

COLLEGE OF SCIENCE  
BUILDING 4





## COLLEGE OF SCIENCE

<http://www.csupomona.edu/~sci>

Donald O. Straney, Dean  
Mandayam Srinivas, Associate Dean

The curricula offered in the College of Science combine fundamental education in science or mathematics with a broad human outlook, aimed at developing the students' mental horizons beyond the limits of their immediate vocational objectives.

Each curriculum is designed to prepare graduates for specific professional positions in industry, government, and teaching or for graduate and professional work in their disciplines. The four-year sequence covers the basic major courses and has sufficient free electives to allow the students to develop specializations within the major and closely-related fields.

General education courses are offered for all students. The need to understand the concepts of modern science and mathematics and their relationship to life in our present world is important. The College of Science also offers basic supporting courses for students enrolled in the professional and technological degree programs in other colleges of the university.

Majors in nine fields leading to the bachelor of science degree are offered by the College of Science. Information concerning the master's curricula may be found in the graduate listings.

The standard teaching credential program is offered for both the elementary specialization and the secondary specialization in a number of majors and minors.

A pre-professional program is offered for students preparing for medical, dental, or veterinary or other health career schools.

The College of Science actively fosters dialogue and joint research among campus scientists through special institutes and symposia. The Institute for Cellular and Molecular Biology (see catalog section on "Special University Centers") and the Institute for Advanced Systems Studies are particularly active in these areas.

An active co-curricular program includes the Science Council; Beta Beta Beta Biological honor society; Biological Sciences Club; Microbiology Club; a chapter of Kappa Mu Epsilon (mathematics); a chapter of student affiliates of the American Chemical Society; Society of Physics Students; Sigma Pi Sigma, national honor society in physics; Upsilon Pi Epsilon, national honor society in Computer Science; the Geology Club and other organizations.

The College of Science supports the concept of international education and encourages students to investigate opportunities for overseas study. Certain courses taken at CSU International Program study centers in foreign countries are equivalent to courses in the College of Science and may be used to fulfill some of the degree requirements offered by the College and/or certain general education requirements. Students should consult the International Programs Bulletin (which is available at the International Center), a department advisor, or the campus International Programs Coordinator for more information.

### Interdisciplinary General Education (IGE)

Students majoring in the various programs in science are encouraged to take part of their General Education requirements through the Interdisciplinary General Education Program (IGE). This IGE program is specially designed to meet the needs of science students particularly in the areas of writing, critical thinking, humanities and the social sciences.

### ENVIRONMENTAL HEALTH SPECIALIST MINOR

The Environmental Health Specialist Minor is an interdisciplinary program which may be pursued by majors in any field. Its purpose is to prepare students for careers as environmental health specialists by meeting the standards for the state internship program. State-employed specialists enforce and administer laws governing water, food and air contamination, noise, land-use planning, occupational health hazards, and animal vectors of disease. The minor is particularly suitable for students majoring in Biology, Microbiology, Zoology and Agricultural Biology.

A full description of the minor is in the "University Programs" section of this catalog.

### PHYSIOLOGY MINOR

The Physiology Minor is an interdisciplinary program which can be elected by students majoring in any field. Its purpose is to improve the training and advising of students in order to facilitate their pursuit of careers in biomedical fields utilizing a knowledge of Physiology. It is particularly appropriate for students majoring in Animal Science, Behavioral Sciences, Biology, Chemistry, Electrical and Computer Engineering (Biomedical Engineering), Foods and Nutrition, Kinesiology, Microbiology and Zoology.

A full description of the minor is located in the "University Programs" section of this catalog.

### SCIENCE, TECHNOLOGY, AND SOCIETY MAJOR

The Science, Technology, and Society (STS) Major is an interdisciplinary program which integrates knowledge in the natural sciences and in technology as well as in history, philosophy, sociology, economics, political science, geography, and anthropology. Students are capable of earning a Bachelor of Arts in Science, Technology, and Society. The STS Major prepares students for jobs that require scientific and technological literacy as well as a broad perspective on science and technology and an ability to write and argue from this perspective. Such jobs include those in law or business which are engaged with aspects of science and technology, in science and technology public policy making or analysis, in science and technology public interest advocacy, and in science journalism.

A full description of the Major is in the "University Programs" section of this catalog.

### SCIENCE, TECHNOLOGY, AND SOCIETY MINOR

The Science, Technology, and Society (STS) Minor is an interdisciplinary program which integrates knowledge in the natural sciences and in technology as well as in the humanities and social sciences. The STS Minor provides science and technology majors with a sense of how science and technology exists in a broader human context. (By contrast the Major opens opportunities for writing- and argument-intensive science- and technology-related careers (such as those in science- and technology-related law and public policy) which are alternative to careers as scientists and technologists.)

A full description of the Minor is in the "University Programs" section of this catalog.

**Departments and Majors****BIOLOGICAL SCIENCES**

Frank Ewers, Chair

Biology major (BS); Biotechnology major (BS); Botany major (BS); Environmental Biology major (BS); Microbiology major (BS): Subplan in Microbiology, Subplan in Medical Technology; Zoology major (BS).

Minors in Botany, Plant Biotechnology, Plant Pathology, Microbiology, Zoology, Environmental Health Specialist, Physiology and Comparative Systems Analysis.

Master of Science in Biological Sciences.

**CHEMISTRY**

Francis Flores, Chair

Chemistry major (BS) Subplan in Chemistry; Subplan in Chemical Sciences; Subplan in Industrial Chemistry; Subplan in Molecular Modeling and Simulation

Minor in Chemistry  
Master of Science in Chemistry

**COMPUTER SCIENCE**

Craig A. Rich, Chair

Computer Science major (BS)  
Minor in Computer Science  
Master of Science in Computer Science

**GEOLOGICAL SCIENCES**

John A. Klasik, Chair

Geology Major (BS)  
Integrated Earth Studies Major (BS)  
Minor in Geology

**MATHEMATICS AND STATISTICS**

Michael Green, Chair

Mathematics Major (BS); Subplan in Pure Mathematics; Subplan in Applied Mathematics; Subplan in Statistics;  
Minors in Statistics and Mathematics  
Master of Science in Mathematics

**PHYSICS**

Steven McCauley, Chair

Physics Major (BS)  
Physics Minor

**Teacher Education and Professional Development**

The College of Science offers numerous programs for preparing teachers of mathematics and science. The details of the science preparation programs can be found under the listings of the individual science departments. The mathematics subject matter preparation program is described in that department's section. In addition, the College sponsors numerous professional development programs for pre-K through grade 12 teachers.

**Center for Education and Equity in Mathematics, Science, and Technology (CEEMaST)**

Judith E. Jacobs, Associate Director Mathematics Teacher Education

Jodye I. Selco, Science Educator

Nicole Wickler, Associate Director Science Teacher Education

CEEMaST coordinates the College of Science's responses to issues in K-12 science and mathematics education. Its purpose is to contribute to the improvement of science and mathematics education in preschool, elementary and secondary schools. To this end it conducts workshops and courses for teachers, consults with local schools and districts, and maintains an instructional materials library for K-12 teachers' use. In addition, CEEMaST coordinates the subject matter preparation programs in science and advises students who are interested in preparing to be science and mathematics teachers. For Information contact Dr. Jodye I. Selco in Building 3, Room 243, contact the CEEMaST office at (909) 869-4063 or visit [www.ceemast.csupomona.edu/](http://www.ceemast.csupomona.edu/)

**Cooperative Education**

This program combines classroom study with closely-related work experience. Its basic purpose is to provide a means whereby a student can combine study at Cal Poly Pomona with work experience. For information see Dr. J. Ernest Simpson (Building 3, Room 233).

**Science Educational Enhancement Services (SEES)**

Faculty Director: Barbara Burke, Extension 3664

SEES is a program that reflects the university's commitment to providing educational services for students enrolled in the College of Science who are first-generation college students, unfamiliar with a university environment, or who for other reasons can benefit from working with faculty and other students to strengthen their connection to the University and enhance their ability to succeed academically. Recognizing the significance of a supportive academic climate, SEES has been established in the College of Science. SEES has an academic focus that constructs a community-based model of education which encourages learning through collaboration and ties together all facets of students' college experiences including personal development, academic achievement, social and civic responsibility, cultural enjoyment, and continued learning related to graduate school and careers.

In SEES, entering students join a community of scholars within the College of Science and engage in academic domain-specific activities with university faculty, staff, peers, and industry and community representatives. Student participants benefit from personalized attention of caring faculty who strive to create a healthy and connected learning environment. SEES promotes academic achievement, college persistence, and improves graduation rates of students members.

**Academic Excellence Workshops**

An Academic Excellence Workshop is a supplement to certain beginning-level chemistry, mathematics, computer science, physics and engineering courses which is open by invitation only. Participants in MEP in the College of Engineering and SEES in the College of Science receive priority consideration as invitees. The Workshop program promotes technical excellence in the subject area while also developing student and communication skills under the guidance of a trained facilitator. An invitation to participate should be regarded as an honor and a unique opportunity.

**Pre-Professional Preparation**

(Pre-Dental, Pre-Medical, Pre-Veterinary, Other)

A science major is often very suitable for undergraduate preparation for medical, dental, veterinary and other professional schools. The list below summarizes the basic requirements for most professional schools. Requirements for a particular school may vary. Students who are interested in pre-professional preparation should consult with the pre-professional program advisor, Dr. John Chan.

**Recommended Courses**

Public Speaking	COM	100	(4)
Freshman English I	ENG	104	(4)
Freshman English II	ENG	105	(4)
Foundations of Biology: Energy and Matter	BIO	121/121L	(3/2)
Foundations of Biology: Reproduction and Dev.	BIO	122/122L	(3/2)
Foundations of Biology: Biodiversity	BIO	123/123L	(3/2)
Biometrics	BIO	211/211L	(3/1)
Genetics	BIO	303	(4)
Cell, Molecular and Developmental Biology	BIO	310	(4)
General Chemistry	CHM	121/121L	(3/1)
General Chemistry	CHM	122/122L	(3/1)
General Chemistry	CHM	123/123L	(3/1)
Organic Chemistry	CHM	314	(3)
Organic Chemistry	CHM	315	(3)
Organic Chemistry	CHM	316	(3)
Organic Chemistry Laboratory	CHM	317L	(1)
Organic Chemistry Laboratory	CHM	318L	(1)
Organic Chemistry Laboratory	CHM	319L	(1)
Analytic Geometry and Calculus I	MAT	114	(4)
Analytic Geometry and Calculus II	MAT	115	(4)
Analytic Geometry and Calculus III	MAT	116	(4)
College Physics	PHY	121/121L	(3/1)
College Physics	PHY	122/122L	(3/1)
College Physics	PHY	123/123L	(3/1)

For additional recommended and support courses, see the pre-professional program advisor, Dr. John Chan (medicine, dentistry, veterinary, etc.).

**COLLEGE OF SCIENCE COURSE DESCRIPTIONS****SCI 101/101A Science and Mathematics: Freshman Experience I (1/1) FW**

Exploration of student and University expectations. Academic success and learning styles. Active learning. Stress and time management. Faculty office hours. Advising and curricular planning. Registration. Student clubs in major. Tutoring and peer groups. Campus resources. On-line resources. Presentations by upper-division students and Student Affairs staff. 1 lecture, 1 two-hour activity. Concurrent enrollment required. SCI 101/101 A and 102/102A together satisfy GE Area E.

**SCI 102/102A Science and Mathematics: Freshman Experience II (1/1) WS**

Explorations in your major. Planning for your career. Setting professional goals. Career tracks in the biological, physical, mathematical and computational sciences. Campus career services. Scientific values and integrity. Co-curricular activities in major. Field trips. Guest lectures by professionals in the various disciplines. 1 lecture, 1 two-hour activity. Concurrent enrollment required. SCI 101/101 A and 102/102A together satisfy GE Area E.

**SCI 110/110A Success in Science (1/1) F**

Overview of the various majors in the College of Science and the role science plays in society. Exploration of student and University

expectations at Cal Poly Pomona. Promotion of life-long learning skills that will enable students to be successful not only in college, but throughout their lives. Campus resources. On-line resources. Speakers. Field trips. Recommended for students in Science Educational Enhancement Services (SEES), but open to all students. 1 lecture, 1 two-hour activity. Concurrent enrollment required. SCI11 0/11 OA and 111/111 A together satisfy GE Area E.

**SCI 111/111A Success in Science (1/1) W**

Continued exploration of the various majors in the College of Science and the role science plays in society. Explorations of career paths. Promotion of life-long learning skills that will enable students to be successful not only in college, but throughout their lives. Scientific values and integrity. Campus resources. On-line resources. Speakers. Field trips. Recommended for students in Science Educational Enhancement Services (SEES), but open to all students. 1 lecture, 1 two-hour activity. Concurrent enrollment required. SCI 110/110A and 111/111 A together satisfy GE Area E.

**SCI 200 Special Study for Lower Division Students (1-2) FWSp**

Individual or group investigation, research, studies or surveys of selected problems. Total credit limited to 4 units, with a maximum of 2 units per quarter.

**SCI 210/210L Physics Concepts and Activities (3/1) FWSp**

Introduction to physics concepts, covering mechanics, heat, sound, light, electricity, magnetism, properties of matter, and modern physics. Inquiry-based laboratory work and student-led activities prepare students to teach science. Subject matter is related to the California Science Content Standards and teaching resources are developed. Includes field work in an elementary school. 3 lectures, 1 three-hour lab. Prerequisite: MAT 191 or equivalent. Concurrent enrollment in SCI 210 and 210L is required.

**SCI 211/211L Chemical Sciences (3/1) WSP**

The basic concepts of chemistry and an overview of the applications of chemistry from atomic theory through biochemistry. Laboratory activities include fundamental experiments that can be adopted for elementary school teaching. 3 lectures, 1 three-hour lab. Concurrent enrollment required.

**SCI 212/212L Earth Sciences (3/1) FWSpSu**

Foundations in the science of Geology and Earth Science with emphasis on applications important in teaching. Laboratory sessions emphasize experiments useful for elementary school teachers. 3 lectures, 1 three-hour lab. Concurrent enrollment required.

**SCI 250 Integrated Science I (5)**

Key facts, theories, tools, and techniques of seven sciences integrated by showing how their phenomena are examples of the same fundamental systems processes, hierarchies and emergence, flows and networks, boundaries and limits. Includes similarities and differences of the scientific method across the sciences, and similarities between the natural and social sciences. No lectures. Multimedia self-study, 2 two-hour, face-to-face skill-training and discussion sessions weekly. One interdisciplinary lab session every 3 weeks. (Also listed as CSA 250)

**SCI 251 Integrated Science II (5)**

Key facts, theories, and techniques of seven sciences integrated by showing their phenomena are examples of the same fundamental systems processes, feedback and regulation, cycles and oscillations,

stability and equilibrium. Includes similarities and differences of the scientific method across the sciences, and similarities between the natural and social sciences. No lectures. Multimedia self-study, 2 two-hour, face-to-face skill-training and discussion sessions weekly. One interdisciplinary lab session every 3 weeks. Prerequisite: SCI/CSA 250. (Also listed as CSA 251)

#### **SCI 299/299A Special Topics for Lower Division Students (1-4)**

Group study of a selected topic, the title to be specified in advance. Total credit limited to 8 units, with a maximum of 4 units per quarter. Instruction is by lecture/problem-solving, laboratory or a combination. Prerequisite: Permission of instructor.

#### **SCI 310 Integrated Science III (6)**

Key facts, theories, tools, and techniques of seven sciences integrated by showing how their phenomena are examples of the same fundamental systems processes, symmetry and duality, chaos and origins, development and evolution. Includes similarities and differences of the scientific method across science, and similarities between the natural and social sciences. No lectures. Multimedia self-study, 2 two-hour, face-to-face skill-training and discussion sessions weekly. One interdisciplinary lab session every 3 weeks. Prerequisite: SCI/CSA 251. (Also listed as CSA 310)

#### **SCI 400 Special Study for Upper Division Students (1-2)**

Individual or group investigation, research, studies or surveys of selected problems. Total credit limited to 4 units, with a maximum of 2 units per quarter.

#### **SCI 450 Philosophic Implications of Science (4) Sp**

Reading and discussion of works of eminent scientists and philosophers concerning those results of science that have a bearing on philosophic problems. Readings may be from authors such as Schrodinger, Russell, Huxley, Chardin, Kuhn. 4 lectures. Prerequisite: senior standing in one of the natural or physical sciences, mathematics or consent of instructor.

#### **SCI/EGR 460 Problems in Oceanographic Studies (3-5)**

Course offered in conjunction with the Southern California Ocean Studies Consortium (SCOSC). Topics vary each term. See chair of Biological Sciences Department for further information. Upper division standing and permission of instructor required.

#### **SCI 470, 471, 472, 473 Cooperative Education (1-4)**

Part-time or full-time work experience that applies scientific principles to practice. To be taken in sequence. Prerequisite: junior standing or approval of co-op coordinator. The work assignment must have prior approval. Maximum 16 units.

#### **SCI 499/499A/499L Special Topics for Upper Division Students (1-4) FWSp (Su)**

Group study of a selected topic, the title to be specified in advance. Total credit limited to 8 units with a maximum of 4 units per quarter. Instruction is by lecture, laboratory or a combination. Prerequisite: permission of instructor.

#### **EGR/SCI 475 Beyond Curie: Women in Math, Science, and Engineering (4)**

Social implications and history of the contribution of women in math, science, and engineering. Examination of how socially defined identities affected the careers of female scientists. Combined with examination of current and specific topics in mathematics, science, and engineering. 4 hours seminar. Prerequisites: One course from each of the following Sub-areas: A1, A2, A3 and B1, B2, B4 and D1, or D2, and D3. Interdisciplinary GE Synthesis Course for Sub-area B5 or D4.

#### **AG/EGR 481, 482 Project Design Principles and Applications (2) (2)**

Selection and completion of scientific/technological synthesis application project under faculty supervision. Multidisciplinary team project. Projects which graduates solve in discipline of practice. Both formal written and oral reports. Minimum time commitment: 120 hours. Prerequisites: One GE course from each of the following Sub-areas: A1, A2, A3 and B1, B2, B4 and upper division standing. GE Synthesis course for Sub-area B5.

#### **EGR 484 or SCI 484 Science and Technology Seminar (4)**

Issues to be explored will include, but not be limited to: the impact of science and technology on civilization and human values; ecological issues; history of science and technology; scientific method and reasoning; health and diseases; medical technology and its ethical implications; general systems theory and its application. Prerequisites: One GE course from each of the following Sub-areas: A1, A2, A3 and B1, B2, B4. GE Synthesis course for Sub-area B5.

### **SCIENCE AND MATHEMATICS EDUCATION COURSE DESCRIPTIONS**

#### **SME 501 Mathematics and Sciences Learning for Adults (3)**

Mathematics and sciences learning theories including cognitive, metacognitive and affective variables in learning mathematics and sciences. Adult development and adult learning theories. Diversity in mathematics and sciences instruction. 3 lecture discussions.

#### **SME 502L Practicum for College Mathematics and Science Faculty (3)**

Development and practice of organizational and andragogical skills appropriate for the college mathematics or science instructor. 3 laboratories. Prerequisite: SME 501 and a concurrent teaching assignment in a college mathematics or science class.

#### **SME 503 Issues in Higher Education for College Faculty (3)**

The historical development of higher education: the California Master Plan; campus and system governance; the role of the faculty; educational and organizational responses to diversity, access, equity and excellence at the post-secondary level; student subgroups and the changing demographics. 3 lecture discussions.



## BIOLOGICAL SCIENCES

www.csupomona.edu/~biology

Majors in Biology, Biotechnology, Botany, Environmental Biology, Microbiology, and Zoology

Frank W. Ewers, Chair

Jill P. Adler-Moore

Steve Alas

Keith E. Arnold

Edward Bobich

Kristin R. Bozak

Graciela Brelles-Mariño

Nancy E. Buckley

Gary C. Carlton

John K. Chan

Wendy Dixon

Sepehr Eskandari

Wely Floriano

Chris D. George

Kristine B. Hartney

Glenn H. Kageyama

Craig LaMunyon

A. Kristopher Lappin

Joan Leong

Wei-Jen Lin

Junjun Liu

David J. Moriarty

Bijay K. Pal

Pamela Sperry

Christos Stathopoulos

Robert J. Talmadge

Lenard R. Troncale

Angel A. Valdes

Yuanxiang Zhao

The Biological Sciences Department offers bachelor's degree programs in Biology, Biotechnology, Botany, Environmental Biology, Microbiology, and Zoology. In addition, minors in Botany, Plant Biotechnology, Plant Pathology, Microbiology, and Zoology are offered, and the department participates in interdisciplinary minors in Comparative System Analysis, Environmental Health Specialist, Physiology, and Quantitative Research. Concurrent enrollment in two of the majors offered by the Biological Sciences Department is not allowed.

Departmental facilities include molecular biology laboratories, a bioinformatics lab with a high performance computer cluster, a microarray facility, greenhouses, controlled environmental units, a radiation biology laboratory, plant and animal collections, and an electron microscope facility. Interdisciplinary research and education in computational and experimental techniques applied to molecular and material modeling, surface science, and engineered materials are supported by the university-wide Center for Macromolecular Modeling and Materials Design (CM3D). Ecological studies are facilitated by accessibility to natural habitats on campus and by the university's proximity to desert, mountain, and seashore areas. Courses in terrestrial marine and fresh water biology provide preparation for teaching, conservation, wildlife management, or graduate research in aquatic biology. Courses in marine biology interact with the Ocean Studies Consortium of the CSU. A variety of field biology courses utilize the CSU Desert Studies Center at Zzyzx, near Baker, California. Students majoring in biological sciences and who have at least a 3.0 GPA have the opportunity to join Beta Beta Beta, an honorary society in the Biological Sciences. For additional information contact the department office.

A cumulative 2.0 GPA is required in core courses in all Biological Sciences majors in order to receive a degree in that major.

### ENVIRONMENTAL HEALTH SPECIALIST MINOR

The Environmental Health Specialist Minor is an interdisciplinary program which may be pursued by majors in any field. Its purpose is to prepare students for careers as environmental health specialists by meeting the standards for the state internship program. State-employed specialists enforce and administer laws governing water, food, and air contamination, noise, land-use planning, occupational health hazards,

and animal vectors of disease. The minor is particularly suitable for students majoring in the biological sciences. A full description of the minor is in the "University Programs" section of this catalog.

### PHYSIOLOGY MINOR

The Physiology Minor is an interdisciplinary program which can be elected by students majoring in any field. Its purpose is to improve the training and advising of students in order to facilitate their pursuit of careers in biomedical fields utilizing a knowledge of physiology. It is particularly appropriate for students majoring in the biological sciences. A full description of the minor is located in the "University Programs" section of this catalog.

### QUANTITATIVE RESEARCH MINOR

The Quantitative Research Minor is an interdisciplinary program which can be taken by students majoring in any field other than Mathematics. Its purpose is to prepare students to conduct quantitative analysis in their chosen discipline. Students acquire practical experience using statistics, principles of experimental design, survey and data analysis techniques. This minor is particularly suited to students majoring in the biological sciences. A full description of this minor is included in the University Programs section of this catalog.

### BIOLOGY MAJOR

The Biology major stresses a balance between the theoretical aspects of biology and actual experience in field and laboratory. The variety of courses offered in a flexible curriculum provides an opportunity for a wide range of experience in both animal and plant sciences.

The offerings of this curriculum provide the student with a preparation for graduate and professional schools in fields ranging from molecular to field biology. The curriculum prepares prospective teachers for the secondary education credential. Graduate courses enable students to complete requirements for the community college credential. For those planning a career as a secondary school teacher a credential is required. Contact department office for additional information.

### Required Core Courses for Major

Required of all students

Foundations of Biology .....	BIO	122/122L (3/2)
Foundations of Biology .....	BIO	123/123L (3/2)
Form and Function in Plants .....	BOT	201/201L (3/2)
Basic Microbiology .....	MIC	201/201L (3/2)
Animal Biology .....	ZOO	201/201L (3/2)
Biometrics .....	BIO	211/211L (3/1)
Genetics .....	BIO	303 (4)
Cell and Molecular Biology .....	BIO	310 (4)
Principles of Ecology .....	BIO	325/325L (3/1)
Principles of Evolution .....	BIO	413 (4)
Cellular Physiology .....	BIO	428/428L (3/2)
or Plant Physiology .....	BOT	428/428L (3/2)
or Microbial Physiology .....	MIC	428/428L (3/2)
or Animal Physiology .....	ZOO	428/428L (3/2)
Scientific Communication .....	BIO	490 (1)

Required Core Units .....

51

### Elective Core Courses

Upper Division courses (other than BIO 400)

offered by the Biological Sciences Dept. of which

12 units must be at the 400-level .....

(16)



**Required Support and Elective Courses**

The following major support courses should be used to satisfy the indicated GE requirements. If these courses are not used to satisfy GE, the total units to degree may be more than 180 units.

Foundations of Biology (B2, B3)	BIO	121/121L	(3/2)
General Chemistry (B1, B3)	CHM	121/121L	(3/1)
General Chemistry/Laboratory	CHM	122/122L	(3/1)
General Chemistry/Laboratory	CHM	123/123L	(3/1)
Organic Chemistry/Laboratory	CHM	201/250L	(3/1)
Elements of Biochemistry/Laboratory	CHM	321/321L	(3/1)
College Physics/Laboratory	PHY	121/121L	(3/1)
College Physics/Laboratory	PHY	122/122L	(3/1)
College Physics/Laboratory	PHY	123/123L	(3/1)
Statistics with Applications	STA	120	(4)
Freshman English I (A2)	ENG	104	(4)
Freshman English II (A3)	ENG	105	(4)
Calculus for Life Science (B4)	MAT	120	(4)
Environment and Society (B5)	BIO	304	(4)
or Biodiversity Conservation (B5)	BIO	340	(4)
Health, Nutrition, and the Integrated Being (E)	FN	203	(4)
or General Psychology (E)	PSY	201	(4)
or Mind, Brain, and Behavior: An Integral View (E)	PSY	210	(4)
or Science and Mathematics: or Science and Mathematics: Freshman Experience I (E)	SCI	101/101A	(1/1)
and Science and Mathematics: Science and Mathematics: Freshman Experience II (E)	SCI	102/102A	(1/1)

**Elective Support Courses**

Approved electives\* ..... (12)  
Students considering graduate work or professional schools, see recommended courses for pre-professional preparation.

\* Approved electives include all 200, 300, and 400-level courses in the Biological Sciences Department not specifically designed for non majors (see course descriptions). Only 2 units of BIO 200 and/or BIO 400 allowed. Also included are any advanced Chemistry or Math courses. See advisor for approval of courses offered by other departments.

**GENERAL EDUCATION REQUIREMENTS**

Students should consult the catalog website [www.csupomona.edu/~academic/catalog/](http://www.csupomona.edu/~academic/catalog/) for current information regarding this requirement. Unless specific courses are stated under Support Courses, see the list of approved courses under General Education Requirements, Areas A through E.

**Area A. Communication and Critical Thinking (12 units)**

1. Oral Communication
2. Written Communication
3. Critical Thinking

**Area B. Mathematics and Natural Sciences (16 units)**

1. Physical Science
2. Biological Science
3. Laboratory Activity
4. Mathematics/Quantitative Reasoning
5. Science and Technology Synthesis

**Area C. Humanities (16 units)**

1. Visual and Performing Arts
2. Philosophy and Civilization
3. Literature and Foreign Languages
4. Humanities Synthesis

**Area D. Social Sciences (20 units)**

1. U.S. History, Constitution, and American Ideals
2. History, Economics, and Political Science
3. Sociology, Anthropology, Ethnic and Gender Studies
4. Social Science Synthesis

**Area E. Lifelong Understanding and Self-development (4 units)****BIOTECHNOLOGY MAJOR**

The Biotechnology major is an interdisciplinary program which provides students with a strong background in both biology and chemistry. It provides the theoretical and practical knowledge needed to understand the numerous industrial applications of biological phenomena, while emphasizing the study of cell and molecular biology. Students can select their upper division electives from six clusters: (1) Physiology; (2) Molecular Biology and Genetics; (3) Microbiology and Pathology; (4) Biochemistry and Molecular Separation Techniques; (5) Agriculture; and, (6) Business. Twenty units must be chosen from one of these clusters (referred to as the student's primary cluster) and an additional 8 units from the other five clusters. This will allow the individual to specialize in a particular area. An important feature of this major is an internship in a biotechnology laboratory for practical experience in the field. This program also satisfies the admission requirements for various graduate and preprofessional schools. This major requires admission to the Biological Sciences Department and completion of the units indicated below. There are no special admission requirements. The Biological Sciences Department also offers a curriculum leading to the Master of Science in Biology with emphasis in Biotechnology.

**Core Courses for Major**

Foundations of Biology	BIO	122/122L	(3/2)
Foundations of Biology	BIO	123/123L	(3/2)
Biometrics	BIO	211/211L	(3/1)
Basic Microbiology	MIC	201/201L	(3/2)
Horizons in Biotechnology	BIO	230	(1)
Genetics	BIO	303	(4)
Cellular and Molecular Biology	BIO	310	(4)
Internship in Biology	BIO	441	(2)
or Cooperative Education	SCI	470	(2)
Concepts of Molecular Biology	BIO	450	(4)
Molecular Biology Techniques	BIO	451/451L	(3/2)
Scientific Communication	BIO	490	(1)
General Chemistry	CHM	122/122L	(3/1)
General Chemistry	CHM	123/123L	(3/1)
Quantitative Analysis	CHM	221/221L	(2/2)
Organic Chemistry	CHM	314	(3)
Organic Chemistry	CHM	315	(3)
Organic Chemistry	CHM	316	(3)
Organic Chemistry Laboratory	CHM	317L	(1)
Organic Chemistry Laboratory	CHM	318L	(1)
Organic Chemistry Laboratory	CHM	319L	(1)
Biochemistry	CHM	327/327L	(3/1)
Biochemistry	CHM	328/328L	(3/1)
Biochemistry	CHM	329/329L	(3/1)
Upper Division Courses			(27)

At least 20 units from one "Primary" cluster and 7 units from any of the other five clusters, to be selected in consultation with faculty advisor. See clusters listed under "Upper Division Course Clusters."

**Support Courses**

The following major support courses should be used to satisfy the indicated GE requirements. If these courses are not used to satisfy GE,

the total units to degree may be more than 180 units.

Foundations of Biology (B2, B3)	BIO	121/121L	(3/2)
General Chemistry (B1, B3)	CHM	121/121L	(3/1)
Freshman English I (A2)	ENG	104	(4)
Freshman English II (A3)	ENG	105	(4)
Calculus for Life Science (B4)	MAT	120	(4)
Health, Nutrition, and the Integrated Being (E)	FN	203	(4)
or General Psychology (E)	PSY	201	(4)
or Mind, Brain, and Behavior: An Integral View (E)	PSY	210	(4)
or Science and Mathematics: Freshman Experience I (E)	SCI	101/101A	(1/1)
and Science and Mathematics: Freshman Experience II (E)	SCI	102/102A	(1/1)
College Physics	PHY	121/121L	(3/1)
College Physics	PHY	122/122L	(3/1)
College Physics	PHY	123/123L	(3/1)

### GENERAL EDUCATION REQUIREMENTS

Students should consult the catalog website [www.csupomona.edu/~academic/catalog/](http://www.csupomona.edu/~academic/catalog/) for current information regarding this requirement. Unless specific courses are stated under Support Courses, see the list of approved courses under General Education Requirements, Areas A through E.

#### Area A. Communication and Critical Thinking (12 units)

1. Oral Communication
2. Written Communication
3. Critical Thinking

#### Area B. Mathematics and Natural Sciences (16 units)

1. Physical Science
2. Biological Science
3. Laboratory Activity
4. Mathematics/Quantitative Reasoning
5. Science and Technology Synthesis

#### Area C. Humanities (16 units)

1. Visual and Performing Arts
2. Philosophy and Civilization
3. Literature and Foreign Languages
4. Humanities Synthesis

#### Area D. Social Sciences (20 units)

1. U.S. History, Constitution, and American Ideals
2. History, Economics, and Political Science
3. Sociology, Anthropology, Ethnic and Gender Studies
4. Social Science Synthesis

#### Area E. Lifelong Understanding and Self-development (4 units)

### Course Descriptions

See course descriptions under appropriate department.

