

# Mathematics

## Overview

The Department of Mathematics is generally recognized as one of the broadest, liveliest, and most distinguished departments of mathematics in the world. With approximately 55 regular faculty members representing most of the major fields of current research, along with 25 to 30 postdoctoral scholars, 180 graduate students, 475 undergraduate majors, one of the finest mathematics libraries in the nation, and a favorable climate in one of America's most exciting and cosmopolitan centers for mathematics research and teaching, UC Berkeley has become a favorite location for the study of mathematics by students and faculty from all over the world.

UC Berkeley is increasingly interested in developing the talents of outstanding mathematics students and has a number of challenging honors-level courses. The department encourages all major students to participate in the annual William Lowell Putnam Mathematical Competition (<http://www.maa.org/awards/putnam.html>). Additionally, the department sponsors undergraduate teams in the annual Mathematical Contest in Modeling, in which teams of three write mathematical solutions to real-life problems. An active Mathematics Undergraduate Student Association (MUSA) (<http://musa.berkeley.edu/>), of which all departmental majors are automatically members, contributes to making Berkeley a stimulating and rewarding place to study mathematics. Moreover, Women in Mathematics at Berkeley (WIM) (<http://wim.math.berkeley.edu/>) serves to foster a community and provide a network amongst the undergraduate women in mathematics at Cal.

Berkeley's mathematics education program is greatly enriched by its large number of graduate students, postdoctoral faculty and fellows, and visiting teachers in residence each year. They come from all over the world to teach courses, participate in seminars, collaborate in research, give talks at the weekly Mathematics Colloquium, and be available as consultants. An affiliated interdisciplinary group, with its own doctoral program, is the Group in Logic and the Methodology of Science (<http://logic.berkeley.edu/>). We have two NSF funded Research Training Groups: one in Representation Theory, Geometry and Combinatorics (<https://math.berkeley.edu/research/training-groups/rtgc/>) and one in Geometry, Topology and Operator Algebras (<https://math.berkeley.edu/research/training-groups/gtoa/>). These groups run seminars, workshops, and other activities and support graduate student and postdoctoral fellows in their areas of interest.

The Department has several graduate student groups (<https://math.berkeley.edu/resources/student-groups/>): the Mathematics Graduate Student Association (MGSA) (<https://math.berkeley.edu/~mgsa/>), comprising all graduate students, the Noetherian Ring (<http://nring.math.berkeley.edu/>), a group of women in mathematics, Unbounded Representation (Urep) (<https://math.berkeley.edu/~urep/>), promoting dialogue on diversity in the math community, and a student lecture series, Many Cheerful Facts.

## Facilities

The Mathematics Library (<http://www.lib.berkeley.edu/math/>) on the first floor of Evans Hall, part of the system of the University of California Libraries (<http://libraries.universityofcalifornia.edu/>), provides researchers and students with access to world-class collections.

The Mathematical Sciences Research Institute (MSRI) (<http://www.msri.org/>) was founded by the National Science Foundation in 1981. In a beautifully designed building on the hills above the Berkeley campus and overlooking San Francisco Bay, about 1,700 mathematicians from around the world come each year to participate in research programs in a wide variety of mathematical topics. The combined and cooperative efforts of the department, the center, and the MSRI provide a program of mathematics courses, workshops, seminars, and colloquia of remarkable variety and exciting intensity.

## Undergraduate Programs

Applied Mathematics (<http://guide.berkeley.edu/archive/2020-21/undergraduate/degree-programs/applied-mathematics/>): BA  
Mathematics (<http://guide.berkeley.edu/archive/2020-21/undergraduate/degree-programs/mathematics/>): BA (also available with a Teaching Concentration), Minor

## Graduate Programs

Applied Mathematics (<http://guide.berkeley.edu/archive/2020-21/graduate/degree-programs/applied-mathematics/>): PhD  
Mathematics (<http://guide.berkeley.edu/archive/2020-21/graduate/degree-programs/mathematics/>): PhD

## Mathematics

Expand all course descriptions [+] Collapse all course descriptions [-]

### MATH 1A Calculus 4 Units

Terms offered: Fall 2021, Spring 2021, Fall 2020

This sequence is intended for majors in engineering and the physical sciences. An introduction to differential and integral calculus of functions of one variable, with applications and an introduction to transcendental functions.

Calculus: Read More [+]

#### Rules & Requirements

**Prerequisites:** Three and one-half years of high school math, including trigonometry and analytic geometry. Students with high school exam credits (such as AP credit) should consider choosing a course more advanced than 1A

**Credit Restrictions:** Students will receive no credit for MATH 1A after completing MATH N1A, MATH 16B, Math N16B or XMATH 1A. A deficient grade in MATH 1A may be removed by taking MATH N1A.

#### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture and 3 hours of discussion per week

#### Additional Details

**Subject/Course Level:** Mathematics/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam required.

Calculus: Read Less [-]

## MATH 1B Calculus 4 Units

Terms offered: Fall 2021, Spring 2021, Fall 2020

Continuation of 1A. Techniques of integration; applications of integration. Infinite sequences and series. First-order ordinary differential equations. Second-order ordinary differential equations; oscillation and damping; series solutions of ordinary differential equations.

Calculus: Read More [+]

### Rules & Requirements

**Prerequisites:** 1A or N1A

**Credit Restrictions:** Students will receive no credit for Math 1B after completing Math N1B, H1B, Xmath 1B. A deficient grade in MATH 1B may be removed by taking MATH N1B or MATH H1B.

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture and 3 hours of discussion per week

### Additional Details

**Subject/Course Level:** Mathematics/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam required.

Calculus: Read Less [-]

## MATH H1B Honors Calculus 4 Units

Terms offered: Fall 2015, Fall 2014, Fall 2013

Honors version of 1B. Continuation of 1A. Techniques of integration; applications of integration. Infinite sequences and series. First-order ordinary differential equations. Second-order ordinary differential equations; oscillation and damping; series solutions of ordinary differential equations.

Honors Calculus: Read More [+]

### Rules & Requirements

**Prerequisites:** 1A

**Credit Restrictions:** Students will receive no credit for Mathematics H1B after completing Mathematics 1B or N1B.

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture and 2 hours of discussion per week

**Summer:** 8 weeks - 5 hours of lecture and 5 hours of discussion per week

### Additional Details

**Subject/Course Level:** Mathematics/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam required.

Honors Calculus: Read Less [-]

## MATH N1A Calculus 4 Units

Terms offered: Summer 2021 8 Week Session, Summer 2020 8 Week Session, Summer 2019 8 Week Session

This sequence is intended for majors in engineering and the physical sciences. An introduction to differential and integral calculus of functions of one variable, with applications and an introduction to transcendental functions.

Calculus: Read More [+]

### Rules & Requirements

**Prerequisites:** Three and one-half years of high school math, including trigonometry and analytic geometry. Students with high school exam credits (such as AP credit) should consider choosing a course more advanced than 1A

**Credit Restrictions:** Students will receive no credit for MATH N1A after completing MATH 1A, MATH 16B or MATH N16B. A deficient grade in MATH N1A may be removed by taking MATH 1A.

### Hours & Format

**Summer:** 8 weeks - 10 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam required.

Calculus: Read Less [-]

## MATH N1B Calculus 4 Units

Terms offered: Summer 2021 8 Week Session, Summer 2020 8 Week Session, Summer 2019 8 Week Session

Continuation of 1A. Techniques of integration; applications of integration. Infinite sequences and series. First-order ordinary differential equations. Second-order ordinary differential equations; oscillation and damping; series solutions of ordinary differential equations.

Calculus: Read More [+]

### Rules & Requirements

**Prerequisites:** 1A or N1A

**Credit Restrictions:** Students will receive no credit for Math N1B after completing Math 1B, H1B, or Xmath 1B. A deficient grade in N1B may be removed by completing Mathematics 1B or H1B.

### Hours & Format

**Summer:** 8 weeks - 10 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam required.

Calculus: Read Less [-]

## MATH 10A Methods of Mathematics: Calculus, Statistics, and Combinatorics 4 Units

Terms offered: Fall 2021, Fall 2020, Fall 2019

The sequence Math 10A, Math 10B is intended for majors in the life sciences. Introduction to differential and integral calculus of functions of one variable, ordinary differential equations, and matrix algebra and systems of linear equations.

Methods of Mathematics: Calculus, Statistics, and Combinatorics: Read More [+]

### Rules & Requirements

**Prerequisites:** Three and one-half years of high school math, including trigonometry and analytic geometry. Students who have not had calculus in high school are strongly advised to take the Student Learning Center's Math 98 adjunct course for Math 10A; contact the SLC for more information

**Credit Restrictions:** Students will receive no credit for Mathematics 10A after completing Mathematics N10A. A deficient grade in Math 10A may be removed by taking Math N10A.

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture and 3 hours of discussion per week

### Additional Details

**Subject/Course Level:** Mathematics/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam required.

Methods of Mathematics: Calculus, Statistics, and Combinatorics: Read Less [-]

## MATH 10B Methods of Mathematics: Calculus, Statistics, and Combinatorics 4 Units

Terms offered: Spring 2021, Spring 2020, Spring 2019

The sequence Math 10A, Math 10B is intended for majors in the life sciences. Elementary combinatorics and discrete and continuous probability theory. Representation of data, statistical models and testing. Sequences and applications of linear algebra.

Methods of Mathematics: Calculus, Statistics, and Combinatorics: Read More [+]

### Rules & Requirements

**Prerequisites:** Continuation of 10A

**Credit Restrictions:** Students will receive no credit for Mathematics 10B after completing Mathematics N10B. A deficient grade in Math 10B may be removed by taking Math N10B.

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture and 3 hours of discussion per week

### Additional Details

**Subject/Course Level:** Mathematics/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam required.

Methods of Mathematics: Calculus, Statistics, and Combinatorics: Read Less [-]

## MATH N10A Methods of Mathematics: Calculus, Statistics, and Combinatorics 4 Units

Terms offered: Summer 2021 8 Week Session, Summer 2020 8 Week Session, Summer 2019 8 Week Session

The sequence Math 10A, Math 10B is intended for majors in the life sciences. Introduction to differential and integral calculus of functions of one variable, ordinary differential equations, and matrix algebra and systems of linear equations.

Methods of Mathematics: Calculus, Statistics, and Combinatorics: Read More [+]

### Rules & Requirements

**Prerequisites:** Three and one-half years of high school math, including trigonometry and analytic geometry. Students who have not had calculus in high school are strongly advised to take the Student Learning Center's Math 98 adjunct course for Math 10A; contact the SLC for more information

**Credit Restrictions:** Students will receive no credit for Math N10A after completing Math 10A. A deficient grade in Math N10A may be removed by completing Math 10A.

### Hours & Format

**Summer:** 8 weeks - 10 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam required.

Methods of Mathematics: Calculus, Statistics, and Combinatorics: Read Less [-]

## MATH N10B Methods of Mathematics: Calculus, Statistics, and Combinatorics 4 Units

Terms offered: Summer 2021 8 Week Session, Summer 2020 8 Week Session, Summer 2019 8 Week Session

The sequence Math 10A, Math 10B is intended for majors in the life sciences. Elementary combinatorics and discrete and continuous probability theory. Representation of data, statistical models and testing. Sequences and applications of linear algebra.

Methods of Mathematics: Calculus, Statistics, and Combinatorics: Read More [+]

### Rules & Requirements

**Prerequisites:** Math 10A or N10A

**Credit Restrictions:** Students will receive no credit for Math N10B after completing Math 10B. A deficient grade in Math N10B may be removed by completing Math 10B.

### Hours & Format

**Summer:** 8 weeks - 10 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam required.

Methods of Mathematics: Calculus, Statistics, and Combinatorics: Read Less [-]

## MATH 16A Analytic Geometry and Calculus 3 Units

Terms offered: Fall 2021, Spring 2021, Fall 2020

This sequence is intended for majors in the life and social sciences. Calculus of one variable; derivatives, definite integrals and applications, maxima and minima, and applications of the exponential and logarithmic functions.

Analytic Geometry and Calculus: Read More [+]

### Rules & Requirements

**Prerequisites:** Three years of high school math, including trigonometry. Consult the mathematics department for details

**Credit Restrictions:** Students will receive no credit for 16A after taking N16A, 1A, or N1A. A deficient grade in Math 16A may be removed by taking Math N16A.

