



COLLEGE OF S



SCIENCE

## COLLEGE OF SCIENCE

Simon J. Bernau, Dean  
Victor P. Abegg, 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.

### Departments and Majors

#### BIOLOGICAL SCIENCES

Lenard Troncale, Chair

Biology major (BS); Biotechnology major (BS); Botany major (BS); Microbiology major (BS); Option in Microbiology, Option 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

Keith Howard, Chair

Chemistry major (BS) Option in Chemistry; Option in Chemical Sciences; Option in Industrial Chemistry  
Minor in Chemistry  
Master of Science in Chemistry

#### COMPUTER SCIENCE

Mandayam Srinivas, Chair

Computer Science major (BS)  
Minors in Computer Systems Organization, Scientific Computer Programming and Artificial Intelligence  
Master of Science in Computer Science

#### GEOLOGICAL SCIENCES

John A. Klasik, Chair

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

**MATHEMATICS**

Claudia Pinter-Lucke, Chair

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

**PHYSICS**

George W. Rainey, 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, Director  
Jack S. Price, Associate Director Mathematics Education  
Cylette R. Willis, Associate Director Science 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. Judith E. Jacobs in Building 3, Room 243, contact the CEEMaST office at (909) 869-4063 or visit <http://www.ceemast.csupomona.edu>.

**Science Institute for Modern Pedagogy and Creative Teaching (Science IMPACT)**

John W. Jewett, Director  
Stephanie A. Saccoman, Program Director

Science IMPACT is a non-profit institute within the College of Science with the goal of improving the teaching of science in grades K-12. It offers workshops, courses, and programs for science teachers in coordination with schools and school districts. For information see Dr. Stephanie Saccoman (Building 8, Room 306).

**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**

The objective of Science Educational Enhancement Services (SEES) is to increase the number of Blacks, Hispanics and American Indians in the sciences and mathematics. The program strives for the retention and graduation of its members by establishing a supportive community

among students with these ethnic backgrounds and having technical career goals. SEES services include special faculty advisors in each department of the college, an orientation course for members who are new to the campus, a study center where students can work together, priority consideration to participate in Academic Excellence Workshops (see below) and clubs for preprofessional students from targeted ethnic groups. For information see Dr. Paul Hiemenz (Building 3, Room 222).

**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. David Steele.

**Recommended Courses**

Freshman English I	ENG	104	(4)
Freshman English II	ENG	105	(4)
Basic Biology	BIO	115/115L	(3/2)
Cell, Molecular and Developmental Biology	BIO	310	(4)
Vertebrate Zoology	ZOO	138/138L	(5)
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)
College Physics	PHY	121	(3)
College Physics	PHY	122	(3)
College Physics	PHY	123	(3)
College Physics Laboratory	PHY	121L	(1)
College Physics Laboratory	PHY	122L	(1)
College Physics Laboratory	PHY	123L	(1)

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

**COLLEGE OF SCIENCE COURSE DESCRIPTIONS****SCI 110/110A Success in Science (1/1) FW**

Orientation to the various majors in the College of Science. Exploration of student and University expectations of science majors. Career opportunities. One-to-one interaction with departmental mentors.

Speakers, field trips. Open only to students in Science Educational Enhancement Services (SEES). May be repeated for a maximum of 4 units. 1 lecture, 1 two-hour activity. Concurrent enrollment required.

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

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 Geological Sciences (3/1) Sp**

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 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.

### **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

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

Lenard R. Troncale, Chair

Jill P. Adler	Chris D. George
Keith E. Arnold	Donald F. Hoyt
Jonathan N. Baskin	James O. Jackson
Jack L. Bath	Glenn H. Kageyama
Kristin R. Bozak	George W. Martinek
Gilbert D. Brum	Larry K. McKane
Nancy E. Buckley	David J. Moriarty
Stephen H. Bryant	Bijay K. Pal
David P. Campbell	Ronald D. Quinn
Gary C. Carlton	Fred Shafia
Peter Castro	Pamela J. Sperry
John K. Chan	David F. Steele
J. Curtis Clark	Glenn R. Stewart
Ronald S. Daniel	Martin F. Stoner
Wendy J. Dixon	Laszlo J. Szijj
Bruce L. Firstman	

The Biological Sciences Department offers bachelor's degree programs in Biology, Biotechnology, Botany, Plant Biotechnology, 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. Departmental facilities include molecular biology laboratories, greenhouses, controlled environmental units, a radiation biology laboratory, plant and animal collections, and an electron microscope facility. 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 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.

### Core Courses for Major

Required of all students

Scientific Communication I	BIO	190	(1)
Environmental Conservation	BIO	201	(3)
Biometrics	BIO	211/211L	(3/1)
Principles of Evolution	BIO	213	(4)
Genetics	BIO	303	(4)
Cell, Molecular, and Developmental Biology	BIO	310	(4)
Principles of Ecology	BIO	325/325L	(3/1)
Cellular Physiology	BIO	435/435L	(3/2)
or Plant Physiology	BOT	422/422L	(3/2)
or Comparative Animal Physiology	ZOO	424/424L	(3/2)
Scientific Communication II	BIO	490	(1)
Plant Structures and Functions	BOT	124/124L	(3/2)
Plant Morphology	BOT	125/125L	(3/2)
Basic Microbiology	MIC	201/201L	(3/2)
Invertebrate Zoology	ZOO	137/137L	(3/2)
Vertebrate Zoology	ZOO	138/138L	(3/2)
Upper Division courses in Biological Sciences			(12)

### Support and Elective Courses

Required of all students

General Chemistry Laboratory	CHM	121L	(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	(3)
College Physics	PHY	122	(3)
College Physics	PHY	123	(3)
College Physics Laboratory	PHY	121L	(1)
College Physics Laboratory	PHY	122L	(1)

College Physics Laboratory	PHY	123L	(1)
Introduction to Statistics	STA	120	(4)
Approved electives**			(14)

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 not specifically designed for non majors (see course descriptions). Also included are any advanced Chemistry or Math courses. See advisor for approval of courses offered by other departments.

### General Education Courses

Underlined courses satisfy both major and GE requirements.

<b>Area 1:</b>			
A. Freshman English I	ENG	104	(4)
B. Select from approved list			(4)
C. Freshman English II	ENG	105	(4)
<b>Area 2:</b>			
A. Calculus for Life Science	MAT	120	(4)
B. General Chemistry	CHM	121	(3)
C. Basic Biology	BIO	115/115L	(3/2)
D. Select from approved list			(4)
<b>Area 3:</b>			
Select one course from each subarea (A-F)			(24)
Select one of the following for Subarea G:			
BIO 205, or KIN/FN 203 or PSY 201 or PSY 210			(4)
<b>Area 4:</b>			
United States History	HST	202	(4)
Introduction to American Government	PLS	201	(4)
<b>Area 5:</b>			
Select two courses from approved list			(8)

### 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-three units must be chosen from one of these clusters (referred to as the student's primary cluster) and an additional 14 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 198-199 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

Biometrics	BIO	211211L	(3/1)
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Horizons in Biotechnology	BIO	230	(1)
Computer Applications in Biology	BIO	256/256L	(1/1)
Cellular, Molecular, and Developmental 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 II	BIO	490	(1)
or Undergraduate Seminar	CHM	493	(2)
General Chemistry Laboratory	CHM	121L	(1)
General Chemistry	CHM	122/122L	(3/1)
General Chemistry	CHM	123/123L	(3/1)
Quantitative Analysis	CHM	221	(4)
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)
Basic Microbiology	MIC	201/201L	(3/2)
Vertebrate Zoology	ZOO	138/138L	(3/2)
or Plant Structure and Function	BOT	124/124L	(3/2)
or Plant Morphology	BOT	125/125L	(3/2)
Upper Division Courses			(36)

At least 21 units from one "Primary" cluster and 11 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

College Physics	PHY	121	(3)
College Physics	PHY	122	(3)
College Physics	PHY	123	(3)
College Physics Laboratory	PHY	121L	(1)
College Physics Laboratory	PHY	122L	(1)
College Physics Laboratory	PHY	123L	(1)
Technical Calculus II	MAT	131	(4)
Technical Calculus III	MAT	132	(4)
Statistics with Applications	STA	120	(4)

### General Education Courses

Underlined courses satisfy both major and GE requirements.

<b>Area 1:</b>			
A. Freshman English I	ENG	104	(4)
B. Select from approved list			(4)
C. Freshman English II	ENG	105	(4)
<b>Area 2:</b>			
A. Technical Calculus I	MAT	130	(4)
B. General Chemistry	CHM	121	(3)
C. Basic Biology	BIO	115/115L	(3/2)
D. Select from approved list			(4)
<b>Area 3:</b>			
Select one course from each subarea (A-F)			(24)
Subarea G. General Psychology	PSY	201	(4)
<b>Area 4:</b>			
United States History	HST	202	(4)
Introduction to American Government	PLS	201	(4)

**Area 5:**

Genetics . . . . .	BIO	303	(4)
Multicultural Organizational Behavior . . . . .	MHR	318	(4)
Total Units in General Education . . . . . 72			
Total Units All Courses . . . . . 198-199			

**Course Descriptions**

See course descriptions under appropriate department.

**Upper Division Course Clusters****Cluster 1 - Physiology**

Cellular Physiology . . . . .	BIO	435/435L(3/2)
Plant Physiology . . . . .	BOT	422/422L(3/2)
Plant Anatomy . . . . .	BOT	435/435L(2/2)
Fundamentals of Physical Chemistry . . . . .	CHM	301/301L(3/1)
Nutrient Biochemistry and Metabolism . . . . .	CHM	454 (3)
Biomedical Instrumentation . . . . .	ECE	435 (3)
Biomedical Instrumentation Laboratory . . . . .	ECE	485L (1)
Advanced Nutrition . . . . .	FN	433 (4)
Biophysics . . . . .	BIO/PHY	410 (4)
Comparative Animal Physiology . . . . .	ZOO	424/424L(3/2)
Histology . . . . .	ZOO	422/422L(2/3)
Endocrinology ** . . . . .	BIO	520/520L(3/1)
Renal Physiology ** . . . . .	BIO	521 (3)
Advanced Plant Physiology** . . . . .	BIO	548/548L(3/2)
Bacterial Physiology ** . . . . .	BIO	560/560L(3/1)

**Cluster 2 - Molecular Biology and Genetics**

Plant Breeding . . . . .	AGR	404/404L(3/1)
Population Genetics . . . . .	BIO	445/445L(3/1)
Advanced Genetics . . . . .	BIO	421 (3)
Recombinant DNA Techniques . . . . .	BIO	455/455L(2/2)
Plant Genetics . . . . .	BOT	403/403L(3/1)
Plant Tissue Culture . . . . .	BOT	456/456L(1/3)
Human Genetics . . . . .	BIO	403/L(3/1)
Recombinant DNA Biochemistry . . . . .	CHM	453 (3)
Microbial Structures and Function . . . . .	MIC	300/300L(3/2)
Biophysics . . . . .	BIO/PHY	410 (4)
Cytogenetics ** . . . . .	BIO	510/510L(2/1)
Advanced Cell Biology ** . . . . .	BIO	535 (4)
Plant Growth and Development ** . . . . .	BIO	550/550L(2/2)
Molecular Biology of Development ** . . . . .	BIO	555 (3)
Animal Tissue Culture ** . . . . .	BIO	565/565L(2/2)
Transmission Electron Microscopy ** . . . . .	BIO	577/577L(2/3)
Scanning Electron Microscopy ** . . . . .	BIO	578/578L(2/3)

**Cluster 3 - Microbiology and Pathology**

Radiation Biology . . . . .	BIO	431/431L(3/1)
Plant Pathology . . . . .	BOT	323/323L(2/2)
Mycology . . . . .	BOT	426/426L(2/2)
Methods in Plant Pathology . . . . .	BOT	441/441L(2/2)
Microbial Structures & Functions . . . . .	MIC	300/300L(3/2)
Immunology-Serology . . . . .	MIC	415/415L(3/2)
Medical Bacteriology . . . . .	MIC	410/410L(3/2)
Medical Mycology . . . . .	MIC	425/425L(3/2)
General Virology . . . . .	MIC	430/430L(3/2)
Hematology . . . . .	MIC	444/444L(3/1)
Cellular Immunity and Disease ** . . . . .	BIO	570/570L(3/1)
Advanced Immunology ** . . . . .	BIO	576/576L(2/1)

**Cluster 4 - Biochemistry and Molecular Separation Techniques**

Elements of Physical Chemistry . . . . .	CHM	304/304A(3/1)
Elements of Physical Chemistry . . . . .	CHM	305/305L(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)
Theory of Chemical Instrumentation . . . . .	CHM	347/347L(1/1)
Organic Analysis . . . . .	CHM	424/424L(2/2)
Enzymology . . . . .	CHM	451/451L(3/1)
Biochemical Preparations . . . . .	CHM	452/452L(1/2)
Recombinant DNA Biochemistry . . . . .	CHM	453 (3)
Biochemical Mechanisms ** . . . . .	CHM	565 (3)
Advanced Clinical Chemistry** . . . . .	CHM	567 (3)

**Cluster 5 - Agriculture**

Food Process Engineering . . . . .	AE	332/332L(3/1)
Plant Growth Regulators . . . . .	AGB	470/470L(2/1)
Mammalian Endocrinology . . . . .	AVS	412 (4)
Food Science and Technology . . . . .	FN	317/317L(3/1)
Food Chemistry and Toxicology . . . . .	FN	420/420L(2/2)
Advanced Plant Propagation . . . . .	HOR	422/422L(3/1)
Soil Chemistry . . . . .	SS	431/431L(3/1)
Immunology Procedures in Animal Production . . . . .	AVS	405/405L(3/1)
Design and Analysis of Experimental Research ** . . . . .	AVS	545 (4)

**Cluster 6 - Business**

Management Information Systems . . . . .	CIS	310 (4)
Training and Development . . . . .	MHR	405 (4)
Management Policies and Systems . . . . .	MHR	410 (4)
Principles of Marketing Management . . . . .	IBM	301 (4)
Production and Operations Management I . . . . .	OM	331 (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.

