

NATURAL SCIENCES AND MATHEMATICS, COLLEGE OF

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Departments

Biological Sciences

Brian T. Livingston, Chair (562) 985-4806

Chemistry and Biochemistry

Christopher Z. Brazier, Chair (562) 985-4941

Geological Sciences

Robert D. Francis, Chair (562) 985-4809

Mathematics and Statistics

Tangan Gao, Chair (562) 985-4721

Physics and Astronomy

Chuheee Kwon, Chair (562) 985-4924

Science Education

Lisa Martin-Hansen, Chair (562) 985-4801

CNSM Academic Advising Center

Advisor: Angela Tuan

Office: HSCI 164

Telephone: (562) 985-1587

Jensen Student Access to Science and Mathematics Center

Co-Directors: Henry C. Fung

Office: HSCI 164

Telephone / FAX: (562) 985-4682 / (562) 985-5104

CNSM Science Learning Center

Director, Jim McKibben

Office: HSCI 164

Telephone (562) 985-4841

Introduction

The College of Natural Sciences and Mathematics (CNSM) provides quality educational opportunities in the life, physical sciences, and mathematics. Alumni of the College demonstrate that science and mathematics graduates are well-prepared to enter graduate and professional schools or to assume responsible positions in industry or government.

The College takes its responsibilities in teacher preparation in the sciences and mathematics very seriously. It participates in projects that provide a stronger, more rigorous, and more engaging set of teacher preparation programs at CSULB. There is funding from the National Science Foundation, NASA, and the Knight Foundation, and in collaboration with Colleges of Education and Liberal Arts, Long Beach Unified School

District, and Long Beach City College.

Departments

Biological Sciences

Chemistry and Biochemistry

Geological Sciences

Mathematics and Statistics

Ocean Studies Institute

Physics and Astronomy

Science Education

Programs at a Glance

Bachelor of Arts:

Chemistry, Physics

Bachelor of Science:

Biochemistry, Biology, Chemistry, Earth Science, Environmental Science and Policy, Geology, Marine Biology, Mathematics, Microbiology, Physics

Master of Science:

Biochemistry, Biology, Chemistry, Geology, Mathematics, Microbiology, Physics, Science Education, Statistics

Certificates:

Biotechnology

Minors:

Applied Mathematics, Biology, Chemistry, Geology, Physiology, Mathematics, Microbiology, Physics, Statistics

Single Subject Teaching Credentials:

Biological Science, Chemistry, Geosciences, Mathematics, Physics

College of Natural Sciences and Mathematics' Academic Advising Center

All students are urged to participate in the Science Safari to Success (for first time freshmen) or EONS (Enrollment and Orientation in Natural Sciences and Mathematics) for transfer students. Programs offered each July (for those entering in August-September) and January (for those entering in January). A department advisor will be available to assist in developing an academic plan. During the semester, students may obtain academic advising by contacting the CNSM Academic Advising Center (HSCI-164) and/or appropriate advisor(s) in the department offering the chosen degree program.

The CNSM Academic Advising Center located in the Hall of Science, Room 164 (HSCI-164) collaborates with the College's undergraduate advisors to provide its majors with academic advising and support services so students can achieve their personal, academic, and career goals. Some of the services provided to CNSM majors include information and resources about academic programs; selection and sequence of courses; assistance with enrollment for courses; helping majors develop short- and long-term goals; assistance in navigating academic requirements, policies, and procedures; and providing appropriate referrals and career planning. The Academic Advising Center staff is available for appointments and some

walk-in assistance. Please contact the Academic Advising Center for more information.

Jensen Student Access to Science and Mathematics (SAS) Center and Programs Offered

The Center (HSCI 164) is dedicated to promoting success for students who pursue majors in the College and those who take courses in its departments. It also facilitates several externally funded programs. The Center provides space for studying, tutoring, mentoring, computer access, and meeting sites for student-centered activities. The Center serves as the resource center for health profession advising, graduate school opportunities, and summer research opportunities and fellowships.

There are a host of activities and programs that strive to involve students and promote their success in science and mathematics. Several federally funded programs, the Center is dependent on external funding, focus on underserved students and address the diversity of our campus. In addition to fostering involvement of students in science and mathematics, they feature an ethnic identity that provides a unique encouragement for our science majors.

MARC/RISE Programs. The College hosts both programs funded by The National Institutes of General Medical Sciences: Minority Access to Research Careers (MARC) and Research Institute for Scientific Enhancement (RISE). Both programs have the goal of increasing the number and quality of students from specifically targeted groups/populations who pursue careers in scientific research. Students supported by these programs carry out state-of-the-art biomedical research projects in conjunction with a member of the faculty. MARC is an honors program (GPA 3.0) for upper division students, while RISE supports students as early as the freshman year and also upper division transfer students. As a result of their research activities, most students present papers at scientific conferences and often co-author publications appearing in leading scientific journals. MARC/RISE students are active in various outreach and mentoring activities.

Beckman Scholars Program. The program focuses on students who have the potential to achieve distinction in their academic fields. Support is provided for students working toward bachelor's degrees in chemistry, biology, or physics in the form of student stipends, laboratory supplies and funds for travel to appropriate scientific meetings. Students receive rigorous training by faculty members in a variety of techniques involved in nucleic acid research, protein biochemistry, biophysics, etc.