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture and 1.5 hours of discussion per week

### Additional Details

**Subject/Course Level:** Mathematics/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam required.

Analytic Geometry and Calculus: Read Less [-]

## MATH 16B Analytic Geometry and Calculus 3 Units

Terms offered: Fall 2021, Spring 2021, Fall 2020

Continuation of 16A. Application of integration of economics and life sciences. Differential equations. Functions of many variables. Partial derivatives, constrained and unconstrained optimization.

Analytic Geometry and Calculus: Read More [+]

### Rules & Requirements

**Prerequisites:** 16A

**Credit Restrictions:** Students will receive no credit for MATH 16B after completing MATH N16B, 1B, or N1B. A deficient grade in Math 16B may be removed by taking Math N16B.

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture and 1.5 hours of discussion per week

### Additional Details

**Subject/Course Level:** Mathematics/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam required.

Analytic Geometry and Calculus: Read Less [-]

## MATH N16A Analytic Geometry and Calculus 3 Units

Terms offered: Summer 2021 8 Week Session, Summer 2020 8 Week Session, Summer 2019 8 Week Session

This sequence is intended for majors in the life and social sciences. Calculus of one variable; derivatives, definite integrals and applications, maxima and minima, and applications of the exponential and logarithmic functions.

Analytic Geometry and Calculus: Read More [+]

### Rules & Requirements

**Prerequisites:** Three years of high school math, including trigonometry

**Credit Restrictions:** Students will receive no credit for 16A after taking N16A, 1A or N1A. A deficient grade in N16A may be removed by completing 16A.

### Hours & Format

**Summer:** 8 weeks - 8 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam required.

Analytic Geometry and Calculus: Read Less [-]

## MATH N16B Analytic Geometry and Calculus 3 Units

Terms offered: Summer 2021 8 Week Session, Summer 2020 8 Week Session, Summer 2019 8 Week Session

Continuation of 16A. Application of integration of economics and life sciences. Differential equations. Functions of many variables. Partial derivatives, constrained and unconstrained optimization.

Analytic Geometry and Calculus: Read More [+]

### Rules & Requirements

**Prerequisites:** Mathematics 16A or N16A

**Credit Restrictions:** Students will receive no credit for Math N16B after Math 16B, 1B or N1B. A deficient grade in N16B may be removed by completing 16B.

### Hours & Format

**Summer:** 8 weeks - 8 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam required.

Analytic Geometry and Calculus: Read Less [-]

## MATH 24 Freshman Seminars 1 Unit

Terms offered: Fall 2021, Spring 2021, Fall 2020

The Berkeley Seminar Program has been designed to provide new students with the opportunity to explore an intellectual topic with a faculty member in a small-seminar setting. Berkeley Seminars are offered in all campus departments, and topics vary from department to department and semester to semester.

Freshman Seminars: Read More [+]

### Rules & Requirements

**Repeat rules:** Course may be repeated for credit when topic changes.

### Hours & Format

**Fall and/or spring:** 15 weeks - 1 hour of seminar per week

### Additional Details

**Subject/Course Level:** Mathematics/Undergraduate

**Grading/Final exam status:** The grading option will be decided by the instructor when the class is offered. Final Exam To be decided by the instructor when the class is offered.

Freshman Seminars: Read Less [-]

## MATH 32 Precalculus 4 Units

Terms offered: Fall 2021, Summer 2021 Second 6 Week Session, Spring 2021

Polynomial and rational functions, exponential and logarithmic functions, trigonometry and trigonometric functions. Complex numbers, fundamental theorem of algebra, mathematical induction, binomial theorem, series, and sequences.

Precalculus: Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** Three years of high school mathematics

**Credit Restrictions:** Students will receive no credit for Math 32 after taking N32, 1A or N1A, 1B or N1B, 16A or N16A, 16B or N16B. A deficient grade in Math 32 may be removed by taking Math N32.

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture and 2 hours of discussion per week

**Summer:** 6 weeks - 5 hours of lecture and 5 hours of discussion per week

### Additional Details

**Subject/Course Level:** Mathematics/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam required.

Precalculus: Read Less [\[-\]](#)

## MATH N32 Precalculus 4 Units

Terms offered: Summer 2021 8 Week Session, Summer 2020 8 Week Session, Summer 2019 8 Week Session

Polynomial and rational functions, exponential and logarithmic functions, trigonometry and trigonometric functions. Complex numbers, fundamental theorem of algebra, mathematical induction, binomial theorem, series, and sequences.

Precalculus: Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** Three years of high school mathematics

**Credit Restrictions:** Students will receive no credit for MATH N32 after completing MATH 32, 1A-1B (or N1A-N1B) or 16A-16B (or N16A-16B), or XMATH 32. A deficient grade in MATH 32 or XMATH 32 maybe removed by taking MATH N32.

### Hours & Format

**Summer:** 8 weeks - 10 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam required.

Precalculus: Read Less [\[-\]](#)

## MATH 39A Freshman/Sophomore Seminar 2 - 4 Units

Terms offered: Spring 2019, Spring 2018, Spring 2010

Freshman and sophomore seminars offer lower division students the opportunity to explore an intellectual topic with a faculty member and a group of peers in a small-seminar setting. These seminars are offered in all campus departments; topics vary from department to department and from semester to semester.

Freshman/Sophomore Seminar: Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** Priority given to freshmen and sophomores

**Repeat rules:** Course may be repeated for credit without restriction.

### Hours & Format

**Fall and/or spring:** 15 weeks - 2-4 hours of seminar per week

### Additional Details

**Subject/Course Level:** Mathematics/Undergraduate

**Grading/Final exam status:** Letter grade. Final Exam To be decided by the instructor when the class is offered.

Freshman/Sophomore Seminar: Read Less [\[-\]](#)

## MATH 49 Supplementary Work in Lower Division Mathematics 1 - 3 Units

Terms offered: Spring 2017, Spring 2016, Fall 2015

Students with partial credit in lower division mathematics courses may, with consent of instructor, complete the credit under this heading.

Supplementary Work in Lower Division Mathematics: Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** Some units in a lower division Mathematics class

**Repeat rules:** Course may be repeated for credit without restriction.

### Hours & Format

**Fall and/or spring:** 15 weeks - 0 hours of independent study per week

### Summer:

6 weeks - 1-5 hours of independent study per week

8 weeks - 1-4 hours of independent study per week

### Additional Details

**Subject/Course Level:** Mathematics/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam not required.

Supplementary Work in Lower Division Mathematics: Read Less [\[-\]](#)



## MATH 53 Multivariable Calculus 4 Units

Terms offered: Fall 2021, Spring 2021, Fall 2020

Parametric equations and polar coordinates. Vectors in 2- and 3-dimensional Euclidean spaces. Partial derivatives. Multiple integrals. Vector calculus. Theorems of Green, Gauss, and Stokes.

Multivariable Calculus: Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** Mathematics 1B or N1B

**Credit Restrictions:** Students will receive no credit for Mathematics 53 after completing Mathematics N53 or W53; A deficient grade in 53 may be removed by completing Mathematics N53 or W53.

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture and 3 hours of discussion per week

### Additional Details

**Subject/Course Level:** Mathematics/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam required.

Multivariable Calculus: Read Less [\[-\]](#)

## MATH H53 Honors Multivariable Calculus 4 Units

Terms offered: Spring 2021, Spring 2020, Spring 2018

Honors version of 53. Parametric equations and polar coordinates. Vectors in 2- and 3-dimensional Euclidean spaces. Partial derivatives. Multiple integrals. Vector calculus. Theorems of Green, Gauss, and Stokes.

Honors Multivariable Calculus: Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** 1B

**Credit Restrictions:** Students will receive no credit for Mathematics H53 after completing Math 53, Math N53, or Math W53.

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture and 3 hours of discussion per week

### Additional Details

**Subject/Course Level:** Mathematics/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam required.

Honors Multivariable Calculus: Read Less [\[-\]](#)

## MATH N53 Multivariable Calculus 4 Units

Terms offered: Summer 2021 8 Week Session, Summer 2020 8 Week Session, Summer 2019 8 Week Session

Parametric equations and polar coordinates. Vectors in 2- and 3-dimensional Euclidean spaces. Partial derivatives. Multiple integrals. Vector calculus. Theorems of Green, Gauss, and Stokes.

Multivariable Calculus: Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** Mathematics 1B or N1B

**Credit Restrictions:** Students will receive no credit for Mathematics N53 after completing Mathematics 53, H53, or W53; A deficient grade in N53 may be removed by completing Mathematics 53, H53, or W53.

### Hours & Format

**Summer:** 8 weeks - 10 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam required.

Multivariable Calculus: Read Less [\[-\]](#)

## MATH W53 Multivariable Calculus 4 Units

Terms offered: Summer 2021 8 Week Session, Summer 2020 8 Week Session, Summer 2019 8 Week Session

Parametric equations and polar coordinates. Vectors in 2- and 3-dimensional Euclidean spaces. Partial derivatives. Multiple integrals. Vector calculus. Theorems of Green, Gauss, and Stokes.

Multivariable Calculus: Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** Mathematics 1B or equivalent

**Credit Restrictions:** Students will receive no credit for Mathematics W53 after completing Mathematics 53 or N53. A deficient grade in Mathematics W53 may be removed by completing Mathematics 53 or N53.

### Hours & Format

**Summer:** 8 weeks - 5 hours of web-based lecture and 5 hours of web-based discussion per week

**Online:** This is an online course.

### Additional Details

**Subject/Course Level:** Mathematics/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam required.

**Instructor:** Hutchings

Multivariable Calculus: Read Less [\[-\]](#)

## MATH 54 Linear Algebra and Differential Equations 4 Units

Terms offered: Fall 2021, Spring 2021, Fall 2020

Basic linear algebra; matrix arithmetic and determinants. Vector spaces; inner product spaces. Eigenvalues and eigenvectors; orthogonality, symmetric matrices. Linear second-order differential equations; first-order systems with constant coefficients. Fourier series.

Linear Algebra and Differential Equations: Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** 1B, N1B, 10B, or N10B

**Credit Restrictions:** Students will receive no credit for Math 54 after taking Math N54 or H54. A deficient grade in Math 54 may be removed by completing Math N54.

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture and 3 hours of discussion per week

### Additional Details

**Subject/Course Level:** Mathematics/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam required.

Linear Algebra and Differential Equations: Read Less [\[-\]](#)

## MATH H54 Honors Linear Algebra and Differential Equations 4 Units

Terms offered: Fall 2021, Fall 2020, Fall 2019

Honors version of 54. Basic linear algebra: matrix arithmetic and determinants. Vectors spaces; inner product spaces. Eigenvalues and eigenvectors; linear transformations. Homogeneous ordinary differential equations; first-order differential equations with constant coefficients. Fourier series and partial differential equations.

Honors Linear Algebra and Differential Equations: Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** 1B

**Credit Restrictions:** Students will receive no credit for Math H54 after completion of Math 54 or N54.

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture and 3 hours of discussion per week

### Additional Details

**Subject/Course Level:** Mathematics/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam required.

Honors Linear Algebra and Differential Equations: Read Less [\[-\]](#)

## MATH N54 Linear Algebra and Differential Equations 4 Units

Terms offered: Summer 2021 8 Week Session, Summer 2020 8 Week Session, Summer 2019 8 Week Session

Basic linear algebra; matrix arithmetic and determinants. Vector spaces; inner product spaces. Eigenvalues and eigenvectors; orthogonality, symmetric matrices. Linear second-order differential equations; first-order systems with constant coefficients. Fourier series.

Linear Algebra and Differential Equations: Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** 1B, N1B, 10B, or N10B

**Credit Restrictions:** Students will receive no credit for Math N54 after completing Math 54 or Math H54; A deficient grade in N54 may be removed by completing Mathematics 54 or H54.

### Hours & Format

**Summer:** 8 weeks - 10 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam required.

Linear Algebra and Differential Equations: Read Less [\[-\]](#)

## MATH W54 Linear Algebra and Differential Equations 4 Units

Terms offered: Summer 2021 8 Week Session

Basic linear algebra; matrix arithmetic and determinants. Vector spaces; inner product spaces. Eigenvalues and eigenvectors; orthogonality, symmetric matrices. Linear second-order differential equations; first-order systems with constant coefficients. Fourier series.