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

Scientific Communication I . . . . .	BIO	190	(1)
Principles of Evolution . . . . .	BIO	213	(4)
Genetics . . . . .	BIO	303	(4)
Cellular, Molecular, and Developmental Biology . . . . .	BIO	310	(4)
Principles of Ecology . . . . .	BIO	325/325L(3/1)	
Scientific Communication II . . . . .	BIO	490	(1)



Plant Structures and Functions	BOT	124/124L	(3/2)
Plant Morphology	BOT	125/125L	(3/2)
Biometrics	BOT	211/211L	(3/1)
General Plant Pathology	BOT	323/323L	(3/1)
California Flora	BOT	343/343L	(1/2)
Plant Ecology	BOT	421/421L	(3/1)
Plant Physiology	BOT	422/422L	(3/2)
Phycology	BOT	433/433L	(2/2)
or Mycology	BOT	425/425L	(2/2)
or Mycology	BOT	426/426L	(2/2)
Plant Anatomy	BOT	435/435L	(2/2)
Basic Microbiology	MIC	201/201L	(3/2)
Invertebrate Zoology	ZOO	137/137L	(3/2)
Vertebrate Zoology	ZOO	138/138L	(3/2)

### Support and Elective Courses

Required of all students

General Chemistry Laboratory	CHM	121L	(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	(3)
College Physics	PHY	122	(3)
College Physics	PHY	123	(3)
College Physics Laboratory	PHY	121L	(1)
College Physics Laboratory	PHY	122L	(1)
College Physics Laboratory	PHY	123L	(1)
Basic Soil Science	SS	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; PHY 304, 340 and 410; HOR 131/L, 323/L, 427/L, AGR 404/L and AGR 421/L. See advisor for approval of other courses offered by other departments.

### General Education Courses

Underlined courses satisfy both major and GE requirements.

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#### Area 1:

A. Freshman English I	ENG	104	(4)
B. Select from approved list			(4)
C. Freshman English II	ENG	105	(4)

#### Area 2:

A. Calculus for Life Science	MAT	120	(4)
B. General Chemistry	CHM	121	(3)
C. Basic Biology	BIO	115/115L	(5)
D. Select from approved list			(4)

#### Area 3:

Select one course from each subarea (A - F)			(24)
Subarea G: Select one of the following:			
BIO 205, KIN/FN 203, PSY 201, or PSY 210			(4)

#### Area 4:

United States History	HST	202	(4)
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Introduction to American Government	PLS	210	(4)
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#### Area 5:

Select two courses from approved list			(8)
Unrestricted Electives			(4)

### BOTANY MINOR

Required of all students

Minimum units			32
Minimum upper division units			12

Basic Biology	BIO	115/115L	(3/2)
Plant Structures and Functions	BOT	124/124L	(3/2)
Plant Morphology	BOT	125/125L	(3/2)
Plus 6 units of BOT prefix courses not including BOT 316			(6)

At least three of the following courses must be completed:

Plant Pathology	BOT	323/323L	(2/2)
California Flora	BOT	343/343L	(1/2)
Plant Ecology *	BOT	421/421L	(3/1)
Plant Physiology **	BOT	422/422L	(3/2)
Plant Anatomy	BOT	435/435L	(2/2)

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

Principles of Evolution	BIO	213	(4)
Genetics	BIO	303	(4)
Plants and People	BIO	307/307A	(3/1)
Principles of Ecology	BIO	325/325L	(3/1)
Plant Nematology	BOT	423/423L	(3/1)
Mycology	BOT	425/425L	(2/2)
Mycology	BOT	426/426L	(2/2)
Phycology	BOT	433/433L	(2/2)
Morphology of Embryophytes	BOT	434/434L	(3/2)
Plant Taxonomy	BOT	436/436L	(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

May be taken by students majoring in Botany.

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	422/422L	(3/2)

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

Seed Production **	AGR	331/331L	(3/1)
Plant Breeding **	AGR	404/404L	(3/1)
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)

Minimum units: 30

\*Prerequisite: BOT 124.

\*\*Prerequisite: BIO 115/115L

\*\*\*Prerequisites: AGR 122 and AGR 221 or AGR 226.

**PLANT PATHOLOGY MINOR**

May be taken by students majoring in Botany.

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)
Plant Structures and Functions	BOT	124/124L	(3/2)
or Plant Morphology	BOT	125/125L	(3/2)
Plant Pathology	BOT	323/323L	(3/2)
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:

Diagnosis and Control of Plant Diseases	BOT	440/440L	(2/2)
Methods in Plant Pathology	BOT	441/441L	(2/2)
Plant Anatomy	BOT	435/435L	(2/2)
Mycology	BOT	425/425L	(2/2)
Plant Physiology*	BOT	422/422L	(3/2)
Mycology	BOT	426/426L	(2/2)

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

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

\*Prerequisite: CHM 201 or consent of instructor.

**MICROBIOLOGY MAJOR**

The Microbiology major chooses one of the two options 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 option 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

Scientific Communication I	BIO	190	(1)
Genetics	BIO	303	(4)
Scientific Communication II	BIO	490	(1)
Plant Morphology	BOT	125/125L	(3/2)

Basic Microbiology	MIC	201/201L	(3/2)
Microbial Structures and Functions	MIC	300/300L	(3/2)
Medical Bacteriology	MIC	410/410L	(3/2)
Immunology-Serology	MIC	415/415L	(3/2)
General Virology	MIC	430/430L	(3/2)
Invertebrate Zoology	ZOO	137/137L	(3/2)
Vertebrate Zoology	ZOO	138/138L	(3/2)

**Option Courses for Major**

Required for specific option

**Microbiology Option**

Cellular Physiology	BIO	435/435L	(3/2)
Concepts of Molecular Biology	BIO	450	(4)
Plant Structures and Functions	BOT	124/124L	(3/2)
Applied Microbiology	MIC	310/310L	(3/2)

**Medical Technology Option**

Clinical Chemistry	CHM	331/331L	(2/2)
Medical Mycology	MIC	425/425L	(3/2)
Hematology	MIC	444/444L	(3/1)
Immunohematology	MIC	445/445L	(3/1)
Human Anatomy	ZOO	234/234L	(2/2)
Human Physiology	ZOO	235/235L	(3/1)
Medical Parasitology	ZOO	425/425L	(3/2)

**Support and Elective Courses**

Required of all students

General Chemistry Laboratory	CHM	121L	(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	(3)
College Physics	PHY	122	(3)
College Physics	PHY	123	(3)
College Physics Laboratory	PHY	121L	(1)
College Physics Laboratory	PHY	122L	(1)
College Physics Laboratory	PHY	123L	(1)

Approved electives (Microbiology Option)**	(14)
Approved electives (Medical Technology Option)**	(3)

\*\* 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 Courses**

Underlined courses satisfy both major and GE requirements.

**Area 1:**

A. Freshman English I	ENG	104	(4)
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- B. Select from approved list ..... (4)  
 C. Freshman English II ..... ENG 105 (4)

**Area 2:**

- A. Calculus for Life Science ..... MAT 120 (4)  
 B. General Chemistry ..... CHM 121 (3)  
 C. Basic Biology ..... BIO 115/115L (3/2)  
 D. Select from approved list ..... (4)

**Area 3:**

- Select one course from each subarea (A-F). ..... (24)

Subarea G. Select one of following:

- BIO 205, KIN/FN 203, PSY 201 or ..... PSY 210 (4)

**Area 4:**

- United States History ..... HST 202 (4)  
 Introduction to American Government ..... PLS 201 (4)

**Area 5:**

- Select two courses from approved list..... (8)

**MICROBIOLOGY MINOR**

Minimum units..... 40

Note: This minor may not be earned by Microbiology majors.

Required of all students

- Basic Biology ..... BIO 115/115L (3/2)  
 College Chemistry ..... CHM 104 (3)  
 College Chemistry ..... CHM 105 (3)  
 College Chemistry Laboratory ..... CHM 141L (1)  
 College Chemistry Laboratory ..... CHM 142L (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)  
 Microbiology Structures and Functions ..... MIC 300/300L (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  
 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 all of the faculty in the microbiology section.

**ZOOLOGY MAJOR**

Qualified Zoology majors are prepared for employment in a variety of state and federal agencies dealing with fisheries, wildlife management, and related subjects.

The curriculum in zoology provides strong premedical, predental, and preveterinary preparation, as well as preparing the student for graduate studies in zoology.

Facilities include a large animal colony, a representative collection of living local reptiles and amphibians and an extensive study collection of bird, mammal, amphibian, reptile and fish specimens. Unique and extensive wild areas are available on the campus for animal studies.

**Core Courses for Major**

Required of all students

- Scientific Communication I ..... BIO 190 (1)  
 Biometrics ..... BIO 211/211L (3/1)  
 Principles of Evolution ..... BIO 213 (4)  
 Genetics ..... BIO 303 (4)  
 Cell, Molecular, and Developmental Biology ..... BIO 310 (4)  
 Principles of Ecology ..... BIO 325/325L (3/1)  
 Scientific Communication II ..... BIO 490 (1)  
 Plant Structures and Functions ..... BOT 124/124L (3/2)  
 Plant Morphology ..... BOT 125/125L (3/2)  
 Basic Microbiology ..... MIC 201/201L (3/2)  
 Invertebrate Zoology ..... ZOO 137/137L (3/2)  
 Vertebrate Zoology ..... ZOO 138/138L (3/2)  
 Introduction to Entomology ..... ZOO 426/426L (3/1)  
 Comparative Animal Physiology ..... ZOO 424/424L (3/2)

Each student will complete at least 5 upper division zoology (ZOO prefix) courses ..... (26)

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

**Support and Elective Courses**

Required of all students

- General Chemistry Laboratory ..... CHM 121L (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 (3)  
 College Physics ..... PHY 122 (3)  
 College Physics ..... PHY 123 (3)  
 College Physics Laboratory ..... PHY 121L (1)  
 College Physics Laboratory ..... PHY 122L (1)  
 College Physics Laboratory ..... PHY 123L (1)  
 Introduction to Statistics ..... STA 120 (4)

Approved Electives \*\* (11)

\*\*Approved electives include any 200, 300, or 400 level courses in the Biological Sciences Department not specifically designed for non-majors. Approved electives also include any advanced Chemistry or Math courses. See advisor for approval of courses offered by other departments.

**General Education Courses**

Underlined courses satisfy both major and GE requirements.

**Area 1:**

- A. Freshman English I ..... ENG 104 (4)  
 B. Select from approved list ..... (4)  
 C. Freshman English II ..... ENG 105 (4)

**Area 2:**

- A. Calculus for Life Science ..... MAT 120 (4)  
 B. General Chemistry ..... CHM 121 (3)  
 C. Basic Biology ..... BIO 115/115L (3/2)  
 D. Select from approved list ..... (4)

**Area 3:**

Select one course from each subarea (A-F). ..... (24)

Subarea G. Select one of following:  
 BIO 205, KIN/FN 203, PSY 201 or PSY 210 . . . . . (4)

**Area 4:**

United States History . . . . .HST 202 (4)  
 Introduction to American Government . . . . .PLS 201 (4)

**Area 5:**

Choose two courses from approved list. . . . . (8)

**ZOOLOGY MINOR**

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

Note: This minor may not be earned by Zoology majors.

Required of all students:

Basic Biology . . . . .BIO 115/115L (3/2)  
 Genetics . . . . .BIO 303 (4)  
 Invertebrate Zoology . . . . .ZOO 137/137L (3/2)  
 Vertebrate Zoology . . . . .ZOO 138/138L (3/2)

Any two from the following courses:

Principles of Evolution . . . . .BIO 213 (4)  
 Principles of Ecology . . . . .BIO 325/325L (3/1)  
 Comparative Animal Physiology . . . . .ZOO 424/424L (3/2)

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

Human Anatomy . . . . .ZOO 234/234L (2/2)  
 Human Physiology . . . . .ZOO 235/235L (3/1)  
 Ornithology . . . . .ZOO 329/329L (2/1)  
 Embryology . . . . .ZOO 414/414L (2/3)  
 Animal Behavior . . . . .ZOO 419/419L (2/1)  
 Histology . . . . .ZOO 422/422L (2/3)  
 Medical Parasitology . . . . .ZOO 425/425L (3/2)  
 Introduction to Entomology . . . . .ZOO 426/426L (3/1)  
 Herpetology . . . . .ZOO 429/429L (2/2)  
 Mammalogy . . . . .ZOO 430/430L (2/2)  
 Public Health Entomology . . . . .ZOO 435/435L (3/1)  
 Evolution of the Invertebrates . . . . .ZOO 438 (4)  
 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:**

Biological Sciences . . . . .BIO 115/115L (5)  
 Basic Biology . . . . .BOT 124/124L (5)  
 Plant Structures and Functions . . . . .ZOO 138/138L (5)

**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)

**Depth Courses: Biological Sciences**

Invertebrate Zoology . . . . .ZOO 137/137L (5)  
 Principles of Evolution . . . . .BIO 213 (4)  
 Genetics . . . . .BIO 303/303L (5)  
 Principles of Ecology . . . . .BIO 325/325L (4)

Select one:

Cellular Physiology . . . . .BIO 435/435L (4)  
 Plant Physiology . . . . .BOT 422/422L (5)  
 Comparative Animal Physiology . . . . .ZOO 424/424L (5)

Two courses from the following at least one with a Lab 8-10 units

Environmental Conservation . . . . .BIO 201 (3)  
 Cell, Molecular, and Developmental Biology . . . . .BIO 310 (4)  
 Plant Morphology . . . . .BOT 125/125L (5)  
 Basic Microbiology . . . . .MIC 201/201L (5)

**BIOLOGY 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. 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 as a prerequisite course for majors who take other courses in Biological Sciences. 3 lectures/problem-solving, 2 three-hour laboratories. Arnold, George.



