School of Physical Sciences

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James S. Bullock, Dean
134 Rowland Hall
Undergraduate Counseling: http://ps.uci.edu/undergraduates (https://ps.uci.edu/undergraduates/)

The School of Physical Sciences offers both professional training and general education in the Departments of Chemistry (https://catalogue.uci.edu/schoolofphysicalsciences/departmentofchemistry/), Earth System Science (https://catalogue.uci.edu/schoolofphysicalsciences/departmentofearthsystemscience/), Mathematics (https://catalogue.uci.edu/schoolofphysicalsciences/departmentofmathematics/) and Physics and Astronomy (https://catalogue.uci.edu/schoolofphysicalsciences/departmentofphysicsandastronomy/). The faculty, active in research and graduate education, are at the same time vitally concerned with undergraduate teaching. We meet the needs of a wide variety of students ranging from those with little technical background who seek insight into the activities and accomplishments of physical scientists to those seeking a comprehensive understanding that will prepare them for creative research in a variety of physical science fields.

Physics, chemistry, mathematics, and earth science have evolved into interdependent but separate intellectual disciplines. This development is reflected in the departmental structure of the School of Physical Sciences, particularly in the Department of Earth System Science, which performs research with the understanding that the planet functions as a system comprised of interdependent parts. Mathematics, physics, and chemistry, while providing the foundation of the technology that dominates contemporary civilization, underlie to an ever-increasing extent the new developments in the biological and social sciences. Earth system science is grounded in the traditional physical sciences while breaking new paths in the quantitative study of changes in the global environment.

Honors

Criteria used by the School of Physical Sciences in selecting candidates for Latin honors at graduation are as follows: Approximately 2 percent will be awarded *summa cum laude,* 4 percent *magna cum laude,* and 10 percent *cum laude.* Latin Honors is based on final-quarter cumulative GPA. Other honors and awards are given on the basis of a student's performance in research, cumulative grade point average, and performance in upper-division courses in the major. Students considered for honors at graduation must have completed 72 units in residence at the University of California. The student's cumulative record at the end of the final quarter is the basis for all decisions regarding honors at graduation. Other important factors are considered visit at **Honors Recognition**. The School of Physical Sciences also grants special honors to students who have distinguished themselves by their work in their major subject.

- Department of Chemistry
- Department of Earth System Science
- Department of Mathematics
- Department of Physics and Astronomy

- Applied and Computational Mathematics, B.S.
- Applied Physics, B.S.
- Chemistry, B.S.
- Chemistry, Ph.D.
- Earth and Atmospheric Sciences, Minor
- Earth System Science, B.S.
- Earth System Science, Ph.D.
- Mathematics for Biology, Minor
- Mathematics, B.S.
- Mathematics, M.S.
- Mathematics, Minor
- Mathematics, Ph.D.
- Physics, B.S.
- Physics, Ph.D.

Each department offers courses that are of value to nonmajors and majors in the sciences. The programs for majors are designed to meet the needs of students planning careers in business, education, or industry; of students planning advanced professional study; and of students planning graduate work that continues their major interest. Students who wish to complete a coordinated set of courses beyond the introductory level in Mathematics and in Earth and Atmospheric Sciences may pursue minors in these areas. Students interested in mathematical and computational biology may complete the Mathematics for Biology minor which prepares them for interdisciplinary graduate studies in this area. Introductory courses in chemistry, mathematics, and physics meet the needs of students majoring in the sciences, mathematics, and engineering and are also appropriate for students in other disciplines who seek a rigorous introduction to the physical sciences. In addition, a number of courses within the School have few or no prerequisites and are directed particularly toward students majoring in areas remote from the sciences.

Planning a Program of Study

Students who choose a major in the School of Physical Sciences have a variety of academic advising and counseling resources available to them. In addition to faculty advisors, there is a Chief Academic Advisor in each department who is responsible for interpreting degree requirements, reviewing student petitions, and assisting with special advising problems. An academic advising and counseling staff, employed in the Associate Dean's Office, is available to serve a broad range of student advising needs. In consultation with their faculty advisor or an academic counselor, students should plan a course of study leading to a major in one of the departments of the School. In carrying out this major, students may often concentrate very heavily in a second department within the School or in some other school. Occasionally students choose to pursue a double major. Permission to do so may be sought by an online application submitted to the Office of the Associate Dean of Physical Sciences.

All initial courses of study for majors includes mathematics through calculus, and calculus is a prerequisite for much of the upper-division work in each major. A student interested in any of the physical sciences should continue mathematical training beyond these prerequisite courses. Furthermore, students interested in either physics or chemistry usually will include work in both of these subjects in their undergraduate careers.

Students in the physical sciences are urged to acquire a working knowledge of computer programming at an early stage of their University studies. This can be accomplished by taking one of the following:

CHEM 5	Scientific Mathematical and Computing Skills
EECS 10	Computational Methods in Electrical and Computer Engineering
EECS 12	Introduction to Programming
ENGRMAE 10	Introduction to Engineering Computations
I&C SCI 31	Introduction to Programming
MATH 9	Introduction to Programming for Numerical Analysis
PHYSICS 53	Introduction to Programming and Numerical Analysis

Career Opportunities

Many of the School of Physical Sciences graduates continue their education beyond the Bachelor's degree level. Some pursue advanced academic degrees in preparation for careers in scientific or medical research, engineering, or postsecondary education. Other students will complete a secondary education credential in order to prepare for careers teaching high school mathematics and science. Some students enter professional school in areas such as medicine, dentistry, law, or business administration. Students who choose not to continue their studies beyond the baccalaureate level most frequently find employment in private business or industry. In addition to technical areas directly related to their major fields of study, students often enter careers in less obviously related fields such as computing, systems analysis, engineering, journalism, marketing, or sales.

The UCI Division of Career Pathways provides services to students and alumni including career counseling, information about job opportunities, a career library, and workshops on resume preparation, job search, and interview techniques. Visit the Division of Career Pathways website (http://career.uci.edu/) for additional information.

Preparation for Teaching Science and Mathematics

Option 1: Earn a Bachelor's Degree, Education Concentration, and Teaching Credential

Physical Sciences students who are interested in pursuing a teaching career should consider the UCI Cal Teach Science and Mathematics Program. This program offers Chemistry, Earth System Science, Mathematics, and Physics majors an option to earn their bachelor's degree concurrently with a California Preliminary Single Subject Teaching Credential. Individuals who hold this credential are authorized to teach science (chemistry, geosciences, or physics) or math in a middle school or high school.

Students complete the degree requirements for their selected major, the requirements for an optional education concentration offered by the same department, and any additional teacher credentialing course requirements that are not included in the major or the concentration. The following courses are required for the Preliminary Single Subject Teaching Credential:

EDUC 55	Knowing and Learning in Mathematics and Science
EDUC 109	Reading and Writing in Mathematics and Science
EDUC 143AW	Classroom Interactions I
EDUC 143BW	Classroom Interactions II

EDUC 148	Complex Pedagogical Design
EDUC 158	Student Teaching Mathematics and Science in Middle/High School (two quarters)
LPS 60	The Making of Modern Science (for chemistry, geosciences, and physics credential candidates only)
MATH 8	Explorations in Functions and Modeling (for mathematics credential candidates only)
PHY SCI 5	California Teach 1: Introduction to Science and Mathematics Teaching
PHY SCI 105	California Teach 2: Middle School Science and Mathematics Teaching
PHYSICS 193	Research Methods
or CHEM 193	Research Methods

Beyond course work, some additional requirements for teacher certification are described below.

With careful, early planning, it is possible for students to complete their bachelor's degree and teacher certification in four years. This is a more time-efficient and cost-effective route than the traditional five-year teacher preparation model, which usually involves a full academic year of teacher education courses and clinical teaching experience after completion of a bachelor's degree.

After the School of Physical Sciences verifies the completion of all requirements for the bachelor's degree and education concentration, students are awarded their degree from UC Irvine. The Preliminary Single Subject Teaching Credential is awarded by the California Commission on Teacher Credentialing (CTC) upon completion of a bachelor's degree and the state-approved UCI teacher education program, which combines course work, student teaching, and a teaching performance assessment. The UCI School of Education must verify completion of all requirements for the teaching credential and then recommend that the credential be awarded to a candidate by the CTC.

Additional Requirements for Teacher Certification. In addition to the required course work for a California Preliminary Single Subject Teaching Credential, the following additional requirements must be satisfied:

a. The School of Physical Sciences requires a *cumulative* GPA of 2.0 (C) to graduate with the bachelor's degree. However, students must earn a grade of C or better in each of the following courses in order to be recommended for the Preliminary Single Subject Credential: PHY SCI 105, EDUC 55, EDUC 143AW, EDUC 143BW, EDUC 148, and EDUC 158.
b. The following must be completed and verified prior to the start of student teaching in EDUC 158:
    i. Pass the California Basic Education Skills Test (CBEST), a basic mathematics and literacy skills test. For more information, visit the CBEST exam website (http://www.ctcexams.nesinc.com/).
    ii. Pass the California Subject Exam for Teachers (CSET) in the discipline in which a candidate plans to earn a Preliminary Single Subject Credential (chemistry, geosciences, mathematics, or physics). Although secondary teachers are only required to pass the CSET exam in one discipline, those who pass the CSET exam in more than one disciplinary field (e.g., physics and mathematics) can be authorized to teach classes in each of those disciplines. For more information visit the CSET exam website (http://www.ctcexams.nesinc.com/). Mathematics majors have an option to waive the CSET exam by completing prescribed course work, referred to as a subject-matter preparation program (SMPP). More information is available at the School of Education's Mathematics SMPP website (https://calteach.uci.edu/).
    iii. Secondary school science teachers in California are expected to have a broad range of general science knowledge in additional to their discipline of specialization, because their Single Subject Teaching Credential in one of the sciences also authorizes them to teach classes in general or integrated science. The general science subtests of the CSET exam cover foundational topics in astronomy, geodynamics, Earth resources, ecology, genetics and evolution, molecular biology and biochemistry, cell and organismal biology, waves, forces and motion, electricity and magnetism, heat transfer and thermodynamics, and structure and properties of matter. Although students can prepare for the CSET exam's general science subtests through independent study, Physical Sciences students can also prepare themselves by taking lower-division courses that cover this content. Some suggested courses include BIO SCI 93 and BIO SCI 94; CHEM 1A-CHEM 1B-CHEM 1C; EARTHSS 1 and EARTHSS 7 and PHYSICS 20A.
    iv. Obtain a Certificate of Clearance from the State of California.
    v. Obtain a TB test with negative results.
c. The following must be completed and verified before the School of Education is able to recommend an individual for the Preliminary Single Subject Credential:
    i. Complete a college-level course or pass an examination on the U.S. Constitution. POL SCI 21A satisfies this requirement. Contact the UCI School of Education Student Affairs Office for information about the exam.
    ii. Obtain a CPR certificate in adult, child, or infant training.

Declaring Intention to Complete the Concentration and Teacher Certification. Prospective teachers who want to complete their degree and a teaching credential in four years are encouraged to start planning early by reviewing the sample programs for the major and the education concentration that they have selected, and to consult with an academic counselor. Interested students are encouraged to get started on the suggested first- and second-year credentialing course work, including PHY SCI 5 and PHY SCI 105, and can do so without officially declaring their intention to complete the concentration or the credential. However, students must declare their intention to complete the optional education concentration and their intention to earn the Preliminary Single Subject Teaching Credential by the end of their second year at the latest, and prior to enrolling in EDUC 55, which they would typically take in fall of their third year. Forms for declaring a selected education concentration and for declaring an intention to complete the teaching credential are available in the Cal Teach Science and Mathematics Resource and Advising Center (137 Bison Modular).

Option 2: Earn a Bachelor's Degree and Education Concentration or Specialization

A second option for students interested in teaching science and mathematics is to earn a teaching credential in a post-baccalaureate teacher preparation program *after* completing their bachelor's degree. UCI and other universities offer such programs, which typically require one academic year of education course work and clinical teaching experience. The Departments of Chemistry, Mathematics, and Physics and Astronomy offer the concentration in Chemistry Education, the specialization in Mathematics for Education, and the concentration in Physics Education, respectively, which are well suited for undergraduates who plan to pursue a teaching credential after finishing their degree. These programs offer strong grounding in the fundamentals of one discipline, and at the same time, emphasize the breadth in natural sciences needed by secondary science teachers. Each department's curriculum includes introductory courses on effective methods of science and mathematics teaching and provides opportunities for practical fieldwork experiences in a secondary school classroom. Detailed requirements for each program are provided in the departmental sections.

Special Programs

Campuswide Honors Collegium

The Campuswide Honors Collegium is available to selected high-achieving students from all academic majors from their freshman through senior years. For more information contact the Campuswide Honors Collegium, 1200 Student Services II; 949-824-5461; honors@uci.edu; or visit the Campuswide Honors Collegium website (http://honors.uci.edu/).

UC Education Abroad Program

Upper-division students have the opportunity to experience a different culture while making progress toward degree objectives through the University's Education Abroad Program (EAP). UCEAP is an overseas study program which operates in cooperation with host universities and colleges throughout the world. Visit the Study Abroad Center website (http://www.cie.uci.edu/) for additional information.

Minor in Biomedical Engineering

The minor in Biomedical Engineering is an interdisciplinary curriculum that includes courses from the Schools of Engineering, Physical Sciences, and Biological Sciences. The minor is designed to provide a student in the physical sciences with the introductory skills needed in the quantitative biomedical arena. See The Henry Samueli School of Engineering section (http://catalogue.uci.edu/thehenrysamuelischoolofengineering/departmentofbiomedicalengineering/biomedicalengineering_minor/) of the *Catalogue* for more information.

Minor in Global Sustainability

The interdisciplinary minor in Global Sustainability trains students to understand the changes that need to be made in order for the human population to live in a sustainable relationship with the resources available on this planet. See Interdisciplinary Studies section (http://catalogue.uci.edu/interdisciplinarystudies/globalsustainability_minor/) of the *Catalogue* for more information.

Physical Sciences Undergraduate Mentoring (PSUM) Program

The Physical Sciences Undergraduate Mentoring Program pairs juniors and seniors in the School of Physical Sciences with business and science professionals in a variety of areas, careers, and industries. Interested students should contact the Student Affairs office, the summer prior to their junior year. See the PSUM website (https://ps.uci.edu/mentors/home/) for more information.

Faculty

Kevork N. Abazajian, Ph.D. University of California, San Diego, *Professor of Physics and Astronomy*

Amir Aghakouchak, Ph.D. University of Stuttgart, *Professor of Civil and Environmental Engineering; Earth System Science* (hydrology, climatology, remote sensing of environment, climate extremes, water-energy nexus, climate change, stochastic modeling, water resources management)

Takeo Akasaki, Ph.D. University of California, Los Angeles, *Professor Emeritus of Mathematics* (ring theory)

Jun F. Allard, Ph.D. University of British Columbia, *Associate Professor of Mathematics; Physics and Astronomy* (mathematical and computational biology)

Steven D. Allison, Ph.D. Stanford University, *Professor of Ecology and Evolutionary Biology; Earth System Science*

Ioan Andricioaei, Ph.D. Boston University, *Professor of Chemistry; Physics and Astronomy* (chemical biology, physical chemistry and chemical physics, theoretical and computational)

Ara Apkarian, Ph.D. Northwestern University, *UCI Distinguished Professor Emeritus of Chemistry* (physical chemistry and chemical physics)

Ramesh D. Arasasingham, Ph.D. University of California, Davis, *Professor of Teaching of Chemistry* (chemical education and inorganic chemistry)

Shane Ardo, Ph.D. Johns Hopkins University, *Professor of Chemistry; Chemical and Biomolecular Engineering; Materials Science and Engineering* (inorganic and organometallic, physical chemistry and chemical physics, polymer, materials, nanoscience)

Herdeline Ann Ardoña, Ph.D. John Hopkins University, *Assistant Professor of Chemical and Biomolecular Engineering; Biomedical Engineering; Chemistry* (biomaterials, self-assembly, optoelectronics, stimuli-responsive materials, in vitro tissue models, biosensors)

Maxx Arguilla, Ph.D. The Ohio State University, *Assistant Professor of Chemistry* (inorganic and organometallic, physical chemistry and chemical physics, polymer, materials, nanoscience)

Kenneth Ascher, Ph.D. Brown University, *Assistant Professor of Mathematics* (algebraic and arithmetic geometry)

Amirfarshad Bahrehbakhsh, Ph.D. Shahid Beheshti University, *Lecturer of Physics and Astronomy*

Pierre F. Baldi, Ph.D. California Institute of Technology, *Director of the Institute for Genomics and Bioinformatics and Distinguished Professor of Computer Science; Biological Chemistry; Biomedical Engineering; Mathematics* (artificial intelligence and machine learning, biomedical informatics, databases and data mining, environmental informatics, statistics and statistical theory)

Jane Baldwin, Ph.D. Princeton University, *Assistant Professor of Earth System Science*

Vladimir Baranovsky, Ph.D. University of Chicago, *Professor of Mathematics* (algebra and number theory)

Laszlo Bardoczi, Ph.D. University of California, Los Angeles, *Assistant Professor of Physics and Astronomy*

Aaron J. Barth, Ph.D. University of California, Berkeley, *Professor of Physics and Astronomy*

Christopher P.J. Barty, Ph.D. Stanford University, *Distinguished Professor of Physics and Astronomy*

Steven W. Barwick, Ph.D. University of California, Berkeley, *Professor of Physics and Astronomy*

Gregory A. Benford, Ph.D. University of California, San Diego, *Professor Emeritus of Physics and Astronomy*

Elizabeth Bess, Ph.D. University of Utah, *Assistant Professor of Chemistry; Molecular Biology and Biochemistry* (chemical biology)

Jianming Bian, Ph.D. Chinese Academy of Sciences, *Associate Professor of Physics and Astronomy*

Donald R. Blake, Ph.D. University of California, Irvine, *UCI Distinguished Professor of Chemistry* (analytical, atmospheric, environmental)

Suzanne A. Blum, Ph.D. University of California, Berkeley, *Professor of Chemistry* (inorganic and organometallic, organic and synthetic, physical chemistry and chemical physics, polymer, materials, nanoscience)

Andrew Borovik, Ph.D. University of North Carolina at Chapel Hill, *UCI Distinguished Professor of Chemistry* (chemical biology, inorganic and organometallic, organic and synthetic)

David A. Brant, Ph.D. University of Wisconsin-Madison, *Professor Emeritus of Chemistry* (biophysical)

James S. Bullock, Ph.D. University of California, Santa Cruz, *Dean of the School of Physical Sciences and Professor of Physics and Astronomy*

David A. Buote, Ph.D. Massachusetts Institute of Technology, *Professor of Physics and Astronomy*

Kieron Burke, Ph.D. University of California, Santa Barbara, *School of Physical Sciences Associate Dean and Distinguished Professor of Chemistry; Physics and Astronomy* (physical chemistry and chemical physics, theoretical and computational)

Ann Marie Carlton, Ph.D. Rutgers University, *Department Vice Chair and Professor of Chemistry* (atmospheric and environmental, physical chemistry and chemical physics, theoretical and computational)

Paul Carter, Ph.D. Brown University, *Assistant Professor of Mathematics* (analysis and partial differential equations, applied and computational mathematics)

David W. Casper, Ph.D. University of Michigan, *Associate Professor of Physics and Astronomy*

Gary A. Chanan, Ph.D. University of California, Berkeley, *Professor Emeritus of Physics and Astronomy*

John Charles Chaput, Ph.D. University of California, Riverside, *Professor of Pharmaceutical Sciences; Chemical and Biomolecular Engineering; Chemistry; Molecular Biology and Biochemistry* (chemical and synthetic biology)

Liu Chen, Ph.D. University of California, Berkeley, *Research Professor and Professor Emeritus of Physics and Astronomy*

Long Chen, Ph.D. Pennsylvania State University, *Professor of Mathematics* (applied and computational mathematics)

Mu-Chun Chen, Ph.D. University of Colorado Boulder, *Professor of Physics and Astronomy*

Alexander L. Chernyshev, Ph.D. Russian Academy of Sciences, *Professor of Physics and Astronomy*

Philip Collins, Ph.D. University of California, Berkeley, *Professor of Physics and Astronomy*

Michael Cooper, Ph.D. University of California, Berkeley, *Professor of Physics and Astronomy*

Asantha R. Cooray, Ph.D. University of Chicago, *Professor of Physics and Astronomy*

Stacy Copp, Ph.D. University of California, Santa Barbara, *Samueli Faculty Development Chair and Assistant Professor of Materials Science and Engineering; Chemical and Biomolecular Engineering; Physics and Astronomy* (soft matter-based photonic materials; metal nanoclusters; polymer nanostructures; self-assembly; biomimetics; machine learning for materials discovery)

Robert Corn, Ph.D. University of California, Berkeley, *UCI Distinguished Professor Emeritus of Chemistry* (analytical, chemical biology, physical chemistry and chemical physics, polymer, materials, nanoscience)

Michael C. Cranston, Ph.D. University of Minnesota, *Department Chair and Professor of Mathematics* (probability)

Elizabeth D. Crook, Ph.D. University of California, Santa Cruz, *Associate Professor of Teaching of Earth System Science*

Claudia I. Czimczik, Ph.D. Max Planck Institute, *Professor of Earth System Science*

Anthony V. Daly, M.F.A. University of California, Irvine, *Lecturer of Physical Sciences*

Christopher J. Davis, Ph.D. Massachusetts Institute of Technology, *Professor of Teaching of Mathematics* (algebra and number theory)

Kristen A. Davis, Ph.D. Stanford University, *Associate Professor of Civil and Environmental Engineering; Earth System Science* (coastal oceanography, fluid mechanics, turbulent flows)

Steven J. Davis, Ph.D. Stanford University, *Professor of Earth System Science; Civil and Environmental Engineering*

Michael B. Dennin, Ph.D. University of California, Santa Barbara, *Professor of Physics and Astronomy*

Robert J. Doedens, Ph.D. University of Wisconsin-Madison, *Professor Emeritus of Chemistry* (inorganic and organometallic)

Franklin Dollar, Ph.D. University of Michigan, *Associate Professor of Physics and Astronomy* (applied physics)

Neil Donaldson, Ph.D. University of Bath, *Lecturer of Mathematics* (differential geometry)

Vy M. Dong, Ph.D. California Institute of Technology, *Professor of Chemistry* (organic and synthetic)

Henri F. Drake, Ph.D. Massachusetts Institute of Technology, *Assistant Professor of Earth System Science*

Ellen R. Druffel, Ph.D. University of California, San Diego, *Fred Kavli Chair in Earth System Science and UCI Distinguished Professor of Earth System Science*

Kimberly D. Edwards, Ph.D. University of California, Irvine, *Professor of Teaching of Chemistry* (general chemistry, chemical education)

Benis Egoh, Ph.D. Stellenboch University, *Assistant Professor of Earth System Science*

Paul C. Eklof, Ph.D. Cornell University, *Professor Emeritus of Mathematics* (logic and algebra)

German A. Enciso Ruiz, Ph.D. Rutgers, the State University of New Jersey, *Professor of Mathematics; Developmental and Cell Biology* (applied and computational mathematics, mathematical and computational biology)

William J. Evans, Ph.D. University of California, Los Angeles, *UCI Distinguished Professor Emeritus of Chemistry* (inorganic and organometallic)

Celia Faiola, Ph.D. Washington State University, *Associate Professor of Ecology and Evolutionary Biology; Chemistry*

Jonathan L. Feng, Ph.D. Stanford University, *Distinguished Professor of Physics and Astronomy*

Asaf Ferber, Ph.D. Tel Aviv University, *Associate Professor of Mathematics* (probabilistic combinatorics)

Julie E. Ferguson, Ph.D. Oxford University, *Associate Professor of Teaching of Earth System Science*

Aleksandr Figotin, Ph.D. Tashkent University of Information Technologies, *Professor of Mathematics; Electrical Engineering and Computer Science* (applied and computational mathematics, mathematical physics)

Sarah Finkeldei, Ph.D. RWTH Aachen University, *Assistant Professor of Chemistry; Chemical and Biomolecular Engineering; Materials Science and Engineering* (nuclear chemistry)

Mark Finkelstein, Ph.D. Stanford University, *Professor Emeritus of Mathematics; Center for Educational Partnerships* (analysis)

Barbara J. Finlayson-Pitts, Ph.D. University of California, Riverside, *Director of AirUCI and UCI Distinguished Professor Emeritus of Chemistry* (analytical, atmospheric and environmental, physical chemistry and chemical physics)

Zachary Fisk, Ph.D. University of California, San Diego, *UCI Distinguished Professor Emeritus of Physics and Astronomy*

Alexandra Florea, Ph.D. Stanford University, *Assistant Professor of Mathematics* (number theory)

Matthew Foreman, Ph.D. University of California, Berkeley, *Distinguished Professor of Mathematics; Logic and Philosophy of Science* (ergodic theory and dynamical systems, logic and foundations)

Efi Foufoula-Georgiou, Ph.D. University of Florida, *Associate Dean of Research and Innovation for the Samueli School of Engineering and Distinguished Professor of Civil and Environmental Engineering; Earth System Science* (hydrology and geomorphology with emphasis on modeling the interactions between the atmosphere, land, and the terrestrial environment at plot to large-watershed scale)

Fillmore Freeman, Ph.D. Michigan State University, *Professor Emeritus of Chemistry* (organic and synthetic, theoretical and computational)

Michael D. Fried, Ph.D. University of Michigan, *Professor Emeritus of Mathematics* (arithmetic geometry and complex variables)

Filipp Furche, Ph.D. University of Karlsruhe, *Professor of Chemistry* (physical chemistry and chemical physics, theoretical and computational)

Nien-Hui Ge, Ph.D. University of California, Berkeley, *Professor of Chemistry* (analytical, chemical biology, physical chemistry and chemical physics, polymer, materials, nanoscience)

Robert B. Gerber, Ph.D. Oxford University, *Professor Emeritus of Chemistry* (atmospheric and environmental, physical chemistry and chemical physics, theoretical and computational)

Isaac Goldbring, Ph.D. University of Illinois at Urbana-Champaign, *Professor of Mathematics; Logic and Philosophy of Science* (logic and foundations)

Anton Gorodetski, Ph.D. Moscow State University, *Professor of Mathematics* (ergodic theory and dynamical systems)

Michael L. Goulden, Ph.D. Stanford University, *Professor of Earth System Science; Ecology and Evolutionary Biology*

Enrico Gratton, Ph.D. University of Rome, *Distinguished Professor of Biomedical Engineering; Developmental and Cell Biology; Physics and Astronomy* (design of new fluorescence instruments, protein dynamics, single molecule, fluorescence microscopy, photon migration in tissues)

Michael T. Green, Ph.D. University of Chicago, *Vice Chair and Professor of Molecular Biology and Biochemistry; Chemistry* (chemical, biology, inorganic and organometallic, physical chemistry and chemical physics, theoretical and computational)

Matthew E. Griffin, Ph.D. California Institute of Technology, *Assistant Professor of Chemistry; Pharmaceutical Sciences* (chemical biology)

Steven P. Gross, Ph.D. University of Texas at Austin, *Professor of Developmental and Cell Biology; Physics and Astronomy* (force generation by molecular motors in living cells)

Zhibin Guan, Ph.D. University of North Carolina at Chapel Hill, *Professor of Chemistry; Biomedical Engineering; Chemical and Biomolecular Engineering; Materials Science and Engineering* (chemical biology, organic and synthetic, polymer, materials, nanoscience)

Alex Guenther, Ph.D. Washington State University, *Professor of Earth System Science*

Arnold Guerra, Ph.D. University of California, Irvine, *Lecturer of Physics and Astronomy*

Patrick Q. Guidotti, Ph.D. University of Zurich, *Professor of Mathematics* (analysis and partial differential equations, applied and computational mathematics)

Gultekin Gulsen, Ph.D. Bogazici University, *Associate Professor of Radiological Sciences; Biomedical Engineering; Electrical Engineering and Computer Science; Physics and Astronomy*

Herbert W. Hamber, Ph.D. University of California, Santa Barbara, *Professor Emeritus of Physics and Astronomy*

Stephen Hanessian, Ph.D. Ohio State University, *Distinguished Professor of Pharmaceutical Sciences; Chemistry* (organic chemistry, medicinal chemistry)

William W. Heidbrink, Ph.D. Princeton University, *Distinguished Professor of Physics and Astronomy*

John C. Hemminger, Ph.D. Harvard University, *UCI Distinguished Professor Emeritus of Chemistry* (analytical, atmospheric and environmental, physical chemistry and chemical physics, polymer, materials, nanoscience)

Alan F. Heyduk, Ph.D. Massachusetts Institute of Technology, *Department Chair and Professor of Chemistry* (inorganic and organometallic)

Hamid Hezari, Ph.D. Johns Hopkins University, *Associate Professor of Mathematics* (analysis and partial differential equations)

Wilson Ho, Ph.D. University of Pennsylvania, *Donald Bren Professor and Professor of Physics and Astronomy; Chemistry*

Allon Hochbaum, Ph.D. University of California, Berkeley, *Associate Professor of Materials Science and Engineering; Chemical and Biomolecular Engineering; Chemistry; Molecular Biology and Biochemistry* (biological materials, protein materials, electronic conductivity in proteins, materials and methods to study microbes and microbial communities)

Amanda J. Holton, Ph.D. University of California, Irvine, *Professor of Teaching of Chemistry* (chemistry, chemical education)

Herbert J. Hopster, Ph.D. Aachen University, *Professor Emeritus of Physics and Astronomy*

Kenneth B. Huber, Ph.D. University of California, Irvine, *Lecturer of Mathematics* (probability)

Paata Ivanisvili, Ph.D. Michigan State University, *Associate Professor of Mathematics* (analysis and partial differential equations, probability)

Kenneth C. Janda, Ph.D. Harvard University, *Professor Emeritus of Chemistry* (physical chemistry and chemical physics)

Elizabeth R. Jarvo, Ph.D. Boston College, *Professor of Chemistry* (inorganic and organometallic, organic and synthetic)

Luis A. Jauregui, Ph.D. Purdue University, *Assistant Professor of Physics and Astronomy*

Svetlana Jitomirskaya, Ph.D. Moscow State University, *Distinguished Professor of Mathematics* (mathematical physics)

Kathleen Johnson, Ph.D. University of California, Berkeley, *Associate Professor of Earth System Science*

Nathan Kaplan, Ph.D. Harvard University, *Associate Professor of Mathematics* (algebra and number theory)

Manoj Kaplinghat, Ph.D. Ohio State University, *Professor of Physics and Astronomy*

Saewung Kim, Ph.D. Georgia Institute of Technology, *Associate Professor of Earth System Science*

Susan M. King, Ph.D. Massachusetts Institute of Technology, *Professor of Teaching of Chemistry* (organic chemistry, chemical education)

Anne A. Kirkby, Ph.D. California Institute of Technology, *Lecturer of Physics and Astronomy*

David P. Kirkby, Ph.D. California Institute of Technology, *Professor of Physics and Astronomy*