### Upper Division Course Clusters

#### Cluster 1 – Physiology

Developmental Biology	BIO	320/320L	(4/1)
Neuroscience	BIO	424	(4)
Neuroanatomy	BIO	426/426L	(4/1)
Cellular Physiology	BIO	428/428L	(3/2)
Radiation Biology	BIO	431/431L	(3/1)

Endocrinology **	BIO	520/520L	(3/1)
Biophysics	BIO/PHY	410	(4)
Plant Physiology	BOT	428/428L	(3/2)
Plant Anatomy	BOT	435/435L	(2/2)
Fundamentals of Physical Chemistry	CHM	301/301L	(3/1)
Biomedical Instrumentation	ECE	435	(3)
Biomedical Instrumentation Laboratory	ECE	485L	(1)
Histology	ZOO	422/422L	(2/3)
Animal Physiology	ZOO	428/428L	(3/2)

#### Cluster 2 – Molecular Biology and Genetics

Biotechnology Applications in Animal Science	AVS	430/430L	(3/1)
Developmental Biology	BIO	320/320L	(4/1)
Human Genetics	BIO	403/403L	(3/1)
Advanced Genetics	BIO	421	(3)
Population Genetics	BIO	445/445L	(3/1)
Recombinant DNA	BIO	455/455L	(2/2)
Bioinformatics	BIO	459/459L	(3/2)
Advanced Cell Biology **	BIO	535	(4)
Molecular Biology of Development **	BIO	555	(4)
Advanced Bacterial Physiology and Genetics	BIO	560/560L	(3/1)
Animal Tissue Culture **	BIO	565/565L	(2/2)
Transmission Electron Microscopy **	BIO	577/577L	(2/3)
Scanning Electron Microscopy **	BIO	578/578L	(2/3)
Biophysics	BIO/PHY	410	(4)
Plant Genetics	BOT	403/403L	(3/1)
Plant Tissue Culture	BOT	456/456L	(2/2)
Recombinant DNA Biochemistry	CHM	453	(3)
Microbial Physiology	MIC	428/428L	(3/2)
Plant Breeding	PLT	404/404L	(3/1)

#### Cluster 3 – Microbiology and Pathology

Developmental Biology	BIO	320/320L	(4/1)
Radiation Biology	BIO	431/431L	(3/1)
Advanced Bacterial Physiology **	BIO	560/560L	(3/1)
Cellular Immunity and Disease **	BIO	570/570L	(3/1)
Plant Pathology	BOT	323/323L	(2/2)
Mycology	BOT	426/426L	(2/2)
Methods in Plant Pathology	BOT	441/441L	(2/2)
Applied Microbiology	MIC	310/310L	(3/2)
Food Microbiology	MIC	320/320L	(2/2)
General Epidemiology	MIC	330	(4)
Medical Bacteriology	MIC	410/410L	(3/2)
Immunology-Serology	MIC	415/415L	(3/2)
Medical Mycology	MIC	425/425L	(3/2)
Microbial Physiology	MIC	428/428L	(3/2)
General Virology	MIC	430/430L	(3/2)
Hematology	MIC	444/444L	(3/1)
Immunohematology	MIC	445/445L	(3/1)
Histology	ZOO	422/422L	(2/3)
Medical Parasitology	ZOO	425/425L	(3/2)

#### Cluster 4 – Biochemistry and Molecular Separation Techniques

Elements of Physical Chemistry	CHM	304/304A	(3/1)
Elements of Physical Chemistry	CHM	305/352L	(3/2)
The Chemist in Industry	CHM	340	(4)
Spectroscopic Methods	CHM	342/342L	(2/2)
Separation Methods	CHM	343/343L	(2/2)
Electroanalytical Methods	CHM	344/344L	(2/2)
Physical Chemistry	CHM	352/352L	(1/2)
Macromolecular Modeling	CHM	416	(4)
Computational Chemistry	CHM	417	(4)
Organic Synthesis	CHM	422/422L	(2/2)
Organic Analysis	CHM	424/424L	(2/2)

Bioanalytical Chemistry	CHM	450	(4)
Enzymology	CHM	451/451L	(3/1)
Recombinant DNA Biochemistry	CHM	453	(3)
Biochemical Mechanisms **	CHM	565	(3)
Biomedical Instrumentation and Measurements	ECE	435/435L	(3/1)

### Cluster 5 - Agriculture

Animal Parasitology	AHS	302/302L	(3/1)
Immunology Procedures in Animal Production	AVS	405/405L	(3/1)
Mammalian Endocrinology	AVS	412	(4)
Biotechnology Applications in Animal Science	AVS	430/430L	(3/1)
Advanced Animal Breeding	AVS	432/432L	(3/1)
Food and Agricultural Marketing Applications	FMA	405	(4)
Agriculture and International Development	FN/IA	445	(4)
Food Safety and Current Issues	FST	325	(4)
Food Chemistry I	FST	420/420L	(3/1)
Food Analysis	FST	422/422L	(3/1)
Principles of HACCP	FST	423/423L	(3/1)
Food Microbiology	MIC	320/320L	(2/2)
Plant Breeding	PLT	404/404L	(3/1)
Crop Diseases	PLT	421/421L	(3/1)
Advanced Plant Propagation	PLT	422/422L	(3/1)
Diseases of Ornamentals	PLT	427/427L	(3/1)
Soil Chemistry	PLT	431/431L	(3/1)
Environmentally Sustainable Agriculture	PLT	437/437L	(3/1)

### Cluster 6 - Business

Regulatory Affairs and Safety Assessment	BIO	405	(4)
Management Information Systems	CIS	310	(4)
Principles of Marketing Management	IBM	301	(4)
Marketing Strategy	IBM	302	(4)
Multicultural Organizational Behavior	MHR	318	(4)
Training and Development	MHR	405	(4)
Advanced Organizational Behavior	MHR	438	(4)
Operations Management	TOM	301	(4)

\*\*500-level courses: No more than 13 units may be counted toward an undergraduate degree. Students must have a 2.75 GPA, have senior standing, and file a special petition to receive undergraduate (or graduate) credit for graduate courses taken as a senior.

### BOTANY MAJOR

The Botany curriculum offers a four-year sequence of foundation courses plus electives to provide the fundamentals of plant sciences as well as the flexibility to permit selection of courses for several lines of study. Such versatility covers the major disciplines of plant science: physiology, morphology and systematics, and also provides for careers in mycology, pathology, ecology, field biology, plant biotechnology and similar occupational areas which require a strong background of basic plant studies.

Of considerable advantage to the program are the various distinct plant communities available nearby for field study and campus resources such as BioTrek, the Ethnobotanical Garden, and the Voorhis Ecological Reserve.

Other centers of botanical study and resources close at hand include the Los Angeles State and County Arboretum, Huntington Botanical Garden, and the Rancho Santa Ana Botanic Garden.

### Core Courses for Major

Required of all students

Foundations of Biology	BIO	122/122L	(3/2)
Foundations of Biology	BIO	123/123L	(3/2)
Biometrics	BIO	211/211L	(3/1)

Genetics	BIO	303	(4)
Principles of Ecology	BIO	325/325L	(3/1)
Principles of Evolution	BIO	413	(4)
Scientific Communication	BIO	490	(1)
Form and Function in Plants	BOT	201/201L	(3/2)
General Plant Pathology	BOT	323/323L	(3/1)
or Plant Pathology	PLT	499	(3)
California Flora	BOT	343/343L	(1/2)
Plant Ecology	BOT	421/421L	(3/1)
Mycology	BOT	425/425L	(2/2)
or Plant Tissue Culture	BOT	456/456L	(2/2)
Plant Physiology	BOT	428/428L	(3/2)
Evolution of Plants	BOT	434/434L	(3/2)
Plant Anatomy	BOT	435/435L	(2/2)

### Support and Elective Courses

The following major support courses should be used to satisfy the indicated GE requirements. If these courses are not used to satisfy GE, the total units to degree may be more than 180 units.

Foundations of Biology (B2, B3)	BIO	121/121L	(3/2)
General Chemistry (B1, B3)	CHM	121/121L	(3/1)
Freshman English I (A2)	ENG	104	(4)
Freshman English II (A3)	ENG	105	(4)
Calculus for Life Science (B4)	MAT	120	(4)
Health, Nutrition, and the Integrated Being (E)	FN	203	(4)
or General Psychology (E)	PSY	201	(4)
or Mind, Brain, and Behavior:			
An Integral View (E)	PSY	210	(4)
or Science and Mathematics:			
Freshman Experience I (E)	SCI	101/101A	(1/1)
and Science and Mathematics:			
Freshman Experience II (E)	SCI	102/102A	(1/1)

General Chemistry	CHM	122/122L	(3/1)
General Chemistry	CHM	123/123L	(3/1)
Organic Chemistry	CHM	201	(3)
Organic Chemistry Laboratory	CHM	250L	(1)
Elements of Biochemistry	CHM	321/321L	(3/1)
College Physics	PHY	121/121L	(3/1)
College Physics	PHY	122/122L	(3/1)
College Physics	PHY	123/123L	(3/1)
Basic Soil Science	PLT	231/231L	(3/1)
Statistics with Applications	STA	120	(4)

Approved Electives\* ..... (14)

Students considering graduate work or professional schools should see recommended courses for preprofessional preparation.

\*Approved electives include any 200, 300, and 400-level courses in the Biological Sciences Department not specifically designed for non-majors. Approved electives also include: any advanced Chemistry or Math courses; BOT 307/307A; PHY 304/304L and PHY 410; PLT 131/L, PLT 323/L, PLT 427/L; PLT 220/220L; PLT 404/404L and PLT 421/421L. See advisor for approval of other courses offered by other departments.

### GENERAL EDUCATION REQUIREMENTS

Students should consult the catalog website [www.csupomona.edu/~academic/catalog/](http://www.csupomona.edu/~academic/catalog/) for current information regarding this requirement. Unless specific courses are stated under Support Courses, see the list of approved courses under General Education Requirements, Areas A through E.

#### Area A. Communication and Critical Thinking (12 units)

1. Oral Communication

2. Written Communication
3. Critical Thinking

**Area B. Mathematics and Natural Sciences (16 units)**

1. Physical Science
2. Biological Science
3. Laboratory Activity
4. Mathematics/Quantitative Reasoning
5. Science and Technology Synthesis

**Area C. Humanities (16 units)**

1. Visual and Performing Arts
2. Philosophy and Civilization
3. Literature and Foreign Languages
4. Humanities Synthesis

**Area D. Social Sciences (20 units)**

1. U.S. History, Constitution, and American Ideals
2. History, Economics, and Political Science
3. Sociology, Anthropology, Ethnic and Gender Studies
4. Social Science Synthesis

**Area E. Lifelong Understanding and Self-development (4 units)**

**BOTANY MINOR**

This minor is not open to students majoring in Biology, Biotechnology, Botany, Environmental Biology, Microbiology, or Zoology.

**Required of all students**

Minimum units . . . . .	32
Minimum upper division units . . . . .	12

Foundations of Biology . . . . .	BIO	123/123L	(3/2)
or Basic Biology . . . . .	BIO	115/115L	(3/2)
Form and Function in Plants . . . . .	BOT	201/201L	(3/2)
or General Botany . . . . .	BOT	124/124L	(3/2)
Plus 6 units of BOT prefix courses not including BOT 316 . . . . .			(6)

At least three of the following courses must be completed:

Form and Function Plants . . . . .	BOT	201/201L	(2/2)
Plant Pathology . . . . .	BOT	323/323L	(2/2)
California Flora . . . . .	BOT	343/343L	(1/2)
Plant Ecology * . . . . .	BOT	421/421L	(3/1)
Plant Physiology ** . . . . .	BOT	428/428L	(3/2)

Any of the following courses may be used to complete the minor:

Genetics . . . . .	BIO	303	(4)
Plants and People . . . . .	BIO	307/307A	(3/1)
Principles of Ecology . . . . .	BIO	325/325L	(3/1)
Principles of Evolution . . . . .	BIO	413	(4)
Plant Nematology . . . . .	BOT	423/423L	(3/1)
Mycology . . . . .	BOT	425/425L	(2/2)
Mycology . . . . .	BOT	426/426L	(2/2)
Evolution of Plants . . . . .	BOT	434/434L	(3/2)
Plant Anatomy . . . . .	BOT	435/435L	(2/2)
Diagnosis and Control of Plant Diseases . . . . .	BOT	440/440L	(2/2)
Methods in Plant Pathology . . . . .	BOT	441/441L	(2/2)
Elements of Organic Chemistry . . . . .	CHM	201	(3)
Organic Chemistry *** . . . . .	CHM	314	(3)

\*Prerequisite: BIO 325.

\*\*Prerequisite: CHM 201 or consent of instructor.

\*\*\*CHM 317 must be taken concurrently.

Note: This minor may not be earned by Botany majors, nor can both Botany and Plant Pathology minors be earned by one student.

**PLANT BIOTECHNOLOGY MINOR**

This minor is not open to students majoring in Biology, Biotechnology, Botany, Environmental Biology, Microbiology, or Zoology.

**Required of all students**

Minimum units . . . . .	32
Minimum upper division units . . . . .	12

The following courses are required for the minor:

Plant Pathology * . . . . .	BOT	323/323L	(2/2)
Plant Genetics *** . . . . .	BOT	403/403L	(3/1)
Plant Physiology * . . . . .	BOT	428/428L	(3/2)

Any of the following courses may be taken to complete the minor:

Concepts of Molecular Biology . . . . .	BIO	450	(4)
Molecular Biology Techniques . . . . .	BIO	451/451L	(3/2)
Mycology . . . . .	BOT	426/426L	(2/2)
Methods in Plant Pathology . . . . .	BOT	441/441L	(2/2)
Plant Tissue Culture . . . . .	BOT	456/456L	(1/3)
Plant Breeding ** . . . . .	PLT	404/404L	(3/1)
Minimum units: 30			

\*Prerequisites: BOT 124/124L or BOT 201/201L.

\*\*Prerequisite: BIO 115/115L.

\*\*\*Prerequisites: PLT 226.

**PLANT PATHOLOGY MINOR**

This minor is not open to students majoring in Biology, Biotechnology, Botany, Environmental Biology, Microbiology, or Zoology.

**Required of all students**

Minimum units . . . . .	32
Minimum upper division units . . . . .	12

The following courses are required for the minor:

Basic Biology . . . . .	BIO	115/115L	(3/2)
or Foundations of Biology . . . . .	BIO	123/123L	(3/2)
Form and Function in Plants . . . . .	BOT	201/201L	(3/2)
or General Botany . . . . .	BOT	124/124L	(3/2)
Plant Pathology . . . . .	BOT	323/323L	(2/2)
Diagnosis and Control of Plant Diseases . . . . .	BOT	440/440L	(2/2)
or Methods in Plant Pathology . . . . .	BOT	441/441L	(2/2)

At least two of the following courses must be completed in addition:

Form and Function in Plants . . . . .	BOT	201/201L	(3/2)
Mycology . . . . .	BOT	425/425L	(2/2)
Mycology . . . . .	BOT	426/426L	(2/2)
Plant Physiology# . . . . .	BOT	428/428L	(3/2)
Diagnosis and Control of Plant Diseases . . . . .	BOT	440/440L	(2/2)
Methods in Plant Pathology . . . . .	BOT	441/441L	(2/2)

#Prerequisite: CHM 201 or consent of instructor.

Any of the above or following courses may be used to complete the minor:

Plant Nematology . . . . .	BOT	423/423L	(3/1)
Post Harvest Physiology of Fruits and Vegetables . . . . .	PLT	351/351L	(3/1)
Crop Diseases . . . . .	PLT	421/421L	(3/1)
Diseases of Ornamental Plants . . . . .	PLT	427/427L	(3/1)

**ENVIRONMENTAL BIOLOGY MAJOR**

The Environmental Biology major is designed for students who want to help solve the environmental problems threatening the organisms and life support systems of our planet. Students are able to specialize by selecting most of their upper-division courses from one of three clusters. The Conservation Biology cluster prepares students to identify and protect critical habitat, manage rare and endangered species, and design ecological preserves. The Ecosystem Ecology and Management cluster equips students to conduct ecological field research, manage natural resources on public and private lands, and assess environmental impacts of proposed actions. The Environmental Microbiology and Biotechnology cluster emphasizes laboratory research to assess water and air quality, transport and fate of pollutants, and environmental health in general. Eighteen units must be taken from one of these clusters (the student's primary cluster) and an additional eleven units from the other two clusters. Students selecting the Conservation Biology cluster or the Ecosystem Ecology and Management cluster take a two-course sequence in Geographic Information Systems (GIS). All students conduct an independent research project or complete an internship with a participating agency or private organization. This provides practical problem-solving experience to complement classroom, laboratory, and field studies.

**Core Courses for Major****Required of all students**

Foundations of Biology	BIO	122/122L	(3/2)
Foundations of Biology	BIO	123/123L	(3/2)
Biometrics	BIO	211/211L	(3/1)
Genetics	BIO	303	(4)
Principles of Ecology	BIO	325/325L	(3/1)
Principles of Evolution	BIO	413	(4)
Internship in Biology	BIO	441	(2)
or Undergraduate Research	BIO	461	(2)
Form and Function in Plants	BOT	201/201L	(3/2)
Animal Biology	ZOO	201/201L	(3/2)
Upper-Division Courses			(29)

At least 18 units from one "Primary" cluster and 11 units from the other two clusters, to be selected in consultation with faculty advisor. At least 15 units must be taken at the 400- or 500-level. See "Upper-Division Clusters."

**Support Courses for Clusters 1 and 2**

The following eight support courses should be used to satisfy the indicated GE requirements. If these courses are not used to satisfy GE, the total units to degree will be more than 180 units.

Foundations of Biology (B2, B3)	BIO	121/121L	(3/2)
Environment and Society* (B5)	BIO	304	(4)
General Chemistry* (B1, B3)	CHM	121/121L	(3/1)
Principles of Economics* (D2)	EC	201 or 202	(4)
Freshman English I (A2)	ENG	104	(4)
Freshman English II (A3)	ENG	105	(4)
Calculus for the Life Sciences (B4)	MAT	120	(4)
Global Regenerative Systems (D4)	RS	302	(4)

Biodiversity Conservation	BIO	340	(4)
General Chemistry	CHM	122/122L	(3/1)
General Chemistry	CHM	123/123L	(3/1)
Organic Chemistry	CHM	201	(3)
Organic Chemistry Laboratory	CHM	250L	(1)
Elements of Biochemistry	CHM	321/321L	(3/1)
Geographic Information Systems	GEO	240/240A	(3/1)

Environmental Modeling with GIS	GEO	445/445A	(3/1)
Principles of Geology	GSC	111	(4)
College Physics	PHY	121/121L	(3/1)
College Physics	PHY	122/122L	(3/1)
Basic Soil Science	PLT	231/231L	(3/1)

**Support Courses for Cluster 3**

The following eight support courses should be used to satisfy the indicated GE requirements. If these courses are not used to satisfy GE, the total units to degree will be more than 180 units.

Foundations of Biology (B2, B3)	BIO	121/121L	(3/2)
Environment and Society (B5)	BIO	304	(4)
General Chemistry (B1, B3)	CHM	121/121L	(3/1)
Principles of Economics (D2)	EC	201 or 202	(4)
Freshman English I (A2)	ENG	104	(4)
Freshman English II (A3)	ENG	105	(4)
Calculus for the Life Sciences (B4)	MAT	120	(4)
Global Regenerative Systems (D4)	RS	302	(4)

General Chemistry	CHM	122/122L	(3/1)
General Chemistry	CHM	123/123L	(3/1)
Organic Chemistry	CHM	314	(3)
Organic Chemistry	CHM	315	(3)
Organic Chemistry	CHM	316	(3)
Organic Chemistry Laboratory	CHM	317L	(1)
Organic Chemistry Laboratory	CHM	318L	(1)
Biochemistry	CHM	327/327L	(3/1)
Biochemistry	CHM	328/328L	(3/1)
Basic Microbiology	MIC	201/201L	(3/2)
College Physics	PHY	121/121L	(3/1)
College Physics	PHY	122/122L	(3/1)
Basic Soil Science	PLT	231/231L	(3/1)

**GENERAL EDUCATION REQUIREMENTS**

Students should consult the catalog website [www.csupomona.edu/~academic/catalog/](http://www.csupomona.edu/~academic/catalog/) for current information regarding this requirement. Unless specific courses are stated under Support Courses, see the list of approved courses under General Education Requirements, Areas A through E.

**Area A. Communication and Critical Thinking (12 units)**

1. Oral Communication
2. Written Communication
3. Critical Thinking

**Area B. Mathematics and Natural Sciences (16 units)**

1. Physical Science
2. Biological Science
3. Laboratory Activity
4. Mathematics/Quantitative Reasoning
5. Science and Technology Synthesis

**Area C. Humanities (16 units)**

1. Visual and Performing Arts
2. Philosophy and Civilization
3. Literature and Foreign Languages
4. Humanities Synthesis

**Area D. Social Sciences (20 units)**

1. U.S. History, Constitution, and American Ideals
2. History, Economics, and Political Science
3. Sociology, Anthropology, Ethnic and Gender Studies
4. Social Science Synthesis

**Area E. Lifelong Understanding and Self-development (4 units)**

**Course Descriptions**

See course descriptions under appropriate department.

**Upper-Division Course Clusters**

**Cluster 1 – Conservation Biology**

Marine Biology	BIO	330/330L	(3/2)
Biological Systematics	BIO	406	(3)
Biology of Ants	BIO	407/407L	(3/2)
Field Studies in the Southwest	BIO	415L	(4)
Field Studies in Baja California	BIO	416L	(4)
Population Ecology	BIO	418/418L	(2/1)
Population Genetics	BIO	445/445L	(3/1)
Mechanisms of Speciation**	BIO	530	(3)
California Flora	BOT	343/343L	(1/2)
Evolution of Plants	BOT	434/434L	(3/2)
Native Plant Materials	PLT	337/337L	(2/1)
Insect Taxonomy	PLT	402/402L	(2/2)
Environmental Factors in Regional Planning	URP	487	(4)
Ornithology	ZOO	435/435L	(3/1)
Entomology	ZOO	426/426L	(3/1)
Herpetology	ZOO	429/429L	(2/2)
Mammalogy	ZOO	430/430L	(2/2)
Ichthyology	ZOO	441/441L	(2/2)

**Cluster 2 – Ecosystem Ecology and Management**

Chaparral Biology	BIO	425/425L	(3/1)
Marine Ecology	BIO	442/442L	(3/2)
Tropical Biology	BIO	485	(3)
Ecology of Fungi**	BIO	525/525L	(2/2)
Community Analysis**	BIO	527/527L	(3/1)
Community Ecology**	BIO	528	(3)
Tropical Field Biology**	BIO	532L	(2-6)
Biogeography**	BIO	540	(3)
Wildlife Ecology**	BIO	575/542L	(2/1)
General Plant Pathology	BOT	323/323L	(2/2)
Plant Ecology	BOT	421/421L	(3/1)
Plant Physiology	BOT	428/428L	(3/2)
General Systems Theory: Hierarchies	CSA	411/411A	(3/1)
General Systems Theory: Testing Hypotheses	CSA	412/412A	(3/1)
General Systems Theory: Man-Made Systems	CSA	413/413A	(3/1)
Applied Ecosystems Engineering	CSA	470	(4)
Photographic Remote Sensing	GEO	410	(4)
Digital Image Processing	GEO	420	(4)
Applied Geomorphology	GSC	323/323L	(3/1)
Politics of Public Policy	PLS	315	(4)
Soil Resource Management and Conservation	PLT	334/334L	(3/1)
Environmentally Sustainable Agriculture	PLT	437/437L	(3/1)
Life Support Processes	RS	301	(4)
Shaping a Sustainable Future	RS	303	(4)

**Cluster 3 – Environmental Microbiology and Biotechnology**

Cell and Molecular Biology	BIO	310	(4)
Water Pollution Biology	BIO	420	(3)
Radiation Biology	BIO	431/431L	(3/1)
Mycology	BOT	425/425L	(2/2)
Mycology	BOT	426/426L	(2/2)
Environmental Resource Management/Laboratory	CE	351/351L	(3/1)

Biochemistry	CHM	329/329L	(3/1)
Air Pollution Problems	CHM	460	(3)
Systems Law as an Active Force	CSA	340/340L	(2/2)
Environmental Law	GEO	413	(4)
Applied Microbiology	MIC	310/310L	(3/2)
General Epidemiology	MIC	330	(4)
Medical Bacteriology	MIC	410/410L	(3/2)
Microbial Physiology	MIC	428/428L	(3/1)
Pesticide and Hazardous Material Laws	PLT	303	(3)
Environmental Toxicology	PLT	411	(4)
Soil Chemistry	PLT	431/431L	(3/1)
Soil Physics	PLT	432/432L	(3/1)

\*\*500-level courses: No more than 13 units may be counted toward an undergraduate degree. Students must have a 2.75 GPA, have senior standing, and file a special petition to receive undergraduate (or graduate) credit for graduate courses taken as a senior.

**MICROBIOLOGY MAJOR**

The Microbiology major chooses one of the two subplans offered by the section, microbiology or medical technology. The core courses of the major provide a strong background in various areas of biology to better prepare students for their chosen field. The program offered in the microbiology major constitutes excellent undergraduate training and can also be oriented toward the preprofessional fields.

Completion of the medical technology subplan satisfies the eligibility requirements established by the California State Department of Health and the Registry of Medical Technologists of the American Society of Clinical Pathologists (ASCP) for acceptance into a one year clinical traineeship at an approved School of Medical Technology.

**Core Courses for Major**

Required of all students

Foundations of Biology	BIO	122/122L	(3/2)
Foundations of Biology	BIO	123/123L	(3/2)
Biometrics	BIO	211/211L	(3/1)
Genetics	BIO	303	(4)
Scientific Communication	BIO	490	(1)
Basic Microbiology	MIC	201/201L	(3/2)
Medical Bacteriology	MIC	410/410L	(3/2)
Immunology-Serology	MIC	415/415L	(3/2)
Microbial Physiology	MIC	428/428L	(3/2)
General Virology	MIC	430/430L	(3/2)

**Subplan Courses for Major**

Required for specific subplan

**Microbiology Subplan**

Cell and Molecular Biology	BIO	310	(4)
Applied Microbiology	MIC	310/310L	(3/2)
or Food Microbiology	MIC	320/320L	(2/2)

**Medical Technology Subplan**

Clinical Chemistry	CHM	331/331L	(2/2)
Medical Mycology	MIC	425/425L	(3/2)
or Medical Parasitology	ZOO	425/425L	(3/2)
Hematology	MIC	444/444L	(3/1)
Immunohematology	MIC	445/445L	(3/1)
Human Physiology	ZOO	235/235L	(3/1)

**Support and Elective Courses**

The following major support courses should be used to satisfy the indicated GE requirements. If these courses are not used to satisfy GE, the total units to degree may be more than 180 units.

Foundations of Biology (B2, B3)	BIO	121/121L	(3/2)
General Chemistry (B1, B3)	CHM	121/121L	(3/1)
Freshman English I (A2)	ENG	104	(4)
Freshman English II (A3)	ENG	105	(4)
Calculus for Life Science (B4)	MAT	120	(4)
Health, Nutrition, and the Integrated Being (E)	FN	203	(4)
or General Psychology (E)	PSY	201	(4)
or Mind, Brain, and Behavior:			
An Integral View (E)	PSY	210	(4)
or Science and Mathematics:			
Freshman Experience I (E)	SCI	101/101A	(1/1)
and Science and Mathematics:			
Freshman Experience II (E)	SCI	102/102A	(1/1)

General Chemistry	CHM	122/122L	(3/1)
General Chemistry	CHM	123/123L	(3/1)
Quantitative Analysis	CHM	221/221L	(3/1)
Organic Chemistry	CHM	314	(3)
Organic Chemistry	CHM	315	(3)
Organic Chemistry	CHM	316	(3)
Organic Chemistry Laboratory	CHM	317L	(1)
Biochemistry	CHM	327/327L	(3/1)
Biochemistry	CHM	328/328L	(3/1)
Biochemistry	CHM	329/329L	(3/1)
College Physics	PHY	121/121L	(3/1)
College Physics	PHY	122/122L	(3/1)
College Physics	PHY	123/123L	(3/1)

Approved electives (Medical Technology Subplan) . . . . . (0)  
 Approved electives (Microbiology Subplan)\*. . . . . (12-13)

\* Approved electives include any 200, 300, and 400-level courses in the Biological Sciences Department not specifically designed for non-majors. Approved electives also include any advanced Chemistry or Math classes.

Students considering graduate work or professional schools should see recommended courses for preprofessional preparation and the professional advisor.

**GENERAL EDUCATION REQUIREMENTS**

Students should consult the catalog website [www.csupomona.edu/~academic/catalog/](http://www.csupomona.edu/~academic/catalog/) for current information regarding this requirement. Unless specific courses are stated under Support Courses, see the list of approved courses under General Education Requirements, Areas A through E.

**Area A. Communication and Critical Thinking (12 units)**

1. Oral Communication
2. Written Communication
3. Critical Thinking

**Area B. Mathematics and Natural Sciences (16 units)**

1. Physical Science
2. Biological Science
3. Laboratory Activity
4. Mathematics/Quantitative Reasoning
5. Science and Technology Synthesis

**Area C. Humanities (16 units)**

1. Visual and Performing Arts
2. Philosophy and Civilization

3. Literature and Foreign Languages
4. Humanities Synthesis

**Area D. Social Sciences (20 units)**

1. U.S. History, Constitution, and American Ideals
2. History, Economics, and Political Science
3. Sociology, Anthropology, Ethnic and Gender Studies
4. Social Science Synthesis

**Area E. Lifelong Understanding and Self-development (4 units)****MICROBIOLOGY MINOR**

This minor is not open to students majoring in Biology, Biotechnology, Botany, Environmental Biology, Microbiology, or Zoology.

Minimum units . . . . . 40

**Required of all students**

Basic Biology	BIO	115/115L	(3/2)
or Foundations of Biology	BIO	123/123L	(3/2)
General Chemistry	CHM	121/121L	(3/1)
General Chemistry	CHM	122/122L	(3/1)
Elements of Organic Chemistry	CHM	201	(3)
Elements of Organic Chemistry Laboratory	CHM	250L	(1)
Elements of Biochemistry	CHM	321/321L	(3/1)
Basic Microbiology	MIC	201/201L	(3/2)
Microbial Physiology	MIC	428/428L	(3/2)

At least two courses from the following list of courses:

Applied Microbiology	MIC	310/310L	(3/2)
or Food Microbiology	MIC	320/320L	(2/2)
Medical Bacteriology	MIC	410/410L	(3/2)
Immunology-Serology	MIC	415/415L	(3/2)
Medical Mycology	MIC	425/425L	(3/2)
General Virology	MIC	430/430L	(3/2)

Other courses may be substituted for those listed above in consultation with the faculty in the microbiology section.

**ZOOLOGY MAJOR**

The curriculum in Zoology provides a solid background for graduate studies and, in addition, prepares students for careers in biomedical and biotechnology research or fish and wildlife management. It also provides ample opportunities for premedical, pre dental, and preveterinary preparation.

After completion of general courses in biology and zoology, students may specialize in one of two broad areas of study: Physiology and Neuroscience or Biodiversity and Systematics. The Physiology and Neuroscience cluster is ideal for students who wish to pursue graduate degrees in physiology and/or neuroscience, as well as those interested in pursuing careers in the health sciences (e.g., medicine, dentistry, optometry, etc.). The Biodiversity and Systematics cluster is designed for students with career aspirations in fish and wildlife management, as well as students who plan to pursue graduate degrees in these areas.

Teaching and research activities include utilization of the following exceptional resources: modern computer facilities; a colony of laboratory animals; a representative collection of living reptiles and amphibians; extensive preserved collections of bird, mammal, amphibian, reptile, fish, arachnid, and insect specimens; the San Dimas Experimental Forest, administered by the U.S. Forest Service; a marine laboratory and two oceanographic research vessels operated by the Southern California Marine Institute; the Desert Studies Center near Baker in the Mojave Desert, operated by the Desert Studies Consortium; and the Voorhis

Ecological Reserve on campus. The new BioTrek facility provides opportunities for students to view adaptations of terrestrial and aquatic animals to the tropical rainforest environment. In the areas of physiology and neuroscience, facilities include state of the art data acquisition and analysis systems, electrophysiological instruments (patch and two-electrode voltage clamp), microinjection systems, cell culture and molecular biology facilities, a variety of light microscopy stations (including fluorescence and live cell imaging), and an electron microscopy center equipped with transmission (thin section and freeze-fracture) and scanning electron microscopes.

**Core Courses for Major**

Required of all students

Foundations of Biology	BIO	122/122L	(3/2)
Foundations of Biology	BIO	123/123L	(3/2)
Biometrics	BIO	211/211L	(3/1)
Genetics	BIO	303	(4)
Cell and Molecular Biology	BIO	310	(4)
Cell Biology Laboratory	BIO	312L	(1)
Principles of Ecology	BIO	325/325L	(3/1)
Principles of Evolution	BIO	413	(4)
Scientific Communication	BIO	490	(1)
Introduction to Invertebrate Zoology	ZOO	237/237L	(3/2)
Introduction to Vertebrate Zoology	ZOO	238/238L	(3/2)
Animal Physiology	ZOO	428/428L	(3/2)

Twenty-two units of upper division courses must be completed from the approved courses included in one of two clusters (Physiology and Neuroscience, and Biodiversity and Systematics). Students do not need to declare a cluster. Courses may be chosen from either of the two clusters indicated below, but a minimum of 3 units must be completed from each cluster. See below for approved courses.

**Physiology and Neuroscience Cluster**

Developmental Biology	BIO	320/320L	(4/1)
Biophysics	BIO	410	(4)
Neuroscience	BIO	424	(4)
Neuroanatomy	BIO	426/426L	(4/1)
Cellular Physiology	BIO	428/428L	(3/2)
Radiation Biology	BIO	431/431L	(3/1)
Concepts of Molecular Biology	BIO	450	(4)
Molecular Biology Techniques	BIO	451/451L	(3/2)
Molecular Biology of Recombinant DNA	BIO	455/455L	(2/2)
Neuromuscular Physiology	BIO	499	(4)
Animal Behavior	ZOO	419/419L	(2/1)
Histology	ZOO	422/422L	(2/3)
Medical Parasitology	ZOO	425/425L	(3/2)
Evolutionary Ecomorphology	ZOO	439/439L	(2/2)
Physiological Ecology	ZOO	440/440L	(3/1)

**Biodiversity and Systematics Cluster**

Marine Biology	BIO	330/330L	(3/1)
Biological Systematics	BIO	406	(3)
Biology of Ants	BIO	407/407L	(3/2)
Field Studies in the Southwest	BIO	415L	(4)
Field Studies in Baja California	BIO	416L	(4)
Population Ecology	BIO	418/418L	(2/1)
Chaparral Biology	BIO	425/425L	(3/1)
Marine Ecology	BIO	442/442L	(3/2)
Tropical Biology	BIO	485	(3)
California Flora	BOT	343/343L	(1/2)
Plant Nematology	BOT	423/423L	(3/1)
Ornithology	ZOO	329/329L	(2/1)

Entomology	ZOO	426/426L	(3/1)
Herpetology	ZOO	429/429L	(3/2)
Mammalogy	ZOO	430/430L	(2/2)
Ichthyology	ZOO	441/441L	(2/2)
Comparative Anatomy of Vertebrates	ZOO	451/451L	(3/2)

Students considering graduate work or professional schools: see recommended courses for preprofessional preparation and consult with the preprofessional advisor.

**Support and Elective Courses**

The following major support courses should be used to satisfy the indicated GE requirements. If these courses are not used to satisfy GE, the total units to degree may be more than 180 units.

Freshman English I (A2)	ENG	104	(4)
Freshman English II (A3)	ENG	105	(4)
Calculus for Life Science (B4)	MAT	120	(4)
General Chemistry (B1, B3)	CHM	121/121L	(3/1)
Foundations of Biology (B2, B3)	BIO	121/121L	(3/2)
Environment and Society (B5)	BIO	304	(4)
or Biodiversity Conservation (B5)	BIO	340	(4)
Health, Nutrition, and the Integrated Being (E)	FN	203	(4)
or General Psychology (E)	PSY	201	(4)
or Mind, Brain, and Behavior:			
An Integrated View (E)	PSY	210	(4)
or Science and Mathematics:			
Freshman Experience I (E)	SCI	101/101A	(1/1)
and Science and Mathematics:			
Freshman Experience II (E)	SCI	102/102A	(1/1)

General Chemistry	CHM	122/122L	(3/1)
General Chemistry	CHM	123/123L	(3/1)
Organic Chemistry	CHM	201	(3)
Organic Chemistry Laboratory	CHM	250L	(1)
Elements of Biochemistry	CHM	321/321L	(3/1)
College Physics	PHY	121/121L	(3/1)
College Physics	PHY	122/122L	(3/1)
College Physics	PHY	123/123L	(3/1)
Statistics with Applications	STA	120	(4)

Approved electives\* ..... (11-12)

\*Approved electives include any 200, 300, or 400 level courses in the Biological Sciences Department. Only 2 units of BIO 200 or BIO 400 allowed. Approved electives also include any advanced Chemistry or Math courses. See advisor for approval of courses offered by other departments.