**BIO 190 Scientific Communication I (1) Every quarter**

An introduction to writing and information resources for biologists. One hour lecture/problem-solving. Staff

**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 only in the Biological Sciences Department office. Total credit for a degree in Biological Sciences is limited to 6 units of BIO 200 and/or 400, with a maximum of 2 units per quarter. Staff.

**+BIO 201 Environmental Conservation (3) Every quarter**

Contemporary environmental issues, and conservation of natural resources. Topics include ecological concepts, population, food, energy, water, wildlife, land use, and pollution. 3 lectures/problem-solving. Prerequisite: BIO 110 or 115. Quinn, Stewart.

**BIO 205 Biological Perspectives on Contemporary Life (4)**

A course designed to enable students to make effective decisions for quality lifestyles by gaining practical knowledge and understanding of the roles that diet, stress, drugs, disease, heredity, sexuality, environmental pollution, and the normal life processes of aging and death play in our lives. 4 lecture discussions. Prerequisite: BIO 110 or BIO 115/115L. George, Quinn.

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

This course explores 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. McKane.

**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. Prerequisites: BIO 115/L, STA 120, and basic algebra skills. Bryant, Carlton, Moriarty.

**BIO 213 Principles of Evolution (4) Every quarter**

Introduction to organic evolution. 4 lectures/problem-solving. Prerequisite: BIO 110 or 115/L, and basic algebra skills. Bryant, Firstman, Troncale.

**BIO 230 Horizons in Biotechnology (1) Once a year**

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 biotechnological industries. 1 lecture. Adler, Dixon.

**BIO 256/256L Computer Applications in Biology (1/1) Once a year**

Use of microcomputers in the acquisition, manipulation, and presentation of numeric and textual data in biology. 1 lecture/problem-solving, 1 three-hour laboratory. Prerequisites: BIO 110 or BIO 115/115L, CS 100 or CIS 101. Clark, Moriarty.

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

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 problems, or a combination. Prerequisite: permission of instructor. Staff.

**BIO 300 Human Heredity (4) Once a year**

Nontechnical introduction to genetic principles with emphasis on humans. Topics include hereditary diseases; gene structure, function and regulation; genetic engineering; human genome; cancer; cloning; genetic technologies in medicine and agriculture; ethical and social issues. For non-biology majors. 4 lectures/problem-solving. Not for core or support credit for students with majors in the Biological Sciences Department. Prerequisite: BIO 110, BIO 115/115L or equivalent. Bryant, Campbell, Martinek.

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

Factual coverage of human sexuality through discussions, lectures, audiovisual material and guest speakers. Topics include myths and misconceptions; sexual response; birth control; sex and the law; fertilization, pregnancy, and childbirth; diseases and dysfunctions; sex and drugs; genital structure and function and recent developments in the study of human sexuality. 4 lecture discussions. May not be used to partially satisfy the requirement for upper division Biological Sciences courses by students with majors in the Biological Sciences Department. Prerequisite: BIO 110, BIO 115/115L, or equivalent. Adler, Daniel, George, McKane, Steele.

**+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. Prerequisites: BIO 110, or BIO 115/115L or consent of instructor. Troncale.

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

Principles of heredity. Introduction to transmission genetics, cytogenetics, molecular genetics and population genetics. 4 lectures/problem-solving. Prerequisite: BIO 110 or 115/115L, and basic algebra skills. Bryant, Campbell, Troncale.

**+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 310 Cell, Molecular, and Developmental 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; cellular mechanisms of development. 4 lectures/problem-solving. Prerequisites: BIO 303 and CHM 106 or 113 and CHM 201 or 314/314L. Bozak, Buckley, Dixon, Sperry, Troncale.



**+BIO 311 AIDS: Current Topics and Concerns (4) Once a year**

Course covers prevalent sexually transmitted diseases in the United States with emphasis on AIDS. Topics covered include distribution, transmission, sexual practices, current research, effects on immune system, treatments, testing, counseling and availability of support groups. Selected topics will be presented by guest speakers. Open to all majors for credit/no credit. May be used for approved elective credit (if taken for grade), but not upper division core credit by students with majors in the Biological Sciences Department. 4 lectures. Prerequisite: BIO 110, BIO 115/115L, or equivalent, or consent of instructor. Adler, George.

**BIO 325/325L Principles of Ecology (3/1) Every quarter**

A study of ecosystems; the interactions between organisms and environment. 3 lectures/problem-solving, 1 three-hour laboratory. 3 one-day weekend field trips. Prerequisite: BIO 115/115L and BIO 211/211L. Bryant, Carlton, Moriarty, Quinn, Szijj.

**BIO 330/330L Marine Biology (3/1) Every quarter**

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. 3 lectures/problem-solving; 1 three-hour laboratory (several weekend field trips required). Prerequisite: BIO 110 or BIO 115/115L or equivalent. This course may be used to fulfill GE Area 2D. If used for G.E., it may only be taken after students have fulfilled GE Areas 2B and 2C as a capstone experience. Arnold, Baskin, Castro.

**BIO 333 Genetics Laboratory (1)**

Hands-on experience in collection and analysis of genetic data. Students will master methodologies for handling DNA, fruit flies and chromosomes. Solution of genetics problems using current analysis techniques. 1 three-hour laboratory. Prerequisite: BIO 303. Bryant, Troncale.

**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. Total credit for a degree in 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. Problem-solving, and mastering the methodology of human karyotyping. 3 lectures/problem-solving, 1 three-hour laboratory, 1 or 2 field trips. Prerequisites: BIO 211 and BIO 303. Bryant.

**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 or 125/125L, ZOO 137/137L or 138/138L, BIO 213; recommended: BIO 303, 325. Clark.

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

Study of general ant biology, including internal and external morphology, identification, behavior, distribution ecology; 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 equivalents, or consent of instructor. 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 or permission of instructor. Staff.

**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 Mts., Arizona. Field trip fee expense required. Lecture, laboratory. Prerequisites: BIO 325/325L. Bryant, Moriarty, Quinn.

**BIO416L 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. Field trip expense required. Lectures/problem-solving, laboratory. Prerequisite: BIO 325/325L. George, Stewart, Szijj.

**BIO 418/418L Population Ecology (2/1) Every other year**

Factors affecting the abundance and distribution of animal populations in their natural environment. 2 lectures/problem-solving, 1 three-hour laboratory. Prerequisite: BIO 325/325L. Bryant, Carleton, Moriarty, Szijj.

**+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, BIO 115/115L, or equivalent. Prerequisite: consent of instructor. Arnold.

**BIO 421 Advanced Genetics (3) Once a year**

Recent advances in genetics with emphasis on gene structure, function, and regulation. 3 lectures/problem-solving. Prerequisite: BIO 303. Bryant, Campbell.

**+BIO 423/423L Cell Biology (2/2)**

General structure and ultrastructure of the cell. 2 lectures/problem-solving, 2 three-hour laboratories. Prerequisite: BOT 124/124L, ZOO 138/138L. Buckley, Campbell, Dixon, Kageyama, Troncale.

**BIO 424 Neuroscience (3)**

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. 3 lectures/problem-solving, demonstrations. Prerequisites: BIO 115/115L, CHM 201/250L or CHM 314/317L, or consent of instructor. 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. Quinn.

**BIO 430/430L Fresh Water Biology (3/2)**

Ecology and natural history of major plant and animal groups in various fresh water habitats, and their relationship to fisheries, wildlife management, water, sanitation, and conservation. 3 lectures/problem-solving, 2 three-hour laboratories. Prerequisite: BOT 125/125L, ZOO 137/137L or consent of instructor. Staff.

**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 Biological Sciences, 8 units of Chemistry, 8 units of Physics. Staff.

**BIO 435/435L Cellular Physiology (3/2) Once a year**

Physiological mechanisms at the cellular level. 3 lectures/problem-solving, 2 three-hour laboratories. Prerequisite: CHM 201/250L or 314/317L. Kageyama.

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

On-the-job training in student's area of interest or academic and practical experience in assisting and tutoring in laboratory or field courses. Limited to upper division students in good standing. Written evaluation from job supervisor or instructor required upon completion. Credit for assisting or tutoring limited to a maximum of 3 units to be earned in at least two courses. Total credit for on-the-job training limited to 6 units. Prerequisite: internship coordinator or laboratory instructor approval of student's application for internship credit (forms available from Biological Sciences Department). Staff.

**BIO 442/442L Marine Ecology (3/2)**

Structure and function of marine ecosystems with emphasis on littoral environments. 3 lectures/problem-solving, 2 three-hour laboratories. Prerequisite: BIO 325/325L, or consent of instructor. Arnold.

**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. Bryant.

**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: consent of instructor. Buckley, Dixon, 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: Consent of instructor. Buckley, Dixon, Sperry, 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, procaryotic and eucaryotic 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 consent of instructor., Pal, Buckley, Dixon.

**BIO 461, 462 Senior Project (2) (2) Every quarter**

Research conducted under faculty supervision. Written thesis in accordance with professional standards required upon completion of

project. Total credit limited to 6 units. Recommended for students in any of the biological sciences majors contemplating graduate or professional school training. Prerequisite: written consent of student's research advisor prior to enrolling. Staff.

**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. Requirements: advanced senior or graduate standing, and consent of instructor. 3 lecture discussions. Prerequisites: BIO 325/325L or equivalent. Szijj.

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

Oral and written presentation of selected topics in biology. 1 lecture/problem-solving. Prerequisites: BIO190, COM 204, and MAT 120 or MAT 130, and BIO 303. Staff.

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

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 lectures/problem-solving, laboratory problems, or a combination. Prerequisite: permission of instructor. 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 Plant Structures and Functions (3/2) Every quarter**

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. Bozak, Stoner.

**BOT 125/125L Plant Morphology (3/2) Every quarter**

Comparative morphology and phylogenetic relationships of plant groups from bacteria to angiosperms. 3 lectures, 2 three-hour laboratories. Prerequisite: BIO 115/115L. Arnold, Clark, Stoner.

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

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 lectures/problem-solving, laboratory, or a combination. Prerequisite: permission of instructor. Staff.

**BOT 307/307L Plants and People (3/1) Once a year**

Natural history and uses of plants important to people. Open to all majors. May be used for approved elective credit but not upper division core credit by students with majors in the Biological Sciences Department. 3 lectures/problem-solving plus field activity. Stoner.

**BOT 310 Plant Products in Food Science (4)**

Whole and derivative products of plants used for human consumption; plant parts and secondary chemistry relating to nutrition and health, food additives, food supplements, and product development; phytopharmacology; economic geography, cultural aspects and practical considerations of sources, demands, and uses; some attention to aquatic plant and macrofungal products. Prerequisites: BIO 110 or BIO 115/115L. 3 lectures plus arranged activities.

**BOT 316/316L Plant Environments (3/1)**

Effects of environmental factors on the growth and distribution of plant materials used in landscaping. Not for core or support credit for majors in the Biological Sciences Department. 3 lectures/problem-solving, 1 three-hour laboratory. Carlton.

**BOT 323/323L General Plant Pathology (2/2) Every quarter**

Principles of the nature, diagnosis, and control of plant diseases caused by bacteria, fungi, nematodes, viruses, and physiological factors. 2 lectures/problem-solving, 2 three-hour laboratories. Prerequisite: BOT 124/124L or 125/125L. Stoner.

**BOT 343/343L California Flora (1/2) Every other year**

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. Prerequisites: BIO 115/115L or BIO 110 and BIO 111L. Recommended course: BOT 124/124L. Clark.

**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: BOT 124/124L, BIO 303. Bozak.

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

A survey of the interactions between plants and the environment. Examination of communities, and ecosystems. Introduction to the effects of climate, soil and animals on plant growth, development, reproduction, and distribution. 3 lectures, 1 three-hour laboratory. Prerequisite: BIO 325/325L. Carlton.

**BOT 422/422L Plant Physiology (3/2) Every other quarter**

Life processes of plants; water relations; nutrition and metabolism; growth and development. 3 lectures/problem-solving, 2 three-hour laboratories. Prerequisites: BOT 124/124L. Bozak.

**+BOT 423/423L Plant Nematology (3/1)**

Classification, morphology, biology, and control of important plant parasitic nematodes. 3 lectures/problem-solving, 1 three-hour laboratory. Prerequisite: BIO 115/115L. May be taken on a CR/NC basis. Stoner.

**BOT 425/425L Mycology (2/2) Once a year**

Morphology, physiology, culture, pathology, taxonomy, and general biology of Acrasiales, Labyrinthales, Myxomycetes, Oomycetes, and Zygomycetes. 2 lectures/problem-solving, 2 three-hour laboratories. Prerequisite: BOT 124/124L or 125/125L or consent of instructor. Stoner.

**BOT 426/426L Mycology (2/2) Once a year**

Morphology, physiology, culture, pathology, taxonomy and general biology of Ascomycetes, Deuteromycetes, and Basidiomycetes. 2 lectures/problem-solving, 2 three-hour laboratories. Prerequisite: BOT 124/124L or 125/125L or consent of instructor. Stoner.

**BOT 433/433L Phycology (2/2)**

Morphology, taxonomy, ecology, and physiology of marine and freshwater algae. Emphasis on local marine habitat. 2 lectures/problem-solving, 2 three-hour laboratories. Prerequisite: BOT 124/124L, BOT 125/125L. Arnold.

**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, BOT 125/125L, BIO 213, or consent of instructor. Clark.

**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 125/125L. Clark.

**BOT 436/436L Plant Taxonomy (2/2)**

Principles of classification and nomenclature of plants, with emphasis on the angiosperms. 2 lectures, 2 three-hour laboratories. Prerequisite: BOT 124/124L or BOT 343/343L. Clark.

**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. Stoner.

**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. 2 lectures/problem-solving, 2 three-hour laboratories. Prerequisite: BOT 323/323L. Stoner.

**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 422/422L. Bozak.

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

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. 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 100 World of Microbes (4)**

Microorganisms and the existence of humans. Elements of microbiology and applications to daily life. For nonbiological science majors. 4 lecture discussions. Jackson.