Abel Klein, Ph.D. Massachusetts Institute of Technology, *Distinguished Professor Emeritus of Mathematics* (mathematical physics)

Natalia Komarova, Ph.D. University of Arizona, *UCI Chancellor's Professor of Mathematics; Ecology and Evolutionary Biology* (applied and computational mathematics, mathematical and computational biology, mathematics of complex social phenomena)

Ilya N. Krivorotov, Ph.D. University of Minnesota, *Professor of Physics and Astronomy*

Katsiaryna Krupchyk, Ph.D. Belarusian State University, *Professor of Mathematics* (analysis and partial differential equations, inverse problems, and imaging)

Andrew J. Lankford, Ph.D. Yale University, *Distinguished Professor of Physics and Astronomy*

Matthew Law, Ph.D. University of California, Berkeley, *Department Vice Chair and Professor of Chemistry; Chemical and Biomolecular Engineering; Materials Science and Engineering* (inorganic and organometallic, physical chemistry and chemical physics, polymer, materials, nanoscience)

Jon M. Lawrence, Ph.D. University of Rochester, *Professor Emeritus of Physics and Astronomy*

Howard Lee, Ph.D. Max Planck Institute for the Science of Light, *Associate Professor of Physics and Astronomy*

Rachel Lehman, Ph.D. University of California, Irvine, *Lecturer of Mathematics* (mathematics education and probability)

Peter Li, Ph.D. University of California, Berkeley, *Chancellor's Professor Emeritus of Mathematics* (geometry and topology)

Shirley Li, Ph.D. Ohio State University, *Assistant Professor of Physics and Astronomy*

Song-Ying Li, Ph.D. University of Pittsburgh, *Professor of Mathematics* (analysis and partial differential equations)

Zhihong Lin, Ph.D. Princeton University, *Professor of Physics and Astronomy*

Renee Link, Ph.D. University of California, Irvine, *Professor of Teaching of Chemistry* (organic chemistry, chemical education)

Chang C. Liu, Ph.D. Scripps Research Institute, *Professor of Biomedical Engineering; Chemistry; Molecular Biology and Biochemistry* (genetic engineering, directed evolution, synthetic biology, chemical biology)

John S. Lowengrub, Ph.D. Courant Institute of Mathematical Sciences, *Chancellor's Professor of Mathematics; Biomedical Engineering* (applied and computational mathematics, mathematical and computational biology)

Zhiqin Lu, Ph.D. Courant Institute of Mathematical Sciences, *Professor of Mathematics* (geometry and topology)

Jeffrey Ludwig, Ph.D. Massachusetts Institute of Technology, *Associate Professor of Teaching of Mathematics* (probability)

Andrej Luptak, Ph.D. Yale University, *Department Chair and Professor of Pharmaceutical Sciences; Chemistry; Molecular Biology and Biochemistry* (chemical biology)

Anna Ma, Ph.D. Claremont Graduate University, *Associate Professor of Mathematics* (mathematical data science, numerical linear algebra)

Katherine Mackey, Ph.D. Stanford University, *Associate Professor of Earth System Science; Ecology and Evolutionary Biology*

Gudrun Magnusdottir, Ph.D. Colorado State University, *Professor of Earth System Science*

Mark A. Mandelkern, Ph.D. University of California, Berkeley, *Research Professor and Professor Emeritus of Physics and Astronomy*

Vladimir A. Mandelshtam, Ph.D. Institute of Spectroscopy, Russian Academy of Sciences, *Professor of Chemistry* (physical chemistry and chemical physics, theoretical and computational)

Stephen Mang, Ph.D. University of California, Irvine, *Department Vice Chair and Associate Professor of Teaching of Chemistry* (chemical education, advanced laboratories)

Alexei A. Maradudin, Ph.D. University of Bristol, *Professor Emeritus of Physics and Astronomy*

Craig C. Martens, Ph.D. Cornell University, *Professor of Chemistry* (physical chemistry and chemical physics, polymer, materials, nanoscience, theoretical and computational)

Rachel Martin, Ph.D. Yale University, *Professor of Chemistry; Molecular Biology and Biochemistry* (analytical, chemical biology, physical chemistry and chemical physics)

Adam Martiny, Ph.D. Technical University of Denmark, *Professor of Earth System Science; Ecology and Evolutionary Biology*

Roger D. McWilliams, Ph.D. Princeton University, *Professor Emeritus of Physics and Astronomy*

Christopher Miles, Ph.D. University of Utah, *Assistant Professor of Mathematics* (applied and computational mathematics, mathematical and computational biology)

George E. Miller, Ph.D. Oxford University, *Professor of Teaching Emeritus of Chemistry* (analytical and radioanalytical chemistry and chemical education)

Eric D. Mjolsness, Ph.D. California Institute of Technology, *Professor of Computer Science; Mathematics* (artificial intelligence and machine learning, biomedical informatics and computational biology, applied mathematics, mathematical biology, modeling languages)

David L. Mobley, Ph.D. University of California, Davis, *Vice Chair and Professor of Pharmaceutical Sciences; Chemistry* (chemical biology, physical chemistry and chemical physics, theoretical and computational)

William R. Molzon, Ph.D. University of Chicago, *Professor Emeritus of Physics and Astronomy*

Connor Mooney, Ph.D. Columbia University, *Associate Professor of Mathematics* (partial differential equations)

Jefferson K. Moore, Ph.D. Oregon State University, *Professor of Earth System Science*

Shaul Mukamel, Ph.D. Tel Aviv University, *UCI Distinguished Professor of Chemistry; Physics and Astronomy* (physical chemistry and chemical physics, polymer, materials, nanoscience, theoretical and computational)

Simona Murgia, Ph.D. Michigan State University, *Professor of Physics and Astronomy*

Craig Murray, Ph.D. University of Edinburgh, *Associate Professor of Chemistry* (atmospheric and environmental, physical chemistry and chemical physics)

Riley D. Newman, Ph.D. University of California, Berkeley, *Professor Emeritus of Physics and Astronomy*

Qing Nie, Ph.D. Ohio State University, *Director of the NSF-Simons Center for Multiscale Cell Fate Research and Distinguished Professor of Mathematics; Biomedical Engineering; Developmental and Cell Biology* (applied and computational mathematics, mathematical and computational biology)

Sergey Nizkorodov, Ph.D. University of Basel, *Co-Director, AirUCI and Professor of Chemistry* (analytical, atmospheric and environmental, physical chemistry and chemical physics)

James S. Nowick, Ph.D. Massachusetts Institute of Technology, *UCI Distinguished Professor of Chemistry; Pharmaceutical Sciences* (chemical biology, organic and synthetic, polymer, materials, nanoscience)

Juan Pedro Ochoa-Ricoux, Ph.D. California Institute of Technology, *Associate Professor of Physics and Astronomy*

Larry E. Overman, Ph.D. University of Wisconsin-Madison, *UCI Distinguished Professor of Chemistry* (inorganic and organometallic, organic and synthetic)

Brian Paegel, Ph.D. University of California, Berkeley, *Associate Dean of Research and Professor of Pharmaceutical Sciences; Biomedical Engineering; Chemistry* (chemical biology, drug discovery, drug discovery, miniaturization, evolution)

Krzysztof Palczewski, Ph.D. Wroclaw University of Science and Technology, *Irving H. Leopold Endowed Chair of Ophthalmology and Donald Bren and Distinguished Professor of Ophthalmology; Chemistry; Physiology and Biophysics*

Xiaoqing Pan, Ph.D. Saarlandes University, *Henry Samueli Endowed Chair and Director of Irvine Materials Research Institute (IMRI) and Professor of Materials Science and Engineering; Chemical and Biomolecular Engineering; Physics and Astronomy* (atomic-scale structure, properties and dynamic behaviors of advanced materials including thin films and nanostructures for memories, catalysts, and energy conversion and storage devices)

Alessandra Pantano, Ph.D. Princeton University, *Professor of Teaching of Mathematics* (algebra and number theory)

William H. Parker, Ph.D. University of Pennsylvania, *Professor Emeritus of Physics and Astronomy*

Joseph Patterson, Ph.D. University of Warwick, *Assistant Professor of Chemistry; Materials Science and Engineering* (polymer, materials, nanoscience)

Roberto Pelayo, Ph.D. California Institute of Technology, *Associate Professor of Teaching of Mathematics* (algebra and data science)

Reginald M. Penner, Ph.D. Texas A&M University, *Associate Dean of the School of Physical Sciences and UCI Chancellor's Professor of Chemistry* (analytical, physical chemistry and chemical physics, polymer, materials, nanoscience)

Eric Potma, Ph.D. University of Groningen, *Professor of Chemistry; Biomedical Engineering; Electrical Engineering and Computer Science* (analytical, chemical biology, physical chemistry and chemical physics)

Thomas L. Poulos, Ph.D. University of California, San Diego, *Professor Emeritus of Molecular Biology and Biochemistry; Chemistry; Pharmaceutical Sciences* (chemical biology)

Michael J. Prather, Ph.D. Yale University, *Professor Emeritus of Earth System Science*

Jennifer A. Prescher, Ph.D. University of California, Berkeley, *Professor of Chemistry; Molecular Biology and Biochemistry; Pharmaceutical Sciences* (chemical biology, organic and synthetic)

Francois W. Primeau, Ph.D. Massachusetts Institute of Technology, *Professor of Earth System Science*

Michael S. Pritchard, Ph.D. University of California, San Diego, *Associate Professor of Earth System Science*

Sergey V. Pronin, Ph.D. University of Chicago, *Associate Professor of Chemistry* (organic and synthetic chemistry)

Arvind Rajaraman, Ph.D. Stanford University, *Professor of Physics and Astronomy*

James T. Randerson, Ph.D. Stanford University, *UCI Chancellor's Professor of Earth System Science; Civil and Environmental Engineering; Ecology and Evolutionary Biology*

Michael Ratz, Ph.D. Technical University of Munich, *Professor of Physics and Astronomy*

David L. Rector, Ph.D. Massachusetts Institute of Technology, *Professor Emeritus of Mathematics* (algebraic topology and computer algebra)

Manuel Reyes, Ph.D. University of California, Berkeley, *Associate Professor of Mathematics* (algebra and number theory)

Markus W. Ribbe, Ph.D. University of Bayreuth, *UCI Chancellor's Professor of Molecular Biology and Biochemistry; Chemistry* (chemical biology, inorganic and organometallic)

Angela J. Rigden, Ph.D. Boston University, *Assistant Professor of Earth System Science*

Eric Rignot, Ph.D. University of Southern California, *Donald Bren Professor of Earth System Science; Civil and Environmental Engineering*

Thorsten Ritz, Ph.D. University of Ulm, *Professor of Physics and Astronomy*

Paul M. Robertson, Ph.D. University of Texas at Austin, *Assistant Professor of Physics and Astronomy*

Judit Romhanyi, Ph.D. Budapest University of Technology and Economy, *Assistant Professor of Physics and Astronomy*

Karl Rubin, Ph.D. Harvard University, *Distinguished Professor Emeritus of Mathematics* (algebra and number theory)

Bernard Russo, Ph.D. University of California, Los Angeles, *Professor Emeritus of Mathematics* (functional analysis)

James E. Rutledge, Ph.D. University of Illinois at Chicago Circle, *Professor Emeritus of Physics and Astronomy*

Scott D. Rychnovsky, Ph.D. Columbia University, *UCI Distinguished Professor of Chemistry* (chemical biology, organic and synthetic)

Donald G. Saari, Ph.D. Purdue University, *UCI Distinguished Professor Emeritus of Economics; Mathematics*

Stephanie Sallum, Ph.D. University of Arizona, *Assistant Professor of Physics and Astronomy*

Eric S. Saltzman, Ph.D. University of Miami, *UCI Distinguished Professor of Earth System Science; Chemistry*

Javier D. Sanchez-Yamagishi, Ph.D. Massachusetts Institute of Technology, *Assistant Professor of Physics and Astronomy*

Thomas Scaffidi, Ph.D. University of Oxford, *Assistant Professor of Physics and Astronomy*

Martin Schechter, Ph.D. New York University, *Professor Emeritus of Mathematics* (analysis and partial differential equations, mathematical physics)

Stephen Scheinberg, Ph.D. Princeton University, *Professor Emeritus of Mathematics*

Richard M. Schoen, Ph.D. Stanford University, *UCI Excellence in Teaching Chair in Mathematics and Distinguished Professor of Mathematics* (geometry and topology, partial differential equations)

Jonas Schultz, Ph.D. Columbia University, *Professor Emeritus of Physics and Astronomy*

A. J. Shaka, Ph.D. Oxford University, *Professor of Chemistry* (chemical biology, physical chemistry and chemical physics)

Kenneth J. Shea, Ph.D. Pennsylvania State University, *UCI Distinguished Professor Emeritus of Chemistry* (analytical, chemical biology, organic and synthetic, polymer, materials, nanoscience)

Matthew Sheldon, Ph.D. University of California, Berkeley, *Associate Professor of Chemistry* (analytical and materials chemistry)

Xiaoyu Shi, Ph.D. University of California, Davis, *Assistant Professor of Chemistry; Biomedical Engineering; Developmental and Cell Biology* (super-resolution microscopy)

Aomawa Shields, Ph.D. University of Washington, *Associate Professor of Physics and Astronomy*

Manabu Shiraiwa, Ph.D. Max Planck Institute for Chemistry, *Professor of Chemistry* (atmospheric and environmental, chemical biology, physical chemistry and chemical physics, theoretical and computational)

Yuri Shirman, Ph.D. University of California, Santa Cruz, *Professor of Physics and Astronomy*

Alice Silverberg, Ph.D. Princeton University, *Distinguished Professor Emerita of Mathematics* (algebra and number theory)

Dennis J. Silverman, Ph.D. Stanford University, *Professor Emeritus of Physics and Astronomy*

Seunghyun Sim, Ph.D. The University of Tokyo, Japan, *Assistant Professor of Chemistry; Biomedical Engineering; Chemical and Biomolecular Engineering* (chemical biology, organic and synthetic, polymer, materials and nanoscience)

Albert Siryaporn, Ph.D. University of Pennsylvania, *Associate Professor of Physics and Astronomy; Molecular Biology and Biochemistry*

Zuzanna S. Siwy, Ph.D. Silesian University of Technology, *Professor of Physics and Astronomy; Biomedical Engineering; Chemistry*

Tammy Ann Smecker-Hane, Ph.D. Johns Hopkins University, *Professor Emeritus of Physics and Astronomy*

James N. Smith, Ph.D. California Institute of Technology, *Professor of Chemistry* (analytical, atmospheric and environmental, physical chemistry and chemical physics)

Luke Smith, Ph.D. University of California, Irvine, *Lecturer of Mathematics* (algebra and number theory)

William H. Smoke, Ph.D. University of California, Berkeley, *Professor Emeritus of Mathematics* (homological algebra)

Henry W. Sobel, Ph.D. Case Western Reserve University, *Professor Emeritus of Physics and Astronomy*

Knut Solna, Ph.D. Stanford University, *Professor of Mathematics* (applied and computational mathematics, inverse problems and imaging, probability)

Soroosh Sorooshian, Ph.D. University of California, Los Angeles, *Director of the Center for Hydrometeorology and Remote Sensing (CHRS) and Distinguished Professor of Civil and Environmental Engineering; Earth System Science* (hydrometeorology, water resources systems engineering, climate studies and application of remote sensing to earth science problems with special focus on the hydrologic cycle and water resources issues of arid and semi-arid zones)

Vojislav Stamenkovic, Ph.D. University of Belgrade, *Professor of Chemical and Biomolecular Engineering; Chemistry* (energy conversion and storage, surface modifications, thin films, nanoscale synthesis, electrochemical interfaces, fuel cells, electrolyzers and batteries)

Ronald J. Stern, Ph.D. University of California, Los Angeles, *Professor Emeritus of Mathematics* (geometry and topology)

Jeffrey D. Streets, Ph.D. Duke University, *Professor of Mathematics* (geometry and topology)

Min-Ying Su, Ph.D. University of California, Irvine, *Professor of Radiological Sciences; Physics and Astronomy*

Peter Taborek, Ph.D. California Institute of Technology, *Professor of Physics and Astronomy*

Agnes Taffard, Ph.D. University of Liverpool, *Professor of Physics and Astronomy*

Timothy Tait, Ph.D. Michigan State University, *Professor of Physics and Astronomy*

Fumiko Tajima, Ph.D. University of Tokyo, *Lecturer of Physics and Astronomy*

Toshiki Tajima, Ph.D. University of California, Irvine, *UCI Endowed Chair and Professor of Physics and Astronomy*

Chuu-Lian Terng, Ph.D. Brandeis University, *Professor Emerita of Mathematics* (differential geometry and integrable systems)

Edriss S. Titi, Ph.D. Indiana University, *Professor Emeritus of Mathematics* (analysis and partial differential equations, applied and computational mathematics)

Douglas J. Tobias, Ph.D. Carnegie Mellon University, *UCI Distinguished Professor of Chemistry* (atmospheric and environmental, chemical biology, physical chemistry and chemical physics, theoretical and computational)

Virginia L. Trimble, Ph.D. California Institute of Technology, *Professor of Physics and Astronomy*

Susan E. Trumbore, Ph.D. Columbia University, *Professor of Earth System Science*

Shiou-Chuan (Sheryl) Tsai, Ph.D. University of California, Berkeley, *Professor of Molecular Biology and Biochemistry; Chemistry; Pharmaceutical Sciences*

Li Sheng Tseng, Ph.D. University of Chicago, *Associate Professor of Mathematics* (geometry and topology, mathematical physics)

Laura Tucker, Ph.D. University of California, San Diego, *Assistant Professor of Teaching of Physics and Astronomy*

Mark Vagins, Ph.D. Yale University, *Adjunct Professor of Physics and Astronomy*

Christopher Vanderwal, Ph.D. Scripps Research Institute, *Department Vice Chair and Professor of Chemistry; Pharmaceutical Sciences* (organic and synthetic)

Isabella Velicogna, Ph.D. Università degli Studi di Trieste, *UCI Chancellor's Fellow and Professor of Earth System Science*

Roman Vershynin, Ph.D. University of Missouri-Columbia, *Professor of Mathematics* (applied and computational mathematics)

Jeffrey Viaclovsky, Ph.D. Princeton University, *Professor of Mathematics* (geometry and topology)

David Van Vranken, Ph.D. Stanford University, *Associate Dean of the School of Physical Sciences and Professor of Chemistry* (organic and synthetic)

Daqing Wan, Ph.D. University of Washington, *Professor of Mathematics* (algebra and number theory)

Frederic Yui-Ming Wan, Ph.D. Massachusetts Institute of Technology, *Professor Emeritus of Mathematics* (applied and computational mathematics, mathematical and computational biology)

Gregory A. Weiss, Ph.D. Harvard University, *Professor of Chemistry; Molecular Biology and Biochemistry; Pharmaceutical Sciences* (analytical, chemical biology, organic and synthetic, polymer, materials, nanoscience)

Frank J. Wessel, Ph.D. University of California, Irvine, *Project Scientist of Physics and Astronomy*

Robert W. West, Ph.D. University of Michigan, *Professor Emeritus of Mathematics* (algebraic topology)

Joel J. Westman, Ph.D. University of California, Los Angeles, *Professor Emeritus of Mathematics* (analysis)

Steven R. White, Ph.D. Cornell University, *Distinguished Professor of Physics and Astronomy*

Daniel Whiteson, Ph.D. University of California, Berkeley, *Professor of Physics and Astronomy; Logic and Philosophy of Science*

Robert J. Whitley, Ph.D. New Mexico State University, *Professor Emeritus of Mathematics* (analysis)

Janet L. Williams, Ph.D. Brandeis University, *Professor Emerita of Mathematics* (probability and statistics)

Dominik Wodarz, Ph.D. Oxford University, *Professor of Population Health and Disease Prevention; Mathematics*

Jesse Wolfson, Ph.D. Northwestern University, *Associate Professor of Mathematics* (topology)

Ruqian Wu, Ph.D. Institute of Physics, Chinese Academy of Science, *Professor of Physics and Astronomy*

Jing Xia, Ph.D. Stanford University, *Professor of Physics and Astronomy*

Huolin Xin, Ph.D. Cornell University, *Professor of Physics and Astronomy; Materials Science and Engineering*

Jack Xin, Ph.D. New York University, *Chancellor's Professor of Mathematics* (applied and computational mathematics)

Jenny Y. Yang, Ph.D. Massachusetts Institute of Technology, *Professor of Chemistry* (inorganic and organometallic, organic and synthetic, polymer, materials, nanoscience)

James J. Yeh, Ph.D. University of Minnesota, *Professor Emeritus of Mathematics* (analysis and partial differential equations, probability)

Hamed Youssefpour, Ph.D. University of California, Irvine, *Lecturer of Mathematics* (mathematical modeling of biological systems)

Clare C. Yu, Ph.D. Princeton University, *Professor of Physics and Astronomy*

Jin Yu, Ph.D. University of Illinois at Urbana-Champaign, *Assistant Professor of Physics and Astronomy; Chemistry*

Jin Yi Yu, Ph.D. University of Washington, *Professor of Earth System Science*

Yifeng Yu, Ph.D. University of California, Berkeley, *Professor of Mathematics* (analysis and partial differential equations, applied and computational mathematics)

Martin Zeman, Ph.D. Humboldt University of Berlin, *Professor of Mathematics; Logic and Philosophy of Science* (logic and foundations)

Charles S. Zender, Ph.D. University of Colorado Boulder, *Professor of Earth System Science; Computer Science*

Xiangwen Zhang, Ph.D. McGill University, *Professor of Mathematics* (geometry and topology)

Hong-Kai Zhao, Ph.D. University of California, Los Angeles, *Chancellor's Professor Emeritus of Mathematics; Computer Science* (applied and computational mathematics, inverse problems and imaging)

Weian Zheng, Ph.D. University of Strasbourg, *Professor Emeritus of Mathematics* (probability theory and financial engineering)

Chemistry Courses

CHEM 1A. General Chemistry. 4 Units.
General chemistry with applications to life sciences, physical sciences, and engineering. Atomic structure; general properties of the elements; covalent, ionic, and metallic bonding; mass relationships.

Prerequisite: MATH 5A or MATH 2A or PHYS 7C or CHEM 1X or CHEM 1P or SAT Mathematics or ACT Mathematics or SAT Subject Chemistry or AP Chemistry or AP Calculus AB or AP Calculus BC. CHEM 1P with a grade of C- or better. SAT Mathematics with a minimum score of 600. ACT Mathematics with a minimum score of 27. SAT Subject Chemistry with a minimum score of 700. AP Chemistry with a minimum score of 3. AP Calculus AB with a minimum score of 3. AP Calculus BC with a minimum score of 3. Placement via a passing score on the UCI placement exam or a passing score on the ALEKS placement exam is also accepted.

Overlaps with CHEM H2A, ENGR 1A, CHEM M2A.

Restriction: Undeclared Majors have first consideration for enrollment. School of Biological Sciences students have first consideration for enrollment. School of Physical Sciences students have first consideration for enrollment. School of Engineering students have first consideration for enrollment. Program in Nursing Science students have first consideration for enrollment. Dept Pharmaceutical Sciences students have first consideration for enrollment. Program in Public Health students have first consideration for enrollment.

(II and VA).

CHEM 1B. General Chemistry. 4 Units.
General chemistry with applications to life sciences, physical sciences, and engineering. Properties of gases, liquids, solids; intermolecular forces; changes of state; properties of solutions; stoichiometry; thermochemistry; and thermodynamics. Course may be offered online.

Prerequisite: CHEM 1A or ENGR 1A or CHEM H2A or AP Chemistry or CHEM M2A. CHEM 1A with a grade of C- or better. ENGR 1A with a grade of C- or better. CHEM H2A with a grade of C- or better. AP Chemistry with a minimum score of 4. CHEM M2A with a grade of C- or better

Overlaps with CHEM H2B, CHEM M2B.

Restriction: School of Biological Sciences students have first consideration for enrollment. School of Physical Sciences students have first consideration for enrollment. School of Engineering students have first consideration for enrollment. Program in Nursing Science students have first consideration for enrollment. Dept Pharmaceutical Sciences students have first consideration for enrollment. Program in Public Health students have first consideration for enrollment. Undeclared Majors have first consideration for enrollment.

(II and Va).

CHEM 1C. General Chemistry . 4 Units.
General chemistry with applications to life sciences, physical sciences, and engineering. Equilibria, aqueous acid-base equilibria, solubility equilibria, oxidation reduction reactions, electrochemistry; kinetics; special topics.

Corequisite: CHEM 1LC
Prerequisite: CHEM 1B. CHEM 1B with a grade of C- or better

Overlaps with CHEM H2C, CHEM M2C.

Restriction: School of Biological Sciences students have first consideration for enrollment. School of Physical Sciences students have first consideration for enrollment. School of Engineering students have first consideration for enrollment. Program in Nursing Science students have first consideration for enrollment. Dept Pharmaceutical Sciences students have first consideration for enrollment. Program in Public Health students have first consideration for enrollment. Undeclared Majors have first consideration for enrollment.

(II and VA).

CHEM 1LC. General Chemistry Laboratory. 3 Units.
Training and experience in basic laboratory techniques. Chemical practice and principles illustrated through experiments related to lecture topics of CHEM 1A-B-C. Materials fee.

Corequisite: CHEM 1C
Prerequisite: CHEM 1B. CHEM 1B with a grade of C- or better

Overlaps with CHEM H2LA, CHEM M2LA.

Restriction: Div of Undergraduate Education students have first consideration for enrollment. School of Biological Sciences students have first consideration for enrollment. School of Physical Sciences students have first consideration for enrollment. School of Engineering students have first consideration for enrollment. Nursing Science Majors have first consideration for enrollment. Pharmaceutical Sciences Majors have first consideration for enrollment. Public Health Sciences Majors have first consideration for enrollment.

CHEM 1LD. General Chemistry Laboratory. 3 Units.
Training and experience in basic laboratory techniques. Chemical practice and principles illustrated through experiments related to lecture topics in CHEM 1A-B-C. Materials fee.

Prerequisite: (CHEM 1C and CHEM 1LC) or CHEM 1LE. CHEM 1C with a grade of C- or better. CHEM 1LC with a grade of C- or better. CHEM 1LE with a grade of C- or better

Overlaps with CHEM H2LB, CHEM M2LB.

Restriction: School of Biological Sciences students have first consideration for enrollment. School of Physical Sciences students have first consideration for enrollment. School of Engineering students have first consideration for enrollment. Program in Nursing Science students have first consideration for enrollment. Pharmaceutical Sciences Majors have first consideration for enrollment. Public Health Sciences Majors have first consideration for enrollment. Undecided/Undeclared students also have first consideration for enrollment.

CHEM 1LE. Accelerated General Chemistry Lab. 3 Units.
Lecture and experiments covering chemical concepts for accelerated students who do not plan to take organic chemistry. Properties of gases, liquids, solutions, and solids; chemical equilibrium and chemical thermodynamics; atomic and molecular structure; chemical kinetics; electrochemistry. Materials fee.

Corequisite: CHEM 1A or ENGR 1A.
Prerequisite: CHEM 1A or ENGR 1A or AP Chemistry. CHEM 1A with a grade of C- or better. ENGR 1A with a grade of C- or better. AP Chemistry with a minimum score of 3

Overlaps with CHEM 1LC.

Restriction: School of Engineering students have first consideration for enrollment.

CHEM 1P. Preparation for General Chemistry . 4 Units.
Units of measurement, dimensional analysis, significant figures; elementary concepts of volume, mass, force, pressure, energy, density, temperature, heat, work; fundamentals of atomic and molecular structure; the mole concept, stoichiometry; properties of the states of matter; gas laws; solutions concentrations.

Restriction: Undeclared Majors have first consideration for enrollment. School of Biological Sciences students have first consideration for enrollment. School of Physical Sciences students have first consideration for enrollment. School of Engineering students have first consideration for enrollment. Program in Nursing Science students have first consideration for enrollment. Dept Pharmaceutical Sciences students have first consideration for enrollment. Program in Public Health students have first consideration for enrollment.

CHEM 1X. General Chemistry Plus. 2 Units.
Units of chemical measurements, dimensional analysis, significant figures; elementary physicochemical concepts; fundamentals of atomic and molecular structure; molar amounts and stoichiometry; properties of the states of matter; solutions concentrations.

Prerequisite: Students who meet the requirements for taking Chem 1A through their SAT, ACT, or AP test scores are not eligible for enrollment in Chem 1X. Specifically, the students must have ALL of the following advisory prerequisites (the inverse of the Chem 1A prerequisites): S02<600 (score below 600 on the SAT Mathematics Reasoning test) A02<27 (score below 27 on the ACT Mathematics test) Z43<700 (score below 700 on the SAT Chemistry subject exam) AP25<3 (score below 3 on the AP Chemistry exam) AP66<3 (score below 3 on the AP Calculus AB Exam) AP68<3 (score below 3 on the AP Calculus BC Exam) Students who meet Chem 1A eligibility through ALEKS-based training are permitted to enroll in Chem 1X. Chem 1X is open to interested BioEASE students.

Grading Option: Pass/no pass only.

CHEM H2A. Honors General Chemistry. 4 Units.
Covers the same material as CHEM 1A-CHEM 1B-CHEM M3C but in greater depth. Additional topics will also be included as time permits.

Corequisite: CHEM H2LA
Prerequisite: AP Chemistry or SAT Subject Chemistry. AP Chemistry with a minimum score of 4. SAT Subject Chemistry with a minimum score of 700

Overlaps with CHEM 1A, CHEM M2A, ENGR 1A.

Restriction: Campuswide Honors Collegium students only.

(II and Va).

CHEM H2B. Honors General Chemistry. 4 Units.
Covers the same material as CHEM 1A-CHEM 1B-CHEM M3C but in greater depth. Additional topics are also included as time permits.

Corequisite: CHEM H2LB
Prerequisite: CHEM H2A and (CHEM H2LA or CHEM M2LA). CHEM H2A with a grade of C- or better. CHEM H2LA with a grade of C- or better. CHEM M2LA with a grade of C- or better

Overlaps with CHEM 1B, CHEM M2B.

Restriction: Campuswide Honors Collegium students only.

(II and VA).

CHEM H2C. Honors General Chemistry. 4 Units.
Covers the same material as CHEM 1A-CHEM 1B-CHEM M3C but in greater depth. Additional topics are also included as time permits.

Prerequisite: CHEM H2B and (CHEM H2LB or CHEM M2LB). CHEM H2B with a grade of C- or better. CHEM H2LB with a grade of C- or better. CHEM M2LB with a grade of C- or better

Overlaps with CHEM 1C, CHEM M2C.

Restriction: Campuswide Honors Collegium students only.

(II and VA).

CHEM H2LA. Honors General Chemistry Laboratory. 3 Units.
Training and experience in fundamental and analytical laboratory techniques through experiments related to lecture topics in CHEM H2A-CHEM H2B-CHEM H2C. Materials fee.