**GENERAL EDUCATION REQUIREMENTS**

Students should consult the catalog website [www.csupomona.edu/~academic/catalog/](http://www.csupomona.edu/~academic/catalog/) for current information regarding this requirement. Unless specific courses are stated under Support Courses, see the list of approved courses under General Education Requirements, Areas A through E.

**Area A. Communication and Critical Thinking (12 units)**

1. Oral Communication
2. Written Communication
3. Critical Thinking

**Area B. Mathematics and Natural Sciences (16 units)**

1. Physical Science
2. Biological Science
3. Laboratory Activity



4. Mathematics/Quantitative Reasoning
5. Science and Technology Synthesis

**Area C. Humanities (16 units)**

1. Visual and Performing Arts
2. Philosophy and Civilization
3. Literature and Foreign Languages
4. Humanities Synthesis

**Area D. Social Sciences (20 units)**

1. U.S. History, Constitution, and American Ideals
2. History, Economics, and Political Science
3. Sociology, Anthropology, Ethnic and Gender Studies
4. Social Science Synthesis

**Area E. Lifelong Understanding and Self-development (4 units)**

**ZOOLOGY MINOR**

This minor is not open to students majoring in Biology, Biotechnology, Botany, Environmental Biology, Microbiology, or Zoology.

Minimum units . . . . . 32  
 Minimum upper division units . . . . . 12

**Required of all students:**

Basic Biology . . . . .	BIO	115/115L	(3/2)
or Foundations of Biology . . . . .	BIO	123/123L	(3/2)
Genetics . . . . .	BIO	303	(4)
Introduction to Invertebrate Zoology . . . . .	ZOO	237/237L	(3/2)
Introduction to Vertebrate Zoology . . . . .	ZOO	238/238L	(3/2)

Any two from the following courses:

Principles of Ecology . . . . .	BIO	325/325L	(3/1)
Principles of Evolution . . . . .	BIO	413	(4)
Animal Physiology . . . . .	ZOO	428/428L	(3/2)

At least two courses from the following list of courses to complete the minor:

Developmental Biology . . . . .	BIO	320/320L	(4/1)
Human Anatomy . . . . .	ZOO	234/234L	(3/2)
Human Physiology . . . . .	ZOO	235/235L	(3/1)
Ornithology . . . . .	ZOO	329/329L	(2/1)
Animal Behavior . . . . .	ZOO	419/419L	(2/1)
Histology . . . . .	ZOO	422/422L	(2/3)
Medical Parasitology . . . . .	ZOO	425/425L	(3/2)
Entomology . . . . .	ZOO	426/426L	(3/1)
Herpetology . . . . .	ZOO	429/429L	(3/2)
Mammalogy . . . . .	ZOO	430/430L	(2/2)
Physiological Ecology of Animals . . . . .	ZOO	440/440L	(3/1)
Ichthyology . . . . .	ZOO	441/441L	(2/2)
Comparative Anatomy of Vertebrates . . . . .	ZOO	451/451L	(3/2)

**Subject Matter Preparation - Program for Prospective Teachers of Science with a Concentration in Biology**

The Biological Sciences Department offers a program in science with a concentration in biology approved by the Commission on Teacher Credentialing. Those individuals who wish to become science teachers with an emphasis in the life sciences in California public schools must complete the comprehensive list of courses as follows. The set of courses are separated into two parts, breadth courses and depth courses in an area of concentration.

**Breadth Courses:**

Foundations of Biology . . . . .	BIO	121/121L	(3/2)
Foundations of Biology . . . . .	BIO	122/122L	(3/2)
Foundations of Biology . . . . .	BIO	123/123L	(3/2)

**Chemistry**

General Chemistry . . . . .	CHM	121/121L	(3/1)
General Chemistry . . . . .	CHM	122/122L	(3/1)
General Chemistry . . . . .	CHM	123/123L	(3/1)

**Geosciences**

Principles of Geology . . . . .	GSC	111/141L	(4/1)
Earth, Time and Life . . . . .	GSC	112/151L	(3/1)
Descriptive Physical Oceanography . . . . .	GSC	335	(4)

**Physics**

College Physics (Mechanics) . . . . .	PHY	121/121L	(3/1)
College Physics (Waves and Heat) . . . . .	PHY	122/122L	(3/1)
College Physics (Electricity and Magnetism) . . . . .	PHY	123/123L	(3/1)

**Interdisciplinary Science**

Senior Level Integrated Science . . . . .	SCI	495	(8)
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**Depth Courses: Biological Sciences**

Biometrics . . . . .	BIO	211/211L	(3/1)
Genetics . . . . .	BIO	303	(4)
Cell and Molecular Biology . . . . .	BIO	310	(4)
Principles of Ecology . . . . .	BIO	325/325L	(3/1)
Principles of Evolution . . . . .	BIO	413	(4)

Select one:

Cellular Physiology . . . . .	BIO	428/428L	(3/2)
Plant Physiology . . . . .	BOT	428/428L	(3/2)
Microbial Physiology . . . . .	MIC	428/428L	(3/2)
Animal Physiology . . . . .	ZOO	428/428L	(3/2)

Select one:

Form and Function in Plants . . . . .	BOT	201/201L	(3/2)
Basic Microbiology . . . . .	MIC	201/201L	(3/2)
Animal Biology . . . . .	ZOO	201/201L	(3/2)

**BIOLOGY COURSE DESCRIPTIONS**

NOTE: For all courses which have both a lecture component and a laboratory component (e.g. BIO 121/121L), both components are corequisites; that is, they must be taken concurrently.

When appropriate, the names of faculty associated with each course are specified; otherwise, "Staff" is noted. Courses approved for CR/NC grading are designated by + and apply only to majors outside the Biological Sciences Department.

**BIO 110 Life Science (3) Every quarter**

Basic concepts in the study of living systems, including human beings. Uses the study of biology to illustrate approaches of science in understanding the universe. The role of science in modern society and the impact of human civilization on other organisms considered. Designed to satisfy the general education requirements for life science. 3 lectures/problem-solving. Staff.

**BIO 111L Life Science Laboratory (1) Every quarter**

An optional laboratory to accompany BIO 110. A basic understanding of living organisms achieved through experiments and demonstrations. This course will satisfy the general education requirements for a laboratory course, 1 three-hour laboratory. Prerequisite: BIO 110 or concurrent enrollment in BIO 110. Staff.

**BIO 115/115L Basic Biology (3/2) Every quarter**

Introduction to living things; covering levels of organization from molecules to ecosystems. Designed for students not majoring in Biology, Biotechnology, Botany, Microbiology, and Zoology. 3 lectures/problem-solving, 2 three-hour laboratories. George.

**BIO 121/121L Foundations of Biology: Energy and Matter – Cycles and Flows (3/2) Fall, Winter**

Defined by the theme of Energy and Matter: Cycles and Flows, this course will examine the acquisition, utilization and flow of energy and matter through various taxa (microbes, plants, animals) and organizational levels (cells, organisms, populations, ecosystems) that comprise living systems. Designed as the first of three foundation courses required of all majors offered by the Biological Sciences Department. This course may be used to satisfy GE requirements in natural science Area B3. 3 lectures/problem-solving, 2 three-hour laboratories. Hartney.

**BIO 122/122L Foundations of Biology: Reproduction and Development (3/2) Winter, Spring**

Reproduction and development are examined at several levels of organization, from molecules, cells and tissues, to organisms, populations and communities. Exemplar organisms are chosen to highlight developmental strategies among biological systems, as well as strategies that maximize reproductive success. Laboratory reinforces biological principles and provides exposure to basic methodology, equipment and data analysis. The second of three foundation courses required of all majors offered by the Biological Sciences Department. 3 lectures/problem-solving, 2 three-hour laboratories. Prerequisite: BIO 121/121L. Staff.

**BIO 123/123L Foundations of Biology: Biodiversity (3/2) Spring, Fall**

Biodiversity is examined at molecular, cellular, organismal and ecological levels with an emphasis on phylogenetic relationships. Laboratory provides exposure to basic laboratory and field techniques and introduces major groups of living organisms, habitats in which they reside and factors affecting their ecology and evolution. The third of three foundation courses required of all majors offered by the Biological Sciences Department. 3 lectures/problem-solving, 2 three-hour laboratories. Prerequisites: BIO 121/121L, 122/122L. Bobich, Ewers.

**BIO 200 Special Study for Lower Division Students (1-2) Every quarter**

Individual or group investigation, research, studies or surveys of selected problems. Enrollment requires: (1) Prior arrangement with a faculty member. (2) Completion of a supervisory form available in the Biological Sciences Department office. Only two units of BIO 200 and/or BIO 400 are allowed as approved electives for a degree in the Biological Sciences Department. May not be used as upper-division core elective. Limited to 2 units per quarter. Staff.

**BIO 207 Careers in Biology (1) Once a year**

Exploration of over 500 career options for majors in the biological sciences. Preparation for a career, finding the right career and landing

the job are covered. 1 lecture/problem-solving. Prerequisite: BIO 110, or BIO 115/115L, or the series of BIO 121/121L, 122/122L and 123/123L. Staff.

**BIO 211/211L Biometrics (3/1) Every quarter**

Applied statistical analysis of biological data. Understanding, interpreting, and performing data analysis in a research context. 3 lectures/problem-solving, 1 three-hour laboratory. It is recommended that students take STA 120 before enrolling in this course. Prerequisites: BIO 115/115L (or the series of BIO 121/121L, 122/122L and 123/123L). Carlton, Moriarty.

**BIO 230 Horizons in Biotechnology (1) Once a year: Winter, Spring**

A survey of the various applications of biotechnology in today's industrial community. Topics include theoretical explanations of recent biotechnological developments, discussion of problems encountered in production, manufacturing and marketing of new products, and future directions in biotechnological research. The course will feature guest lecturers from various biotechnology industries. 1 lecture. Adler, Olson.

**BIO 299/299A/299L Special Topics for Lower Division Students (1-4) Every quarter**

Group study of a selected topic for lower-division students. Course title and number of units are specified in advance. Instruction by lecture, problem-solving activity, laboratory, or a combination of formats. Students receive credit for multiple courses with the BIO 299/299A/299L designation if course titles are different. Total credit limited to 8 units, with a maximum of 4 units per quarter. Staff.

**BIO 300 Genetics and Human Issues (4) Once a year**

Nontechnical introduction to genetic principles with emphasis on humans. Topics include gene structure, function and regulation, hereditary diseases, genetic engineering, human genome, cloning, genetic technologies in medicine and agriculture, cancer, forensics, genetic fingerprinting, human behavior, ethical and social issues. 4 lectures/problem-solving. Open to all majors. Not for core or support credit for students with majors in the Biological Sciences Department. Prerequisites: one GE course from each of the following Sub-areas: A1, A2, A3 and B1, B2, B4 (BIO 110 or BIO 115/115L). GE Synthesis course for Sub-area B5. Kageyama, Troncale

**BIO 301 Human Sexuality (4) Every quarter**

Candid and factual coverage of human sexuality through lectures, films, guest speakers and discussion. Topics include anatomy and physiology, sexual response, hormones, birth control and ethical implications, fertilization, pregnancy and childbirth, sexual behavior and human values, diseases and dysfunctions, sex and the law, myths, misconceptions and recent developments in the study of human sexuality. 4 hours of lecture/week. May be used for an approved elective support course, but not for upper division core credit by students with majors in the Biological Sciences Department. Prerequisite: one GE course from each of the following Sub-areas: A1, A2, A3 and B1, B2, B4 (BIO 110, or BIO 115/115L, or BIO 121,121L). GE Synthesis course for Sub-area B5. George, LaMunyon.

**+BIO 302 Biology of Cancer (4) Once a year**

Topics include causes and symptoms of cancer, molecular and cell biology of cancer, lung, skin and other major "site" cancers, chemotherapy, immunotherapy, present research and psychosocial aspects. Material is presented by guest lecturers including specialists

and cancer patients. May be used for approved elective credit but not upper division core credit by students with majors in the Biological Sciences Department. 4 lectures/problem-solving. Prerequisite: one GE course from each of the following Sub-areas: A1, A2, A3 and B1, B2, B4 (BIO 110, or BIO 115/115L, or BIO 121,121L). GE Synthesis course for Sub-area B5. Troncale.

#### **BIO 303 Genetics (4) Every quarter**

Principles of heredity. Introduction to transmission (Mendelian) genetics, cytogenetics, molecular genetics and population genetics. 4 lectures/problem-solving. Prerequisite: BIO 110; or BIO 115/115L; or the series of BIO 121/121L, 122/122L and 123/123L. Alas, LaMunyon, Kageyama, Troncale.

#### **BIO 304 Environment and Society (4) Every quarter**

Contemporary environmental problems related to the use of natural resources by modern societies. Ecological issues discussed include impacts on the availability of food, water, and energy by a rapidly growing world population, and the effects of pollution, global climate change, land use, and decreasing biodiversity on ecosystems and societies. 4 lecture/discussions. Open to all majors. Prerequisite: one GE course from each of the following Sub-areas: A1, A2, A3 and B1, B2, B4 (BIO 110, or BIO 115/115L, or BIO 121/121L). GE Synthesis course for Sub-area B5. Staff.

#### **+BIO 305 Aquatic Ecology for Environmental Engineers (4) Once a year**

Ecological principles and their application to productivity, pollution, and other problems with emphasis on natural and man-made aquatic habitats. Not for core or support credit for students with majors in the Biological Sciences Department. 4 lectures/problem-solving. Prerequisite: BIO 110. Arnold.

#### **BIO 309 Biology of the Brain (4) Once a year**

The fundamental structural and functional organization of the human brain and how this knowledge underlies simple to complex behaviors in humans. Concepts will be derived from mathematics, physics, chemistry, biology, genetics, neuroscience, pharmacology and brain imaging technology, and applied to issues in health, psychology and society. 4 hours lecture/ discussion. Open to all majors. May be approved for core course credit only for students who have not taken BIO 424. Prerequisites: one course from each of the following Sub-areas: A1, A2, A3 and B1, B2, B4 (BIO 110, or BIO 115/115L, or BIO 121/121L). GE Synthesis course for Sub-area B5. Eskandari, Kageyama.

#### **BIO 310 Cell and Molecular Biology (4) Every quarter**

Cellular processes and molecular interactions, including transport, chemical signaling, cell-cell adhesion, intercellular communication, support and movement, energy conversions, digestion, assembly of macro-molecules and organelles, gene control in prokaryotes and eukaryotes. 4 lectures/problem-solving. Prerequisite: BIO 303, CHM 201/250L (or the series of CHM 314/317L, CHM 315/318L, and CHM 316/319L). Alas, Buckley, Floriano, LaMunyon, Liu, Sperry, Zhao.

#### **+BIO 311 Sexually Transmitted Diseases: Current Issues (4) Twice a year**

An overview of the biology of sexually transmitted diseases (STD), including AIDS and the impact these diseases and current therapies have on society at large. Topics include distribution, transmission, sexual practices, current scientific research, effects on immune system, treatments, testing and counseling. Selected topics will be presented by guest speakers. Not for core or support credit for students with majors in the Biological Sciences Department. Two 2-hour lectures/discussions. Open to all majors. Prerequisite: one GE course from each of the

following Sub-areas: A1, A2, A3 and B1, B2, B4 (BIO 110, or BIO 115/115L, or BIO 121/121L). GE Synthesis course for Sub-area B5. Staff.

#### **BIO 320/320L Developmental Biology (4/1) Once a year**

Cellular processes and molecular and genetic mechanisms in the embryonic development of multicellular organisms, cellular differentiation, histogenesis and organogenesis. 4 hours lecture/problem-solving; 1 three-hour laboratory. Prerequisites: BIO 115/115L (or the series of BIO 121/121L, 122/122L, BIO 123/123L), BIO 303, BIO 310, and CHM 123/123L. LaMunyon.

#### **BIO 325/325L Principles of Ecology (3/1) Fall, Spring**

Survey of ecological theory and practice, including interactions between organisms and their environment. 3 lectures, 1 three-hour laboratory. 2 one-day weekend field trips. Prerequisites: BIO 115/115L (or the series of BIO 121/121L, 122/122L and 123/123L) and BIO 211/211L. Carlton.

#### **BIO 328 Biology of Human Aging (4) Once a year**

Recent results of biomedical, physical, and chemical research integrated to explain the aging process. Topics include human aging diseases, animal experimental models, and cell, molecular, and genetic mechanisms of aging that lead to practical advice on how to mitigate human aging. May be used for approved elective, but not for upper division core credit. Prerequisites: One GE course from each of the following Sub-areas: A1, A2, A3 and B1, B2, B4 (BIO 110 or BIO 115, or equivalent). GE Synthesis course for Area B5. Troncale.

#### **BIO 330/330L Marine Biology (3/1) Fall, Winter**

Characteristics of the marine environment and its life, with an emphasis on the ecology of marine ecosystems and the impact of humans. A discussion of the living marine resources and the significance of their use. Three 1-hour lectures discussions; 1 three-hour laboratory (five week-end field trips required). Open to all majors. Prerequisites: One GE course from each of the following Sub-areas: A1, A2, A3 and B1, B2, B4 (BIO 110, or BIO 115/115L, or BIO 121/121L). GE Synthesis course for Sub-area B5. Valdes.

#### **BIO 340 Biodiversity Conservation (4) Winter**

Understanding global patterns of biological diversity, the impact of humans on natural systems and diversity, and use of scientific principles to protect and restore diversity. Open to all majors. Prerequisites: One GE course from each of the following Sub-areas: A1, A2, A3 and B1, B2, B4 (BIO 110, or BIO 115/115L, or BIO 121/121L). GE Synthesis course for Sub-area B5. Staff.

#### **BIO 400 Special Study for Upper Division Students (1-2) Every quarter**

Individual or group investigation of selected problems or supervised attendance for juniors and seniors at department seminars. Discussions and reports required. Enrollment requires: (1) Prior arrangement with a faculty member. (2) Completion of a supervisory form available from the Biological Sciences Department office. Only 2 units of BIO 200 and/or BIO 400 are allowed as approved electives for Biology majors. Total credit for a degree other biological sciences is limited to 6 units of BIO 200 and/or BIO 400, with a maximum of 2 units per quarter. Staff.

#### **BIO 403/403L Human Genetics (3/1)**

Study of single and multi-gene human diseases, chromosome aberrations, sex determination, immunogenetics, genetic counseling and genomics. Problem-solving, and mastering the concepts of medical and biochemical genetics. 3 lectures/problem-solving. 1 three-hour laboratory. Corequisite enrollment not required. Prerequisites: BIO 303 and BIO 310. Alas.

**BIO 405 Regulatory Affairs and Safety Assessment (4)**

An examination of governmental laws and regulations governing the safety of biological products, such as foods, drugs, medical devices and biologics, and basic approaches to assessing the safety of biological products. Use of toxicological methods to determine safety of biological products and concepts in risk determination and assessment. Development and evaluation of a series of in class assignments with class discussion and a capstone project performed with small student groups culminating as in-class presentations. 4 lecture units. Prerequisites: General Introductory Biology Course, BIO 121, BIO 122, BIO 123 or equivalent. Dixon.

**BIO 406 Biological Systematics (3)**

Interpretation of biological variability; kinds and origins of organismic variation, the species and speciation, phylogenetic inference, classification and nomenclature. 3 lectures/problem-solving. Prerequisite: BOT 124/124L; ZOO 137/137L (or ZOO 237/237L), or ZOO 138/138L (or ZOO 238/238L), or BOT 201/201L, or ZOO 201/201L. Staff.

**BIO 407/407L Biology of Ants (3/2) Once a year**

Study of general ant biology, including internal and external morphology, identification, chemical communication and behavior, plants and other symbiotic relationships; ecology and the evolution of social behavior and its significance in ants. 3 lectures/problem-solving, 2 three-hour laboratory/field problems. Prerequisite: ZOO 426/426L, or BIO 325/325L, or PLT 300, or PLT 402/402L. George.

**BIO 410 Biophysics (4) Every other year**

Concepts and mechanisms involved in the interpretation of biological systems. A description of living processes in physical terms. 4 lectures/problem-solving. (This course is also listed as PHY 410.) Prerequisite: PHY 123. Staff.

**BIO 413 Principles of Evolution (4) Fall, Winter**

History of evolutionary thought, origin of life, geological and paleontological history of the earth and findings derived from, but not limited to, such disciplines as genetics, ecology, systematics and zoogeography. Focus on mechanisms of evolutionary change at micro- and macroevolutionary levels. 4 lectures/problem-solving/discussion. Prerequisite: BIO 115/115L (or the series of BIO 121/121L, 122/122L and 123/123L); and BIO 303. Valdes.

**BIO 415L Field Studies in the Southwest (4) Once a year**

Ecology and natural history of Southwest habitats; field research projects involving species diversity and community organization. one-week trip to Chiricahua Mountains, Arizona. Students will be responsible for field-trip expenses. Consent of instructor required. Lectures/problem solving, laboratory. Prerequisites: BIO 325/325L and consent of instructor. Moriarty.

**BIO 416L Field Studies in Baja California (4) Once a year**

One-week field trip covering the ecology and natural history of Baja California. Field research projects in and near Bahia de Los Angeles. Students will be responsible for field-trip expenses. Consent of instructor required. Lectures/problem solving, laboratory. Prerequisites: BIO 325/325L and consent of instructor. George.

**BIO 418 Population Ecology (3) Every other year**

Introduction to models describing demographics and species interactions. Factors affecting the abundance and distribution of animal populations in their natural environment. 3 lectures/problem-solving. Prerequisite: BIO 325/325L. Moriarty.

**+BIO 420 Water Pollution Biology (3) Once a year**

Major pollutants and their effects on aquatic organisms, human health, and use of water resources. 3 lectures/problem-solving. Prerequisite: BIO 110, or BIO 115/115L, or the series of BIO 121/121L, 122/122L and 123/123L. Arnold.

**BIO 421 Advanced Genetics (4) Once a year**

Recent advances in genetics with emphasis on molecular methods of gene mapping, quantitative genetics and population and evolutionary genetics. 4 lectures/problem-solving. Prerequisite: BIO 303. LaMunyon.

**BIO 424 Neuroscience (4)**

Structural and functional organization of the nervous system, its evolution, development, and plasticity. Basic anatomy and physiology of neurons, sensory processing, learning and memory, neuroanatomical pathways, brain imaging, and neuropathology. 4 lectures/problem-solving, demonstrations. Prerequisites: BIO 115/115L (or the series of BIO 121/121L, 122/122L and 123/123L); and CHM 201/250L or CHM 314/317L. Kageyama.

**BIO 425/425L Chaparral Biology (3/1) Every other year**

Structure, function, and management of the California chaparral. 3 lectures/problem-solving, 1 three-hour laboratory. Some one-day field trips. Prerequisite: BIO 325/325L. Staff.

**BIO 426/426L Neuroanatomy (4/1) Once a year**

Structural and functional organization of the human brain, spinal cord and peripheral nervous system. Designed for students destined for professions in the health field. 4 lectures/problem-solving, 1 three-hour laboratory. Prerequisite: BIO 115/115L or the series of BIO 121/121L, 122/122L and 123/123L. Kageyama.

**BIO 428/428L Cellular Physiology (3/2) Once a year**

Physiological mechanisms at the cellular level. 3 lectures/problem-solving, 2 three-hour laboratories. Prerequisite: BIO 115/115L (or the series of BIO 121/121L, 122/122L and 123/123L); and CHM 201/250L or CHM 314/317L. Kageyama, Talmadge.

**BIO 431/431L Radiation Biology (3/1) Once a year**

Introduction to radioisotope tracer techniques, radiometric analysis, effects of ionizing radiation, radiation safety and health physics as applied to life sciences and public health. 3 lectures/problem-solving, 1 three-hour laboratory. Prerequisite: 12 units of courses in the Biological Sciences, 8 units of Chemistry, 8 units of Physics. Eskandari, Siegel.

**BIO 441 Internship in Biology (1-2) Every quarter**

On-the-job training in student's area of interest. The internship is arranged by the student and is not a continuation of an ongoing job or volunteer experience. Requirements include a minimum of 4-5 hours service per week per unit credit and an oral presentation or written report describing the internship experience upon completion. Grade will be based on a written evaluation from the job supervisor and an evaluation of the student presentation or report by the internship coordinator. Total credit limited to 6 units. Prerequisite: junior standing and approval by the internship coordinator and job supervisor. Application forms available from the Biological Sciences Dept. Staff.

**BIO 442/442L Marine Ecology (3/2) Once a year**

Structure and function of marine ecosystems with emphasis on littoral environments. 3 lectures/problem-solving, 2 three-hour laboratories,

required field trips. Prerequisite: BIO 325/325L. Valdes.

### **BIO 445/445L Population Genetics (3/1)**

Theory and experimental results in population genetics; the interrelation of population genetics and ecological and evolutionary studies. 3 lectures/problem-solving, 1 three-hour laboratory. Possible required field trips. Prerequisites: BIO 211/211L and BIO 303. Staff.

### **BIO 450 Concepts of Molecular Biology (4) Once a year**

The molecular basis and control mechanisms of biological processes such as information-processing, energy-processing, assembly of macromolecules into functional units, and evolution of macromolecules. 4 lectures/problem-solving. Prerequisite: BIO 310, CHM 321/321L (or the series of CHM 327/327L, CHM 328/328L, and CHM 329/329L). Buckley, Liu, Sperry, Troncale.

### **BIO 451/451L Molecular Biology Techniques (3/2) Once a year**

Principles and practice of major techniques used in isolation and characterization of biologically important macromolecules, with primary emphasis on centrifugation, chromatography, and electrophoresis. 3 lectures/problem-solving, 2 three-hour laboratories. Prerequisite: BIO 310, CHM 321/321L (or the series of CHM 327/327L, CHM 328/328L, and CHM 329/329L). Buckley, Liu, Troncale.

### **BIO 455/455L Molecular Biology of Recombinant DNA (2/2) Once a year**

Molecular biology of nucleic acids including isolation, purification and analysis of virus, plasmid, prokaryotic and eukaryotic DNA; restriction endonuclease analysis, Southern blotting and molecular hybridization with radioactive probe; concepts on strategies of gene cloning and usefulness of cloned genes. 2 lectures/problem-solving, 2 three-hour laboratories. Prerequisites: BIO 303, MIC 201/201L, and CHM 321/321L or CHM 327/327L. Pal.

### **BIO 459/459L Bioinformatics (3/2) Fall**

A survey, comparison, and evaluation of computational techniques and software applications currently used to store, organize, manipulate, and explore biological information. Students learn how to retrieve, compare, and analyze nucleic acid sequences, amino acid sequences, and protein structures. Some of the topics covered are: overview of biological databases and other online resources; sequence-based analysis of genes and proteins; sequence alignments; phylogenetic reconstruction; protein 3D structure alignment; structural classification of proteins; prediction of protein structure and function. This is a hands-on course focused on developing practical bioinformatics skills. Class meets three times a week for 1-hour lecture followed by 2-hours computer lab. Prerequisite: BIO 303 or CHM 329 or permission of instructor. Floriano

### **BIO 461 Undergraduate Research (2) Every quarter**

Laboratory, field, or computational research conducted under faculty supervision. Recommended for students in any of the biological sciences majors contemplating graduate or professional school training. Enrollment requires: (1) Prior arrangement with a faculty member. (2) Completion of a supervisory form available in the Biological Sciences Department office. Up to 4 units are allowed as upper-division core electives or approved electives for a degree in the Biological Sciences Department. Staff.

### **BIO 462 Senior Thesis (2) Every quarter**

Written thesis in accordance with professional standards based on laboratory, field, or computational research. Recommended for students in any of the biological sciences majors contemplating graduate or professional school training. Enrollment requires: (1) Prior arrangement

with a faculty member. (2) Completion of a supervisory form available in the Biological Sciences Department office. Limited to 2 units as upper-division core electives or approved electives for a degree in the Biological Sciences Department. Staff.

### **BIO 463/463L Computer-assisted Drug Design (3/1)**

This course covers the use of computational tools in the discovery of medical drugs. Students are introduced to general aspects of drug discovery and development, and basic principles of drug action and pharmacology. Scientific literature describing the discovery process of currently marketed drugs is used to illustrate applications of computational methods. Students apply these methods during laboratory exercises. At the conclusion of the course, students will have a good understanding of the principles of drug action, a working knowledge of the main computer-assisted techniques used in the design of pharmacologically active drugs, and a general knowledge of drugs currently used to treat hypertension and diabetes. Prerequisites: BIO 459/459L or CHM 417 is recommended but not required. Floriano.

### **BIO 465 Stem Cell Biology (3)**

The course provides an overview of current stem cell research and its potential applications in regenerative medicine and pharmaceutical drug or environmental chemical toxicity tests. It will cover the following topics: 1) brief introduction to mammalian embryo development; 2) the roles of stem cells in embryo development and its regulation; 3) mouse embryonic stem cells and its applications; 4) human embryonic stem cells and its applications; 5) human adult stem cells and its applications; 6) cancer stem cell research; 7) plant stem cells; and 8) the bioethics and future directions of stem cell research. Prerequisites: BIO 303 and BIO 310 are recommended. Zhao.

### **BIO 485 Tropical Biology (3) Once a year**

A lecture course designed to introduce the physical and biological characteristics of tropical environments, with special emphasis on the ecosystems found in the northern portion of South America. 3 lecture discussions. Consent of instructor required. Prerequisites: BIO 325/325L, advanced senior or graduate standing and consent of instructor. Staff.

### **BIO 488S Interpretation of Science Service Learning (4) Every Quarter**

A community service-learning course covering methods and techniques necessary to develop professional oral and written interpretive skills in the sciences. This capstone course draws on the student's prior coursework and knowledge in the sciences as they design and develop formal interpretive exhibits, tours, and presentations that enhance their audience's understanding of science. The student will utilize these products in interpreting science for community groups at Biological Sciences learning centers at BioTrek. Staff.

### **BIO 490 Scientific Communication (1) Every quarter**

Oral and written presentation of selected topics in biology. Open only to students in senior standing. 1 lecture/problem-solving. Prerequisite: senior standing. Staff.

### **BIO 495/495L Experimental Traditions (2/2)**

The rich history of the experimental sciences and its impact on modern research efforts will be explored through the application of classic and state-of-the-art techniques to the solution to contemporary research questions. Topics that reflect the expertise and research interests of instructor(s) vary quarterly. Total credit limited to 8 units, with a maximum of 4 units per quarter. Two 3-hour sessions per week as either laboratory instruction (2 units) or combined lecture/lab problem solving (4 units). Prerequisites: BIO 123/123L and CHM 123/123L. Other

background: (specified in advance) may be stipulated at the discretion of instructor(s). Staff.

**BIO 499/499A/499L Special Topics for Upper Division Students (1-4)  
Every quarter**

Group study of a selected topic for upper-division students. Course title and number of units are specified in advance. Instruction by lecture, problem-solving activity, laboratory, or a combination of formats. Students receive credit for multiple courses with the BIO 499/499A/499L designation if course titles are different. Total credit limited to 8 units, with a maximum of 4 units per quarter. May be used as upper-division core elective. Staff.

Graduate courses are listed in the graduate section of the catalog.

**BOTANY COURSE DESCRIPTIONS**

NOTE: For all courses which have both a lecture and a laboratory component (e.g. BOT 124/124L), both components are corequisites; that is, they must be taken concurrently.

When appropriate, the names of faculty associated with each course are specified; otherwise "Staff" is noted.

**BOT 124/124L General Botany (3/2) Fall**

Introduction to the relationship between the structures of plants and their functions. Topics also include plant classification, genetics, growth and development, evolution and ecology. Emphasis on flowering plants. 3 lectures, 2 three-hour laboratories. Prerequisite: BIO 115/115L. Carlton.

**BOT 201/201L Form and Function in Plants (3/2) Fall, Spring**

The interplay of the physiology of seed plants with their anatomy and morphology. The anatomical and physiological bases of development, growth regulation, water relations, reproduction, food production and transport. 3 lectures/problem-solving, 2 three-hour laboratories. Prerequisite: BOT 124/124L or the series of BIO 121/121L, 122/122L and 123/123L. Bobich.

**BOT 299/299A/299L Special Topics for Lower Division Students (1-4)  
Every quarter**

Group study of a selected topic for lower-division students. Course title and number of units are specified in advance. Instruction by lecture, problem-solving activity, laboratory, or a combination of formats. Students receive credit for multiple courses with the BOT299/299A/299L designation if course titles are different. Total credit limited to 8 units, with a maximum of 4 units per quarter. Staff.

**BOT 307/307A Plants and People (3/1)**

Natural history and importance of plants in human affairs: plants and people as interactive partners in life; impacts on history, civilization, science, nutrition, medicine, qualities of life, and survival; unique plant chemicals, economic products, phytogeography, ethnobotany, biotechnology, current issues. Elective open to all majors. 3 lecture-discussions plus field activities off campus, which are scheduled for entire class or individuals. May be used for approved elective, but not upper division core credit. Prerequisites: One GE course from each of the following Sub-areas: A1, A2, A3 and B1, B2, B4 (BIO 110, or BIO 115, or BIO 121/121L). GE Synthesis course for Sub-area B5. Staff.

**BOT 323/323L General Plant Pathology (2/2) Fall**

Principles of the nature, development, epidemiology, diagnosis, and control of plant diseases caused by bacteria, fungi, nematodes, viruses, and environmental factors. 2 lectures/problem-solving, 2 three-hour

laboratories. Prerequisite: the series of BIO 121/121L, 122/122L and 123/123L; or BOT 124/124L; or BOT 125/125L; or BOT 201/201L. Staff.

**BOT 343/343L California Flora (1/2)**

Identification of California wildland plants using dichotomous keys. Recognition of common plant families. Overview of the geographic distribution of plants in southern California. 1 lecture, 2 three-hour laboratories, required field trips. Prerequisite: the series of BIO 121/121L, 122/122L and 123/123L; or BOT 124/124L. Bobich.

**BOT 403/403L Plant Genetics (3/1)**

Principles of plant inheritance and reproduction. Discussion of cytogenetics, population genetics, cytoplasmic inheritance, and gene transfer. Introduction to the methods of plant biotechnology. 3 lectures/problem-solving, 1 three-hour laboratory. Prerequisites: BIO 303, BOT 124/124L (or the series of BIO 121/121L, 122/122L and 123/123L). Bozak.

**BOT 421/421L Plant Ecology (3/1) Every other year**

A survey of the interactions between plants and their physical and biotic environment. Examination of populations, communities, and ecosystems. The effects of climate, soil and other organisms on plant growth, development and reproduction. 3 lectures, 1 three-hour laboratory. 1 field trip. Prerequisite: BIO 325/325L. Carlton.