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

A study of morphology, metabolism, classification, and cultivation of bacteria with emphasis on problem-solving, identification, and growth of microbes. The role of microbes in disease processes and concepts of immunity and resistance are discussed. 3 lectures, 2 three-hour laboratories. Prerequisite: BIO 110 or 115/115L; CHM 104, 141L or CHM 111, 151L. McKane, Shafia, Staff.

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

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, laboratory, or a combination of both. Prerequisite: Permission of instructor. Staff.

**MIC 300/300L Microbial Structures and Functions (3/2) Every quarter**

Advanced aspects of general microbiology with emphasis upon structure and function of cell components, nutritional types of bacteria, and growth and enumeration of bacteria. 3 lectures/problem-solving, 2 three-hour laboratories. Prerequisite: MIC 201/201L, CHM 201, and 250L or 314, 315 and 317L. Dixon, Shafia.

**MIC 310/310L Applied Microbiology (3/2) Once a 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, CHM 201, and 250L or 314, 315, and 317L. Dixon, Jackson.

**MIC 320/320L Food Microbiology (2/2) Once a year**

The microbiology of foods as related to storage, transit, human consumption, and health. For foods and nutrition majors. 2 lectures/problem-solving, 2 three-hour laboratories. Prerequisites: MIC 201/201L, CHM 201 and 250L. Dixon.

**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, 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 300/300L. Jackson.

**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 lectures/problem-solving, 2 three-hour laboratories. Prerequisite: MIC 300/300L. Adler.

**MIC 422/422L Clinical Laboratory Procedures (2/2)**

Principles and methods in clinical analysis and evaluation of fluids, cells, tissues, and other body components, waste products, or derivatives. 2 lectures/problem-solving, 2 three-hour laboratories. Prerequisite: CHM 328/328L, ZOO 235/235L. Staff.

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

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

**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 300/300L. Pal.

**MIC 444/444L Hematology (3/1) Every other quarter**

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: ZOO 138/138L or permission of instructor. 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 415/415L or permission of instructor. Chan.

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

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 lectures/problem-solving, laboratory, or a combination. Prerequisite: permission of instructor. Staff

**ZOOLOGY COURSE DESCRIPTIONS**

For all courses which have both a lecture component and a laboratory component (e.g. ZOO 137/137L), 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 112/112L The World of Animals (3/1)**

Characteristics, reproduction, behavior, ecology, and interactions with mankind of the major groups of invertebrate and vertebrate animals. 3 lectures, 1 two-hour activity. Staff.

**ZOO 137/137L Invertebrate Zoology (3/2) Every quarter**

Evolution and general biology of major phyla of invertebrate animals, Protozoa to Chordata; introduction to the structure and function of invertebrate organ systems. 3 lectures, 2 three-hour laboratories. Prerequisite: BIO 115/115L. Staff.



**ZOO 138/138L Vertebrate Zoology (3/2) Every quarter**

Evolution and general biology of animals within the phylum Chordata; introduction to the structure and function of vertebrate organ systems, 3 lectures, 2 three-hour laboratories. Prerequisite: BIO 115/115L. Baskin, Hoyt.

**ZOO 234/234L Human Anatomy (2/2) 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. 2 lectures/problem-solving, 2 three-hour laboratories. Prerequisite: BIO 115/115L. Bath.

**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. Steele.

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

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 lectures/problem-solving, laboratory, or a combination of both. Prerequisite: permission of instructor. Staff.

**ZOO 329/329L Ornithology (2/1) Once a year**

The evolution, anatomy and physiology of birds with special emphasis on behavior and ecological relationships of species of the Pacific Coast. 2 lectures/problem-solving, 1 three-hour laboratory, or field exercises, or projects. Two weekend field trips are required for credit in this course. Prerequisite: ZOO 138/138L or consent of instructor. Moriarty, Szijj.

**ZOO 411/411L Biology of Spiders (1/2) Every other year**

Recognition of the local spider families, and study of general spider biology, including basic morphology, behavior, ecology, ontogeny, evolution and higher systematics. 1 lecture/problem, 2 three-hour laboratories. Prerequisite: ZOO 137/137L or consent of instructor. Firstman.

**ZOO 414/414L Embryology (2/3) Every quarter**

Embryonic development of the vertebrate body. 2 lectures/problem-solving, 3 three-hour laboratories. Prerequisite: ZOO 138/138L. Firstman.

**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 138/138L or equivalent. Firstman.

**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 consent of instructor. Szijj.

**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. Roche.

**ZOO 424/424L Comparative Animal Physiology (3/2) Every quarter**

Introduction to functions of vertebrate and invertebrate organ systems. 3 lectures/problem-solving, 2 three-hour laboratories. Prerequisites: ZOO 138/138L, CHM 123/123L (formerly 106/143L), BIO 211/211L. Hoyt.

**ZOO 425/425L Medical Parasitology (3/2) Once 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: ZOO 137/137L. Castro.

**ZOO 426/426L Introduction to 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. Prerequisites: BIO 115/115L, ZOO 137/137L or consent of instructor. Edmonds, George.

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

Morphology, classification, distribution, ecology, behavior and conservation of amphibians and reptiles; identification, and field study of local species. 2 lectures/problem-solving, 2 three-hour laboratories. Prerequisite: ZOO 138/138L or equivalent. Stewart.

**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 equivalent. Stewart.

**ZOO 435/435L Public Health Entomology (3/1)**

Role of insects, mites, ticks and other arthropods in the causation and transmission of human disease. 3 lectures/problem-solving, 1 three-hour laboratory. Staff.

**ZOO 437 Evolution of the Vertebrates (4) Every other year**

A survey of vertebrate adaptive radiation since the first appearance of the subphylum Vertebrata in the late Cambrian, including a study of the fossil evidence, and the macroevolutionary novelties which permitted the success of the various vertebrate clades. 4 lectures. Prerequisite: ZOO 138/138L. Firstman.

**ZOO 438 Evolution of the Invertebrates (4) Every other year**

A systematic survey of all invertebrate groups including the minor phyla, with emphasis upon comparative morphology and phylogeny, including also comparative developmental and physiological evidence of evolutionary relationships between the higher taxa. 4 lectures/problem-solving. Prerequisite: ZOO 137/137L or equivalent. Firstman.

**ZOO 440/440L Physiological Ecology of Animals (3/1)**

A combined lecture and group discussion of the physiological and behavioral adaptations of animals to their environment. Emphasis on energetics, thermoregulation, and the evolution of endothermy and homeothermy in terrestrial vertebrates. Additional topics selected by students. Lab consists of an independent research project. 3 lectures/problem-solving, 1 three-hour laboratory. Prerequisite: BIO211/211L, ZOO 424/424L or consent of instructor. Hoyt.

**ZOO 441/441L Ichthyology (2/2) Once a 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 and consent of instructor. Baskin.

**ZOO 451/451L Comparative Anatomy of Vertebrates (3/2)**

An evolutionary analysis of the vertebrates based on the structure of organ systems. Includes discussion of the principles of comparative biology, and the significance of comparative morphological data for understanding vertebrate history. 3 lectures/problem-solving. 2 three-hour laboratories. Prerequisite: ZOO 138/138L. Baskin.

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

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 lectures/problem-solving, laboratory, or a combination. Prerequisite: consent of instructor. Staff.



## CHEMISTRY

Keith Howard, Chair

Lisa A. Alex	Elisheva Goldstein
Victor P. Abegg	George Gutnikov
Samir Anz	David A. Haner
Philip Beauchamp	Michael L. Keith
Fredrick Bet-Pera	Douglas A. Klumpp
Charles Bowen	Mary Zi-ping Luo
Ruth J. Bowen	Charles Millner
David Brown	Patrick William Mobley
Barbara Burke	Nelson Scott
Joe Casalnuovo	J. Ernest Simpson
Francis Flores	Laurie S. Starkey
Herb Fynewever	Edward D. Walton

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 three rigorous tracks or options of study leading to the Bachelor of Science degree in Chemistry.

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

The Chemical Sciences option 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 option is designed for those students who plan a career in the chemical industries and businesses. Option 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 baccalaureate degree in chemistry earned by following any of the options may be certified by the American Chemical Society as having met its standards for professionalism at the undergraduate level, provided that a suitable pattern of electives is chosen. Students should consult with departmental advisors to determine which courses are required in their option for certification.

Chemistry majors following either the Chemistry or Chemical Sciences Option 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 Option. 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.

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 option 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 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)

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

### OPTION COURSES FOR MAJOR

Required for specific options

#### 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	CHM304/304A	(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)

**SUPPORT AND ELECTIVE COURSES**

Required of all students

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 OPTION**

Differential Equations	MAT 216	(4)
Electives, unrestricted.		(19-21)

**CHEMICAL SCIENCES OPTION**

*Electives, restricted.		(14-20)
Electives, unrestricted		(10-15)

**INDUSTRIAL CHEMISTRY OPTION**

An approved Computer Science course	CS XXX	(4)
or Discrete Structures	CS 130	(4)
Statistical Methods in Engineering		
and Physical Science	STA 309	(3)
Materials Science and Engineering	MTE 207	(3)
Materials Science and Engineering Laboratory.	MTE 317L	(1)
**Cooperative Education	SCI 470	(4)
or Cooperative Education	SCI 471	(2)
and Cooperative Education	SCI 472	(2)
*Electives, restricted.		(12-14)
Electives, unrestricted.		(6-9)

\*Consult the Chemistry Department for details and restrictions.

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

**GENERAL EDUCATION COURSES****Area 1:**

A. Freshman English I	ENG 104	(4)
B. and C. Consult the catalog		(8)

**Area 2:**

A. Calculus and Analytic Geometry	MAT 114	(4)
B. General Physics	PHY 131/131L	(3/1)
C. Basic Biology	BIO 115/115L	(3/2)
D. Select one course.		(4)

**Area 3:**

A. Select one course.		(4)
B. Select one course.		(4)
C. Select one course.		(4)

A reading knowledge of a foreign language, especially German, is strongly recommended for students planning advanced study in science.

D. For industrial Chemistry option:

Principles of Economics	EC 201	(4)
For other options: See approved List		(4)
E. Select one course.		(4)
F. Select one course.		(4)

G. For Industrial Chemistry Option:

General Psychology	PSY 201	(4)
For other options: See approved list.		(4)

**Area 4:**

United States History	HST 202	(4)
Introduction to American Government	PLS 201	(4)

**Area 5:**

Upper division. Minimum  
Consult the Chemistry Department or an advisor about the specific groups of courses allowed in this area.

**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 138/138L	(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.

**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. Prerequisite to CHM 121: high school chemistry or CHM 103/103A and high school algebra. Concurrent: CHM 121L, 122L, 123L, respectively.

**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 concurrently with CHM 121, 122, 123, respectively.

**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. 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. Prerequisite: CHM 123/123L. Students are advised to take 221/221L as soon as possible after completing 123/123L. Concurrent enrollment required.

**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. Concurrent: 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 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: Permission of instructor.

**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 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. 3 lectures/problem-solving. Prerequisite: MAT 216 or equivalent, CHM 123 and one year of college physics.

**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: CHM 123/123L. Concurrent: CHM 317L, 318L, 319L, respectively for Chemistry majors.

**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 123/123L. Concurrent: CHM 314.

**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. Concurrent: CHM 315.

**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. Concurrent: CHM 316.

**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. Not open for credit to Chemistry majors. 3 lectures/problem-solving, 1 three-hour laboratory. Concurrent enrollment required. Prerequisite: CHM 201 and 250L, or CHM 315 and 318L.

**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 315 and 317. 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 221/221L and 327/327L or 321/321L. 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. Involves some inorganic synthesis. Prerequisite: CHM 221/221L. Concurrent enrollment required.

**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. Involves some inorganic synthesis. Prerequisite: CHM 221/221L. Concurrent enrollment required.

**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. Involves some inorganic synthesis. Prerequisite: 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 352A/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. 2 three-hour laboratories. Prerequisite: CHM 352L. Concurrent: CHM 313.

**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. 3 lectures/problem-solving. Prerequisite: CHM 313 or 305.

**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 and 305 or 313.

**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.

**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.

**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.

**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: CHM 221/221L, 316 and 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 221/221L, 316 and 319L and 313 or 305.

**CHM 424/424L Organic Analysis (2/2) F**

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: CHM 221/221L, 316 and 319L. Concurrent enrollment required.

**CHM 446/446L Corrosion Chemistry (3/1) W**

The basic principles of theoretical and applied electrochemistry as it pertains to corrosion. Thermodynamics and kinetics of oxidation. Aqueous corrosion, stress corrosion, hydrogen cracking, fatigue. Corrosion testing, inhibition and design. Cathodic and anodic protection, metal and chemical coatings. 3 lectures/problem-solving, 1 three-hour laboratory. Prerequisite: CHM 305 or 313 or consent of instructor.

**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, 319 and CHM 305 or 313, or consent of instructor.

**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 with consent of instructor. 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 or consent of instructor. 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 or consent of instructor. 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 or consent of instructor.

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

Concepts of air pollution: major air pollutants; sources; future problems. 3 lectures/problem-solving. Prerequisite: senior standing or consent of instructor.

**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. Prerequisite: permission of Instructor.

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

## COMPUTER SCIENCE

Mandayam Srinivas, Chair

Debra A. Brum	Hsun K. Liu
John R. Fisher	Halina Przymusinska
Bruce P. Hillam	Craig A. Rich
Esther Jennings	H. Norton Riley
Peter A. Laszlo	Daisy F. Sang
Chung Lee	Barry Soroka
Hsi-Chiu Liu	Lan Yang

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 freshmen 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.

On-campus students wishing to change their major to Computer Science should first pass both Mat 114 and CS 140 with a grade of C or better before petitioning for change of major. 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.

Membership is open to CS majors in the Bits and Chips Computer Club and local chapters of ACM and IEEE and they may also be invited to join UPE, the national honor society in computer science. Students must have a grade of "C" or better in all the CS prerequisites.

The department's Bachelor of Science program in Computer Science is fully accredited by the Computing Sciences Accreditation Commission (CSAC).