Bridges to the Baccalaureate Program. This program is funded by the National Institutes of General Medical Sciences and its goal is to provide historically underserved community college students with research opportunities in the biomedical sciences and to facilitate transition into baccalaureate and doctorate granting institutions.

LS-AMP Program. The College hosts the National Science Foundation's Louis Stokes Alliance for Minority Participation (LS-AMP) program. Its goal is to improve the mathematics and science preparation for historically underserved students majoring in the sciences, mathematics, and engineering and to enhance their

opportunities for graduate studies.

Physics Teacher Education Coalition (PhysTEC) Program.

The CSULB PhysTEC Program, supported by the American Physical Society, National Science Foundation, and the CSULB's College of Natural Sciences and Mathematics, is a collaborative project between the Department of Physics and Astronomy, Department of Science Education, and the Teacher-in-Residence program recruited from local high schools. The PhysTEC Program aims to increase the number of physics majors earning teaching credentials at CSULB by actively recruiting, providing opportunities for early teaching experiences, and continuing the support structures for teachers at all levels. For additional information, please see <www.physicsatthebeach.com>.

Physical Science and Mathematics Scholarship Program.

The CSULB Physical Science and Mathematics Scholarship (PSMS) Program, funded by the National Science Foundation, is to increase diversity in the science, technology, engineering, and mathematics workforce and graduate studies. Qualified students are eligible for scholarships and access to best practices which contribute to student success and competitive applications for advanced studies. More information is available at www.csulb.edu/psmscholarship.

Science and Mathematics Enrichment and Peer Mentor

Programs. This program is designed to provide first time freshmen in the College of Natural Sciences and Mathematics with the guidance and personal support. The program assists students to enroll in classes appropriate for their major and background, provides them with enriched learning experiences, and peer role models during their first academic year. The Science and Mathematics Enrichment Program (SMEP) begins the week prior to the start of the fall semester. To be part of the program, students must be declared science or math majors. Peer mentoring provides students opportunities for tutoring to strengthen academic and communication skills.

Honors in Biological Sciences. This program was initiated by a grant from the Howard Hughes Medical Institute. Open to students with majors or career goals in the life sciences or related fields, it features an honors curriculum including courses in bioinformatics and research design as well as undergraduate research leading to a senior honors thesis and presentation at scientific conferences.

Health Professions Advising Office (HPAO)

This office (HSC1-164) provides a wide range of advising and support services for students pursuing preparation and application to professional schools. The HPAO offers individual counseling, academic planning, application assistance, and many other resources designed specialty for students interested in medicine, dentistry, veterinary, pharmacy, optometry, podiatry, chiropractic, physician assistant, physical therapy, and graduate nursing.

College of Natural Sciences and Mathematics' Science Learning Center

The CNSM Science Learning Center is located in Hall of Science, Room 110 (HSCI-110). This is a hands-on museum that houses many displays and exhibits from the College's six departments; Biological Sciences, Chemistry and Biochemistry, Geological Sciences, Mathematics and Statistics, Physics and Astronomy, and Science Education. The exhibits demonstrate concepts that are easier to understand through direct

physical involvement and personal discovery. Visitors are encouraged to turn the handles, push the buttons, and twist the knobs to enable the visitor's personal discoveries of science behind the display. These exhibits compliment the K-12 science curricula. The Science Learning Center also has a 27 foot Mobile Science Museum. Converted from a motor home into a hands-on laboratory, it makes visits to local schools, industry, and community events. Groups interested in visiting the CNSM Science Learning Center, or arranging for a visit by the Mobile Science Museum may contact the Science Learning Center for additional information (562-985-4841).

Student Research Opportunities

Faculty members in the College involve more than 200 students annually, both undergraduate and graduate, in a variety of research activities. Many of these students are supported by research grants, especially during the summer months. Each year many of these students present the results of their research at scientific conferences. It is not unusual for a student to be an author on an article appearing in a major scientific journal.

Early each fall semester, the College, in collaboration with the Jensen Student Access to Sciences and Mathematics Center, hosts an Annual Research Symposium for students to present their findings of the research conducted in laboratories of CNSM faculty. The Symposium is open to members of the University and the greater Southern California community.

The Electron Microscopy Facility

The study of the natural sciences requires observation of the macroscopic, microscopic, and sub-microscopic character of our universe. The College has a modern Electron Microscope (EM) Facility, utilizing a Joel-1200EXII transmission electron microscope (TEM), which is used by several undergraduate courses in addition to undergraduate and graduate research projects. The EM Facility also houses additional TEMs and an AMR 1000 scanning electron microscope has analytical capabilities.

Student Organizations

The College of Natural Sciences and Mathematics Student Council sponsors annual events including the Nobel Laureate series and student-faculty-staff mixer. There are various social and academic-related programs that offer peer support, as well as opportunities for students and faculty to interact outside of the classroom.

Other student-led groups offer activities for students who are planning careers in one of the health professions (medicine, dentistry, etc.). The Organization of PreProfessional Students (T.O.P.P.S.) and Association of Pre-Dental Students (A.P.D.S.) have speaker series with representatives from professional schools; the group also holds social functions and provides a peer advising network. Chicanos/Latinos for Community Medicine (CCM) sponsors community outreach activities, an annual workshop on interviewing techniques, and an annual conference on applying to medical/professional schools.