**BOT 425/425L Mycology (2/2) Even years (see BOT 426)**

Morphology, physiology, culture, pathology, taxonomy, ecology and general biology of Acrasiales, Labyrinthales, Myxomycetes, Oomycetes, and Zygomycetes. 2 lectures/problem-solving, 2 three-hour laboratories. Prerequisite: the series of BIO 121/121L, 122/122L and 123/123L; or BOT 124/124L; or BOT 125/125L; or BOT 201/201L. Staff.

**BOT 426/426L Mycology (2/2) Odd years (see BOT 425)**

Morphology, physiology, culture, pathology, taxonomy, ecology, and general biology of Ascomycetes, Deuteromycetes, and Basidiomycetes. 2 lectures/problem-solving, 2 three-hour laboratories. Prerequisite: the series of BIO 121/121L, 122/122L and 123/123L; or BOT 124/124L; or BOT 125/125L; or BOT 201/201L. Staff.

**BOT 428/428L Plant Physiology (3/2) Fall, Winter**

Life processes of plants; water relations; nutrition and metabolism; growth and development. 3 lectures/problem-solving, 2 three-hour laboratories. Prerequisite: the series of BIO 121/121L, 122/122L and 123/123L; or BOT 124/124L. Bozak.

**BOT 434/434L Evolution of Plants (3/2)**

Evolution of plants as illustrated by the comparative morphology, reproductive patterns, and fossil record of green algae, bryophytes, and vascular plants. 3 lectures/problem-solving, 2 three-hour laboratories. Prerequisite: BOT 124/124L, or BOT 201/201L and BIO 413. Bobich.

**BOT 435/435L Plant Anatomy (2/2) Every other year**

Microscopic study of representative common plants dealing with origin, development, and structure of cells, tissues and tissue systems in roots, stems, and leaves. 2 lectures/problem-solving, 2 three-hour laboratories. Prerequisite: BOT 124/124L or BOT 201/201L. Bobich, Ewers.

**BOT 440/440L Diagnosis and Control of Plant Diseases (2/2)  
Every other year**

Principles and practice in the diagnosis of plant diseases and in the prescription of control measures; cultural remedies, disease

management, and integrated controls; field practice; and a review of advances in plant pathology. 2 lectures/problem-solving, 2 three-hour laboratories. Field trips required. Prerequisite: BOT 323/323L. Staff.

**BOT 441/441L Methods in Plant Pathology (2/2) Every other year**

Laboratory and greenhouse methods for isolation, identification, inoculation, and disease assessment for plant pathogenic bacteria, fungi, and viruses which are plant pathogens. Emphasis on screening procedures and other experimental skills. Discussion of emerging problems, application and progress in plant pathology. 2 lectures/problem-solving, 2 three-hour laboratories. Prerequisite: BOT 323/323L. Staff.

**BOT 456/456L Plant Tissue Culture (2/2) Once a year**

Methods and applications, including: selection and sterilization of explants; preparation and sterilization of media; sterile techniques; incubation of cultures; review of literature. 2 lectures/problem-solving, 2 three-hour laboratories. Prerequisite: BOT 428/428L. Bozak.

**BOT 499/499A/499L Special Topics for Upper Division Students (1-4) Every quarter**

Group study of a selected topic for upper-division students. Course title and number of units are specified in advance. Instruction by lecture, problem-solving activity, laboratory, or a combination of formats. Students receive credit for multiple courses with the BOT 499/499A/499L designation if course titles are different. Total credit limited to 8 units, with a maximum of 4 units per quarter. May be used as upper-division core elective. Staff.

**MICROBIOLOGY COURSE DESCRIPTIONS**

NOTE: For all courses which have both a lecture component and a laboratory component (e.g. BIO 115/115L), both components are corequisites; that is, they must be taken concurrently.

When appropriate, the names of faculty associated with each course are specified, otherwise, "Staff" is noted.

**MIC 201/201L Basic Microbiology (3/2) Every quarter**

A study of morphology, function, metabolism, and genetics of microorganisms. The roles of microorganisms in environment and disease processes are discussed. Identification and growth of microorganisms are emphasized in the laboratory exercises. 3 hours lecture, 2 three-hour laboratories. Prerequisite: BIO 110, or BIO 115/115L, or the series of BIO 121/121L, 122/122L and 123/123L; CHM 121/121L or CHM 103/103A. Brelles-Mariño, Dixon, Lin, Stathopoulos.

**MIC 299/299A/299L Special Topics for Lower Division Students (1-4) Every quarter**

Group study of a selected topic for lower-division students. Course title and number of units are specified in advance. Instruction by lecture, problem-solving activity, laboratory, or a combination of formats. Students receive credit for multiple courses with the MIC 299/299A/299L designation if course titles are different. Total credit limited to 8 units, with a maximum of 4 units per quarter. Staff.

**MIC 301 Germs and You (4) Once a year**

The world of the microbes and their interactions with human. Emphasis on both the beneficial and harmful effects of microbes on human and our daily life. 4 lecture/discussion. The course is offered as a Science and Technology Synthesis course in Area B4. Not for core or support credit for students with majors in the Biological Sciences Department. Prerequisite: One GE course from each of the following Sub-areas: A1,

A2, A3 and B3 (BIO 110, or BIO 115/115L, or BIO 121/121L). GE Synthesis course for Sub-area B4. Brelles-Mariño.

**MIC 310/310L Applied Microbiology (3/2) Every other year**

The microbiology of foods, air, water, and sewage, stressing the utilization of microbial activities in manufacturing processes of foods, types and prevention of food spoilage, aims and methods of water treatment and sewage disposal. 3 lectures/problem-solving. 2 three-hour laboratories. Prerequisite: MIC 201/201L; CHM 201 and CHM 250L (or CHM 314, CHM 315, and CHM 317L). Dixon.

**MIC 320/320L Food Microbiology (3/1) Every other year**

The roles of microorganisms in food spoilage, food borne illness, and fermentation. Factors that influence microbial growth and control in foods are discussed. 3 hours lecture, 1 three-hour laboratories. Prerequisites: MIC 201/201L. Dixon, Lin.

**MIC 330 General Epidemiology (4) Once a year**

Fundamental concepts in the study of disease occurrence in human populations. Emphasis on descriptive epidemiology, formulation of hypotheses, and analytic epidemiology, and case studies with problem solving. 4 lectures/problem-solving. Prerequisites: MIC 201/201L, and STA 120 or BIO 211/211L. Chan.

**MIC 410/410L Medical Bacteriology (3/2) Every other quarter**

Characteristics of disease-producing bacteria, their means of transmission, host-parasite interactions, and laboratory methods of diagnosis. 3 lectures/problem-solving, 2 three-hour laboratories. Prerequisite: MIC 201/201L. Stathopoulos.

**MIC 415/415L Immunology-Serology (3/2) Every other quarter**

Principles of serology and immunology with emphasis on mechanisms of evaluating resistance to pathogens, and on mechanism of response to antigens on the molecular and cellular level. 3 hours lecture/problem-solving, 2 three-hour laboratories. Prerequisite: BIO 115/115L or the series of BIO 121/121L, BIO 122/122L, and BIO 123/123L, MIC 201/201L. Adler.

**MIC 425/425L Medical Mycology (3/2) Once a year**

Characteristics, habitats, diseases and laboratory identification of fungi which cause human and animal diseases. 3 hours lecture/problem-solving, 2 three-hour laboratories. Prerequisite: MIC 201/201L. Adler.

**MIC 428/428L Microbial Physiology (3/2) Twice a year**

Life processes of prokaryotic microorganisms. The diverse nutritional requirements and metabolism exhibited by microorganisms, structure and function, nutritional requirements, growth. 3 lectures/problem-solving, 2 three-hour laboratories. Prerequisites: MIC 201/201L; CHM 201 and CHM 250L (or CHM 314, 315, 316, and 317L). Brelles-Marino, Dixon.

**MIC 430/430L General Virology (3/2) Every other quarter**

Chemical composition and physical structure of viruses; their mechanism of reproduction; relationship to humans, animals, and plants. Introduction to diagnostic techniques used in the isolation and identification of viruses. 3 lectures/problem-solving, 2 three-hour laboratories. Prerequisite: MIC 201/201L. Pal.

**MIC 435/435L Microbial Ecology (2/2)**

The course involves the examination of microorganisms in their natural environments including terrestrial and aquatic environments, community

and biofilm development, microbe-microbe interactions, cell-to-cell communication mechanisms, and current and traditional methods of microbial analysis in natural environments. Roles of microbial populations and communities in biogeochemical cycling, ecosystem functioning, industrial, agricultural, and environmental applications will be studied. Laboratory reinforces the principles and provides exposure to methods used in microbial ecology with a special emphasis on molecular approaches. The laboratory course will include a field trip. Prerequisite: MIC 201/201L required, CHM 321 and BIO 450 recommended. Brelles-Marino.

#### **MIC 436/436L Plant-Microbe Interactions (2/2)**

The course is devoted to study some of the ways in which microorganisms interact with plants, from the beneficial viewpoint to the detrimental one. Although plants interact with bacteria, fungi, viruses and nematodes, the emphasis will be on bacteria and mycorrhizal fungi. Processes such as nitrogen fixation, mycorrhization, plant-growth promotion and biological control will be studied. Technological approaches such as the preparation and application of inoculants and the genetic and ecological consequences of releasing modified strains will also be discussed. Laboratory reinforces the principles and provides exposure to methods used in both traditional and molecular approaches. The laboratory course will include field sampling and greenhouse experiments together with bench work. The course is open to students from the College of Agriculture. Prerequisite: MIC 201/201L. Brelles-Marino.

#### **MIC 444/444L Hematology (3/1) Once a year**

The anatomy, physiology, and pathology of the normal hematopoietic system; frequently encountered blood dyscrasias related to human red blood cells. 3 lectures/problem-solving, 1 three-hour laboratory. Prerequisite: MIC 201/201L, MIC 415/415L. Chan.

#### **MIC 445/445L Immunohematology (3/1) Once a year**

General characteristics of human blood group antigens; antigen-antibody reactions related to human red blood cells and human diseases. 3 lectures/problem-solving and 1 three-hour laboratory. Prerequisite: MIC 201/201L, MIC 415/415L. Chan.

#### **MIC 499/499A/499L Special Topics for Upper Division Students (1-4) Every quarter**

Group study of a selected topic for upper-division students. Course title and number of units are specified in advance. Instruction by lecture, problem-solving activity, laboratory, or a combination of formats. Students receive credit for multiple courses with the MIC 499/499A/499L designation if course titles are different. Total credit limited to 8 units, with a maximum of 4 units per quarter. May be used as upper-division core elective. Staff.

#### **ZOOLOGY COURSE DESCRIPTIONS**

For all courses which have both a lecture component and a laboratory component (e.g. ZOO 237/237L), both components are co-requisites, that is, they must be taken concurrently.

When appropriate, the names of faculty associated with each course are specified; otherwise, "Staff" is noted.

#### **ZOO 201/201L Animal Biology (3/2) Twice a year**

Introduction to the biology of animals. Evolution, phylogenetics, food intake, respiration, water balance, reproduction, internal communication and coordination, locomotion and other aspects of the biology of invertebrates and vertebrates. 3 lectures/problem-solving, 2 three-hour

laboratories. Not open to Zoology majors. Prerequisite: BIO 115/115L or the series of BIO 121/121L, 122/122L and 123/123L. Lappin, Leong.

#### **ZOO 234/234L Human Anatomy (3/2) Every quarter**

Lectures devoted to a description of human gross anatomy. Laboratories emphasize systematic anatomy and use preserved human organs and dissected cadavers when available. 3 lectures/problem-solving, 2 three-hour laboratories. Prerequisite: BIO 115/115L or the series of BIO 121/121L, 122/122L and 123/123L. Staff.

#### **ZOO 235/235L Human Physiology (3/1) Every quarter**

Functions of the major organ systems of the human body with emphasis on homeostatic mechanisms. 3 lectures/problem-solving, 1 three-hour laboratory. Prerequisite: BIO 115/115L or the series of BIO 121/121L, 122/122L and 123/123L. Staff.

#### **ZOO 237/237L Introduction to Invertebrate Zoology (3/2) Once a year**

Introduction to the evolution, phylogenetics, anatomy, physiology and ecology of the major phyla of invertebrate animals. 3 lectures/problem-solving, 2 three-hour laboratories. Not open to Biology majors. Prerequisites: BIO 115/115L or the series of BIO 121/121L, BIO 122/122L and BIO 123/123L. Leong

#### **ZOO 238/238L Introduction to Vertebrate Zoology (3/2) Twice a year**

Introduction to the evolution, phylogenetics, anatomy, physiology and natural history of vertebrates. 3 lectures/problem-solving, 2 three-hour laboratories. Not open to Biology majors. Prerequisite: BIO 115/115L or the series of BIO 121/121L, 122/122L and 123/123L. Lappin.

#### **ZOO 299/299A/299L Special Topics for Lower Division Students (1-4) Every quarter**

Group study of a selected topic for lower-division students. Course title and number of units are specified in advance. Instruction by lecture, problem-solving activity, laboratory, or a combination of formats. Students receive credit for multiple courses with the ZOO 299/299A/299L designation if course titles are different. Total credit limited to 8 units, with a maximum of 4 units per quarter. Staff.

#### **ZOO 415/415L Human Embryology (4) Once a year**

Descriptive human developmental anatomy, including general embryogeny through fetal period, the origins of the major organ systems, and sense organs. 3 lectures/problem-solving, 1 three-hour laboratory. Prerequisite: ZOO 238/238L. Staff.

#### **ZOO 419/419L Animal Behavior (2/1) Once a year**

Biological, physiological, genetic and anatomical principles of animal behavior. Ethology and experimental psychology involving wild and laboratory animals. 2 lectures/problem-solving, 1 three-hour laboratory. Prerequisite: ZOO 138/138L, or ZOO 201/201L, or ZOO 238/238L. Staff.

#### **ZOO 422/422L Histology (2/3) Once a year**

Microscopic study of vertebrate tissues; organology and correlation of form with function. 2 lectures/problem-solving, 3 three-hour laboratories, taught in the audio-tutorial mode. Prerequisite: ZOO 138/138L, or ZOO 201/201L, or ZOO 238/238L. Talmadge.

#### **ZOO 425/425L Medical Parasitology (3/2) Twice a year**

Study of protozoan and helminth parasites of humans: diagnosis, life cycles, pathology, epidemiology and control. 3 lectures/problem-solving, 2 three-hour laboratories. Prerequisite: BIO 115/115L or the series of BIO 121/121L, 122/122L and 123/123L. Staff.



**ZOO 426/426L Entomology (3/1) Once a year**

General aspects of insect structure and function, development, behavior and influence on human activity; includes a survey of the principal insect groups. 3 lectures/problem-solving, 1 three-hour laboratory. Prerequisite: BIO 211/211L, or ZOO 201/201L, or ZOO 237/237L. Leong.

**ZOO 428/428L Animal Physiology (3/2) Twice a year**

Principles of animal physiology presented through an organ-system approach. Cellular and molecular mechanisms also discussed to provide current views of physiological principles. Emphasis on mammals, but other vertebrate taxa also covered. Laboratory reinforces physiological principles and provides exposure to basic methodology, equipment, and data analysis. Prerequisites: BIO 211/211L and BIO 310. Co-requisites: ZOO 428/428L. Eskandari.

**ZOO 429/429L Herpetology (3/2) Once a year**

Evolution, morphology, classification, distribution, ecology, behavior and conservation of amphibians and reptiles; identification, and field study of local species. 3 lectures/problem-solving, 2 three-hour laboratories. Prerequisite: ZOO 138/138L, or ZOO 201/201L, or ZOO 238/238L. Lappin.

**ZOO 430/430L Mammalogy (2/2) Once a year**

Morphology, classification, distribution, ecology, behavior and conservation of mammals; identification, and field study of local species. 2 lectures/problem-solving, 2 three-hour laboratories. Prerequisite: ZOO 138/138L, or ZOO 201/201L, or ZOO 238/238L. Staff.

**ZOO 435/435L Ornithology (3/1) Once a year**

The evolution, ecology, anatomy, and physiology of birds with emphasis on species of the Pacific Coast. Two half-day field trips (held on weekends) are required for credit in this course. 3 lectures/problem-solving, 1 three-hour laboratory. Prerequisite: ZOO 138/138L, or ZOO 201/201L, or ZOO 238/238L. Moriarty.

**ZOO 439/439L Evolutionary Ecomorphology (2/2)**

The course focuses on how the form of animals is shaped by their natural environment and evolutionary history. Traditional and current methods in morphometrics, functional morphology, biomechanics, and animal ecology and behavior will be studied. Systems in terrestrial and aquatic environments, including feeding, locomotion, and social interactions, will be examined with respect to abiotic and biotic factors. Laboratory reinforces principles and provides practical exposure to laboratory and field methods used in Evolutionary Ecomorphology, with special emphasis on animal performance testing. Laboratory includes a quarter project. Prerequisites: BIO 123/123L; ZOO 201/201L or ZOO 238/238L. BIO 211/211L; PHY 121/121L are recommended. Junior standing is required. Lappin.

**ZOO 441/441L Ichthyology (2/2) Every other year**

The structure, relationships, classification, general biology and zoogeography of fishes. Collection identification and field study of local species, and laboratory work with preserved and living material. 2 lectures/problem-solving and 2 three-hour laboratories. Prerequisite: ZOO 138/138L, or ZOO 201/201L, or ZOO 238/238L. Staff.

**ZOO 499/499A/499L Special Topics for Upper Division Students (1-4) Every quarter**

Group study of a selected topic for upper-division students. Course title and number of units are specified in advance. Instruction by lecture, problem-solving activity, laboratory, or a combination of formats. Students receive credit for multiple courses with the ZOO 499/499A/499L designation if course titles are different. Total credit limited to 8 units, with a maximum of 4 units per quarter. May be used as upper-division core elective. Staff.

**CHEMISTRY**

[www.csupomona.edu/~chemistry](http://www.csupomona.edu/~chemistry)>

Francis Flores, Chair

Hossein Ahmadzadeh	Philip Lukeman
Lisa A. Alex	Charles Millner
Samir Anz	Patrick William Mobley
Philip Beauchamp	Rakesh Mogul
Fredrick Bet-Pera	Peter Oelschlaeger
Barbara Burke	Michael Page
Joe Casalnuovo	James Rego
Timothy Corcoran	Nelson Scott
George Gutnikov	Shantanu Sharma
Floyd Klavetter	Laurie S. Starkey
Michael Keith	Edward D. Walton
Xiao-Chuan Liu	Xuehe Zheng

The Chemistry Department offers a flexible program of studies designed to prepare students for careers in private industry and government or for highly diverse graduate study. Students may direct their efforts into all the major areas of chemistry and into certain interdisciplinary areas. This is accomplished by choosing one of four rigorous tracks or subplans of study leading to the Bachelor of Science degree in Chemistry.

The Chemistry subplan emphasizes the chemistry-physics interface. The curriculum of this subplan leads to the more traditional careers and graduate training in chemistry.

The Chemical Sciences subplan stresses the growing body of knowledge at the chemistry-life sciences interface. Beyond the core curriculum students may pursue programs in the chemistry of plants, animals or human beings (biochemistry, clinical chemistry, marine biochemistry, pre-medicine, pre-dentistry, etc.). Upon consultation with a departmental advisor, the student may select courses from a list of restricted electives thereby achieving a program meeting that individual's career goals.

The Industrial Chemistry subplan is designed for those students who plan a career in the chemical industries and businesses. Subplan courses have been chosen to provide some background in material sciences as well as industrial chemistry. Restricted elective packages create a flexible program which will meet a variety of career goals.

The Molecular Modeling and Simulation subplan provides chemistry students the opportunity of exploring novel applications of computational chemistry in fields ranging from the life sciences to chemical physics. This subplan prepares students for much sought after careers in pharmaceutical and related industries as well as for academia.

The Chemistry program is approved by the American Chemical Society, and the baccalaureate degree earned by following the Chemistry Subplan is certified by the A.C.S. as having met its standards for professionalism at the undergraduate level. Students following the Chemical Sciences or the Industrial Chemistry Subplan may also earn A.C.S. certification for their degree, provided that a suitable pattern of electives is chosen. Students should consult with departmental advisors to determine which courses are required in their subplan for certification of their degree.

Chemistry majors following either the Chemistry or Chemical Sciences Subplan can earn up to 16 units of credit for approved work experience under the heading of Cooperative Education. This work experience is an integral part of the Industrial Chemistry Subplan. Additional details will

be found listed at the beginning of the "College of Science" section of this catalog.

The department also offers a minor in chemistry to students from other majors. This should be of special interest to non-chemistry majors whose curriculum already involves substantial chemistry requirements, such as chemical engineering, microbiology and pre-professional majors.

The department is equipped with state-of-the-art instruments such as FT-NMR, GCs, LCs, GC-MS, LC-MS, FT-IR, stopped flow spectrophotometer, atomic absorption spectrometer, general electrochemical work stations, etc.

Students interested in becoming members of the American Chemical Society may join the Student Affiliates of the American Chemical Society. Additional information can be obtained from the Chemistry Department.

**ONE YEAR MASTER OF SCIENCE PROGRAM:** The department offers a Master's degree which can be completed in five years of combined undergraduate and graduate study. Should a student decide to pursue this program, a decision should be made in the beginning of the junior year so that a departmental petition may be initiated. The petition will outline the tentative program for the 4th and 5th years and should be planned together with completion of appropriate petitions to the Office of Graduate Studies. Interested students should contact the department's graduate advisor.

Two notable features are associated with the program. (1) Students will be eligible to take selected graduate courses in their senior year and (2) the senior project which is required of all Chemistry majors can be extended into an appropriate research problem which would be the subject of the student's master's thesis.

**CORE COURSES FOR MAJOR**

Required of all students. A 2.0 cumulative GPA is required in core courses, including subplan courses, in order to receive a degree in the major.

General Chemistry	CHM 121/121L	(3/1)
General Chemistry	CHM 122/122L	(3/1)
General Chemistry	CHM 123/123L	(3/1)
Quantitative Analysis	CHM 221/221L	(2/2)
Organic Chemistry	CHM 314	(3)
Organic Chemistry	CHM 315	(3)
Organic Chemistry	CHM 316	(3)
Organic Chemistry Laboratory	CHM 317L	(1)
Organic Chemistry Laboratory	CHM 318L	(1)
Organic Chemistry Laboratory	CHM 319L	(1)
Spectroscopic Methods	CHM 342/342L	(2/2)
Separation Methods	CHM 343/343L	(2/2)
Electroanalytical Methods	CHM 344/344L	(2/2)
Physical Chemistry Laboratory	CHM 352A/352L	(3)
Organic Analysis	CHM 424/424L	(2/2)
or Organic Synthesis	CHM 422/422L	
Senior Research Project	CHM 491	(3)
Senior Research Project	CHM 492	(3)
Undergraduate Seminar	CHM 493	(2)
Advanced Chemistry Electives		(6-8)

Two elective courses, approved 300, 400-level or higher excluding CHM 400, 491, 492, 493, 499. For the Industrial Chemistry Subplan only, choose from the following: CHM 402, 409, 413, 446/446L, 450, 452/452L, 460.

**SUBPLAN COURSES FOR MAJOR**

Required for specific subplans

**CHEMISTRY**

Physical Chemistry	CHM	311	(3)
Physical Chemistry	CHM	312	(3)
Physical Chemistry	CHM	313	(3)
Physical Chemistry Laboratory	CHM	353L	(2)
Inorganic Chemistry	CHM	401	(3)
Inorganic Chemistry	CHM	402	(3)
Elements of Biochemistry	CHM	321/321L	(3/1)
or Biochemistry	CHM	327/327L	(3/1)
and Biochemistry	CHM	328/328L	(3/1)

**CHEMICAL SCIENCES**

Elements of Physical Chemistry	CHM	304/304A	(3/1)
Elements of Physical Chemistry	CHM	305	(3)
Biochemistry	CHM	327/327L	(3/1)
Biochemistry	CHM	328/328L	(3/1)
Biochemistry	CHM	329/329L	(3/1)

**INDUSTRIAL CHEMISTRY**

Elements of Physical Chemistry	CHM	304/304A	(3/1)
and Elements of Physical Chemistry	CHM	305	(3)
or Physical Chemistry	CHM	311	(3)
and Physical Chemistry	CHM	312	(3)
and Physical Chemistry	CHM	313	(3)
Chemistry in Industry	CHM	340	(4)
Elements of Biochemistry	CHM	321/321L	(3/1)
or Biochemistry	CHM	327/327L	(3/1)
or Inorganic Chemistry	CHM	401	(3)

**MOLECULAR MODELING AND SIMULATION**

Physical Chemistry	CHM	311	(3)
Physical Chemistry	CHM	312	(3)
Physical Chemistry	CHM	313	(3)
Introduction to Molecular Modeling	CHM	260	(4)
Methods of Data Acquisition	CHM	418	(4)
Select at least two courses from the following:			(8)
CHM 360, 416, 417, and 420			

**SUPPORT AND ELECTIVE COURSES**

The following major support courses should be used to satisfy the indicated GE requirements. If these courses are not used to satisfy GE, the total units to degree may be more than 180 units.

Freshman English I (A2)	ENG	104	(4)
Calculus and Analytic Geometry (B4)	MAT	114	(4)
General Physics (B1, B3)	PHY	131/131L	(3/1)
Basic Biology (B2, B3)	BIO	115/115L	(3/2)
NOTE: A reading knowledge of a foreign language (C3), especially German, is strongly recommended for students planning advanced study in science.			
Introduction to C++	CS	128	(4)
Calculus and Analytic Geometry	MAT	115	(4)
Calculus and Analytic Geometry	MAT	116	(4)
General Physics	PHY	132/132L	(3/1)
General Physics	PHY	133/133L	(3/1)

**CHEMISTRY SUBPLAN**

Differential Equations	MAT	216	(4)
Electives, unrestricted		(0-5)	

**CHEMICAL SCIENCES SUBPLAN**

Electives, restricted (Consult Chemistry Department)		(9-11)	
Electives, unrestricted		(0-2)	

**INDUSTRIAL CHEMISTRY SUBPLAN**

Principles of Economics (D2)	EC	201	(4)
General Psychology (E)	PSY	201	(4)
Statistical Methods in Engineering and Physical Science	STA	309	(3)
**Cooperative Education	SCI	470	(4)
or Cooperative Education	SCI	471	(2)
and Cooperative Education	SCI	472	(2)
Electives, restricted (Consult Chemistry Department)		(6)	
Electives, unrestricted		(0-3)	

\*\*If a suitable Cooperative Education position is not available, an additional advanced chemistry elective should be taken.

**MOLECULAR MODELING AND SIMULATION**

Select a minimum of 4 units from the following courses:

Biophysics	PHY/BIO	410	(4)
Sampling Theory and Applications	STA	310	(4)
Introduction to Numerical Methods	MAT	201	(4)
Laplace Transforms and Fourier Series	MAT	317	(3)
Computer Programming with Chemical and Materials Engineering Applications	CHE	132/142L	(2/1)
Chemical and Materials Engineering Data Treatment	CHE	133	(2)
Materials Science Engineering	MTE	207	(3)

Unrestricted Electives . . . . . (0-1)

**GENERAL EDUCATION REQUIREMENTS**

Students should consult the catalog website [www.csupomona.edu/~academic/catalog/](http://www.csupomona.edu/~academic/catalog/) for current information regarding this requirement. Unless specific courses are stated under Support Courses, see the list of approved courses under General Education Requirements, Areas A through E.

**Area A. Communication and Critical Thinking (12 units)**

1. Oral Communication
2. Written Communication
3. Critical Thinking

**Area B. Mathematics and Natural Sciences (16 units)**

1. Physical Science
2. Biological Science
3. Laboratory Activity
4. Mathematics/Quantitative Reasoning
5. Science and Technology Synthesis

**Area C. Humanities (16 units)**

1. Visual and Performing Arts
2. Philosophy and Civilization
3. Literature and Foreign Languages
4. Humanities Synthesis

**Area D. Social Sciences (20 units)**

1. U.S. History, Constitution, and American Ideals
2. History, Economics, and Political Science
3. Sociology, Anthropology, Ethnic and Gender Studies
4. Social Science Synthesis

**Area E. Lifelong Understanding and Self-development (4 units)****CHEMISTRY MINOR**

Minimum units 29

Minimum upper-division units 12

General Chemistry	CHM 121/121L	(3/1)
General Chemistry	CHM 122/122L	(3/1)
General Chemistry	CHM 123/123L	(3/1)
Organic Chemistry Elements	CHM 201/250L	(3/1)
or Organic Chemistry	CHM 314/317L	(3/1)
Quantitative Analysis	CHM 221/221L	(2/2)
Physical Chemistry Fundamentals	CHM 301/301A	(3/1)
or Elements of Physical Chemistry	CHM 304/304A	(3/1)
or Physical Chemistry	CHM 311	(3)
Chemistry Electives		(5)
Two courses 300-level or higher excluding CHM 400, 491, 492, 493, 499.		

**SUBJECT MATTER PREPARATION – Program for Prospective Teachers of Science with a Concentration in Chemistry**

The Department of Chemistry offers a program in science with a concentration in chemistry approved by the Commission on Teacher Credentialing. Those individuals who wish to become science teachers with an emphasis in chemistry in California public schools must complete the comprehensive list of courses as follows. The set of courses are separated into two parts: breadth course and depth courses in area of concentration.

**Breadth courses:****Biological Sciences**

Basic Biology	BIO 115/115L	(3/2)
Plant Structures and Functions	BOT 124/124L	(3/2)
Vertebrate Zoology	ZOO 238/238L	(3/2)

**Chemistry**

General Chemistry	CHM 121/121L	(3/1)
General Chemistry	CHM 122/122L	(3/1)
General Chemistry	CHM 123/123L	(3/1)

**Geosciences**

Principles of Geology	GSC 111/141L	(3/1)
Earth, Time and Life	GSC 112/151L	(3/1)
Descriptive Physical Oceanography	GSC 335	(4)

**Physics**

College Physics	PHY 131/131L	(3/1)
College Physics	PHY 132/132L	(3/1)
College Physics	PHY 133/133L	(3/1)

**Interdisciplinary Science**

Senior Level Integrated Science	SCI 495	(8)
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**Depth Courses:****Chemistry**

Quantitative Analysis	CHM 221/221L	(2/2)
Physical Chemistry	CHM 304/304A	(3/1)
Physical Chemistry Laboratory	CHM 352A/L	(1/2)
Organic Chemistry	CHM 314/317L	(3/1)
Organic Chemistry	CHM 315/318L	(3/1)
Organic Chemistry	CHM 316/319L	(3/1)
Elements of Biochemistry	CHM 321/321L	(3/1)
Senior Research Project	CHM 491	(3)
Senior Research Project	CHM 492	(3)

Select 2 from the following 3 integrated courses:

Spectroscopic Methods	CHM 342/342L	(2/2)
Separation Methods	CHM 343/343L	(2/2)
Electroanalytical Methods	CHM 344/344L	(2/2)

**COURSE DESCRIPTIONS**

The notations F, W, Sp, Su, and even or odd indicate which quarter(s) of even or odd numbered calendar years the course is normally offered. Courses not designated "even" or "odd" are offered each year. Some courses may be taken with the consent of the instructor.

**CHM 101/101L Consumer Chemistry (3/1)**

Introduction to atoms, molecules and bondings. Petrochemicals, plastics and fibers. Air and water pollution. Body chemistry, foods, drugs and poisons. Chemical and nuclear energy. Not open to students who have credit for CHM 103 or 121. 3 lectures, 1 laboratory. Concurrent enrollment required.

**CHM 103/103A Fundamentals of Chemistry (3/1) FWSp**

Atoms, molecules and physical states of matter. Important classes of chemical compounds and chemical reactions. Experimentation as the approach to solving problems of natural phenomena. Not open to students who have credit for CHM 121. 3 lectures, 1 recitation. Concurrent enrollment required.

**CHM 121, 122, 123 General Chemistry (3) (3) (3) FWSpSu**

Atomic theory of structure and bonding, chemical equations, gas laws, oxidation-reduction, electrochemistry, states of matter, equilibrium, acids and bases, thermodynamics and reaction kinetics and their applications to chemistry, physics, and engineering sciences. 3 lectures/problem-solving. To be taken in sequence. Corequisite: CHM 121L, 122L, 123L, respectively. Students must have taken high school chemistry or CHM 103/103A prior to registering in CHM 121/121L. Prerequisite to CHM 121: Within the last 3 quarters, a minimum placement score on the appropriate MDPT or a minimum grade of C in MAT 12, or MAT 106, or MAT 125, or MAT 191, or STA 120; or within the last 18 months either 550 or higher on the SAT I or II or 23 or higher on the ACT. Prerequisite to CHM 122: Minimum grade of C- in CHM 121; Prerequisite to CHM 123: Minimum grade of C- in CHM 122.

**CHM 121L, 122L, 123L General Chemistry Laboratory (1) (1) (1) FWSpSu**

Laboratory to accompany General Chemistry lecture series. Experiments in basic quantitative analysis techniques, gas measurements, acid-base, pH, and redox titrations, electrochemistry, kinetics, thermo-dynamics, and ionic equilibria and qualitative analysis procedures. 1 three-hour laboratory. To be taken in sequence. Corequisite: CHM 121, 122, 123, respectively. Prerequisite to CHM 122L: minimum grade of C- in CHM 121L. Prerequisite to CHM 123L: minimum grade of C- in CHM 122L.

**CHM 200 Special Study for Lower Division Students (1-2)**

Individual or group investigation, research, studies or surveys of selected problems. Total credit limited to 4 units, with a maximum of 2 units per quarter.

**CHM 201 Elements of Organic Chemistry (3) FWSpSu**

The fundamental concepts of organic chemistry with emphasis on practical applications. For students who are required to take one quarter of organic chemistry. Not open for credit to chemistry majors. 3 lectures/problem-solving. Prerequisite: CHM 122/122L. Concurrent: CHM 250L.

**CHM 210 Chemistry in Life, Civilization and the World (4) FWSp**

A study of the impact of chemistry on life, civilization, and the world. How applications of chemical knowledge, science and technology affect the human experience. Chemistry as a central science of technology. Benefits and risks of science and technology. 4 lectures/problem-solving. Prerequisites: One course each in GE Areas 2A, B, and C.

**CHM 221/221L Quantitative Analysis (2/2) FWSpSu**

Fundamentals of gravimetric and volumetric analysis. Acid-base concepts and pH calculations. Statistical concepts including data reduction and error analysis. Focus on laboratory work, with class discussion supplying supporting theory. 2 lectures/problem-solving, 2 three-hour laboratories. Students are advised to take 221/221L as soon as possible after completing 123/123L. Concurrent enrollment required. Prerequisite: minimum grade of D in CHM 123/123L.