### CORE COURSES

Required of all students

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)
Assembly Language Programming	.CS	264	(4)
Numerical Methods	.CS	301	(4)
Formal Languages	.CS	310	(4)
Design and Analysis of Algorithms	.CS	331	(4)
Computer Organization	.CS	365	(4)
Microprocessor Systems	.CS	405	(4)
Programming Languages	.CS	408	(4)
Artificial Intelligence	.CS	420	(4)

Operating Systems	.CS	431	(4)
Database Systems	.CS	435	(4)
Compiler Design	.CS	440	(4)
Undergraduate Seminar	.CS	463	(2)
Computer Science Electives (including 16 units from the following list)			(20)
Introductory Computer Graphics	.CS	245	(4)
Symbolic Programming	.CS	352	(4)
Object-Oriented Design and Programming	.CS	356	(4)
Parallel Processing	.CS	370	(4)
Introduction to Computer Networks	.CS	380	(4)
Computer Simulation	.CS	390	(4)
Advanced Operating Systems	.CS	432	(4)
Advanced Compiler Design	.CS	441	(4)
Advanced Computer Graphics	.CS	445	(4)
Computability	.CS	450	(4)
Secure Communication	.CS	460	(4)
Software Engineering	.CS	480	(4)
Software Engineering	.CS	481	(4)
Honors	.CS	490	(4)

### SUPPORT COURSES

Required of all students

General Physics	.PHY	132	(3)
General Physics	.PHY	133	(3)
General Physics Laboratory	.PHY	132L	(1)
General Physics Laboratory	.PHY	133L	(1)
General Chemistry	.CHM	121	(3)
General Chemistry	.CHM	121L	(1)
Analytic Geometry and Calculus	.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 COURSES

Required of all students

#### Area 1:

Freshman English I	.ENG	104	(4)
Other			(8)

#### Area 2:

Life Science	.BIO	110	(3)
Analytic Geometry and Calculus	.MAT	114	(4)
Analytic Geometry and Calculus	.MAT	115	(4)
General Physics	.PHY	131	(3)
General Physics Laboratory	.PHY	131L	(1)
Other			(4)

#### Areas 3-5:

As required by the University			(44)
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### UNRESTRICTED ELECTIVES (6 units)

#### MINOR IN ARTIFICIAL INTELLIGENCE

##### 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)

Formal Languages . . . . .	CS	310	(4)
Symbolic Programming . . . . .	CS	352	(4)
Artificial Intelligence . . . . .	CS	420	(4)
Cognitive Processes . . . . .	PSY	334	(4)
Critical Thinking . . . . .	PHL	202	(4)
Total units required for the Minor: . . . . . 40			

### MINOR IN COMPUTER SYSTEMS ORGANIZATION

#### 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)
Computer Logic . . . . .	CS	210	(4)
Assembly Language Programming . . . . .	CS	264	(4)
Computer Organization . . . . .	CS	365	(4)
Microprocessor Systems . . . . .	CS	405	(4)
Operating Systems . . . . .	CS	431	(4)
Total units required for the Minor: . . . . . 40			

### MINOR IN SCIENTIFIC COMPUTER PROGRAMMING

#### 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)
Numerical Methods . . . . .	CS	301	(4)

Choose 3 of the following courses:

Introduction to Computer Graphics . . . . .	CS	245	(4)
Design and Analysis of Algorithms . . . . .	CS	331	(4)
Computer Simulation . . . . .	CS	390	(4)
Numerical Methods in Differential Equations . . . . .	MAT	402	(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 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 grade of C or better, or consent of instructor. 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 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: MAT 105 with a grade of C or better, 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 a high-level language. Software development tools and environments. Written essay required. 4 lectures/problem-solving. Prerequisite: eligibility to enroll in MAT 114, or consent of instructor.

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

Program design and development using the object oriented approach. Software documentation and testing. Modularization, reuse, graphic user interfaces, and exception handling. 4 lectures/problem-solving. Prerequisite: CS 140 and MAT 114 with a grade 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. Searching and sorting. Linked lists, stacks, queues, sets. Analysis of algorithms. Sequential files. 4 lectures/problem-solving. Prerequisite: CS 130 and CS 141 with grades of C or better, or consent of instructor.

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

Trees, graphs, hash tables. Random access and indexed files. 4 lectures/problem-solving. Prerequisite: CS 240 with a grade of C or better, or consent of instructor.

#### CS 245 Introductory Computer Graphics (4)

Basic concepts in 2-dimensional graphics. Display devices, programming for vector and raster graphics, language structure and components, 2-dimensional transformations, windowing, clipping, simple hidden line removal, coloring. 4 lectures/problem-solving. Prerequisite: CS 241 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 grade C or better, or consent of instructor. Cannot be used for CS elective credit.

#### **CS 264 Assembly Language Programming (4)**

Assembly and machine coding of computers. Archetypal Von Neumann architecture and cycle of operation, instruction sets, addressing modes, macros and system I/O. Applied programming projects. 4 lectures/problem-solving. Prerequisite: 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 310 Formal Languages (4)**

Regular and context-free grammars and languages, acceptors, ambiguity, closure properties, normal forms, non-deterministic machines, limitations of context-free languages. 4 lectures/problem-solving. Prerequisite: CS 210 and CS 241 with grades of C or better, or consent of instructor.

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

Development of algorithms, top-down structured programming, program correctness, backtrack programming, branch and bound methods, efficient algorithm implementation, algorithm complexity analysis. 4 lectures/problem-solving. Prerequisite: CS 241 and MAT 116 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. Coverage of Lisp and Prolog. 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. Algorithmic decomposition vs. object-oriented decomposition. Class diagrams, object diagrams, module diagrams, and process diagrams. Comprehensive examples using a case study approach. 4 lectures/problem-solving. Prerequisite: CS 240 or CS 256 with grades of C or better, or consent of instructor.

#### **CS 365 Computer Organization (4)**

Fundamental characteristics of logical devices used in computer architecture. Building blocks and organization of digital computers, including the arithmetic/logic, control and memory units, and input/output devices and interfaces. Microprocessor system design. 4 lectures/problem-solving. Prerequisite: CS264 and PHY 133 with grades 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. Prerequisite: CS 331 with a grade of C or better, or consent of instructor.

#### **CS 380 Introduction to Computer Networks (4)**

Network architectures and layered protocols. Network service interfaces; addressing and routing; flow and congestion control. Local and metropolitan area networks. Higher level protocols. 4 lectures/problem-solving. Prerequisite: CS 241 and CS 365 with grades of C or better, or consent of instructor.

#### **CS 390 Computer Simulation (4)**

Overview of computer simulation. Model building, implementation, validation. Discrete and continuous simulation models. Application of simulation techniques to scientific research. Graphical representation of simulation models and survey of simulation languages. 4 lectures/problem-solving. Prerequisite: STA 326 or STA 330 and CS 241 with a grade 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 405 Microprocessor Systems (4)**

The microprocessor and support integrated circuits (ICs) as a unified system and their programming implications. Study and application of ICs for communications, peripheral adaptors, arithmetic processors, floppy disc and CRT controllers in a system context. 4 lectures/problem-solving. Prerequisite: CS 365 with a grade of C or better, or consent of instructor.

#### **CS 408 Programming Languages (4)**

Formal definition of programming languages. Global properties of algorithmic languages including scope of declarations, storage allocation, grouping of statements, binding time, subroutines, coroutines. List processing, string manipulation and data description. Run time representation of program and data structures. 4 lectures/problem-solving. Prerequisite: CS 264 and CS 310 with grades of C or better, or consent of instructor.

#### **CS 420 Artificial Intelligence (4)**

Heuristic programming, searching problem spaces, theorem-proving programs, game playing programs, decision-making programs, question answering programs. Consideration of ethical and social dilemmas posed by AI. Technical paper required. 4 lectures/problem-solving. Prerequisite: STA 326 and CS 310 with a grade of C or better, or consent of instructor.

#### **CS 431 Operating Systems (4)**

Modern operating systems overview. Loading, linking, address binding and memory management. Processes and their synchronization primitives, resource management. Monitors and kernels. Multiprogramming and multiprocessing. Concurrent operations and hardware I/O. Deadlock, file management and job control. Issues of security, privacy and property rights as they relate to operating system functions. Technical paper required. 4 lectures/problem-solving. Prerequisite: CS 241 and CS 264 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. Advanced topics including distributed systems, concurrency, and recovery. Technical paper required. 4 lectures/problem-solving. Prerequisite: CS 241 with a grade of C or better, or consent of instructor.

**CS 440 Compiler Design (4)**

Lexical analysis, parsing and basic compiling techniques including syntax-directed translation. 4 lectures/problem-solving. Prerequisite: CS 241, CS 264 and CS 310 with grades of C or better, or consent of instructor.

**CS 441 Advanced Compiler Design (4)**

Run-time environments, parsing techniques, intermediate code generation and optimization, object code generation and optimization. 4 lectures/problem-solving. Prerequisite: CS 440 with a grade of C or better, or consent of instructor.

**CS 445 Advanced Computer Graphics (4)**

Advanced concepts and applications of three-dimensional computer graphics. Object modeling by surface modeling and solid modeling. Curve and patch generation algorithms. Surface rendering by hidden surface removal and shading. Survey of recent developments in visualization including virtual reality. 4 lectures/problem-solving. Prerequisite: CS 245 with a grade of C or better, or consent of instructor.

**CS 450 Computability (4)**

Turing machines, RAM machines, primitive and mu recursion, Godel numbering, Church-Turing thesis, decidability, Markov and Post systems, algorithmically unsolvable problems. 4 lectures/problem-solving. Prerequisite: CS 310 with a grade of C or better, or consent of instructor.

**CS 460 Secure Communication (4)**

Public-key systems, digital signatures, ciphers, the Data Encryption Standard, access security, control of information flow. 4 lectures/problem-solving. Prerequisite: senior standing in Computer Science and CS 301 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. Prerequisite: senior standing in computer science and a passing score on GWT.

**CS 475 Computers and Society**

Social, ethical, legal, political and economic issues associated with computing. Analysis of issues in written essays; discussion of case studies. Exposure to issues through a skills acquisition exercise. 4 seminars. Prerequisite: ENG 104. Computer experience recommended.

**CS 480, 481 Software Engineering (4)(4)**

Software engineering process including requirements engineering, specification techniques, design concepts and methods, software testing and integration concepts, verification and validation, quality assurance and configuration management, post-development software evolution and documentation. 4 lectures/problem-solving. Prerequisite: CS 241 with a grade 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

John A. Klasik, Chair

David R. Berry  
David R. Jessey  
Jonathan A. Nourse  
Donald W. Tarman

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 education.

Students entering the Geological Sciences Department are offered two programs leading to a Bachelor's of Science Degree. Majors may select from two options; Geology or Integrated Earth Studies (IES). The Geology Option is a comprehensive curriculum in the geological sciences and support courses in mathematical, physical and biological sciences. The Integrated Earth Studies Option, through its interdisciplinary character, addresses two important contemporary needs: the training of environmental specialists and the training of teachers.

For students majoring in disciplines other than Geology, a Minor in Geology can be earned through appropriately directed Geoscience course work. The Geology Minor promotes student exposure to a broad range of required and elective Geoscience courses. 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. 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.

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.

### GEOLOGY OPTION

#### Core Courses for Major

Required of all students. A 2.0 cumulative GPA is required in core courses, including option 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)
Earth, Time and Life Laboratory	.GSC	151L	(1)
Computer Graphics for Geologists	.GSC	175/175L	(2/2)
Mineralogy	.GSC	215/215L	(3/1)
Hand Specimen Petrology	.GSC	219/219L	(2/2)

Introduction to Geochemistry	.GSC	300/300L	(3/1)
Applied 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)
Ground Water Geology	.GSC	360/360L	(3/1)
Engineering Geology	.GSC	415/415L	(3/1)
or Geotechnology	.GSC	321/321L	(3/1)
Sedimentary Geology	.GSC	423/423L	(3/2)
Igneous and Metamorphic Petrology	.GSC	424L	(3)
Igneous and Metamorphic Petrography	.GSC	425L	(2)
Ore Deposits	.GSC	433/433L	(3/1)
or Geotectonics	.GSC	444/444L	(3/1)
Field Methods	.GSC	455/455L	(1/3)
Senior Thesis	.GSC	461	(2)
Senior Thesis	.GSC	462	(2)
Senior Seminar	.GSC	463	(2)
Summer Field Geology	.GSC	490	(8)
Total core units			(81)

### Support and Elective Courses

Required of specific options

General Chemistry	.CHM	122/122L	(3/1)
General Chemistry	.CHM	123/123L	(3/1)
Introduction to Geographic Information Systems	.GEO	240/240A	(4)
Analytic Geometry and Calculus	.MAT	115	(4)
Analytic Geometry and Calculus	.MAT	116	(4)
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)
Introduction to Statistics	.STA	120	(4)
Total support units			(36)
Units to Complete GE			(81)
Unrestricted Electives			(9-8)

### General Education Courses

#### Area 1:

A. Freshman English I	.ENG	104	(4)
B and C, two additional courses			(8)

#### Area 2:

A. Analytic Geometry and Calculus	.MAT	114	(4)
B. General Chemistry/Laboratory	.CHM	121/121L	(3/1)
C. Basic Biology	.BIO	115/115L	(3/2)
or Life Science	.BIO	110/111L	3/1
D. Geologic Catastrophes	.GSC	350/350A	(3/1)

#### Area 3:

Select one course from each area. Minimum total (28)

#### Area 4:

United States History	.HST	202	(4)
and Introduction to American Government	.PLS	201	(4)

#### Area 5: (Upper Division) - 8 units

(A total of 12 upper division units required in GE - four in Area 2d and eight in Area 5.)

See Schedule of Classes for approved courses.