Linear Algebra and Differential Equations: Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** Math 1B, N1B, 10B, or N10B

**Credit Restrictions:** Students will receive no credit for MATH W54 after completing MATH 54, or MATH N54. A deficient grade in MATH W54 may be removed by taking MATH 54, MATH N54, MATH 54, or MATH N54.

### Hours & Format

**Summer:** 8 weeks - 5.5 hours of web-based lecture and 6 hours of web-based discussion per week

**Online:** This is an online course.

### Additional Details

**Subject/Course Level:** Mathematics/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam required.

**Instructor:** Nadler

Linear Algebra and Differential Equations: Read Less [\[-\]](#)



## MATH 55 Discrete Mathematics 4 Units

Terms offered: Fall 2021, Spring 2021, Fall 2020

Logic, mathematical induction sets, relations, and functions. Introduction to graphs, elementary number theory, combinatorics, algebraic structures, and discrete probability theory.

Discrete Mathematics: Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** Mathematical maturity appropriate to a sophomore math class. 1A-1B recommended

**Credit Restrictions:** Students will receive no credit for Math 55 after completion of Math N55 or Computer Science 70. A deficient grade in Math 55 may be removed by completing Math N55.

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture and 2 hours of discussion per week

### Additional Details

**Subject/Course Level:** Mathematics/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam required.

Discrete Mathematics: Read Less [\[-\]](#)

## MATH N55 Discrete Mathematics 4 Units

Terms offered: Summer 2021 8 Week Session, Summer 2020 8 Week Session, Summer 2019 8 Week Session

Logic, mathematical induction sets, relations, and functions. Introduction to graphs, elementary number theory, combinatorics, algebraic structures, and discrete probability theory.

Discrete Mathematics: Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** Mathematical maturity appropriate to a sophomore math class. 1A-1B recommended

**Credit Restrictions:** Students will receive no credit for 55 after taking N55 or Computer Science 70. A deficient grade in Math N55 may be removed by completing Math 55.

### Hours & Format

**Summer:** 8 weeks - 10 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam required.

Discrete Mathematics: Read Less [\[-\]](#)

## MATH 74 Transition to Upper Division Mathematics 3 Units

Terms offered: Fall 2021, Fall 2020, Spring 2009

The course will focus on reading and understanding mathematical proofs. It will emphasize precise thinking and the presentation of mathematical results, both orally and in written form. The course is intended for students who are considering majoring in mathematics but wish additional training.

Transition to Upper Division Mathematics: Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** 53 and 54

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture and 2 hours of discussion per week

**Summer:** 8 weeks - 6 hours of lecture and 0-2 hours of discussion per week

### Additional Details

**Subject/Course Level:** Mathematics/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam required.

Transition to Upper Division Mathematics: Read Less [\[-\]](#)

## MATH 91 Special Topics in Mathematics 4 Units

Terms offered: Spring 2016, Fall 2012, Spring 2012

Topics to be covered and the method of instruction to be used will be announced at the beginning of each semester that such courses are offered. See department bulletins.

Special Topics in Mathematics: Read More [\[+\]](#)

### Rules & Requirements

**Repeat rules:** Course may be repeated for credit without restriction.

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture per week

**Summer:** 8 weeks - 6 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam required.

Special Topics in Mathematics: Read Less [\[-\]](#)

## MATH 96 College Algebra 2 Units

Terms offered: Summer 2019 Second 6 Week Session, Summer 2017 8 Week Session, Summer 2015 10 Week Session

Elements of college algebra. Designed for students who do not meet the prerequisites for 32. Offered through the Student Learning Center.

College Algebra: Read More [+]

### Rules & Requirements

**Repeat rules:** Course may be repeated for credit without restriction.

### Hours & Format

**Fall and/or spring:** 15 weeks - 4 hours of workshop per week

### Summer:

6 weeks - 10 hours of workshop per week

8 weeks - 10 hours of workshop per week

### Additional Details

**Subject/Course Level:** Mathematics/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam required.

College Algebra: Read Less [-]

## MATH 98 Supervised Group Study 1 - 4 Units

Terms offered: Fall 2021, Summer 2021 3 Week Session, Spring 2021

Directed Group Study, topics vary with instructor.

Supervised Group Study: Read More [+]

### Rules & Requirements

**Repeat rules:** Course may be repeated for credit up to a total of 4 units.

### Hours & Format

**Fall and/or spring:** 15 weeks - 1-4 hours of directed group study per week

### Summer:

3 weeks - 5-20 hours of directed group study per week

8 weeks - 1.5-7.5 hours of directed group study per week

### Additional Details

**Subject/Course Level:** Mathematics/Undergraduate

**Grading/Final exam status:** Offered for pass/not pass grade only. Final exam not required.

Supervised Group Study: Read Less [-]

## MATH 98BC Berkeley Connect 1 Unit

Terms offered: Fall 2021, Spring 2021, Fall 2020

Berkeley Connect is a mentoring program, offered through various academic departments, that helps students build intellectual community. Over the course of a semester, enrolled students participate in regular small-group discussions facilitated by a graduate student mentor (following a faculty-directed curriculum), meet with their graduate student mentor for one-on-one academic advising, attend lectures and panel discussions featuring department faculty and alumni, and go on field trips to campus resources. Students are not required to be declared majors in order to participate.

Berkeley Connect: Read More [+]

### Rules & Requirements

**Repeat rules:** Course may be repeated for credit without restriction.

### Hours & Format

**Fall and/or spring:** 15 weeks - 1 hour of discussion per week

### Additional Details

**Subject/Course Level:** Mathematics/Undergraduate

**Grading/Final exam status:** Offered for pass/not pass grade only. Final exam not required.

Berkeley Connect: Read Less [-]

## MATH 99 Supervised Independent Study 1 - 4 Units

Terms offered: Spring 2017, Spring 2016, Fall 2015

Supervised independent study by academically superior, lower division students. 3.3 GPA required and prior consent of instructor who is to supervise the study. A written proposal must be submitted to the department chair for pre-approval.

Supervised Independent Study: Read More [+]

### Rules & Requirements

**Prerequisites:** Restricted to freshmen and sophomores only. Consent of instructor

**Credit Restrictions:** Enrollment is restricted; see the Introduction to Courses and Curricula section of this catalog.

**Repeat rules:** Course may be repeated for credit without restriction.

### Hours & Format

**Fall and/or spring:** 15 weeks - 1-4 hours of independent study per week

**Summer:** 8 weeks - 1-4 hours of independent study per week

### Additional Details

**Subject/Course Level:** Mathematics/Undergraduate

**Grading/Final exam status:** Offered for pass/not pass grade only. Final exam not required.

Supervised Independent Study: Read Less [-]

## MATH C103 Introduction to Mathematical Economics 4 Units

Terms offered: Fall 2021, Fall 2020, Spring 2020

Selected topics illustrating the application of mathematics to economic theory. This course is intended for upper-division students in Mathematics, Statistics, the Physical Sciences, and Engineering, and for economics majors with adequate mathematical preparation. No economic background is required.

Introduction to Mathematical Economics: Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** Math 53 and 54

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam required.

**Formerly known as:** 103

**Also listed as:** ECON C103

Introduction to Mathematical Economics: Read Less [\[-\]](#)

## MATH 104 Introduction to Analysis 4 Units

Terms offered: Fall 2021, Summer 2021 8 Week Session, Spring 2021

The real number system. Sequences, limits, and continuous functions in  $\mathbb{R}$  and  $\mathbb{R}^n$ . The concept of a metric space. Uniform convergence, interchange of limit operations. Infinite series. Mean value theorem and applications. The Riemann integral.

Introduction to Analysis: Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** 53 and 54. 55 or an equivalent exposure to proofs

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture per week

**Summer:** 8 weeks - 8 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam required.

Introduction to Analysis: Read Less [\[-\]](#)

## MATH H104 Honors Introduction to Analysis 4 Units

Terms offered: Fall 2021, Fall 2020, Fall 2019

Honors section corresponding to 104. Recommended for students who enjoy mathematics and are good at it. Greater emphasis on theory and challenging problems.

Honors Introduction to Analysis: Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** 53 and 54. 55 or an equivalent exposure to proofs

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam required.

Honors Introduction to Analysis: Read Less [\[-\]](#)

## MATH 105 Second Course in Analysis 4 Units

Terms offered: Spring 2021, Spring 2020, Spring 2019

Differential calculus in  $\mathbb{R}^n$ : the derivative as a linear map; the chain rule; inverse and implicit function theorems. Lebesgue integration on the line; comparison of Lebesgue and Riemann integrals. Convergence theorems. Fourier series,  $L^2$  theory. Fubini's theorem, change of variable.

Second Course in Analysis: Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** 104

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam required.

Second Course in Analysis: Read Less [\[-\]](#)

## MATH 110 Linear Algebra 4 Units

Terms offered: Fall 2021, Summer 2021 8 Week Session, Spring 2021  
Matrices, vector spaces, linear transformations, inner products, determinants. Eigenvectors. QR factorization. Quadratic forms and Rayleigh's principle. Jordan canonical form, applications. Linear functionals.

Linear Algebra: Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** 54 or a course with equivalent linear algebra content. 55 or an equivalent exposure to proofs is recommended

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture and 2 hours of discussion per week

**Summer:** 8 weeks - 5 hours of lecture and 3 hours of discussion per week

### Additional Details

**Subject/Course Level:** Mathematics/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam required.

Linear Algebra: Read Less [\[-\]](#)

## MATH H110 Honors Linear Algebra 4 Units

Terms offered: Fall 2021, Fall 2020, Fall 2019  
Honors section corresponding to course 110 for exceptional students with strong mathematical inclination and motivation. Emphasis is on rigor, depth, and hard problems.

Honors Linear Algebra: Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** 54 or a course with equivalent linear algebra content. 55 or an equivalent exposure to proofs

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam required.

Honors Linear Algebra: Read Less [\[-\]](#)

## MATH 113 Introduction to Abstract Algebra 4 Units

Terms offered: Fall 2021, Summer 2021 8 Week Session, Spring 2021  
Sets and relations. The integers, congruences, and the Fundamental Theorem of Arithmetic. Groups and their factor groups. Commutative rings, ideals, and quotient fields. The theory of polynomials: Euclidean algorithm and unique factorizations. The Fundamental Theorem of Algebra. Fields and field extensions.

Introduction to Abstract Algebra: Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** 54 or a course with equivalent linear algebra content. 55 or an equivalent exposure to proofs

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture per week

**Summer:** 8 weeks - 8 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam required.

Introduction to Abstract Algebra: Read Less [\[-\]](#)

## MATH H113 Honors Introduction to Abstract Algebra 4 Units

Terms offered: Spring 2021, Spring 2020, Spring 2019  
Honors section corresponding to 113. Recommended for students who enjoy mathematics and are willing to work hard in order to understand the beauty of mathematics and its hidden patterns and structures. Greater emphasis on theory and challenging problems.

Honors Introduction to Abstract Algebra: Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** 54 or a course with equivalent linear algebra content. 55 or an equivalent exposure to proofs

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam required.

Honors Introduction to Abstract Algebra: Read Less [\[-\]](#)

## MATH 114 Second Course in Abstract Algebra 4 Units

Terms offered: Spring 2021, Spring 2020, Spring 2019

Further topics on groups, rings, and fields not covered in Math 113.

Possible topics include the Sylow Theorems and their applications to group theory; classical groups; abelian groups and modules over a principal ideal domain; algebraic field extensions; splitting fields and Galois theory; construction and classification of finite fields.

Second Course in Abstract Algebra: Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** 110 and 113, or consent of instructor

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam required.

Second Course in Abstract Algebra: Read Less [\[-\]](#)

## MATH 115 Introduction to Number Theory 4 Units

Terms offered: Fall 2021, Summer 2021 8 Week Session, Spring 2021

Divisibility, congruences, numerical functions, theory of primes. Topics selected: Diophantine analysis, continued fractions, partitions, quadratic fields, asymptotic distributions, additive problems.

Introduction to Number Theory: Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** Math 55 is recommended

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture per week

**Summer:** 8 weeks - 8 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam required.

Introduction to Number Theory: Read Less [\[-\]](#)

## MATH 116 Cryptography 4 Units

Terms offered: Fall 2021, Fall 2020, Fall 2018

Construction and analysis of simple cryptosystems, public key cryptography, RSA, signature schemes, key distribution, hash functions, elliptic curves, and applications.