Southern California Marine Institute (SCMI)

The Institute operates a number of research vessels,

and provides the mechanism whereby students from CSU Ocean Studies Consortium campuses at Dominguez Hills, Fullerton, Long Beach, Los Angeles, Northridge, Pomona, San Diego, and San Marcos, as well as Occidental College and the University of Southern California can share courses and degree programs. In addition, Institute staff conduct research and facilitate the research of CSU faculty. The major focus is on harbors and coastal areas, with emphasis on environmental issues.

California Desert Studies Consortium

CSULB participates in the California Desert Studies Consortium, which has a Desert Studies Center in the heart of the Mojave Desert at Soda Springs near the town of Baker. The surrounding area consists of typical Mojave Desert with dry lakes, sand dunes, and mountain ranges; it is the gateway to Death Valley and the Kelso Dunes. The Center has facilities for teaching field classes and for research. California State Universities at Dominguez Hills, Fullerton, Long Beach, Los Angeles, Northridge, Pomona, and San Bernardino are the Consortia members.

Institute for Integrated Research in Materials, Environment, and Society (IIRMES)

IIRMES promotes and enhances educational and research opportunities for faculty, graduate and undergraduate students and the greater community at large. The major goals and accompanying benefits include research and scholarly activity; development of instructional programs to provide student training and research; and contribution to community service. IIRMES promotes cross-application of analytical techniques; facilitates access to state-of-the-art instrumentation for researchers; sponsors colloquia, lectures, and conferences; promotes interdisciplinary workshops and collaborations with other universities to create research possibilities for faculty and students; promotes educational programs and research opportunities for CSULB undergraduate and graduate students; provides analytical services for scientific community; and serves as a core CSU facility for elemental microanalysis.

CSUPERB Core Facility for Micro-Chemical Elemental Analysis (FEMCA)

California State University Program for Education and Research in Biotechnology (CSUPERB) has created a core facility for elemental micro-chemical analysis (FEMCA). FEMCA's principal goal is to enhance the educational and research opportunities of students and faculty members in the CSU system who wish to pursue novel research in biotechnology. The facility builds on strong interdisciplinary ties between the biological, chemical, and physical sciences. FEMCA is housed within IIRMES for molecular and elemental analysis; scanning, transmission and atomic force microscopy; as well as purpose-built clean-room facilities for organic and inorganic extractions and sample preparation.

Center for Education in Proteomics Analysis (CEPA)

A grant from the W.M. Keck Foundation and supplemental funds provided by the College of Natural Sciences and Mathematics at CSULB enabled purchase of an Applied Biosystems 4800 Matrix Assisted Laser Desorption Ionization, tandem Time of Flight Mass Spectrometer for protein and polypeptide analysis and identification. CEPA is part of

IIRMES' Facility for Elemental Micro Chemical Analysis (FEMCA), and is the only one of its kind in the USA that focuses on the use of this technology for undergraduate training and research.

Courses (NSCI)

LOWER DIVISION

190A. Experience Success Program - 1 (1)

Prerequisite: Open to Freshman only.

Learn and adopt organizational time management study and test taking skills. Increase your awareness of science and mathematics related career options. Make connections with CNSM programs, resources, and people.

Letter grade only (A-F). (Seminar 1 hr)

190B. Experience Success Program - 2 (1)

Prerequisite: NSCI 190A.

Explore science/math careers via job shadowing experiences and community based mini-internships. Learn about summer internship and research opportunities.

Letter grade only (A-F). (Seminar 1 hr.)

191. Selected Topics in Natural Sciences and Mathematics (1-3 units)

Prerequisite: Lower division pre-major in Biology, Biochemistry, Chemistry, Geology, Marine Biology, Microbiology, or Physics

Specific topics of current interest in the natural sciences.

(Lecture 1 hr/unit). May be repeated to a maximum of 3 units with different topics in different semesters. Topics will be announced in the Schedule of Classes.

Letter Grading only (A-F)

296. Introduction to Biomedical Research Methods (3 units)

Prerequisite: GE foundation requirements and consent of instructor.

Introduction to principles and ethics of experimentation, hypothesis formulation, and testing. Data measurement, analysis and presentation. Students will learn how to find and read scientific literature, keep a laboratory notebook and basic data graphing and analysis skills.

Letter grading only (A-F). Same course as ENGR 296. Not open for credit to students with credit in ENGR 296.

UPPER DIVISION

305. Origami in Science, Mathematics, and Education (3)

Prerequisites: GE Foundation requirements.

Hands-on instruction in the creation of origami works of fine art. Applications of folding materials in science, engineering, mathematics, and as a pedagogical tool in education.

(Lecture 3 hrs.)

361. Scientific Research Communications (3)

Prerequisite: G.E. foundation courses; score of 11 or higher on the GEAR Placement Examination or successfully completed the necessary portfolio course that is a prerequisite for a GEAR Writing Intensive Capstone.

Introduction to technical writing for students pursuing research careers. Accessing and using research literature. Writing technical and research reports for various purposes and audiences. Oral presentation of research and scientific information. Includes intensive writing.