Corequisite: CHEM H2A
Prerequisite: AP Chemistry or SAT Subject Chemistry. AP Chemistry with a minimum score of 4. SAT Subject Chemistry with a minimum score of 700

Overlaps with CHEM M2LA, CHEM 1LC.

Restriction: Campuswide Honors Collegium students only.

CHEM H2LB. Honors General Chemistry Laboratory. 3 Units.
Training and experience in fundamental and analytical laboratory techniques through experiments related to lecture topics in CHEM H2A-CHEM H2B-CHEM H2C. Materials fee.

Corequisite: CHEM H2B
Prerequisite: CHEM H2A and (CHEM H2LA or CHEM M2LA). CHEM H2A with a grade of B or better. CHEM H2LA with a grade of B or better. CHEM M2LA with a grade of B or better

Overlaps with CHEM M2LB, CHEM 1LD.

Restriction: No credit for CHEM 1LC if taken after CHEM H2LB or CHEM M2LB.

CHEM H2LC. Honors General Chemistry Laboratory. 3 Units.
Training and experience in fundamental and analytical laboratory techniques through experiments related to lecture topics in CHEM H2A-CHEM H2B-CHEM H2C. Materials fee.

Corequisite: CHEM H2C
Prerequisite: CHEM H2B and (CHEM H2LB or CHEM M2LB). CHEM H2B with a grade of B or better. CHEM H2LB with a grade of B or better. CHEM M2LB with a grade of B or better

CHEM M2A. Majors General Chemistry Lecture. 4 Units.
Covers the same material as CHEM 1A but in greater depth. Additional topics are included as time permits.

Corequisite: MATH 5A or MATH 2A or PHYS 7C or CHEM 1X
Prerequisite: MATH 5A or MATH 2A or PHYS 7C or CHEM 1X or CHEM 1P or SAT Mathematics or ACT Mathematics or SAT Subject Chemistry or AP Chemistry or AP Calculus AB or AP Calculus BC. CHEM 1P with a grade of C- or better. SAT Mathematics with a minimum score of 600. ACT Mathematics with a minimum score of 27. SAT Subject Chemistry with a minimum score of 700. AP Chemistry with a minimum score of 3. AP Calculus AB with a minimum score of 3. AP Calculus BC with a minimum score of 3. Placement via a passing score on the ALEKS placement exam is also accepted.

Overlaps with CHEM 1A, CHEM H2A, ENGR 1A.

Restriction: Chemistry Majors have first consideration for enrollment.

(II and Va).

CHEM M2B. Majors General Chemistry Lecture. 4 Units.
Covers the same material as CHEM 1B but in greater depth. Additional topics will also be included as time permits.

Prerequisite: CHEM M2A and CHEM M2LA. CHEM M2A with a grade of C- or better. CHEM M2LA with a grade of C- or better

Overlaps with CHEM H2B, CHEM 1B.

Restriction: Chemistry Majors have first consideration for enrollment.

(II and Va).

CHEM M2C. Majors General Chemistry Lecture. 4 Units.
Covers the same material as CHEM 1C but in greater depth. Additional topics are also included as time permits.

Prerequisite: CHEM M2B and CHEM M2LB. CHEM M2B with a grade of C- or better. CHEM M2LB with a grade of C- or better

Overlaps with CHEM 1C, CHEM H2C.

Restriction: Chemistry Majors have first consideration for enrollment.

(II and Va).

CHEM M2LA. Majors General Chemistry Laboratory. 3 Units.
Training and experience in basic laboratory techniques through experiments related to lecture topics in CHEM 1A-CHEM 1B-CHEM M3C. Materials fee.

Prerequisite or corequisite: CHEM M2A. CHEM M2A with a grade of C- or better. High school chemistry.

Overlaps with CHEM H2LA, CHEM 1LC.

Restriction: Chemistry Majors only.

CHEM M2LB. Majors General Chemistry Laboratory. 3 Units.
Training and experience in basic laboratory techniques through experiments related to lecture topics in CHEM 1A-CHEM 1B-CHEM M3C. Materials fee.

Corequisite: CHEM 1B or CHEM H2B or CHEM M2B
Prerequisite: (CHEM 1B or CHEM H2B or CHEM M2B) and (CHEM M2A or CHEM H2A) and (CHEM M2LA or CHEM H2LA). CHEM 1B with a grade of C- or better. CHEM H2B with a grade of C- or better. CHEM M2B with a grade of C- or better. CHEM M2A with a grade of C- or better. CHEM H2A with a grade of C- or better. CHEM M2LA with a grade of C- or better. CHEM H2LA with a grade of C- or better

Overlaps with CHEM H2LB, CHEM 1LD.

Restriction: Chemistry Majors only.

CHEM M3C. Majors Quantitative Analytical Chemistry. 4 Units.
Topics include equilibria, aqueous acid-base equilibria, solubility equilibria, oxidation reduction reactions, electrochemistry, and kinetics with a special emphasis on the statistical treatment of data and analytical methods of chemical analysis.

Corequisite: CHEM M3LC
Prerequisite: (CHEM 1B or CHEM H2B or CHEM M2B) and (CHEM M2LB or CHEM H2LB). CHEM 1B with a grade of C- or better. CHEM H2B with a grade of C- or better. CHEM M2B with a grade of C- or better. CHEM M2LB with a grade of C- or better. CHEM H2LB with a grade of C- or better

Restriction: Chemistry Majors only.

(II and VA).

CHEM M3LC. Majors Quantitative Analytical Chemistry Laboratory. 4 Units.
Foundational principles of analytical chemistry and experimental methods for quantitative analysis of real samples. Materials fee.

Prerequisite: (CHEM 1B or CHEM H2B or CHEM M2B) and (CHEM M2LB or CHEM H2LB). CHEM 1B with a grade of C- or better. CHEM H2B with a grade of C- or better. CHEM M2B with a grade of C- or better. CHEM M2LB with a grade of C- or better. CHEM H2LB with a grade of C- or better

Restriction: Chemistry Majors only.

CHEM 5. Scientific Mathematical and Computing Skills. 4 Units.
Introduces students to mathematical skills, including complex numbers, linear algebra, differential equations, multivariable calculus, infinite series, Fourier series, and integral transforms; and computing skills, including plotting, data analysis (statistics and curve fitting), linear algebra, symbolic mathematics, and spectral analysis.

Prerequisite or corequisite: (CHEM 1C or CHEM H2C or CHEM M3C or CHEM M2C) and MATH 2D. CHEM 1C with a grade of C- or better. CHEM H2C with a grade of C- or better. CHEM M3C with a grade of C- or better. CHEM M2C with a grade of C- or better

Restriction: Chemistry Majors have first consideration for enrollment.

CHEM 11. New Chemistry Student Seminar. 1 Workload Unit.
Seminar for students who recently joined the chemistry major. Addresses available tracks in the major, research opportunities in the chemistry department, careers in chemistry, and relevant programs and resources for students.

Grading Option: Workload Credit P/NP Only.

Restriction: Freshmen students, transfer students, and students who recently changed their major to Chemistry have first consideration for enrollment.

CHEM 14. Sense and Sensibility in Science. 4 Units.
Gives an overview of scientific methods and heuristics through group exercises and discussion. Discusses the benefits and limitations of applying rational scientific approaches to real-world examples from philosophy, cognitive and social psychology, game theory, economics, political science, law, and negotiation.

(II and V.A.).

CHEM 51A. Organic Chemistry. 4 Units.
Fundamental concepts relating to carbon compounds with emphasis on structural theory and the nature of chemical bonding, stereochemistry, reaction mechanisms, and stereoscopic, physical, and chemical properties of the principal classes of carbon compounds.

Corequisite: CHEM 1LD
Prerequisite: (CHEM 1C or CHEM H2C or CHEM M2C or CHEM M3C) and (CHEM 1LD or CHEM H2LB or CHEM M2LB). CHEM 1C with a grade of C- or better. CHEM H2C with a grade of C- or better. CHEM M2C with a grade of C- or better. CHEM M3C with a grade of C- or better. CHEM 1LD with a grade of C- or better. CHEM H2LB with a grade of C- or better. CHEM M2LB with a grade of C- or better

Restriction: Undeclared Majors have first consideration for enrollment. School of Biological Sciences students have first consideration for enrollment. School of Physical Sciences students have first consideration for enrollment. School of Engineering students have first consideration for enrollment. Program in Nursing Science students have first consideration for enrollment. Dept Pharmaceutical Sciences students have first consideration for enrollment. Program in Public Health students have first consideration for enrollment.

CHEM 51B. Organic Chemistry. 4 Units.
Fundamental concepts relating to carbon compounds with emphasis on structural theory and the nature of chemical bonding, stereochemistry, reaction mechanisms, and stereoscopic, physical, and chemical properties of the principal classes of carbon compounds.

Prerequisite: CHEM 51A and (CHEM 1LD or CHEM M52LA or CHEM H52LA). CHEM 51A with a grade of C- or better. CHEM 1LD with a grade of C- or better. CHEM M52LA with a grade of C- or better. CHEM H52LA with a grade of C- or better

Overlaps with CHEM H52B.

Restriction: Undeclared Majors have first consideration for enrollment. School of Physical Sciences students have first consideration for enrollment. School of Biological Sciences students have first consideration for enrollment. School of Engineering students have first consideration for enrollment. Program in Nursing Science students have first consideration for enrollment. Dept Pharmaceutical Sciences students have first consideration for enrollment. Program in Public Health students have first consideration for enrollment.

CHEM 51C. Organic Chemistry. 4 Units.
Fundamental concepts relating to carbon compounds with emphasis on structural theory and the nature of chemical bonding, stereochemistry, reaction mechanisms, and stereoscopic, physical, and chemical properties of the principal classes of carbon compounds.

Prerequisite: CHEM 51B and (CHEM 51LB or CHEM M52LB or CHEM H52LB). CHEM 51B with a grade of C- or better. CHEM 51LB with a grade of C- or better. CHEM M52LB with a grade of C- or better. CHEM H52LB with a grade of C- or better

Overlaps with CHEM H52C.

Restriction: Undeclared Majors have first consideration for enrollment. School of Physical Sciences students have first consideration for enrollment. School of Biological Sciences students have first consideration for enrollment. School of Engineering students have first consideration for enrollment. Program in Nursing Science students have first consideration for enrollment. Dept Pharmaceutical Sciences students have first consideration for enrollment. Program in Public Health students have first consideration for enrollment.

CHEM 51LB. Organic Chemistry Laboratory. 3 Units.
Modern techniques of organic chemistry, using selected experiments to illustrate topics introduced in CHEM 51A-CHEM 51B-CHEM 51C. Materials fee.

Corequisite: CHEM 51B
Prerequisite: CHEM 51A and (CHEM 1LD or CHEM H2LB or CHEM M2LB). CHEM 51A with a grade of C- or better. CHEM 1LD with a grade of C- or better. CHEM H2LB with a grade of C- or better. CHEM M2LB with a grade of C- or better

Overlaps with CHEM H52LA, CHEM M52LA.

Restriction: School of Biological Sciences students have first consideration for enrollment. School of Physical Sciences students have first consideration for enrollment. School of Engineering students have first consideration for enrollment. Program in Nursing Science students have first consideration for enrollment. Dept Pharmaceutical Sciences students have first consideration for enrollment. Program in Public Health students have first consideration for enrollment. Undeclared Majors have first consideration for enrollment.

CHEM 51LC. Organic Chemistry Laboratory. 3 Units.
Modern techniques of organic chemistry, using selected experiments to illustrate topics introduced in CHEM 51A-B-C. Materials fee.

Corequisite: CHEM 51C
Prerequisite: CHEM 51B and CHEM 51LB. CHEM 51B with a grade of C- or better. CHEM 51LB with a grade of C- or better

Overlaps with CHEM H52LB, CHEM M52LB.

Restriction: School of Biological Sciences students have first consideration for enrollment. School of Physical Sciences students have first consideration for enrollment. School of Engineering students have first consideration for enrollment. Program in Nursing Science students have first consideration for enrollment. Dept Pharmaceutical Sciences students have first consideration for enrollment. Program in Public Health students have first consideration for enrollment. Undeclared Majors have first consideration for enrollment.

CHEM 51LD. Organic Chemistry Laboratory. 3 Units.
Modern techniques of organic chemistry using selected experiments to illustrate topics introduced in CHEM 51A-CHEM 51B-CHEM 51C. Materials fee.

Prerequisite: CHEM 51C and CHEM 51LC. CHEM 51C with a grade of C- or better. CHEM 51LC with a grade of C- or better

Overlaps with CHEM H52LC, CHEM M52LC.

Restriction: School of Biological Sciences students have first consideration for enrollment. School of Physical Sciences students have first consideration for enrollment. School of Engineering students have first consideration for enrollment. Program in Nursing Science students have first consideration for enrollment. Dept Pharmaceutical Sciences students have first consideration for enrollment. Program in Public Health students have first consideration for enrollment. Undeclared Majors have first consideration for enrollment.

CHEM H52LA. Honors Organic Chemistry Laboratory. 3 Units.
Fundamental techniques of modern experimental organic chemistry. Materials fee.

Corequisite: CHEM 51A
Prerequisite: (CHEM 1C or CHEM H2C or CHEM M2C or CHEM M3C) and (CHEM M2LB or CHEM H2LB or CHEM 1LD). CHEM 1C with a grade of C- or better. CHEM H2C with a grade of C- or better. CHEM M2C with a grade of C- or better. CHEM M3C with a grade of C- or better. CHEM M2LB with a grade of C- or better. CHEM H2LB with a grade of C- or better. CHEM 1LD with a grade of C- or better

Overlaps with CHEM 51LB, CHEM M52LA.

Restriction: Campuswide Honors Collegium students only.

CHEM H52LB. Honors Organic Chemistry Laboratory. 3 Units.
Fundamental techniques of modern experimental organic chemistry. Materials fee.

Corequisite: CHEM 51B
Prerequisite: CHEM 51A and CHEM H52LA. CHEM 51A with a grade of C- or better. CHEM H52LA with a grade of C- or better

Overlaps with CHEM M52LB, CHEM 51LC.

CHEM H52LC. Honors Organic Chemistry Laboratory. 3 Units.
Fundamental techniques of modern experimental organic chemistry. Materials fee.

Prerequisite: CHEM 51B and CHEM H52LB. CHEM 51B with a grade of C- or better. CHEM H52LB with a grade of C- or better

Overlaps with CHEM 51LD, CHEM M52LC.

CHEM M52LA. Majors Organic Chemistry Laboratory. 3 Units.
Modern techniques of organic chemistry, using selected experiments to illustrate topics introduced in CHEM 51A-B-C. Materials fee.

Corequisite: CHEM 51A
Prerequisite: (CHEM 1C or CHEM H2C or CHEM M2C or CHEM M3C) and (CHEM H2LB or CHEM M2LB or CHEM 1LD). CHEM 1C with a grade of C- or better. CHEM H2C with a grade of C- or better. CHEM M2C with a grade of C- or better. CHEM M3C with a grade of C- or better. CHEM H2LB with a grade of C- or better. CHEM M2LB with a grade of C- or better. CHEM 1LD with a grade of C- or better

Overlaps with CHEM H52LA, CHEM 51LB.

Restriction: Chemistry Majors only.

CHEM M52LB. Majors Organic Chemistry Laboratory. 3 Units.
Modern techniques of organic chemistry, using selected experiments to illustrate topics introduced in CHEM 51A-B-C. Materials fee.

Corequisite: CHEM 51B
Prerequisite: CHEM 51A and CHEM M52LA. CHEM 51A with a grade of C- or better. CHEM M52LA with a grade of C- or better

Overlaps with CHEM H52LB, CHEM 51LC.

Restriction: Chemistry Majors only.

CHEM M52LC. Majors Organic Chemistry Laboratory. 3 Units.
Modern techniques of organic chemistry, using selected experiments to illustrate topics introduced in CHEM 51A-B-C. Materials fee.

Corequisite: CHEM 51C
Prerequisite: CHEM 51B and (CHEM M52LB or CHEM H52LB). CHEM 51B with a grade of C- or better. CHEM M52LB with a grade of C- or better. CHEM H52LB with a grade of C- or better

Overlaps with CHEM H52LC, CHEM 51LD.

Restriction: Chemistry Majors only.

CHEM H90. The Idiom and Practice of Science. 4 Units.
A series of fundamental and applied problems in the chemical sciences are addressed. Topics may include the periodic table, electronic structure of atoms, chemical bonding, molecular structure, thermodynamics, and kinetics, with applications to energy and the environment, and/or biochemistry.

Restriction: Campuswide Honors Collegium students only.

(II and Va).

CHEM 100. Special Topics in Chemistry. 4 Units.
Devoted to current topics in the advanced fields of chemical sciences. Topics addressed vary each quarter.

Prerequisite: (CHEM 51C or CHEM H52C) and (CHEM M3C or CHEM M2C or CHEM 1C or CHEM H2C)

Repeatability: May be taken for credit 3 times as topics vary.

Restriction: Chemistry Honors students only. Chemistry Majors have first consideration for enrollment.

CHEM 100S. Laboratory Safety for Chemists.
Provide students with the fundamentals of safety involved in chemical laboratory work.

Prerequisite or corequisite: CHEM 51C

Grading Option: Pass/no pass only.

Restriction: Chemistry Majors have first consideration for enrollment.

CHEM 101W. Writing in Chemical Sciences. 4 Units.
Students receive guidance on preparing research papers, proposals, reports, and other forms of scientific writing in chemistry-related fields, on effectively searching for and using chemical information, and on communicating data in poster and platform presentations.

Prerequisite: Satisfactory completion of the Lower-Division Writing requirement.

Restriction: Upper-division students only. Chemistry Majors have first consideration for enrollment.

(Ib)

CHEM 107. Inorganic Chemistry. 4 Units.
Introduction to modern inorganic chemistry. Principles of structure, bonding, and chemical reactivity with application to compounds of the main group and transition elements, including organometallic chemistry.

Prerequisite: CHEM 51C or CHEM H52C

Restriction: Chemistry Majors have first consideration for enrollment.

CHEM 107L. Inorganic Chemistry Laboratory. 3 Units.
Modern techniques of inorganic and organometallic chemistry, including experience with glove box, Schlenk line, and vacuum line methods. Materials fee.

Corequisite: CHEM 100S
Prerequisite: CHEM 107 and CHEM 100S

Restriction: Chemistry Majors have first consideration for enrollment.

CHEM 125. Advanced Organic Chemistry. 4 Units.
Rapid-paced comprehensive treatment of organic chemistry. Focuses on molecular structure, reactivity, stability, scope and mechanisms of organic reactions. Topics include: structure and bonding; theoretical organic chemistry; acidity and basicity; reactive intermediates; pericyclic reactions; stereochemistry; organic synthesis; natural products; organic photochemistry.

Prerequisite: CHEM 51C

Restriction: Chemistry Majors have first consideration for enrollment.

CHEM 127. Inorganic Chemistry II. 4 Units.
Advanced treatment of selected fundamental topics in inorganic chemistry, building on material presented in Chemistry 107. Molecular symmetry with applications to electronic structure and spectroscopy. Reaction kinetics and mechanisms; inorganic synthesis and catalysis; bioinorganic chemistry.

Prerequisite: CHEM 107

Restriction: Chemistry Majors have first consideration for enrollment.

CHEM 128. Introduction to Chemical Biology. 4 Units.
Introduction to the basic principles of chemical biology: structures and reactivity; chemical mechanisms of enzyme catalysis; chemistry of signalling, biosynthesis, and metabolic pathways.

Corequisite: CHEM 128L
Prerequisite: (CHEM 51C or CHEM H52C)

Restriction: Chemistry Majors have first consideration for enrollment.

CHEM 128L. Introduction to Chemical Biology Laboratory Techniques. 3 Units.
Introduction to the basic laboratory techniques of chemical biology: electrophoresis, plasmid preparation, PCR, protein expression, isolation, and kinetics. Materials fee.

Corequisite: CHEM 128

Restriction: Chemistry Majors have first consideration for enrollment.

CHEM 132A. Chemical Thermodynamics, Kinetics, and Dynamics. 4 Units.
Energy, entropy, and the thermodynamic potentials. Chemical equilibrium. Chemical kinetics.

Corequisite: CHEM 5 or MATH 3D
Prerequisite: MATH 2D and (PHYS 7D or PHYS 7E) and (CHEM 5 or (MATH 3D and (EECS 10 or EECS 12 or MAE 10 or ICS 31)))

Overlaps with CHEM 131C.

Restriction: Chemistry Majors have first consideration for enrollment.

CHEM 132B. Quantum Principles, Spectroscopy, and Bonding. 4 Units.
Principles of quantum chemistry with applications to the elements of atomic structure, energy levels, and spectroscopy.

Prerequisite: (CHEM 132A or CBE 40C) and (PHYS 7D or PHYS 7E). CHEM 132A with a grade of C- or better

Restriction: Chemistry Majors have first consideration for enrollment.

CHEM 132C. Molecular Structure and Elementary Statistical Mechanics. 4 Units.
Principles of quantum mechanics with applications to molecular spectroscopy and structure determination, and chemical bonding in simple molecules. Elements of statistical mechanics.

Prerequisite: CHEM 132B

Overlaps with CHEM 131B.

Restriction: Chemistry Majors have first consideration for enrollment.

CHEM 133. Nuclear and Radiochemistry. 4 Units.
Advanced treatment of nuclear structure, nuclear reactions, and radioactive-decay processes. Introduction to nuclear activation analysis, isotope effects, radiation chemistry, hot-atom chemistry, nuclear age-dating methods, nuclear reactors, and nuclear power.

Prerequisite: (CHEM M3C or CHEM 1C or CHEM H2C or CHEM M2C) and MATH 2D

Same as CBE 176.

Restriction: Chemistry Majors have first consideration for enrollment. Chemical Engineering Majors have first consideration for enrollment.

Concurrent with CHEM 233 and CBE 276.

CHEM 133L. Nuclear and Radiochemistry Laboratory. 3 Units.
Practical aspects of production, separation, safe handling, detection, and measurement of radioactive isotopes. Experiments use the UCI nuclear reactor and emphasize uses of radioisotopes in chemistry, engineering, biology, and medicine. Materials fee.

Prerequisite or corequisite: CHEM 133

Restriction: Chemistry Majors have first consideration for enrollment.

CHEM 138. Introduction to Computational Organic Chemistry. 4 Units.
An introduction to the use of computational chemistry to investigate reaction mechanisms, to calculate structures, and to predict properties of molecules. Students have the opportunity to perform calculations employing computational methods which are widely used in various fields of chemistry. Materials fee.

Prerequisite: CHEM 51C

Restriction: Chemistry Majors have first consideration for enrollment.

CHEM 141. Environmental Chemistry. 4 Units.
Processes that control the fate of chemicals in the environment. Chemistry of the atmosphere, hydrosphere, and soils, especially as it pertains to pollutants.

Prerequisite: (CHEM 51C or CHEM H52C) and (MATH 2B or AP Calculus BC). AP Calculus BC with a minimum score of 4

CHEM 145A. Gas-Phase Atmospheric Chemistry. 4 Units.
Sources, chemistry, sinks, and measurements of key atmospheric gaseous species. Chemistry of photochemical oxidant formation, transformation of key inorganic and organic trace gases, and stratospheric ozone cycling. Applications of atmospheric chemistry models to control strategies.

Prerequisite: CHEM 132A and CHEM 132B and CHEM 132C

Concurrent with CHEM 245A.

CHEM 145B. Multi-Phase Atmospheric Chemistry. 4 Units.
Chemical and physical processes leading to the production, aging, and removal of atmospheric particles. Multi-phase processes involving gases, particles, water droplets, and environmental surfaces. Approaches for modeling these processes with applications to control strategies.

Prerequisite: CHEM 145A

Concurrent with CHEM 245B.

CHEM 150. Computational Chemistry. 4 Units.
Basic concepts, methods, and techniques in computational chemistry: density functional and wavefunction theory, molecular property calculations, analysis tools, potential energy surfaces, vibrational effects, molecular dynamics simulations.

Corequisite: CHEM 132A
Prerequisite: MATH 3A and (CHEM 132A or PHYS 113A)

Restriction: Chemistry Majors have first consideration for enrollment.

Concurrent with CHEM 250.

CHEM 150L. Computational Chemistry Laboratory. 4 Units.
Introduction to the practice of modern computational chemistry through a series of advanced computational experiments.

Prerequisite: CHEM 150 and (CHEM 5 or PHYS 50 or EECS 12)

Restriction: Chemistry Majors have first consideration for enrollment.

Concurrent with CHEM 250L.

CHEM 152. Advanced Analytical Chemistry. 5 Units.
In-depth treatment of modern instrumental methods for quantitative analysis of real samples and basic principles of instrument design. Laboratory experiments using spectroscopic, chromatographic, mass spectrometric, and other instrumental methods. Materials fee.

Prerequisite: (CHEM 1C or CHEM M3C or CHEM H2C or CHEM M2C) and (CHEM M3LC or CHEM H2LC)

Restriction: Chemistry Majors have first consideration for enrollment.

CHEM 153. Physical Chemistry Laboratory. 4 Units.
Introduction to the modern experimental approaches and software tools used in spectroscopy, kinetics, electrochemistry, and other physical chemistry experiments. Basics of interfacing with instruments using LabView. Materials fee.

Corequisite: CHEM 132C

Restriction: Chemistry Majors have first consideration for enrollment.

CHEM 156. Advanced Laboratory in Chemistry and Synthesis of Materials. 4 Units.
Modern synthesis and characterization of organic and inorganic materials including polymers, nanomaterials, and biomaterials. State-of-the-art characterization techniques include gel permeation chromatography, dynamic light scattering, thermal analysis, mechanical analysis, electron and scanning probe microscopy, X-ray diffraction, and porosimetry. Materials fee.

Prerequisite: (CHEM 51C or CHEM H52C) and (CHEM 51LC or CHEM H52LC or CHEM M52LC) and (CHEM 131A or CHEM 132B or PHMS 171)

Restriction: Chemistry Majors have first consideration for enrollment.

CHEM 160. Organic Synthesis Laboratory. 4 Units.
Modern experimental techniques in organic synthesis including experience with thin-layer chromatography, liquid chromatography, and gas chromatography. Modern methods of structure elucidation including FT NMR are employed in the characterization of products. Materials fee.

Corequisite: CHEM 100S
Prerequisite: CHEM 51C and CHEM 100S and (CHEM 51LC or CHEM H52LC or CHEM M52LC)

Restriction: Chemistry Majors have first consideration for enrollment.

CHEM 177. Medicinal Chemistry. 4 Units.
An introduction of the basics of drug activity and mechanisms. Strategies used to identify lead compounds such as natural product chemistry, combinatorial chemistry, molecular modeling, and high-through put screening. Relationship of molecular structure to pharmacological activity.

Prerequisite: CHEM 51A and CHEM 51B and CHEM 51C and (BIOL 98 or CHEM 128)

Same as PHMS 177.

Restriction: Pharmaceutical Sciences Majors have first consideration for enrollment.

CHEM 177L. Medicinal Chemistry Laboratory. 3 Units.
An introduction of the basics of drug activity and mechanisms. Strategies used to identify lead compounds such as natural product chemistry, combinatorial chemistry, molecular modeling, and high-through put screening. Relationship of molecular structure to pharmacological activity. Materials fee.

Corequisite: PHRMSCI 177 or CHEM 177.
Prerequisite: CHEM 51A and CHEM 51B and CHEM 51C and BIOL 100 and (BIOL 98 or CHEM 128)

Same as PHMS 177L.

Restriction: Pharmaceutical Sciences Majors have first consideration for enrollment.

(Ib)

CHEM 180. Undergraduate Research. 4 Units.
Research for credit arranged with a faculty member to sponsor and supervise work. Student time commitment of 10 to 15 hours per week is expected, and a written research report is required at the end of each quarter.

Prerequisite or corequisite: CHEM 100S

Repeatability: May be repeated for credit unlimited times.

CHEM 180W. Senior Thesis in Chemistry. 4 Units.
Students receive guidance on preparing research papers, proposals, reports, and other forms of scientific writing in chemistry-related fields; on effectively searching for and using chemical information; and on communicating data in poster and platform presentations.

Prerequisite: CHEM 180 or CHEM 199 or PHYS 195 or ESS 199 or CEMS 199 or CEE 199 or MAE 199 or BIOL 199 or PUBH 199. CHEM 180 with a grade of A or better. CHEM 199 with a grade of A or better. PHYS 195 with a grade of A or better. ESS 199 with a grade of A or better. CEMS 199 with a grade of A or better. CEE 199 with a grade of A or better. MAE 199 with a grade of A or better. BIOL 199 with a grade of A or better. PUBH 199 with a grade of A or better. Consent of the instructor is also accepted. Satisfactory completion of the Lower-Division Writing requirement.

Restriction: Upper-division students only. Chemistry Majors have first consideration for enrollment.

(Ib)

CHEM H180A. Honors Research in Chemistry. 4 Units.
Undergraduate honors research in Chemistry. A student time commitment of 10-15 hours per week is required.

Restriction: Chemistry Honors students only. Campuswide Honors Collegium students only.

CHEM H180B. Honors Research in Chemistry. 4 Units.
Undergraduate honors research in Chemistry. A student time commitment of 10-15 hours per week is required.

Prerequisite: CHEM H180A

Restriction: Campuswide Honors Collegium students only.

CHEM H180C. Honors Research in Chemistry. 4 Units.
Undergraduate honors research in Chemistry. A student time committment of 10-15 hours per week is required.

Prerequisite: CHEM H180B

Restriction: Chemistry Honors students only. Chemistry majors participating in the Campuswide Honors Program students only.

CHEM H181W. Honors Seminar in Chemistry. 2 Units.
Students will receive guidance in the preparation of oral and written research presentations. A written thesis will be prepared and a formal research seminar will be presented.

Corequisite: CHEM H180C
Prerequisite: CHEM H180A and CHEM H180B. Satisfactory completion of the Lower-Division Writing requirement.

(Ib)

CHEM 192. Tutoring in Chemistry. 2 Units.
Enrollment limited to participants in the Chemistry Peer Tutoring Program.

Repeatability: May be taken for credit 9 times.

Restriction: The first eight may be taken for a letter grade. The remaining ten units must be taken Pass/Not Pass only. NOTE: No more than eight units may be counted toward the 180 units required for graduation. Satisfies no degree requirement other than contribution to the 180-unit total.

CHEM 193. Research Methods. 4 Units.
Explores tools of inquiry for developing and implementing science research projects. Students undertake independent projects requiring data collection, analysis, and modeling, and the organization and presentation of results. Additional topics include ethical issues and role of scientific literature.

Prerequisite: BIOL 14 or PS 5

Same as BIOL 108, PHYS 193.

CHEM 197. Professional Internship. .5-4 Units.
Internship program that provides students with opportunity to develop professional skills necessary for competitive placement in their chosen chemical-inspired industry. Students gain new and field-specific skills outside the classroom while participating in a supervised internship.