Cryptography: Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** 55

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture and 0-2 hours of discussion per week

**Summer:** 8 weeks - 6 hours of lecture and 0-4 hours of discussion per week

### Additional Details

**Subject/Course Level:** Mathematics/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam required.

Cryptography: Read Less [\[-\]](#)

## MATH 118 Fourier Analysis, Wavelets, and Signal Processing 4 Units

Terms offered: Spring 2020, Spring 2019, Fall 2017

Introduction to signal processing including Fourier analysis and wavelets.

Theory, algorithms, and applications to one-dimensional signals and multidimensional images.

Fourier Analysis, Wavelets, and Signal Processing: Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** 53 and 54

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam required.

Fourier Analysis, Wavelets, and Signal Processing: Read Less [\[-\]](#)

## MATH 121A Mathematical Tools for the Physical Sciences 4 Units

Terms offered: Fall 2021, Fall 2020, Fall 2019

Intended for students in the physical sciences who are not planning to take more advanced mathematics courses. Rapid review of series and partial differentiation, complex variables and analytic functions, integral transforms, calculus of variations.

Mathematical Tools for the Physical Sciences: [Read More](#) [+]

### Rules & Requirements

**Prerequisites:** 53 and 54

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam required.

Mathematical Tools for the Physical Sciences: [Read Less](#) [-]

## MATH 121B Mathematical Tools for the Physical Sciences 4 Units

Terms offered: Spring 2021, Spring 2020, Spring 2019

Intended for students in the physical sciences who are not planning to take more advanced mathematics courses. Special functions, series solutions of ordinary differential equations, partial differential equations arising in mathematical physics, probability theory.

Mathematical Tools for the Physical Sciences: [Read More](#) [+]

### Rules & Requirements

**Prerequisites:** 53 and 54

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam required.

Mathematical Tools for the Physical Sciences: [Read Less](#) [-]

## MATH 123 Ordinary Differential Equations 4 Units

Terms offered: Fall 2021, Fall 2020, Fall 2019

Existence and uniqueness of solutions, linear systems, regular singular points. Other topics selected from analytic systems, autonomous systems, Sturm-Liouville Theory.

Ordinary Differential Equations: [Read More](#) [+]

### Rules & Requirements

**Prerequisites:** 104

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam required.

Ordinary Differential Equations: [Read Less](#) [-]

## MATH 124 Programming for Mathematical Applications 4 Units

Terms offered: Spring 2021, Spring 2020, Spring 2019

An introduction to computer programming with a focus on the solution of mathematical and scientific problems. Basic programming concepts such as variables, statements, loops, branches, functions, data types, and object orientation. Mathematical/scientific tools such as arrays, floating point numbers, plotting, symbolic algebra, and various packages. Examples from a wide range of mathematical applications such as evaluation of complex algebraic expressions, number theory, combinatorics, statistical analysis, efficient algorithms, computational geometry, Fourier analysis, and optimization. Mainly based on the Julia programming language, but some examples will demonstrate other languages such as MATLAB, Python, C, and Mathematica.

Programming for Mathematical Applications: [Read More](#) [+]

### Rules & Requirements

**Prerequisites:** Math 53, 54, 55

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture and 1 hour of discussion per week

### Additional Details

**Subject/Course Level:** Mathematics/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam required.

Programming for Mathematical Applications: [Read Less](#) [-]



## MATH 125A Mathematical Logic 4 Units

Terms offered: Fall 2021, Fall 2020, Fall 2019

Sentential and quantificational logic. Formal grammar, semantical interpretation, formal deduction, and their interrelation. Applications to formalized mathematical theories. Selected topics from model theory or proof theory.

Mathematical Logic: Read More [+]

### Rules & Requirements

**Prerequisites:** Math 104 and 113 or consent of instructor

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam required.

Mathematical Logic: Read Less [-]

## MATH 126 Introduction to Partial Differential Equations 4 Units

Terms offered: Fall 2021, Summer 2021 8 Week Session, Spring 2021  
Waves and diffusion, initial value problems for hyperbolic and parabolic equations, boundary value problems for elliptic equations, Green's functions, maximum principles, a priori bounds, Fourier transform. Introduction to Partial Differential Equations: Read More [+]

### Rules & Requirements

**Prerequisites:** 53 and 54

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture per week

**Summer:** 8 weeks - 6 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam required.

Introduction to Partial Differential Equations: Read Less [-]

## MATH 127 Mathematical and Computational Methods in Molecular Biology 4 Units

Terms offered: Fall 2017, Fall 2016, Spring 2016

Introduction to mathematical and computational problems arising in the context of molecular biology. Theory and applications of combinatorics, probability, statistics, geometry, and topology to problems ranging from sequence determination to structure analysis.

Mathematical and Computational Methods in Molecular Biology: Read More [+]

### Rules & Requirements

**Prerequisites:** 53, 54, and 55; Statistics 20 recommended

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam required.

Mathematical and Computational Methods in Molecular Biology: Read Less [-]

## MATH 128A Numerical Analysis 4 Units

Terms offered: Fall 2021, Spring 2021, Fall 2020

Programming for numerical calculations, round-off error, approximation and interpolation, numerical quadrature, and solution of ordinary differential equations. Practice on the computer.

Numerical Analysis: Read More [+]

### Rules & Requirements

**Prerequisites:** 53 and 54

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture and 1 hour of discussion per week

**Summer:** 8 weeks - 4 hours of lecture and 4 hours of discussion per week

### Additional Details

**Subject/Course Level:** Mathematics/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam required.

Numerical Analysis: Read Less [-]

## MATH 128B Numerical Analysis 4 Units

Terms offered: Spring 2021, Spring 2020, Spring 2019

Iterative solution of systems of nonlinear equations, evaluation of eigenvalues and eigenvectors of matrices, applications to simple partial differential equations. Practice on the computer.

Numerical Analysis: Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** 110 and 128A

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture and 1 hour of discussion per week

**Summer:** 8 weeks - 6 hours of lecture and 1.5 hours of discussion per week

### Additional Details

**Subject/Course Level:** Mathematics/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam required.

Numerical Analysis: Read Less [\[-\]](#)

## MATH W128A Numerical Analysis 4 Units

Terms offered: Summer 2021 8 Week Session

Numerical Analysis: Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** MATH 53, MATH 54

**Credit Restrictions:** Students will receive no credit for MATH W128A after completing MATH 128A. A deficient grade in MATH W128A may be removed by taking MATH 128A, or MATH 128A.

### Hours & Format

**Summer:** 8 weeks - 4 hours of web-based lecture and 4 hours of web-based discussion per week

**Online:** This is an online course.

### Additional Details

**Subject/Course Level:** Mathematics/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam required, with common exam group.

**Instructor:** Persson

Numerical Analysis: Read Less [\[-\]](#)

## MATH 130 Groups and Geometries 4 Units

Terms offered: Fall 2020, Spring 2020, Spring 2019

Isometries of Euclidean space. The Platonic solids and their symmetries.

Crystallographic groups. Projective geometry. Hyperbolic geometry.

Groups and Geometries: Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** 110 and 113

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam required.

Groups and Geometries: Read Less [\[-\]](#)

## MATH 135 Introduction to the Theory of Sets 4 Units

Terms offered: Fall 2021, Fall 2020, Fall 2019

Set-theoretical paradoxes and means of avoiding them. Sets, relations,

functions, order and well-order. Proof by transfinite induction and

definitions by transfinite recursion. Cardinal and ordinal numbers and

their arithmetic. Construction of the real numbers. Axiom of choice and its consequences.

Introduction to the Theory of Sets: Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** Math 104 and 113 or consent of instructor

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam required.

Introduction to the Theory of Sets: Read Less [\[-\]](#)

## MATH 136 Incompleteness and Undecidability 4 Units

Terms offered: Spring 2021, Spring 2020, Fall 2019

Functions computable by algorithm, Turing machines, Church's thesis. Unsolvability of the halting problem, Rice's theorem. Recursively enumerable sets, creative sets, many-one reductions. Self-referential programs. Godel's incompleteness theorems, undecidability of validity, decidable and undecidable theories.

Incompleteness and Undecidability: Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** Math 104 and 113 or consent of instructor

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam required.

Incompleteness and Undecidability: Read Less [\[-\]](#)

## MATH 140 Metric Differential Geometry 4 Units

Terms offered: Spring 2021, Spring 2020, Spring 2019

Frenet formulas, isoperimetric inequality, local theory of surfaces in Euclidean space, first and second fundamental forms. Gaussian and mean curvature, isometries, geodesics, parallelism, the Gauss-Bonnet-Von Dyck Theorem.

Metric Differential Geometry: Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** 104

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam required.

Metric Differential Geometry: Read Less [\[-\]](#)

## MATH 141 Elementary Differential Topology 4 Units

Terms offered: Fall 2021, Fall 2020, Fall 2019

Manifolds in  $n$ -dimensional Euclidean space and smooth maps, Sard's Theorem, classification of compact one-manifolds, transversality and intersection modulo 2.

Elementary Differential Topology: Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** 104 or equivalent and linear algebra

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam required.

Elementary Differential Topology: Read Less [\[-\]](#)

## MATH 142 Elementary Algebraic Topology 4 Units

Terms offered: Fall 2021, Fall 2020, Fall 2019

The topology of one and two dimensional spaces: manifolds and triangulation, classification of surfaces, Euler characteristic, fundamental groups, plus further topics at the discretion of the instructor.

Elementary Algebraic Topology: Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** 104 and 113

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam required.

Elementary Algebraic Topology: Read Less [\[-\]](#)

## MATH 143 Elementary Algebraic Geometry 4 Units

Terms offered: Spring 2021, Spring 2020, Fall 2018

Introduction to basic commutative algebra, algebraic geometry, and computational techniques. Main focus on curves, surfaces and Grassmannian varieties.

Elementary Algebraic Geometry: Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** 113

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam required.

Elementary Algebraic Geometry: Read Less [\[-\]](#)

## MATH 151 Mathematics of the Secondary School Curriculum I 4 Units

Terms offered: Fall 2021, Fall 2020, Fall 2019

Theory of rational numbers based on the number line, the Euclidean algorithm and fractions in lowest terms. The concepts of congruence and similarity, equation of a line, functions, and quadratic functions.

Mathematics of the Secondary School Curriculum I: Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** 1A-1B, 53, or equivalent

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture and 0-1 hours of discussion per week

### Additional Details

**Subject/Course Level:** Mathematics/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam required.

Mathematics of the Secondary School Curriculum I: Read Less [\[-\]](#)

## MATH 152 Mathematics of the Secondary School Curriculum II 4 Units

Terms offered: Spring 2021, Spring 2020, Spring 2019

Complex numbers and Fundamental Theorem of Algebra, roots and factorizations of polynomials, Euclidean geometry and axiomatic systems, basic trigonometry.

Mathematics of the Secondary School Curriculum II: Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** 151; 54, 113, or equivalent

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture and 0-1 hours of discussion per week

### Additional Details

**Subject/Course Level:** Mathematics/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam required.

Mathematics of the Secondary School Curriculum II: Read Less [\[-\]](#)

## MATH 160 History of Mathematics 4 Units

Terms offered: Spring 2021, Spring 2020, Spring 2019

History of algebra, geometry, analytic geometry, and calculus from ancient times through the seventeenth century and selected topics from more recent mathematical history.

History of Mathematics: Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** 53, 54, and 113

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam required.

History of Mathematics: Read Less [\[-\]](#)

## MATH 170 Mathematical Methods for Optimization 4 Units

Terms offered: Fall 2021, Fall 2020, Spring 2020

Linear programming and a selection of topics from among the following: matrix games, integer programming, semidefinite programming, nonlinear programming, convex analysis and geometry, polyhedral geometry, the calculus of variations, and control theory.

Mathematical Methods for Optimization: Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** 53 and 54

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam required.

Mathematical Methods for Optimization: Read Less [\[-\]](#)

## MATH 172 Combinatorics 4 Units

Terms offered: Spring 2021, Fall 2019, Spring 2018

Basic combinatorial principles, graphs, partially ordered sets, generating functions, asymptotic methods, combinatorics of permutations and partitions, designs and codes. Additional topics at the discretion of the instructor.

Combinatorics: Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** 55

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam required.