Letter grade only (A-F). Same course as HHS 361, CLA 361, and ENGR 361. Not open for credit to students with credit in HHS 361,

CLA 361, or ENGR 361.

390. Experience Success Program for STEM Transfer Students (1)

Prerequisite: Open only to first semester transfer students with majors in CNSM or COE.

Learn to master time management, test taking skills, CV, professional statements and cover letter writing. Explore STEM careers. Learn about CNSM programs and opportunities which will support your professional growth.

Letter grade only (A-F). (Seminar 1 hr)

490. Special Topics in the Natural Sciences (1-3)

Prerequisites: At least upper division standing in the College of Natural Sciences and Mathematics and consent of instructor.

Faculty and student discussions and analysis of a current topic in the natural sciences.

May be repeated to a maximum of 6 units with different topics. Letter grade only (A-F). (Lecture 1-3 hrs.)

490L. Special Topics in the Natural Sciences, Laboratory (1-3)

Prerequisite: At least upper division standing in the College of Natural Sciences and Mathematics and consent of instructor.

Laboratory topics from selected areas of natural sciences.

Letter grade only (A-F). (Laboratory 2-9 hours).

492. Internships In Natural Science (3)

Prerequisites: Major in the College of Natural Sciences and Mathematics, completion of 9 units of upper division science coursework, a 2.5 GPA overall or 2.75 GPA in the student's major, and consent of instructor prior to registration.

Qualifying students placed in a major or career-related assignment in private industry or at a public agency. May be placed in either a volunteer or paid work assignment. Teacher aide positions may be used for students interested in pursuing a career in science education in K-12 schools.

Learning assignments will be arranged through the Career Development Center and the instructor. Final written report required. Class attendance and internships to be arranged by the instructor. Minimum of 120 hours of field experience required. Credit/No credit grading only. May be repeated to a maximum of 6 units

496. Advanced Behavioral Research Methods (3)

Prerequisites: ENGR 296 or NSCI 296, and HHS 361 or CLA 361 or ENGR 361 or NSCI 361, or consent of instructor.

An advanced study of the theoretical and practical aspects of conducting biomedical research including hypothesis formulation, experimental design, assessment of error within empirical data, and the preparation of sound and fundable grant proposals.

Same course as ENGR 496. Not open for credit to students with credit in ENGR 496

Letter grade only (A-F).

GRADUATE LEVEL

501. Project Management for Scientists (3)

Prerequisites: Consent of instructor. Not open to majors in the College of Business Administration.

Best practices utilized in scientific project management; includes project initiation, team dynamics, planning, scheduling, risk management, control, closure and evaluation. Applying gained knowledge to manage a project in their own scientific discipline. Offered in online or hybrid format.

Letter grade only (A-F). (Lecture 3 hrs)

502. Leadership and Management for Scientists (3)

Prerequisites: Consent of instructor. Not open to majors in the College of Business Administration.

Prepares students entering science-related careers with a foundation in management skills. Fundamentals of leadership, teamwork, motivation, planning, and organizational strategy and structure are presented along with human resource management topics including performance management, recruitment and selection, compensation and employment law. Offered in online or hybrid format.

Letter grade only (A-F). (3 hours activity)

503. Accounting and Finance for Scientists (3)

Prerequisites: Consent of instructor. Not open to majors in the College of Business Administration.

Introduction to concepts of accounting and financial management, focusing on scientific grants and contracts. Topics include: budgeting, planning and control; break-even, cost benefit and financial statement analysis; time-value of money; risk-return; capital and long term financing and investments. Offered in online or hybrid format.

Letter grade only (A-F). (3 hours activity)

504. Introduction to Regulatory Science (3)

Prerequisites: Consent of instructor. Not open to majors in the College of Business Administration.

Introduction to legal and regulatory issues important in engineering, technology, and scientific activities in the pharmaceutical and medical device industries. Offered in online or hybrid format.

Letter grade only (A-F). (3 hours activity)

505. Professional Ethics (3)

Prerequisites: Consent of instructor. Not open to majors in the College of Business Administration.

Introduction to the standards of professional practice and codes of ethics in the responsible conduct of scientific research. Course objectives fulfill the federally mandated requirements and professional standards for training in the area of scientific ethics and best practices. Offered in online or hybrid format.

Letter grade only (A-F). (3 hours activity)

BIOLOGICAL SCIENCES

College of Natural Sciences and Mathematics

Department Chair: Brian T. Livingston

Department Office: Hall of Science (HSCI) 104

Telephone / FAX: (562) 985-4806 / (562) 985-8878

Website: www.csulb.edu/depts/biology

Faculty: Bengt J. Allen, James W. Archie, Flora Banuett, Judith A. Brusslan, Ashley Carter, Jesse G. Dillon, Elizabeth D. Eldon, Deborah Fraser, Henry C. Fung, Editte Gharakhanian, Gwen Goodmanlowe, Eric J. Haas-Stapleton, David G. Huckaby Kevin M. Kelley, Balwant S. Khatra, Laura Kingsford, Lisa S. Klig, Kay K. Lee-Fruman, Brian T. Livingston, Christopher G. Lowe, Steven L. Manley, Douglass Pace, Jacqueline Pal, Bruno G. Pernet, Shenaz Rehmat, Bryan C. Rourke, Gary Shin, Kevin Sinchak, Theodore Stankowich, Houg-Wei Tsai, Dessie L. A. Underwood, Christine Whitcraft, Raymond R. Wilson, Jr., Kelly A. Young, Mason X. Zhang