Prerequisite: Enrollment requires completion of an application form. Student selection is made by a selection committee.

Repeatability: May be taken for credit for 13 units.

Restriction: Upper-division students only. Chemistry Majors only.

CHEM 199. Independent Study in Chemistry. 1-4 Units.
Independent research with Chemistry faculty. Student time commitment of three to four hours per week per unit is expected, and a written report on the independent study is required at the end of each quarter of enrollment.

Repeatability: Unlimited as topics vary.

CHEM 200. Conduct of Research . .5-2 Units.
Introduces new graduate students to ethical conduct of scientific research, mentoring, and current research in the Department of Chemistry.

Repeatability: May be taken for credit 2 times.

CHEM 201. Organic Reaction Mechanisms I. 4 Units.
Advanced treatment of basic mechanistic principles of modern organic chemistry. Topics include molecular orbital theory, orbital symmetry control of organic reactions, aromaticity, carbonium ion chemistry, free radical chemistry, the chemistry of carbenes and carbanions, photochemistry, electrophilic substitutions, aromatic chemistry.

Prerequisite: CHEM 132A and CHEM 132B and CHEM 132C

CHEM 202. Organic Reaction Mechanisms II. 4 Units.
Topics include more in-depth treatment of mechanistic concepts, kinetics, conformational analysis, computational methods, stereoelectronics, and both solution and enzymatic catalysis.

Prerequisite: CHEM 201. CHEM 201 with a grade of B- or better

CHEM 203. Organic Spectroscopy. 4 Units.
Modern methods used in structure determination of organic molecules. Topics include mass spectrometry; ultraviolet, chiroptical, infrared, and nuclear magnetic resonance spectroscopy.

Prerequisite: (CHEM 51A and CHEM 51B and CHEM 51C) or (CHEM H52A and CHEM H52B and CHEM H52C)

Restriction: Graduate students only.

CHEM 204. Organic Synthesis I. 4 Units.
Fundamentals of modern synthetic organic chemistry is developed. Major emphasis is on carbon-carbon bond forming methodology. Topics include carbonyl annelations, cycloadditions, sigmatropic rearrangements, and organometallic methods.

CHEM 205. Organic Synthesis II. 4 Units.
Fundamentals of modern synthetic organic chemistry will be developed. Major emphasis this quarter is on natural product total synthesis and retrosynthetic (antithetic) analysis.

Prerequisite: CHEM 204. CHEM 204 with a grade of B- or better

CHEM 206. Advanced Data Acquisition and Analysis. 4-6 Units.
Introduces students to a variety of practical laboratory techniques, including lock-in, boxcar, coincidence counting, noise filtering, PID control, properties of common transducers, computer interfacing to instruments, vacuum technology, laboratory safety, basic mechanical design, and shop skills. Materials fee.

Same as PHYS 206.

Concurrent with PHYS 106.

CHEM 207. Applied Physical Chemistry. 4 Units.
Introduction to fundamental concepts in molecular structure and reactivity: theory of bonding, valence and molecular orbitals; structure and reactivity in inorganic chemistry; elements in molecular group theory; nomenclature in organic chemistry; and survey of macromolecules.

Same as PHYS 207.

CHEM 208. Math Methods. 4 Units.
Applications of mathematics to physical and chemical problems. Calculus of special functions, complex variables and vectors; linear vector spaces and eigenvalue problems. Differential equations.

Same as PHYS 208.

CHEM 213. Chemical Kinetics. 4 Units.
Surveys gas phase and organic reaction mechanisms and their relationship to kinetic rate laws; treats the basic theory of elementary reaction rates. A brief presentation of modern cross-sectional kinetics is included.

Prerequisite: CHEM 132A and CHEM 132B and CHEM 132C

CHEM 215. Inorganic Chemistry I. 4 Units.
Principles of modern inorganic chemistry with applications to chemical systems of current interest. Inorganic phenomena are organized into general patterns which rationalize observed structures, stabilities, and physical properties.

Prerequisite: CHEM 107 and CHEM 132A and CHEM 132B and CHEM 132C

Restriction: Graduate students only.

CHEM 216. Organometallic Chemistry. 4 Units.
Synthesis and reactivity of organometallic complexes with an emphasis on mechanisms. Topics include bonding and fluxional properties; metal-carbon single and multiple bonds; metal š-complexes. Applications to homogenous catalysis and organic synthesis are incorporated throughout the course.

Prerequisite: CHEM 107 or CHEM 215. CHEM 215 with a grade of B- or better

CHEM 217. Physical Inorganic Chemistry. 4 Units.
General principles of the spectroscopy and magnetism of inorganic compounds. Characterization of inorganic complexes by infrared, near-infrared, visible, ultraviolet, NMR, EPR, EXAFS, and Mossbauer spectroscopies. Some necessary group theory developed.

Prerequisite: CHEM 215. CHEM 215 with a grade of B- or better

CHEM 218. Metallobiochemistry . 4 Units.
A review of the biochemistry of metallic elements emphasizing: methods for studying metals in biological systems; the chemical basis for nature's exploitation of specific elements; structures of active sites; mechanisms; solid-state structures and devices; metals in medicine.

Prerequisite or corequisite: CHEM 131C or CHEM 132C

Same as MBB 248.

CHEM 219. Chemical and Structural Biology. 4 Units.
A survey of the organic chemistry underlying biological function. Introduction to chemical genetics, receptor-ligand interactions, small molecule agonists and antagonists, combinatorial synthesis, high throughput assays, molecular evolution, protein and small molecule design.

Restriction: Graduate students only.

CHEM 220. Advanced Chemical Biology. 4 Units.
Modern topics in chemical biology, with an emphasis on application of principles from organic chemistry to biological research and biotechnology. Topics include methods to generate, identify, and manipulate major classes of biomolecules including nucleic acids, carbohydrates, lipids, and secondary metabolites.

Prerequisite: CHEM 219. CHEM 219 with a grade of B- or better

Restriction: Graduate students only.

CHEM 221A. Fundamentals of Molecular Biophysics. 4 Units.
An overview of the principles and concepts in molecular biophysics. Topics covered include energy and entropy in biology, non-equilibrium reaction kinetics, random walks and molecular diffusion, molecular forces in biology.

Prerequisite: Undergraduate courses in physical chemistry and biochemistry.

Repeatability: May be taken for credit 3 times.

CHEM 223. Biological Macromolecules. 4 Units.
Introduction to nucleic acid and protein structure, dynamics, and function. Topics include analytical methods, molecular evolution, folding, and catalysis.

Same as PHMS 223.

CHEM 225. Polymer Chemistry: Synthesis and Characterization of Polymers. 4 Units.
Structure of synthetic and natural polymers. Survey of modern polymer synthetic methods. Molecular weight and molecular weight distribution. Chain conformation and stereochemistry. Introduction to polymer characterization, chain models, and solution behavior.

Prerequisite: Undergraduate courses in organic and physical chemistry.

CHEM 228. Electromagnetism. 4 Units.
Maxwell’s equations, electrodynamics, electromagnetic waves and radiation, wave propagation in media, interference and quantum optics, coherent and incoherent radiation, with practical applications in interferometry, lasers, waveguides, and optical instrumentation.

Same as PHYS 228.

CHEM 229A. Mathematical Methods for the Physical Sciences. 4 Units.
Mathematical and numerical analysis using Mathematica and C programming, as applied to problems in physical science.

Same as PHYS 229A.

Concurrent with PHYS 100.

CHEM 230. Classical Mechanics and Electromagnetic Theory. 4 Units.
Fundamentals of classical mechanics and electromagnetic theory are developed with specific application to molecular systems. Newtonian, Lagrangian, and Hamiltonian mechanics are developed. Boundary value problems in electrostatics are investigated. Multipole expansion and macroscopic media are discussed from a molecular viewpoint.

Prerequisite: CHEM 132A and CHEM 132B and CHEM 132C

CHEM 231A. Fundamentals of Quantum Mechanics. 4 Units.
The postulates of quantum mechanics are discussed and applied to a variety of model problems.

Prerequisite: CHEM 131A and CHEM 131B and CHEM 131C

CHEM 231B. Applications of Quantum Mechanics. 4 Units.
Approximate methods for solving atomic and molecular structure problems are developed, and the application of quantum mechanics to spectroscopy is introduced.

Prerequisite: CHEM 231A. CHEM 231A with a grade of B- or better

CHEM 231C. Molecular Spectroscopy. 4 Units.
Theory and techniques of spectroscopy as used for the study of molecular and condensed phase properties. Coherent time domain spectroscopies are covered.

Prerequisite: CHEM 231B. CHEM 231B with a grade of B- or better

CHEM 232A. Thermodynamics and Introduction to Statistical Mechanics. 4 Units.
A detailed discussion from an advanced point of view of the principles of classical thermodynamics. The fundamentals of statistical mechanics. Topics include an introduction to ensemble theory, Boltzmann statistics, classical statistical mechanics, and the statistical mechanics of ideal gas systems.

Prerequisite: CHEM 131A and CHEM 131B and CHEM 131C

CHEM 232B. Advanced Topics in Statistical Mechanics. 4 Units.
Continued discussion of the principles of statistical mechanics. Applications to topics of chemical interest including imperfect gases, liquids, solutions, and crystals. Modern techniques such as the use of autocorrelation function methods.

Prerequisite: CHEM 232A. CHEM 232A with a grade of B- or better

CHEM 232C. Non-Equilibrium Statistical Mechanics. 4 Units.
Phenomenology of material processes, including: kinetic theories of transport and continuum, linear response theory, critical phenomena of phase transition, self-assembly, and nucleation.

CHEM 233. Nuclear and Radiochemistry. 4 Units.
Advanced treatment of nuclear structure, nuclear reactions, and radioactive-decay processes. Introduction to nuclear activation analysis, isotope effects, radiation chemistry, hot-atom chemistry, nuclear age-dating methods, nuclear reactors, and nuclear power.

Same as CBE 276.

Restriction: Graduate students only.

Concurrent with CHEM 133 and CBE 176.

CHEM 237. Mathematical Methods in Chemistry. 4 Units.
Survey of essential math methods in chemistry. Topics may include series and limits, complex analysis, Fourier and Laplace transforms, linear algebra and operators (theory and algorithms), differential equations, and probability concepts for stochastic processes.

CHEM 238. Special Topics in Density Functional Theory . 1-4 Units.
Advanced topics in density functional theory.

Prerequisite: One year of graduate quantum mechanics, or the equivalent.

Repeatability: Unlimited as topics vary.

Restriction: Graduate students only.

CHEM 239. Machine Learning in Chemistry. 4 Units.
Introductory course in machine learning, accessible to any graduate student in chemistry. Covers the basics of theory and practice of machine learning in modern chemistry. No coding or previous experience required.

Prerequisite: Must be familiar with standard computer operation.

Restriction: Graduate students only.

CHEM 241. Current Issues Related to Air Quality, Climate, and Energy. 4 Units.
Current issues related to the atmosphere, climate, and air quality in the context of energy conversion and sustainability. Topics include transportation systems; building design; impacts on humans and ecosystems; modeling and meteorology; economics; and application to public policies.

Prerequisite: MAE 261 or CHEM 245 or ESS 240. MAE 261 with a grade of B- or better. CHEM 245 with a grade of B- or better. ESS 240 with a grade of B- or better

Same as MAE 260.

Restriction: Graduate students only.

CHEM 243. Advanced Instrumental Analysis. 4 Units.
Theory and applications of modern advanced instrumental methods of analysis. Includes data acquisition, storage, retrieval, and analysis; Fourier transform methods; vacuum technologies; magnetic sector; quadrupole and ion trap mass spectrometry; surface science spectroscopic methods; lasers and optics.

Prerequisite: CHEM 152 and CHEM 132C. CHEM 152 with a grade of B or better. CHEM 132C with a grade of B or better

CHEM 244. Detection and Measurement of Radiation. 4 Units.
Basic principles of detection and measurement of ionizing radiation; both theory and practical aspects of measurement techniques for alpha, beta, gamma, and neutron radiation, properties of different detector materials, electronics and data treatments, and analysis.

Prerequisite: CHEM 233 or CBE 276. CHEM 233 with a grade of B- or better. CBE 276 with a grade of B- or better

Same as CBE 277.

Restriction: Graduate students only.

CHEM 245A. Gas-Phase Atmospheric Chemistry. 4 Units.
Sources, chemistry, sinks, and measurements of key atmospheric gaseous species. Chemistry of photochemical oxidant formation, transformation of key inorganic and organic trace gases, and stratospheric ozone cycling. Applications of atmospheric chemistry models to control strategies.

Prerequisite: CHEM 132A and CHEM 132B and CHEM 132C

Concurrent with CHEM 145A.

CHEM 245B. Multi-Phase Atmospheric Chemistry. 4 Units.
Chemical and physical processes leading to the production, aging, and removal of atmospheric particles. Multi-phase processes involving gases, particles, water droplets, and environmental surfaces. Approaches for modeling these processes with applications to control strategies.

Prerequisite: CHEM 245A. CHEM 245A with a grade of B- or better

Concurrent with CHEM 145B.

CHEM 245C. Special Topics in Atmospheric Chemistry. 4 Units.
The subjects covered vary from year to year.

Prerequisite: CHEM 245B. CHEM 245B with a grade of B- or better

Repeatability: Unlimited as topics vary.

CHEM 246. Separations and Chromatography. 4 Units.
Introduction to modern separation techniques such as gas chromatography, high-performance liquid chromatography, supercritical fluid chromatography, capillary electrophoresis, and field flow fractionation. Applications of these separation strategies are discussed.

CHEM 248. Electrochemistry. 4 Units.
Fundamentals of electrochemistry including thermodynamics and the electrochemical potential, charge transfer kinetics, and mass transfer. Methods based on controlled potential and controlled current are described; the effects of slow heterogeneous kinetics and the perturbation caused by homogeneous chemistry are discussed.

CHEM 249. Analytical Spectroscopy. 4 Units.
Advanced treatment of spectroscopic techniques and instrumentation. Atomic and molecular absorption, emission, and scattering processes and their application to quantitative chemical analysis are outlined. Puts different spectroscopic techniques in perspective and demonstrates most appropriate applications to analytical problems.

CHEM 250. Computational Chemistry. 4 Units.
Basic concepts, methods, and techniques in computational chemistry: density functional and wavefunction theory, molecular property calculations, analysis tools, potential energy surfaces, vibrational effects, molecular dynamics simulations.

Restriction: Graduate students only.

Concurrent with CHEM 150.

CHEM 250L. Computational Chemistry Laboratory. 4 Units.
Introduction to the practice of modern computational chemistry through a series of advanced computational experiments.

Prerequisite: CHEM 250. CHEM 250 with a grade of B- or better

Restriction: Graduate students only.

Concurrent with CHEM 150L.

CHEM 251. Special Topics in Organic Chemistry. 1-4 Units.
Advanced topics in organic chemistry.

Repeatability: Unlimited as topics vary.

CHEM 252. Special Topics in Physical Chemistry. 1-4 Units.
Advanced topics in physical chemistry. Materials fee.

Repeatability: Unlimited as topics vary.

CHEM 254. Special Topics in Computational and Theoretical Chemistry. 4 Units.
Subjects covered vary from year to year.

Repeatability: Unlimited as topics vary.

CHEM 255. Special Topics in Quantum Science. 1 Unit.
Advanced topics in quantum science.

Repeatability: Unlimited as topics vary.

Restriction: Graduate students only.

CHEM 263. Materials Chemistry . 4 Units.
An introduction to crystalline solids, descriptive crystal chemistry, solid-state synthesis and characterization techniques, x-ray and electron diffraction, phase diagrams, electronic band structure of extended solids, semi conductors, and nanoscale inorganic materials.

CHEM 264. Analytical Methods for Organic Nanomaterials. 4 Units.
Fundamentals of analytical techniques related to measuring the structure and dynamics of organic nanomaterials. Topics include transmission electron microscopy, cryo-electron microscopy, liquid phase electron microscopy, scanning electron microscopy, atomic force microscopy, light scattering, small angle X-ray, and neutron scattering.

Restriction: Graduate students only.

CHEM 266. Current Topics in Chemical, Applied, and Materials Physics. 1 Unit.
The subjects covered vary from year to year. Connection between fundamental principles and implementations in practice in science, industry, and technology.

Repeatability: May be repeated for credit unlimited times.

Same as PHYS 266.

CHEM 267. Photochemistry. 4 Units.
Photochemical and photovoltaic processes in molecules and semiconductors; quantum mechanics; statistical thermodynamics; kinetics; and experimental techniques relevant to photon absorption and emission; photochemical charge separation, recombination, and transport of electrons and ions; and interfacial redox chemistry.

Restriction: Seniors only. Graduate students only.

CHEM 273. Technical Communication Skills. 2 Units.
Development of effective communication skills, oral and written presentations, through examples and practice.

Grading Option: Satisfactory/unsatisfactory only.

Same as PHYS 273.

CHEM 280. Research. 2-12 Units.
Supervised original research toward the preparation of a Ph.D dissertation or M.S. thesis.

Repeatability: May be repeated for credit unlimited times.

Restriction: Graduate students only.

CHEM 290. Seminar. 1 Unit.
Weekly seminars and discussions on general and varied topics of current interest in chemistry.

Repeatability: May be repeated for credit unlimited times.

Restriction: Graduate students only.

CHEM 291. Research Seminar. 4 Units.
Detailed discussion of research problems of current interest in the Department. Format, content, and frequency of the course are variable.

Repeatability: Unlimited as topics vary.

Restriction: Graduate students only.

CHEM 292. Graduate Symposium. 2 Units.
Students present public seminars on literature-based research topics in contemporary chemistry. Topics to be chosen by student and approved by instructor.

Grading Option: Satisfactory/unsatisfactory only.

Repeatability: May be repeated for credit unlimited times.

CHEM 299. Independent Study. 1-4 Units.
Independent research with Chemistry faculty.

Repeatability: May be repeated for credit unlimited times.

Restriction: Graduate students only.

CHEM 399. University Teaching. 1-4 Units.
Required of and limited to Teaching Assistants.

Grading Option: Satisfactory/unsatisfactory only.

Repeatability: May be repeated for credit unlimited times.

Earth System Science Courses

EARTHSS 1. Introduction to Earth System Science. 4 Units.
Covers the origin and evolution of the Earth, its atmosphere, and oceans, from the perspective of biogeochemical cycles, energy use, and human impacts on the Earth system.

(II and VA).

EARTHSS 3. Oceanography. 4 Units.
Examines circulation of the world oceans and ocean chemistry as it relates to river, hydrothermal vent, and atmospheric inputs. Geological features, the wide variety of biological organisms, and global climate changes, such as greenhouse warming, are also studied.

(II and Va).

EARTHSS 5. The Atmosphere. 4 Units.
The composition and circulation of the atmosphere with a focus on explaining the fundamentals of weather and climate. Topics include solar and terrestrial radiation, clouds, and weather patterns.

(II and VA).

EARTHSS 7. Physical Geology. 4 Units.
Introduction to Earth materials and processes. Topics include rocks and minerals, plate tectonics, volcanoes, earthquakes, Earth surface processes, Earth resources, geologic time, and Earth history. Laboratory work involves hands-on study of geologic materials, maps, and exercises pertaining to geologic processes. Materials fee.

(II and VA).

EARTHSS 15. Introduction to Global Climate Change. 4 Units.
Introduction of scientific, technological, environmental, economic, and social aspects underlying the threat and understanding of global climate change. Human and natural drivers of climate. Impacts of climate on natural, managed, and human systems, including their vulnerability and ability to adapt.

(II and (VA or VIII)).

EARTHSS 17. Hurricanes, Tsunamis, and Other Catastrophes. 4 Units.
Introduction to the basic science and state of predictability of various natural catastrophic events including earthquakes, volcanic eruptions, tsunamis, landslides, floods, hurricanes, fires, and asteroid impacts and their interactions and implications with human society in the U.S. and globally.

Overlaps with PUBHLTH 90.

(II and (VA or VIII)).

EARTHSS 19. Introduction to Modeling the Earth System. 4 Units.
Simulate the Earth's system using computer models. Covers the interaction of the air, land, and ocean, and explores how changes to one part of the environment affect the complete Earth system. Utilizes technological tools to understand scientific principles.

(II and Vb).

EARTHSS 21. On Thin Ice: Climate Change and the Cryosphere. 4 Units.
Introduction of the basic science that governs the cryosphere and its interaction with the climate system. Covers some of the significant economic, sociological, and political consequences of the recent melting of the cryosphere driven by anthropogenic climate change.

(II and (VA or VIII)).

EARTHSS 23. Air Pollution: From Urban Smog to Global Change . 4 Units.
Air pollution occurs on regional to global scales. A wide range of air pollution sources and physical, chemical, and meteorological sciences behind air pollution are introduced. The consequences of air pollution to our society are also discussed.

(II and (VA or VIII)).

EARTHSS 40A. Earth System Chemistry. 4 Units.
To understand the cycling of matter on Earth, we need to learn about the chemistry of elements and molecules in the environment. Introduces students to the understanding of how chemical principles apply in context to their everyday lives.

Restriction: Environmental Science and Policy Majors have first consideration for enrollment. Environmental Science Majors have first consideration for enrollment.

(II and VA).

EARTHSS 40B. Earth System Biology. 4 Units.
Earth System Science is a highly interdisciplinary field that requires knowledge of various components of the Earth as a system, including the biosphere. Students are introduced to several fundamental principles of biology, from the smallest cells to the largest ecosystems.

Restriction: Environmental Science and Policy Majors have first consideration for enrollment. Environmental Science Majors have first consideration for enrollment.

(II)

EARTHSS 40C. Earth System Physics. 4 Units.
Covers the fundamental physical forces and laws that affect the Earth system, such as electromagnetic radiation and energy transfer, atmospheric and ocean dynamics. Also covers aspects of physics related to environmental issues, such as electricity generation and transmission.

Restriction: Environmental Science and Policy Majors have first consideration for enrollment. Environmental Science Majors have first consideration for enrollment.

(II and VA).

EARTHSS 45. New Student Seminar. 1 Unit.
Weekly meetings led by faculty, current students, and staff, to provide information on the Department of Earth System Science, campus resources, and special programs and opportunities. Designed for students who recently joined the Earth System Science and Environmental Science majors.

Grading Option: Pass/no pass only.

Restriction: Environmental Science Majors have first consideration for enrollment. Earth System Science Majors have first consideration for enrollment. New students only (freshman, transfer, and change of major).

EARTHSS 51. Land Interactions. 4 Units.
The role of terrestrial processes in the Earth system. Provides an introduction to ecosystem processes that regulate the cycling of energy, water, carbon, and nutrients. Analysis of the impact of human activities. Materials fee.

Corequisite: CHEM 1C

Restriction: Environmental Science Majors have first consideration for enrollment. Earth System Science Majors have first consideration for enrollment.

EARTHSS 53. Ocean Biogeochemistry. 4 Units.
Overview of oceanography for those interested in Earth System Science. Focus is on physical, chemical, and biological processes that drive biogeochemical cycling in the oceans. Coastal systems are also reviewed, with an emphasis on California waters.

Prerequisite: CHEM 1C

Restriction: Earth System Science Majors have first consideration for enrollment. Environmental Science Majors have first consideration for enrollment.

EARTHSS 55. Earth's Atmosphere. 4 Units.
Composition, physics, and circulation of Earth's atmosphere with an emphasis on explaining the role of atmospheric processes in shaping the climate system. Topics include atmospheric composition, the global energy balance, radiative transfer and climate, atmospheric circulation, and climate sensitivity.

Corequisite: PHYSICS 3B or PHYSICS 7C
Prerequisite: (MATH 2B or MATH 5B) and (PHYSICS 3B or PHYSICS 7C)

Restriction: Earth System Science Majors have first consideration for enrollment. Environmental Science Majors have first consideration for enrollment.

EARTHSS 70A. Sustainable Energy Systems. 4 Units.
Addresses how modern energy services can be provided sustainably and the challenges and barriers that must be overcome. Major environmental issues are discussed, such as climate change, air pollution, and resource demands.

Prerequisite or corequisite: EARTHSS 40C or PHYSICS 3C or PHYSICS 7E

Restriction: Environmental Science and Policy Majors have first consideration for enrollment. Environmental Science Majors have first consideration for enrollment. Earth System Science Majors have first consideration for enrollment.

EARTHSS 70B. Sustainable Food and Water Systems. 4 Units.
Explores the biophysical underpinnings of food production, the history of agricultural development, and a range of environmental issues facing agricultural systems, including water management, climate change, and land use.

Corequisite: EARTHSS 40B
Prerequisite: EARTHSS 40B or (BIO SCI 93 and BIO SCI 94)

Restriction: Earth System Science Majors have first consideration for enrollment. Environmental Science Majors have first consideration for enrollment. Environmental Science and Policy Majors have first consideration for enrollment.

EARTHSS 100. Special Topics in Earth System Science. 1-4 Units.
Devoted to current topics in the field of Earth System Science. Topics addressed vary each quarter.

Prerequisite: (EARTHSS 51 and EARTHSS 53 and EARTHSS 55) or (EARTHSS 70A and EARTHSS 70B)

Repeatability: May be taken for credit for 12 units as topics vary.

Restriction: Environmental Science and Policy Majors have first consideration for enrollment. Earth System Science Majors have first consideration for enrollment.

EARTHSS 112. Global Climate Change and Impacts. 4 Units.
Observations over the 20th century show extensive changes in atmospheric composition, climate and weather, and biological systems that have paralleled industrial growth. Evidence of globally driven changes in these biogeochemical systems is studied, including projected impacts over the 21st century.

Prerequisite: (EARTHSS 51 and EARTHSS 53 and EARTHSS 55) or (EARTHSS 70A and EARTHSS 70B)

Restriction: Environmental Science and Policy Majors have first consideration for enrollment. Environmental Science Majors have first consideration for enrollment. Earth System Science Majors have first consideration for enrollment.

EARTHSS 114. Earth System Science Laboratory and Field Methods. 4 Units.
Introduction to methods used to measure exchange of gases and energy between the atmosphere and terrestrial ecosystems. Laboratories include data acquisition and isotopic and chromatographic analysis. Field measurements at UCI's Marsh Reserve include microclimate, hydrology, trace-gas exchange, and plant growth. Materials fee.

Prerequisite: (EARTHSS 51 and EARTHSS 53 and EARTHSS 55) or (EARTHSS 70A and EARTHSS 70B)

Restriction: Environmental Science and Policy Majors have first consideration for enrollment. Environmental Science Majors have first consideration for enrollment. Earth System Science Majors have first consideration for enrollment.

EARTHSS 115. Aquatic Field Methods. 4 Units.
Students design sampling plans, conduct field research techniques, and carry out data analyses that are relevant to aquatic field research. Aquatic field sites covered in the course include marine, estuarine, and fluvial systems. Materials fee.

Prerequisite: (EARTHSS 51 and EARTHSS 53 and EARTHSS 55) or (EARTHSS 70A and EARTHSS 70B)

Restriction: Environmental Science and Policy Majors have first consideration for enrollment. Environmental Science Majors have first consideration for enrollment. Earth System Science Majors have first consideration for enrollment.

EARTHSS 116. Introduction to Environmental Data Science. 4 Units.
Analysis and interpretation of geophysical data, including functional fitting, probability density functions, and multidimensional time-series methods, with applications in atmospheric, oceanic, and biogeochemical sciences.

Prerequisite: (EARTHSS 51 and EARTHSS 53 and EARTHSS 55) or (EARTHSS 70A and EARTHSS 70B)

Restriction: Environmental Science and Policy Majors have first consideration for enrollment. Environmental Science Majors have first consideration for enrollment. Earth System Science Majors have first consideration for enrollment.

EARTHSS 118. Analysis, Modeling, and Visualization of Multidimensionnal Environmental Data. 4 Units.
Students learn programming and numerical methods in Python with applications in Earth System Science and ecology. Topics include regression, uncertainty and significance, the development of simple box models, and the visualization of multi-dimensional climate and satellite datasets.

Prerequisite: I&C SCI 31 or EARTHSS 116

Restriction: Environmental Science and Policy Majors have first consideration for enrollment. Environmental Science Majors have first consideration for enrollment. Earth System Science Majors have first consideration for enrollment.

EARTHSS 122. Atmospheric Dynamics. 4 Units.
Fluid dynamical processes that determine the large-scale flow of the atmosphere and ocean. Most important are interactions between the density stratification and the Coriolis force associated with Earth's rotation. Topics include circulation, vorticity, planetary waves, and their role in climate.

Prerequisite: EARTHSS 55 and (PHYSICS 7C or PHYSICS 3B)

Restriction: Environmental Science Majors have first consideration for enrollment. Earth System Science Majors have first consideration for enrollment.

EARTHSS 124. Weather Analysis. 4 Units.
Provides an overview of weather systems in midlatitudes and tropics. The fundamental dynamics possible for these weather systems are described. Elementary weather analysis and forecasting techniques are introduced.

Prerequisite: EARTHSS 55 or EARTHSS 40C or (PHYSICS 3A and PHYSICS 3B and PHYSICS 3C) or (PHYSICS 7C and PHYSICS 7E)

Restriction: Earth System Science Majors have first consideration for enrollment. Environmental Science Majors have first consideration for enrollment.

EARTHSS 130. Physical Oceanography. 4 Units.
Physical processes that determine the distribution of water properties such as salt and temperature. Fluid-dynamical underpinnings of physical oceanography. Wave motions. The wind-driven and thermohaline circulation. Similarities and differences between ocean and atmosphere dynamics.

Prerequisite: (PHYSICS 7C or PHYSICS 3B) and EARTHSS 53

Restriction: Earth System Science Majors have first consideration for enrollment.

EARTHSS 132. Terrestrial Hydrology. 4 Units.
Comprehensive treatment of modern conceptual and methodological approaches to hydrological science. Combines qualitative understanding of hydrological processes with quantitative representation, approaches to measurement, and treatment of uncertainty. Components of the hydrological cycle and their linkages within the coupled Earth system.

Prerequisite: (EARTHSS 51 and EARTHSS 55) or (EARTHSS 40C and EARTHSS 70B)

Restriction: Environmental Science and Policy Majors have first consideration for enrollment. Environmental Science Majors have first consideration for enrollment. Earth System Science Majors have first consideration for enrollment.

EARTHSS 133. Soil: It's the Good Dirt. 4 Units.
An introduction to the critical role soils play in sustaining land ecosystems and humans. Covers how soils form and how human actions contribute to the pollution and loss but also the health and productivity of soils.

Prerequisite: (EARTHSS 51 and EARTHSS 53 and EARTHSS 55) or (EARTHSS 70A and EARTHSS 70B)

Restriction: Environmental Science and Policy Majors only. Environmental Science Majors only. Earth System Science Majors only.

EARTHSS 134. Fundamentals of GIS for Environmental Science. 5 Units.
Introduction to Geographic Information Systems (GIS). Topics include fundamentals of cartography, creating/editing GIS data, linking spatial and tabular data, georeferencing, map projections, geospatial analysis, spatial statistics, and the development of GIS models. Examples from hydrology, ecology, and geology.