Combinatorics: Read Less [\[-\]](#)

## MATH 185 Introduction to Complex Analysis 4 Units

Terms offered: Fall 2021, Summer 2021 8 Week Session, Spring 2021

Analytic functions of a complex variable. Cauchy's integral theorem, power series, Laurent series, singularities of analytic functions, the residue theorem with application to definite integrals. Some additional topics such as conformal mapping.

Introduction to Complex Analysis: Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** 104

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture per week

**Summer:** 8 weeks - 8 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam required.

Introduction to Complex Analysis: Read Less [\[-\]](#)

## MATH H185 Honors Introduction to Complex Analysis 4 Units

Terms offered: Spring 2021, Spring 2020, Spring 2019

Honors section corresponding to Math 185 for exceptional students with strong mathematical inclination and motivation. Emphasis is on rigor, depth, and hard problems.

Honors Introduction to Complex Analysis: Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** 104

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam required.

Honors Introduction to Complex Analysis: Read Less [\[-\]](#)

## MATH 189 Mathematical Methods in Classical and Quantum Mechanics 4 Units

Terms offered: Fall 2020, Fall 2015, Fall 2014

Topics in mechanics presented from a mathematical viewpoint: e.g., hamiltonian mechanics and symplectic geometry, differential equations for fluids, spectral theory in quantum mechanics, probability theory and statistical mechanics. See department bulletins for specific topics each semester course is offered.

Mathematical Methods in Classical and Quantum Mechanics: Read More [+]

### Rules & Requirements

**Prerequisites:** 104, 110, 2 semesters lower division Physics

**Repeat rules:** Course may be repeated for credit without restriction.

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam required.

Mathematical Methods in Classical and Quantum Mechanics: Read Less [-]

## MATH 191 Experimental Courses in Mathematics 1 - 4 Units

Terms offered: Fall 2021, Fall 2020, Spring 2020

The topics to be covered and the method of instruction to be used will be announced at the beginning of each semester that such courses are offered. See departmental bulletins.

Experimental Courses in Mathematics: Read More [+]

### Rules & Requirements

**Prerequisites:** Consent of instructor

**Repeat rules:** Course may be repeated for credit without restriction.

### Hours & Format

**Fall and/or spring:** 15 weeks - 1-4 hours of seminar per week

### Summer:

6 weeks - 2.5-10 hours of seminar per week

8 weeks - 1.5-7.5 hours of seminar per week

### Additional Details

**Subject/Course Level:** Mathematics/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam required.

Experimental Courses in Mathematics: Read Less [-]

## MATH 195 Special Topics in Mathematics 4 Units

Terms offered: Spring 2021, Spring 2011, Spring 2004

Lectures on special topics, which will be announced at the beginning of each semester that the course is offered.

Special Topics in Mathematics: Read More [+]

### Rules & Requirements

**Prerequisites:** Consent of instructor

**Repeat rules:** Course may be repeated for credit without restriction.

### Hours & Format

**Fall and/or spring:** 15 weeks - 0 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam required.

Special Topics in Mathematics: Read Less [-]

## MATH 196 Honors Thesis 4 Units

Terms offered: Spring 2017, Spring 2016, Spring 2015

Independent study of an advanced topic leading to an honors thesis.

Honors Thesis: Read More [+]

### Rules & Requirements

**Prerequisites:** Admission to the Honors Program; an overall GPA of 3.3 and a GPA of 3.5 in the major

**Repeat rules:** Course may be repeated for credit without restriction.

### Hours & Format

**Fall and/or spring:** 15 weeks - 0 hours of independent study per week

### Summer:

6 weeks - 1-5 hours of independent study per week

8 weeks - 1-4 hours of independent study per week

### Additional Details

**Subject/Course Level:** Mathematics/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam not required.

Honors Thesis: Read Less [-]



## MATH 197 Field Study 1 - 4 Units

Terms offered: Spring 2016, Spring 2015, Spring 2014

For Math/Applied math majors. Supervised experience relevant to specific aspects of their mathematical emphasis of study in off-campus organizations. Regular individual meetings with faculty sponsor and written reports required. Units will be awarded on the basis of three hours/week/unit.

Field Study: [Read More](#) [+]

### Rules & Requirements

**Prerequisites:** Upper division standing. Written proposal signed by faculty sponsor and approved by department chair

**Credit Restrictions:** Enrollment is restricted; see the Course Number Guide in the Bulletin.

**Repeat rules:** Course may be repeated for credit without restriction.

### Hours & Format

**Fall and/or spring:** 15 weeks - 3-3 hours of fieldwork per week

**Summer:** 8 weeks - 3-3 hours of fieldwork per week

### Additional Details

**Subject/Course Level:** Mathematics/Undergraduate

**Grading/Final exam status:** Offered for pass/not pass grade only. Final exam not required.

Field Study: [Read Less](#) [-]

## MATH 198 Directed Group Study 1 - 4 Units

Terms offered: Fall 2019, Spring 2017, Fall 2016

Topics will vary with instructor.

Directed Group Study: [Read More](#) [+]

### Rules & Requirements

**Prerequisites:** Must have completed 60 units and be in good standing

**Repeat rules:** Course may be repeated for credit without restriction.

### Hours & Format

**Fall and/or spring:** 15 weeks - 1-4 hours of directed group study per week

**Summer:** 8 weeks - 1-4 hours of directed group study per week

### Additional Details

**Subject/Course Level:** Mathematics/Undergraduate

**Grading/Final exam status:** Offered for pass/not pass grade only. Final exam not required.

Directed Group Study: [Read Less](#) [-]

## MATH 198BC Berkeley Connect 1 Unit

Terms offered: Fall 2021, Spring 2021, Fall 2020

Berkeley Connect is a mentoring program, offered through various academic departments, that helps students build intellectual community. Over the course of a semester, enrolled students participate in regular small-group discussions facilitated by a graduate student mentor (following a faculty-directed curriculum), meet with their graduate student mentor for one-on-one academic advising, attend lectures and panel discussions featuring department faculty and alumni, and go on field trips to campus resources. Students are not required to be declared majors in order to participate.

Berkeley Connect: [Read More](#) [+]

### Rules & Requirements

**Repeat rules:** Course may be repeated for credit without restriction.

### Hours & Format

**Fall and/or spring:** 15 weeks - 1 hour of discussion per week

### Additional Details

**Subject/Course Level:** Mathematics/Undergraduate

**Grading/Final exam status:** Offered for pass/not pass grade only. Final exam not required.

Berkeley Connect: [Read Less](#) [-]

## MATH 199 Supervised Independent Study and Research 1 - 4 Units

Terms offered: Fall 2019, Fall 2018, Fall 2017

Supervised Independent Study and Research: [Read More](#) [+]

### Rules & Requirements

**Prerequisites:** The standard college regulations for all 199 courses

**Repeat rules:** Course may be repeated for credit without restriction.

### Hours & Format

**Fall and/or spring:** 15 weeks - 0 hours of independent study per week

### Summer:

6 weeks - 1-5 hours of independent study per week

8 weeks - 1-4 hours of independent study per week

### Additional Details

**Subject/Course Level:** Mathematics/Undergraduate

**Grading/Final exam status:** Offered for pass/not pass grade only. Final exam not required.

Supervised Independent Study and Research: [Read Less](#) [-]

## MATH 202A Introduction to Topology and Analysis 4 Units

Terms offered: Fall 2021, Fall 2020, Fall 2019

Metric spaces and general topological spaces. Compactness and connectedness. Characterization of compact metric spaces. Theorems of Tychonoff, Urysohn, Tietze. Complete spaces and the Baire category theorem. Function spaces; Arzela-Ascoli and Stone-Weierstrass theorems. Partitions of unity. Locally compact spaces; one-point compactification. Introduction to measure and integration. Sigma algebras of sets. Measures and outer measures. Lebesgue measure on the line and  $\mathbb{R}^n$ . Construction of the integral. Dominated convergence theorem.

Introduction to Topology and Analysis: Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** 104

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Graduate

**Grading:** Letter grade.

Introduction to Topology and Analysis: Read Less [\[-\]](#)

## MATH 202B Introduction to Topology and Analysis 4 Units

Terms offered: Spring 2021, Spring 2020, Spring 2019

Measure and integration. Product measures and Fubini-type theorems. Signed measures; Hahn and Jordan decompositions. Radon-Nikodym theorem. Integration on the line and in  $\mathbb{R}^n$ . Differentiation of the integral. Hausdorff measures. Fourier transform. Introduction to linear topological spaces, Banach spaces and Hilbert spaces. Banach-Steinhaus theorem; closed graph theorem. Hahn-Banach theorem. Duality; the dual of  $L^p$ . Measures on locally compact spaces; the dual of  $C(X)$ . Weak and weak-\* topologies; Banach-Alaoglu theorem. Convexity and the Krein-Milman theorem. Additional topics chosen may include compact operators, spectral theory of compact operators, and applications to integral equations.

Introduction to Topology and Analysis: Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** 202A and 110

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Graduate

**Grading:** Letter grade.

Introduction to Topology and Analysis: Read Less [\[-\]](#)

## MATH 204 Ordinary Differential Equations 4 Units

Terms offered: Fall 2016, Spring 2016, Fall 2014

Rigorous theory of ordinary differential equations. Fundamental existence theorems for initial and boundary value problems, variational equilibria, periodic coefficients and Floquet Theory, Green's functions, eigenvalue problems, Sturm-Liouville theory, phase plane analysis, Poincaré-Bendixon Theorem, bifurcation, chaos.

Ordinary Differential Equations: Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** 104

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Graduate

**Grading:** Letter grade.

Ordinary Differential Equations: Read Less [\[-\]](#)

## MATH 205 Theory of Functions of a Complex Variable 4 Units

Terms offered: Spring 2021, Spring 2020, Fall 2018

Normal families. Riemann Mapping Theorem. Picard's theorem and related theorems. Multiple-valued analytic functions and Riemann surfaces. Further topics selected by the instructor may include: harmonic functions, elliptic and algebraic functions, boundary behavior of analytic functions and HP spaces, the Riemann zeta functions, prime number theorem.

Theory of Functions of a Complex Variable: Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** 185

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Graduate

**Grading:** Letter grade.

Theory of Functions of a Complex Variable: Read Less [\[-\]](#)

## MATH 206 Banach Algebras and Spectral Theory 4 Units

Terms offered: Fall 2021, Fall 2020, Fall 2018

Banach algebras. Spectrum of a Banach algebra element. Gelfand theory of commutative Banach algebras. Analytic functional calculus. Hilbert space operators.  $C^*$ -algebras of operators. Commutative  $C^*$ -algebras. Spectral theorem for bounded self-adjoint and normal operators (both forms: the spectral integral and the "multiplication operator" formulation). Riesz theory of compact operators. Hilbert-Schmidt operators. Fredholm operators. The Fredholm index. Selected additional topics.

Banach Algebras and Spectral Theory: Read More [+]

### Rules & Requirements

**Prerequisites:** 202A-202B

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Graduate

**Grading:** Letter grade.

Banach Algebras and Spectral Theory: Read Less [-]

## MATH 208 $C^*$ -algebras 4 Units

Terms offered: Spring 2021, Fall 2019, Spring 2018

Basic theory of  $C^*$ -algebras. Positivity, spectrum, GNS construction. Group  $C^*$ -algebras and connection with group representations. Additional topics, for example,  $C^*$ -dynamical systems, K-theory.

$C^*$ -algebras: Read More [+]

### Rules & Requirements

**Prerequisites:** 206

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Graduate

**Grading:** Letter grade.

$C^*$ -algebras: Read Less [-]

## MATH 209 Von Neumann Algebras 4 Units

Terms offered: Spring 2017, Spring 2014, Spring 2012

Basic theory of von Neumann algebras. Density theorems, topologies and normal maps, traces, comparison of projections, type classification, examples of factors. Additional topics, for example, Tomita Takasaki theory, subfactors, group actions, and noncommutative probability.

Von Neumann Algebras: Read More [+]

### Rules & Requirements

**Prerequisites:** 206

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Graduate

**Grading:** Letter grade.

Von Neumann Algebras: Read Less [-]

## MATH 212 Several Complex Variables 4 Units

Terms offered: Fall 2021, Fall 2019, Spring 2016

Power series developments, domains of holomorphy, Hartogs' phenomenon, pseudo convexity and plurisubharmonicity. The remainder of the course may treat either sheaf cohomology and Stein manifolds, or the theory of analytic subvarieties and spaces.