Administrative Support Coordinator: Catherine Durham

Credential: James Kisiel, Tim Williamson

Undergraduate:

General Biology – Kay K. Lee-Fruman and Ashley Carter

Biology Education – Gwen Goodmanlowe

Cell and Molecular Biology and Physiology – Kay K. Lee-Fruman

Marine Biology – Gwen Goodmanlowe

Microbiology – Jesse Dillon

Organismal Biology – Gwen Goodmanlowe

Graduate: Kevin Sinchak, Kay Bellitti

Health Professions Advising Office (HSCI 164)

Biotechnology Certificate Advisor: Lisa S. Klig

Students desiring information should contact the department office for referral to one of the faculty advisors.

Career Possibilities

Biologist • Lab Technician • Biological Aide • Technical Writer • Biological Illustrator • Forester • Quality Control Technician • Biomedical Engineer • Pharmaceutical Sales Representative • Fish and Wildlife Biologist • Food Technologist • Microbiologist • Criminologist • Dietitian • Medical Technologist • Health Planner • Physician's Assistant • Medical Librarian • Respiratory Therapist • Curator • Ecologist • Environmental Specialist • Sanitarian (Some of these, and other careers, require additional education or experience. For more information, see www.careers.csulb.edu.) Various entry-level trainee positions in business and industry are available for graduates regardless of academic discipline.

Introduction

The biological sciences include all of the areas of scientific endeavor centered around the general question of the nature of life. Such diverse areas as biochemistry, ecology, paleontology, and animal behavior are all part of the biological sciences. The discipline of biochemistry is located in the Department of Chemistry and Biochemistry and the discipline of paleontology is located in the Department of Geological Sciences. For information about the programs in these disciplines, consult the appropriate section of this catalog. The remaining disciplines of the

biological sciences represented in the College of Natural Sciences and Mathematics are located in the Department of Biological Sciences, which offers five degrees: a Bachelor of Science in Biology, a Bachelor of Science in Marine Biology, a Bachelor of Science in Microbiology, a Master of Science in Biology, and a Master of Science in Microbiology. The B.S. in Biology has, in addition to a general option, three specialized options in Biology Education, Organismal Biology, and Molecular Cell Biology and Physiology. See below for the specific requirements for each of these degrees and options. The Department of Biological Sciences also participates in the Desert Studies Consortium and the Ocean Studies Institute. Information on the latter program is listed in this catalog under Ocean Studies Institute.

Academic Advising and Facilitated Enrollment into Classes

All entering students who declare a major in a degree program offered by this department need to contact the College of Natural Sciences and Mathematics' Academic Advising Center (HSCI 164) and participate in the College's Science Safari to Success (for first time freshmen) or EONS (Enrollment and Orientation in the Natural Sciences and Mathematics for transfer students) Program. These programs are held in June/July for those starting in the Fall Semester and in January for those starting in the Spring Semester. Department advisors will be available to provide an overview of the students' chosen baccalaureate degree program, to assist with academic advisement, to provide information on the many career opportunities available, and to aid students in enrolling in classes. Contact the CNSM Academic Advising Center (HSCI 164), Jensen Student Access to Sciences and Mathematics Center (HSCI 164), or department office for additional information.

The Richard B. Loomis Research Award

This annual departmental award provides supply and travel support for thesis research projects. Graduate students submit research proposals to the department's Graduate Studies Committee, which grants funding to the more meritorious proposals.

Handloser Graduate Student Tuition Grant

The Handloser Graduate Student Tuition Grant is offered to an outstanding M.S. Biology applicant interested in pursuing master's thesis research in the area of marine biology.

Frank Schatzlein Scholarship Award

The Frank Schatzlein Scholarship Award is available to an outstanding undergraduate student in biological sciences, with upper division standing, studying in the area of cellular physiology. Applications can be obtained from the Biological Sciences Department Office during the month of March.

Linda Warren Graham Medical Technology Scholarship

The Linda Warren Graham Medical Technology Scholarship is available to senior microbiology majors who have applied/ been accepted into a Clinical Laboratory Scientist (or a Medical Technology) Internship program. Scholarship applications can be obtained from the Biological Sciences Department Office during the month of November prior to graduation.

Financial Support, Assistantships

The Department of Biological Sciences offers to graduate students a limited number of teaching associate and graduate assistant appointments. Forms requesting consideration for these appointments are available in the department's Graduate Office. Duties consist of approximately 20 hours per week devoted to preparation and/or instruction in general undergraduate laboratory classes. These appointments are limited to a maximum of six semesters per individual.

The department also has a limited number of technical assistant positions as well as some hourly employment. Several members of the faculty have grants that provide for research assistantships. A number of scholarships are available through the university.

Graduate and Health Professional Preparation

The department provides preparation for advanced study at the graduate level and for entry into various health professional schools. Students should consider the degree requirements listed in the catalog as minimal; some graduate schools, professional schools, or careers may require additional coursework in mathematics, physics, chemistry, or biological sciences.