Prerequisite: (EARTHSS 51 and EARTHSS 53) or (EARTHSS 70A and EARTHSS 70B)

Restriction: Environmental Science and Policy Majors have first consideration for enrollment. Earth System Science Majors have first consideration for enrollment.

EARTHSS 138. Satellite Remote Sensing for Earth System Science. 4 Units.
Satellite remote sensing data are increasingly used to study the Earth system. Provides an overview of the principles behind remote sensing, and the types of satellite data available for study of the oceans, land, and atmosphere.

Prerequisite: (EARTHSS 51 and EARTHSS 53) or (EARTHSS 70A and EARTHSS 70B)

Restriction: Environmental Science and Policy Majors have first consideration for enrollment. Environmental Science Majors have first consideration for enrollment. Earth System Science Majors have first consideration for enrollment.

EARTHSS 140. Advanced Geology. 4 Units.
Introduces students to the geological processes which have formed and continue to shape the Earth. Topics include geological time, minerals and the rock cycle, plate tectonics and associated geological hazards, earth resources, and earth surface processes. Materials fee.

Prerequisite: EARTHSS 51 or EARTHSS 70B

Overlaps with EARTHSS 7.

Restriction: Environmental Science and Policy Majors have first consideration for enrollment. Environmental Science Majors have first consideration for enrollment. Earth System Science Majors have first consideration for enrollment.

EARTHSS 141. Air Quality Management. 4 Units.
Fundamental science and terminology of regional air quality issues and developing and implementing the strategies used to prevent and mitigate air pollution impacts. Topics include setting regional air quality goals, applying measurements and numerical models, cost/benefits analysis, evaluation and enforcement.

Prerequisite: EARTHSS 40A and EARTHSS 40B and EARTHSS 40C

Restriction: Environmental Science and Policy Majors have first consideration for enrollment.

EARTHSS 142. Atmospheric Chemistry. 4 Units.
Chemistry of the troposphere and stratosphere. Topics include processes controlling the lifetime and reaction pathways of chemicals in the atmosphere, the role of the atmosphere in biogeochemical cycles, and interactions between atmospheric chemistry and the physical climate system.

Prerequisite: (CHEM 1C or CHEM M2C or CHEM H2C or CHEM M3C) and (PHYSICS 3C or PHYSICS 7E) and (MATH 2B or MATH 5B or AP Calculus BC). AP Calculus BC with a minimum score of 4

Restriction: Earth System Science Majors have first consideration for enrollment. Environmental Science Majors have first consideration for enrollment.

EARTHSS 144. Marine Geochemistry and Biogeochemistry. 4 Units.
Processes controlling the major and minor element composition of seawater and element distributions in the ocean. Gas exchange, carbon dioxide system, stable isotopes, radionuclides as tracers and chronometers, particle fluxes, organic geochemistry, sediment geochemistry, global cycles of biogeochemically important elements.

Prerequisite: EARTHSS 53 or CHEM 51C

Restriction: School of Physical Sciences students have first consideration for enrollment. Environmental Science Majors have first consideration for enrollment. Earth System Science Majors have first consideration for enrollment.

EARTHSS 146. Consequences of Air Pollution. 4 Units.
From public health to the global climate system, this course explores the impacts of air pollution from the beginning of human history to current and emerging issues. Scientific concepts behind air pollution and solutions are discussed.

Prerequisite: (EARTHSS 51 and EARTHSS 53 and EARTHSS 55) or (EARTHSS 40C and EARTHSS 70A)

Restriction: Environmental Science and Policy Majors have first consideration for enrollment. Environmental Science Majors have first consideration for enrollment. Earth System Science Majors have first consideration for enrollment.

EARTHSS 148. Marine Ecosystems and Global Change. 4 Units.
Presents an overview of marine ecosystem structure, diversity, and processes in the context of global change, including the impacts of climate warming, ocean acidification, marine fisheries, and anthropogenic additions of nutrients and pollutants.

Prerequisite: EARTHSS 53 or (EARTHSS 70A and EARTHSS 70B)

Restriction: Environmental Science and Policy Majors have first consideration for enrollment. Environmental Science Majors have first consideration for enrollment. Earth System Science Majors have first consideration for enrollment.

Concurrent with EARTHSS 248.

EARTHSS 154. Ecosystem Services. 4 Units.
Covers what ecosystem services are, how to classify them, what the impacts of land degradation are on ecosystem services, how to quantify and value them, and the importance of mainstreaming ecosystem services in decision-making.

Prerequisite: (EARTHSS 70A and EARTHSS 70B) or (EARTHSS 51 and EARTHSS 53 and EARTHSS 55)

EARTHSS 156. The Future of Forests. 4 Units.
Introduces students to the determinants of global forest distribution; ecosystem services associated with forest functioning; threats to forests resulting from climate and land-use change; and, opportunities for conserving natural forests in the near future.

Prerequisite: (EARTHSS 70A and EARTHSS 70B) or (EARTHSS 51 and EARTHSS 53 and EARTHSS 55)

Restriction: Environmental Science and Policy Majors have first consideration for enrollment. Earth System Science Majors have first consideration for enrollment.

EARTHSS 162. The Impact of Climate Change on California's Landscape. 4 Units.
Overview of anticipated impacts of climate change on California's landscape. Includes projections of future climate; anticipated impacts on ecology, hydrology, wildfire, coastal environment, and agriculture; and efforts to reduce greenhouse gas emissions or adapt to climate change through land management.

Prerequisite: (EARTHSS 51 and EARTHSS 53 and EARTHSS 55) or (EARTHSS 70A and EARTHSS 70B)

Restriction: Environmental Science and Policy Majors have first consideration for enrollment. Environmental Science Majors have first consideration for enrollment. Earth System Science Majors have first consideration for enrollment.

EARTHSS 164. Ecosystem Ecology. 4 Units.
A mechanistic perspective on ecosystem processes. Covers ecosystem development, element cycling, and interactions with plants and microbes. The role of ecosystems in environmental change is also addressed.

Prerequisite: BIO SCI E106 or EARTHSS 51 or EARTHSS 60A or CHEM 51C

Same as BIO SCI E118.

Restriction: Earth System Science Majors have first consideration for enrollment. Ecology and Evolutionary Biol Majors have first consideration for enrollment. Environmental Science Majors have first consideration for enrollment.

EARTHSS 168. Physiological Plant Ecology. 4 Units.
An examination of the interactions between plants and their environment. Emphasis on the underlying physiological mechanisms of plant function, adaptations and responses to stress, and the basis of the distribution of plants and plant assemblages across the landscape.

Prerequisite: EARTHSS 51 or BIO SCI 94 or (EARTHSS 60A and EARTHSS 60C)

Same as BIO SCI E127.

Restriction: Biological Sciences Majors have first consideration for enrollment. Environmental Science Majors have first consideration for enrollment. Earth System Science Majors have first consideration for enrollment.

EARTHSS 171. Microbial Biogeochemistry. 4 Units.
Develops an understanding of microorganisms in the context of their environment, environmental impact, and role in the global cycles of C,N,P, etc. Focuses on tools used to evaluate microbial diversity and function, and applications of microbial ecology.

Prerequisite: (EARTHSS 51 and EARTHSS 53 and EARTHSS 55) or (EARTHSS 70A and EARTHSS 70B)

Restriction: Environmental Science and Policy Majors only. Environmental Science Majors only. Earth System Science Majors only.

EARTHSS 176W. Marine Conservation, Policy, and Society. 4 Units.
Conservation of marine ecosystems is important yet challenging due to competing physical, ecological, social, and regulatory issues. Students explore the principles of marine conservation, the scientific basics of marine ecosystems, and political and social processes involved with resource protection.

Prerequisite: (EARTHSS 51 and EARTHSS 53 and EARTHSS 55) or (EARTHSS 70A and EARTHSS 70B). Satisfactory completion of the Lower-Division Writing requirement.

Restriction: Upper-division students only. Environmental Science and Policy Majors have first consideration for enrollment. Environmental Science Majors have first consideration for enrollment. Earth System Science Majors have first consideration for enrollment.

(Ib)

EARTHSS 177W. Documenting and Understanding Earth System Change. 4 Units.
Students select a time series of key environmental interest as the focus for their writing.They become familiar with common writing practices for the Earth Sciences, and exercise their ability to use the scientific method to produce reports.

Prerequisite: (EARTHSS 51 and EARTHSS 53 and EARTHSS 55) or (EARTHSS 70A and EARTHSS 70B). Satisfactory completion of the Lower-Division Writing requirement.

Restriction: Upper-division students only. Environmental Science and Policy Majors only. Environmental Science Majors only. Earth System Science Majors only.

(Ib)

EARTHSS 179. Climate Solutions. 4 Units.
Introduction to climate change science and impacts on the health of people and the planet with a focus on the multi-dimensional aspects of solutions to the climate crisis.

Same as ENGRMAE 119, UPPP 111.

Restriction: Upper-division students only.

EARTHSS 184. Understanding the Carbon Cycle for Climate Change Solutions. 4 Units.
Covers the scientific principles of the carbon cycle and tools for climate change mitigation. Topics include carbon dioxide buildup, its relation to climate change, achieving net-zero emissions, and proposed sequestration technologies. Also explores economic and equity implications.

Prerequisite: (EARTHSS 51 and EARTHSS 53 and EARTHSS 55) or (EARTHSS 70A and EARTHSS 70B) or (CHEM 1C and MATH 2B)

Restriction: Earth System Science Majors have first consideration for enrollment. Environmental Science and Policy Majors have first consideration for enrollment.

EARTHSS 190A. Senior Seminar on Global Sustainability I. 2 Units.
Students attend weekly seminar to discuss current issues in global sustainability. Weekly attendance at Global Sustainability Forum is also required. Seminar utilized to analyze forum presentations. Prepare bibliography.

Same as BIO SCI 191A, SOCECOL 186A.

Restriction: Seniors only. Global Sustainability Minors have first consideration for enrollment.

EARTHSS 190B. Senior Seminar on Global Sustainability II. 2 Units.
Students attend weekly seminar to discuss current issues in global sustainability. Weekly attendance at Global Sustainability Forum is also required. Seminar utilized to analyze forum presentations. Prepare research proposal.

Prerequisite: BIO SCI 191A or SOCECOL 186A or EARTHSS 190A

Same as BIO SCI 191B, SOCECOL 186B.

Restriction: Seniors only.

EARTHSS 190CW. Writing/Senior Seminar on Global Sustainability III. 4 Units.
Students attend weekly seminar to discuss current issues in global sustainability. Weekly attendance at Global Sustainability Forum also is required. Seminar utilized to analyze Forum presentations and to prepare senior research paper. Prepare/write research paper under direction of faculty member.

Prerequisite: BIO SCI 191B or EARTHSS 190B or SOCECOL 186B. BIO SCI 191B or EARTHSS 190B or SOCECOL 186B. Satisfactory completion of the Lower-Division Writing requirement.

Same as BIO SCI 191CW, SOCECOL 186CW.

Restriction: Seniors only.

(Ib)

EARTHSS 191. Introduction to Research in Earth System Science. 1 Unit.
Weekly presentations by Earth System Science faculty describing ongoing research in their laboratories. Students are introduced to the range of research topics and methods in Earth System Science and to the research opportunities available within the Department.

Prerequisite: (EARTHSS 60A and EARTHSS 60B) or (EARTHSS 51 and EARTHSS 53)

Grading Option: Pass/no pass only.

Restriction: Earth & Atmospheric Sciences Minors have first consideration for enrollment. Environmental Science Majors have first consideration for enrollment. Earth System Science Majors have first consideration for enrollment.

EARTHSS 192. Careers in Earth System Science. 1 Unit.
A weekly seminar course designed to help students transition to post-graduation career paths. Topics include designing effective resumes, applying to graduate school, and seeking employment. Also includes presentations by faculty, business, and government leaders describing potential environmental science career trajectories.

Grading Option: Pass/no pass only.

Restriction: Environmental Science and Policy Majors have first consideration for enrollment. Environmental Science Majors have first consideration for enrollment. Earth System Science Majors have first consideration for enrollment.

EARTHSS 197. Independent Study in Earth System Science. .5-4 Units.
Field study, educational outreach, or other independent projects under faculty direction. Interested students should arrange with an ESS faculty member to supervise and support an independent study project. A written summary is required at the end of each quarter.

Grading Option: Pass/no pass only.

Repeatability: May be taken for credit for 12 units.

EARTHSS 198W. Senior Thesis in Earth System Science. 4 Units.
Students receive guidance on the effective oral and written communication of research results. Students prepare and present a seminar, a poster, and a written thesis describing their research in Earth System Science.

Prerequisite: Two quarters of EARTHSS 199. Satisfactory completion of the Lower-Division Writing requirement.

Overlaps with EARTHSS H198.

(Ib)

EARTHSS H198. Honors Thesis in Earth System Science. 4 Units.
Students receive guidance on effective written and oral communication of research results. Students prepare and present a seminar, poster, and written thesis describing their honors research in Earth System Science. Submission of the thesis and successful completion of this course will also satisfy the UCI upper-division writing requirement.

Prerequisite: ESS 199A and ESS 199B

Restriction: Consent of instructor to enroll and Prerequisite required

(Ib)

EARTHSS 199. Undergraduate Research. 1-4 Units.
For undergraduates with majors in science or engineering. Interested students should arrange with an ESS faculty member to supervise and support a research project. A written summary is required at the end of each quarter.

Repeatability: May be taken for credit for 12 units.

EARTHSS H199A. Honors Research in Earth System Science. 4 Units.
Undergraduate honors research in Earth System Science. A student commitment of 10-15 hours a week is expected, and a written report is required at the end of the quarter.

Restriction: Earth System Science Honors students only. Campuswide Honors Collegium students only.

EARTHSS H199B. Honors Research in Earth System Science. 4 Units.
Undergraduate honors research in Earth System Science. A student commitment of 10-15 hours a week is expected, and a written report is required at the end of the quarter.

Restriction: Earth System Science Honors students only. Campuswide Honors Collegium students only.

EARTHSS H199C. Honors Research in Earth System Science. 4 Units.
Undergraduate honors research in Earth System Science. A student commitment of 10-15 hours a week is expected, and a written report is required at the end of the quarter.

Restriction: Earth System Science Honors students only. Campuswide Honors Collegium students only.

EARTHSS 200. Global Physical Climatology. 4 Units.
A descriptive overview of Earth’s climate system and energy budget. Large-scale circulations, key physical processes, and climate sensitivity of the atmosphere, ocean, land surface, and cryosphere.

Restriction: Graduate students only.

EARTHSS 204. Humans in the Earth System. 4 Units.
Focuses on the human systems of energy and food production which have the greatest effects on the Earth system. Assess the physical mechanisms and feedbacks of human-nature interactions and consider approaches of mitigation, interventions, and adaptation.

Restriction: Graduate students only. Earth System Science Majors only.

EARTHSS 212. Geoscience Modeling and Data Analysis. 4 Units.
Computer-based course. Fundamental statistical techniques needed to analyze Earth system data and models. Basic numerical techniques to solve Earth system models. Focuses on linear and non-linear ordinary differential equations, as well as simple partial differential equations.

Restriction: Graduate students only.

EARTHSS 215. Cryosphere. 4 Units.
A global perspective of the major components of the cryosphere. Includes current extent and trends, mass balance, energetics, and physical processes. Quantitative assessment of current state, in situ and remote observations, and interactions with climate.

Restriction: Graduate students only.

EARTHSS 225. Marine Biogeochemistry. 4 Units.
Overview of ocean biology and biogeochemistry, with a focus on lower trophic levels and the roles of biota in the marine biogeochemical cycles of key elements.

Restriction: Doctor of Philosophy Degree students have first consideration for enrollment. Graduate students only. Earth System Science Majors have first consideration for enrollment.

EARTHSS 226. Land Surface Processes. 4 Units.
A mechanistic perspective of the structure and functioning of terrestrial ecosystems. Includes processes such as nutrient cycling, biogeochemical cycling, mass balance, energetics, terrestrial hydrology, and water cycle.

Restriction: Graduate students only.

EARTHSS 230. Physical Oceanography. 4 Units.
Physical processes that determine the distribution of water properties such as salt and temperature. Fluid-dynamical underpinnings of physical oceanography. Wave motions. The wind-driven and thermohaline circulation. Similarities and differences between ocean and atmosphere dynamics.

Prerequisite: MATH 2D and PHYSICS 7A and PHYSICS 7B and PHYSICS 7E

Restriction: Graduate students only.

EARTHSS 238. Satellite Remote Sensing for Earth System Science. 4 Units.
Satellite remote sensing data are increasingly used to study the Earth system. Provides an overview of the principles behind remote sensing, and the types of satellite data available for study of the oceans, land, and atmosphere.

EARTHSS 242. Advanced Atmospheric Chemistry. 4 Units.
Chemistry of the troposphere and stratosphere. Topics include: processes controlling the lifetime and reaction pathways of chemicals in the atmosphere, the role of the atmosphere in biogeochemical cycles, and interactions between atmospheric chemistry and the physical climate system.

Restriction: Graduate students only.

EARTHSS 244. Introduction to Atmospheric Dynamics. 4 Units.
Covers fundamentals of atmospheric dynamics including thermodynamics, quasi-geostrophy, the weak-temperature gradient of the tropics, and the turbulent boundary layer.

Restriction: Graduate students only.

EARTHSS 248. Marine Ecosystems and Global Change. 4 Units.
Presents an overview of marine ecosystem structure, diversity, and processes in the context of global change, including the impacts of climate warming, ocean acidification, marine fisheries, and anthropogenic additions of nutrients and pollutants.

Prerequisite: EARTHSS 224. EARTHSS 224 with a grade of B- or better

Restriction: Graduate students only.

EARTHSS 256. Paleoclimatology and Paleoceanography. 4 Units.
Explores past changes in Earth's climate. Topics include tools and techniques used to reconstruct past climate from natural archives; records and mechanisms of past climate changes throughout Earth history; and lessons learned from the paleo-record for prediction of future climate.

Restriction: Graduate students only.

EARTHSS 264. Ecosystem Ecology . 4 Units.
A mechanistic perspective on ecosystem processes. Covers ecosystem development, element cycling, and interactions with plants and microbes. The role of ecosystems in environmental change is also addressed.

Prerequisite: CHEM 51C

EARTHSS 266. Global Biogeochemical Cycles. 4 Units.
Global biogeochemical cycling of the elements. Topics include global cycling of carbon, nitrogen, oxygen, and sulfur; impact of human activities on biogeochemical processes.

Restriction: Graduate students only.

EARTHSS 280A. Special Topics in Earth System Science. 1-4 Units.
Each quarter is devoted to current topics in the field of Earth System Science. Topics addressed vary each quarter.

Repeatability: Unlimited as topics vary.

EARTHSS 280B. Special Topics in Earth System Science. 1-4 Units.
Each quarter is devoted to current topics in the field of Earth System Science. Topics addressed vary each quarter.

Prerequisite: EARTHSS 280A. EARTHSS 280A with a grade of B- or better

Repeatability: Unlimited as topics vary.

EARTHSS 280C. Special Topics in Earth System Science. 1-4 Units.
Each quarter is devoted to current topics in the field of Earth System Science. Topics addressed vary each quarter.

Prerequisite: EARTHSS 280B. EARTHSS 280B with a grade of B- or better

Repeatability: Unlimited as topics vary.

EARTHSS 286A. Special Topics in Biogeochemistry. 1-4 Units.
Each quarter is devoted to in-depth analysis of a subarea in biogeochemistry which is undergoing rapid development. Topics addressed vary each quarter.

Repeatability: Unlimited as topics vary.

Restriction: Graduate students only.

EARTHSS 286B. Special Topics in Biogeochemistry. 1-4 Units.
Each quarter is devoted to in-depth analysis of a subarea in biogeochemistry which is undergoing rapid development. Topics addressed vary each quarter.

Prerequisite: EARTHSS 286A. EARTHSS 286A with a grade of B- or better

Repeatability: Unlimited as topics vary.

Restriction: Graduate students only.

EARTHSS 286C. Special Topics in Biogeochemistry. 1-4 Units.
Each quarter is devoted to in-depth analysis of a subarea in biogeochemistry which is undergoing rapid development. Topics addressed vary each quarter.

Prerequisite: EARTHSS 286B. EARTHSS 286B with a grade of B- or better

Repeatability: Unlimited as topics vary.

Restriction: Graduate students only.

EARTHSS 288C. Special Topics in Ecosystems. 1-4 Units.
Each quarter is devoted to current topics relating to Ecosystems. Topics addressed vary each quarter.

Prerequisite: EARTHSS 288B. EARTHSS 288B with a grade of B- or better

Repeatability: Unlimited as topics vary.

EARTHSS 290. Seminar. 1 Unit.
Weekly seminars and discussions on topics of general and current interest in Earth System Science. Topics addressed vary each quarter.

Grading Option: Satisfactory/unsatisfactory only.

Repeatability: Unlimited as topics vary.

Restriction: Graduate students only.

EARTHSS 298. Practicum in Earth System Science. 4 Units.
Designed to introduce first-year graduate students to research. Students explore research opportunities and develop a proposal for a summer research project under the direction of a faculty mentor.

Restriction: Graduate students only.

EARTHSS 299. Research. 2-12 Units.
Supervised original research in areas of Earth System Science.

Repeatability: May be repeated for credit unlimited times.

EARTHSS 399. University Teaching. 1-4 Units.
Limited to Teaching Assistants.

Grading Option: Satisfactory/unsatisfactory only.

Repeatability: May be repeated for credit unlimited times.

Restriction: Graduate students only.

Mathematics Courses

MATH 1A. Pre-Calculus I. 4 Workload Units.
Basic equations and inequalities, linear and quadratic functions, and systems of simultaneous equations.

Grading Option: Workload Credit Letter Grade with P/NP.

MATH 1B. Pre-Calculus II. 4 Units.
Preparation for calculus and other mathematics courses. Exponentials, logarithms, trigonometry, polynomials, and rational functions. Satisfies no requirements other than contribution to the 180 units required for graduation.

Prerequisite: Recommended: A passing score on the Pre-Calculus Self-Assessment exam, or a score of 450 or higher on the Mathematics section of the SAT Reasoning Test. Not for students with a score of 3 or higher on the AP Calc AB exam. Not for students with a score of 3 or higher on the AP Calc BC exam.

Restriction: MATH 1B may not be taken for credit if taken after MATH 2A.

MATH 2A. Single-Variable Calculus I. 4 Units.
Introduction to derivatives, calculation of derivatives of algebraic and trigonometric functions; applications including curve sketching, related rates, and optimization. Exponential and logarithm functions.

Prerequisite: MATH 1B or SAT Mathematics or ACT Mathematics. MATH 1B with a grade of C- or better. SAT Mathematics with a minimum score of 650. ACT Mathematics with a minimum score of 29. Placement via the Calculus Placement exam (fee required) is also accepted.

Overlaps with MATH 5A, MATH 7A.

Restriction: School of Physical Sciences students have first consideration for enrollment. School of Engineering students have first consideration for enrollment. School of Info & Computer Sci students have first consideration for enrollment.

(Vb)

MATH 2B. Single-Variable Calculus II. 4 Units.
Definite integrals; the fundamental theorem of calculus. Applications of integration including finding areas and volumes. Techniques of integration. Infinite sequences and series.

Prerequisite: MATH 2A or MATH 5A or MATH 7A or AP Calculus AB or AP Calculus BC. AP Calculus AB with a minimum score of 3. AP Calculus BC with a minimum score of 3

Overlaps with MATH 7B.

Restriction: School of Physical Sciences students have first consideration for enrollment. School of Engineering students have first consideration for enrollment. School of Info & Computer Sci students have first consideration for enrollment.

(Vb)

MATH 2D. Multivariable Calculus I. 4 Units.
Differential and integral calculus of real-valued functions of several real variables, including applications. Polar coordinates.

Prerequisite: MATH 2B or MATH 5B or MATH 7B or AP Calculus BC. AP Calculus BC with a minimum score of 4

Overlaps with MATH H2D.

Restriction: School of Physical Sciences students have first consideration for enrollment. School of Engineering students have first consideration for enrollment. School of Info & Computer Sci students have first consideration for enrollment. Undeclared Majors have first consideration for enrollment.

(Vb)

MATH 2E. Multivariable Calculus II. 4 Units.
The differential and integral calculus of vector-valued functions. Implicit and inverse function theorems. Line and surface integrals, divergence and curl, theorems of Greens, Gauss, and Stokes.

Prerequisite: MATH 2D or MATH H2D

Restriction: School of Physical Sciences students have first consideration for enrollment. School of Engineering students have first consideration for enrollment.

MATH H2D. Honors Multivariable Calculus I. 4 Units.
Differential and integral calculus of real-valued functions of several real variables, including applications. Polar coordinates. Covers the same material as MATH 2D-E, but with a greater emphasis on the theoretical structure of the subject matter.

Prerequisite: MATH 2B or MATH 5B or MATH 7B or (AP Calculus BC and (MATH H3A or MATH 3A)). MATH 2B with a grade of A or better. MATH 5B with a grade of A or better. MATH 7B with a grade of A or better. AP Calculus BC with a minimum score of 5. MATH H3A with a grade of B- or better. MATH 3A with a grade of A or better

Overlaps with MATH 2D.

(Vb)

MATH H2E. Honors Multivariable Calculus II. 4 Units.
Differential and integral calculus of real-valued functions of several real variables, including applications. Polar coordinates. Covers the same material as MATH 2D-E, but with a greater emphasis on the theoretical structure of the subject matter.

Prerequisite: MATH H2D. MATH H2D with a grade of B- or better

Overlaps with MATH 2E.

MATH 3A. Introduction to Linear Algebra. 4 Units.
Systems of linear equations, matrix operations, determinants, eigenvalues and eigenvectors, vector spaces, subspaces, and dimension.

Prerequisite: MATH 2B or MATH 5B or MATH 7B or AP Calculus BC. AP Calculus BC with a minimum score of 4

Overlaps with ICS 6N, MATH H3A.

Restriction: Undeclared Majors have first consideration for enrollment. School of Physical Sciences students have first consideration for enrollment. School of Engineering students have first consideration for enrollment.

(Vb)

MATH 3D. Elementary Differential Equations. 4 Units.
Linear differential equations, variation of parameters, constant coefficient cookbook, systems of equations, Laplace transforms, series solutions.

Prerequisite: (MATH 3A or MATH H3A) and (MATH 2D or MATH H2D)

Restriction: School of Physical Sciences students have first consideration for enrollment. School of Engineering students have first consideration for enrollment.

MATH H3A. Honors Introduction to Linear Algebra. 4 Units.
Systems of linear equations, matrix operations, determinants, eigenvalues, eigenvectors, vector spaces, subspaces, and dimension.

Prerequisite: MATH 2B or MATH 5B or MATH 7B or AP Calculus BC. MATH 2B with a grade of A or better. MATH 5B with a grade of A or better. MATH 7B with a grade of A or better. AP Calculus BC with a minimum score of 5

Overlaps with MATH 3A, ICS 6N.

Restriction: School of Physical Sciences students only. School of Engineering students only. Mathematics Majors only. Undeclared Majors only.

MATH 5A. Calculus for Life Sciences I. 4 Units.
Differential calculus with applications to life sciences. Exponential, logarithmic, and trigonometric functions. Limits, differentiation techniques, optimization and difference equations.

Prerequisite: MATH 1B or SAT Mathematics or ACT Mathematics. MATH 1B with a grade of C- or better. SAT Mathematics with a minimum score of 650. ACT Mathematics with a minimum score of 29. Placement via the Calculus Placement exam (fee required) is also accepted.

Overlaps with MATH 2A, MATH 7A.

Restriction: School of Biological Sciences students have first consideration for enrollment.

(Vb)

MATH 5B. Calculus for Life Sciences II. 4 Units.
Integral calculus and multivariable calculus with applications to life sciences. Integration techniques, applications of the integral, phase plane methods and basic modeling, basic multivariable methods.

Prerequisite: MATH 5A or MATH 2A or MATH 7A or AP Calculus AB or AP Calculus BC. AP Calculus AB with a minimum score of 3. AP Calculus BC with a minimum score of 3

Restriction: School of Biological Sciences students have first consideration for enrollment. Cannot be taken for credit after MATH 2B.

(Vb)

MATH 8. Explorations in Functions and Modeling. 4 Units.
Explorations of applications and connections in topics in algebra, geometry, calculus, and statistics for future secondary math educators. Emphasis on nonstandard modeling problems.

Corequisite: MATH 2A or MATH 5A or MATH 7A
Prerequisite: MATH 2A or MATH 5A or MATH 7A or AP Calculus AB or AP Calculus BC. AP Calculus AB with a minimum score of 3. AP Calculus BC with a minimum score of 3

MATH 9. Introduction to Programming for Numerical Analysis. 4 Units.
Introduction to computers and programming using Matlab and Python. Representation of numbers and precision, input/output, functions, custom data types, testing/debugging, reading exceptions, plotting data, numerical differentiation, basics of algorithms. Analysis of random processes using computer simulations.

Prerequisite: MATH 2A or MATH 5A or MATH 7A or AP Calculus AB or AP Calculus BC. AP Calculus AB with a minimum score of 3. AP Calculus BC with a minimum score of 3

Restriction: Mathematics Majors have first consideration for enrollment.

(II and Vb).

MATH 10. Introduction to Programming for Data Science. 4 Units.
Introduction to Python for data science. Selecting appropriate data types; functions and methods; plotting; the libraries NumPy, pandas, scikit-learn. Foundations of machine learning.

Corequisite: (MATH 2D or MATH H2D) and (MATH 3A or MATH H3A)
Prerequisite: (MATH 2D or MATH H2D) and (MATH 3A or MATH H3A) and MATH 9

Restriction: Mathematics Majors have first consideration for enrollment.

(II and VB).

MATH 13. Introduction to Abstract Mathematics. 4 Units.
Introduction to formal definition and rigorous proof writing in mathematics. Topics include basic logic, set theory, equivalence relations, and various proof techniques such as direct, induction, contradiction, contrapositive, and exhaustion.

Prerequisite: MATH 2A or MATH 5A or MATH 7A or ICS 6D or AP Calculus AB or AP Calculus BC. AP Calculus AB with a minimum score of 3. AP Calculus BC with a minimum score of 3

Restriction: Mathematics Majors have first consideration for enrollment.

MATH 99. New Math Major Seminar for First-Year and Transfer Students. 1 Unit.
A series of presentations and activities to help first-year and transfer students transition to the UCI mathematics majors. Presentations are given by faculty, current students, and school staff to ensure that students make the most of the math major.

Grading Option: Pass/no pass only.

Restriction: New math majors only, including transfer students majoring in math.

MATH 105A. Numerical Analysis I. 4 Units.
Introduction to the theory and practice of numerical computation with an emphasis on solving equations. Solving transcendental equations; linear systems, Gaussian elimination, QR factorization, iterative methods, eigenvalue computation, power method.