**INTEGRATED EARTH STUDIES OPTION****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)
Earth, Time, and Life lab . . . . .	GSC	151L	(1)
Computer Graphics for Geologists . . . . .	GSC	175/175L(2/2)	
Mineralogy . . . . .	GSC	215/215L(3/1)	
Hand Specimen Petrology . . . . .	GSC	219/219L(2/2)	
Introduction to Geochemistry . . . . .	GSC	300/300L(3/1)	
Meteorology . . . . .	GSC	304	(4)
Studies of a Blue Planet . . . . .	GSC	320	(4)
Geotechnology . . . . .	GSC	321/321L(3/1)	
Applied Geomorphology . . . . .	GSC	323/323L(3/1)	
Descriptive Physical Oceanography . . . . .	GSC	335	(4)
Groundwater Geology . . . . .	GSC	360/360L(3/1)	
Integrated Science 4 or 8 units . . . . .	SCI	495	4/8

Total core units required . . . . . (57-61)

**Support and Elective Courses**

General Chemistry . . . . .	CHM	122/122L(3/1)	
General Chemistry . . . . .	CHM	123/123L(3/1)	
Environmental conservation . . . . .	BIO	201	(3)
Field Geography . . . . .	GEO	309	(4)
Geography of California . . . . .	GEO	351	(4)
Introduction to Geographic Information Systems . . . . .	GEO	240/240A	(4)
Advanced Geographic Information Systems I . . . . .	GEO	442/442A	(4)
Advanced Geographic Information Systems II . . . . .	GEO	443/443A	(4)
College Algebra . . . . .	MAT	105	(4)
College Physics . . . . .	PHY	121	(3)
College Physics . . . . .	PHY	122	(3)
College Physics . . . . .	PHY	123	(3)
College Physics Lab . . . . .	PHY	121L	(1)
College Physics Lab . . . . .	PHY	122L	(1)
College Physics Lab . . . . .	PHY	123L	(1)
Basic Soil Science . . . . .	SS	231/231L(3/1)	
Statistics with Applications . . . . .	STA	120	(4)
Total support units . . . . .			(63)
Units to complete GE . . . . .			(78-73)
Unrestricted Electives . . . . .			(1-6)
if 8 units of SCI 495 . . . . .			(1-2)

**General Education Courses****Area 1:**

A. Freshman English I . . . . .	ENG	104	(4)
B and C. Two additional courses . . . . .			(8)

**Area 2:**

A. Trigonometry . . . . .	MAT	106	(4)
B. College Chemistry/Laboratory . . . . .	CHM	121/121L(3/1)	
C. Basic Biology . . . . .	BIO	115/115L(3/2)	
or Life Science . . . . .	BIO	110/111L(3/1)	
D. Geologic Catastrophes . . . . .	GSC	350/350A	(4)

**Area 3:**

Select one course from each subsection. Minimum total . . . . . (28)

**Area 4:**

United States History . . . . .	HST	202	(4)
and Introduction to American Government . . . . .	PLS	201	(4)

**Area 5: (Upper Division) - 8 units**

(A total of 12 upper division units required in GE-four in Area 2d and eight in Area 5.)

See Schedule of Classes for approved courses.

**MINOR IN GEOLOGY**

Minimum units . . . . .			(33)
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)
Hand Specimen Petrology . . . . .	GSC	219/219L(2/2)	

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**

The Geological Sciences Department offers a program in science with a concentration in Geology approved by the Commission on Teacher Credentialing. Those individuals who wish to become science teachers with an emphasis in the geological 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:****Biological Sciences**

Basic Biology . . . . .	BIO	115/115L	(5)
Plant Structures and Functions Botany . . . . .	BOT	124/124L	(5)

**Zoology**

Vertebrate Zoology . . . . .	ZOO	138/138L	(5)
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**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 with Lab . . . . .	GSC	111/141L(4/1)	
Earth, Time and Life with Lab . . . . .	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****Geological Sciences**

Introduction to Astronomy . . . . .	GSC	116	(4)
Computer Graphics for Geologists . . . . .	GSC	175/175L(2/2)	
Mineralogy . . . . .	GSC	215/215L(3/1)	
Hand Specimen Petrology . . . . .	GSC	219/219L(2/2)	

Meteorology .....	GSC	304	(4)
Applied Geomorphology .....	GSC	323/323L	(3/1)
Geologic Catastrophes .....	GSC	350	(4)

Select one pair of courses from the following pairs:

Geotechnology .....	GSC	321/321L	(3/1)
Invertebrate Paleontology .....	GSC	331/331L	(3/1)
Stratigraphy .....	GSC	332/332L	(3/1)
Structural Geology .....	GSC	333/333L	(3/1)
Groundwater Geology .....	GSC	360/360L	(3/1)
Geotectonics .....	GSC	444/444L	(3/1)

### Course Description

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. 3 lectures per week. Corequisite: GSC 141L (optional for non-majors).

#### +GSC 112 Earth, Time and Life (3) FW

Changes in continents and ocean basins, fossil populations during successive geological ages, 3 lectures. May be taken without laboratory by non-majors.

#### +GSC 116 Introduction to Astronomy (4) FWSp

A non-quantitative synthesis of the current knowledge of the cosmos and analysis of the techniques used in its investigation. The class is composed of two major components. The first considers our solar system. Topics include the sun, planets, moons, comets, asteroids and meteors, their place in the universe and discussion of theories of their origin and evolution. The second part of the class looks beyond our solar system to examine such subjects as stars, galaxies, nebulae, black holes, pulsars, and quasars. Additionally, the class will study the broader nature of the universe, how it may have started, its present state, its future evolution and its ultimate destiny. Special emphasis will be given throughout the course to new information revealed by satellite data and unmanned space missions. 4 lecture discussions per week.

#### +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 or permission of instructor. Laboratory optional for non-majors.

#### GSC 151L Earth, Time and Life Laboratory (1) FW

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 or permission of instructor. Optional for non-majors. Field trips required. Field trip fee required.

#### GSC 175/175L Computer Graphics for Geologists (2/2) Sp

Practical exercises in the utilization of computer software to solve geological problems. Computerized preparation of geologic diagrams, reports and presentations. Fundamental instruction in the C++ programming language to enable the coding and compilation of simple programs to process geologic data. 2 lectures, 2 three-hour laboratories. Prerequisites: GSC 111, GSC 141L.

#### GSC 200 Special Study for Lower Division Students (1-2) FWSp(Su)

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 rock-forming minerals. Blowpipe and qualitative spectroscopic analysis. Physical and chemical properties of minerals and introductory morphologic crystallography. 3 lectures/problem-solving, 1 three-hour laboratory. Prerequisites: GSC 111 GSC 141L, CHM 121/121L. Field trip fee required.

#### GSC 219/219L Hand Specimen Petrology (2/2) W

Emphasis on rock collecting and field relationships. Rock identification based largely on megascopic properties. Students will be required to make field trips and field collections. 2 lectures/problem-solving, 2 three-hour laboratories. Prerequisites: GSC 111, GSC 141L. Field trip fee required.

#### +GSC 250 Environmental Geology (4) FW

Application of geologic principles to selected environmental problems; topics include resources (water, minerals and energy), geologic hazards (floods, earthquakes and landslides) and environmental planning (waste disposal, construction siting and environmental impact statements). 4 lectures. 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. Prerequisite: Permission of instructor.

#### GSC 300/300L Introduction to Geochemistry (3/1) F

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: 1 year of college-level chemistry.

#### **GSC 304 Meteorology (4) W**

Framework topics, such as atmospheric structure, composition, global heat budget, pressure and humidity form the base upon which a process-oriented, semiquantitative, descriptive survey of major weather phenomena, including winds, clouds, precipitation and storms, is conducted. 4 lectures/problem-solving. Prerequisites: PHY 121 or consent of instructor.

#### **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 warming, El Nino, ozone depletion, sea level changes, coastal development, energy extraction from the ocean, desalination and satellite monitoring of earth are investigated. 4 lecture discussions per week. Prerequisites: One course each from General Education Area II, A, B, C.

#### **GSC 321/321L Geotechnology (3/1) FWSp(Su)**

Fundamentals of geology applied to engineering problems. Includes rock types, structure, erosion, sedimentation, seismic explorations and rock/soil movements. 3 lectures/problem-solving, 1 three-hour laboratory. For Civil Engineering majors. Prerequisite: ENG 104, CE 134/134L. Field trips required. Field trip fee required.

#### **GSC 323/323L Applied Geomorphology (3/1) F**

Practical/Empirical Geomorphology of Landforms and Terrain analysis of Surficial Geology. The systematic description and analysis of landscapes and processes that change them - processes of landform development, analysis of modern surfaces, recognition of older landforms obscured by modern erosional overprinting; use of remote sensing techniques in landform analysis; quantitative measures of landform evolution. 3 lecture discussions and 1 three-hour laboratory per week. Required field trips. Field trip fee required. Prerequisite: GSC 111, GSC 141L, GSC 219/219L.

#### **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, CHM 122/122L.

#### **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**

Structural features and deformation of the earth's crust. Solution of geologic field problems. 3 lectures/problem-solving, 1 three-hour laboratory. Prerequisites: Mat 106, GSC 175/175L, GSC 111, GSC 141L. 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 Descriptive Physical Oceanography (4) F**

A survey of physical, chemical and geological oceanography. Emphasis centers on the major physical and chemical properties of sea water and such physical processes as ocean circulations, tides and waves. Ocean basin physiography, sedimentation and evolution are also discussed. 4 lectures/problem-solving; cruise. Prerequisites: CHM 121 & PHY 121. Field trips required. Field trip fee required.

#### **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 Geologic Catastrophes (4) FWSp (Su)**

Scientific description, measurement and observation of geologic catastrophes resulting from active plate tectonic phenomena. Emphasis on earthquakes, volcanic eruptions, landslides and glacially-controlled sea level changes. Floods and associated erosion/deposition may also be addressed. Case histories of past geologic catastrophes. 4 lectures/problem solving. Field trip fee required.

#### **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. Prerequisites: GSC 111, GSC 141L, MAT 105 or higher, PHY 121 and PHY 121L or PHY 131 and PHY 131L.

#### **GSC 400 Special Study for Upper Division Students (1-2) FWSp (Su)**

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 (3/1)**

Geologic site investigations; field mapping; subsurface investigations. Geologic analysis of slope stability; subsidence; geology of dam and tunnel construction; ground water geology; seismicity and active fault tectonics; urban geology and engineering geologic reports. 3 lectures/problem-solving, 1 three-hour laboratory. Prerequisites: GSC 111, GSC 141L, or GSC 321/321L. Field trips required.

**GSC 423/423L Sedimentary Geology (3/2) Sp**

Stratigraphic procedures, correlation, depositional environments, classification and origin of stratigraphic units, descriptive chemical, mineralogic and textural studies of sedimentary rocks, using petrographic, sieve and sedimentation 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 and MAT 115. 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. Prerequisites: GSC 215/215L. GSC 219/219L or GSC 424, GSC 333/333L. 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 and GSC 219/219L or consent of instructor.

**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 or permission of instructor.

**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 219/219L and GSC 333/333L. Field trips required. 3 lectures/problem-solving, 1 three-hour laboratory.

**GSC 455/445L Field Methods (1/3) Sp (even years)**

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 219/219L and GSC 333/333L. Field trips required. Field trip fee required.

**GSC 461, 462 Senior Thesis (2) F W Sp**

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) F W Sp**

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 (even years)**

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 455/455L. Field trip fee required.

**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. Prerequisite: permission of instructor.

# MATHEMATICS

Claudia Pinter-Lucke, Chair

Charles Amelin	Harriet Lord
Bernard Banks	Daniel A. Marcus
Simon Bernau	Henryka Maslowski
Hasan Celik	Frank P. Mathur
Yu Chang	Jim McKinney
Tse-yee Chen	Lilian Metlitzky
Hsin Ya Fan	John C. Morgan, II
Carlos Ford-Livene	Martin Nakashima
Dhanwant Singh Gill	Alan Radnitz
Frank Glaser	Kamta Rai
Jack E. Hofer	Richard A. Robertson
Larry D. Irwin	Barbara Shabell
Judith Jacobs	Carol Smith
Alan Krinik	V. Merriline Smith
Kei A. Lee	Weiqing Xie

The Mathematics Department 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.

However, 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 Mathematics Department 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 and 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.