Students desiring entrance into a graduate school to obtain a master's or doctoral degree in some area of the biological sciences should determine the entrance requirements for the school(s) of interest early in their undergraduate years. Specifically, students contemplating graduate work in mathematically oriented areas of the biological sciences should consider taking more calculus (MATH 122, 123, 224, and 364A or 370A will substitute for MATH 119A and 119B) and those contemplating graduate work in chemically oriented areas should consider taking additional chemistry (CHEM 220A,B; 251; 377A,B; 441A,B).

Students desiring entrance into one of the various health-related professional schools should consult with the Health Professions Advising Office in the College of Natural Sciences and Mathematics' Jensen Student Access to Science and Mathematics (SAS) Center (HSCI 164) for more information. Most of these schools do not require students to major in any particular discipline but favor holders of a bachelor's degree; and want students who have done well in their major and who also took the prerequisite courses required by that particular school.

Undergraduate Programs

Bachelor of Science in Biology

This degree includes a general option in biology and three additional options for those desiring a more specialized program.

Admission Under Impaction

Refer to the following website for additional impaction criteria: <http://www.csulb.edu/depts/enrollment/admissions/>.

Biology (120 units)

This degree major is designed for students pursuing careers that involve the study of life. This general option is designed to expose students to a wide range of biological topics and is the most flexible option in terms of courses required. With the right elective choices, this option can work for students planning on future careers in health professions or graduate and professional studies in Biological Sciences. Students may not combine this option with any other in the B.S. in Biology nor with the B.S. in Marine Biology or Microbiology as part of a dual major. This option requires approximately 77-81 units in the major, of which 36-38 are in lower division and 41-43 are in upper division.

All students must achieve at least a 2.0 grade-point average in each of the following: 1. the entire college record, 2. all units attempted at CSULB, and 3. all courses in the major.

In addition students must receive a C or better in all upper division major courses.

Degree Progress

Pre-Biology majors must complete the following requirements within the specified time of declaring the pre-major. Some students may need to take courses during Summer Session to meet these requirements. Students who have not met the requirements by the required semester must either declare another major or meet with an Academic Advisor to determine if the student's performance in the courses merits an additional semester to complete.

Freshmen: A grade "C" or better must be achieved in CHEM 111A, BIOL 211, and MATH 119A (or 122) within one and a half calendar years.

Lower Division:

Take all of the following courses:

BIOL 211 Introduction to Evolution and Diversity (4)
Prerequisite/Corequisite: CHEM 111A with a grade of "C" or better.

BIOL 212 Intro to Cell and Molecular Biology (4)
Prerequisites: BIOL 211, CHEM 111A with grades of "C" or better.
Prerequisite/Corequisite: CHEM 111B.

BIOL 213 Intro to Ecology and Physiology (4)
Prerequisites: BIOL 211, 212, CHEM 111B, each with a grade of "C" or better

NOTE: BIOL 111, BIOL 111L, BIOL 212, BIOL 212L, BIOL 213, BIOL 213L are required if courses were taken prior to catalog year 2010-11.

BIOL 260 Biostatistics (3)
Prerequisites: BIOL 201 or BIOL 211 or BIOL 207 or MICR 200; MATH 111 or MATH 113 or MATH 119A or MATH 122

all with a grade of "C" or better.

CHEM 111A General Chemistry (5)

Prerequisite: A passing score on the Chemistry Placement Examination.

Corequisite: MATH 109 or higher.

CHEM 111B General Chemistry (5)

Prerequisites: CHEM 111A and MATH 113 or MATH 115 or MATH 119A or MATH 122 all with a grade of "C" or better.

CHEM 220A Organic Chemistry I (3)

Prerequisite: CHEM 111B with a grade of "C" or better.
Corequisites: CHEM 224 is required for students repeating course. CHEM 223A must be taken concurrently if required by a degree plan.

CHEM 220B Organic Chemistry II (3)

Prerequisite: CHEM 220A with a grade of "C" or better.
Corequisite: CHEM 223B or CHEM 320L except for students who previously earned a "C" or better in CHEM 223B or CHEM 320L.

CHEM 223A Organic Chemistry Laboratory I (1)

Corequisite: CHEM 220A, except for students who have previously earned a "C" or better in CHEM 220A.

CHEM 223B Organic Chemistry Laboratory II (1)

Prerequisites: CHEM 220A and CHEM 223A, both with a grade of "C" or better.
Corequisite: CHEM 220B, except for students who have previously earned a "C" or better in CHEM 220B.

Take one course from the following:

MATH 119A Survey of Calculus I (3)

Prerequisite: Appropriate MDPT placement or a grade of "C" or better in MATH 113.

MATH 122 Calculus (4)

Prerequisite: Appropriate MDPT placement or a grade of "C" or better in MATH 111 and MATH 113.

Take one of the following courses:

PHYS 100A General Physics (4)

Prerequisite: MATH 109 or MATH 113 or MATH 119A or MATH 122.

PHYS 151 Mechanics and Heat (4)

Prerequisite/Corequisite: MATH 122.

Take one of the following courses:

PHYS 100B General Physics (4)

Prerequisite: PHYS 100A.