Corequisite: MATH 105LA
Prerequisite: (MATH 3A or MATH H3A) and MATH 9

Overlaps with MAE 185.

MATH 105B. Numerical Analysis II. 4 Units.
Introduction to the theory and practice of numerical computation with an emphasis on topics from calculus and approximation theory. Lagrange interpolation; Gaussian quadrature; Fourier series and transforms; Methods from data science including least squares and L1 regression.

Corequisite: MATH 105LB
Prerequisite: MATH 105A

MATH 105LA. Numerical Analysis Laboratory. 1 Unit.
Provides practical experience to complement the theory developed in Mathematics 105A.

Corequisite: MATH 105A

MATH 105LB. Numerical Analysis Laboratory. 1 Unit.
Provides practical experience to complement the theory developed in Mathematics 105B.

Corequisite: MATH 105B

MATH 107. Numerical Differential Equations. 4 Units.
Theory and applications of numerical methods to initial and boundary-value problems for ordinary and partial differential equations.

Corequisite: MATH 107L
Prerequisite: MATH 3D and MATH 105B

MATH 107L. Numerical Differential Equations Laboratory. 1 Unit.
Provides practical experience to complement the theory developed in Mathematics 107.

Corequisite: MATH 107

MATH 110A. Optimization I. 4 Units.
Introduction to optimization, linear search method, trust region method, Newton method, linear programming, linear, and non-linear least square methods.

Corequisite: MATH 121B
Prerequisite: (MATH 2D or MATH H2D) and MATH 10 and MATH 121B

Restriction: Mathematics Majors have first consideration for enrollment.

MATH 110B. Optimization II. 4 Units.
The simplex method, interior point method, penalty barrier method, primal dual method, augmented Lagrangian method, and stochastic gradient method.

Prerequisite: MATH 110A. MATH 110A with a grade of C- or better

Restriction: Mathematics Majors have first consideration for enrollment.

MATH 112A. Introduction to Partial Differential Equations and Applications I. 4 Units.
Introduction to ordinary and partial differential equations and their applications in engineering and science. Basic methods for classical PDEs (potential, heat, and wave equations). Classification of PDEs, separation of variables and series expansions, special functions, eigenvalue problems.

Prerequisite: (MATH 2E or MATH H2E) and MATH 3D

MATH 112B. Introduction to Partial Differential Equations and Applications II. 4 Units.
Introduction to partial differential equations and their applications in engineering and science. Basic methods for classical PDEs (potential, heat, and wave equations). Green functions and integral representations, method of characteristics.

Prerequisite: MATH 112A

MATH 112C. Introduction to Partial Differential Equations and Applications III. 4 Units.
Nonhomogeneous problems and Green's functions, Sturm-Liouville theory, general Fourier expansions, applications of partial differential equations in different areas of science.

Prerequisite: MATH 112B

MATH 113A. Mathematical Modeling in Biology I. 4 Units.
Discrete mathematical and statistical models; difference equations, population dynamics, Markov chains, and statistical models in biology.

Prerequisite: MATH 2B or MATH 5B or MATH 7B or AP Calculus BC. AP Calculus BC with a minimum score of 4

MATH 113B. Mathematical Modeling in Biology II. 4 Units.
Linear algebra; differential equations models; dynamical systems; stability; hysteresis; phase plane analysis; applications to cell biology, viral dynamics, and infectious diseases.

Prerequisite: MATH 113A

MATH 115. Mathematical Modeling. 4 Units.
Mathematical modeling and analysis of phenomena that arise in engineering physical sciences, biology, economics, or social sciences.

Prerequisite: MATH 112A

MATH 117. Dynamical Systems. 4 Units.
Introduction to the modern theory of dynamical systems including contraction mapping principle, fractals and chaos, conservative systems, Kepler problem, billiard models, expanding maps, Smale's horseshoe, topological entropy.

Prerequisite: MATH 3D and MATH 140A

MATH 118. The Theory of Differential Equations. 4 Units.
Existence and uniqueness of solutions, continuous dependence of solutions on initial conditions and parameters, Lyapunov and asymptotic stability, Floquet theory, nonlinear systems, and bifurcations.

Prerequisite: MATH 3D and MATH 140A

MATH 120A. Introduction to Abstract Algebra: Groups. 4 Units.
Axioms for group theory; permutation groups, matrix groups. Isomorphisms, homomorphisms, quotient groups. Advanced topics as time permits. Special emphasis on doing proofs.

Prerequisite: (MATH 3A or MATH H3A) and MATH 13. MATH 13 with a grade of C- or better

Restriction: Mathematics Majors have first consideration for enrollment.

MATH 120B. Introduction to Abstract Algebra: Rings and Fields. 4 Units.
Basic properties of rings; ideals, quotient rings; polynomial and matrix rings. Elements of field theory.

Prerequisite: MATH 120A. MATH 120A with a grade of C- or better

Restriction: Mathematics Majors have first consideration for enrollment.

MATH 120C. Introduction to Abstract Algebra: Galois Theory. 4 Units.
Galois Theory: proof of the impossibility of certain ruler-and-compass constructions (squaring the circle, trisecting angles); nonexistence of analogues to the "quadratic formula" for polynomial equations of degree 5 or higher.

Prerequisite: MATH 120B

MATH H120A. Honors Introduction to Graduate Algebra I. 5 Units.
Introduction to abstract linear algebra, including bases, linear transformation, eigenvectors, canonical forms, inner products, and symmetric operators. Introduction to groups, rings, and fields, including examples of groups, group actions, Sylow theorems, modules over principal ideal domains, polynomials, and Galois groups.

Prerequisite: (MATH 3A or MATH H3A) and MATH 13 and (MATH 120A or MATH 121A). MATH 13 with a grade of A or better. MATH 120A with a grade of A or better. MATH 121A with a grade of A or better

Restriction: Mathematics Honors students only.

Concurrent with MATH 206A.

MATH H120B. Honors Introduction to Graduate Algebra II. 5 Units.
Introduction to abstract linear algebra, including bases, linear transformation, eigenvectors, canonical forms, inner products, and symmetric operators. Introduction to groups, rings, and fields, including examples of groups, group actions, Sylow theorems, modules over principal ideal domains, polynomials, and Galois groups.

Prerequisite: MATH H120A

Restriction: Mathematics Honors students only.

Concurrent with MATH 206B.

MATH H120C. Honors Introduction to Graduate Algebra III. 5 Units.
Introduction to abstract linear algebra, including bases, linear transformation, eigenvectors, canonical forms, inner products, and symmetric operators. Introduction to groups, rings, and fields, including examples of groups, group actions, Sylow theorems, modules over principal ideal domains, polynomials, and Galois groups.

Prerequisite: MATH H120B

Restriction: Mathematics Honors students only.

Concurrent with MATH 206C.

MATH 121A. Linear Algebra I. 4 Units.
Introduction to modern abstract linear algebra. Special emphasis on students doing proofs. Vector spaces, linear independence, bases, dimension. Linear transformations and their matrix representations. Theory of determinants.

Prerequisite: (MATH 3A or MATH H3A) and MATH 13. MATH 13 with a grade of C- or better

Restriction: Mathematics Majors have first consideration for enrollment.

MATH 121B. Linear Algebra II. 4 Units.
Introduction to modern abstract linear algebra. Special emphasis on students doing proofs. Canonical forms; inner products; similarity of matrices.

Prerequisite: MATH 121A. MATH 121A with a grade of C- or better

Restriction: Mathematics Majors have first consideration for enrollment.

MATH 130A. Probability I. 4 Units.
Combinatorial probability, conditional probabilities, independence, discrete and continuous random variables, expectation and variance, common probability distributions.

Prerequisite: MATH 3A or MATH H3A

MATH 130B. Probability II. 4 Units.
Joint distributions, sums of independent random variables, conditional distributions and conditional expectation, covariances, moment generating functions, limit theorems.

Prerequisite: MATH 130A or STAT 120A

MATH 130C. Stochastic Processes. 4 Units.
Markov chains, Brownian motion, Gaussian processes, applications to option pricing and Markov chain Monte Carlo methods.

Prerequisite: MATH 130B

MATH 134A. Fixed Income. 4 Units.
Overview of interest theory, time value of money, annuities/cash flows with payments that are not contingent, loans, sinking funds, bonds, general cash flow and portfolios, immunization, duration and convexity, swaps.

Prerequisite: MATH 130A or STAT 120A

Overlaps with MATH 133C.

MATH 134B. Mathematics of Financial Derivatives. 4 Units.
General derivatives; call/put options; hedging and investment strategies: spreads and collars; risk management; forwards and futures; bonds.

Prerequisite: MATH 130A. MATH 130A with a grade of C- or better

Overlaps with MATH 133A.

MATH 134C. Mathematical Models for Finance. 4 Units.
General properties of options: option contracts (call and put options, European, American and exotic options); binomial option pricing model, Black-Scholes option pricing model; risk-neutral pricing formula using Monte-Carlo simulation; option greeks and risk management; interest rate derivatives, Markowitz portfolio theory.

Prerequisite: MATH 134B or MATH 133A

Overlaps with MATH 133B.

Restriction: Mathematics Majors have first consideration for enrollment.

MATH 140A. Elementary Analysis I. 4 Units.
Introduction to real analysis, including convergence of sequence, infinite series, differentiation and integration, and sequences of functions. Students are expected to do proofs.

Prerequisite: (MATH 2D or MATH H2D) and (MATH 3A or MATH H3A) and MATH 13. MATH 13 with a grade of C- or better

Restriction: Mathematics Majors have first consideration for enrollment.

MATH 140B. Elementary Analysis II. 4 Units.
Introduction to real analysis including convergence of sequences, infinite series, differentiation and integration, and sequences of functions. Students are expected to do proofs.

Prerequisite: MATH 140A. MATH 140A with a grade of C- or better

Restriction: Mathematics Majors have first consideration for enrollment.

MATH 140C. Analysis in Several Variables . 4 Units.
Rigorous treatment of multivariable differential calculus. Jacobians, Inverse and Implicit Function theorems.

Prerequisite: MATH 140B

MATH H140A. Honors Introduction to Graduate Analysis I. 5 Units.
Construction of the real number system, topology of the real line, concepts of continuity, differential and integral calculus, sequences and series of functions, equicontinuity, metric spaces, multivariable differential and integral calculus, implicit functions, curves and surfaces.

Prerequisite: (MATH 2E or MATH H2E) and (MATH 3A or MATH H3A) and MATH 13 and MATH 121A and MATH 140A. MATH 2E with a grade of A or better. MATH H2E with a grade of A or better. MATH 13 with a grade of A or better. MATH 121A with a grade of A or better. MATH 140A with a grade of A or better

Concurrent with MATH 205A.

MATH H140B. Honors Introduction to Graduate Analysis II. 5 Units.
Construction of the real number system, topology of the real line, concepts of continuity, differential and integral calculus, sequences and series of functions, equicontinuity, metric spaces, multivariable differential and integral calculus, implicit functions, curves and surfaces.

Prerequisite: MATH H140A. MATH H140A with a grade of C- or better

Concurrent with MATH 205B.

MATH H140C. Honors Introduction to Graduate Analysis III. 5 Units.
Construction of the real number system; topology of the real line; concepts of continuity, differential, and integral calculus; sequences and series of functions, equicontinuity, metric spaces, multivariable differential, and integral calculus; implicit functions, curves and surfaces.

Prerequisite: MATH H140B. MATH H140B with a grade of C- or better

Concurrent with MATH 205C.

MATH 141. Introduction to Topology. 4 Units.
The elements of naive set theory and the basic properties of metric spaces. Introduction to topological properties.

Prerequisite: MATH 140A

MATH 147. Complex Analysis. 4 Units.
Rigorous treatment of basic complex analysis: analytic functions, Cauchy integral theory and its consequences, power series, residue calculus, harmonic functions, conformal mapping. Students are expected to do proofs.

Prerequisite or corequisite: MATH 140B

MATH 150. Introduction to Mathematical Logic. 4 Units.
First order logic through the Completeness Theorem for predicate logic.

Prerequisite: MATH 13 or (ICS 6B and ICS 6D). MATH 13 with a grade of C- or better. ICS 6B with a grade of C- or better. ICS 6D with a grade of C- or better

Overlaps with LPS 105B, PHIL 105B.

MATH 161. Modern Geometry. 4 Units.
Euclidean Geometry; Hilbert's Axioms; Absolute Geometry; Hyperbolic Geometry; the Poincare Models; and Geometric Transformations.

Prerequisite: MATH 13 or (ICS 6B and ICS 6D). MATH 13 with a grade of C- or better. ICS 6B with a grade of C- or better. ICS 6D with a grade of C- or better

Restriction: Mathematics Majors have first consideration for enrollment.

MATH 162A. Introduction to Differential Geometry I. 4 Units.
Applications of advanced calculus and linear algebra to the geometry of curves and surfaces in space.

Prerequisite: (MATH 2E or MATH H2E) and MATH 3D

MATH 162B. Introduction to Differential Geometry II. 4 Units.
Applications of advanced calculus and linear algebra to the geometry of curves and surfaces in space.

Prerequisite: MATH 162A. MATH 162A with a grade of C- or better

MATH 173A. Introduction to Cryptology I. 4 Units.
Introduction to some of the mathematics used in the making and breaking of codes, with applications to classical ciphers and public key systems. Includes topics from number theory, probability, and abstract algebra.

Prerequisite: (MATH 2B or MATH 5B or MATH 7B or AP Calculus BC) and (MATH 3A or MATH H3A) and (MATH 13 or (ICS 6B and ICS 6D)). AP Calculus BC with a minimum score of 4

MATH 173B. Introduction to Cryptology II. 4 Units.
Introduction to some of the mathematics used in the making and breaking of codes, with applications to classical ciphers and public key systems. The mathematics covered includes topics from number theory, probability, and abstract algebra.

Prerequisite: MATH 173A

MATH 175. Combinatorics . 4 Units.
Introduction to combinatorics including basic counting principles, permutations, combinations, binomial coefficients, inclusion-exclusion, derangements, ordinary and exponential generating functions, recurrence relations, Catalan numbers, Stirling numbers, and partition numbers.

Prerequisite: (MATH 2B or MATH 5B or MATH 7B or AP Calculus BC) and MATH 13. AP Calculus BC with a minimum score of 4. MATH 13 with a grade of C- or better

MATH 176. Mathematics of Finance. 4 Units.
After reviewing tools from probability, statistics, and elementary differential and partial differential equations, concepts such as hedging, arbitrage, Puts, Calls, the design of portfolios, the derivation and solution of the Blac-Scholes, and other equations are discussed.

Prerequisite: MATH 3A or MATH H3A

Same as ECON 135.

Restriction: Business Economics Majors have first consideration for enrollment. Economics Majors have first consideration for enrollment. Quantitative Economics Majors have first consideration for enrollment. Mathematics Majors have first consideration for enrollment.

MATH 178. Mathematical Machine Learning. 6 Units.
Theoretical introduction to Mathematical Machine Learning. Mathematical foundations and coding implementations using Python libraries such as scikit-learn and Keras. Supervised and unsupervised learning; regression and classification; loss functions; overfitting and the bias-complexity tradeoff. Prominent algorithms in machine learning.

Prerequisite: MATH 10 and MATH 121A and MATH 140A

Overlaps with CS 178.

MATH 180A. Number Theory I. 4 Units.
Introduction to number theory and applications. Divisibility, prime numbers, factorization. Arithmetic functions. Congruences. Quadratic residue. Diophantine equations. Introduction to cryptography.

Prerequisite: (MATH 3A or MATH H3A) and MATH 13. MATH 13 with a grade of C- or better

Restriction: Mathematics Majors have first consideration for enrollment.

MATH 180B. Number Theory II. 4 Units.
Introduction to number theory and applications. Analytic number theory, character sums, finite fields, discrete logarithm, computational complexity. Introduction to coding theory. Other topics as time permits.

Prerequisite: MATH 180A

Restriction: Mathematics Majors have first consideration for enrollment.

MATH 184. History of Mathematics. 4 Units.
Topics vary from year to year. Some possible topics: mathematics in ancient times; the development of modern analysis; the evolution of geometric ideas. Students will be assigned individual topics for term papers.

Corequisite: MATH 184L
Prerequisite: MATH 120A and MATH 140A

Restriction: Mathematics Majors have first consideration for enrollment.

MATH 184L. History of Mathematics Lesson Lab. 1 Unit.
Aspiring math teachers research, design, present, and peer review middle school or high school math lessons that draw from history of mathematics topics.

Corequisite: MATH 184
Prerequisite: PS 5

MATH 192. Studies in the Learning and Teaching of Secondary Mathematics. 2 Units.
Focus is on historic and current mathematical concepts related to student learning and effective math pedagogy, with fieldwork in grades 6-14.

Grading Option: Pass/no pass only.

Repeatability: May be repeated for credit unlimited times.

MATH 194. Problem Solving Seminar. 2 Units.
Develops ability in analytical thinking and problem solving, using problems of the type found in the Mathematics Olympiad and the Putnam Mathematical Competition. Students taking the course in fall will prepare for and take the Putnam examination in December.

Grading Option: Pass/no pass only.

Repeatability: May be taken for credit 2 times.

MATH 195W. Mathematical Writing. 4 Units.
Techniques of mathematical writing and communication. Covers effectively writing mathematical papers, creating effective presentations, and communicating mathematics in a variety of media. Focuses on utilizing LaTeX for typesetting mathematics.

Prerequisite: MATH 120A or MATH 121A or MATH 140A. MATH 120A with a grade of C- or better. MATH 121A with a grade of C- or better. MATH 140A with a grade of C- or better. Satisfactory completion of the Lower-Division Writing requirement.

Restriction: Mathematics Majors have first consideration for enrollment.

(Ib)

MATH 199A. Special Studies in Mathematics. 1-4 Units.
Supervised reading. For outstanding undergraduate Mathematics majors in supervised but independent reading or research of mathematical topics.

Repeatability: Unlimited as topics vary.

MATH 199B. Special Studies in Mathematics. 1-4 Units.
Supervised reading. For outstanding undergraduate Mathematics majors in supervised but independent reading or research of mathematical topics.

Repeatability: Unlimited as topics vary.

MATH 199C. Special Studies in Mathematics. 1-4 Units.
Supervised reading. For outstanding undergraduate Mathematics majors in supervised but independent reading or research of mathematical topics.

Repeatability: Unlimited as topics vary.

MATH 205A. Introduction to Graduate Analysis. 5 Units.
Construction of the real number system, topology of the real line, concepts of continuity, differential and integral calculus, sequences and series of functions, equicontinuity, metric spaces, multivariable differential and integral calculus, implicit functions, curves and surfaces.

Prerequisite: Recommended: MATH 2E and MATH 3A and MATH 13, or equivalent.

Concurrent with MATH H140A.

MATH 205B. Introduction to Graduate Analysis. 5 Units.
Construction of the real number system, topology of the real line, concepts of continuity, differential and integral calculus, sequences and series of functions, equicontinuity, metric spaces, multivariable differential and integral calculus, implicit functions, curves and surfaces.

Prerequisite: MATH 205A. MATH 205A with a grade of B- or better

Concurrent with MATH H140B.

MATH 205C. Introduction to Graduate Analysis. 5 Units.
Construction of the real number system, topology of the real line, concepts of continuity, differential and integral calculus, sequences and series of functions, equicontinuity, metric spaces, multivariable differential and integral calculus, implicit functions, curves and surfaces.

Prerequisite: MATH 205B. MATH 205B with a grade of B- or better

Concurrent with MATH H140C.

MATH 210A. Real Analysis. 4 Units.
Measure theory, Lebesgue integral, signed measures, Radon-Nikodym theorem, functions of bounded variation and absolutely continuous functions, classical Banach spaces, Lp spaces, integration on locally compact spaces and the Riesz-Markov theorem, measure and outer measure, product measure spaces.

Prerequisite: Recommended: MATH 140C or equivalent.

MATH 210B. Real Analysis. 4 Units.
Measure theory, Lebesgue integral, signed measures, Radon-Nikodym theorem, functions of bounded variation and absolutely continuous functions, classical Banach spaces, Lp spaces, integration on locally compact spaces and the Riesz-Markov theorem, measure and outer measure, product measure spaces.

Prerequisite: MATH 210A. MATH 210A with a grade of B- or better

MATH 210C. Real Analysis. 4 Units.
Measure theory, Lebesgue integral, signed measures, Radon-Nikodym theorem, functions of bounded variation and absolutely continuous functions, classical Banach spaces, Lp spaces, integration on locally compact spaces and the Riesz-Markov theorem, measure and outer measure, product measure spaces.

Prerequisite: MATH 210B. MATH 210B with a grade of B- or better

MATH 211A. Topics in Analysis . 4 Units.
Studies in selected areas of Real Analysis, a continuation of MATH 210A-MATH 210B-MATH 210C. Topics addressed vary each quarter.

Prerequisite: Recommended: MATH 210C

MATH 218A. Introduction to Manifolds and Geometry. 4 Units.
General topology and fundamental groups, covering space; Stokes theorem on manifolds, selected topics on abstract manifold theory.

Prerequisite: Recommended: MATH 140C and MATH 121B, or equivalent.

MATH 218B. Introduction to Manifolds and Geometry. 4 Units.
General topology and fundamental groups, covering space; Stokes theorem on manifolds, selected topics on abstract manifold theory.

Prerequisite: MATH 218A. MATH 218A with a grade of B- or better

MATH 218C. Introduction to Manifolds and Geometry. 4 Units.
General topology and fundamental groups, covering space; Stokes theorem on manifolds, selected topics on abstract manifold theory.

Prerequisite: MATH 218B. MATH 218B with a grade of B- or better

MATH 220A. Analytic Function Theory. 4 Units.
Standard theorems about analytic functions. Harmonic functions. Normal families. Conformal mapping.

Prerequisite: Recommended: MATH 140C or equivalent.

MATH 220B. Analytic Function Theory. 4 Units.
Standard theorems about analytic functions. Harmonic functions. Normal families. Conformal mapping.

Prerequisite: MATH 220A. MATH 220A with a grade of B- or better

MATH 220C. Analytic Function Theory. 4 Units.
Standard theorems about analytic functions. Harmonic functions. Normal families. Conformal mapping.

Prerequisite: MATH 220B. MATH 220B with a grade of B- or better

MATH 222A. Several Complex Variables and Complex Geometry. 4 Units.
Several Complex variables, d-bar problems, mappings, Kaehler geometry, de Rham and Dolbeault Theorems, Chern Classes, Hodge Theorems, Calabi conjecture, Kahler-Einstein geometry, Monge-Ampere.

Prerequisite: MATH 220C. MATH 220C with a grade of B- or better

MATH 225A. Introduction to Numerical Analysis and Scientific Computing. 4 Units.
Introduction to fundamentals of numerical analysis from an advanced viewpoint. Error analysis, approximation of functions, nonlinear equations.

Prerequisite: Recommended: MATH 3D and MATH 105B and MATH 140A and MATH 121A and MATH 112A, or equivalent.

Restriction: Graduate students only.

MATH 225B. Introduction to Numerical Analysis and Scientific Computing. 4 Units.
Introduction to fundamentals of numerical analysis from an advanced viewpoint. Numerical linear algebra, numerical solutions of differential equations; stability.

Prerequisite: MATH 225A. MATH 225A with a grade of B- or better

Restriction: Graduate students only.

MATH 225C. Introduction to Numerical Analysis and Scientific Computing. 4 Units.
Introduction to fundamentals of numerical analysis from an advanced viewpoint. Numerical linear algebra, numerical solutions of differential equations; stability.

Prerequisite: Recommended: MATH 3D and MATH 105B and MATH 140A and MATH 121A and MATH 112A, or equivalent.

Restriction: Graduate students only.

MATH 226A. Computational Differential Equations. 4 Units.
Finite difference and finite element methods. Quick treatment of functional and nonlinear analysis background: weak solution, Lp spaces, Sobolev spaces. Approximation theory. Fourier and Petrov-Galerkin methods; mesh generation. Elliptic, parabolic, hyperbolic cases in 226A-B-C, respectively.

Prerequisite: Recommended: MATH 3D and MATH 112A and (MATH 140B or MATH 105B), or equivalent.

MATH 226B. Computational Differential Equations. 4 Units.
Finite difference and finite element methods. Quick treatment of functional and nonlinear analysis background: weak solution, Lp spaces, Sobolev spaces. Approximation theory. Fourier and Petrov-Galerkin methods; mesh generation. Elliptic, parabolic, hyperbolic cases in 226A-B-C, respectively.

Prerequisite: Recommended: MATH 3D and MATH 112A and (MATH 140B or MATH 105B), or equivalent.

MATH 226C. Computational Differential Equations. 4 Units.
Finite difference and finite element methods. Quick treatment of functional and nonlinear analysis background: weak solution, Lp spaces, Sobolev spaces. Approximation theory. Fourier and Petrov-Galerkin methods; mesh generation. Elliptic, parabolic, hyperbolic cases in 226A-B-C, respectively.

Prerequisite: Recommended: MATH 3D and MATH 112A and (MATH 140B or MATH 105B), or equivalent.

MATH 227A. Mathematical and Computational Biology. 4 Units.
Analytical and numerical methods for dynamical systems, temporal-spatial dynamics, steady state, stability, stochasticity. Application to life sciences: genetics, tissue growth and patterning, cancers, ion channels gating, signaling networks, morphogen gradients. Analytical methods.

Prerequisite: Recommended: MATH 2A and MATH 2B and MATH 3A, or equivalent.

MATH 227B. Mathematical and Computational Biology. 4 Units.
Analytical and numerical methods for dynamical systems, temporal-spatial dynamics, steady state, stability, stochasticity. Application to life sciences: genetics, tissue growth and patterning, cancers, ion channels gating, signaling networks, morphogen gradients. Numerical simulations.

Prerequisite: MATH 227A. MATH 227A with a grade of B- or better

MATH 227C. Mathematical and Computational Biology . 4 Units.
Analytical and numerical methods for dynamical systems, temporal-spatial dynamics, steady state, stability, stochasticity. Application to life sciences: genetics, tissue growth and patterning, cancers, ion channels gating, signaling networks, morphogen gradients. Probabilistic methods.

Prerequisite: MATH 227A. MATH 227A with a grade of B- or better

MATH 228. Topics in Applied Math Careers. 2-4 Units.
Prepares students for math careers in industry.

Prerequisite: A basic course in programming; familiarity with probability and differential equations at the upper undergraduate level.

Repeatability: May be taken for credit 1 times as topics vary.

Restriction: Graduate students only.

MATH 230A. Algebra. 4 Units.
Elements of the theories of groups, rings, fields, modules. Galois theory. Modules over principal ideal domains. Artinian, Noetherian, and semisimple rings and modules.

Prerequisite: Recommended: MATH 120A and MATH 121A and MATH 120B, or equivalent.

MATH 230B. Algebra. 4 Units.
Elements of the theories of groups, rings, fields, modules. Galois theory. Modules over principal ideal domains. Artinian, Noetherian, and semisimple rings and modules.

Prerequisite: MATH 230A. MATH 230A with a grade of B- or better

MATH 230C. Algebra. 4 Units.
Elements of the theories of groups, rings, fields, modules. Galois theory. Modules over principal ideal domains. Artinian, Noetherian, and semisimple rings and modules.

Prerequisite: MATH 230B. MATH 230B with a grade of B- or better

MATH 232A. Algebraic Number Theory. 4 Units.
Algebraic integers, prime ideals, class groups, Dirichlet unit theorem, localization, completion, Cebotarev density theorem, L-functions, Gauss sums, diophantine equations, zeta functions over finite fields. Introduction to class field theory.

Prerequisite: MATH 230C. MATH 230C with a grade of B- or better

MATH 232B. Algebraic Number Theory. 4 Units.
Algebraic integers, prime ideals, class groups, Dirichlet unit theorem, localization, completion, Cebotarev density theorem, L-functions, Gauss sums, diophantine equations, zeta functions over finite fields. Introduction to class field theory.

Prerequisite: MATH 232A. MATH 232A with a grade of B- or better

MATH 232C. Algebraic Number Theory. 4 Units.
Algebraic integers, prime ideals, class groups, Dirichlet unit theorem, localization, completion, Cebotarev density theorem, L-functions, Gauss sums, diophantine equations, zeta functions over finite fields. Introduction to class field theory.

Prerequisite: MATH 232B. MATH 232B with a grade of B- or better

MATH 233A. Algebraic Geometry. 4 Units.
Basic commutative algebra and classical algebraic geometry. Algebraic varieties, morphisms, rational maps, blow ups. Theory of schemes, sheaves, divisors, cohomology. Algebraic curves and surfaces, Riemann-Roch theorem, Jacobians, classification of curves and surfaces.

Prerequisite: MATH 230C. MATH 230C with a grade of B- or better

MATH 233B. Algebraic Geometry. 4 Units.
Basic commutative algebra and classical algebraic geometry. Algebraic varieties, morphisms, rational maps, blow ups. Theory of schemes, sheaves, divisors, cohomology. Algebraic curves and surfaces, Riemann-Roch theorem, Jacobians, classification of curves and surfaces.

Prerequisite: MATH 233A. MATH 233A with a grade of B- or better

MATH 233C. Algebraic Geometry. 4 Units.
Basic commutative algebra and classical algebraic geometry. Algebraic varieties, morphisms, rational maps, blow ups. Theory of schemes, sheaves, divisors, cohomology. Algebraic curves and surfaces, Riemann-Roch theorem, Jacobians, classification of curves and surfaces.

Prerequisite: MATH 233B. MATH 233B with a grade of B- or better

MATH 234B. Topics in Algebra. 4 Units.
Group theory, homological algebra, and other selected topics.

Prerequisite: MATH 230C. MATH 230C with a grade of B- or better

Repeatability: Unlimited as topics vary.

MATH 234C. Topics in Algebra. 4 Units.
Group theory, homological algebra, and other selected topics.

Prerequisite: MATH 230C. MATH 230C with a grade of B- or better

Repeatability: Unlimited as topics vary.

MATH 240A. Differential Geometry. 4 Units.
Riemannian manifolds, connections, curvature, and torsion. Submanifolds, mean curvature, Gauss curvature equation. Geodesics, minimal submanifolds, first and second fundamental forms, variational formulas. Comparison theorems and their geometric applications. Hodge theory applications to geometry and topology.

Prerequisite: MATH 218A. MATH 218A with a grade of B- or better

MATH 240B. Differential Geometry. 4 Units.
Riemannian manifolds, connections, curvature and torsion. Submanifolds, mean curvature, Gauss curvature equation. Geodesics, minimal submanifolds, first and second fundamental forms, variational formulas. Comparison theorems and their geometric applications. Hodge theory applications to geometry and topology.

Prerequisite: MATH 240A. MATH 240A with a grade of B- or better

MATH 240C. Differential Geometry. 4 Units.
Riemannian manifolds, connections, curvature and torsion. Submanifolds, mean curvature, Gauss curvature equation. Geodesics, minimal submanifolds, first and second fundamental forms, variational formulas. Comparison theorems and their geometric applications. Hodge theory applications to geometry and topology.