**CHM 250L Elements of Organic Chemistry Laboratory (1) FWSpSu**

Introduction to general techniques of the organic laboratory for the separation, purification and identification of organic substances. Survey of the laboratory preparation and reactions of different functional groups with emphasis on the practical application. 1 three-hour laboratory. Not open for credit to chemistry majors. Prerequisite: CHM 122/122L. Prerequisite or concurrent enrollment: CHM 201.

**CHM 256L Glassblowing (1) Sp**

Fundamental techniques of laboratory glassblowing. A practical course to teach students to construct and repair special pieces of glass apparatus used in advanced chemistry courses and senior project work. 1 three-hour laboratory, scheduled by arrangement.

**CHM 260 Molecular Modeling in Chemistry (4) SpF**

Conformational analysis of organic molecules and visualization of their properties using molecular mechanics. Illustration of structure determinations, energies, and related background principles. Unifying theme is the coupling of computational predictions with experimental results. 4 lectures/problem-solving. Prerequisite: CHM 314.

**CHM 299/299A/299L Special Topics for Lower Division Students (1-4)**

Group study of a selected topic, the title to be specified in advance. Total credit limited to 8 units, with a maximum of 4 units per quarter. Instruction is by lecture, laboratory or a combination.

**CHM 301/301A Fundamentals of Physical Chemistry (3/1) FSp**

Thermodynamic properties of chemical species and their application; kinetics, measurements of physical properties of molecules. Not open to students whose majors require CHM 304 or CHM 311. 3 lectures/problem-solving, 1 recitation. Prerequisite: CHM 123.

**CHM 304/304A, 305 Elements of Physical Chemistry (3/1) (3) FW**

A two-quarter sequence of physical chemistry covering properties of gases, chemical thermodynamics, solutions, electrochemistry, reaction kinetics, and atomic and molecular structure. To be taken in sequence. 3 lectures/problem-solving, 1 recitation for 304, 3 lectures/problem-solving for 305. Prerequisite: MAT 116, CHM 123, PHY 133, or their equivalents. Concurrent with CHM 305: CHM 352A/352L.

**CHM 306 History and Philosophy of Chemistry (4) W**

The history of chemistry from antiquity to the present, milestones in the development of chemistry and their impact on science and technology. How the chemistry way of knowing (using the scientific method) differs from that used in other disciplines. The philosophical atmosphere in

which a particular chemist lived and its limiting or directing influence on the making of that chemist. 4 lectures per week.

**CHM 311, 312, 313 Physical Chemistry (3) (3) FSu, WSu, SpF**

Properties of gases, kinetic molecular theory, chemical thermodynamics, phase equilibria, solutions, electrochemistry, chemical kinetics, atomic and molecular spectroscopy, photochemistry, colloids and macromolecules. To be taken in sequence. Required for certification by the American Chemical Society. 3 lectures/problem-solving. Prerequisites to CHM 311: MAT 216 or equivalent, CHM 123 and PHY 133/133L; Prerequisites to CHM 312: CHM 123, MAT 216, PHY 133/133L; Prerequisites to CHM 313: CHM 311 and CHM 312.

**CHM 314, 315, 316 Organic Chemistry (3)(3)(3) FWSpSu**

Modern concepts of chemical bonding, molecular structure, principles of stereochemistry and conformation, reaction mechanisms and synthetic pathways. All common classes and substituents of organic compounds treated. Carbohydrates, heterocyclics and other biologically significant compounds may be introduced. To be taken in sequence. 3 lectures/problem-solving. Prerequisite to CHM 314: CHM 123. Prerequisite to CHM 315: minimum grade of C- in CHM 314. Prerequisite to CHM 316: minimum grade of C- in CHM 315.

**CHM 317L Organic Chemistry Laboratory (1) FWSpSu**

Introduction to general techniques of the organic laboratory for the separation, purification and identification of organic substances. Interpretation of IR spectra of organic compounds. 1 three-hour laboratory. Prerequisite: CHM 123; CHM 314 (or concurrent enrollment).

**CHM 318L Organic Chemistry Laboratory (1) FWSpSu**

Application of reaction mechanisms toward the synthesis of organic molecules. Interpretation of IR and NMR spectra of organic molecules. 1 three-hour laboratory. Prerequisite: CHM 317L; CHM 315 (or concurrent enrollment).

**CHM 319L Organic Chemistry Laboratory (1) FWSpSu**

Multistep syntheses. Extensive interpretation of IR and NMR spectra of organic compounds. 1 three-hour laboratory. Prerequisite: CHM 318L; CHM 316 (or concurrent enrollment).

**CHM 321/321L Elements of Biochemistry (3/1) FWSpSu**

The fundamental concepts of biochemistry with emphasis on structure-function relationships as they relate to carbohydrates, lipids, proteins, and nucleic acids. Designed for students who are required to take one quarter of biochemistry. 3 lectures/problem-solving, 1 three-hour laboratory. Concurrent enrollment required. Prerequisite: CHM 201 and 250L, or CHM 315 and 317L.

**CHM 327 Biochemistry (3) FW**

Chemistry of carbohydrates, lipids, proteins and enzymes. Enzyme reactions and kinetics; glycolysis and the citric acid cycle metabolism. Prerequisite: CHM 316 and 317L. Corequisite: CHM 327L.

**CHM 327L Biochemistry Laboratory (1) FW**

Laboratory work includes the study of pH and buffers, carbohydrates, lipids, proteins and enzyme kinetics. Qualitative and quantitative methods employing instrumental analysis are included. Corequisite: CHM 327.

**CHM 328 Biochemistry (3) WSp**

Chemistry of vitamins, trace metals and important agents in metabolic

control; glyoxalate cycle, pentose phosphate pathway, electron transport, cellular control, photosynthesis and nucleic acid structures. Nutritional chemistry, as it relates to vitamin function, is also covered. Prerequisite: CHM 327, 327L. Corequisite: CHM 328L.

### **CHM 328L Biochemistry Laboratory (1) WSp**

Standard curve for protein analysis as well as spectrophotometric quantitation, isolation and partial purification of biomolecules using centrifugation, liquid column chromatography, salts, heat treatment and electrophoresis. Laboratory work includes study of tissue extracts and other instrumental methods in biochemistry. Corequisite: CHM 328.

### **CHM 329 Biochemistry (3) SpSu**

Metabolism of lipids and nucleic acids, biochemistry of DNA replication, RNA transcription, protein translation and membrane dynamics. Prerequisite: CHM 328, 328L. Corequisite: CHM 329L.

### **CHM 329L Biochemistry Laboratory (1) SpSu**

Purification and analysis of membranes, analysis of protein ligand interactions, extraction and denaturation of DNA. Laboratory work includes denaturing electrophoresis, spectrophotometry and other instrumental methods in biochemistry. Corequisite: CHM 329.

### **CHM 331/331L Clinical Chemistry (2/2) WSp**

Introduction to the principles and procedures used in the clinical laboratory for the analysis of blood and urine specimens. 2 lectures/problem-solving, 2 three-hour laboratories. Prerequisites: CHM 327/327L or 321/321L, and minimum grade of D in 221/221L. Concurrent enrollment required.

### **CHM 340 The Chemist in Industry (4) Sp**

Survey of roles and expectations for chemists in industry and applications of chemical reactions and principles in the petroleum, biotechnology, pharmaceuticals, food, inorganics, polymers, aerospace, coatings and metal industries. Interfaces with economics, patents, chemical engineering and communication. Guest speakers and plant visits. 4 lectures/problem-solving. Prerequisites: CHM 123/123L and 201 or 314.

### **CHM 342/342L Spectroscopic Methods (2/2) (F)**

Theory and practice of modern analytical techniques based primarily on optical spectroscopy such as UV, IR, AAS, AFS, AES and fluorescence. 2 lectures/problem-solving, 2 three-hour laboratories. Concurrent enrollment required. Prerequisite: minimum grade of D in CHM 221/221L.

### **CHM 343/343L Separation Methods (2/2) (W)**

Theory and practice of modern analytical separation methods primarily encompassing various chromatographic techniques. 2 lectures/problem-solving, 2 three-hour laboratories. Concurrent enrollment required. Prerequisite: minimum grade of D in CHM 221/221L.

### **CHM 344/344L Electroanalytical Methods (2/2) (Sp)**

Theory and practice of modern analytical electrochemistry, with particular emphasis on potentiometry, voltammetry, amperometry, coulometry, chronopotentiometry and cyclic and pulse methods. 2 lectures/problem-solving, 2 three-hour laboratories. Prerequisite: minimum grade of D in CHM 221/221L.

### **CHM 347/347L Theory of Chemical Instrumentation (1/1) Sp**

Theory of chemical instrument systems with emphasis on the selection of instrumentation appropriate to a measurement or control problem. 1

lecture/problem, 1 three-hour laboratory. Prerequisite: CHM 344/344L.

### **CHM 352/352L Physical Chemistry/Laboratory (1/2) W**

Laboratory experiments illustrating principles of physical chemistry. 1 recitation and 2 three-hour laboratories. Prerequisite: CHM 221/221L; CHM 304 or 311. Concurrent: CHM 305 or 312.

### **CHM 353L Physical Chemistry Laboratory (2) Sp**

Advanced laboratory applications of physical chemistry. Required for certification by the American Chemical Society. 2 three-hour laboratories. Prerequisite: CHM 352L. Concurrent: CHM 313.

### **CHM 360 Introduction to Molecular Simulations (4) Sp**

Modeling of electrostatic interactions between atoms and molecules, fundamentals of statistical mechanics. Use of methods such as Monte Carlo and molecular dynamics simulations to demonstrate these concepts. 4 lectures/problem solving. Prerequisites: CHM 123, 260, MAT 116, PHY 133 and CS 128 or their equivalents.

### **CHM 400 Special Study for Upper Division Students (1-2)**

Individual or group investigation, research, studies or surveys of selected problems. Total credit limited to 4 units, with a maximum of 2 units per quarter.

### **CHM 401, 402 Inorganic Chemistry (3) (3) FW**

Modern concepts of inorganic chemistry including chemical bonding, acid/base, coordination chemistry, kinetics, organo-metallics and catalysis. To be taken in sequence. Required for certification by the American Chemical Society. 3 lectures/problem-solving. Prerequisite to CHM 401: CHM 313 or CHM 305; to CHM 402: CHM 401.

### **CHM 409 Polymer Chemistry (3) Sp, odd years**

Types of polymers and polymerization reactions; properties of polymer solutions and the determination of molecular weights; elasticity and other bulk properties. 3 lectures/problem-solving. Prerequisites: CHM 316, CHM 305 or 313, and MAT 216.

### **CHM 411 Reaction Kinetics (3) W**

Kinetics and mechanisms of chemical reactions. Transition state theory, collision theory, photochemical excitation and dissociation, homogeneous and heterogeneous catalysis. Analysis and solution of problems. 3 lectures/problem-solving. Prerequisite: CHM 305 or 313; MAT 216.

### **CHM 413 Introduction to Colloid and Surface Chemistry (3) Sp, even years**

Gas-liquid, gas-solid and solid-liquid interfaces. Adsorption and surface area determination. The electrical double layer and its relation to flocculation and electrokinetic phenomena. 3 lectures/problem-solving. Prerequisite: CHM 305 or 313.

### **CHM 415 Chemical Thermodynamics (3) F**

Fundamental aspects of chemical thermodynamics, including the first, second, and third laws. Studies of chemical and phase equilibria, enthalpy, entropy, work and free energy. Relationship to molecular structure and statistical mechanics. 3 lectures/problem-solving. Prerequisite: CHM 305 or 313; MAT 216.

### **CHM 416 Macromolecular Modeling (4) F, even years**

Theoretical studies and applications of computational techniques to macromolecular (i.e. polymers, proteins, and nucleic acids) structure, stability and function. Brownian dynamics, Poisson-Boltzmann electro-

statics, potential of mean force, and homology modeling. Molecular graphics to aid in application of methods and interpretation of results. 4 lectures/problem-solving. Prerequisites: CHM 260, and either CHM 327 or 321.

#### **CHM 417 Computational Biochemistry (4) W, even years**

Theoretical underpinnings of computational methods in modern biochemistry and practical training in use of them. Sequence entry, and editing, sequence alignment, phylogenetic analysis, homology searching, elementary protein structure prediction, display and evaluation of 3D molecular structures. 4 lectures/problems-solving. Prerequisites: CHM 260, 321, 327 or BIO 450.

#### **CHM 418 Methods of Data Acquisition (4) Sp**

Concepts behind collection of experimental data in chemistry. Methods required for the analysis of data. Methods and experimental considerations required for implementation of electron/photon counting for quantitative analysis. 3 lectures/one recitation. Prerequisites: CHM 352A/352L, MAT 216.

#### **CHM 419 Introduction to Quantum Chemistry (3) F, even years**

Mathematical preliminaries, postulates of quantum chemistry, wave functions for some simple chemical models, the central force problem, the Aufbau principle, hybrid orbitals, approximation methods and Hund's multiplicity rule. 3 lectures/problem-solving. Prerequisite: CHM 305 or 313; MAT 216.

#### **CHM 420 Computational Chemistry (4) Sp, odd years**

Applied quantum mechanical studies of molecular geometries, electronic excited states, potential energy surfaces and conformational structures spanning from small diatomic species to large biochemical molecules. Spectroscopic problems emphasized. Molecular graphics used to aid in both ab initio and molecular mechanics. 4 lectures/problem-solving. Prerequisite: CHM 313, MAT 216.

#### **CHM 421 Solution Equilibria in Analytical Chemistry (2) F**

Study of advanced acid-base theory, complexation, nonaqueous acid-base, solvent extraction and ion-exchange equilibria. 2 lectures. Prerequisite: CHM 313 or 305.

#### **CHM 422/422L Organic Synthesis (2/2) W**

Theoretical and practical study of synthetic strategies in organic chemistry. 2 lectures/problem-solving, 2 three-hour laboratories. Prerequisites: A minimum grade of D in CHM 221/221L, and a minimum grade of C in CHM 316 and D- in CHM 319L. Concurrent enrollment required.

#### **CHM 423/423L Physical Organic Chemistry (2/2) W, odd years**

Theoretical and practical study of experimental techniques used by organic chemists to investigate problems in reaction mechanisms, catalysis, solution chemistry and substituent effects. 2 lectures/problem-solving, 2 three-hour laboratories. Prerequisites: CHM 316, CHM 319L, CHM 313 or 305, and minimum grade of D in CHM 221/221L.

#### **CHM 424/424L Organic Analysis (2/2) Sp**

Structure determination of organic compounds by elemental and functional group analysis using classical methods and modern chromatographic and spectroscopic methods. 2 lectures, 2 three-hour laboratories. Prerequisites: minimum grade of D in CHM 221/221L, and minimum grade of C in CHM 316 and D- in 319L. Concurrent enrollment.

#### **CHM 448/448L Modern FT-NMR (3/1) F**

Fundamentals of one- and two-dimensional NMR and basic understanding of the pulse sequences for a variety of NMR experiments (proton, C-13, SPT, INEPT, DEPT, COSY, HETCOR and NOE). Interpretation of such spectra to determine organic structures. Experience on FT-NMR instrument in weekly sessions to be arranged with instructor. Prerequisites: CHM 316, 319L and CHM 305 or 313.

#### **CHM 450 Bioanalytical Chemistry (4) Sp, odd years**

Application of instrumental analytical techniques to problems in biotechnology and clinical medicine. Uniqueness of problems inherent in analysis of biological samples and the application of state-of-the-art separation and assay techniques. Prerequisites: CHM 221/221L and CHM 327/327L or CHM 221/221L and CHM 321/321L. 4 lectures/problem-solving.

#### **CHM 451/451L Enzymology (3/1) F, even years**

The nature of enzymes including enzyme kinetics, mechanisms of enzyme-catalyzed reactions, enzyme inhibitors, classification of enzymes. 3 lectures/problem-solving, 1 three-hour laboratory. Prerequisite: CHM 329/329L. Concurrent enrollment required.

#### **CHM 452/452L Biochemical Preparations (1/2) W, even years**

Isolation of some eight different materials from plant and animal sources, such as a blood protein fraction, a plant nucleic acid, a plant terpene, a hormone preparation, a metabolic intermediate and a urinary excretion product. 1 lecture/problem, 2 three-hour laboratories. Prerequisite: CHM 329/329L. Concurrent enrollment required.

#### **CHM 453 Recombinant DNA Biochemistry (3) Sp**

Fundamental aspects of the biochemistry of Recombinant DNA and its applications to current biochemical research and industry. Includes germane aspects of the chemistry, structure and biochemistry of RNA and DNA macromolecules. 3 lectures/problem-solving. Prerequisite: CHM 329/329L or taken concurrently.

#### **CHM 454 Nutrient Biochemistry and Metabolism (3) W, odd years**

An advanced course covering the biochemistry of vitamins, minerals, carbohydrates, lipids and proteins. For example: absorption, transport metabolism and storage of these important biochemicals. 3 lectures/problem-solving. Prerequisite: CHM 329/329L.

#### **CHM 460 Air Pollution Problems (3) W**

Concepts of air pollution: major air pollutants; sources; future problems. 3 lectures/problem-solving. Prerequisite: MAT 216.

#### **CHM 491, 492 Senior Research Project (3) (3) FWSpSu**

Senior level research or project. Individual consultation and supervision. Independent literature review, project design, data collection and interpretation of results. Formal report. Prerequisite: minimum GPA of 2.0 in major.

#### **CHM 493 Undergraduate Seminar (2) FWSp**

A study of current developments in chemistry and a discussion of periodical literature at an appropriate level. 2 lecture discussions. Prerequisites: All required 300-level chemistry courses.

#### **CHM 499/499A/499L Special Topics for Upper Division Students (1-4)**

Group study of a selected topic, the title to be specified in advance. Total credit limited to 8 units, with a maximum of 4 units per quarter. Instruction is by lecture, laboratory or a combination.

Graduate courses are listed in the Graduate Studies section of the catalog.

# COMPUTER SCIENCE

www.csupomona.edu/~cs

Craig A. Rich, Chair

Debra A. Brum	Barry Soroka
Robert W. Kerbs	Mandayam Srinivas
Hsun K. Liu	Fang "Daisy" Tang
Amar Raheja	Lan Yang
Salam N. Salloum	Gilbert Young
Daisy F. Sang	

The Computer Science program blends practice and theory in both hardware and software, and it provides an excellent foundation in computer languages, computer architecture, large-scale system software and the design, analysis, and application of many types of algorithms. Success in mathematics is a good indicator for success in the Computer Science program. High school students planning to major in Computer Science should take as much math and science as possible. Entering freshpersons who do not meet the prerequisites for the first year calculus sequence (Mat 114-116) should expect to take between one and three quarters longer to graduate. Transfer students should try to take two years of calculus, a year of physics and programming through data structures (equivalent to CS 140, 141, 240, 241). Transfer students without this background should expect to take an additional year to finish the program.

Computer Science majors on probation or subject to disqualification for three or more quarters may be disqualified at the discretion of the department chair.

The department also offers a graduate program leading to the M.S. degree. Details are given in the "Graduate Studies" section of the catalog.

Computer Science majors are invited to join the Computer Science Society (CSS) club and the local chapters of Association of Computing Machinery (ACM) and IEEE.

The department's Bachelor of Science program in Computer Science is fully accredited by the Computing Accreditation Commission/ Accreditation Board for Engineering and Technology (CAC/ABET).

## CORE COURSES

Discrete Structures	CS	130	(4)
Introduction to Computer Science	CS	140	(4)
Introduction to Programming and Problem-solving	CS	141	(4)
Computer Logic	CS	210	(4)
Data Structures and Algorithms I	CS	240	(4)
Data Structures and Algorithms II	CS	241	(4)
C++ Programming	CS	256	(4)
Computer Organization and Assembly Programming	CS	264	(4)
Language Translation and Automata	CS	311	(4)
Design and Analysis of Algorithms	CS	331	(4)
Computer Architecture	CS	365	(4)
Programming Languages	CS	408	(4)
Operating Systems	CS	431	(4)
Undergraduate Seminar	CS	463	(2)
Software Engineering	CS	480	(4)
Computer Science Electives		27	

At least 24 units from the following:

Programming Graphical User Interfaces	CS	245	(4)
Numerical Methods	CS	301	(4)
Symbolic Programming	CS	352	(4)
Object-Oriented Design and Programming	CS	356	(4)
Parallel Processing	CS	370	(4)
Computer Networks	CS	380	(4)
Compilers and Interpreters	CS	411	(4)
Artificial Intelligence	CS	420	(4)
Database Systems	CS	435	(4)
Computer Graphics	CS	445	(4)
Computability	CS	450	(4)
Secure Communication	CS	460	(4)
Software Engineering Practice	CS	481	(4)
Honors	CS	490	(4)
Special Topics for Upper Division Students	CS	499	(1-4)

No more than 4 units from the following: CS 400, CS 461, CS 462, MAT 216, MAT 370, MAT 380, MAT 381, MAT 402, MAT 470, MAT 480, MAT 485, MAT 486.

Subject to department approval, no more than 4 units from the following: CS 299, SCI 470, SCI 471, SCI 472, SCI 473, EGR 461, EGR 462, EGR 463.

NOTE: A 2.0 cumulative GPA is required in core courses including subplan courses for the major in order to receive a degree in the major.

## SUPPORT COURSES

The following major support courses should be used to satisfy the indicated GE requirements. If these courses are not used to satisfy GE, the total units to degree may be more than 180 units.

Analytic Geometry and Calculus I* (B4)	MAT	114	(4)
and Analytic Geometry and Calculus II* (B4)	MAT	115	(4)
Life Science* (B2)	BIO	110	(3)
Life Science Laboratory* (B3)	BIO	111L	(1)
Computers and Society* (B5)	CS	375	(4)
General Physics* (B1)	PHY	131	(3)
General Physics Laboratory* (B3)	PHY	131L	(1)
General Physics	PHY	132	(3)
General Physics	PHY	133	(3)
General Physics Laboratory	PHY	132L	(1)
General Physics Laboratory	PHY	133L	(1)
Analytic Geometry and Calculus III	MAT	116	(4)
Linear Algebra	MAT	208	(4)
Calculus of Several Variables	MAT	214	(3)
Statistical Methods for Computer Scientists	STA	326	(4)

## GENERAL EDUCATION REQUIREMENTS

Students should consult the catalog website [www.csupomona.edu/~academic/catalog/](http://www.csupomona.edu/~academic/catalog/) for current information regarding this requirement. Unless specific courses are stated under Support Courses, see the list of approved courses under General Education Requirements, Areas A through E.

### Area A, Communication and Critical Thinking (12 units)

1. Oral Communication
2. Written Communication
3. Critical Thinking



**Area B. Mathematics and Natural Sciences (16 units)**

1. Physical Science
2. Biological Science
3. Laboratory Activity
4. Mathematics/Quantitative Reasoning
5. Science and Technology Synthesis

**Area C. Humanities (16 units)**

1. Visual and Performing Arts
2. Philosophy and Civilization
3. Literature and Foreign Languages
4. Humanities Synthesis

**Area D. Social Sciences (20 units)**

1. U.S. History, Constitution, and American Ideals
2. History, Economics, and Political Science
3. Sociology, Anthropology, Ethnic and Gender Studies
4. Social Science Synthesis

**Area E. Lifelong Understanding and Self-development (4 units)**

**MINOR IN COMPUTER SCIENCE**

**Required Courses**

Discrete Structures .....	CS	130	(4)
Introduction to Computer Science .....	CS	140	(4)
Introduction to Programming and Problem-Solving .....	CS	141	(4)
Data Structures and Algorithms I .....	CS	240	(4)
Data Structures and Algorithms II .....	CS	241	(4)
Design and Analysis of Algorithms .....	CS	331	(4)

Choose 3 from the following courses:

Programming Graphical User Interfaces .....	CS	245	(4)
Numerical Methods .....	CS	301	(4)
Language Translation and Automata .....	CS	311	(4)
Symbolic Programming .....	CS	352	(4)
Object-Oriented Design and Programming .....	CS	356	(4)
Artificial Intelligence .....	CS	420	(4)
Computability .....	CS	450	(4)
Secure Communication .....	CS	460	(4)
Software Engineering .....	CS	480	(4)

Total units required for the Minor: ..... 36

**COURSE DESCRIPTIONS**

**CS 101 Introduction to Computers for Non-CS Majors (4)**

Basic concepts of computer hardware and software. Computer literacy. Detailed instruction in the use of a microcomputer software package including word processor, spreadsheet and database manager. Computer applications, impact of computers on society, responsibilities of the user. 4 lectures/problem-solving. Cannot be used for CS elective credit.

**CS 125 FORTRAN (4)**

Data types, evaluation of expressions, control statements, functions and subroutines, interactive and file I/O. Program development, documentation, and testing. Problem analysis and algorithm design. Applications to numeric problems and character-processing. 4 lectures/problem-solving. Prerequisites: MAT 105 and MAT 106 with grades of C or better, or consent of instructor.

**CS 128 Introduction to C++ (4)**

Basic concepts of computer software and programming. Data types, expressions, control structures, functions, file and stream I/O. Use of

pointers and dynamic storage allocation. Structured and abstract data types. Problem-solving techniques. 4 lectures/problem-solving. Prerequisites: MAT 105 and 106 with grades of C or better, or consent of instructor. Cannot be used for CS elective credit.

**CS 130 Discrete Structures (4)**

Fundamental topics for Computer Science, such as logic, proof techniques, sets, basic counting rules, relations, functions and recursion, graphs and trees. 4 lectures/problem-solving. Prerequisite: eligibility for MAT 112 or consent of instructor.

**CS 140 Introduction to Computer Science (4)**

Basic concepts of Computer Science, including hardware and software. Ethical and social impacts of computing. Problem-solving methods. Programming in an object-oriented language. Written essay required. 4 lectures/problem-solving. Prerequisite: eligibility for MAT 114 or consent of instructor.

**CS 141 Introduction to Programming and Problem-Solving (4)**

Design, implementation, documentation and testing of programs in an object-oriented language. Modularization and reusability of software. File I/O, and exception handling. 4 lectures/problem-solving. Prerequisites: CS 140 and MAT 114 with grades of C or better, or consent of instructor.

**CS 200 Special Study for Lower Division Students (1-2)**

Individual or group investigation, research, studies or surveys of selected problems. Total credit limited to 4 units, with a maximum of 2 units per quarter.

**CS 210 Computer Logic (4)**

Boolean algebra with applications to computers and logic design. The Arithmetic Logical Unit, logical properties of flip-flops and sequential machines. Applied projects. 4 lectures/problem-solving. Prerequisite: CS 130 with a grade of C or better, or consent of instructor.

**CS 240 Data Structures and Algorithms I (4)**

Abstract data types and their implementations. Linked and array-based data structures. Lists, stacks, queues. Recursion. Hashing and searching. Analysis of algorithms. 4 lectures/problem-solving. Prerequisites: CS 130 and CS 141 with grades of C or better, or consent of instructor.

**CS 241 Data Structures and Algorithms II (4)**

Trees, priority queues, graphs, sets, and maps. Sorting algorithms. Random access, indexed and direct files. Indexing techniques. 4 lectures/problem-solving. Prerequisite: CS 240 with a grade of C or better, or consent of instructor.

**CS 245 Programming Graphical User Interfaces (4)**

Computer interfaces. Usability of interactive systems. GUI development processes. GUI components. Input and viewing devices. Event-handling. Animation use in GUIs. Problem-solving techniques. 4 lectures. Prerequisite: CS 141 with a grade of C or better, or consent of instructor.

**CS 256 C++ Programming (4)**

Class encapsulation, inheritance, polymorphism, object storage management, and exception handling. Standard template library including template classes and generic algorithms. Software reuse and object-oriented programming. 4 lectures/problem-solving. Prerequisite: CS 128 or CS 141 with a grade of C or better, or consent of instructor.

**CS 264 Computer Organization and Assembly Programming (4)**

Von Neumann machine. Instruction set architecture. Addressing modes. Assembly programming. Arrays and records. Subroutines and macros. I/O and interrupts. Interfacing and communication. 4 lectures/problem-solving. Prerequisites: CS 210 and CS 240 with grades of C or better, or consent of instructor.

**CS 299/299A/299L Special Topics for Lower Division Students (1-4)**

Group study of a selected topic, the title to be specified in advance. Total credit limited to 8 units, with a maximum of 4 units per quarter. Instruction is by lecture, laboratory or a combination. Prerequisite: consent of instructor.

**CS 301 Numerical Methods (4)**

Error analysis, zeros of a function, systems of linear equations, interpolation, Chebyshev approximation, least squares approximation, numerical integration and differentiation, random processes. 4 lectures/problem-solving. Prerequisites: MAT 208 and MAT 214 and either CS 125 or CS 240 with grades of C or better, or consent of instructor.

**CS 311 Language Translation and Automata (4)**

Introduction to language translation. Regular expressions. Finite automata. Lexical analysis. Context-free grammars and push down automata. Syntax analysis. 4 lectures/problem-solving. Prerequisite: CS 241 with a grade of C or better, or consent of instructor.

**CS 331 Design and Analysis of Algorithms (4)**

Algorithm design techniques including divide-and-conquer, the greedy method, dynamic programming, backtracking, and branch-and-bound. Analysis of sorting and searching. Tractability. Complexity analysis using basic asymptotic notation. Prerequisites: CS 241 and MAT 208 with grades of C or better, or consent of instructor.

**CS 352 Symbolic Programming (4)**

Languages for processing symbolic data with emphasis on applications in artificial intelligence. 4 lectures/problem-solving. Prerequisite: CS 241 with a grade of C or better, or consent of instructor.

**CS 356 Object-Oriented Design and Programming (4)**

Elements of the object model. Abstraction, encapsulation, modularity and hierarchy. Structural and behavioral diagrams. Implementation and programming of system design. Comprehensive examples using a case study approach. 4 lectures/problem-solving. Prerequisite: CS 241 with a grade of C or better, or consent of instructor.

**CS 365 Computer Architecture (4)**

Data representations. Computer arithmetic. Data path and control unit design. Pipelining. Memory technology and hierarchy. I/O devices and interfacing. Multiprocessing and alternative architectures. 4 lectures/problem-solving. Prerequisite: CS 264 with a grade of C or better, or consent of instructor.

**CS 370 Parallel Processing (4)**

The taxonomy of concurrent and parallel systems. Communication and synchronization, multicomputer and multiprocessor systems. Shared-memory and message passing programming paradigms; parallel problem solving. 4 lectures/problem-solving. Prerequisites: CS 256 and CS 331 with grades of C or better, or consent of instructor.

**CS 375 Computers and Society (4)**

Impact of computers on individuals and on society. Various current uses of computers, how these have evolved, and what the future might bring. Benefits and dangers of information technology. How the Internet and computers have fundamentally changed the way we work, play, and interact with others. Consequent rise of new social and legal issues, making it essential for everyone to acquire a working understanding of the role of computers in our daily lives. 4 lecture-discussions. Fulfills GE Synthesis requirement in Area B5 or D4. Prerequisites: Completion of courses in GE areas B1-B4 and D1-D3.

**CS 380 Computer Networks (4)**

Network architectures and standards. Layers and protocols. Circuit switching, packet switching and routing. Client-server concepts. Network security. Web computing. Privacy, intellectual property rights and acceptable use. 4 lectures/problem-solving. Prerequisites: CS 241 and CS 264 with grades of C or better, or consent of instructor.

**CS 400 Special Study for Upper Division Students (1-2)**

Individual or group investigation, research, studies or surveys of selected problems. Total credit limited to 4 units, with a maximum of 2 units per quarter.

**CS 408 Programming Languages (4)**

Concepts in programming languages. Virtual machines and abstraction. Syntax and semantics. Declarations and types. Scoping and binding. Data abstraction. Control abstraction. Run-time organization. Programming paradigms. 4 lectures/problem-solving. Prerequisites: CS 264 and CS 311 with grades of C or better, or consent of instructor.

**CS 411 Compilers and Interpreters (4)**

Language translation systems. Parsing techniques. Run-time environments. Syntax-directed translation. Intermediate code generation and optimization. 4 lectures/problem-solving. Prerequisite: CS 311 with a grade of C or better, or consent of instructor.

**CS 420 Artificial Intelligence (4)**

Overview of the different application areas of AI. Introduction to basic AI concepts and techniques such as heuristic search, knowledge representation, automated reasoning. In-depth discussion of several AI application areas: their specific problems, tools and techniques. Consideration of ethical and social dilemmas posed by AI. 4 lectures/problem-solving. Prerequisites: STA 326 and CS 311 with grades of C or better, or consent of instructor.

**CS 431 Operating Systems (4)**

Overview of operating systems. Operating system structures. Process management. Concurrency and synchronization. Deadlock. Processor management. Scheduling and dispatch. Memory management. Virtual memory. Device management. File systems. Security, privacy and acceptable use. 4 lectures/problem-solving. Prerequisites: CS 241 and CS 365 with grades of C or better, or consent of instructor.

**CS 435 Database Systems (4)**

Database system fundamentals. System components and architecture. Data models, including Entity-Relationship model, relational model and object-oriented model. Theory of database design and data manipulation processes using relational algebra and calculus. SQL in programming language environments. Introduction to concurrency, security, recovery, and transaction handling. Ethical and social issues. 4 lectures/problem-solving. Prerequisite: CS 241 with a grade of C or better, or consent of instructor.

**CS 445 Computer Graphics (4)**

Basic concepts in 2D and 3D graphics. Graphics hardware. Drawing concepts in 2D and 3D graphics. Geometric transformations. Windowing and clipping algorithms. Simple hidden line and surface removal. Color models and applications. 3D modeling. Animation. OpenGL libraries. 4 lectures/problem-solving. Prerequisites: CS 241 and CS 256 with grades of C or better, or consent of instructor.

**CS 450 Computability (4)**

Abstract models of computation, including Turing machines. Church-Turing thesis. Decidability. Theoretical and practical capabilities and limitations of computing machines. 4 lectures/problem-solving. Prerequisite: CS 311 with a grade of C or better, or consent of instructor.

**CS 460 Secure Communication (4)**

Public-key systems, digital signatures, ciphers, the Advanced Encryption Standard, access security, control of information flow. 4 lectures/problem-solving. Prerequisite: CS 241 with a grade of C or better, or consent of instructor.

**CS 461, 462 Senior Project (2)(2)**

Selection and completion of a project under faculty supervision. Projects typical of problems which graduates must solve in their fields of employment. Project results are presented in a formal report. Minimum of 120 hours total time.

**CS 463 Undergraduate Seminar (2)**

Technical presentations by students on current developments in computer science. Seminar discussions of ethical, social and economic impacts of technology. Essays on seminar topics. 2 lecture discussions. Prerequisites: senior standing in computer science and a passing score on GWT.

**CS 480 Software Engineering (4)**

Models of the software development process and metrics. Software requirements and specifications. Methodologies, tools and environments. Human-computer interaction. Software design and architecture. Project management. Cost estimation. Testing and validation. Maintenance and evolution. 4 lectures/problem-solving. Prerequisite: CS 331 with a grade of C or better, or consent of instructor.

