Services (<http://www.career.arizona.edu/>) also assists current UA students in finding and landing internships and other career-related experiences. Career counseling, resume reviews, help with interview skills, and assistance with graduate school applications are just a few of the other services they provide.

Internships and Outside Programs

Internships

UA Career Services is the most up-to-date source for information on internships available to students. They can also help critique your resume, hone your interview

skills, and more. Internships are a great way to gain work-related experience prior to graduation, and in some cases, they have led to offers of permanent jobs for our students after they graduate.

Students who already have an internship lined up may earn credit for the experience through the College of Letters, Arts, and Science internship program: <http://clas.arizona.edu/internships/gain-edge-your-career-search/>.

Summer Programs

A wide variety of summer research programs, known as Research Experiences for Undergraduates (or REUs), exist for mathematical sciences majors. Many of these programs not only provide experience that can help students land a job (or graduate school offer) after graduation, they frequently also pay students to participate! Many of the programs require computer programming experience, so it is recommended that students fulfill their math major computer programming requirement early on in their undergraduate careers. For more information about the types of programs available, see our website (<http://math.arizona.edu/academics/undergrads/opportunities/external#sum>).

Semester Programs

Opportunities also exist for mathematical sciences majors to spend a term studying at another institution, either in the United States or abroad. A list of some programs with a strong mathematical focus can be found on our website (<http://math.arizona.edu/academics/undergrads/opportunities/external#sem>).

Scholarships and Financial Aid

Scholarships

Continuing mathematical sciences majors may be able to apply for a scholarship from the Department of Mathematics. Amounts vary from year to year and may depend on academic performance, financial need, and availability of funds. Past awards have ranged from \$100 to \$2000. When scholarships are available, information about how and when to apply will be sent out to our majors and posted on our website (<http://math.arizona.edu/academics/undergrads/scholarships>). Students are also encouraged to check the University's Scholarship-matching program frequently for additional scholarship opportunities (<https://scholarshipuniverse.arizona.edu>).

Scholarships for Mathematics Education students

Some special scholarships are available specifically to students in the Secondary Mathematics Education Program. In particular, the Noyce scholarship is available to fund \$10,000 per year for Juniors and Seniors in the program.

Financial Aid

The Office of Scholarships and Financial Aid (<http://financialaid.arizona.edu/>) has the most complete information about scholarships, grants, loans, and other ways to help finance your education.

For More Information
Contact the Math Center:
mathcenter@math.arizona.edu
<http://mathcenter.math.arizona.edu>



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