Prerequisite: MATH 240B. MATH 240B with a grade of B- or better

MATH 245A. Topics in Geometric Analysis. 4 Units.
Studies in selected areas of differential geometry, a continuation of MATH 240A-MATH 240B-MATH 240C. Topics addressed vary each quarter.

Prerequisite: MATH 218A. MATH 218A with a grade of B- or better

Repeatability: Unlimited as topics vary.

MATH 245B. Topics in Geometric Analysis. 4 Units.
Studies in selected areas of differential geometry, a continuation of MATH 240A-MATH 240B-MATH 240C. Topics addressed vary each quarter.

Prerequisite: MATH 245A. MATH 245A with a grade of B- or better

Repeatability: Unlimited as topics vary.

MATH 245C. Topics in Geometric Analysis. 4 Units.
Studies in selected areas of differential geometry, a continuation of MATH 240A-MATH 240B-MATH 240C. Topics addressed vary each quarter.

Prerequisite: MATH 245B. MATH 245B with a grade of B- or better

Repeatability: Unlimited as topics vary.

MATH 249. Topics in Differential Geometry. 4 Units.
Studies in selected areas of differential geometry. Topics addressed vary each quarter.

Repeatability: Unlimited as topics vary.

Restriction: Graduate students only.

MATH 250A. Algebraic Topology. 4 Units.
Provides fundamental materials in algebraic topology: fundamental group and covering space, homology and cohomology theory, and homotopy group.

Prerequisite: Recommended: MATH 120B and MATH 141, or equivalent.

MATH 250B. Algebraic Topology. 4 Units.
Provides fundamental materials in algebraic topology: fundamental group and covering space, homology and cohomology theory, and homotopy group.

Prerequisite: MATH 250A. MATH 250A with a grade of B- or better

MATH 250C. Algebraic Topology. 4 Units.
Provides fundamental materials in algebraic topology: fundamental group and covering space, homology and cohomology theory, and homotopy group.

Prerequisite: MATH 250B. MATH 250B with a grade of B- or better

MATH 260A. Functional Analysis. 4 Units.
Normed linear spaces, Hilbert spaces, Banach spaces, Stone-Weierstrass Theorem, locally convex spaces, bounded operators on Banach and Hilbert spaces, the Gelfand-Neumark Theorem for commutative C*-algebras, the spectral theorem for bounded self-adjoint operators, unbounded operators on Hilbert spaces.

Prerequisite: MATH 210C and MATH 220C. MATH 210C with a grade of B- or better. MATH 220C with a grade of B- or better

MATH 260B. Functional Analysis. 4 Units.
Normed linear spaces, Hilbert spaces, Banach spaces, Stone-Weierstrass Theorem, locally convex spaces, bounded operators on Banach and Hilbert spaces, the Gelfand-Neumark Theorem for commutative C*-algebras, the spectral theorem for bounded self-adjoint operators, unbounded operators on Hilbert spaces.

Prerequisite: MATH 260A. MATH 260A with a grade of B- or better

MATH 260C. Functional Analysis. 4 Units.
Normed linear spaces, Hilbert spaces, Banach spaces, Stone-Weierstrass Theorem, locally convex spaces, bounded operators on Banach and Hilbert spaces, the Gelfand-Neumark Theorem for commutative C*-algebras, the spectral theorem for bounded self-adjoint operators, unbounded operators on Hilbert spaces.

Prerequisite: MATH 260B. MATH 260B with a grade of B- or better

MATH 268C. Topics in Functional Analysis. 4 Units.
Selected topics such as spectral theory, abstract harmonic analysis, Banach algebras, operator algebras, and other related topics.

Prerequisite: MATH 268B

Repeatability: Unlimited as topics vary.

MATH 270A. Probability. 4 Units.
Probability spaces, distribution, and characteristic functions. Strong limit theorems. Limit distributions for sums of independent random variables. Conditional expectation and martingale theory. Stochastic processes.

Prerequisite: MATH 210C. MATH 210C with a grade of B- or better. Recommended: MATH 130C or equivalent.

MATH 270B. Probability. 4 Units.
Probability spaces, distribution and characteristic functions. Strong limit theorems. Limit distributions for sums of independent random variables. Conditional expectation and martingale theory. Stochastic processes.

Prerequisite: MATH 270A. MATH 270A with a grade of B- or better

MATH 270C. Probability. 4 Units.
Probability spaces, distribution and characteristic functions. Strong limit theorems. Limit distributions for sums of independent random variables. Conditional expectation and martingale theory. Stochastic processes.

Prerequisite: MATH 270B. MATH 270B with a grade of B- or better

MATH 271A. Stochastic Processes. 4 Units.
Processes with independent increments, Wiener and Gaussian processes, function space integrals, stationary processes, Markov processes.

Prerequisite: MATH 210C. MATH 210C with a grade of B- or better

Overlaps with STAT 270.

MATH 271B. Stochastic Processes. 4 Units.
Processes with independent increments, Wiener and Gaussian processes, function space integrals, stationary processes, Markov processes.

Prerequisite: MATH 271A. MATH 271A with a grade of B- or better

Overlaps with STAT 270.

MATH 271C. Stochastic Processes. 4 Units.
Processes with independent increments, Wiener and Gaussian processes, function space integrals, stationary processes, Markov processes.

Prerequisite: MATH 271B. MATH 271B with a grade of B- or better

Overlaps with STAT 270.

MATH 274. Topics in Probability. 4 Units.
Selected topics, such as theory of stochastic processes, martingale theory, stochastic integrals, stochastic differential equations.

Prerequisite: Recommended: MATH 270C.

Repeatability: Unlimited as topics vary.

Restriction: Graduate students only.

MATH 280A. Mathematical Logic. 4 Units.
Basic set theory; models, compactness, and completeness; basic model theory; Incompleteness and Gödel's Theorems; basic recursion theory; constructible sets.

Prerequisite: Recommended: MATH 150.

MATH 280B. Mathematical Logic. 4 Units.
Basic set theory; models, compactness, and completeness; basic model theory; Incompleteness and Gödel's Theorems; basic recursion theory; constructible sets.

Prerequisite: MATH 280A. MATH 280A with a grade of B- or better

MATH 280C. Mathematical Logic. 4 Units.
Basic set theory; models, compactness, and completeness; basic model theory; Incompleteness and Gödel's Theorems; basic recursion theory; constructible sets.

Prerequisite: MATH 280B. MATH 280B with a grade of B- or better

MATH 281A. Set Theory. 4 Units.
Ordinals, cardinals, cardinal arithmetic, combinatorial set theory, models of set theory, Gödel's constructible universe, forcing, large cardinals, iterate forcing, inner model theory, fine structure.

MATH 281B. Set Theory. 4 Units.
Ordinals, cardinals, cardinal arithmetic, combinatorial set theory, models of set theory, Gödel's constructible universe, forcing, large cardinals, iterate forcing, inner model theory, fine structure.

Prerequisite: MATH 281A. MATH 281A with a grade of B- or better

MATH 281C. Set Theory. 4 Units.
Ordinals, cardinals, cardinal arithmetic, combinatorial set theory, models of set theory, Gödel's constructible universe, forcing, large cardinals, iterate forcing, inner model theory, fine structure.

Prerequisite: MATH 281B. MATH 281B with a grade of B- or better

MATH 282A. Model Theory. 4 Units.
Languages, structures, compactness, and completeness. Model-theoretic constructions. Omitting types theorems. Morley's theorem. Ranks, forking. Model completeness. O-minimality. Applications to algebra.

MATH 282B. Model Theory. 4 Units.
Languages, structures, compactness and completeness. Model-theoretic constructions. Omitting types theorems. Morley's theorem. Ranks, forking. Model completeness. O-minimality. Applications to algebra.

Prerequisite: MATH 282A. MATH 282A with a grade of B- or better

MATH 282C. Model Theory. 4 Units.
Languages, structures, compactness and completeness. Model-theoretic constructions. Omitting types theorems. Morley's theorem. Ranks, forking. Model completeness. O-minimality. Applications to algebra.

Prerequisite: MATH 282B. MATH 282B with a grade of B- or better

MATH 290A. Methods in Applied Mathematics. 4 Units.
Introduction to ODEs and dynamical systems: existence and uniqueness. Equilibria and periodic solutions. Bifurcation theory. Perturbation methods: approximate solution of differential equations. Multiple scales and WKB. Matched asymptotic. Calculus of variations: direct methods, Euler-Lagrange equation. Second variation and Legendre condition.

MATH 290B. Methods in Applied Mathematics. 4 Units.
Introduction to ODEs and dynamical systems: existence and uniqueness. Equilibria and periodic solutions. Bifurcation theory. Perturbation methods: approximate solution of differential equations. Multiple scales and WKB. Matched asymptotic. Calculus of variations: direct methods, Euler-Lagrange equation. Second variation and Legendre condition.

Prerequisite: MATH 290A

MATH 290C. Methods in Applied Mathematics. 4 Units.
Introduction to ODEs and dynamical systems: existence and uniqueness. Equilibria and periodic solutions. Bifurcation theory. Perturbation methods: approximate solution of differential equations. Multiple scales and WKB. Matched asymptotic. Calculus of variations: direct methods, Euler-Lagrange equation. Second variation and Legendre condition.

Prerequisite: MATH 290B

MATH 295A. Partial Differential Equations. 4 Units.
Theory and techniques for linear and nonlinear partial differential equations. Local and global theory of partial differential equations: analytic, geometric, and functional analytic methods.

Prerequisite: MATH 210C. MATH 210C with a grade of B- or better. Recommended: MATH 112B and MATH 112C or equivalent.

MATH 295B. Partial Differential Equations. 4 Units.
Theory and techniques for linear and nonlinear partial differential equations. Local and global theory of partial differential equations: analytic, geometric, and functional analytic methods.

Prerequisite: MATH 295A. MATH 295A with a grade of B- or better

MATH 295C. Partial Differential Equations. 4 Units.
Theory and techniques for linear and nonlinear partial differential equations. Local and global theory of partial differential equations: analytic, geometric, and functional analytic methods.

Prerequisite: MATH 295B. MATH 295B with a grade of B- or better

MATH 296. Topics in Partial Differential Equations. 4 Units.
Studies in selected areas of partial differential equations, a continuation of MATH 295A-MATH 295B-MATH 295C. Topics addressed vary each quarter.

Prerequisite: MATH 295C. MATH 295C with a grade of B- or better

Repeatability: Unlimited as topics vary.

Restriction: Graduate students only.

MATH 297. Mathematics Colloquium. 1 Unit.
Weekly colloquia on topics of current interest in mathematics.

Grading Option: Satisfactory/unsatisfactory only.

Repeatability: May be repeated for credit unlimited times.

MATH 298A. Seminar . 2 Units.
Seminars organized for detailed discussion of research problems of current interest in the Department. The format, content, frequency, and course value are variable.

Grading Option: Satisfactory/unsatisfactory only.

Repeatability: Unlimited as topics vary.

MATH 298B. Seminar . 2 Units.
Seminars organized for detailed discussion of research problems of current interest in the Department. The format, content, frequency, and course value are variable.

Prerequisite: MATH 298A. MATH 298A with a grade of B- or better

Grading Option: Satisfactory/unsatisfactory only.

Repeatability: Unlimited as topics vary.

MATH 298C. Seminar . 2 Units.
Seminars organized for detailed discussion of research problems of current interest in the Department. The format, content, frequency, and course value are variable.

Prerequisite: MATH 298B. MATH 298B with a grade of B- or better

Grading Option: Satisfactory/unsatisfactory only.

Repeatability: Unlimited as topics vary.

MATH 299A. Supervised Reading and Research. 1-12 Units.
Supervised reading and research with Mathematics faculty.

Repeatability: May be repeated for credit unlimited times.

MATH 299B. Supervised Reading and Research. 1-12 Units.
Supervised reading and research with Mathematics faculty.

Prerequisite: MATH 299A. MATH 299A with a grade of B- or better

Repeatability: May be repeated for credit unlimited times.

MATH 299C. Supervised Reading and Research. 1-12 Units.
Supervised reading and research with Mathematics faculty.

Prerequisite: MATH 299B. MATH 299B with a grade of B- or better

Repeatability: May be repeated for credit unlimited times.

MATH 399. University Teaching. 1-4 Units.
Limited to Teaching Assistants.

Grading Option: Satisfactory/unsatisfactory only.

Repeatability: May be repeated for credit unlimited times.

Physical Sciences Courses

PHY SCI 5. California Teach 1: Introduction to Science and Mathematics Teaching. 3 Units.
First in a series for students interested in becoming middle or high school teachers of mathematics or science. Students gain an understanding of effective, research-based teaching strategies. Includes supervised field experience in a K-12 classroom.

Same as BIO SCI 14.

Restriction: School of Biological Sciences students have first consideration for enrollment. School of Physical Sciences students have first consideration for enrollment. School of Engineering students have first consideration for enrollment. School of Info & Computer Sci students have first consideration for enrollment.

PHY SCI 9. Introduction to Computation for Scientists and Engineers. 6 Units.
Introduces principles, techniques, and computational tools for quantitative approach to basic problem solving in physics and engineering. Project-based course that actively explores how programing techniques are used for solving STEM real-world problems.

Prerequisite or corequisite: MATH 2A or AP Calculus AB or AP Calculus BC. AP Calculus AB with a minimum score of 4. AP Calculus BC with a minimum score of 3

Same as I&C SCI 9.
Overlaps with PHYSICS 2.

Restriction: Lower-division students only.

(II and (Va or Vb)).

PHY SCI 80. Skills Development. 1.5 Workload Unit.
Undergraduates identify, cultivate, and practice relevant soft skills applicable to careers in mathematics and science. The focus is on career readiness, how to market oneself to future employers, and what to expect from the professional world.

Prerequisite: Satisfactory completion of the Lower-Division Writing requirement.

Grading Option: Workload Credit Letter Grade with P/NP.

Restriction: School of Physical Sciences students have first consideration for enrollment.

PHY SCI 105. California Teach 2: Middle School Science and Mathematics Teaching. 3 Units.
Second in a series for students interested in becoming middle or high school teachers of mathematics or science. Students gain an understanding of effective, research-based teaching strategies for grades 6-8. Includes supervised field experience in a middle school classroom.

Prerequisite: PHY SCI 5

Same as BIO SCI 101.

Restriction: School of Physical Sciences students have first consideration for enrollment. School of Biological Sciences students have first consideration for enrollment. School of Info & Computer Sci students have first consideration for enrollment. School of Engineering students have first consideration for enrollment.

PHY SCI 139W. Technical Writing and Communication Skills. 4 Units.
Workshop in writing technical reports, journal articles, proposals. Oral presentations. Communicating with the public. May not be used in satisfaction of any School or departmental requirement.

Prerequisite: Satisfactory completion of the Lower-Division Writing requirement.

Restriction: Upper-division students only. School of Physical Sciences students have first consideration for enrollment.

(Ib)

PHY SCI 220. Science Communication Skills. 2 Units.
Development of effective communication skills, oral and written presentations. Topics range from the art of creating keynote slides to strategically crafting a personal story, culminating in a live presentation to an invited audience.

Physics and Astronomy Courses

PHYSICS 2. Introduction to Mathematical Methods for Physics. 4 Units.
Provides the applied mathematics and problem solving/presentation skills necessary for success in an introductory physics sequence. Focuses on practical exercises in problem solving. Covers kinematics in one and two dimensions in detail. Additional topics include vectors, differentiation, and integration.

Corequisite: MATH 2A or MATH 5A
Prerequisite: MATH 2A or MATH 5A or AP Calculus AB or AP Calculus BC. AP Calculus AB with a minimum score of 3. AP Calculus BC with a minimum score of 3

Restriction: PHYSICS 2 may not be taken for credit if taken after PHYSICS 7C.

PHYSICS 3A. Basic Physics I. 4 Units.
Introductory physics with applications to life sciences. Vectors; motion, force, and energy.

Corequisite: MATH 2A or MATH 5A
Prerequisite: MATH 2A or MATH 5A or AP Calculus AB or AP69. AP Calculus AB with a minimum score of 3. AP69 with a minimum score of 3

Restriction: PHYSICS 3A may not be taken for credit if taken after PHYSICS 7C.

(II and VA).

PHYSICS 3B. Basic Physics II. 4 Units.
Introductory physics with applications to life sciences. Energy and thermodynamics; waves and sound; optics.

Prerequisite: PHYSICS 3A or AP Physics C: Mechanics. AP Physics C: Mechanics with a minimum score of 5

(II and VA).

PHYSICS 3C. Basic Physics III. 4 Units.
Introductory physics with applications to life sciences. Electricity and magnetism; electromagnetic waves; modern physics.

Corequisite: MATH 2B or MATH 5B
Prerequisite: PHYSICS 3A or AP Physics C: Mechanics. AP Physics C: Mechanics with a minimum score of 5. A score of 4 or higher on the AP Calculus BC exam

(II and Va).

PHYSICS 3LB. Basic Physics Laboratory. 1.5 Unit.
Practical applications of electronics and classical physics to biology. Goals include skill to use oscilloscope and other basic instrumentation. Materials fee.

PHYSICS 3LC. Basic Physics Laboratory. 1.5 Unit.
Practical applications of physics to medical imaging. Topics include optics, radioactivity, and acoustics. Materials fee.

PHYSICS 7C. Classical Physics. 4 Units.
Topics include force, energy, momentum, rotation, and gravity.

Corequisite: MATH 2B
Prerequisite: Recommended: PHYS 2 or (MATH 2D and (CHEM 1C or CHEM H2C or CHEM M3C) or CHEM M2C) or AP Physics C: Mechanics or AP Physics C: Electricity and Magnetism or SAT Mathematics or ACT Mathematics or passing score on self-assessment test. PHYS 2 with a grade of C or better. AP Physics C: Mechanics with a minimum score of 4. AP Physics C: Electricity and Magnetism with a minimum score of 4. SAT Mathematics with a minimum score of 650. ACT Mathematics with a minimum score of 27. Students are recommended to take a self-assessment test provided by the UCI Department of Physics and Astronomy. If the student can fairly easily answer at least 75 percent of the questions with a calculator, but no other help, then the student is ready to take Physics 7C and should enroll in it if they have completed one year of high school physics and are Math 2B ready (or have credit for Math 2B).

Restriction: Some offerings restricted to Physics Majors.

(II and VA).

PHYSICS 7D. Classical Physics. 4 Units.
Electricity and magnetism.

Corequisite: PHYSICS 7LD and MATH 2D
Prerequisite: PHYSICS 7C and (MATH 2B or AP Calculus BC). AP Calculus BC with a minimum score of 4

Restriction: Physics Majors have first consideration for enrollment.

(II and Va).

PHYSICS 7E. Classical Physics. 4 Units.
Fluids; oscillations; waves; and optics.

Prerequisite: PHYSICS 7C and MATH 2B

Restriction: Physics Majors have first consideration for enrollment.

(II and VA).

PHYSICS 7LC. Classical Physics Laboratory. 1 Unit.
Experiments related to lecture topics in Physics 7C. Materials fee.

Corequisite: PHYSICS 7C

Restriction: Physics Majors have first consideration for enrollment.

PHYSICS 7LD. Classical Physics Laboratory. 1 Unit.
Electricity and magnetism.

Corequisite: PHYSICS 7D

Restriction: Physics Majors have first consideration for enrollment.

PHYSICS 14. Energy and the Environment. 4 Units.
The physics of society's energy production and consumption, and of their influences on the environment. Topics include fossil and renewable energy resources; nuclear power; prospects for a hydrogen economy; efficient and environmentally benign transportation; efficient home and commercial energy usage.

(II and Va).

PHYSICS 15. Physics of Music. 4 Units.
Introduces basic physical principles underlying generation and properties of music, including basic properties of sound waves, musical scales and temperament, musical instruments, and acoustics of music halls. No mathematics background required, but high school algebra is recommended.

(II)

PHYSICS 18. How Things Work. 4 Units.
Survey of the physical basis of modern technology, with an emphasis on electronics and materials. Topics include power generation and distribution, communication (radio, TV, telephone, computers, tape recorders, CD players), imaging (optics, x-rays, MRI), and modern materials (alloys, semiconductors, superconductors).

(II)

PHYSICS 19. Great Ideas of Physics. 4 Units.
Introduces non-science majors to physics, examining important breakthroughs and controversies. Potential topics: Einstein's Relativity; Heisenberg's Uncertainty Principle; black holes; extra-dimensions; antimatter. Case studies illustrate the essential nature of scientific review and independent confirmation of results. No mathematics background required.

(II)

PHYSICS 20A. Introduction to Astronomy. 4 Units.
History of astronomy. Underlying physics. Objects in the solar system and how they are studied. Properties of stars: their formation, structure, and evolution. Pulsars and black holes. Galaxies and quasars.

(II and VA).

PHYSICS 20B. Cosmology: Humanity's Place in the Universe. 4 Units.
An overview of the origin, evolution, and ultimate fate of the Universe. Galaxies and dark matter. The Big Bang and dark energy. Ancient world models.

(II and VA).

PHYSICS 20D. Space Science. 4 Units.
Space exploration. Human missions to the moon, Mars, and beyond. Space stations, observatories, and deep-space probes. Robots and drones on distant worlds. Propulsion mechanisms, rockets, space flight, and the dangers of solar radiation.

(II and VA).

PHYSICS 20E. Life in the Universe. 4 Units.
An overview of the scientific quest to discover life elsewhere in the universe. Topics include the origin of life on Earth, Mars, extra-solar planets, interstellar travel, and extra-terrestrial intelligence.

(II and Va).

PHYSICS 21. Special Topics in Physics. 4 Units.
Topics addressed vary each quarter. Past topics have included physics and music, Newton, planetary science. Lectures on areas of special interest in physics used to introduce students to scientific method, fundamental laws of science, qualitative and quantitative analysis of data.

Repeatability: Unlimited as topics vary.

Overlaps with PHYSICS 12, PHYSICS XI12.

(II)

PHYSICS 50. Introductory Mathematical Physics. 4 Units.
Introduction to math methods for upper-division physics. Taylor and Fourier series; complex algebra; ordinary differential equations; matrices, tensors and vector spaces; eigensystems; orthogonal coordinates; vector calculus and fields. Symbolic computation with Mathematica is incorporated throughout.

Corequisite: MATH 2E
Prerequisite: MATH 3A

Overlaps with PHYSICS 100.

Restriction: Physics Majors have first consideration for enrollment.

PHYSICS 51A. Modern Physics. 4 Units.
Wave-particle duality; quantum mechanics; special relativity; statistical mechanics.

Prerequisite: (PHYSICS 7E or PHYSICS 3C) and MATH 2D

Overlaps with PHYSICS 61A.

Restriction: No Physics Majors.

PHYSICS 52A. Fundamentals of Experimental Physics. 2 Units.
Optics: lenses, mirrors, polarization, lasers, optical fibers, interference, spectra. Materials fee.

Corequisite: PHYSICS 7E or PHYSICS 3C.

Restriction: Physics Majors have first consideration for enrollment.

PHYSICS 52B. Fundamentals of Experimental Physics. 2 Units.
Circuits: oscilloscope, meters, DC and AC circuits. Materials fee.

Prerequisite: PHYSICS 7D or PHYSICS 3B

Restriction: Physics Majors have first consideration for enrollment.

PHYSICS 52C. Fundamentals of Experimental Physics. 2 Units.
Data analysis: random and systematic errors, curve fitting; nuclear counting; quantum experiments. Error analysis: random and systematic errors, curve fitting, nuclear counting, and quantum experiments. Materials fee.

Prerequisite: PHYSICS 51A or PHYSICS 61A

Restriction: Physics Majors have first consideration for enrollment.

PHYSICS 53. Introduction to Programming and Numerical Analysis. 4 Units.
Introduction to structured programming; in-depth training in python. Elementary numerical methods applied to physics problems.

Prerequisite: MATH 3A and MATH 3D

Restriction: Physics Majors have first consideration for enrollment.

PHYSICS 60. Thermal Physics. 4 Units.
Introduction to thermodynamics and systems of many particles. Topics include first and second laws of thermodynamics, ideal gas laws, kinetic theory, heat engines and refrigerators, thermodynamic potentials, phase transitions, dilute solutions, chemical equilibrium, and basic statistical distributions.

Prerequisite: (PHYSICS 7E or PHYSICS 3C) and MATH 2D

Restriction: Physics Majors only.

PHYSICS 61A. Modern Physics for Majors. 4 Units.
Special relativity; Heisenberg Uncertainty Principle and wave-particle duality; the Schrödinger equation.

Prerequisite: (PHYSICS 7E or PHYSICS 3C) and MATH 2D

Overlaps with PHYSICS 51A.

Restriction: Physics Majors only.

PHYSICS 61B. Modern Physics for Majors. 4 Units.
Hydrogen atom; spin and angular momentum; multi-electron atoms and the periodic table; introductions to nuclear physics, particle physics, and cosmology.

Prerequisite: PHYSICS 61A or PHYSICS 51A

Restriction: Physics Majors only.

PHYSICS 61C. Introduction to Astrophysics. 4 Units.
Introduction to fundamental topics in astrophysics, including stellar structure and evolution; stellar remnants; detection and characterization of exoplanets; physics of interstellar gas and star-forming regions.

Prerequisite: PHYSICS 61A or PHYSICS 51A

PHYSICS H80. Impact of World War I on Science. 4 Units.
Introduction to science in 1914 and WWI. Participants in groups of two or three will pick a preferred science; find out what happened to it during and after the war; write reports and present what they learned.

Restriction: Campuswide Honors Collegium students only.

(II)

PHYSICS H90. The Idiom and Practice of Science. 4 Units.
A series of fundamental and applied scientific problems of social relevance. Possible topics include Newton's Law, calculus, earthquake physics, and radiation.

Restriction: Campuswide Honors Collegium students only.

(II and Va).

PHYSICS 99. Current Topics in Physics. 2 Units.
Designed to introduce undergraduate students to current topics in physics. Focus is discussion of selected readings on current research issues.

Repeatability: Unlimited as topics vary.

PHYSICS 100. Computational Methods. 4 Units.
Mathematical and numerical analysis using Mathematica and C programming, as applied to problems in physical science.

Corequisite: MATH 2E
Prerequisite: MATH 3A or MATH H3A

Overlaps with PHYSICS 50.

Concurrent with PHYSICS 229A.

PHYSICS 106W. Advanced Data Acquisition, Analysis, and Scientific Writing. 4 Units.
Introduces modern practical laboratory techniques for developing data interface devices, acquiring and analyzing data, and writing up results in manuscript format. Experiments include interfacing with instruments through software and hardware development, PID controller, Fourier analysis, and lock-in amplifier.

Prerequisite: PHYSICS 52B and PHYSICS 194

Concurrent with PHYSICS 206 and CHEM 206.

(Ib)

PHYSICS 111A. Classical Mechanics. 4 Units.
One-dimensional motion and oscillations; three-dimensional motion, non-inertial coordinates, conservation laws, and Lagrangian and Hamiltonian dynamics; rigid body motion and relativity.

Corequisite: PHYSICS 50
Prerequisite: (PHYSICS 7E or PHYSICS 3C)

PHYSICS 111B. Classical Mechanics. 4 Units.
One-dimensional motion and oscillations; three-dimensional motion, non-inertial coordinates, conservation laws, and Lagrangian and Hamiltonian dynamics; rigid body motion and relativity.

Prerequisite: PHYSICS 111A

PHYSICS 112A. Electromagnetic Theory. 4 Units.
Electric, magnetic, and gravitational fields and potentials; electrodynamics; mechanical and electromagnetic waves and radiation.

Prerequisite: (PHYSICS 7D or PHYSICS 3B) and PHYSICS 50

PHYSICS 112B. Electromagnetic Theory. 4 Units.
Electric, magnetic, and gravitational fields and potentials; electrodynamics; mechanical and electromagnetic waves and radiation.

Prerequisite: PHYSICS 7E and PHYSICS 112A

PHYSICS 113A. Quantum Mechanics. 4 Units.
The wave function and its interpretation; time independent and time dependent Schrödinger equation; Hilbert space and the uncertainty principle; systems in one to three dimensions; the hydrogen atom, angular momentum and spin.

Prerequisite: (PHYSICS 51A or PHYSICS 61A) and PHYSICS 50

PHYSICS 113B. Quantum Mechanics. 4 Units.
Identical particles in quantum systems; atoms and the periodic table; theories of solids; time-independent perturbation theory; fine structure of hydrogen, the Zeeman effect and hyperfine structure; the variational principle; the WKB approximation and tunneling.

Prerequisite: PHYSICS 111B and PHYSICS 112B and PHYSICS 113A

PHYSICS 113C. Quantum Mechanics. 4 Units.
Symmetries and conservation laws in quantum mechanics; degeneracy; quantum dynamics and selection rules; scattering theory; time-dependent perturbation theory; emission and absorption of radiation; Fermi's golden rule; selected contemporary topics.

Prerequisite: PHYSICS 111B and PHYSICS 112B and PHYSICS 113B

PHYSICS 115A. Statistical Physics. 4 Units.
Microscopic theory of temperature, heat, and entropy; kinetic theory; multicomponent systems; quantum statistics.

Prerequisite: PHYSICS 50 and (PHYSICS 60 or CHEM 1C or ENGRMAE 91)

PHYSICS 116. Relativity and Black Holes. 4 Units.
Introduces students to both special and general relativity; includes the formalism of four-vectors, equivalence principle, curved space-time, and modern issues with black holes.

Prerequisite: PHYSICS 50 and PHYSICS 111A

PHYSICS 120. Electronics for Scientists. 4 Units.
Applications of modern semiconductor devices to physical instrumentation. Characteristics of semiconductor devices, integrated circuits, analog and digital circuits. Materials fee.

Prerequisite: PHYSICS 52B

Concurrent with PHYSICS 220.

PHYSICS 121W. Advanced Laboratory. 4 Units.
Experiments in atomic, condensed matter, quantum, nuclear, particle, and plasma physics. Introduction to instrumentation, computational methods for data analysis, and a first experience in the research laboratory.

Prerequisite: (PHYSICS 51B or PHYSICS 61B or PHYSICS 61C) and (PHYSICS 52C or PHYSICS 193) and (PHYSICS 194 or EDUC 143BW)

Repeatability: May be taken for credit 3 times.

Restriction: Physics Majors only.

(Ib)

PHYSICS 125A. Mathematical Physics. 4 Units.
Complex variables; Legendre and Bessel functions; complete sets of orthogonal functions; partial differential equations; integral equations; calculus of variations; coordinate transformations; special functions and series.

Prerequisite: PHYSICS 50 and MATH 3D

PHYSICS 125B. Mathematical Physics. 4 Units.
Complex variables; Legendre and Bessel functions; complete sets of orthogonal functions; partial differential equations; integral equations; calculus of variations; coordinate transformations; special functions and series.

Prerequisite: PHYSICS 125A and PHYSICS 113A

PHYSICS 133. Introduction to Condensed Matter Physics. 4 Units.
Phenomena of solids and their interpretation in terms of quantum theory.