**CS 481 Software Engineering Practice (4)**

Team and project-oriented software engineering. Practice in the hands-on process of software production and quality control. Coverage of advanced topics such as embedded systems, real-time systems, and usage-oriented software design. Documentation and management methods for analysis, design, implementation and testing phases of software production. Survey and usage of CASE tools. Focus on issues of system integration and engineering, testing, and maintenance. Prerequisites: CS 435 and CS 480 with grades of C or better, or consent of instructor.

**CS 490 Honors (4)**

In-depth study of a topic of current interest to computer science. Students will be expected to perform individual research and projects and present their results in class. Enrollment is limited. 4 lectures/problem-solving. Prerequisite: consent of instructor.

**CS 499/499A/499L Special Topics for Upper Division Students (1-4)**

Group study of a selected topic, the title to be specified in advance. Total credit limited to 8 units, with a maximum of 4 units per quarter. Instruction is by lecture, laboratory or a combination. Prerequisite: consent of instructor.

## GEOLOGICAL SCIENCES

geology.csupomona.edu/

John A. Klasik, Chair

David R. Berry

David R. Jessey

Jeffrey S. Marshall

Jonathan A. Nourse

Jascha Polet

The Geological Sciences Department offers undergraduate programs which place emphasis on an empirical, applications-oriented approach to learning and career training. The program balances classroom theory and laboratory application with field experiences. Such an applied approach to learning and career training, guided by faculty who consider as paramount the welfare of the student, leads to a strong academic program. The application of this teaching philosophy has been successful in producing graduates with broad capabilities, ready to confront new challenges as professional geologists or in post-graduate educational settings.

Students entering the Geological Sciences Department are offered two programs leading to a Bachelor's of Science Degree: Geology or Integrated Earth Studies (IES). The Geology Major is a comprehensive curriculum in the geological sciences with support courses in mathematical, physical and biological sciences. The Integrated Earth Studies Major, through its interdisciplinary character, addresses two important contemporary needs: the need for environmental scientists and for teachers of science.

Students majoring in disciplines other than Geology, can minor in Geology through appropriately directed Geoscience course work. The Geology Minor promotes student exposure to a broad range of required and elective Geoscience courses. A minor in Geology allows students majoring in other disciplines to pursue interests in Geology or for in-depth studies which compliment the student's major. The minor program serves to enhance a student's employment opportunities in a chosen profession or simply to provide formal recognition of an interest in the physical world. The minor is especially advantageous to students majoring in such fields as geography, civil engineering, biology, science education as well as those in the College of Environmental Design.

For those planning careers as secondary school science teachers, a single subject credential in Science is required. This credential is obtained by completing course work in Education and passing the National Teacher Examination. The latter can be waived by taking the courses listed in the Subject Matter Preparation Program for Prospective Teachers of Science with a concentration in Geology. This program is listed separately below after Geology Curriculum Requirements.

### GEOLGY MAJOR (B.S.)

#### Core Courses for Major

Required of all students. A 2.0 cumulative GPA is required in core courses, including subplan courses, to receive a degree in the major.

Principles of Geology	.....GSC	111	(4)
Earth, Time and Life	.....GSC	112	(3)
Principles of Geology Laboratory	.....GSC	141L	(1)
Megascopeic Petrography	.....GSC	145L	(1)
Earth, Time and Life Laboratory	.....GSC	151L	(1)
Mineralogy	.....GSC	215/215L	(3/1)
Field Methods	.....GSC	255/255L	(1/3)
Introduction to Geochemistry	.....GSC	300/300L	(3/1)
GIS Applications for Earth Scientists	.....GSC	310/310L	(1/2)

Geomorphology	.....GSC	323/323L	(3/1)
Optical Mineralogy	.....GSC	325/325L	(2/2)
Invertebrate Paleontology	.....GSC	331/331L	(3/1)
Structural Geology	.....GSC	333/333L	(3/1)
Groundwater Geology	.....GSC	360/360L	(3/1)
Engineering Geology I	.....GSC	321/321L	(3/1)
or Engineering Geology II	.....GSC	415/415L	(3/1)
Sedimentary Geology	.....GSC	423/423L	(3/2)
Igneous and Metamorphic Petrology	.....GSC	424	(3)
Igneous and Metamorphic Petrography	.....GSC	425L	(2)
Ore Deposits	.....GSC	433/433L	(3/1)
or Geotectonics	.....GSC	444/444L	(3/1)
Senior Thesis	.....GSC	461	(2)
Senior Thesis	.....GSC	462	(2)
Senior Seminar	.....GSC	463	(2)
Summer Field Geology	.....GSC	490L	(8)
or Field Module (2 units)	.....GSC	491L	(8)

Total core units.....(77)

### Support and Elective Courses

The following major support courses should be used to satisfy the indicated GE requirements. If these courses are not used to satisfy GE, the total units to degree may be more than 180 units.

Basic Biology (B2, B3)	.....BIO	115/115L	(3/2)
or Life Science (B2, B3)	.....BIO	110/111L	3/1
General Chemistry (B1, B3)	.....CHM	121/121L	(3/1)
Freshman English I (A2)	.....ENG	104	(4)
Natural Disasters (B5)	.....GSC	350	(4)
Analytic Geometry and Calculus (B4)	.....MAT	114	(4)

General Chemistry	.....CHM	122/122L	(3/1)
General Chemistry	.....CHM	123/123L	(3/1)
Analytic Geometry and Calculus	.....MAT	115	(4)
Analytic Geometry and Calculus	.....MAT	116	(4)
General Physics	.....PHY	131/131L	(3/1)
General Physics	.....PHY	132/132L	(3/1)
General Physics	.....PHY	133/133L	(3/1)

Total support units.....(28)  
 Units to Complete GE.....(68-69)  
 Unrestricted Electives.....(7-6)

### GENERAL EDUCATION REQUIREMENTS

Students should consult the catalog website [www.csupomona.edu/~academic/catalog/](http://www.csupomona.edu/~academic/catalog/) for current information regarding this requirement. Unless specific courses are stated under Support Courses, see the list of approved courses under General Education Requirements, Areas A through E.

#### Area A. Communication and Critical Thinking (12 units)

1. Oral Communication
2. Written Communication
3. Critical Thinking

#### Area B. Mathematics and Natural Sciences (16 units)

1. Physical Science
2. Biological Science
3. Laboratory Activity
4. Mathematics/Quantitative Reasoning
5. Science and Technology Synthesis

**Area C. Humanities (16 units)**

1. Visual and Performing Arts
2. Philosophy and Civilization
3. Literature and Foreign Languages
4. Humanities Synthesis

**Area D. Social Sciences (20 units)**

1. U.S. History, Constitution, and American Ideals
2. History, Economics, and Political Science
3. Sociology, Anthropology, Ethnic and Gender Studies
4. Social Science Synthesis

**Area E. Lifelong Understanding and Self-development (4 units)****INTEGRATED EARTH STUDIES MAJOR (B.S.)****Core Courses for Major**

Principles of Geology .....	GSC	111	(4)
Earth, Time, and Life .....	GSC	112	(3)
Introduction to Astronomy .....	GSC	116	(4)
Principles of Geology Lab .....	GSC	141L	(1)
Megascopic Petrography .....	GSC	145L	(1)
Earth, Time, and Life Lab .....	GSC	151L	(1)
Mineralogy .....	GSC	215/215L	(3/1)
Introduction to Geochemistry .....	GSC	300/300L	(3/1)
GIS Applications for Earth Scientists .....	GSC	310/310L	(1/2)
Meteorology .....	GSC	304	(4)
Studies of a Blue Planet .....	GSC	320	(4)
Engineering Geology I/Lab .....	GSC	321/321L	(3/1)
Geomorphology .....	GSC	323/323L	(3/1)
Exploring the Oceans: Oceanography .....	GSC	335	(4)
Groundwater Geology .....	GSC	360/360L	(3/1)

Total core units required ..... (49)

**Support and Elective Courses**

The following major support courses should be used to satisfy the indicated GE requirements. If these courses are not used to satisfy GE, the total units to degree may be more than 180 units.

Basic Biology (B2, B3) .....	BIO	115/115L	(3/2)
or Life Science (B2, B3) .....	BIO	110/111L	(3/1)
General Chemistry (B1, B3) .....	CHM	121/121L	(3/1)
Natural Disasters (B5) .....	GSC	350	(4)
Trigonometry (B4) .....	MAT	106	(4)

General Chemistry .....	CHM	122/122L	(3/1)
General Chemistry .....	CHM	123/123L	(3/1)
Environment and Society .....	BIO	304	(4)
Geography of California .....	GEO	351	(4)
Geographic Information Systems .....	GEO	240/240A	(4)
Advanced Geographic Information Systems II .....	GEO	442/442A	(4)
Advanced Geographic Information Systems III .....	GEO	443/443A	(4)
College Algebra .....	MAT	105	(4)
College Physics .....	PHY	121/121L	(3)
College Physics .....	PHY	122/122L	(3)
College Physics .....	PHY	123/123L	(3)
Basic Soil Science .....	PLT	231/231L	(3/1)

Total support units ..... (48)

Units to complete GE ..... (68-69)

Unrestricted Electives ..... (0-15)

**GENERAL EDUCATION REQUIREMENTS**

Students should consult the catalog website [www.csupomona.edu/~academic/catalog/](http://www.csupomona.edu/~academic/catalog/) for current information regarding this requirement. Unless specific courses are stated under Support Courses, see the list of approved courses under General Education Requirements, Areas A through E.

**Area A. Communication and Critical Thinking (12 units)**

1. Oral Communication
2. Written Communication
3. Critical Thinking

**Area B. Mathematics and Natural Sciences (16 units)**

1. Physical Science
2. Biological Science
3. Laboratory Activity
4. Mathematics/Quantitative Reasoning
5. Science and Technology Synthesis

**Area C. Humanities (16 units)**

1. Visual and Performing Arts
2. Philosophy and Civilization
3. Literature and Foreign Languages
4. Humanities Synthesis

**Area D. Social Sciences (20 units)**

1. U.S. History, Constitution, and American Ideals
2. History, Economics, and Political Science
3. Sociology, Anthropology, Ethnic and Gender Studies
4. Social Science Synthesis

**Area E. Lifelong Understanding and Self-development (4 units)****MINOR IN GEOLOGY**

Minimum units .....	(30)
Minimum lower-division units (excluding GSC 101) .....	(17)
Minimum upper-division units .....	(16)
Principles in Geology .....	GSC 111 (4)
Principles of Geology Laboratory .....	GSC 141L (1)
Earth, Time, and Life .....	GSC 112 (3)
Earth, Time, and Life Laboratory .....	GSC 151L (1)
Megascopic Petrography .....	GSC 145L (1)

It is required that the student confer with a minor advisor in the planning and selection of the minor curriculum.

**Subject Matter Preparation - Program for Prospective Teachers of Science with a Concentration in Geology**

Note: The listed curriculum is pending approval by the State Commission on Teacher Credentialing. Anyone interested please check with the Department of interest for current status.

**Breadth Courses:****Biological Sciences**

Foundations of Biology .....	BIO	121/121L	(3/2)
Foundations of Biology .....	BIO	122/122L	(3/2)
Foundations of Biology .....	BIO	123/123L	(3/2)

**Chemistry**

General Chemistry .....	CHM	121/121L	(3/1)
General Chemistry .....	CHM	122/122L	(3/1)
General Chemistry .....	CHM	123/123L	(3/1)

**Geosciences**

Principles of Geology	GSC	111/141L	(4/1)
Introduction to Astronomy	GSC	116	(4)
Natural Disasters	GSC	350	(4)

**Physics**

College Physics (Mechanics)	PHY	*121/121L	(3/1)
College Physics (Waves and Heat)	PHY	*122/122L	(3/1)
College Physics (Electricity and Magnetism)	PHY	*123/123L	(3/1)

\*PHY 131/L, 132/L, and 133/L are acceptable substitutes.

**Interdisciplinary Science**

Service Learning K-12 Field Experience (SCI 200 or 299 or 400 or 499) with permission of department			(2)
Research Capstone	SCI	494L	(4)
Seminar Capstone	SCI	495	(4)
Science, Technology and Society (IGE 222 and 223, or STS 201 and PHL 483)			(8)

**Depth Courses in Geological Sciences**

Earth, Time and Life with Lab	GSC	112/151L	(3/1)
Introduction to Oceanography	GSC	120	(4)
Megascopic Petrography	GSC	145L	(1)
Mineralogy	GSC	215/215L	(3/1)
Field Methods	GSC	255/255L	(1/3)
Introduction to Geochemistry	GSC	300/300L	(3/1)
Meteorology	GSC	304	(4)
GIS Applications for Earth Scientists	GSC	310/310L	(1/2)
Studies of a Blue Planet	GSC	320	(4)
Engineering Geology I	GSC	321/321L	(3/1)
Geomorphology	GSC	323/323L	(3/1)
Groundwater Geology	GSC	360/360L	(3/1)

**COURSE DESCRIPTIONS**

NOTE: For all courses which have both a lecture component and a laboratory component (e.g., GSC 215/215L), both components are corequisites; that is, they must be taken concurrently.

F, W, Sp and Su notations indicate the quarter(s) each course is normally offered. Unless otherwise specified, the course is offered each year during the indicated quarter(s). Parentheses signify that the course may be offered during the quarter(s) they enclose. Courses approved for CR/NC grading designated by a dagger (+) (non-majors only).

Field Trip Fee is required for various courses to cover transportation costs and varies according to type of transportation used.

**+GSC 101/101A The Earth Revealed (3/1) FWSp(Su)**

A broad ranging non-quantitative examination of basic concepts in the physical earth sciences. Subject areas are geology, oceanography, the atmosphere and the Earth's place in the solar system. 3 lectures and 1 recitation per week. Does not satisfy laboratory science requirement.

**+GSC 111 Principles of Geology (4) FWSp(Su)**

An introduction to minerals, rocks and geologic features which comprise the Earth; analysis of internal and external processes controlling the features of the planet. 4 lectures per week. Corequisite: GSC 141L (optional for non-majors).

**+GSC 112 Earth, Time and Life (3) FW(Su)**

Changes in continents and ocean basins, fossil populations during successive geological ages, 3 lectures. Corequisite: GSC 151L (optional for non-majors).

**+GSC 116 Introduction to Astronomy (4) FWSp(Su)**

A synthesis of our current knowledge of the cosmos and techniques used in its investigation. Primary emphasis is on the composition, history, and dynamics of the solar system (the sun, planets, moons, comets, asteroids, and meteors) and theories of its origin and evolution. The second part of the course examines the nature of stars, galaxies, and the universe as interpreted from analysis of starlight. Topics include distance, magnitude, luminosity, temperature, and composition of stars, stellar evolution, other solar systems, and search for extraterrestrial life. Special attention is given to independent stargazing activities, current celestial events, and new information revealed by satellite data or unmanned space missions. 4 hours lecture.

**+GSC 120 Introduction to Oceanography (4) FWSp(Su)**

An introduction to the marine sciences. Dealing primarily with the properties of water, ocean currents, waves, tides, beaches, marine life, marine resources and the nature and origin of the sea floor. 4 lectures. Field trip fee required.

**+GSC 141L Principles of Geology Laboratory (1) FWSp(Su)**

Classification of minerals and rocks. Reading and interpreting topographic and geologic maps. 1 three-hour laboratory. Must be taken concurrently with +GSC 111. Laboratory optional for non-majors.

**GSC 145L Megascopic Petrography (1) Sp**

Identification of common igneous, metamorphic and sedimentary rocks, as well as rock-forming minerals in hand sample. Emphasis is placed upon modern classification schemes and recognition of rock textures. Required field trips to collect rock samples and make observations of rock outcrops. 1 three-hour laboratory. Prerequisites: GSC 111 and GSC 141L.

**+GSC 151L Earth, Time and Life Laboratory (1) FW(Su)**

Classification of fossil invertebrates, studies of paleogeographic maps and geologic maps and problems in structural geology. 1 three-hour laboratory. Must be taken concurrently with GSC 112. Optional for non-majors. Field trips required. Field trip fee required.

**GSC 200 Special Study for Lower Division Students (1-2) FWSp**

Individual or group investigation, research, studies or surveys of selected problems. Total credit limited to 4 units, with the maximum of 2 units per quarter.

**GSC 215/215L Mineralogy (3/1) F**

Identification, occurrence, origin and uses of the common minerals. Quantitative x-ray diffraction microanalysis, physical and chemical properties of minerals and introductory morphologic crystallography. Three lectures, one three-hour laboratory. Prerequisites: GSC 111, GSC 141L. Field trip fee required.

**GSC 225 Quantitative Applications in the Earth Sciences (4) Sp**

Solving realistic quantitative problems in the Earth Sciences using standard mathematical procedures as well as more specialized techniques. Use of symbols, scientific notation and units. Different functional forms of the geotherm. Earthquake statistics. Determining angles and distances from maps and cross-sections. Analysis of plate motions. Geological and geophysical data visualization using graphing. Hazard analysis. Calculation of rates of geological processes and volumes of geological landforms. 4 hours of lecture and problem solving. Prerequisites: MAT 115 or consent of the instructor.

**GSC 255/255L Field Methods (1/3) F**

Techniques of recognizing, mapping, analyzing and interpreting geologic structures and earth features. Surveying with plane table, alidade, Brunton compass and tape. 1 lecture/problem, 3 three-hour laboratories. Prerequisites: GSC 145L. Field trips required. Field trip fee required.

**GSC 299/299A Special Topics for Lower Division Students (1-4)**

Group study of a selected topic, the title to be specified in advance. Total credit limited to 8 units, with a maximum of 4 units per quarter. Instruction is by lecture/problem-solving, laboratory or a combination.

**GSC 300/300L Introduction to Geochemistry (3/1) FW**

An examination of the interrelationship of geology and chemistry in the near surface environment. The course focuses on low temperature groundwater systems and geothermal fluids. Topics of discussion include the chemistry of meteoric and connate waters, application of Eh-pH and log fugacity of O<sub>2</sub> diagrams to the modeling of aqueous fluids, stable isotopic fractionation in the hydrosphere, chemical reactions at the water-rock interface and dynamics of hydrothermal systems. 3 lectures/problems, one 3-hour laboratory. Prerequisites: CHM 121/121L.

**GSC 304 Meteorology (4) W**

Framework topics, such as atmospheric structure, composition, heating, pressure, humidity form the base upon which a process-oriented semi-quantitative, descriptive survey of major weather phenomena, including winds, clouds, precipitation, and storms is conducted. 4 lecture/discussions. Prerequisites: One GE course from each of the following Sub-areas: A1, A2, A3 and B1, B2, and B4. GE Synthesis course for Sub-area B5.

**GSC/PHY 307/307L Introduction to Global Geophysics (3/1) F**

The physics of the solid Earth and its applications. The following topics will be discussed: the theory of plate tectonics; magnetism, seismology and gravity; radioactivity and heat; the deep interior of the Earth and physical processes of the mantle and core; applications to specific regions on Earth. Throughout the course, special attention will be given to new research results and the interpretation of actual data. 3 hours of lecture + 3 hours lab. Prerequisite: MAT 112.

**GSC 310/310L GIS Applications for Earth Scientists-Part I (1/2)**

Practical techniques for converting traditional coordinate-based geoscience data into digital map layers. Digitizing methods applied to creation of geologic, hydrologic, meteorologic, and oceanographic maps. One hour lecture plus two 3-hour laboratory sessions.

**GSC 311/311L GIS Applications for Earth Scientists-Part II(1/2)**

Practical GIS methods for geologic map representation and quantitative analysis of real-world coordinate-based geoscience data. Manipulation and enhancement of digital data layers in contemporary drafting programs. Creation and interpretation of contour maps, isopach maps, and slope stability maps. Three-dimensional analysis of borehole data; construction of cross section images. One hour lecture plus two 3-hour laboratories.

**GSC 320 Studies of a Blue Planet (4) FSp**

Science-based issues related to the ocean-atmosphere system which directly impact Humankind are examined. Global environmental change, El Niño/La Niña, ozone depletion, sea level changes, coastal development, alternative energy sources and satellite monitoring of earth are investigated. Four lecture/discussions per week. Prerequisites: One GE course from each of the following Sub-areas: A1, A2, A3 and B1, B2, B4. GE Synthesis course for Sub-area B5.

**GSC 321/321L Engineering Geology I (3/1)**

Fundamentals of geology applied to engineering problems. Includes rock types, structure, erosion, sedimentation, seismic explorations, rock/soil movements, and dam site evaluations. Individual and group study of selected engineering geology problems. Instruction is carried out in the field and laboratory. Laboratory fee is required. 3 hours lecture/discussion, 1 laboratory. Pre-requisites: one course from each of the following Sub-areas: A1, A2, A3 and B1, B2, B4. GE Synthesis course for Sub-area B5.

**GSC 323/323L Geomorphology (3/1) F**

Introduction to the modern geologic study of Earth surface processes and landforms. Geomorphic analysis of landscape evolution, dynamic equilibrium, and topographic response to tectonic and climatic forcing. Terrain analysis utilizing geomorphic field data, remote sensing imagery, and numerical models. Emphasis on practical applications to natural hazards and resource problems. Topics may include active tectonics, river systems, hill slopes, coastlines, glaciers, soils, wind, and climate change. This course includes 3 lecture discussions and 1 field laboratory (3 hrs.) per week. Required field trips during lab sessions and on at least one weekend. Prerequisite: GSC 111 or permission from instructor.

**GSC 325/325L Optical Mineralogy (2/2) W**

The chemistry (primarily phase relationships) of the common rock-forming minerals. The description, composition, texture and origin of the common rock-forming minerals according to their optical properties as determined with the petrographic microscope. 2 lectures/problem-solving, 2 three-hour laboratories. Prerequisite: GSC 215/215L.

**GSC 331/331L Invertebrate Paleontology (3/1) Sp**

Morphology and evolution of fossil invertebrates. Includes discussion of ancient environments and changes in life forms with time. 3 lectures/problem-solving, 1 three-hour laboratory. Prerequisite: GSC 112 and GSC 151L. Field trips required. Field trip fee required.

**GSC 333/333L Structural Geology (3/1) F**

Investigation of the deformation of the earth's lithosphere. Solution of geologic field problems. 3 lectures/problem-solving, 1 three-hour laboratory. Prerequisites: GSC 111, GSC 141L, GSC 145L, and GSC 255/255L. Field trips required. Field trip fee required.

**GSC 334/334L Exploration Geophysics (3/1)**

Geophysical techniques. Gravity, magnetic, electrical and seismic methods applied to the solution of geologic problems. 3 lectures/problem-solving, 1 three-hour laboratory. Prerequisites: GSC 111, GSC 141L, PHY 132 and PHY 132L or PHY 122 and PHY 122L. Field trips required. Field trip fee required.

**GSC 335 Exploring the Oceans: Oceanography (4)**

Fundamental ocean processes emphasizing physical, chemical, and geological oceanography. Topics include currents, tides, waves, beaches, chemistry of ocean water, ocean basin evolution and physiography, and sedimentation as well as specific, relevant biological processes. Research vessel cruise. Lecture/discussion/demonstration. Prerequisites: one course from each of the following Sub-areas: A1, A2, A3 and B1, B2, B4. GE Synthesis course for Sub-area B5.

**GSC 338 Coastal Processes (4)**

Geologic development of and the hydrologic and geologic processes acting within beach, deltaic and estuarine environments. Field trip required. 4 lectures/problem-solving. Prerequisites: GSC 111, GSC 120 or 335. Upper division standing. Field trips required. Field trip fee required.

**GSC 340 Marine Geology (4)**

The physiography, sedimentology, structure, origin and evolution of the ocean basins and continental margins. Facts, data, speculation derived from a variety of texts, journals, maps. 4 lectures/problem-solving. Prerequisites: GSC 335 or 120, and GSC 111, upper division standing. Field trips required. Field trip fee required.

**GSC 350 Natural Disasters (4) FWSp (Su)**

The scientific study of natural disasters and their impact on humankind. A variety of hazards related to plate tectonics and climate are examined from a scientific perspective. Topics may include earthquakes, tsunami, volcanic eruptions, landslides, flooding, hurricanes, tornadoes, and climate change. Recent events and notable case histories are studied through lecture, Internet, video, field trips, and student presentations. GE Synthesis course for Sub-area B4.

**GSC 351/351L Petroleum Geology (3/1)**

Origin and occurrence of petroleum and related products. Study of the geologic structure and stratigraphy of major oil and gas fields. 3 lectures/problem-solving, 1 three-hour laboratory. Prerequisites: GSC 141L and GSC 151L. Field trips required. Field trip fee required.

**GSC 360/360L Groundwater Geology (3/1) W (even years)**

Groundwater occurrence and movement. Role in hydrologic cycle and geologic processes. Groundwater resource evaluation, geotechnical problems and contamination. 3 lectures/problem-solving, 1 three-hour laboratory.

**GSC 400 Special Study for Upper Division Students (1-2) FWSp**

Individual or group investigation, research, studies or surveys of selected problems. Total credit limited to 4 units, with a maximum of 2 units per quarter.

**GSC 415/415L Engineering Geology II (3/1) F**

Application of geologic and geophysical principles to engineering problems encountered in the geotechnical industry. Lecture topics include earthquake faults and seismology of Southern California, earthquake-induced strong ground motion and site effects, seismic instrumentation and shake maps, probabilistic hazard analysis, Alquist-Priolo/fault trench studies, stability analysis of slopes and dams, and case studies of landslides, earthquakes, and dam failures. Laboratory sessions involve 3-dimensional analysis of geologic data, field measurement and analysis of unstable slopes, and investigation of dam sites. 3 units lecture/discussion scheduled for evening. 1 unit laboratory requires field trips to be conducted on selected Saturdays. Prerequisites: Equivalent of GSC 111/GSC 141L or GSC 321/GSC 321L.

**GSC 423/423L Sedimentary Geology (3/2) Sp**

Stratigraphic procedures, correlation, depositional environments, classification and origin of stratigraphic units, chemical, mineralogic and textural studies of sedimentary rocks, using petrographic, mechanical and x-ray techniques. Theory of the classification and origin of these rocks. Field trips. 3 lectures, 2 three-hour laboratories. Prerequisite: GSC 325/325L. Field trips required. Laboratory fee required.

**GSC 424 Igneous and Metamorphic Petrology (3) Sp**

Theory of the origin, classification, chemistry and mineralogy of igneous and metamorphic rocks. 3 lectures. Prerequisites: GSC 325/325L. Corequisite: GSC 425L.

**GSC 425L Igneous and Metamorphic Petrography (2) Sp**

Mineralogy, texture and description of igneous and metamorphic rocks

with the petrographic microscope, mineral separation techniques and x-ray diffraction. Field trips. Prerequisite GSC 325. Corequisite GSC 424. 2 three-hour laboratories. Field trips required. Field trip fees required.

**GSC 433/433L Ore Deposits (3/1) W (even years)**

A systematic study of the deposition of metallic ores. Preparation of comprehensive ore deposit models is stressed requiring the integration of mineralogy, petrology and structural geology. Discussions and practical exercises on wall rock alteration, paragenesis, metal zoning and fluid inclusion geothermometry are important components of the course. Laboratory examination of polished sections and thin sections from "classic" mining districts throughout the world and field trips to important mining districts compliment the lecture. Three lectures and one 3 hour lab. Prerequisite: GSC 215/215L. Required field trips. Field trip fee required.

**GSC 440/440L Exploration and Mining Geology (3/1) Sp (even years)**

Planning and implementation of mineral exploration programs, resource extraction and ore-processing. Course topics include mineral economics, exploration planning, exploration techniques, ore deposit valuation and mining and processing systems. Special emphasis is placed on the economic theory and practical aspects of development of precious metal properties. Laboratory exercises focus on all aspects of exploration from field exercises involving claim staking, geochemical/geophysical prospecting and underground mine mapping to on-campus work with computer generated ore reserve models and automated data base literature searches. 3 lectures, 1 three-hour laboratory. Prerequisites: GSC 111, GSC 215/215L.

**GSC 441/441L Micropaleontology (3/1)**

Morphology, classification and evolution of major plant and animal microfossil groups with emphasis on the Foraminiferida. Use of microfossils in petroleum exploration and paleoenvironmental reconstruction. 3 lectures/problem-solving, 1 three-hour laboratory. Prerequisites: GSC 112, GSC 151L and GSC 331/331L.

**GSC 444/444L Geotectonics (3/1) W (odd years)**

Study of the major tectonic elements of the Earth, their geometry, kinematics and dynamics with special emphasis on the Cordillera of Western North America. All of the tectonic features will be analyzed in the context of plate tectonics. Prerequisites: GSC 111, GSC 141L. Field trips required. 3 lectures/problem-solving, 1 three-hour laboratory.

**GSC 450/450L Introduction to Seismology, Earthquakes and Earth Structure (3/1) W**

The study of the generation, propagation and recording of seismic waves and of the sources that produce them. Stress and strain. Body waves and ray theory. Surface waves and free oscillations. Seismometry. Interpretation of seismograms. Determination of Earth structure. Reflection seismology. Seismic sources. Strong motion seismology and earthquake hazard. Earthquake statistics. Seismotectonics. 3 hours of lecture + 3 hours lab. Prerequisite: MAT 115 or consent of the instructor.

**GSC 461, 462 Senior Thesis (2) FWSp**

Independent research study into a geologic problem of scientific merit following standard scientific methodology. Topic selection, research techniques, data analysis and formal write up are done under close guidance and supervision of a GSC faculty research advisor. Successful completion of GSC 461 and 462 requires submission of a formal, written report in appropriate scientific style. In certain cases, publication of research results in appropriate scientific journal or as an abstract may be accepted in lieu of report.



**GSC 463 Senior Seminar (2) FWSp**

A formal, oral presentation of senior thesis results. This presentation will be judged on clarity, organization, scientific merit and the presenter's ability to discuss and to respond to faculty and student questioning in an effective and persuasive manner. Students should not enroll in GSC 463 until senior thesis is near completion.

**GSC 490L Summer Field Geology (8) Su**

A six-week course in geological field methods. Preparation of geological maps of metamorphic, igneous and sedimentary rock areas. Geologic report on areas mapped. Prerequisite: GSC 255/255L. Field trip fee required.

**GSC 491L Field Module (2) FWSpSu**

Advanced geologic mapping in a variety of geologic settings. Field reports, maps and cross-sections required. Techniques emphasized include surveying, GPS mapping, satellite and aerial photo interpretation, Brunton compass pace and traverse. Each module requires a minimum of five field days with additional field and lab time as necessary to complete the assignments. Students are expected to complete four (4) modules to fulfill the GSC degree requirement. Each module must be topically distinctive. Modules must be taken from at least two different instructors. Total credit limited to 8 units with a maximum of 4 units per quarter.

**GSC 499/499A/499L Special Topics for Upper Division Students (1-4) FWSp(Su)**

Group study of a selected topic, the title to be specified in advance. Total credit limited to 8 units with a maximum of 4 units per quarter. Instruction is by lecture, laboratory or a combination.

## MATHEMATICS AND STATISTICS

www.csupomona.edu/~math

Michael Green, Chair

Charles Amelin	Claudia Pinter-Lucke
Brent Deschamp	Kamta Rai
Dhanwant Singh Gill	Laurie Riggs
Berit Givens	Amber Rosin
Patricia Hale	Randall Swift
Hoon Kim	Jennifer Switkes
Alan Krinik	Hubertus F. von Bremen
Christine Latulippe	Robin Wilson
Joe Latulippe	Greisy Winicki-Landman
Karen Linton	Weiqing Xie
Lilian Metlitzky	Phil Yates
Ioana Mihaila	
Jungwon Chris Mun	
Martin Nakashima	

The Department of Mathematics and Statistics offers a flexible major program which may be adapted to serve a variety of needs and interests. Students may develop elective patterns which will prepare them for entry into employment in industry and government.

Each student is urged to develop an elective pattern which will also be preparatory for graduate study either in mathematics or in some quantitative discipline in the sciences, engineering, economics or business. Courses at the 500-level are available as part of a master's degree graduate program.

The Department of Mathematics and Statistics recommends that each student use several free electives to develop depth in some discipline other than mathematics.

Transfer students should complete as much of the calculus sequence as possible before entering Cal Poly Pomona. Physics courses to be transferred should be those which require calculus concurrently or as a prerequisite.

A high school student planning a major in mathematics should complete one year of physics, one year of chemistry and four years of mathematics to include thorough preparation in trigonometry and advanced algebra.

Students majoring in mathematics who have at least a 3.0 GPA may join the honorary society, Kappa Mu Epsilon. Additional information can be obtained from the Department of Mathematics and Statistics.

### CORE COURSES FOR MAJOR

Required of all students. A 2.0 cumulative GPA is required in core courses, including subplan courses, in order to receive a degree in the major.

Introduction to C++	CS	128	(4)
or FORTRAN	CS	125	
Analytic Geometry and Calculus III	MAT	116	(4)
Introduction to Numerical Methods	MAT	201	(4)
Introduction to Linear Algebra	MAT	208	(4)
Calculus of Several Variables I	MAT	214	(3)
Calculus of Several Variables II	MAT	215	(3)
Differential Equations	MAT	216	(4)
Basic Set Theory and Logic	MAT	310	(4)
Intermediate Analysis I	MAT	314	(4)

Intermediate Analysis II	MAT	315	(4)
Modern Algebra	MAT	417	(4)
Modern Algebra	MAT	418	(4)
Complex Variables	MAT	428	(4)
Applied Probability Theory	STA	241	(4)
Applied Statistics	STA	341	(4)

### SUBPLAN COURSES FOR MAJOR

Required for specific subplan

### Secondary Teacher Preparation/Pure Math

Choose six courses from the following list. No more than two courses may be selected from MAT 330, MAT 415, MAT 416. The courses marked with "#" are suggested for those students who are preparing for a secondary teaching credential (see Subject Matter Preparation - Program for Prospective Teachers in Mathematics). The courses marked with a "+" are suggested for those students preparing to go on to graduate studies.