Several Complex Variables: Read More [+]

### Rules & Requirements

**Prerequisites:** 185 and 202A-202B or their equivalents

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Graduate

**Grading:** Letter grade.

Several Complex Variables: Read Less [-]

## MATH 214 Differentiable Manifolds 4 Units

Terms offered: Spring 2021, Spring 2020, Fall 2018

Smooth manifolds and maps, tangent and normal bundles. Sard's theorem and transversality, Whitney embedding theorem. Morse functions, differential forms, Stokes' theorem, Frobenius theorem. Basic degree theory. Flows, Lie derivative, Lie groups and algebras. Additional topics selected by instructor.

Differentiable Manifolds: Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** 202A

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Graduate

**Grading:** Letter grade.

Differentiable Manifolds: Read Less [\[-\]](#)

## MATH 215A Algebraic Topology 4 Units

Terms offered: Fall 2021, Fall 2020, Fall 2019

Fundamental group and covering spaces, simplicial and singular homology theory with applications, cohomology theory, duality theorem. Homotopy theory, fibrations, relations between homotopy and homology, obstruction theory, and topics from spectral sequences, cohomology operations, and characteristic classes. Sequence begins fall.

Algebraic Topology: Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** 113 and point-set topology (e.g. 202A)

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Graduate

**Grading:** Letter grade.

**Instructors:** 113C, 202A, and 214

Algebraic Topology: Read Less [\[-\]](#)

## MATH 215B Algebraic Topology 4 Units

Terms offered: Spring 2021, Spring 2020, Spring 2019

Fundamental group and covering spaces, simplicial and singular homology theory with applications, cohomology theory, duality theorem. Homotopy theory, fibrations, relations between homotopy and homology, obstruction theory, and topics from spectral sequences, cohomology operations, and characteristic classes. Sequence begins fall.

Algebraic Topology: Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** 215A, 214 recommended (can be taken concurrently)

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Graduate

**Grading:** Letter grade.

**Instructors:** 113C, 202A, and 214

Algebraic Topology: Read Less [\[-\]](#)

## MATH C218A Probability Theory 4 Units

Terms offered: Fall 2021, Fall 2020, Fall 2019, Fall 2018, Fall 2017

The course is designed as a sequence with Statistics C205B/Mathematics C218B with the following combined syllabus. Measure theory concepts needed for probability. Expectation, distributions. Laws of large numbers and central limit theorems for independent random variables. Characteristic function methods. Conditional expectations, martingales and martingale convergence theorems. Markov chains. Stationary processes. Brownian motion.

Probability Theory: Read More [\[+\]](#)

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Graduate

**Grading:** Letter grade.

**Also listed as:** STAT C205A

Probability Theory: Read Less [\[-\]](#)

## MATH C218B Probability Theory 4 Units

Terms offered: Spring 2021, Spring 2020, Spring 2019

The course is designed as a sequence with with Statistics C205A/ Mathematics C218A with the following combined syllabus. Measure theory concepts needed for probability. Expectation, distributions. Laws of large numbers and central limit theorems for independent random variables. Characteristic function methods. Conditional expectations, martingales and martingale convergence theorems. Markov chains. Stationary processes. Brownian motion.

Probability Theory: Read More [\[+\]](#)

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Graduate

**Grading:** Letter grade.

**Also listed as:** STAT C205B

Probability Theory: Read Less [\[-\]](#)

## MATH 219 Dynamical Systems 4 Units

Terms offered: Spring 2021, Spring 2020, Spring 2018

Diffeomorphisms and flows on manifolds. Ergodic theory. Stable manifolds, generic properties, structural stability. Additional topics selected by the instructor.

Dynamical Systems: Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** 214

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Graduate

**Grading:** Letter grade.

Dynamical Systems: Read Less [\[-\]](#)

## MATH 220 Introduction to Probabilistic Methods in Mathematics and the Sciences 4 Units

Terms offered: Spring 2012, Spring 2011, Spring 2010

Brownian motion, Langevin and Fokker-Planck equations, path integrals and Feynman diagrams, time series, an introduction to statistical mechanics, Monte Carlo methods, selected applications.

Introduction to Probabilistic Methods in Mathematics and the Sciences:

Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** Some familiarity with differential equations and their applications

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Graduate

**Grading:** Letter grade.

Introduction to Probabilistic Methods in Mathematics and the Sciences:

Read Less [\[-\]](#)

## MATH 221 Advanced Matrix Computations 4 Units

Terms offered: Fall 2020, Spring 2020, Spring 2018

Direct solution of linear systems, including large sparse systems: error bounds, iteration methods, least square approximation, eigenvalues and eigenvectors of matrices, nonlinear equations, and minimization of functions.

Advanced Matrix Computations: Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** Consent of instructor

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture per week

**Summer:** 8 weeks - 6 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Graduate

**Grading:** Letter grade.

Advanced Matrix Computations: Read Less [\[-\]](#)

## MATH 222A Partial Differential Equations 4 Units

Terms offered: Fall 2021, Fall 2020, Fall 2019

The theory of boundary value and initial value problems for partial differential equations, with emphasis on nonlinear equations. Laplace's equation, heat equation, wave equation, nonlinear first-order equations, conservation laws, Hamilton-Jacobi equations, Fourier transform, Sobolev spaces.

Partial Differential Equations: Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** 105 or 202A

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Graduate

**Grading:** Letter grade.

Partial Differential Equations: Read Less [\[-\]](#)

## MATH 222B Partial Differential Equations 4 Units

Terms offered: Spring 2021, Spring 2020, Spring 2019

The theory of boundary value and initial value problems for partial differential equations, with emphasis on nonlinear equations. Second-order elliptic equations, parabolic and hyperbolic equations, calculus of variations methods, additional topics selected by instructor.

Partial Differential Equations: Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** 105 or 202A

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Graduate

**Grading:** Letter grade.

Partial Differential Equations: Read Less [\[-\]](#)

## MATH C223A Advanced Topics in Probability and Stochastic Process 3 Units

Terms offered: Fall 2021, Fall 2020, Fall 2016, Fall 2014

The topics of this course change each semester, and multiple sections may be offered. Advanced topics in probability offered according to students demand and faculty availability.

Advanced Topics in Probability and Stochastic Process: Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** Statistics C205A-C205B or consent of instructor

**Repeat rules:** Course may be repeated for credit with instructor consent.

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Graduate

**Grading:** Letter grade.

**Also listed as:** STAT C206A

Advanced Topics in Probability and Stochastic Process: Read Less [\[-\]](#)

## MATH C223B Advanced Topics in Probability and Stochastic Processes 3 Units

Terms offered: Spring 2021, Spring 2020, Spring 2019

The topics of this course change each semester, and multiple sections may be offered. Advanced topics in probability offered according to students demand and faculty availability.

Advanced Topics in Probability and Stochastic Processes: Read More [\[+\]](#)

### Rules & Requirements

**Repeat rules:** Course may be repeated for credit with instructor consent.

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Graduate

**Grading:** Letter grade.

**Also listed as:** STAT C206B

Advanced Topics in Probability and Stochastic Processes: Read Less [\[-\]](#)



## MATH 224A Mathematical Methods for the Physical Sciences 4 Units

Terms offered: Fall 2020, Fall 2019, Fall 2016

Introduction to the theory of distributions. Fourier and Laplace transforms. Partial differential equations. Green's function. Operator theory, with applications to eigenfunction expansions, perturbation theory and linear and non-linear waves. Sequence begins fall.

Mathematical Methods for the Physical Sciences: Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** Graduate status or consent of instructor

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Graduate

**Grading:** Letter grade.

**Instructors:** 112 or 113C; 104A and 185, or 121A-121B-121C, or 120A-120B-120C.

Mathematical Methods for the Physical Sciences: Read Less [\[-\]](#)

## MATH 224B Mathematical Methods for the Physical Sciences 4 Units

Terms offered: Spring 2015, Spring 2014, Spring 2013

Introduction to the theory of distributions. Fourier and Laplace transforms. Partial differential equations. Green's function. Operator theory, with applications to eigenfunction expansions, perturbation theory and linear and non-linear waves. Sequence begins fall.

Mathematical Methods for the Physical Sciences: Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** Graduate status or consent of instructor

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Graduate

**Grading:** Letter grade.

Mathematical Methods for the Physical Sciences: Read Less [\[-\]](#)

## MATH 225A Metamathematics 4 Units

Terms offered: Fall 2021, Fall 2020, Fall 2019

Metamathematics of predicate logic. Completeness and compactness theorems. Interpolation theorem, definability, theory of models.

Metamathematics of number theory, recursive functions, applications to truth and provability. Undecidable theories. Sequence begins fall.

Metamathematics: Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** 125A and (135 or 136)

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Graduate

**Grading:** Letter grade.

Metamathematics: Read Less [\[-\]](#)

## MATH 225B Metamathematics 4 Units

Terms offered: Spring 2021, Spring 2020, Spring 2019

Metamathematics of predicate logic. Completeness and compactness theorems. Interpolation theorem, definability, theory of models.

Metamathematics of number theory, recursive functions, applications to truth and provability. Undecidable theories. Sequence begins fall.

Metamathematics: Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** 125A and (135 or 136)

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Graduate

**Grading:** Letter grade.

Metamathematics: Read Less [\[-\]](#)

## MATH 227A Theory of Recursive Functions 4 Units

Terms offered: Spring 2021, Fall 2015, Fall 2013

Recursive and recursively enumerable sets of natural numbers; characterizations, significance, and classification. Relativization, degrees of unsolvability. The recursion theorem. Constructive ordinals, the hyperarithmetical and analytical hierarchies. Recursive objects of higher type. Sequence begins fall.

Theory of Recursive Functions: Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** Mathematics 225B

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Graduate

**Grading:** Letter grade.

**Instructor:** 225C.

Theory of Recursive Functions: Read Less [\[-\]](#)

## MATH 228A Numerical Solution of Differential Equations 4 Units

Terms offered: Fall 2021, Fall 2020, Fall 2019

Ordinary differential equations: Runge-Kutta and predictor-corrector methods; stability theory, Richardson extrapolation, stiff equations, boundary value problems. Partial differential equations: stability, accuracy and convergence, Von Neumann and CFL conditions, finite difference solutions of hyperbolic and parabolic equations. Finite differences and finite element solution of elliptic equations.

Numerical Solution of Differential Equations: Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** 128A

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Graduate

**Grading:** Letter grade.

**Instructor:** 128A-128B.

Numerical Solution of Differential Equations: Read Less [\[-\]](#)

## MATH 228B Numerical Solution of Differential Equations 4 Units

Terms offered: Spring 2021, Spring 2020, Spring 2019

Ordinary differential equations: Runge-Kutta and predictor-corrector methods; stability theory, Richardson extrapolation, stiff equations, boundary value problems. Partial differential equations: stability, accuracy and convergence, Von Neumann and CFL conditions, finite difference solutions of hyperbolic and parabolic equations. Finite differences and finite element solution of elliptic equations.

Numerical Solution of Differential Equations: Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** 128A

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Graduate

**Grading:** Letter grade.

**Instructor:** 128A-128B.

Numerical Solution of Differential Equations: Read Less [\[-\]](#)

## MATH 229 Theory of Models 4 Units

Terms offered: Spring 2019, Spring 2015, Spring 2013

Syntactical characterization of classes closed under algebraic operations. Ultraproducts and ultralimits, saturated models. Methods for establishing decidability and completeness. Model theory of various languages richer than first-order.

Theory of Models: Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** 225B

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Graduate

**Grading:** Letter grade.

Theory of Models: Read Less [\[-\]](#)

## MATH 235A Theory of Sets 4 Units

Terms offered: Fall 2018, Spring 2014, Fall 2011

Axiomatic foundations. Operations on sets and relations. Images and set functions. Ordering, well-ordering, and well-founded relations; general principles of induction and recursion. Ranks of sets, ordinals and their arithmetic. Set-theoretical equivalence, similarity of relations; definitions by abstraction. Arithmetic of cardinals. Axiom of choice, equivalent forms, and consequences. Sequence begins fall.