Prerequisite: PHYSICS 113B and PHYSICS 115A

PHYSICS 134A. Physical and Geometrical Optics. 4 Units.
Focuses on the practical aspects of optics and optical engineering, starting at the fundamentals. Topics include geometrical optics, ray tracing, polarization optics, interferometers, and diffractive optics.

Prerequisite: PHYSICS 52A

Concurrent with CBEMS 242A.

PHYSICS 135. Plasma Physics. 4 Units.
Basic concepts, orbits, kinetic and fluid equations, Coulomb collisions, fluctuations, scattering, radiation.

Prerequisite: PHYSICS 112B

Concurrent with PHYSICS 239A.

PHYSICS 136. Introduction to Particle Physics. 4 Units.
Experimental techniques and theoretical concepts of high-energy phenomena: accelerators and detectors; classification of particles and interactions; particle properties; symmetries and mass multiplets; production and decay mechanisms.

Prerequisite: PHYSICS 113B

PHYSICS 137. Introduction to Cosmology. 4 Units.
Solution of the differential equations governing the expansion of the Universe. Observational determinations of the parameters governing the expansion. Big Bang inflation, primordial nucleosynthesis, and cosmic microwave background. Dark matter, dark energy, and large-scale structure of the Universe.

Prerequisite or corequisite: PHYSICS 111A

PHYSICS 138. Astrophysics of Galaxies. 4 Units.
Introduction to the solar neighborhood, Milky Way, and other galaxies. Interstellar medium. Star formation. Stellar populations. Evolution of spiral, elliptical, and irregular galaxies. Supermassive black holes, quasars, and active galaxies. Galaxies as probes of the expansion rate of the Universe.

Prerequisite: PHYSICS 111A and PHYSICS 61C

PHYSICS 139. Observational Astrophysics. 4 Units.
Telescopes and astronomical observations, imaging with CCD detectors and image processing techniques. Photometry and spectroscopy of stars, galaxies, and quasars. Advanced imaging techniques such as deconvolution, adaptive optics, and interferometry.

Corequisite: PHYSICS 194
Prerequisite: PHYSICS 52C and (PHYSICS 53 or I&C SCI 45C or EECS 12) and PHYSICS 61C

PHYSICS 143A. Lasers 1 - Oscillators and Amplifiers. 4 Units.
Semiclassical and quantum-mechanical development of electro-magnetic interactions with matter. Atomic rate equations and amplification of light via stimulated emission in gases, solids, liquids, and plasmas. Optical components and resonators that enable production of coherent radiation from laser oscillators.

Prerequisite: PHYSICS 61B and PHYSICS 112A and PHYSICS 112B

Concurrent with PHYSICS 243A.

PHYSICS 143B. Lasers 2 - Beams and Pulses. 4 Units.
Hermite-gaussian and Laguerre-gaussian laser beam solutions of the paraxial wave equation, characterization of laser beams, laser resonator design, ABCD matrix formalism for laser beam and laser pulse propagation, methods for ultra-short duration laser pulse formation, manipulation, amplification, and measurement.

Prerequisite: PHYSICS 61A and PHYSICS 112A and PHYSICS 112B

Concurrent with PHYSICS 243B.

PHYSICS 144. Stellar Astrophysics. 4 Units.
Stars: their structure and evolution; physical state of the interior; the Hertzprung- Russell diagram, stellar classification, and physical principles responsible for the classification; star formation; nuclear burning; giant and dwarf stars; neutron stars and black holes.

Prerequisite: (PHYSICS 51A or PHYSICS 61A) and PHYSICS 111A and PHYSICS 112A

PHYSICS 145. High-Energy Astrophysics. 4 Units.
Production of radiation by high-energy particles, white dwarfs, neutron stars, and black holes. Evolution of galactic nuclei, radio galaxies, quasars, and pulsars. Cosmic rays and the cosmic background radiation.

Prerequisite: (PHYSICS 51A or PHYSICS 61A) and PHYSICS 111A and PHYSICS 112A

PHYSICS 146A. Biophysics of Molecules and Molecular Machines. 4 Units.
Physical concepts and experimental and computational techniques used to study the structure and function of biological molecules and molecular machines with examples from enzyme action, protein folding, molecular motors, photobiology, chemotaxis, and vision.

Prerequisite: PHYSICS 115A

Concurrent with PHYSICS 230A.

PHYSICS 146B. Biophysics of Molecules and Molecular Machines. 4 Units.
Physical concepts and experimental and computational techniques used to study the structure and function of biological molecules and molecular machines with examples from enzyme action, protein folding, molecular motors, photobiology, chemotaxis, and vision.

Prerequisite: PHYSICS 115A

Concurrent with PHYSICS 230B.

PHYSICS 150. Special Topics in Physics and Astronomy. 4 Units.
Current topics in physics. Includes topics from nano-science, biological sciences, astrophysics, and the common use of estimation across subdisciplines within physics.

Repeatability: Unlimited as topics vary.

PHYSICS 191. Field Experience in Physics Education. 1-4 Units.
Students develop and perform physics assemblies at neighboring public schools.

Prerequisite: PHYSICS 7C and PHYSICS 7D and PHYSICS 7E

Grading Option: Pass/no pass only.

Repeatability: May be taken for credit for 8 units.

PHYSICS 192. Tutoring in Physics. 1-2 Units.
Formalizes the already existing free tutoring for the lower-division physics courses that is provided by the Society of Physics Students (SPS). Includes instructions on tutoring techniques.

Prerequisite: PHYSICS 7E

Grading Option: Pass/no pass only.

Repeatability: May be taken for credit for 12 units.

Restriction: Society of Physics Students (SPS) tutoring program students only.

PHYSICS 193. Research Methods. 4 Units.
Explores tools of inquiry for developing and implementing science research projects. Students undertake independent projects requiring data collection, analysis, and modeling, and the organization and presentation of results. Additional topics include ethical issues and role of scientific literature.

Prerequisite: BIO SCI 14 or PHY SCI 5

Same as BIO SCI 108, CHEM 193.

PHYSICS 194. Research Communication for Physics Majors. 2 Units.
Students learn the fundamentals of communicating about research. Topics include preparing abstracts, proposals, and literature reviews. Provides preparation for presentation of independent research projects in PHYSICS 121 and PHYSICS 196.

Prerequisite: PHYSICS 61A or PHYSICS 51A. Satisfactory completion of the Lower-Division Writing requirement.

Restriction: Physics Majors only.

PHYSICS 195. Undergraduate Research. 4 Units.
Independent research under the guidance of a Physics faculty member.

Grading Option: Pass/no pass only.

Repeatability: May be repeated for credit unlimited times.

Restriction: Juniors only. Physics Majors only.

PHYSICS 196A. Thesis in Physics I. 2 Units.
Independent research for seniors conducted under the guidance of a faculty member. Students' research results are discussed in oral presentations, and a written proposal, progress report, and thesis are submitted.

Corequisite: PHYSICS 194

Overlaps with PHYSICS H196A.

Restriction: Physics Majors only.

PHYSICS 196B. Thesis in Physics II. 4 Units.
Independent research for seniors conducted under the guidance of a faculty member. Students' research results are discussed in oral presentations, and a written proposal, progress report, and thesis are submitted.

Prerequisite: PHYSICS 196A

Overlaps with PHYSICS H196B.

Restriction: Physics Majors only.

PHYSICS 196C. Thesis in Physics III. 4 Units.
Independent research for seniors conducted under the guidance of a faculty member. Students' research results are discussed in oral presentations, and a written proposal, progress report, and thesis are submitted.

Prerequisite: PHYSICS 196B

Overlaps with PHYSICS H196C.

Restriction: Physics Majors only.

PHYSICS H196A. Honors Thesis in Physics I. 2 Units.
Independent research for seniors conducted under the guidance of a faculty member. Students' research results are discussed in oral presentations, and a written proposal, progress report, and thesis are submitted.

Corequisite: PHYSICS 194

Overlaps with PHYSICS 196A.

Restriction: Physics Majors only. Campuswide Honors Collegium students only. Honors Program in Physics students only.

PHYSICS H196B. Honors Thesis in Physics II. 4 Units.
Independent research for seniors conducted under the guidance of a faculty member. Students' research results are discussed in oral presentations, and a written proposal, progress report, and thesis are submitted.

Prerequisite: PHYSICS H196A

Overlaps with PHYSICS 196B.

Restriction: Physics Majors only. Campuswide Honors Collegium students only. Honors Program in Physics students only.

PHYSICS H196C. Honors Thesis in Physics III. 4 Units.
Independent research for seniors conducted under the guidance of a faculty member. Students' research results are discussed in oral presentations, and a written proposal, progress report, and thesis are submitted.

Prerequisite: PHYSICS H196B

Overlaps with PHYSICS 196C.

Restriction: Physics Majors only. Campuswide Honors Collegium students only. Honors Program in Physics students only.

PHYSICS 199. Readings on Special Topics. 1-4 Units.
Readings in selected areas of Physics. Topics addressed vary each quarter.

Grading Option: Pass/no pass only.

Repeatability: May be repeated for credit unlimited times.

PHYSICS 206. Advanced Data Acquisition and Analysis. 4-6 Units.
Introduces students to a variety of practical laboratory techniques, including lock-in, boxcar, coincidence counting, noise filtering, PID control, properties of common transducers, computer interfacing to instruments, vacuum technology, laboratory safety, basic mechanical design, and shop skills. Materials fee.

Same as CHEM 206.

Concurrent with PHYSICS 106.

PHYSICS 207. Applied Physical Chemistry. 4 Units.
Introduction to fundamental concepts in molecular structure and reactivity: theory of bonding, valence and molecular orbitals; structure and reactivity in inorganic chemistry; elements in molecular group theory; nomenclature in organic chemistry; and survey of macromolecules.

Same as CHEM 207.

PHYSICS 208. Math Methods. 4 Units.
Applications of mathematics to physical and chemical problems. Calculus of special functions, complex variables and vectors; linear vector spaces and eigenvalue problems. Differential equations.

Same as CHEM 208.

PHYSICS 211. Classical Mechanics. 4 Units.
Variational principles, Lagrange's equations; applications to two body problems, small oscillation theory, and other phenomena. Hamilton's equations. Hamilton-Jacobi theory. Canonical transformations.

Restriction: Graduate students only.

PHYSICS 212A. Mathematical Physics. 4 Units.
Complex variables and integration; ordinary and partial differential equations; the eigenvalue problem.

Restriction: Graduate students only.

PHYSICS 213A. Electromagnetic Theory. 4 Units.
Electrostatics; magnetostatics; relativity; classical electron theory; fields in vacuum and matter; retardation; radiation and absorption; dispersion; propagation of light; diffraction; geometric optics; theories of the electric and magnetic properties of materials; scattering.

PHYSICS 213B. Electromagnetic Theory. 4 Units.
Electrostatics; magnetostatics; relativity; classical electron theory; fields in vacuum and matter; retardation; radiation and absorption; dispersion; propagation of light; diffraction; geometric optics; theories of the electric and magnetic properties of materials; scattering.

Prerequisite: PHYSICS 213A

PHYSICS 214A. Statistical Physics. 4 Units.
Maxwell-Boltzmann, Bose-Einstein, Fermi-Dirac statistics; ideal and imperfect gases; thermodynamic properties of solids; transport theory.

Restriction: Graduate students only.

PHYSICS 214C. Many Body Theory. 4 Units.
Application of field theory methods, perturbative and non-perturbative, to many particle systems; second quantization, Feynman diagrams, linear response theory, and functional integral methods applied to the ground state and at finite temperature.

Prerequisite: PHYSICS 214A and PHYSICS 215A and PHYSICS 215B. PHYSICS 214A with a grade of B- or better. PHYSICS 215A with a grade of B- or better. PHYSICS 215B with a grade of B- or better

Restriction: Graduate students only.

PHYSICS 215A. Quantum Mechanics. 4 Units.
Foundations; Dirac notation; basic operators and their eigenstates; perturbation theory; spin.

Restriction: Graduate students only.

PHYSICS 215B. Quantum Mechanics. 4 Units.
Atomic physics; scattering theory, formal collision theory; semi-classical radiation theory; many body systems.

Prerequisite: PHYSICS 215A. PHYSICS 215A with a grade of B- or better

Restriction: Graduate students only.

PHYSICS 220. Electronics for Scientists. 4 Units.
Applications of modern semiconductor devices to physical instrumentation. Characteristics of semiconductor devices, integrated circuits, analog and digital circuits.

Restriction: Graduate students only.

Concurrent with PHYSICS 120.

PHYSICS 222. Continuum Mechanics. 4 Units.
Introduction to the continuum limit and stress and strain tensors. Hydrodynamics of perfect fluids; two-dimensional problems, motion of incompressible viscous fluids, Navier Stokes equations. Basic elasticity theory. Description of viscoelastic materials. Introduction to nonlinear behavior instabilities.

PHYSICS 223. Machine Learning and Statistics. 4 Units.
Theory and practice of machine learning and statistics for physics and astronomy. Topics include: clustering, dimensionality reduction, Bayesian statistics, Markovchains, variational inference, supervised and unsupervised learning, neural networks and modern deep learning architectures. Familiarity with python numerical programing assumed.

Restriction: Graduate students only.

PHYSICS 228. Electromagnetism. 4 Units.
Maxwell's equations, electrodynamics, electromagnetic waves and radiation, wave propagation in media, interference and quantum optics, coherent and incoherent radiation, with practical applications in interferometry, lasers, waveguides, and optical instrumentation.

Same as CHEM 228.

PHYSICS 229A. Mathematical Methods for the Physical Sciences. 4 Units.
Mathematical and numerical analysis using Mathematica and C programming, as applied to problems in physical science.

Same as CHEM 229A.

Concurrent with PHYSICS 100.

PHYSICS 230A. Biophysics of Molecules and Molecular Machines. 4 Units.
Physical concepts and experimental and computational techniques used to study the structure and function of biological molecules and molecular machines with examples from enzyme action, protein folding, molecular motors, photobiology, chemotaxis, and vision.

Concurrent with PHYSICS 146A.

PHYSICS 230B. Biophysics of Molecules and Molecular Machines. 4 Units.
Physical concepts and experimental and computational techniques used to study the structure and function of biological molecules and molecular machines with examples from enzyme action, protein folding, molecular motors, photobiology, chemotaxis, and vision.

Concurrent with PHYSICS 146B.

PHYSICS 234A. Elementary Particle Physics. 4 Units.
Overview of Standard Model theory and phenomenology. Electromagnetic, strong and weak forces, quark model, interactions with matter, particle detectors and accelerators.

Prerequisite: PHYSICS 215B. PHYSICS 215B with a grade of B- or better

PHYSICS 234B. Advanced Elementary Particle Physics. 4 Units.
SU(3)xSU(2)xU(1) model of strong, weak, and electromagnetic interactions. K-meson system and CP violation, neutrino masses and mixing, grand-unified theories, supersymmetry, introduction to cosmology and its connection to particle physics.

Prerequisite: PHYSICS 234A and PHYSICS 235A. PHYSICS 234A with a grade of B- or better. PHYSICS 235A with a grade of B- or better

PHYSICS 234C. Advanced Elementary Particle Physics. 4 Units.
SU(3)xSU(2)xU(1) model of strong, weak, and electromagnetic interactions. K-meson system and CP violation, neutrino masses and mixing, grand-unified theories, supersymmetry, introduction to cosmology and its connection to particle physics.

Prerequisite: PHYSICS 234A and PHYSICS 235A. PHYSICS 234A with a grade of B- or better. PHYSICS 235A with a grade of B- or better

PHYSICS 235A. Quantum Field Theory. 4 Units.
Canonical quantization, scalar field theory, Feynman diagrams, tree-level quantum electrodynamics.

Prerequisite: PHYSICS 215B. PHYSICS 215B with a grade of B- or better

Restriction: Graduate students only.

PHYSICS 235B. Advanced Quantum Field Theory. 4 Units.
Pathintegral techniques, loop diagrams, regularization and renormalization, anomalies.

Prerequisite: PHYSICS 235A. PHYSICS 235A with a grade of B- or better

Restriction: Graduate students only.

PHYSICS 235C. Modern Topics in Advanced Quantum Field Theory. 4 Units.
Quantum field theory: spinor-helicity techniques, topological objects, and symmetry breakdown.

Prerequisite: PHYSICS 235B. PHYSICS 235B with a grade of B- or better

Restriction: Graduate students only.

PHYSICS 238A. Condensed Matter Physics. 4 Units.
Bonding in solids; crystal symmetry and group theory, elastic properties of crystals; lattice vibrations, interaction of radiation with matter; cohesion of solids; the electron gas; electron energy bands in solids; ferromagnetism; transport theory; semiconductors and superconductors; many-body perturbation theory.

Prerequisite: (PHYSICS 214A or CHEM 232A) and (PHYSICS 215B or CHEM 231B). PHYSICS 214A with a grade of B- or better. CHEM 232A with a grade of B- or better. PHYSICS 215B with a grade of B- or better. CHEM 231B with a grade of B- or better

PHYSICS 238B. Condensed Matter Physics. 4 Units.
Bonding in solids; crystal symmetry and group theory, elastic properties of crystals; lattice vibrations, interaction of radiation with matter; cohesion of solids; the electron gas; electron energy bands in solids; ferromagnetism; transport theory; semiconductors and superconductors; many-body perturbation theory.

Prerequisite: PHYSICS 238A. PHYSICS 238A with a grade of B- or better

PHYSICS 238C. Condensed Matter Physics. 4 Units.
Bonding in solids; crystal symmetry and group theory, elastic properties of crystals; lattice vibrations, interaction of radiation with matter; cohesion of solids; the electron gas; electron energy bands in solids; ferromagnetism; transport theory; semiconductors and superconductors; many-body perturbation theory.

Prerequisite: PHYSICS 238B. PHYSICS 238B with a grade of B- or better

PHYSICS 239A. Plasma Physics. 4 Units.
Basic concepts, orbits, kinetic and fluid equations, Coulomb collisions, fluctuations, scattering, radiation.

Restriction: Graduate students only.

Concurrent with PHYSICS 135.

PHYSICS 239B. Plasma Physics. 4 Units.
Magnetic confinement, MHD equilibrium and stability, collisional transport.

Prerequisite: PHYSICS 239A. PHYSICS 239A with a grade of B- or better

Restriction: Graduate students only.

PHYSICS 239C. Plasma Physics. 4 Units.
Linear waves and instabilities, uniform un-magnetized and magnetized plasmas, non-uniform plasmas.

Prerequisite: PHYSICS 239B. PHYSICS 239B with a grade of B- or better

Restriction: Graduate students only.

PHYSICS 240A. Galactic Astrophysics. 4 Units.
The morphology, kinematics, and evolution of our Milky Way and other galaxies. Topics include stellar formation and stellar evolution, end states of stars (supernovae, neutron stars), the distribution of stars, interstellar gas and mass in galaxies. The Local Group.

PHYSICS 240B. Cosmology. 4 Units.
An introduction to modern cosmology set within the context of general relativity. Topics include the expansion history of the Universe, inflation, the cosmic microwave background, density fluctuations, structure formation, dark matter, dark energy, and gravitational lensing.

PHYSICS 240C. Radiative Processes in Astrophysics. 4 Units.
Exploration of radiation mechanisms (electron scattering, synchrotron emission, collisional excitation, and more) and radiative transfer through matter including absorption and emission. Includes such observational astrophysics topics as spectroscopic study of atoms and nuclei, X-rays, and cosmic rays.

PHYSICS 241A. Solar System and Extrasolar Planets. 4 Units.
Formation, evolution, and habitability of planetary systems. Observational and theoretical study of the origin and evolution of the Solar System, present day dynamical state of the Solar System (asteroids, Kuiper Belt Objects, Oort cloud), planetary atmospheres, processes governing planetary climate.

Corequisite: PHYSICS 242

Restriction: Graduate students only.

PHYSICS 241B. Stellar Astrophysics. 4 Units.
Physics of stellar interiors and equations of stellar structure. Stellar atmospheres and absorption processes. Introduction to stellar winds. Thermonuclear reactions, nucleosynthesis, and solar neutrinos. Binary stars and mass accretion. White dwarfs, supernovae, neutron stars, and black holes.

Prerequisite: PHYSICS 242. PHYSICS 242 with a grade of B- or better

PHYSICS 241C. Extragalactic Astrophysics. 4 Units.
The physics and phenomenology of galaxies; star formation, interstellar medium, and intergalactic medium. Galaxy structure and dynamics. Galaxy evolution, stellar populations, and scaling relations; the relationship between galaxy properties and environment. Galaxy clusters and active galactic nuclei.

Prerequisite: PHYSICS 242. PHYSICS 242 with a grade of B- or better

PHYSICS 241D. Early Universe Physics. 4 Units.
Includes a thorough quantum treatment of the generation of perturbations during inflation and various topics related to kinetic theory in an expanding Universe. Other topics include the astrophysics and cosmology of weakly interacting particles.

Prerequisite: PHYSICS 240B. PHYSICS 240B with a grade of B- or better

PHYSICS 242. Astro Fundamentals. 4 Units.
Introduction to topics in astrophysics including measurement of stellar properties, stellar structure and evolution, stellar remnants and supernovae, the interstellar medium, exoplanets, gravitational lensing, galactic structure, extragalactic distance measurements, and the expanding universe.

Restriction: Graduate students only.

PHYSICS 243A. Lasers 1 - Oscillators and Amplifiers. 4 Units.
Semiclassical and quantum-mechanical development of electro-magnetic interactions with matter. Atomic rate equations and amplification of light via stimulated emission in gases, solids, liquids, and plasmas. Optical components and resonators that enable production of coherent radiation from laser oscillators.

Restriction: Graduate students only.

Concurrent with PHYSICS 143A.

PHYSICS 243B. Lasers 2 - Beams and Pulses. 4 Units.
Hermite-gaussian and Laguerre-gaussian laser beam solutions of the paraxial wave equation, characterization of laser beams, laser resonator design, ABCD matrix formalism for laser beam and laser pulse propagation, methods for ultra-short duration laser pulse formation, manipulation, amplification, and measurement.

Restriction: Graduate students only.

Concurrent with PHYSICS 146B.

PHYSICS 246. Special Topics in Astrophysics. 4 Units.
Outlines and emphasizes a subarea of astrophysics that is undergoing rapid development.

Repeatability: May be repeated for credit unlimited times.

Restriction: Graduate students only.

PHYSICS 247. Special Topics in Particle Physics. 4 Units.
Current topics in particle non-accelerator-based research fields.

Repeatability: May be repeated for credit unlimited times.

Restriction: Graduate students only.

PHYSICS 248. Special Topics in Condensed Matter Physics. 4 Units.
Outlines and emphasizes a subarea of condensed matter physics that is undergoing rapid development.

Repeatability: Unlimited as topics vary.

Restriction: Graduate students only.

PHYSICS 249. Special Topics in Plasma Physics. 4 Units.
Outlines and emphasizes a subarea of plasma physics that is undergoing rapid development.

Prerequisite: PHYSICS 239A and PHYSICS 239B. PHYSICS 239A with a grade of B- or better. PHYSICS 239B with a grade of B- or better

Grading Option: Satisfactory/unsatisfactory only.

Repeatability: May be repeated for credit unlimited times.

PHYSICS 250. Physics and Astronomy Communications Skills. 4 Units.
Fundamentals of effectively communicating research through written and oral platforms. Topics include writing compelling proposals and journal articles for peer review, and the development of engaging oral presentations of science results and significance to a wide range of audiences.

Restriction: Graduate students only.

PHYSICS 255. General Relativity. 4 Units.
An introduction to Einstein’s theory of gravitation. Tensor analysis, Einstein’s field equations, astronomical tests of Einstein’s theory, gravitational waves.

PHYSICS 260A. Seminar in Condensed Matter Physics. 1 Unit.
Seminar designed to acquaint students with recent advances in solid state physics. Lecturers from the Department of Physics and Astronomy (both faculty and graduate students), other UCI departments, and other institutions.

Grading Option: Satisfactory/unsatisfactory only.

Repeatability: May be repeated for credit unlimited times.

Restriction: Graduate students only.

PHYSICS 260B. Seminar in Condensed Matter Physics. 1 Unit.
Seminar designed to acquaint students with recent advances in solid state physics. Lecturers from the Department of Physics and Astronomy (both faculty and graduate students), other UCI departments, and other institutions.

Grading Option: Satisfactory/unsatisfactory only.

Repeatability: May be repeated for credit unlimited times.

Restriction: Graduate students only.

PHYSICS 260C. Seminar in Condensed Matter Physics. 1 Unit.
Seminar designed to acquaint students with recent advances in solid state physics. Lecturers from the Department of Physics and Astronomy (both faculty and graduate students), other UCI departments, and other institutions.

Grading Option: Satisfactory/unsatisfactory only.

Repeatability: May be repeated for credit unlimited times.

Restriction: Graduate students only.

PHYSICS 261A. Seminar in Plasma Physics. 1 Unit.
Advanced topics in plasma physics: wave propagation, nonlinear effects, kinetic theory and turbulence, stability problems, transport coefficients, containment, and diagnostics. Applications to controlled fusion and astrophysics.

Grading Option: Satisfactory/unsatisfactory only.

Restriction: Graduate students only.

PHYSICS 261B. Seminar in Plasma Physics. 1 Unit.
Advanced topics in plasma physics: wave propagation, nonlinear effects, kinetic theory and turbulence, stability problems, transport coefficients, containment, and diagnostics. Applications to controlled fusion and astrophysics.

Grading Option: Satisfactory/unsatisfactory only.

Restriction: Graduate students only.

PHYSICS 261C. Seminar in Plasma Physics. 1 Unit.
Advanced topics in plasma physics: wave propagation, nonlinear effects, kinetic theory and turbulence, stability problems, transport coefficients, containment, and diagnostics. Applications to controlled fusion and astrophysics.

Grading Option: Satisfactory/unsatisfactory only.

Restriction: Graduate students only.

PHYSICS 263A. Seminar in Particle Physics. 1 Unit.
Discussion of advanced topics and reports of current research results in theoretical and experimental particle physics and cosmic rays.

Grading Option: Satisfactory/unsatisfactory only.

Repeatability: May be repeated for credit unlimited times.

Restriction: Graduate students only.

PHYSICS 263B. Seminar in Particle Physics. 1 Unit.
Discussion of advanced topics and reports of current research results in theoretical and experimental particle physics and cosmic rays.

Grading Option: Satisfactory/unsatisfactory only.

Repeatability: May be repeated for credit unlimited times.

Restriction: Graduate students only.

PHYSICS 263C. Seminar in Particle Physics. 1 Unit.
Discussion of advanced topics and reports of current research results in theoretical and experimental particle physics and cosmic rays.

Grading Option: Satisfactory/unsatisfactory only.

Repeatability: May be repeated for credit unlimited times.

Restriction: Graduate students only.

PHYSICS 265A. Seminar in Astrophysics. 1 Unit.
Acquaints students with current research in astrophysics. Lecturers from the Department of Physics and Astronomy and from other institutions.

Grading Option: Satisfactory/unsatisfactory only.

Repeatability: May be repeated for credit unlimited times.

Restriction: Graduate students only.

PHYSICS 265B. Seminar in Astrophysics. 1 Unit.
Acquaints students with current research in astrophysics. Lecturers from the Department of Physics and Astronomy and from other institutions.

Grading Option: Satisfactory/unsatisfactory only.

Repeatability: May be repeated for credit unlimited times.

Restriction: Graduate students only.

PHYSICS 265C. Seminar in Astrophysics. 1 Unit.
Acquaints students with current research in astrophysics. Lecturers from the Department of Physics and Astronomy and from other institutions.

Grading Option: Satisfactory/unsatisfactory only.

Repeatability: May be repeated for credit unlimited times.

Restriction: Graduate students only.

PHYSICS 266. Current Topics in Chemical, Applied, and Materials Physics. 1 Unit.
The subjects covered vary from year to year. Connection between fundamental principles and implementations in practice in science, industry, and technology.

Repeatability: May be repeated for credit unlimited times.

Same as CHEM 266.

PHYSICS 268. Seminar in Systems Microbiology Research. 1 Unit.
A research and journal club seminar that covers topics on bacteria and phage using approaches and principles from biology, engineering, and physics.

Grading Option: Satisfactory/unsatisfactory only.

Repeatability: May be repeated for credit unlimited times.

Same as MOL BIO 268, ENGRMSE 267.

Restriction: Upper-division students only. Graduate students only.

PHYSICS 269. Seminar in Teaching Physics. 2 Units.
Techniques for effective teaching. Covers active listening and student engagement, problem-solving skills, peer instruction and collaborative learning, and evaluation. Required of all new Teaching Assistants.

Grading Option: Satisfactory/unsatisfactory only.

PHYSICS 273. Technical Communication Skills. 2 Units.
Development of effective communication skills, oral and written presentations, through examples and practice.

Grading Option: Satisfactory/unsatisfactory only.

Same as CHEM 273.

PHYSICS 291. Research Seminar. 1-4 Units.
Detailed discussion of research problems of current interest in the Department. Format, content, and frequency of the course are variable.

Repeatability: May be repeated for credit unlimited times.

Restriction: Graduate students only.

PHYSICS 295. Experimental Research. 4-12 Units.
With the approval of a faculty member, a student may pursue a research program in experimental physics. Typical areas include astrophysics, condensed matter physics, elementary particle physics, and plasma physics.

Grading Option: Satisfactory/unsatisfactory only.

Repeatability: May be repeated for credit unlimited times.

Restriction: Graduate students only. School of Physical Sciences students only.

PHYSICS 296. Theoretical Research. 4-12 Units.
With approval of a faculty member, a student may pursue a research program in theoretical physics. Typical areas include astrophysics, condensed matter physics, elementary particle physics, and plasma physics.

Grading Option: Satisfactory/unsatisfactory only.

Repeatability: May be repeated for credit unlimited times.

Restriction: Graduate students only. School of Physical Sciences students only.

PHYSICS 298. Physics Colloquium. 1 Unit.
Seminar held each week, in which a current research topic is explored. Frequently, off-campus researchers are invited to present the seminar, and on occasion a faculty member or researcher from the Department will speak.

Grading Option: Satisfactory/unsatisfactory only.

Repeatability: May be repeated for credit unlimited times.

Restriction: School of Physical Sciences students only.

PHYSICS 299. Reading of Special Topic. 4-12 Units.
With special consent from a faculty member who will agree to supervise the program, a student may receive course credit for individual study of some area of physics.

Restriction: Graduate students only.

PHYSICS 395. Laboratory Teaching. 1 Unit.
Required of and limited to teaching assistants of undergraduate laboratory courses. Designed to teach the necessary skills required of teaching assistants for these courses.

Grading Option: Satisfactory/unsatisfactory only.

Repeatability: May be repeated for credit unlimited times.

PHYSICS 399. University Teaching. 1-4 Units.
Required of and limited to Teaching Assistants.

Grading Option: Satisfactory/unsatisfactory only.

Repeatability: May be repeated for credit unlimited times.