History of Mathematics #	MAT	306	(4)
Topology +	MAT	321	(4)
Introduction to Number Theory #, +	MAT	325	(4)
Modern Euclidean Geometry #	MAT	330	(4)
Graph Theory #	MAT	370	(4)
Advanced Calculus +	MAT	413	(4)
Foundations of Geometry #	MAT	415	(4)
Projective Geometry #	MAT	416	(4)
Abstract Linear Algebra +	MAT	419	(4)
Differential Geometry #	MAT	420	(4)
Functions of a Complex Variable +	MAT	429	(4)
Combinatorics	MAT	470	(4)
Foundations of Mathematics +	MAT	450	(4)
Topics in Contemporary Secondary School Math III#	MAT	497/497A(3/1)	

### Applied Mathematics

The student must complete two two-quarter sequences from the list below:

Mathematics of Operations Research	MAT	380	(4)
Mathematics of Operations Research	MAT	381	(4)
Numerical Analysis I	MAT	401	(4)
Numerical Analysis II	MAT	402	(4)
Differential Equations I	MAT	431	(4)
Differential Equations II	MAT	432	(4)
Mathematical Modeling and Simulation	MAT	485	(4)
Mathematical Modeling and Simulation	MAT	486	(4)

The student must complete two additional courses from the list above or the list below:

Graph Theory	MAT	370	(4)
Combinatorics	MAT	470	(4)
Mathematical Programming	MAT	480	(4)

### Statistics

Choose 16 units from the following:

Sampling Theory and Applications	STA	310	(4)
Nonparametric Statistics	STA	420	(4)
Applied Survival Analysis	STA	425	(4)
Applied Regression	STA	432	(4)

Introduction to Random Processes	STA	430	(4)
ANOVA and Design of Experiments	STA	435	(4)
Mathematical Statistics I	STA	440	(4)
Mathematical Statistics II	STA	441	(4)
Special Topics	STA	499	(1-4)
Computer Simulation	CS	390	(4)
Choose additional 8 units in consultation with your advisor			(8)

**SUPPORT AND ELECTIVE COURSES**

The following major support courses should be used to satisfy the indicated GE requirements. If these courses are not used to satisfy GE, the total units to degree may be more than 180 units.

Analytic Geometry and Calculus I (B4)	MAT	114	(4)
Freshman Composition (A2)	ENG	104	(4)
General Physics (B1)	PHY	131	(3)
General Physics Laboratory (B3)	PHY	131L	(1)
Analytic Geometry and Calculus II (B4)	MAT	115	(4)
General Physics	PHY	132	(3)
General Physics	PHY	133	(3)
General Physics Laboratory	PHY	132L	(1)
General Physics Laboratory	PHY	133L	(1)
Unrestricted Electives			(17)

**GENERAL EDUCATION COURSES**

Students should consult the catalog website [www.csupomona.edu/~academic/catalog/](http://www.csupomona.edu/~academic/catalog/) for current information regarding this requirement. Courses must be selected from the list of approved courses under General Education Requirements, Areas A through E.

**Area A (12 units)**

1. Oral Communication
2. Written Communication
3. Critical Thinking

**Area B (16 units)**

1. Physical Science
2. Biological Science
3. Laboratory Activity
4. Mathematics/Quantitative Reasoning
5. Science and Technology Synthesis

**Area C (16 units)**

1. Visual and Performing Arts
2. Philosophy and Civilization
3. Literature and Foreign Languages
4. Humanities Synthesis

**Area D (20 units)**

1. U.S. History, Constitution, and American Ideals
2. History, Economics, and Political Science
3. Sociology, Anthropology, Ethnic, and Gender Studies
4. Social Science Synthesis

**Area E (4 units)**

Lifelong Understanding and Self-development

**SUBJECT MATTER PREPARATION – Program for Prospective Teachers in Mathematics**

The Department of Mathematics and Statistics offers a program in mathematics approved by the Commission on Teacher Credentialing. Those individuals who wish to become mathematics teachers in California public schools must complete the comprehensive list of courses that follows. The core courses in the mathematics major

together with appropriate selected courses in the pure subplan will satisfy most of the courses on the list. The rest of the required courses can be chosen to satisfy the free elective requirements for the degree.

Analytic Geometry and Calculus I	MAT	114	(4)
Analytic Geometry and Calculus II	MAT	115	(4)
Analytic Geometry and Calculus III	MAT	116	(4)
Introduction to Linear Algebra	MAT	208	(4)
Calculus of Several Variables I	MAT	214	(3)
Calculus of Several Variables II	MAT	215	(3)
History of Math	MAT	306	(4)
Introduction to Logic and Set Theory	MAT	310	(4)
Intermediate Analysis I	MAT	314	(4)
Introduction to Number Theory	MAT	325	(4)
Modern Euclidean Geometry	MAT	330	(4)
Foundations of Geometry	MAT	415	(4)
or Projective Geometry	MAT	416	(4)
Modern Algebra I	MAT	417	(4)
Modern Algebra II	MAT	418	(4)
Topics in Contemporary			
Secondary School Mathematics I	MAT	495/495A	(4)
Topics in Contemporary			
Secondary School Mathematics II	MAT	496/496A	(4)
Topics in Contemporary			
Secondary School Mathematics III	MAT	497/497A	(4)
Applied Probability Theory	STA	241	(4)
Applied Statistics	STA	341	(4)
Introduction to C++	CS	128	(4)

Select one course from the following: (4)

MAT 201, 370, 380, 480, 485, CS 390, CHE 415, OM 419, STA 432, STA 435

**MINOR IN MATHEMATICS**

Analytic Geometry and Calculus I	MAT	114	(4)
Analytic Geometry and Calculus II	MAT	115	(4)
Analytic Geometry and Calculus III	MAT	116	(4)
Calculus of Several Variables I	MAT	214	(3)
Calculus of Several Variables II	MAT	215	(3)
Differential Equations	MAT	216	(4)
or Elementary Linear Algebra and Differential			
Equations	MAT	224	(4)
Introduction to Linear Algebra	MAT	208	(4)

In addition to the above courses, choose any four upper division courses (except MAT 394, 395, 400, 461, 462, 463, 491, 492, 493, 494, 495, 496, 497, STA 309, 315). No more than two upper division STA courses can be counted towards the Mathematics Minor (see Statistics Minor). No more than one of MAT 317 or MAT 318 can be counted towards the mathematics minor.

Minimum number of units required: (41)

It is recommended that the student confer with a minor advisor in the selection of courses. Since a maximum of flexibility is afforded, the student is cautioned to pay very careful attention to the prerequisites for the courses selected.

**STATISTICS MINOR**

Required Courses			
Analytic Geometry and Calculus I	MAT	114	(4)
Analytic Geometry and Calculus II	MAT	115	(4)
Analytic Geometry and Calculus III	MAT	116	(4)

Introduction to Linear Algebra . . . . .	MAT	208	(4)
Calculus of Several Variables I . . . . .	MAT	214	(3)
Calculus of Several Variables II . . . . .	MAT	215	(3)
Applied Probability Theory . . . . .	STA	241	(4)
and Applied Statistics . . . . .	STA	341	(4)
or Statistical Methods for Computer Scientists	STA	326	(4)
Applied Regression Analysis . . . . .	STA	432	(4)
or ANOVA and Design of Experiments . . . . .	STA	435	(4)
Choose 8 units from the following:			
Sampling Theory and Applications . . . . .	STA	310	(4)
Nonparametric Statistics . . . . .	STA	420	(4)
Applied Survival Analysis . . . . .	STA	425	(4)
Introduction to Random Processes . . . . .	STA	430	(4)
Applied Regression Analysis . . . . .	STA	432	(4)
ANOVA and Design of Experiments . . . . .	STA	435	(4)
Mathematical Statistics I . . . . .	STA	440	(4)
Mathematical Statistics II . . . . .	STA	441	(4)
Special Topics . . . . .	STA	499	(1-4)

Minimum number of units required . . . . . (42)

**ELM REQUIREMENT**

All students must take the Entry-Level Math Test or satisfy exemptions prior to enrollment or a hold will be placed on all course registration. Students will not be allowed to enroll in any Mathematics coursework unless they have satisfied the ELM requirement. If the student's ELM score is below the minimum required for General Education level Mathematics coursework, the student must enroll in the appropriate preparatory courses the first quarter of their enrollment.

**PREPARATORY MATHEMATICS PROGRAM**

A three-quarter sequence of courses is provided for students needing intensive mathematics review in order to enroll in General Education mathematics or statistics courses. Courses receive unit load credit but not baccalaureate credit. Students must have achieved prerequisite scores on the ELM or the MDPT in order to enroll in MAT 10, MAT 11, or MAT 12.

**MATHEMATICS DIAGNOSTIC PLACEMENT TEST (MDPT)**

All pre-baccalaureate and many 100 level mathematics/statistics courses have prerequisites that may be satisfied by the CSU/UC Mathematics Diagnostic Placement Test (MDPT). The MDPT has two levels: Mathematical Analysis, and Precalculus. The Math Analysis Test places students into MAT 10, MAT 11, MAT 12, MAT 105, MAT 106, MAT 125, MAT 137, MAT 191, and STA 120. The Precalculus Test places students into MAT 12, MAT 105, MAT 106, MAT 112, MAT 114, MAT 120 and MAT 130. MDPT scores are valid for placement for three quarters (including summer).

The Department of Mathematics and Statistics administers the MDPT each quarter. To take the test, students must sign up in advance with the Department, Room 8-113, or online at the Department of Mathematics and Statistics home page.

**INFORMATION ABOUT PREREQUISITES**

The prerequisites for MAT 10, MAT 11, MAT 12, MAT 105, MAT 106, MAT 112, MAT 114, MAT 120, MAT 125, MAT 130, MAT 191 and STA 120 are time-sensitive. The calculation of elapsed time may include quarters in which the student is not enrolled at Cal Poly Pomona (including summer quarter). Please refer to the schedule of classes for current deadlines for specific courses.

Grades below C in a course may be used to extend the time in which a student is eligible to enroll in that course. A grade of D-, D, D+, or C- will extend the eligibility to enroll in the course for two quarters. A grade of F or WU will extend the eligibility for one quarter.

**COURSE DESCRIPTIONS**

F, W, Sp, and Su notations indicate the quarter(s) each course is normally offered. Unless otherwise specified, the course is offered this year during the indicated quarter(s).

**MAT 10 Prealgebra (4) FWSpSu**

Geometry, measurement geometry, introduction to algebra including variable expressions, linear equations, polynomials, techniques of factoring, integer exponents. 4 lecture/problem-solving. Letter grade only. Course does not earn Baccalaureate credit.

**MAT 11 Basic Algebra (4) FWSpSu**

Applications of linear equations, techniques of factoring, rational expressions, linear inequalities, graphs of linear functions, systems of linear equations, rational exponents and radicals, quadratic equations. 4 lecture/problem-solving. Letter grade only. Prerequisite: within the last three quarters, must have earned either a minimum placement score on the ELM or the appropriate MDPT, or C or better in MAT 10. Course does not earn Baccalaureate credit.

**MAT 12 Intermediate Algebra (4) FWSpSu**

Complex numbers, advanced quadratic equations with applications, quadratic and rational inequalities, functions, conic sections, logarithms, non-linear systems of equations, sequences and series, binomial expansions. 4 lecture/problem-solving. Letter grade only. Prerequisite: within the last three quarters, must have achieved either a minimum placement score on the ELM or the appropriate MDPT, or C or better in MAT 11. Course does not earn Baccalaureate credit.

**MAT 105 College Algebra (4) FWSpSu**

Real numbers, inequalities, absolute value, coordinate systems, functions, progressions, linear and quadratic systems, polynomials, rationals, exponentials, and logs, and mathematical induction. 4 lecture/problem-solving. Prerequisites: Within the last three quarters, must have either achieved a minimum placement score on the appropriate MDPT or C or better in MAT 12, or MAT 106, or MAT 125, or MAT 191, or STA 120; or, within the last 18 months must have earned either 550 or better on the SAT or 23 or better on the ACT.

**MAT 106 Trigonometry (4) FWSpSu**

The circular functions, general reduction formulas, inverse functions, graphs, Law of Sines, Law of Cosines, identities and complex numbers. 4 lecture/problem-solving. Prerequisites: Within the last three quarters, must have either achieved a minimum placement score on the appropriate MDPT or C or better in MAT 12, or MAT 105, or MAT 125, or MAT 191, or STA 120; or, within the last 18 months must have earned either 550 or better on the SAT or 23 or better on the ACT.

**MAT 112 Preparation for Calculus (4) FWSpSu**

Function, theory, techniques for graphing functions (polynomials, rational functions, trigonometry functions, exponential functions, log functions, and compositions of these such as trig polynomials), solutions of systems of linear and non-linear equations, inequalities, introduction to limits. 4 lecture/problem-solving. Prerequisites: within the last three quarters, must have achieved either a minimum placement score on the appropriate MDPT, or C or better in both MAT 105 and MAT 106.

**MAT 114 Analytic Geometry and Calculus I (4) FWSpSu**

Functions, limits, continuity, derivatives of all functions including trig, exponential, log, inverse trig and implicit functions. Applications of derivatives including max/min problems. 4 lecture/problem-solving. Prerequisite: within the last three quarters, must have achieved either a minimum placement score on the appropriate MDPT or B or better in both MAT 105 and MAT 106 or C or better in MAT 112.

**MAT 115 Analytic Geometry and Calculus II (4) FWSpSu**

Definite and indefinite integrals. The Fundamental Theorem of Calculus. Applications of the definite integral. Integration techniques including integration by parts, integrals of trig products, partial fractions, substitution, trig substitution. Hyperbolic functions. 4 lecture/problem-solving. Prerequisite: C or better in MAT 114 or consent of the instructor.

**MAT 116 Analytic Geometry and Calculus III (4) FWSpSu**

Sequences and series, L'Hospital's rule, improper integrals, polar coordinates, parametric equations and conic sections. 4 lecture/problem-solving. Prerequisites: C or better in MAT 115 or consent of the instructor.

**MAT 120 Calculus for the Life Sciences (4) FWSp**

Study of the calculus of algebraic, exponential and logarithmic functions. Graphing, limits, derivatives, differentials and integrals of single variable functions listed above. Brief introduction to partial derivatives and double integrals of multivariable functions. Special emphasis is given to applications in life sciences. 4 lecture/problem-solving. Prerequisites: within the last three quarters, must have achieved either a minimum placement score on the appropriate MDPT, or C or better in MAT 105.

**MAT 125 Introductory Calculus for Business (4) FWSpSu**

Graphing, differentiation, integration of rational and exponential functions, with special emphasis on applications to business. Not open to any student whose major requires the MAT 114 sequence. 4 lecture/problem-solving. Prerequisite: within the last three quarters, must have achieved either a minimum placement score on the appropriate MDPT, or C or better in MAT 12, or MAT 105, or MAT 106, or MAT 191, or STA 120.

**MAT 130 Technical Calculus I (4) FWSpSu**

Differential calculus of rational functions and applications of the derivative. Integral calculus and applications of the integral. 4 lecture/problem-solving. Prerequisite: within the last three quarters, must have achieved either a minimum placement score on the appropriate MDPT, or B or better in both MAT 105 and MAT 106 or C or better in MAT 112.

**MAT 131 Technical Calculus II (4) FWSpSu**

Analytic geometry. Derivatives and integrals of trigonometric, logarithmic, and exponential functions and applications. Infinite Series. 4 lecture/problem-solving. Prerequisite: C or better in MAT 130 or consent of instructor.

**MAT 132 Technical Calculus III (4) FWSp**

Techniques of multidimensional calculus, introduction to ordinary differential equations and Laplace transforms. 4 lecture/problem-solving. Prerequisite: C or better in MAT 131 or consent of instructor.

**MAT 191 Survey of Mathematics (4) FWSpSu**

Emphasis on modern applications of selected topics from sets, logic,

probability, statistics and mathematical modeling. 4 lecture/problem-solving. Prerequisites: Within the last 3 quarters, must have either achieved a minimum placement score on the appropriate MDPT or C or better in MAT 12, or MAT 105, or MAT 106, or MAT 125, or STA 120; or, within last year must have earned 50 or better on the ELM; or, within the last 18 months must have earned either 550 or better on the SAT or 23 or better on the ACT.

**MAT 194 Mathematical Concepts for Elementary School Teachers: Number Systems (4)**

Development of the real number system including sets, operations and properties; topics in number theory. Development of problem solving strategies, introduction to proof and inductive and deductive reasoning. Application of technology to these topics. 4 lecture/problems. Students must complete MAT 194, MAT 394, MAT 395, and MAT 494 to meet the GE Area B4 requirement. Prerequisites: Within the last 3 quarters, must have either achieved a minimum placement score on the appropriate MDPT or C or better in MAT 12, or MAT 105, or MAT 106, or MAT 125, or STA 120; or, within last year must have earned 50 or better on the ELM; or, within the last 18 months must have earned either 550 or better on the SAT or 23 or better on the ACT.

**MAT 200 Special Study for Lower Division Students (1-2)**

Individual or group investigation, research, studies or surveys of selected problems. Total credit limited to 4 units, with a maximum of 2 units per quarter.

**MAT 201 Introduction to Numerical Methods (4) FSp**

Numerical methods of topics from algebra and calculus. Topics will include function evaluation and graphing, limits, summation, solving nonlinear equations, numerical integration and differentiation and an introduction to numerical error. 4 lecture/problem-solving. Prerequisite: C or better in MAT 116 and CS 128 or consent of instructor.

**MAT 208 Introduction to Linear Algebra (4) FWSpSu**

Introduction to linear transformations of the plane, vector space of  $n$ -tuples, matrix algebra, determinants, systems of linear equations. 4 lecture/problem-solving. Prerequisite: C or better in MAT 214 or consent of instructor.

**MAT 214 Calculus of Several Variables I (3) FWSpSu**

Introduction to vectors, dot products, cross products, equations of lines and planes. Calculus of Vector Valued Functions including unit tangents, unit normals and curvature. Introduction to multivariable functions, the Differential Calculus of Multivariable Functions, the chain rule, applications including extreme problems and Lagrange multipliers. 3 lecture/problem-solving. Prerequisite: C or better in MAT 116 or consent of instructor.

**MAT 215 Calculus of Several Variables II (3) FWSpSu**

Integral Calculus of Multivariable functions, double and triple Integrals, applications of double and triple integrals, line and surface integrals, Green's Theorem, Divergence Theorem, Stokes Theorem. 3 lecture/problem-solving. Prerequisite: C or better in MAT 214 or consent of instructor.

**MAT 216 Differential Equations (4) FWSpSu**

The theory of ordinary differential equations with emphasis on the linear case. 4 lecture/problem-solving. Prerequisite: C or better in MAT 116 or consent of instructor.

**MAT 224 Elementary Linear Algebra and Differential Equations (4)**

Separable and linear ordinary differential equations; numerical and analytical solutions. Linear algebra: vectors in  $n$ -space, matrices, linear transformations, eigenvalues, eigenvectors, diagonalization; applications to the study of systems of linear differential equations. 4 lecture/problem-solving. Prerequisite: C or better in MAT 116 or consent of instructor.

**MAT 299/299A/299L Special Topics for Lower Division Students (1-4)**

Group study of a selected topic, the title to be specified in advance. Total credit limited to 8 units, with a maximum of 4 units per quarter. Lecture/Activity/Laboratory or a combination. Prerequisite: Consent of instructor.

**MAT 306 History of Mathematics (4) FSp**

Development of mathematics over four millennia. Recommended for students preparing to teach mathematics. 4 lecture. Prerequisite: C or better in MAT 215 or consent of instructor.

**MAT 310 Basic Set Theory and Logic (4) FWSp**

Basic set theory and logic, relations, functions, mathematical induction, countable and uncountable sets. Emphasis on how to present and understand mathematical proof. 4 lecture/problem-solving. Prerequisite: C or better in MAT 116 or consent of instructor.

**MAT 314, 315 Intermediate Analysis (4) (4) FW/WSp**

Metric spaces and continuity. Analysis of functions of a single variable. Sequences, limits, continuity, differentiation, integration, introduction to function spaces. 4 lecture/problem-solving. Prerequisite for MAT 314: C or better in MAT 215 and MAT 310 or consent of instructor. Prerequisite for MAT 315: C or better in MAT 314 or consent of instructor.

**MAT 317 Laplace Transforms and Fourier Series (3) FWSpSu**

Introduction to Fourier Series and Integrals with applications. Elementary theory of Laplace transformation with applications including the solution of differential equations. 3 lecture/problem-solving. Prerequisite: C or better in MAT 216 or consent of instructor.

**MAT 318 Mathematical Analysis of Engineering Problems (3) FSpSu**

Introduction to the algebra and calculus of vectors including the divergence and Stokes' theorem. Introduction to analytic functions of a complex variable. Not open to mathematics majors for math elective credit. 3 lecture/problem-solving. Prerequisite: C or better in MAT 215 or consent of instructor.

**MAT 321 Introduction to Topology (4) F**

Topology of the line and plane, topological spaces, continuity and topological equivalence and topics selected from the following: bases and sub-bases, metric and normed spaces, countability axioms, separation axioms, compactness, connectedness, product spaces, completeness and function spaces. 4 lecture/problem-solving. Prerequisite: C or better in MAT 310 or consent of instructor.

**MAT 325 Introduction to the Theory of Numbers (4) FW**

Fundamentals of the system of integers, divisibility, congruences, theorems of Fermat and Wilson, power residues and indices, quadratic reciprocity, factorization techniques, diophantine equations, theorems of Euler, Gauss and Lagrange. Elementary results concerning the distribution of primes. 4 lecture/problem-solving. Prerequisite: junior standing or consent of instructor.

**MAT 330 Modern Euclidean Geometry (4) FW**

Euclidean geometry using modern techniques of transformations, inversions. Extension of elementary geometry to elegant results on triangles, circles, polygons, famous theorems of geometry, unsolved problems. Introduction to deductive reasoning and techniques of proof. 4 lecture/problem-solving. Prerequisite: consent of instructor.

**MAT 370 Graph Theory (4) FSp**

The study of graphs, trees, Eulerian, Hamiltonian, planar graphs, connectivity, coloring, independence and covering numbers, directed graphs, theorems of Menger, Ramsey with applications. 4 lecture/problem-solving. Prerequisite: consent of instructor.

**MAT 380 Mathematics of Operations Research (4) F (even years)**

Introduction to mathematics of linear programming (LP): algebra and geometry of simplex method, solution of LP problems by Gauss-Jordan elimination method. Duality theory and sensitivity analysis. Development of revised and dual simplex algorithms. Introduction to parametric and separable convex programming. Applications of LP: computational considerations, case studies. 4 lecture/problem-solving. Prerequisites: C or better in MAT 208 and 215 or consent of instructor.

**MAT 381 Mathematics of Operations Research (4) W (odd years)**

Solution of transportation, transshipment and assignment problems. Formulation and solution of network problems: maximal flow, minimal spanning tree, shortest route problems; PERT-CPM techniques. Introduction to dynamic and integer programming. Elements of game theory, solution of games by linear programming. Introduction to non-linear programming: Kuhn-Tucker conditions, quadratic and convex programming; SUMP solution procedure. 4 lecture/problem-solving. Prerequisite: C or better in MAT 380 or consent of instructor.

**MAT 394 Elementary Mathematics from an Advanced Viewpoint: Algebra (4) FWSpSu**

Analysis of patterns and functions; proportional reasoning as foundational to algebra; inductive and deductive reasoning; proofs. 4 lecture/problem-solving. Prerequisite: C or better in MAT 194 or equivalent. (See Mathematics department for details).

**MAT 395 Elementary Geometry from an Advanced Viewpoint: Geometry (4) FWSpSu**

Analysis of construction of geometric figures; estimation and measurement of perimeter, area and volumes of shapes; induction and deductive geometric proofs. 4 lecture/problem-solving. Prerequisites: C or better in MAT 394.

**MAT 400 Special Study for Upper Division Students (1-2)**

Individual or group investigation, research, studies or surveys of selected problems. Total credit limited to 4 units, with a maximum of 2 units per quarter.

**MAT 401 Numerical Analysis (4) F (odd years)**

Theoretical error and machine error associated with algorithms. Solutions of non-linear equations, systems of linear equations and systems of non-linear equations. 4 lecture/problem-solving. Prerequisite: C or better in MAT 201, MAT 208, MAT 215 and CS 128 or consent of instructor.

**MAT 402 Numerical Methods in Differential Equations (4) W (even years)**

Polynomial interpolation, cubic splines, numerical differentiation and integration, numerical solutions of differential equations including

Runga-Kutta methods and predictor-corrector methods for solving initial value problems and the shooting method for solving boundary value problems. 4 lecture/problem-solving. Prerequisites: C or better in MAT 216 and either MAT 401 or CS 301 or consent of instructor.

#### **MAT 413 Advanced Calculus (4) Sp (odd years)**

Differential and integral calculus of functions and transformations in several real variables. 4 lecture/problem-solving. Prerequisite: C or better in MAT 315 or consent of instructor.

#### **MAT 415 Foundations of Geometry (4) Sp (even years)**

Axiomatic development of selected topics from Euclidean and neutral geometries; introduction to non-Euclidean geometry with emphasis on the hyperbolic case. 4 lecture/problem-solving. Prerequisite: C or better in MAT 208 and 215 or consent of instructor.

#### **MAT 416 Projective Geometry (4) Sp (odd years)**

Synthetic and analytic treatment of selected topics from projective geometry; classical theorems, conics, polarities; quadratic and bilinear forms. 4 lecture/problem-solving. Prerequisite: C or better in MAT 208 and 215 or consent of instructor.

#### **MAT 417, 418 Modern Algebra (4) (4) FW/WSp**

Introduction to algebraic structures; groups, rings, integral domains, fields; mappings with emphasis on morphisms. 4 lecture/problem-solving. Prerequisite for MAT 417: C or better in MAT 310 or consent of instructor. Prerequisite for MAT 418: C or better in MAT 417 or consent of instructor.

#### **MAT 419 Abstract Linear Algebra (4) Sp (even years)**

Vector spaces and dimension, linear transformations, dual spaces, adjoints of transformations, multilinear forms, eigenvectors, the Cayley-Hamilton theorem, inner product spaces, orthogonality, similarity transformations, the spectral theorem, Jordan form. 4 lecture/problem-solving. Prerequisite: C or better in MAT 208 or consent of instructor.

#### **MAT 420 Differential Geometry (4) W (even years)**

The Frenet formulas, covariant derivatives, frame fields, the structure equations, differential forms on a surface, normal curvature, Gaussian curvatures; intrinsic geometry of surfaces in  $E^3$ , the Gauss and Bonnet theorem. 4 lecture/problem-solving. Prerequisite: C or better in MAT 314 and MAT 216 or consent of instructor.

#### **MAT 428 Functions of a Complex Variable I (4) F (odd years) W**

Algebra and geometry of complex numbers; analyticity, mappings of elementary functions; Cauchy integral formula, Taylor and Laurent series, the residue theorem; conformal mapping with applications. 4 lectures/problem-solving. Prerequisite: C or better in MAT 314 or consent of instructor.

#### **MAT 429 Functions of a Complex Variable II (4)**

Check with Department. Continuation of Topics in MAT 428. 4 lecture/problem-solving. Prerequisite: C or better in MAT 428 or consent of instructor.

#### **MAT 431, 432 Differential Equations (4) (4) W/Sp (odd years)**

Partial differential equations with applications to wave actions, heat transfer and fluid flow. Ordinary differential equations; linear with variable coefficients, linear systems; stability and qualitative behavior of solutions. 4 lecture/problem-solving. Prerequisite: C or better in MAT 216 and 208 or consent of instructor.

#### **MAT 444 Vector and Tensor Analysis (4) W (odd years)**

An integrated course in the algebra and calculus of vectors and tensors; topics in differential geometry; applications to mechanics of deformable media, hydrodynamics, general relativity. 4 lecture/problem-solving. Prerequisite: C or better in MAT 208 and 216 or consent of instructor. PHY 321 is recommended.

#### **MAT 450 Foundations of Mathematics (4) Sp (odd years)**

Introduction to axiom systems including consistency, independence, satisfiability and completeness; transfinite arithmetic; the continuum hypothesis; well-ordering and its equivalents. 4 lecture/problem-solving. Prerequisite: C or better in MAT 310 or consent of the instructor.

#### **MAT 461, 462 Senior Project (2) (2)**

Selection and completion of a project under faculty supervision. Projects typical of problems which graduates must solve in their fields of employment. Project results are presented in a formal report. Minimum of 120 hours total time.

#### **MAT 463 Undergraduate Seminar (2)**

Discussions through seminar methods of new developments in the fields of student's particular interests. 2 lecture/discussion. Prerequisite: senior standing in mathematics.

#### **MAT 470 Combinatorics (4) FW**

Study of enumeration techniques, permutations, combinations, principle of inclusion and exclusion, finite fields, combinatorial designs, error-correcting codes. 4 lecture/problem-solving. Prerequisite: C or better in MAT 208 or consent of instructor.

#### **MAT 480 Mathematical Programming (4) Sp (odd years)**

Treatment of linear inequalities, duality, general algorithms, application of linear programming. Introduction to discrete and nonlinear programming. 4 lecture/problem-solving. Prerequisite: C or better in MAT 208 and either CS 125 or 128 or consent of instructor.

#### **MAT 485, 486 Mathematical Modeling and Simulation (4) (4) W/Sp (even years)**

Introduction to the general principles of modeling. Models will be selected from the areas such as physics, biology, political science, chemistry, engineering and business. Analytical, numerical and simulation methods will be used to solve the models. 4 lecture/problem-solving. Prerequisites: C or better in the following courses: CS 128 or CS 125, MAT 201, MAT 208, MAT 216 and STA 241 or consent of instructor.

#### **MAT 492 Technological Applications in Mathematics (4) WSu**

Use of computers, microcomputers, calculators and other technologies in doing mathematics. Evaluation and utilization of instructional software in mathematics; use of application software including databases and spreadsheets; social issues related to microcomputer use. This course is intended for future teachers at the middle and high school levels. 4 lecture/problem-solving.

#### **MAT 493 Algebraic Structures and Computing for Elementary and Middle School Teachers (4) FSp**

Development of algebraic structures from groups to fields. Study of modular arithmetic, relationships and functions. Use of the computer, to investigate algebraic relationships and algorithms. 4 lecture/problem-solving.

**MAT 494 Elementary Mathematics from an Advanced Viewpoint:  
Probability, Statistics, and Data Analysis (4)**

Basic notions of chance and probability, inferences, predictions and arguments based on data collection, organization and representation. 4 lectures/problem-solving. Prerequisite: C or better in MAT 394.

**MAT 495/495A, 496/496A, 497/497A Topics in Contemporary Secondary  
School Mathematics I, II, III (3/1) (3/1) (3/1) F/W/Sp**

Examination of the high school mathematics curriculum from an advanced viewpoint. Analysis of current issues and trends in secondary school mathematics. Use of technology in learning mathematics. Assessment of students' competency in mathematics. Field experiences in educational and non-educational settings. The first two quarters of the sequence are graded on a CR/NC. 3 hours lecture, 1 two-hour activity. Prerequisites: Completion of 28 units of 300 and 400-level mathematics courses, including MAT 417, 325, 306 and a course in Geometry selected from MAT 330, 415, or 416 or the equivalent of these three courses.

**MAT 499/499A/499L Special Topics for Upper Division Students (1-4)**

Group study of a selected topic, the title to be specified in advance. Total credit limited to 8 units with a maximum of 4 units per quarter. Prerequisite: consent of instructor. Lecture/activity/laboratory or combination of these.



## STATISTICS

Hoon Kim, Coordinator

### STA 120 Statistics with Applications (4) FWSpSu

Collection and summarization of data; measures of central tendency and dispersion; probability; binomial and normal distributions, confidence intervals and hypothesis-testing. Not open to mathematics or engineering majors. 4 lecture/problem-solving. Prerequisites: Within the last THREE quarters, must have either achieved a minimum placement score on the appropriate MDPT or C or better in MAT 12, or MAT 105, or MAT 106, or MAT 125, or MAT 191; or, within the last year must have earned 50 or better on the ELM; or, within the last 18 months must have earned either 550 or better on the SAT or 23 or better on the ACT.

### STA 200 Special Study for Lower Division Students (1-2)

Individual or group investigation, research, studies or surveys of selected problems. Total credit limited to 4 units, with a maximum of 2 units per quarter.

### STA 210 Statistical Computing (4) Sp

Use of computer packages, inferences about means of two populations, dependent and independent samples, small and large samples, inferences about proportions and variances, correlation and regression. 4 lecture/problem-solving. Prerequisite: C or better in STA 120 or consent of instructor.

### STA 220 Discrete Probability Models (4) W

Set-theoretic approach to probability in finite sample spaces. Conditional probability, independence, binomial, hypergeometric and related distributions. 4 lecture/problem-solving. Prerequisite: C or better in MAT 105 or consent of instructor.

### STA 241 Applied Probability Theory (4) FW

Rules of Probability, random variables, expected values of random variables, distribution of functions of a random variable. Discrete and continuous probability distributions with applications. Sampling methods. Descriptive statistics, central limit theorem and estimation. 4 lecture/problem-solving. Prerequisite: C or better in MAT 116 or MAT 131 or consent of instructor. Not open to students with credit in STA 315 or ECE 315.

### STA 299/299A/299L Special Topics for Lower Division Students (1-4)

Group study of a selected topic; the title to be selected in advance. Total credit limited to 8 units, with a maximum of 4 units per quarter. Lecture/activity/laboratory or a combination. Prerequisite: consent of instructor.

### STA 309 Statistical Methods in Engineering and the Physical Sciences (3) FWSp

The uses of statistics in testing, inspection and production, measures of central tendency and dispersion, probability, binomial and normal distributions, sampling theory, hypothesis-testing and estimation, comparison of two populations. Not open to students required to take STA 315 or ECE 315. 3 lecture/problem-solving. Prerequisite: C or better in MAT 116 or MAT 131 or consent of instructor.

### STA 310 Sampling Theory and Applications (4) Sp (odd years)

Random Sampling including stratified, cluster, systematic, multistage, multiphase, and probability sampling methods. Derivations of estimators, error bounds and sample sizes. 4 lecture/problem-solving. Prerequisite: C or better in STA 120 or equivalent or consent of instructor

### STA 315 Probability and Statistics for Engineers (4)

Statistical and probabilistic concepts for the analysis of electrical and electronic systems associated with random phenomena. Application to communication, control, instrumentation and logic systems. 4 lecture/problem-solving. Prerequisite: C or better in MAT 215 or consent of instructor. Not open to students with credit in ECE 315, STA 309 or students required to take STA 241.

### STA 326 Statistical Methods for Computer Scientists (4) FWSpSu

Rules of Probability. Discrete and continuous distributions including the multinomial distribution. Sampling distributions. Point and interval estimation. Hypothesis-testing. Large and small sample inferences for means, proportions and variances. Introduction to queueing theory and regression. 4 lecture/problem-solving. Prerequisite: C or better in MAT 214 or consent of instructor. Not open to students required to take STA 241.

### STA 341 Applied Statistics (4) FWSp

Joint distributions, central limit theorem. Maximum likelihood estimation. Point and interval estimation, hypothesis-testing. Small and large sample inferences. Contingency table analysis and Chi-square tests. Linear regression and correlation. Use of computer package for applied problems. 4 lecture/problem-solving. Prerequisite: C or better in STA 241 and MAT 215 or consent of instructor.

### STA 400 Special Study for Upper Division Students (1-2)

Individual or group investigation, research, studies or surveys of selected problems. Total credit limited to 4 units, with a maximum of 2 units per quarter.