Theory of Sets: Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** 125A and 135

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Graduate

**Grading:** Letter grade.

**Instructor:** 125A and 135.

Theory of Sets: Read Less [\[-\]](#)

## MATH 236 Metamathematics of Set Theory 4 Units

Terms offered: Fall 2021, Fall 2014, Fall 2010

Various set theories: comparison of strength, transitive, and natural models, finite axiomatizability. Independence and consistency of axiom of choice, continuum hypothesis, etc. The measure problem and axioms of strong infinity.

Metamathematics of Set Theory: Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** 225B and 235A

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Graduate

**Grading:** Letter grade.

Metamathematics of Set Theory: Read Less [\[-\]](#)

## MATH 239 Discrete Mathematics for the Life Sciences 4 Units

Terms offered: Spring 2011, Fall 2008, Spring 2008

Introduction to algebraic statistics and probability, optimization, phylogenetic combinatorics, graphs and networks, polyhedral and metric geometry.

Discrete Mathematics for the Life Sciences: Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** Statistics 134 or equivalent introductory probability theory course, or consent of instructor

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Graduate

**Grading:** Letter grade.

Discrete Mathematics for the Life Sciences: Read Less [\[-\]](#)

## MATH C239 Discrete Mathematics for the Life Sciences 4 Units

Terms offered: Spring 2013

Introduction to algebraic statistics and probability, optimization, phylogenetic combinatorics, graphs and networks, polyhedral and metric geometry.

Discrete Mathematics for the Life Sciences: Read More [\[+\]](#)

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Graduate

**Grading:** Letter grade.

**Also listed as:** MCELLBI C244

Discrete Mathematics for the Life Sciences: Read Less [\[-\]](#)

## MATH 240 Riemannian Geometry 4 Units

Terms offered: Fall 2021, Fall 2019, Fall 2018

Riemannian metric and Levi-Civita connection, geodesics and completeness, curvature, first and second variations of arc length. Additional topics such as the theorems of Myers, Synge, and Cartan-Hadamard, the second fundamental form, convexity and rigidity of hypersurfaces in Euclidean space, homogeneous manifolds, the Gauss-Bonnet theorem, and characteristic classes.

Riemannian Geometry: Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** 214

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Graduate

**Grading:** Letter grade.

Riemannian Geometry: Read Less [\[-\]](#)

## MATH 241 Complex Manifolds 4 Units

Terms offered: Spring 2021, Spring 2020, Fall 2017

Riemann surfaces, divisors and line bundles on Riemann surfaces, sheaves and the Dolbeault theorem on Riemann surfaces, the classical Riemann-Roch theorem, theorem of Abel-Jacobi. Complex manifolds, Kahler metrics. Summary of Hodge theory, groups of line bundles, additional topics such as Kodaira's vanishing theorem, Lefschetz hyperplane theorem.

Complex Manifolds: Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** 214 and 215A

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Graduate

**Grading:** Letter grade.

Complex Manifolds: Read Less [\[-\]](#)

## MATH 242 Symplectic Geometry 4 Units

Terms offered: Fall 2021, Fall 2020, Spring 2019

Basic topics: symplectic linear algebra, symplectic manifolds, Darboux theorem, cotangent bundles, variational problems and Legendre transform, hamiltonian systems, Lagrangian submanifolds, Poisson brackets, symmetry groups and momentum mappings, coadjoint orbits, Kahler manifolds.

Symplectic Geometry: Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** 214

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Graduate

**Grading:** Letter grade.

Symplectic Geometry: Read Less [\[-\]](#)

## MATH C243 Seq: Methods and Applications 3 Units

Terms offered: Spring 2015, Spring 2014

A graduate seminar class in which a group of students will closely examine recent computational methods in high-throughput sequencing followed by directly examining interesting biological applications thereof.

Seq: Methods and Applications: Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** Graduate standing in Math, MCB, and Computational Biology; or consent of the instructor

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Graduate

**Grading:** Letter grade.

**Instructor:** Pachter

**Also listed as:** MCELLBI C243

Seq: Methods and Applications: Read Less [\[-\]](#)

## MATH 245A General Theory of Algebraic Structures 4 Units

Terms offered: Fall 2017, Fall 2015, Spring 2014

Structures defined by operations and/or relations, and their homomorphisms. Classes of structures determined by identities. Constructions such as free objects, objects presented by generators and relations, ultraproducts, direct limits. Applications of general results to groups, rings, lattices, etc. Course may emphasize study of congruence- and subalgebra-lattices, or category-theory and adjoint functors, or other aspects.

General Theory of Algebraic Structures: Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** Math 113

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Graduate

**Grading:** Letter grade.

General Theory of Algebraic Structures: Read Less [\[-\]](#)

## MATH 249 Algebraic Combinatorics 4 Units

Terms offered: Spring 2021, Spring 2020, Fall 2019

(I) Enumeration, generating functions and exponential structures, (II) Posets and lattices, (III) Geometric combinatorics, (IV) Symmetric functions, Young tableaux, and connections with representation theory. Further study of applications of the core material and/or additional topics, chosen by instructor.

Algebraic Combinatorics: Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** 250A or consent of instructor

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Graduate

**Grading:** Letter grade.

Algebraic Combinatorics: Read Less [\[-\]](#)

## MATH 250A Groups, Rings, and Fields 4 Units

Terms offered: Fall 2021, Fall 2020, Fall 2019

Group theory, including the Jordan-Holder theorem and the Sylow theorems. Basic theory of rings and their ideals. Unique factorization domains and principal ideal domains. Modules. Chain conditions. Fields, including fundamental theorem of Galois theory, theory of finite fields, and transcendence degree.

Groups, Rings, and Fields: Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** 114 or consent of instructor

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Graduate

**Grading:** Letter grade.

Groups, Rings, and Fields: Read Less [\[-\]](#)

## MATH 250B Commutative Algebra 4 Units

Terms offered: Spring 2021, Spring 2020, Spring 2019

Development of the main tools of commutative and homological algebra applicable to algebraic geometry, number theory and combinatorics.

Commutative Algebra: Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** 250A

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Graduate

**Grading:** Letter grade.

Commutative Algebra: Read Less [\[-\]](#)

## MATH 251 Ring Theory 4 Units

Terms offered: Fall 2021, Fall 2016, Spring 2013

Topics such as: Noetherian rings, rings with descending chain condition, theory of the radical, homological methods.

Ring Theory: Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** 250A

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Graduate

**Grading:** Letter grade.

Ring Theory: Read Less [\[-\]](#)

## MATH 252 Representation Theory 4 Units

Terms offered: Fall 2021, Fall 2020, Fall 2015

Structure of finite dimensional algebras, applications to representations of finite groups, the classical linear groups.

Representation Theory: Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** 250A

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Graduate

**Grading:** Letter grade.

Representation Theory: Read Less [\[-\]](#)

## MATH 253 Homological Algebra 4 Units

Terms offered: Fall 2016, Fall 2014, Summer 2014 10 Week Session

Modules over a ring, homomorphisms and tensor products of modules, functors and derived functors, homological dimension of rings and modules.

Homological Algebra: Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** 250A

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Graduate

**Grading:** Letter grade.

Homological Algebra: Read Less [\[-\]](#)

## MATH 254A Number Theory 4 Units

Terms offered: Fall 2021, Fall 2020, Fall 2019

Valuations, units, and ideals in number fields, ramification theory, quadratic and cyclotomic fields, topics from class field theory, zeta-functions and L-series, distribution of primes, modular forms, quadratic forms, diophantine equations, P-adic analysis, and transcendental numbers. Sequence begins fall.

Number Theory: Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** 250A for 254A; 254A for 254B

**Repeat rules:** Course may be repeated for credit with instructor consent.

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Graduate

**Grading:** Letter grade.

**Instructor:** 250A.

Number Theory: Read Less [\[-\]](#)

## MATH 254B Number Theory 4 Units

Terms offered: Spring 2021, Spring 2020, Spring 2019

Valuations, units, and ideals in number fields, ramification theory, quadratic and cyclotomic fields, topics from class field theory, zeta-functions and L-series, distribution of primes, modular forms, quadratic forms, diophantine equations, P-adic analysis, and transcendental numbers. Sequence begins fall.

Number Theory: Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** 254A

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Graduate

**Grading:** Letter grade.

**Instructor:** 250A.

Number Theory: Read Less [\[-\]](#)



## MATH 255 Algebraic Curves 4 Units

Terms offered: Spring 2019, Fall 2014, Fall 2011

Elliptic curves. Algebraic curves, Riemann surfaces, and function fields. Singularities. Riemann-Roch theorem, Hurwitz's theorem, projective embeddings and the canonical curve. Zeta functions of curves over finite fields. Additional topics such as Jacobians or the Riemann hypothesis.

Algebraic Curves: Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** 250A-250B or consent of instructor

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Graduate

**Grading:** Letter grade.

Algebraic Curves: Read Less [\[-\]](#)

## MATH 256A Algebraic Geometry 4 Units

Terms offered: Fall 2021, Fall 2020, Fall 2019

Affine and projective algebraic varieties. Theory of schemes and morphisms of schemes. Smoothness and differentials in algebraic geometry. Coherent sheaves and their cohomology. Riemann-Roch theorem and selected applications. Sequence begins fall.

Algebraic Geometry: Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** 250A-250B for 256A; 256A for 256B

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Graduate

**Grading:** Letter grade.

**Instructor:** 250A.

Algebraic Geometry: Read Less [\[-\]](#)

## MATH 256B Algebraic Geometry 4 Units

Terms offered: Spring 2021, Spring 2020, Spring 2019

Affine and projective algebraic varieties. Theory of schemes and morphisms of schemes. Smoothness and differentials in algebraic geometry. Coherent sheaves and their cohomology. Riemann-Roch theorem and selected applications. Sequence begins fall.

Algebraic Geometry: Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** 256A

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Graduate

**Grading:** Letter grade.

**Instructor:** 250A.

Algebraic Geometry: Read Less [\[-\]](#)

## MATH 257 Group Theory 4 Units

Terms offered: Spring 2021, Spring 2018, Spring 2014

Topics such as: generators and relations, infinite discrete groups, groups of Lie type, permutation groups, character theory, solvable groups, simple groups, transfer and cohomological methods.

Group Theory: Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** 250A

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Graduate

**Grading:** Letter grade.

Group Theory: Read Less [\[-\]](#)

## MATH 258 Harmonic Analysis 4 Units

Terms offered: Fall 2021, Fall 2020, Fall 2018

Basic properties of Fourier series, convergence and summability, conjugate functions, Hardy spaces, boundary behavior of analytic and harmonic functions. Additional topics at the discretion of the instructor.

Harmonic Analysis: Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** 206 or a basic knowledge of real, complex, and linear analysis

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Graduate

**Grading:** Letter grade.

Harmonic Analysis: Read Less [\[-\]](#)

## MATH 261A Lie Groups 4 Units

Terms offered: Fall 2021, Spring 2021, Spring 2020

Lie groups and Lie algebras, fundamental theorems of Lie, general structure theory; compact, nilpotent, solvable, semi-simple Lie groups; classification theory and representation theory of semi-simple Lie algebras and Lie groups, further topics such as symmetric spaces, Lie transformation groups, etc., if time permits. In view of its simplicity and its wide range of applications, it is preferable to cover compact Lie groups and their representations in 261A. Sequence begins Fall.

Lie Groups: Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** 214

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Graduate

**Grading:** Letter grade.

**Instructor:** 214.

Lie Groups: Read Less [\[-\]](#)

## MATH 261B Lie Groups 4 Units

Terms offered: Fall 2020, Fall 2017, Spring 2016

Lie groups and Lie algebras, fundamental theorems of Lie, general structure theory; compact, nilpotent, solvable, semi-simple Lie groups; classification theory and representation theory of semi-simple Lie algebras and Lie groups, further topics such as symmetric spaces, Lie transformation groups, etc., if time permits. In view of its simplicity and its wide range of applications, it is preferable to cover compact Lie groups and their representations in 261A. Sequence begins Fall.

Lie Groups: Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** 214

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Graduate

**Grading:** Letter grade.

**Instructor:** 214.

Lie Groups: Read Less [\[-\]](#)

## MATH 270 Hot Topics Course in Mathematics 2 Units

Terms offered: Spring 2019, Spring 2018, Fall 2017

This course will give introductions to current research developments. Every semester we will pick a different topic and go through the relevant literature. Each student will be expected to give one presentation. Hot Topics Course in Mathematics: Read More [\[+\]](#)

### Rules & Requirements

**Repeat rules:** Course may be repeated for credit when topic changes.

### Hours & Format

**Fall and/or spring:** 15 weeks - 1.5 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Graduate

**Grading:** Offered for satisfactory/unsatisfactory grade only.

Hot Topics Course in Mathematics: Read Less [\[-\]](#)

## MATH 272 Interdisciplinary Topics in Mathematics 1 - 4 Units

Terms offered: Spring 2019

Advanced topics chosen by the instructor. The content of this course changes, as in the case of seminars.