PHYS 152 Electricity and Magnetism (4)

Prerequisite: PHYS 151;
Prerequisite/Corequisite: MATH 123.

The following courses do not meet any specific or elective requirements for this major: BIOL 100, BIOL 101 or MICR 101, BIOL 153, BIOL 153L, BIOL 200, BIOL 200L, BIOL 201 or MICR 200, BIOL 205, BIOL 205L, BIOL 207, BIOL 208

Upper Division:

Take all of the following courses:

BIOL 312 Evolutionary Biology (3)

Prerequisites: BIOL 211, BIOL 212, BIOL 213, BIOL 260 all with a grade of "C" or better.

BIOL 340 Molecular Cell Biology (3)

Prerequisites: BIOL 211, BIOL 212, all with a grade of "C" or better.

BIOL 350 General Ecology (3)

Prerequisites: BIOL 211, BIOL 212, BIOL 213, BIOL 260; MATH 119A or MATH 122 all with a grade of "C" or better.

BIOL 370 General Genetics (4)

Prerequisites: BIOL 211, BIOL 212 and either BIOL 260 or CHEM 251 all with a grade of "C" or better.

BIOL 480 Seminars (1)

Prerequisites: Consent of Department of Biological Sciences. (Undergraduates and classified post-baccalaureates enroll in BIOL 480; graduates enroll in

BIOL 580). Undergraduates must have filed for graduation and be in their last semester. Graduates must have been admitted to the department as a graduate student. Classified post-baccalaureates must have been admitted to a second baccalaureate or a certificate.

Take at least one of the following courses/course pairs in physiology:

BIOL 342 Human/Mammalian Phys (3)

Prerequisites: BIOL 211, BIOL 212, BIOL 213 all with grade of "C" or better.

and

BIOL 342L Lab in Human/Mammalian Phys (1)

Prerequisite/Corequisite: BIOL 342 with a grade of "C" or better.

or

BIOL 345 Comparative Animal Phys(3)

Prerequisites: BIOL 211, BIOL 212, BIOL 213 all with grade of "C" or better.

and

BIOL 345L Lab in Comp Animal Phys (1)

Prerequisite/Corequisite: BIOL 345 with a grade of "C" or better.

or

BIOL 447 Molecular Plant Physiology (3)

Prerequisites: BIOL 340, BIOL 370, both with grade of "C" or better.

Take two of the following courses in organismal diversity.

One of the courses must be BIOL 313, BIOL 316, BIOL 324, BIOL 427, or BIOL 439:

BIOL 311 General Microbiology (4)

Prerequisites: BIOL 211, BIOL 212; CHEM 111B, all with a grade of "C" or better.

BIOL 313 Invertebrate Zoology (4)

Prerequisites: BIOL 211, BIOL 212, BIOL 213 all with a grade of "C" or better, and consent of instructor.

BIOL 316 General Entomology (4)

Prerequisites: BIOL 211, BIOL 212, BIOL 213 all with grade of "C" or better.

BIOL 324 Vertebrate Zoology (4)

Prerequisites: BIOL 211, BIOL 212, BIOL 213 all with grade of "C" or better.

BIOL 419, Ichthyology (3)

Prerequisites: BIOL 211, BIOL 212, BIOL 213, BIOL 260 and at least 6 additional units of upper division biological science, all with a grade of "C" or better. Recommended: BIOL 350, BIOL 353, and BIOL 370.

BIOL 421 Herpetology (3)

Prerequisites: BIOL 260, BIOL 350, and one additional upper division biology course, all with a grade of "C" or better. Recommended: BIOL 312, BIOL 324, or BIOL 370.

BIOL 423 Mammalogy (3)

Prerequisites: At least one of BIOL 312, BIOL 324, or BIOL 350, with a grade of "C" or better.

BIOL 424 Ornithology (3)

Prerequisites: BIOL 211, BIOL 212, BIOL 213, BIOL 260 and three units of upper division BIOL, all with a grade of "C" or better. Recommended: BIOL 350.

BIOL 427 Vascular Plant Systematics (4)

Prerequisite: BIOL 312 or BIOL 370 with a grade of "C" or better.

BIOL 439 Plant Morphology (4)

Prerequisite: BIOL 312 or BIOL 370 with a grade of "C" or better.

Take three additional upper division courses in the Department of Biological Sciences totaling a minimum of nine units. At least six of these units must be at the 400 level. Courses outside of BIOL that can also count toward these units

include GEOG 481, CHEM 441A, and CHEM 448.

Courses that will not count towards these units are BIOL 300, BIOL 301, BIOL 304, BIOL 305; MICR 300.

To meet prerequisite standards for courses in this program's requirements, a "C" or better is necessary in the following: BIOL 211, BIOL 212, BIOL 213, BIOL 260, BIOL 340, BIOL 342/BIOL 345, BIOL 370, CHEM 111A, CHEM 111B, CHEM 220A, CHEM 223A, MATH 119A, MATH 122.

Students contemplating graduate or professional school should consider taking 1-3 units of BIOL 496 in addition to the requirements listed above. With prior permission of the advisor for this option, students may use 3 units of BIOL 496 as an elective.