### STA 420 Nonparametric Statistics (4) W (odd years)

Common nonparametric tests such as permutation tests, sign tests, Wilcoxon test, chi-square test and rank correlation tests. Null distributions and their approximations. 4 lecture/problem-solving. Prerequisite: C or better in STA 210 or STA 326 or STA 341 or consent of instructor.

### STA 425 Applied Survival Analysis (4) (even years)

Survival models. Types of censoring. Life-tables. Estimation of survival functions from complete and incomplete mortality data. Actuarial and maximum likelihood methods. Kaplan-Meier estimator, Mantel-Haenszel and Log-rank tests. Probit and Logit models. Use of computer package such as SAS or MINITAB or S-plus. 4 lecture/problem-solving. Prerequisite: C or better in STA 341 or STA 326 or consent of instructor.

### STA 430 Introduction to Random Processes (4) Sp (even years)

General types of stochastic processes. Random walks, Poisson processes, counting processes, Markov chains and topics from other areas, such as Markov jump processes, Birth-death processes, Gaussian processes. 4 lecture/problem-solving. Prerequisite: C or better in STA 326 or STA 241 or consent of instructor.

### STA 432 Applied Regression Analysis (4) F (odd years)

Matrix approach to regression models, least square estimation, correlation, multiple regression, transformation of variables, analysis of residuals, multicollinearity and auto-correlation. Use of computer packages for applied problems. 4 lecture/problem-solving. Prerequisites: C or better in STA 326 or STA 341 and MAT 208 or consent of instructor.

**STA 435 Analysis of Variance and Design of Experiments (4) F (even years)**

ANOVA techniques, computer solutions, randomized groups and blocks designs, interactions, analysis of covariance. Latin square, split-plot, simple and confounded factorial designs; treatment of missing data, incomplete block designs. 4 lecture/problem-solving. Prerequisite: C or better in STA 326 or STA 341 or consent of instructor.

**STA 440 Mathematical Statistics I (4) W (odd years)**

Discrete and continuous probability distributions; moments, moment generating functions, special distributions, distributions of functions of random variables. 4 lecture/problem-solving. Prerequisite: C or better in MAT 215 or consent of instructor.

**STA 441 Mathematical Statistics II (4) Sp (odd years)**

Asymptotic distributions; central limit theorem; point and interval estimation; completeness and sufficient statistics; Neyman-Pearson theory of testing hypotheses. 4 lecture/problem-solving. Prerequisite: C or better in STA 440 or consent of instructor.

**STA 499/499A/499L Special Topics for Upper Division Students (1-4)**

Group study of a selected topic, the title to be specified in advance. Total credit limited to 8 units with a maximum of 4 units per quarter. Lecture/activity/laboratory or combination of these. Prerequisite: consent of instructor.

Graduate courses are listed in the "Graduate Studies" section of the catalog.

## PHYSICS

[www.csupomona.edu/~physics](http://www.csupomona.edu/~physics)

Steven McCauley, Chair

Nina Abramzon	Roger L. Morehouse
Antonio Aurilia	George W. Rainey
Suketu Bhavsar	Alexander Rudolph
John Fang	Homeyra Sadaghiani
Barbara Hoeling	Ertan Salik
Kai-Shue Lam	Peter B. Siegel
Hector C. Mireles	Alexander Small
Mary Mogge	Kurt G. Vandervoot

The major in physics prepares students for careers as physicists with industry, government, university laboratories, and in teaching. Through suitably chosen electives, students may emphasize the interdisciplinary areas of biophysics, astrophysics, computational physics, health physics, geophysics, physical chemistry, engineering or mathematics.

Physics majors enjoy relatively small upper division classes spanning experimental and theoretical aspects of classical and modern physics. They each complete a senior project under faculty supervision. Additionally, they are encouraged to participate in other independent or group study/research activities sponsored by individual faculty.

Students majoring in physics have the opportunity to join the honorary society, Sigma Pi Sigma. Additional information concerning membership can be obtained from the Physics Department.

For those planning a career as a secondary school teacher, a Single Subject Credential in Science is required. This credential is obtained by completing coursework in Education and passing the National Teacher Examination. The latter can be waived by taking the courses listed in the Waiver Program. See the Director of the Center for Education and Equity in Mathematics, Science and Technology.

### CORE COURSES FOR MAJOR

Required of all students. A minimum 2.0 cumulative GPA is required in core courses, including subplan courses, in order to receive a degree in the major.

General Physics	PHY	131	(3)
General Physics	PHY	132	(3)
General Physics	PHY	133	(3)
General Physics Laboratory	PHY	131L	(1)
General Physics Laboratory	PHY	132L	(1)
General Physics Laboratory	PHY	133L	(1)
General Physics	PHY	234	(3)
General Physics Laboratory	PHY	234L	(1)
Elementary Modern Physics	PHY	235	(3)
Elementary Modern Physics Laboratory	PHY	235L	(1)
Fundamentals of Mathematical Physics	PHY	308	(4)
Fundamentals of Mathematical Physics	PHY	309	(4)
Physics of Electric and Magnetic Phenomena	PHY	314	(4)
Physics of Electric and Magnetic Phenomena	PHY	315	(4)
Mechanics	PHY	321	(4)
Mechanics	PHY	322	(4)
Thermal Physics	PHY	333	(4)
Quantum Mechanics	PHY	401	(4)
Quantum Mechanics	PHY	402	(4)
Optics	PHY	417	(3)
Optics Laboratory	PHY	417L	(1)
Advanced Physics Laboratory	PHY	430L	(1)

Solid State Physics Laboratory	PHY	431L	(1)
Nuclear Physics Laboratory	PHY	432L	(1)
Senior Project	PHY	461	(2)
Senior Project	PHY	462	(2)
Undergraduate Seminar	PHY	463	(2)

### SUPPORT AND ELECTIVE COURSES

The following major support courses should be used to satisfy the indicated GE requirements. If these courses are not used to satisfy GE, the total units to degree may be more than 180 units.

Life Science* (B2)	BIO	110	(3)
and Life Science Laboratory* (B3)	BIO	111L	(1)
or Foundations of Biology* (B2, B3)	BIO	121/121L	(3/2)
General Chemistry* (B1, B3)	CHM	121/121L	(4)
Analytic Geometry and Calculus I* (B4)	MAT	114	(4)
General Chemistry	CHM	122/122L	(4)
General Chemistry	CHM	123/123L	(4)
Introduction to C++	CS	128	(4)
or FORTRAN	CS	125	(4)
Analytic Geometry and Calculus II	MAT	115	(4)
Analytic Geometry and Calculus III	MAT	116	(4)
Calculus of Several Variables	MAT	214	(3)
Calculus of Several Variables	MAT	215	(3)
Differential Equations	MAT	216	(4)

Advanced Electives (12)  
To be chosen from upper division courses in Physics or related fields in consultation with advisor; at least 4 units of these must be in Physics.)

Unrestricted Electives (0-1)

### GENERAL EDUCATION REQUIREMENTS

Students should consult the catalog website [www.csupomona.edu/~academic/catalog/](http://www.csupomona.edu/~academic/catalog/) for current information regarding this requirement. Unless specific courses are stated under Support Courses, see the list of approved courses under General Education Requirements, Areas A through E.

#### Area A. Communication and Critical Thinking (12 units)

1. Oral Communication
2. Written Communication
3. Critical Thinking

#### Area B. Mathematics and Natural Sciences (16 units)

1. Physical Science
2. Biological Science
3. Laboratory Activity
4. Mathematics/Quantitative Reasoning
5. Science and Technology Synthesis

#### Area C. Humanities (16 units)

1. Visual and Performing Arts
2. Philosophy and Civilization
3. Literature and Foreign Languages
4. Humanities Synthesis

#### Area D. Social Sciences (20 units)

1. U.S. History, Constitution, and American Ideals
2. History, Economics, and Political Science
3. Sociology, Anthropology, Ethnic and Gender Studies
4. Social Science Synthesis

#### Area E. Lifelong Understanding and Self-development (4 units)

**PHYSICS MINOR**

College Physics	PHY	121/121L	(4)
and College Physics	PHY	122/122L	(4)
and College Physics	PHY	123/123L	(4)
or			
General Physics	PHY	131/131L	(4)
and General Physics	PHY	132/132L	(4)
and General Physics	PHY	133/133L	(4)
and General Physics	PHY	234	(3)
and Elementary Modern Physics	PHY	235	(3)

A minimum of 30 units in physics, including the above, must be taken. Of these 30 units at least 12 units must be chosen from upper division courses (except that no more than 4 units may be from PHY 301, PHY 302, and PHY 303) and no more than 12 units at the 100-level. (30)

**Subject Matter Preparation – Program for Prospective Teachers of Science with a Concentration in Physics**

The Physics Department offers a program in science with a concentration in physics approved by the Commission on Teacher Credentialing. Those individuals who wish to become science teachers with an emphasis in physics in California public schools must complete the comprehensive list of courses as follows. The set of courses are separated into two parts, breadth courses and depth courses in an area of concentration.

**Breadth Courses:****Biological Sciences**

Foundations of Biology	BIO	121/121L	(3/2)
Foundations of Biology	BIO	122/122L	(3/2)
Foundations of Biology	BIO	123/123L	(3/2)

**Chemistry**

General Chemistry	CHM	121/121L	(3/1)
General Chemistry	CHM	122/122L	(3/1)
General Chemistry	CHM	123/123L	(3/1)

**Geosciences**

Principles of Geology	GSC	111/141L	4/1
Earth, Time and Life	GSC	112/151L	(3/1)
Descriptive Physical Oceanography	GSC	335	(4)

**Physics**

General Physics (Mechanics)	PHY	131/131L	(3/1)
General Physics (Waves and Heat)	PHY	132/132L	(3/1)
General Physics (Electricity and Magnetism)	PHY	133/133L	(3/1)

**Interdisciplinary Science**

Senior Level Integrated Science	SCI	495	(8)
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**Depth Courses:**

General Physics	PHY	234/234L	(3/1)
Elementary Modern Physics	PHY	235/235L	(3/1)
Electronics for Scientists	PHY	304	(4)
Fundamentals of Mathematical Physics	PHY	308	(4)
Fundamentals of Mathematical Physics	PHY	309	(4)
Physics of Electric and Magnetic Phenomena	PHY	314	(4)
Mechanics	PHY	321	(4)
Thermal Physics	PHY	333	(4)

Select one:

Advanced Physics Laboratory	PHY	430L	(1)
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Solid State Physics Laboratory	PHY	431L	(1)
Nuclear Physics Laboratory	PHY	432L	(1)
Select one:			
Applied Optics	PHY	344	(4)
Computational Physics	PHY	409	(4)
Biophysics	PHY	410	(4)
Optics	PHY	417/417L	(3/1)

**COURSE DESCRIPTIONS**

The quarters in which particular courses are offered are indicated by the F, W, Sp, Su notations. If a course is not given each year, an indication of its offering in odd or even years is given.

**PHY 102 Fundamentals of Physics (4)**

Various theories of matter and energy and the principles and laws that describe their behavior and applications. Some special knowledge of modern science that will function in a socially desirable manner in the lives of students. 4 lectures. Prerequisite: A college math course. PHY 102 is not open to students who have credit for PHY 121 or 131. May be graded on CR/NC basis.

**PHY 105/105L Physics of Musical Sound (4) Sp (even years)**

The fundamentals of acoustics and its application to music-vibrations, wave, hearing, pure tones, complex tones, resonance, scales, consonance, and the physics of musical instruments. 3 lecture/problems, 1 three-hour laboratory.

**PHY 121 College Physics (3) FWSpSu**

A study of vectors, motion, forces, gravity, work and energy, momentum, angular motion and mechanical properties of matter. 3 lectures/problem-solving. Not for students majoring in physics or engineering. Prerequisite: MAT 106, or MAT 114, or equivalent. Corequisite: PHY 121L.

**PHY 122 College Physics (3) FWSpSu**

Heat, wave motion, sound, light and optical devices. 3 lectures/problem-solving. Prerequisite: PHY 121 and PHY 121L. Corequisite: PHY 122L.

**PHY 123 College Physics (3) FWSpSu**

Electricity and magnetism, DC and AC circuits, electronics, atomic and nuclear physics. 3 lectures/problem-solving. Prerequisite: PHY 122 and PHY 122L. Corequisite: PHY 123L.

**PHY 121L, 122L, 123L College Physics Laboratory (1) (1) (1) FWSpSu**

Laboratory to accompany College Physics lecture series. Experiments in mechanics, hydrostatics, wave motion, thermodynamics, optics, electricity and magnetism, and atomic and nuclear physics. 1 three-hour laboratory. To be taken in sequence concurrently with PHY 121, 122, 123, respectively.

**PHY 131 General Physics (3) FWSpSu**

Fundamental principles of mechanics, vectors, statics, uniform motion, accelerated motion, work and energy, momentum, and rotational motion. 3 lectures/problem-solving. Prerequisite: MAT 114 or MAT 130. Corequisites: MAT 115 or MAT 131, and PHY 131L.

**PHY 132 General Physics (3) FWSpSu**

Fundamental principles of fluid mechanics, harmonic motion, waves, thermodynamics, and kinetic theory. 3 lectures/problem-solving. Prerequisite: MAT 115 or MAT 131, C- or better in PHY 131. Corequisites: MAT 116 or MAT 132, and PHY 132L.

**PHY 133 General Physics (3) FWSpSu**

Fundamental principles of electricity and magnetism, Coulomb's law, electric fields, potential, properties of dielectrics, capacitance, Ohm's law, magnetism and magnetic fields, measuring instruments, and induced emf. 3 lectures/problem-solving. Prerequisite: MAT 115 or MAT 131, C- or better in PHY 131. Corequisites: MAT 116 or MAT 132, and PHY 133L.

**PHY 131L, 132L, 133L General Physics Laboratory (1) (1) (1) FWSpSu**

Laboratory to accompany General Physics lecture series. Experiments in mechanics, hydrostatics, wave motion, thermodynamics, optics, and electricity and magnetism. 1 three-hour laboratory. To be taken concurrently with PHY 131, 132, 133, respectively.

**PHY 200 Special Study for Lower Division Students (1-2) FWSpSu**

Individual or group investigation, research, study or survey of selected problems. Approval of problem must be obtained in the Physics Department office prior to enrollment. Total credit limited to 4 units with a maximum of 2 units per quarter.

**PHY 234 General Physics (3) W**

AC circuits, electromagnetic oscillations, Maxwell's equations and electromagnetic waves, geometric optics, physical optics, and special theory of relativity. 3 lectures/problem-solving. Prerequisite: PHY 132, 133, with C- or better in both courses..

**PHY 234L General Physics Laboratory (1) W**

Experiments on optics and electromagnetism. 1 three-hour laboratory. .

**PHY 235 Elementary Modern Physics (3) Sp**

Origin of the quantum theory; Bohr theory; wave mechanics and atomic structure; introduction to nuclear physics. 3 lectures/problem-solving. Prerequisite: PHY 234.

**PHY 235L Elementary Modern Physics Laboratory (1) Sp**

Experiments illustrative of modern physics. 1 three-hour laboratory. .

**PHY 299, 299A, 299L Special Topics for Lower Division Students (1-4) FWSpSu**

Group study of a selected topic, the title to be specified in advance. Total credit limited to 8 units, with a maximum of 4 units per quarter. Instruction is by lecture, laboratory or a combination.

**PHY 301 Energy and Society (4) F**

Study of how petroleum, solar, nuclear, and other energy sources generate electricity, power vehicles, and the like. Emphasis is on elementary physics principles. Coverage includes historical patterns of societal energy use, renewable and nonrenewable resources, fuel conservation methods, and environmental impacts. Open to all majors. 4 lectures. Prerequisites: one course from each of the following Sub-areas: A1, A2, A3 and B1, B2 (Physics), B4. GE Synthesis course for Sub-area B5.

**PHY 302 Physics of Everyday Experience (4) W**

Investigation into physics associated with everyday life experiences with applications to natural phenomena, social issues, and technological advances. Examples include thermodynamics of global warming; effects of earthquake waves on building vibrations; optical principles in optical communication. 4 onehour lecture/discussions. Prerequisites: one

course from each of the following Subareas: A1, A2, A3 and Subareas B1, B2 (Physics), B4. GE Synthesis course for Subarea B5.

**PHY 303 The Universe in Ten Weeks (4) FSp**

This course investigates answers to questions such as: What is the nature of the cosmos? How did the universe begin? What are the smallest constituents of the universe and what are their properties?, etc., through a historical-sociological-scientific overview of our present understanding of the universe. The emphasis is on the modern description of the beginning of the universe, its constitution, and its evolution, as discovered and interpreted by astronomers and chemists, mathematicians and physicists. 4 lectures. Prerequisite: Completion of GE Area A and Sub-areas B1, B2, and B4, including a physics or astronomy course from B1. GE Synthesis course for Sub-area B5.

**PHY 304/304L Electronics for Scientists (3/1) F**

For students majoring in biological sciences, chemistry, geology and other scientific areas, as well as for physics majors. Basic concepts of electrical circuits and solid state devices. Circuit analysis and operation of instruments commonly encountered in science laboratory. 3 lectures/problem-solving, 1 three-hour laboratory. Prerequisite: PHY 123 or 133.

**PHY 306 History of Physics (4) F**

This course addresses questions such as: How did Physics begin in the ancient Greek world? Why was the scientific tradition continued and developed in the Islamic world while Western Europe fell into a dark age? Why did the Scientific Revolution occur in the time and place that it did? How has the relationship of science and religion changed through time? How have the discoveries of modern Physics modified our worldview? What is it about Physics that makes it a unique way of learning about the world? 4 lecture/discussions. Open to all majors. Prerequisites: one course from each of the following Sub-areas: A1, A2, A3 and B1, B2, and B4. GE Synthesis course for Sub-area B5.

**PHY/GSC 307/307L Introduction to Global Geophysics (3/1) F**

The physics of the solid Earth and its applications. The following topics will be discussed: the theory of plate tectonics; magnetics, seismology and gravity; radioactivity and heat; the deep interior of the Earth and physical processes of the mantle and core; applications to specific regions on Earth. Throughout the course, special attention will be given to new research results and the interpretation of actual data. 3 hours of lecture + 3 hours lab. Prerequisite: MAT 112.

**PHY 308 Fundamentals of Mathematical Physics (4) F**

Applications of mathematical tools to problems in the study of electromagnetism, mechanics and quantum mechanics. Linear algebra, coordinate systems, vector analysis, ordinary differential equations, Fourier series. 4 lectures/problem-solving. Prerequisites: PHY 235, MAT 215, 216.

**PHY 309 Fundamentals of Mathematical Physics (4) W**

Continuation of PHY 308. Applications of gamma, beta and error functions; functions of a complex variable; partial differential equations and boundary value problems; series solutions of ordinary differential equations in physics problems. 4 lectures/problem-solving. Prerequisite: PHY 308.

**PHY 310 Fundamentals of Mathematical Physics (4) Sp (even years)**

Continuation of PHY 308 and 309. Applications of calculus of variations, tensor analysis, integral transforms, probability and statistics to physics problems. 4 lectures/problem-solving. Prerequisite: PHY 309.

**PHY 314, 315 Physics of Electric and Magnetic Phenomena (4) (4) WSp**

Electrostatics, magnetostatics, circuit theory, time-varying fields, Maxwell's equations and electromagnetic waves. 4 lectures/problem-solving. Courses must be taken in sequence. Prerequisite: PHY 308, PHY 309 (latter may be taken concurrently with PHY 314).

**PHY 321, 322 Mechanics (4) (4) WSp**

Vector algebra, principles of Newtonian mechanics, conservative forces, harmonic motion, central-force motion, the two-body problem, center of mass coordinates, statics and dynamics of rigid bodies, accelerated coordinate systems, normal coordinates and Lagrange's equations. 4 lectures/problem-solving. Courses must be taken in sequence. Prerequisite: PHY 308, PHY 309 (latter may be taken concurrently with PHY 321).

**PHY 333 Thermal Physics (4) F**

Fundamental principles of thermodynamics and kinetic theory of gases. 4 lectures/problem-solving. Prerequisite: PHY 132 and MAT 215, 216.

**PHY 344 Applied Optics (4) F**

Geometrical optics and wave optics with an emphasis on technological applications. 4 lectures/problem-solving. Prerequisite: PHY 131 or 121.

**PHY 400 Special Study for Upper Division Students (1-2) FWSpSu**

Individual or group investigation, research, study or survey of selected problems. Approval of problem must be obtained in the Physics Department office prior to enrollment. Total credit limited to 4 units with a maximum of 2 units per quarter.

**PHY 401 Quantum Mechanics (4) F**

Introduction to quantum mechanics, including Schrodinger equation, hydrogen atom, degeneracy, perturbation theory, multi-electron atoms, matrix mechanics. 4 lectures/problem-solving. PHY 401 and 402 must be taken in sequence. Prerequisites: PHY 235 or CHM 313, and PHY 309.

**PHY 402 Quantum Mechanics (4) W**

Continuation of PHY 401. Introduction to quantum mechanics, including Schrodinger equation, hydrogen atom, degeneracy, perturbation theory, multi-electron atoms, matrix mechanics. 4 lectures/problem-solving. PHY 401 and 402 must be taken in sequence. Prerequisites: PHY 235 or CHM 313, and PHY 309.

**PHY 403 Advanced Quantum Mechanics (4) Sp**

Advanced topics in quantum mechanics, including approximation methods, time-dependent perturbation theory, relativistic theory and frontiers. 4 lectures/problem-solving. Prerequisite: PHY 402.

**PHY 404 Introduction to High Energy Physics (4) W (odd years)**

History and concepts of high energy and elementary particle physics; fundamental interactions; quantum numbers, invariance principles and conservation laws; SU(3) quark model and QCD; particle detectors and accelerators. 4 lectures. Prerequisite: PHY 401. Corequisite: PHY 402.

**PHY 406 Solid State Physics (4) W (even years)**

Crystallography, crystal imperfections, diffusion. Metals, ionic crystals, covalent crystals, molecular crystals. Transport properties and specific heat of metals. Electronic states in solids, physical properties of semiconductors, theory of semiconductor devices. Behavior of dielectrics, magnetism and superconductors. 4 lectures/problem-solving. Corequisite: PHY 309.

**PHY 407 Statistical Physics (4) Sp (odd years)**

Study of the statistical behavior of physical systems composed of large numbers of similar particles. Derivation and application of the distribution functions for the cases of Maxwell-Boltzmann statistics, Bose-Einstein statistics and Fermi-Dirac statistics. 4 lectures/problem-solving. Prerequisite: PHY 235 and PHY 333.

**PHY 409 Computational Physics (4) F (odd years)**

Computational methods, which include numerical integration, the solution of differential and transcendental equations, and statistical analysis, are applied to problems in mechanics, electromagnetism, quantum mechanics and non-linear dynamics. Familiarity with programming techniques such as loops, arrays, and functions is expected, at the level of CS 128 or ECE 114. 4 lectures/problem-solving. Prerequisites: PHY 133 and one of MAT 208, MAT 216, or MAT 224.

**PHY 410 Biophysics (4) W (odd years)**

Concepts and mechanisms involved in the interpretation of biological systems. A description of living processes in physical terms. (See also BIO 410) 4 lectures/problem-solving. Prerequisite: PHY 123, or PHY 132 and 133.

**PHY 417 Optics (3) Sp**

Mirrors, lenses and optical instruments; interference, diffraction, polarization and elements of spectroscopy; lasers and holography. 3 lectures/problem-solving. Prerequisite: PHY 234. Corequisite for physics majors: PHY 417L.

**PHY 417L Optics Laboratory (1) Sp**

Laboratory to be taken concurrently with PHY 417. One 3-hour laboratory.

**PHY 420 Acoustics (4) Sp (odd years)**

The fundamentals of acoustical vibrations, baffle effects, resonance and filters, and transmission phenomena will be presented using differential equations and complex variables. 4 lectures/problem-solving. Prerequisites: PHY 132 and MAT 215, 216.

**PHY 422 Plasma Physics (4) F (even years)**

Fundamental concepts and ideas in the study of ionized gases, including orbit theory, the "two-fluid" equations, magnetohydrodynamics and the Vlasov theory. Plasma phenomena, such as waves, diffusion, equilibrium, stability and others. 4 lectures/problem-solving. Prerequisite: PHY 133.

**PHY 424 Astrophysics (4) F (odd years)**

Basic astrophysical data, stellar atmospheres and spectra, stellar structure and evolution, galactic structure and interstellar matter, galaxies and cosmology. 4 lectures/problem-solving. Prerequisite: PHY 235.

**PHY 425 Space Physics (4) W (even years)**

Planetary motions, gravitation, celestial mechanics, interplanetary space missions, techniques of space borne planetary observation, planetary physics. 4 lectures/problem-solving. Prerequisites: PHY 235, 321 (may be taken concurrently).

**PHY 426 Relativity, Gravity and Black Holes (4) Sp (even years)**

Review of special relativity, principle of equivalence, tensors, the metric tensor, general theory of relativity, cosmological models, gravitational

waves, black holes, Hawking radiation, quantum gravity, connection with elementary particle theories. 4 lectures/problem-solving. Prerequisite: PHY 235, 315 (may be taken concurrently), 322 (may be taken concurrently).

#### **PHY 430L Advanced Physics Laboratory (1) F**

Topics in advanced experimental physics with emphasis on electromagnetism and mechanics. One 3-hour laboratory. Prerequisites: PHY 235, 235L, 315, 322. (PHY 430L, 431L and 432L may be taken in any order.)

#### **PHY 431L Solid State Physics Laboratory (1) W**

Topics in experimental solid state physics. One 3-hour laboratory. Prerequisites: PHY 235, 235L, 315, 322. (PHY 430L, 431L and 432L may be taken in any order.)

#### **PHY 432L Nuclear Physics Laboratory (1) F**

Topics in experimental nuclear physics. One 3-hour laboratory. Prerequisites: PHY 235, 235L, 315, 322. (PHY 430L, 431L, and 432L may be taken in any order.)

#### **PHY 441 Internship in Physics (2) FWSpSu**

Practical, on-the-job training and work experience in physics. Approval of Physics Department Chair required prior to enrollment. Course grade

determined by internship coordinator and on-job supervisor. Total credit limited to 6 units.

#### **PHY 461, 462 Senior Project (2) (2) FWSpSu**

Selection and completion of a project under faculty supervision. Projects typical of problems which graduates must solve in their fields of employment. Project results presented in a formal report and brief oral presentation. Approval of Physics department chair required prior to enrollment.

#### **PHY 463 Undergraduate Seminar (2) Sp**

Study of current developments in physics and discussion of periodicals of an appropriate level. 2 lecture discussions. Prerequisite: PHY 234.

#### **PHY 499/499A/499L Special Topics for Upper Division Students (1-4) FWSpSu**

Group study of a selected topic, the title to be specified in advance. Total credit limited to 8 units with a maximum of 4 units per quarter. Instruction is by lecture, laboratory or a combination.

#### **PHY 550 Seminar in Physics (1-3)**

Special study in selected areas of physics. Seminar, 1 to 3 hours. Maximum of 6 units may be earned.



## INSTITUTE FOR ADVANCED SYSTEMS STUDIES

One of the Minors offered in the College of Science is Comparative Systems Analysis. It is also offered as a Certificate Program through the College of the Extended University Program.

Len Troncale, Director, Institute; Coordinator, Minor

The Institute offers interdisciplinary courses for general education as well as leading to the Minor and Certificate in Comparative Systems Analysis (CSA). The general systems processes studied by the Institute are ideal unifying themes that synthesize knowledge of both natural and social systems at a fundamental level. The Minor is designed to complement a wide variety of major fields from the various schools in the University. The diverse specialties of Systems Analysis in Business, Management, Information Systems, Computer Systems, Environmental Design fields and Engineering constitute the fastest growing job category in the United States over the next decade according to government statistics. Students completing this Minor in conjunction with a major in their specialty fields will have developed skills in high demand for analyzing complex modern societal problems. Coursework in this Minor emphasizes the pure science aspects of systems; it focuses on what might be called the special theoretical knowledge of systems fundamental to the many practical applications mentioned above. Laboratory and field experiences in the Minor focus on application of transdisciplinary techniques and methodology and expose the student to ideas and faculty from a broad spectrum of specialties unified by general systems analytic approaches. According to our surveys, CSA graduates are sought after by high technology firms because they are adept at the critically-needed skills of large-scale, interdisciplinary team communications and production. The Minor and Certificate in Comparative Systems Analysis requires the completion of a minimum of 32 units. Admission to the Minor and Certificate Programs is required previous to enrollment in these courses. Interested students should contact Dr. Troncale.

### COURSE DESCRIPTIONS

NOTE: For all courses which have both a lecture component and a laboratory component (e.g. CSA 201/201A), both components are corequisites; that is, they must be taken concurrently. All the following are taught by interdisciplinary teams of Institute Fellows.

#### CSA 201/201A Humans and the Environment—Resources (2/2)

The dynamic relationship between people, earth's natural resources, and environmental problems: a transdisciplinary approach with problem-oriented activities emphasizing general systems concepts for synthesis and comparison. Uses the case study approach for depth.

#### CSA 202/202A Humans and the Environment – Organizations (2/2)

How political, economic and cultural organizations and human values impact people, the uses of technology and people's relationship with the environment. A transdisciplinary approach with problem-oriented activities emphasizing general systems concepts for synthesis and comparison. Uses the case study approach for depth.

#### CSA 250 Integrated Science I (5)

Key facts, theories, tools, and techniques of seven sciences integrated by showing how their phenomena are examples of the same fundamental systems processes, hierarchies and emergence, flows and networks, boundaries and limits. Includes similarities and differences of the scientific method across the sciences, and similarities between the natural and social sciences. No lectures. Multimedia self-study, two 2-hour, face-to-face skill-training and discussion sessions weekly. One

interdisciplinary lab session every 3 weeks. (Also listed as SCI/CSA 250)

#### CSA 251 Integrated Science II (5)

Key facts, theories, and techniques of seven sciences integrated by showing their phenomena are examples of the same fundamental systems processes, feedback and regulation, cycles and oscillations, stability and equilibrium. Includes similarities and differences of the scientific method across the sciences, and similarities between the natural and social sciences. No lectures. Multimedia self-study, 2 two-hour, face-to-face skill-training and discussion sessions weekly. One interdisciplinary lab session every 3 weeks. Prerequisite: SCI/CSA 250. (Also listed as SCI 251)

#### CSA 300 History and Philosophy of Systems Science (6)

History and context of general systems theory from classical philosophy to the present; its tenets, strengths, weaknesses and relationship to conventional and design disciplines, the relevance of systems science to complex human problems. Survey of its literature, investigators, institutions and organizations. 4 lecture discussions.

#### CSA 305 General Morphology and Systems Allometry (4)

General principles of morphology and their application to various sciences. Dimensionless morphology in mathematics and the natural sciences. Mathematical structures and concepts developed morphologically to illustrate the method. Identification, and rigorous empirical, statistical testing of trends observable across level-to-level evolution of natural hierarchies. 4 lectures. Prerequisite: approval of instructor.

#### CSA 309 Comparative Science of Origins (4)

Cross-disciplinary survey of the mechanisms of origin of most levels of living and nonliving systems using synthetic concepts to integrate the scientific evidence. Emergence of sub-atomic particles to clusters of galaxies, from the origins of consciousness to civilization. Impact of scientific findings on centuries-old philosophical debates and human values. 4 lecture discussions.

#### CSA 310 Integrated Science III (6)

Key facts, theories, tools, and techniques of seven sciences integrated by showing how their phenomena are examples of the same fundamental systems processes, symmetry and duality, chaos and origins, development and evolution. Includes similarities and differences of the scientific method across science, and similarities between the natural and social sciences. No lectures. Multimedia self-study, 2 two-hour, face-to-face skill-training and discussion sessions weekly. One interdisciplinary lab session every 3 weeks. Prerequisite: SCI/CSA 251. (Also listed as SCI 310)

#### CSA 340/340A Systems Law and Legislation (2/2)

Law applied to optimizing and correcting systems; survey of legislation and case law dealing with environmental problems. Emphasis on the special difficulties in writing laws of a multidisciplinary nature. 2 lectures, 2 two-hour activities.

#### CSA 350/350A Multimetrics (2/2)

Techniques and methods of measurement systems; comparative uses of metrics; design and application of metrics to human and environmental problems. Emphasis on exploration of the application of metric principles to the evaluation of qualitative differences. 3 lectures, 1 two-hour activity. Prerequisite: Any statistics course.



**CSA 411/411A General Systems Theory I: Processes (3/1)**

Use of 80 candidate systems processes isomorphic across natural and social systems to describe how they work. Insights into the similarities and differences between natural and social systems. Impacts on society. 3 lectures, 1 two-hour activity. A computerized multimedia, distanced learning course.

**CSA 412/412A General Systems Theory II: Linkages (3/1)**

Survey of hundreds linkage propositions between systems processes learned in CSA 411. 3 lectures, 1 two-hour activity. Prerequisite: CSA 411/411A.

**CSA 413/413A General Systems Theory III: Artificial Systems Research (3/1)**

Use of systems processes in cyberspace models to study man-made systems malfunctions. Use of systems processes to engineer optimal systems. 3 lectures, 1 two-hour activity. Prerequisite: CSA 412/412A.

**CSA 440 General Systems Modeling and Simulation (4)**

Using isomorphies and systems-level computer simulation tools in modeling complex dynamical systems and their problems. Survey, comparison and training in use of STELLA, EXTEND, CAST and GENSYNS with testing of their use of systems concepts. Evaluating global system models and their effects on decision-makers 4 lecture discussions.

**CSA 450 Comparative Systems Analysis I. (4)**

Evolution of systems approach to problem solving; comparative overview of dozens of systems methodologies. Case studies illustrating successful versus unsuccessful applications of the systems approach to governmental, biological, social, economic and technological problems. 4 lectures. Prerequisites: CSA 300.

**CSA 451/451L Comparative Systems Analysis II. (3/1)**

New approaches to modeling emerging from the sciences of complexity. Case studies illustrating applications of systems analysis techniques and design of new techniques. 3 lectures, 1 three-hour laboratory. Prerequisite: CSA 450.

**CSA 470 Applied Ecosystems Engineering (4)**

History, potential and critical analysis of applications of natural systems concepts to environmental systems engineering. Linked systems isomorphies, allometry, modeling and techniques applied to systems taxonomies of current large-scale environmental, energy and societal problems. 4 lecture discussions. Prerequisites: BIO 325/325L; CSA 413/413A.

**CSA 490 Seminar in Comparative Systems Analysis (1-4)**

Special problems in selected areas of comparative systems analysis. Each seminar will have a subtitle describing its nature and content. Seminar, 1 to 4 hours. May be repeated for a maximum of 8 units. Prerequisite: consent of instructor.