Interdisciplinary Topics in Mathematics: [Read More](#) [+]

### Rules & Requirements

**Prerequisites:** Consent of instructor

**Repeat rules:** Course may be repeated for credit without restriction.

### Hours & Format

**Fall and/or spring:** 15 weeks - 3-3 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Graduate

**Grading:** Letter grade.

Interdisciplinary Topics in Mathematics: [Read Less](#) [-]

## MATH 273 Topics in Numerical Analysis 4 Units

Terms offered: Spring 2016, Spring 2014

Advanced topics chosen by the instructor. The content of this course changes, as in the case of seminars.

Topics in Numerical Analysis: [Read More](#) [+]

### Rules & Requirements

**Prerequisites:** Consent of instructor

**Repeat rules:** Course may be repeated for credit without restriction.

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Graduate

**Grading:** Letter grade.

Topics in Numerical Analysis: [Read Less](#) [-]

## MATH 274 Topics in Algebra 4 Units

Terms offered: Spring 2021, Spring 2020, Spring 2018

Advanced topics chosen by the instructor. The content of this course changes, as in the case of seminars.

Topics in Algebra: [Read More](#) [+]

### Rules & Requirements

**Prerequisites:** Consent of instructor

**Repeat rules:** Course may be repeated for credit without restriction.

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Graduate

**Grading:** Letter grade.

Topics in Algebra: [Read Less](#) [-]

## MATH 275 Topics in Applied Mathematics 4 Units

Terms offered: Fall 2021, Fall 2018, Spring 2017

Advanced topics chosen by the instructor. The content of this course changes, as in the case of seminars.

Topics in Applied Mathematics: [Read More](#) [+]

### Rules & Requirements

**Prerequisites:** Consent of instructor

**Repeat rules:** Course may be repeated for credit without restriction.

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Graduate

**Grading:** Letter grade.

Topics in Applied Mathematics: [Read Less](#) [-]

## MATH 276 Topics in Topology 4 Units

Terms offered: Spring 2021, Fall 2017, Spring 2016

Advanced topics chosen by the instructor. The content of this course changes, as in the case of seminars.

Topics in Topology: [Read More](#) [+]

### Rules & Requirements

**Prerequisites:** Consent of instructor

**Repeat rules:** Course may be repeated for credit without restriction.

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Graduate

**Grading:** Letter grade.

Topics in Topology: [Read Less](#) [-]

## MATH 277 Topics in Differential Geometry 4 Units

Terms offered: Fall 2021, Fall 2020, Spring 2020

Advanced topics chosen by the instructor. The content of this course changes, as in the case of seminars.

Topics in Differential Geometry: [Read More](#) [+]

### Rules & Requirements

**Prerequisites:** Consent of instructor

**Repeat rules:** Course may be repeated for credit without restriction.

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Graduate

**Grading:** Letter grade.

Topics in Differential Geometry: [Read Less](#) [-]

## MATH 278 Topics in Analysis 4 Units

Terms offered: Fall 2021, Spring 2021, Spring 2020

Advanced topics chosen by the instructor. The content of this course changes, as in the case of seminars.

Topics in Analysis: [Read More](#) [+]

### Rules & Requirements

**Prerequisites:** Consent of instructor

**Repeat rules:** Course may be repeated for credit without restriction.

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Graduate

**Grading:** Letter grade.

Topics in Analysis: [Read Less](#) [-]

## MATH 279 Topics in Partial Differential Equations 4 Units

Terms offered: Fall 2021, Spring 2021, Fall 2020

Advanced topics chosen by the instructor. The content of this course changes, as in the case of seminars.

Topics in Partial Differential Equations: [Read More](#) [+]

### Rules & Requirements

**Prerequisites:** Consent of instructor

**Repeat rules:** Course may be repeated for credit without restriction.

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Graduate

**Grading:** Letter grade.

Topics in Partial Differential Equations: [Read Less](#) [-]

## MATH 290 Seminars 1 - 6 Units

Terms offered: Spring 2017, Spring 2015, Fall 2014

Topics in foundations of mathematics, theory of numbers, numerical calculations, analysis, geometry, topology, algebra, and their applications, by means of lectures and informal conferences; work based largely on original memoirs.

Seminars: Read More [\[+\]](#)

### Rules & Requirements

**Repeat rules:** Course may be repeated for credit without restriction.

### Hours & Format

**Fall and/or spring:** 15 weeks - 0 hours of seminar per week

### Additional Details

**Subject/Course Level:** Mathematics/Graduate

**Grading:** Letter grade.

Seminars: Read Less [\[-\]](#)

## MATH 295 Individual Research 1 - 12 Units

Terms offered: Summer 2016 10 Week Session, Spring 2016, Fall 2015

Intended for candidates for the Ph.D. degree.

Individual Research: Read More [\[+\]](#)

### Rules & Requirements

**Repeat rules:** Course may be repeated for credit without restriction.

### Hours & Format

**Fall and/or spring:** 15 weeks - 1-12 hours of independent study per week

### Summer:

3 weeks - 5 hours of independent study per week

6 weeks - 2.5-30 hours of independent study per week

8 weeks - 1.5-60 hours of independent study per week

### Additional Details

**Subject/Course Level:** Mathematics/Graduate

**Grading:** The grading option will be decided by the instructor when the class is offered.

Individual Research: Read Less [\[-\]](#)

## MATH N295 Individual Research 0.5 - 5 Units

Terms offered: Summer 2021 8 Week Session, Summer 2006 10 Week Session, Summer 2002 10 Week Session

Intended for candidates for the Ph.D. degree.

Individual Research: Read More [\[+\]](#)

### Rules & Requirements

**Repeat rules:** Course may be repeated for credit without restriction.

### Hours & Format

**Summer:** 8 weeks - 1-5 hours of independent study per week

### Additional Details

**Subject/Course Level:** Mathematics/Graduate

**Grading:** The grading option will be decided by the instructor when the class is offered.

Individual Research: Read Less [\[-\]](#)

## MATH N297 General Academic Internship 0.5 Units

Terms offered: Prior to 2007

This is an independent study course designed to provide structure for graduate students engaging in summer internship opportunities. Requires a paper exploring how the theoretical constructs learned in academic courses were applied during the internship.

General Academic Internship: Read More [\[+\]](#)

### Rules & Requirements

**Repeat rules:** Course may be repeated for credit without restriction.

### Hours & Format

**Summer:** 8 weeks - 2.5 hours of independent study per week

### Additional Details

**Subject/Course Level:** Mathematics/Graduate

**Grading:** Offered for satisfactory/unsatisfactory grade only.

General Academic Internship: Read Less [\[-\]](#)

## MATH 299 Reading Course for Graduate Students 1 - 6 Units

Terms offered: Fall 2018, Fall 2017, Fall 2016

Investigation of special problems under the direction of members of the department.

Reading Course for Graduate Students: Read More [+]

### Rules & Requirements

**Repeat rules:** Course may be repeated for credit without restriction.

### Hours & Format

**Fall and/or spring:** 15 weeks - 0 hours of independent study per week

### Summer:

6 weeks - 1-5 hours of independent study per week

8 weeks - 1-4 hours of independent study per week

### Additional Details

**Subject/Course Level:** Mathematics/Graduate

**Grading:** The grading option will be decided by the instructor when the class is offered.

Reading Course for Graduate Students: Read Less [-]

## MATH 301 Undergraduate Mathematics Instruction 1 - 2 Units

Terms offered: Fall 2018, Spring 2018, Fall 2017

May be taken for one unit by special permission of instructor. Tutoring at the Student Learning Center or for the Professional Development Program.

Undergraduate Mathematics Instruction: Read More [+]

### Rules & Requirements

**Prerequisites:** Permission of SLC instructor, as well as sophomore standing and at least a B average in two semesters of calculus. Apply at Student Learning Center

**Repeat rules:** Course may be repeated for credit up to a total of 4 units.

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 hours of seminar and 4 hours of tutorial per week

### Additional Details

**Subject/Course Level:** Mathematics/Professional course for teachers or prospective teachers

**Grading:** Offered for pass/not pass grade only.

Undergraduate Mathematics Instruction: Read Less [-]

## MATH 302 Teaching Workshop 1 Unit

Terms offered: Summer 2002 10 Week Session, Summer 2001 10 Week Session

Mandatory for all graduate student instructors teaching summer course for the first time in the Department. The course consists of practice teaching, alternatives to standard classroom methods, guided group and self-analysis, classroom visitations by senior faculty member.

Teaching Workshop: Read More [+]

### Hours & Format

**Summer:** 8 weeks - 1 hour of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Professional course for teachers or prospective teachers

**Grading:** Offered for satisfactory/unsatisfactory grade only.

Teaching Workshop: Read Less [-]

## MATH 303 Professional Preparation: Supervised Teaching of Mathematics 2 - 4 Units

Terms offered: Spring 2017, Spring 2016, Fall 2015

Meeting with supervising faculty and with discussion sections. Experience in teaching under the supervision of Mathematics faculty.

Professional Preparation: Supervised Teaching of Mathematics: Read More [+]

### Rules & Requirements

**Prerequisites:** 300, graduate standing and appointment as a Graduate Student Instructor

**Repeat rules:** Course may be repeated for credit without restriction.

### Hours & Format

**Fall and/or spring:** 15 weeks - 2-4 hours of independent study per week

### Additional Details

**Subject/Course Level:** Mathematics/Professional course for teachers or prospective teachers

**Grading:** Offered for satisfactory/unsatisfactory grade only.

Professional Preparation: Supervised Teaching of Mathematics: Read Less [-]

## MATH 375 Teaching Workshop 4 Units

Terms offered: Fall 2021, Spring 2021, Fall 2020

Mandatory for all graduate student instructors teaching for the first time in the Mathematics Department. The course consists of practice teaching, alternatives to standard classroom methods, guided group and self-analysis of videotapes, reciprocal classroom visitations, and an individual project.

Teaching Workshop: Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** 300, graduate standing and appointment as a Graduate Student Instructor

### Hours & Format

**Fall and/or spring:** 15 weeks - 2 hours of lecture per week

### Additional Details

**Subject/Course Level:** Mathematics/Professional course for teachers or prospective teachers

**Grading:** Offered for satisfactory/unsatisfactory grade only.

**Formerly known as:** Mathematics 300

Teaching Workshop: Read Less [\[-\]](#)

## MATH 600 Individual Study for Master's Students 1 - 6 Units

Terms offered: Summer 2006 10 Week Session, Fall 2005, Spring 2005

Individual study for the comprehensive or language requirements in consultation with the field adviser.

Individual Study for Master's Students: Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** For candidates for master's degree

**Credit Restrictions:** Course does not satisfy unit or residence requirements for master's degree.

**Repeat rules:** Course may be repeated for credit without restriction.

### Hours & Format

**Fall and/or spring:** 15 weeks - 1-6 hours of independent study per week

**Summer:** 8 weeks - 1.5-10 hours of independent study per week

### Additional Details

**Subject/Course Level:** Mathematics/Graduate examination preparation

**Grading:** Offered for satisfactory/unsatisfactory grade only.

Individual Study for Master's Students: Read Less [\[-\]](#)

## MATH 602 Individual Study for Doctoral Students 1 - 8 Units

Terms offered: Fall 2019, Fall 2018, Fall 2016

Individual study in consultation with the major field adviser intended to provide an opportunity for qualified students to prepare themselves for the various examinations required for candidates for the Ph.D. Course does not satisfy unit or residence requirements for doctoral degree.

Individual Study for Doctoral Students: Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** For qualified graduate students

**Repeat rules:** Course may be repeated for credit without restriction.

### Hours & Format

**Fall and/or spring:** 15 weeks - 1-8 hours of independent study per week

### Additional Details

**Subject/Course Level:** Mathematics/Graduate examination preparation

**Grading:** Offered for satisfactory/unsatisfactory grade only.

Individual Study for Doctoral Students: Read Less [\[-\]](#)