## CORE COURSES FOR MAJOR

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

Introduction to C++	.CS	128	(4)
or FORTRAN	.CS	125	
Applied Probability Theory	.STA	330	(4)
Applied Statistics	.STA	331	(4)
Analytic Geometry and Calculus	.MAT	116	(4)
Introduction to Numerical Methods	.MAT	201	(4)
Introduction to Linear Algebra	.MAT	208	(4)
Calculus of Several Variables	.MAT	214	(3)
Calculus of Several Variables	.MAT	215	(3)
Differential Equations	.MAT	216	(4)
Basic Set Theory and Logic	.MAT	310	(4)

Intermediate Analysis	.MAT	314	(4)
Intermediate Analysis	.MAT	315	(4)
Modern Algebra	.MAT	417	(4)
Modern Algebra	.MAT	418	(4)
Complex Variables	.MAT	428	(4)

## OPTION COURSES FOR MAJOR

Required for specific option

### 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, MAT 420. 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)
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)
Foundations of Mathematics +	.MAT	450	(4)

## 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	.MAT	401	(4)
Numerical Analysis	.MAT	402	(4)
Differential Equations	.MAT	431	(4)
Differential Equations	.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:

Nonparametric Statistics	.STA	340	(4)
Applied Regression	.STA	432	(4)
Stochastic 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**

Required of all students

General Physics . . . . .	PHY	132	(3)
General Physics . . . . .	PHY	133	(3)
General Physics Laboratory . . . . .	PHY	132L	(1)
General Physics Laboratory . . . . .	PHY	133L	(1)
Unrestricted Electives . . . . .			(31)

**GENERAL EDUCATION COURSES**

**Area 1:**

A. Freshman Composition . . . . .	ENG	104	(4)
B and C. Choose two courses in consultation with advisor. . . . .			(8)

**Area 2:**

A. Analytic Geometry and Calculus . . . . .	MAT	114	(4)
Analytic Geometry and Calculus . . . . .	MAT	115	(4)
B. General Physics . . . . .	PHY	131	(3)
Physics Lab . . . . .	PHY	131L	(1)
C. Life Science . . . . .	BIO	110	(3)
D. Choose in consultation with advisor (Upper Division) . . . . .			(4)

**Area 3:**

Select one course from each area. Minimum total . . . . . (28)

**Area 4:**

United States History . . . . .	HST	202	(4)
Introduction to American Government . . . . .	PLS	201	(4)

**Area 5:**

Upper Division-Select two courses. . . . . (8)

**SUBJECT MATTER PREPARATION - Program for Prospective Teachers in Mathematics**

The Mathematics Department 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 option 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	
Modern Algebra I . . . . .	MAT	417	(4)
Modern Algebra II . . . . .	MAT	418	(4)
Topics and Issues in Contemporary Secondary School Mathematics . . . . .	MAT	495	(4)
Topics and Issues in Contemporary Secondary School Mathematics . . . . .	MAT	496	(4)
Topics and Issues in Contemporary			

Secondary School Mathematics . . . . .	MAT	497	(4)
Applied Probability Theory . . . . .	STA	330	(4)
Applied Statistics . . . . .	STA	331	(4)
Pascal . . . . .	CS	120	(4)
or a college-level course in C			

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 . . . . .	MAT	114	(4)
Analytic Geometry and Calculus . . . . .	MAT	115	(4)
Analytic Geometry and Calculus . . . . .	MAT	116	(4)
Calculus of Several Variables . . . . .	MAT	214	(3)
Calculus of Several Variables . . . . .	MAT	215	(3)
Differential Equations . . . . .	MAT	216	(4)
Introduction to Linear Algebra . . . . .	MAT	208	(4)

In addition to the above courses, choose any four upper division courses (except MAT 391,392, 400, 461,462, 463, 491, 492, 493, 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**

Analytic Geometry and Calculus . . . . .	MAT	114	(4)
Analytic Geometry and Calculus . . . . .	MAT	115	(4)
Analytic Geometry and Calculus . . . . .	MAT	116	(4)
Introduction to Linear Algebra . . . . .	MAT	208	(4)
Calculus of Several Variables . . . . .	MAT	214	(3)
Calculus of Several Variables . . . . .	MAT	215	(3)
Applied Probability Theory . . . . .	STA	330	(4)
Applied Statistics . . . . .	STA	331	(4)
Applied Regression . . . . .	STA	432	(4)

Choose 8 units from the following:

Nonparametric Statistics . . . . .	STA	340	(4)
Stochastic 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)

Minimum number of units required: . . . . . (42)

For two or more courses with a common course description, each lower-numbered course must be passed with a C or better (or the student must obtain a written consent of the instructor) as a prerequisite for each higher-numbered course.



**MATHEMATICS DIAGNOSTIC PLACEMENT TEST (MDPT)**

There is a MDPT test prerequisite required for all introductory and GE level mathematics and statistics courses. THIS REQUIREMENT MUST BE MET WITHIN THE IMMEDIATE THREE QUARTERS PRIOR TO ENROLLMENT IN MATHEMATICS AND STATISTIC COURSES. There are two tests: Mathematical Analysis (for MAT 12, 105, 106, 125, 137, 191, STA 120); and Precalculus (for MAT 112, 114, 120, 130). All test results include cutoff scores for lower level courses. Tests are given each quarter, including summer quarter. Students must register in advance at the Mathematics Department Office (Building 8, Room 108) or online at the Math Department home page, <http://www.csupomona.edu/~Math>.

**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. Some courses include weekly tutorial-laboratories. Courses receive unit load credit but not baccalaureate credit. Students must have achieved prerequisite scores on ELM or MDPT in order to enroll in MAT 010, 011, 012.

**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).

All students must take the Entry-Level Math Test 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.

**MAT 010 Prealgebra (4) FWSp**

Geometry, measurement geometry, introduction to algebra including variable expressions, linear equations, polynomials, techniques of factoring, integer exponents. 4 lectures/problem-solving. Two-hour tutorial laboratory. Letter grade only. Prerequisite: minimum placement score on ELM or appropriate MDPT. Course does not earn Baccalaureate credit.

**MAT 011 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 lectures/problem-solving. One-hour tutorial laboratory. Letter grade only. Prerequisite: minimum placement score on ELM or appropriate MDPT or C or better in MAT 010 within three (3) quarters. Course does not earn Baccalaureate credit.

**MAT 012 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 lectures/problem-solving. Letter grade only. Prerequisite: minimum placement score on ELM or appropriate MDPT or C or better in MAT 011 within three (3) quarters. 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 and

mathematical induction. 4 lectures/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 012; or, within the last 18 months must have earned either 560 or better on the SAT or 26 or better on the ACT.

**MAT 106 Trigonometry (4) FWSpSu**

The circular functions, general reduction formulas, inverse functions, graphs, exponential and logarithmic functions, Law of Sines, Law of Cosines, identities and complex numbers. 4 lectures/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 012; or, within the last 18 months must have earned either 560 or better on the SAT or 26 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), conic sections, solutions of systems of linear and non-linear equations, inequalities, introduction to limits. 4 lectures/problem-solving. Prerequisites: must have either achieved the minimum placement score on the appropriate MDPT or C or better in MAT 105 and MAT 106 or equivalent within three quarters.

**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 lectures/problem-solving. Prerequisite: must have achieved either the minimum placement score on the appropriate MDPT or B or better in MAT 105 and MAT 106 or equivalent or C or better in MAT 112 within three quarters.

**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 lectures/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, Polar Coordinates, Parametric equations and Conic Sections. 4 lectures/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-problems. Prerequisites: must have achieved either the minimum placement score on appropriate MDPT or C or better in MAT 105 or equivalent within three quarters.

**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 lectures/problem-solving. Prerequisite: have achieved the minimum placement score on the appropriate MDPT or C or better in MAT 012 within three quarters.

**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 lectures/problem-solving. Prerequisite: must have achieved the minimum placement score on the appropriate MDPT or B or better in MAT 105 and MAT 106 or equivalent or C or better in MAT 112 within three quarters.

**MAT 131 Technical Calculus II (4) FWSpSu**

Analytic geometry. Derivatives and integrals of trigonometric, logarithmic, and exponential functions and applications. Infinite Series. 4 lectures/problem-solving. Prerequisite: C or better in MAT 106 and MAT 130 or consent of instructor.

**MAT 132 Technical Calculus III (4) FWSpSu**

Techniques of multidimensional calculus, introduction to ordinary differential equations and Laplace transforms. 4 lectures/problem-solving. Prerequisite: C or better in MAT 131 or consent of instructor.

**MAT 137 Survey of Geometry (4) Check with Department**

Logical systems; Euclidean Geometry, Coordinate Geometry; Geometry in Space, lines, planes, volumes and surface areas; Applications. 4 lectures/problem-solving. Prerequisites: must have achieved the minimum placement score on the appropriate MDPT or C or better in MAT 012 within three quarters.

**MAT 191 Survey of Mathematics (4) FWSpSu**

Emphasis on modern applications of selected topics from sets, logic, probability, statistics and mathematical modeling. 4 lecture-problems. Prerequisites: Within the last 3 quarters, must have either achieved a minimum placement score on the appropriate MDPT or C or better in MAT 012; or, within last year must have earned 550 or better on the ELM; or, within the last 18 months must have earned either 560 or better on the SAT or 26 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 lectures/problem-solving. Prerequisite: C or better in MAT 116 and CS 120 or CS 125 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 lectures/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 lectures/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 lectures/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 lectures/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) F**

Development of mathematics over four millennia. Recommended for students preparing to teach mathematics. 4 lectures. Prerequisite: C or better in MAT 215, or consent of instructor.

**MAT 310 Basic Set Theory and Logic (4) FSp**

Basic set theory and logic, relations, functions, mathematical induction, countable and uncountable sets. Emphasis on how to present and understand mathematical proof. 4 lectures/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 lectures/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 lectures/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 lectures/problem-solving. Prerequisite: C or better in MAT 215, or consent of instructor.

**MAT 321 Introduction to Topology (4) F (Odd years)**

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 lectures/problem-solving. Prerequisite: C or better in MAT 310, or consent of instructor.

**MAT 325 Introduction to the Theory of Numbers (4) Sp**

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 lectures/problem-solving. Prerequisite: junior standing or consent of instructor.

#### **MAT 330 Modern Euclidean Geometry (4) W**

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 lectures/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 lectures/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 lectures/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 lectures/problem-solving. Prerequisite: C or better in MAT 380, or consent of instructor.

#### **MAT 391 Elementary Mathematics from an Advanced Viewpoint (4) FWSp**

Development of the real number system through the reals; development of numeration systems; elementary concepts of algebra; introduction to number theory; elementary group and field theory. Development of problem-solving strategies and application of technology to these topics. 4 lectures/problem-solving. Prerequisite: C or better in MAT 191.

#### **MAT 392 Elementary Geometry from an Advanced Viewpoint I (4) FWSp**

Introduction to Metric and non-Metric geometry; development of inductive and deductive geometric proofs; congruence and similarity; and basic concepts of topology. 4 lecture-problems. Prerequisites: C or better in MAT 391.

#### **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 lectures/problem-solving. Prerequisite: C or better in MAT 201, MAT 208, MAT 215 and CS 120 or CS 125 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 Runge-Kutta methods and predictor-corrector methods for solving initial value problems and the shooting method for solving boundary value problems. 4 lectures/problem-solving. Prerequisites: C or better in MAT 216 and 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 lectures/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 lectures/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 lectures/problem-solving. Prerequisite: C or better in MAT 208 and 215, or consent of instructor.

#### **MAT 417, 418 Modern Algebra (4) (4) FW/Sp**

Introduction to algebraic structures; groups, rings, integral domains, fields; mappings with emphasis on morphisms. 4 lectures/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 lectures/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 lectures/problem-solving. Prerequisite: C or better in MAT 314 and MAT 216, or consent of instructor.

#### **MAT 428, 429 Functions of a Complex Variable (4) (4) F (every year)/ W (odd years)**

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/problems. Prerequisites for MAT 428: C or better in MAT 314 or consent of instructor. Prerequisite for MAT 429: 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 lectures/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 lectures/problem-solving. Prerequisite: C or better in MAT 208 and 216. PHY 321 is recommended, or consent of instructor.

**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 lectures/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 discussions. 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 lectures/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 lectures/problem-solving. Prerequisite: C or better in MAT 208 and CS 125, or 120, 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 lectures/problem-solving. Prerequisites: C or better in the following courses: CS 120 or CS 125, MAT 201, MAT 208, MAT 216 and STA 330 or consent of instructor.

**MAT 491 Elementary Geometry from an Advanced Viewpoint II (4) FWSp**

Introduction to congruence and similarity through constructions and deductive proofs; motion geometry involving translations, rotations and flips; tessellations; topology; coordinate geometry programming in LOGO. 4 lectures/problem-solving. Prerequisite: C or better in MAT 392.

**MAT 492 Technological Applications in Mathematics (4) W**

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. 4 lectures/problem-solving. Prerequisite: C or better in MAT 491 or consent of instructor.

**MAT 493 Algebraic Structures and Computing for Elementary and Middle School Teachers (4) Check with Department**

Development of algebraic structures from groups to fields. Study of modular arithmetic, relationships and functions. Use of the computer, including programming in BASIC, to investigate algebraic relationships and algorithms. 4 lectures/problem-solving. Prerequisite: C or better in MAT 491 or permission of the instructor.

**MAT 495/495A, 496/496A, 497/497A Topics in Contemporary Secondary 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

D. Singh Gill, 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 lectures/problem-solving. Prerequisites: Within the last two quarters, must have either achieved a minimum placement score on the appropriate MDPT or C or better in MAT 012; or, within last 3 quarters must have earned 550 or better on the ELM; or, within the last 18 months must have earned either 560 or better on the SAT I or SAT II or 26 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 (odd years)

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 lectures/problem-solving. Prerequisite: C or better in STA 120 or consent of instructor.

### STA 220 Discrete Probability Models (4) W (odd years)

Set-theoretic approach to probability in finite sample spaces. Conditional probability, independence, binomial, hypergeometric and related distributions. 4 lectures/problem-solving. Prerequisite: C or better in MAT 105, or 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 lectures/problem-solving. Prerequisite: C or better in MAT 214 or MAT 131 or consent of instructor.

### STA 310 Sampling Survey Methods (4) Sp

Simple random sampling, stratified, cluster, systematic, multistage, multiphase and probability sampling methods, source of errors, sample size estimation. Not open to math majors for upper division math elective credit. 4 lectures/problem-solving. Prerequisite: C or better in STA 120 or equivalent or consent of instructor.

### STA 315 Probability and Statistics for Engineers (4)

(Check with Department)

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 lectures/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 330.

### STA 340 Nonparametric Statistics (4) W (even 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 lectures/problem-solving. Prerequisite: C or better in STA 210 or STA 326 or STA 331, or consent of instructor.

### STA 326 Statistical Methods for Computer Scientists (4) FWSp

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 lectures/problem-solving. Prerequisites: C or better in MAT 214 or consent of instructor. Not open to students required to take STA 330.

### STA 330 Applied Probability Theory (4) FW

Rules of probability, random variables, expected values of random variables, moment generating functions. Discrete and continuous probability distributions, including bivariate distributions, with applications. 4 lectures/problem-solving. Prerequisite: C or better in MAT 215. Not open to students with credit in STA 315 or ECE 315.

### STA 331 Applied Statistics (4) WSp

Central limit theorem, maximum likelihood estimation. Point and interval estimation and hypothesis-testing. Small and large sample inferences. Contingency table analysis and Chi-square tests. 4 lectures/problem-solving. Prerequisite: C or better in STA 330 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 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 lectures/problem-solving. Prerequisite: C or better in STA 326 or STA 330 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 lectures/problem-solving. Prerequisites: C or better in STA 326 or STA 331 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 founded factorial designs; treatment of missing data, incomplete block designs. 4 lectures/problem-solving. Prerequisite: C or better in STA 326 or STA 331 or STA 441 or consent of instructor.

**STA 440 Mathematical Statistics I (4) W (even years)**

Discrete and continuous probability distributions; moments, moment generating functions, special distributions, distributions of functions of random variables. 4 lectures/problem-solving. Prerequisite: C or better in MAT 215, or consent of instructor.

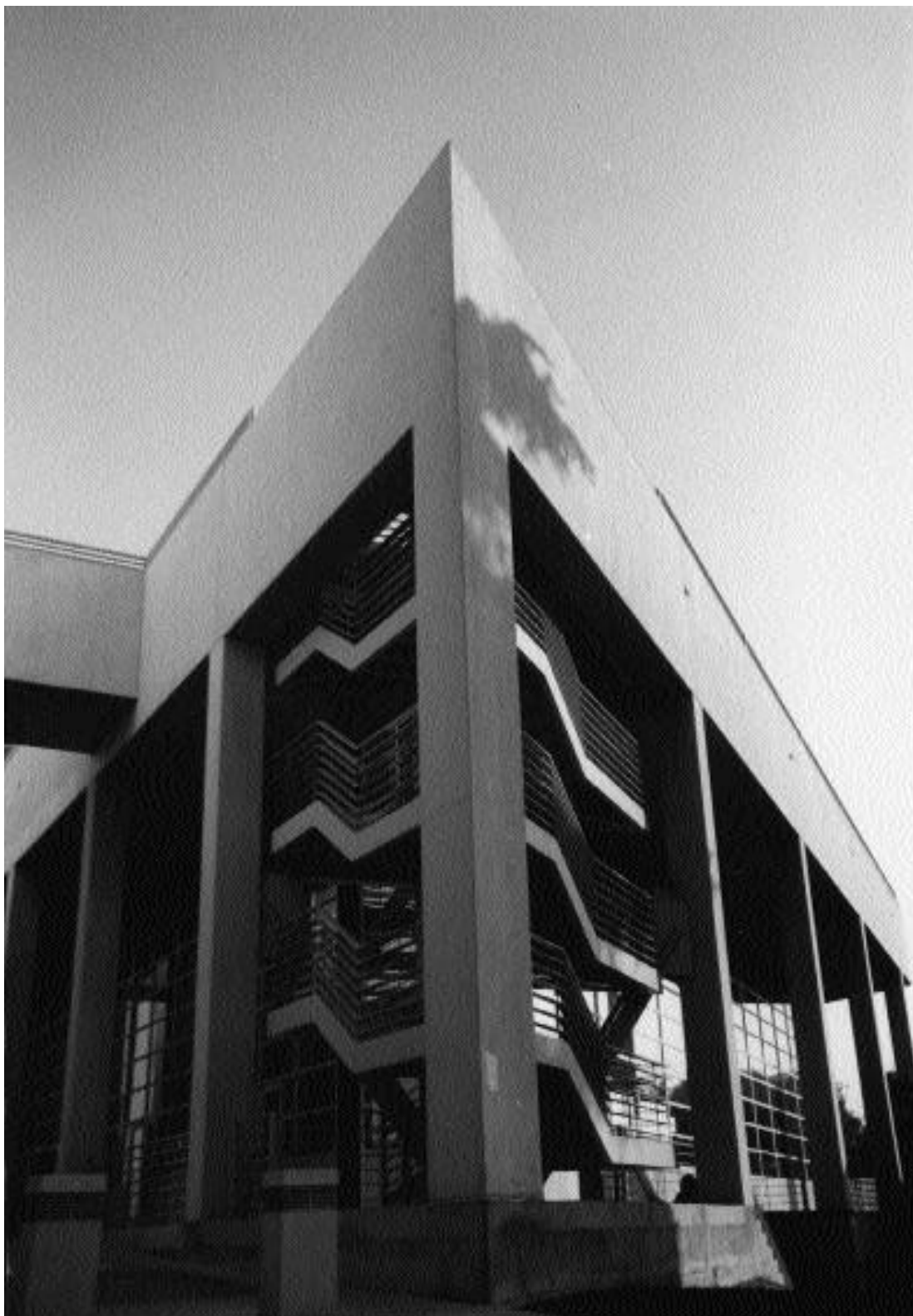
**STA 441 Mathematical Statistics II (4) Sp (even years)**

Asymptotic distributions; central limit theorem; point and interval estimation; completeness and sufficient statistics; Neyman-Pearson theory of testing hypotheses. 4 lectures/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

George W. Rainey, Chair

Antonio Aurilia	Harvey S. Leff
Robert T. Bush	John Mallinckrodt
Soumya Chakravarti	Steven W. McCauley
Barry H. Dorfman	Mary E. Mogge
John Fang	Roger L. Morehouse
John W. Jewett	Barton Palatnick
Kai-Shue Lam	Peter B. Siegel

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 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 option 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)
Elementary Modern Physics	PHY	235	(3)
General Physics Laboratory	PHY	234L	(1)
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

Required of all students

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 (15)

### GENERAL EDUCATION COURSES

#### Area 1:

A. Freshman English I	ENG	104	(4)
B. Select one course from this area.			(4)
C. Select one course from this area.			(4)

#### Area 2:

A. Analytic Geometry and Calculus	MAT	114	(4)
B. General Chemistry	CHM	121/121L	(4)
C. Life Science	BIO	110	(3)
and Life Science Laboratory	BIO	111L	(1)
or Basic Biology	BIO	115/115L	(5)
D. Select one course in consultation with advisor.			(4)

#### Area 3:

A. Select one course from this area.			(4)
B. Select one course from this area.			(4)
C. Select one course from this area.			(4)
D. Select one course from this area.			(4)
E. Select one course from this area.			(4)
F. Select one course from this area.			(4)
G. Select one course from this area.			(4)

#### Area 4:

Introduction to American Government	PLS	201	(4)
United States History	HST	202	(4)

#### Area 5:

Select 8 units from the approved list. Recommended courses: HST 421, CHM 306 and MAT 306.

### PHYSICS MINOR

College Physics	PHY	121/141L	(4)
and College Physics	PHY	122/142L	(4)
and College Physics	PHY	123/143L	(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 which at least 12 units must be chosen from upper division courses and no more than 12 units may be 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

Basic Biology	BIO	115/115L	(5)
Plant Structures and Functions	BOT	124/124L	(5)
Vertebrate Zoology	ZOO	138/138L	(5)

##### 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	131/131L	(3/1)
College Physics (Waves and Heat)	PHY	132/132L	(3/1)
College Physics (Electricity and Magnetism)	PHY	133/133L	(3/1)

##### Interdisciplinary Science

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

##### Physics

General Physics	PHY	234/234L	(3/1)
Electromagnetic Waves	PHY	235/235L	(3/1)
General Physics Elementary			(3/1)

##### Modern Physics

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)
Solid State Physics Laboratory	PHY	431L	(1)
Nuclear Physics Laboratory	PHY	432L	(1)

#### Select one:

Energy and the Environment	PHY	340	(4)
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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, then the year in which it will next be offered is also given.

#### PHY 102 Fundamentals of Physics (4) FWSp

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 104L Conceptual Physics Lab (1) FWSp Su

Introductory experiments in physics covering mechanics, thermodynamics, waves, sound, light, electricity, magnetism and modern physics. One three-hour laboratory period. Prerequisite: A college math course. No corequisites; may be taken concurrently with Physics 102. PHY 104L is not open to students who have credit for PHY 121L or 131L.

#### PHY 105/105L Physics of Musical Sound (4) Sp

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 115/115L Physics Concepts: A Hands-on Approach (4) Sp

Introduction to physics concepts covering waves, sound, and light. Hands on inquiry and laboratory activities appropriate for elementary school teachers are emphasized. Two three-hour periods integrating inquiry, discussion, lecture and laboratory activities. Prerequisite: A college math course. Phy 115 is not open to students who have credit for PHY121 or 131 or SCI 210.

#### 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 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. Corequisites: MAT 115 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: C- or better in PHY 131. Corequisites: MAT 116 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: C- or better in PHY 131. Corequisites: MAT 116 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. Corequisite for physics majors: PHY 234L.

**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. Corequisite for physics majors: PHY 235L.

**PHY 254L General Physics Laboratory (1) W**

Experiments on optics and electromagnetism. 1 three-hour laboratory. Must be taken concurrently with PHY 234.

**PHY 255L Elementary Modern Physics Laboratory (1) Sp**

Experiments illustrative of modern physics. 1 three-hour laboratory. Must be taken concurrently with PHY 235.

**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. Prerequisite: consent of instructor.

**PHY 301 Energy and Society (4) Sp**

Study of how humans use energy, including solar, nuclear, and other sources, to generate electricity, power vehicles, manufacture products,

and the like. Emphasis is on elementary physics principles. Coverage includes a historical overview of societal energy use, the study of how energy is stored and transferred, advantages and disadvantages of renewable and non-renewable resources, how fuels can be conserved, and how energy processes affect the environment. 4 lectures. Prerequisite: one college level physics lecture course.

**PHY 302 Physics of Everyday Experience (4) W**

Investigation into the physics associated with experiences in everyday life. Areas of physics covered include energy, waves, electromagnetism and optics. Applications of principles to common phenomena - weather, sound, aurorae, rainbows, halos, glories and the like. Applications of the principles to relevant social issues - thermodynamics of global warming; propagation of earthquake waves and effects on building vibrations; principles involved in electromagnetic transportation, such as electric cars and magnetic levitation vehicles, optical principles associated with optical communication. 4 lectures. Prerequisite: one college level physics lecture course.

**PHY 303 The Universe in Ten Weeks (4) Sp**

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: Areas 2A, 2B, and 2C.

**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**

History of physics from Thales of Miletus to the present with special emphasis on 19th and 20th century developments. 4 lectures. Prerequisite: PHY 131 or 121.

**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 to 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 to 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 340 Energy and the Environment (4) Sp (even years)**

Alternative energy technologies with a critical evaluation of their potential for solving the energy crisis and their impact on the environment. Natural resources, energy storage and transport, pollution, radiation hazards, energy conservation efforts, and outlook. 4 lectures/problem-solving. Prerequisite: PHY 131 or PHY 121.

**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, 402 Quantum Mechanics (4) (4) FW**

Introduction to quantum mechanics, including Schrodinger equation, hydrogen atom, degeneracy, perturbation theory, multi-electron atoms, matrix mechanics. 4 lectures/problem-solving. 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) Sp (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. Prerequisites: PHY 401, 402.

**PHY 406 Solid State Physics (4) W**

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. Prerequisite: PHY 235 and PHY 309.

**PHY 407 Statistical Physics (4) W (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, 333 and MAT 215.

**PHY 409 Computational Physics (4) F**

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. 4 lectures/problem-solving. Prerequisites: PHY 235, 309 and CS 120 or 125.

**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 314.

**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. 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. Prerequisite: consent of instructor.

**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, Coordinator, Minor; Director, Institute

Fellows of the Institute:

Chuck Amelin (Math)	Jim Manley (Philosophy)
Bernard Banks (Math)	Frank Mathur (Math)
David Berry (Geology)	Walter Maya (Chemistry)
Soumya Chakravarti (Physics)	Steve McCauley (Physics)
Richard DeNouvellis (Educ.)	Ron Quinn (Biology)
Carlos Ford-Livene (Math)	Carl Rathman (Engineering)
Dhanwant Gill (Math)	Harold Schleifer (Library)
Larry Herber (Geology)	Len Troncale (Biology)
Chung Lee (Computer Sci.)	Mark vonWodtke (Land. Arch.)
John Lyle (Land. Arch.)	

With Associate Fellows: Mike Hamilton (Ecology); Albert Wilson (Astronomy & Math); and Donna Wilson (Psychology & Math)

The Institute offers interdisciplinary courses for general purposes as well as leading to the Minor and Certificate in Comparative Systems Analysis. 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. 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 and the earth's resources: a transdisciplinary approach to theory 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 - Organization (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 to theory with problem-oriented activities emphasizing general systems concepts for synthesis and comparison. Uses the case study approach for depth.

#### 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 (4)

General principles of morphology and their application to various fields. Dimensionless morphology in mathematics and the natural sciences. Mathematical structures and concepts developed morphologically to illustrate the method. 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 Natural Systems Science A Synthesis (4)

Strengths and limits of the scientific method and its differences between disciplines. Use of seven transdisciplinary processes to unify the learning, understanding and comparison of fundamental facts and theories in case studies of astronomy, physics, chemistry, biology, geology, computer science and mathematics and their impact on values. 4 lecture discussions.

#### CSA 340/340A Systems Law as an Active Force (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 including internship.

#### 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 Hierarchies (3/1)

Introduction to hypotheses of natural systems evaluation and optimization. Origins of hierarchical structure underlying established sciences on the astronomical, physical, chemical, biological, social and artificial levels. 3 lectures, 1 two-hour activity. Prerequisite: For students selecting mathematical approach BIO 115/115L, for others only BIO 110/111L.

#### CSA 412/412L General Systems Theory Testing Hypotheses (3/1)

Identification of trends observable in level-to-level evolution of natural hierarchies; emphasizes rigorous testing of the validity of the general systems field axioms abstracted from these trends. 3 lectures, 1 two-hour activity. Prerequisite: CSA 411/411A.

#### CSA 413/413A General Systems Theory Man-made Systems (3/1)

Applications of systems field axioms to the study of man-made systems malfunctions. Use of axioms to engineer optimal societal 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. Prerequisite: CSA 303 or 304.

**CSA 450 Introduction to Systems Theory (4)**

Evolution of systems approach to problem solving; comparative overview of systems methodology. Case studies illustrating successful versus unsuccessful applications of the systems approach to governmental, biological, social, economic and technological problems. 4 lectures. Prerequisite STA 236.

**CSA 451/451L Techniques of Systems Analysis (3/1)**

Modeling of complex systems; analog and digital simulation, critical path methods; optimization methods, 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 11-4)**

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.