Option in Biology Education (120 units)

This option is designed solely for students who wish to become secondary school Biology teachers. This option requires 80-87 units in the major, of which 46-48 are lower division and 34-39 are upper division. Prospective students should consult the Single Subject Science Education Advisor in the Department of Science Education early to plan their program.

All students must achieve at least a 2.0 grade-point average in each of the following: 1. the entire college record, 2. all units attempted at CSULB, and 3. all courses in the major.

In addition, students must receive a "C" or better in all upper division major courses.

Degree Progress

Pre-Biology majors must complete the following requirements within the specified time of declaring the pre-major. Some students may need to take courses during Summer Session to meet these requirements. Students who have not met the requirements by the required semester must either declare another major or meet with an Academic Advisor to determine if the student's performance in the courses merits an additional semester to complete.

Freshmen: A grade "C" or better must be achieved in CHEM 111A, BIOL 211, and MATH 119A (or 122) within one and a half calendar years.

Requirements

Lower Division:

Take all of the following:

BIOL 211 Introduction to Evolution and Diversity (4)
Prerequisite/Corequisite: CHEM 111A with a grade of "C" or better.

BIOL 212 Intro to Cell and Molecular Biology (4)
Prerequisites: BIOL 211, CHEM 111A with grades of "C" or better.
Prerequisite/Corequisite: CHEM 111B.

BIOL 213 Intro to Ecology and Physiology (4)
Prerequisites: BIOL 211, 212, CHEM 111B, each with a grade of "C" or better.

NOTE: BIOL 111, BIOL 111L, BIOL 212, BIOL 212L, BIOL 213, BIOL 213L are required if courses were taken prior to catalog year 2010-11.

BIOL 260 Biostatistics (3)
Prerequisites: BIOL 201 or BIOL 211 or BIOL 207 or MICR 200; MATH 111 or MATH 113 or MATH 119A or MATH 122 all with a grade of "C" or better.

ASTR 100 Astronomy (3)

Corequisites: One course from General Education Category B.2 and ASTR 100L.

CHEM 111A General Chemistry (5)

Prerequisites: A passing score on the Chemistry Placement Examination.

Corequisite: MATH 109 or higher.

CHEM 111B General Chemistry (5)

Prerequisites: CHEM 111A and MATH 113 or MATH 115 or MATH 119A or MATH 122 all with a grade of "C" or better.

Choose either:

GEOL 106 Earth Science for Teachers (4)

Prerequisites/Corequisites: A course that fulfills the A.1 GE requirement and three years of high school mathematics, including algebra, geometry, and intermediate algebra or the equivalent.

or both of the following:

GEOL 102 General Geology (3)

Prerequisites/Corequisites: A course that fulfills the A.1 GE requirement and three years of high school mathematics including algebra, geometry, and intermediate algebra or the equivalent.

GEOL 104 Geology Laboratory (1)

Prerequisites/Corequisites: A course that fulfills the A.1 GE requirement and three years of high school mathematics including algebra, geometry, and intermediate algebra or the equivalent, and concurrent or prior enrollment in GEOL 102.

Take one of the following courses:

MATH 119A Survey of Calculus I (3)

Prerequisite: Appropriate MDPT placement or a grade of "C" or better in MATH 113.

MATH 122 Calculus I (4)

Prerequisite: Appropriate MDPT placement or a grade of "C" or better in MATH 111 and MATH 113.

Take one of the following courses:

BIOL 201 General Microbiology for Health

Professionals (4)

Prerequisites: CHEM 111A or CHEM 140 with a grade of "C" or better and GE Foundation requirements.

BIOL 311 General Microbiology (4)

Prerequisites: BIOL 211, BIOL 212; CHEM 111B, all with a grade of "C" or better.

Take one of the following courses:

PHYS 100A General Physics (4)

Prerequisite: MATH 109 or MATH 113 or MATH 119A or MATH 122.

PHYS 151 Mechanics and Heat (4)

Prerequisite/Corequisite: MATH 122.

Take one of the following courses:

PHYS 100B General Physics (4)

Prerequisite: PHYS 100A.

PHYS 152 Electricity and Magnetism (4)

Prerequisite: PHYS 151 Prerequisite/Corequisite: MATH 123.

These courses do not meet any specific or elective requirements for this major: BIOL 100, BIOL 101, BIOL 200, BIOL 200L, BIOL 205, BIOL 205L, BIOL 207, BIOL 208

Take either:

CHEM 227 Organic Chemistry (3)

Prerequisite: CHEM 111A with a grade of "C" or better; CHEM 111B is recommended.

Or all four of the following courses lower-division courses:

CHEM 220A Organic Chemistry I (3)

Prerequisite: CHEM 111B with a grade of "C" or better.
Corequisites: CHEM 224 is required for students repeating course. CHEM 223A must be taken concurrently if required by a degree plan.

CHEM 220B Organic Chemistry II (3)

Prerequisite: CHEM 220A with a grade of "C" or better. Corequisite: CHEM 223B or CHEM 320L except for students who previously earned a "C" or better in CHEM 223B or CHEM 320L.

CHEM 223A Organic Chemistry Laboratory I (1)

Prerequisite: CHEM 220A, except for students who have previously earned a "C" or better in CHEM 220A.

CHEM 223B Organic Chemistry Laboratory II (1)

Prerequisites: CHEM 220A and CHEM 223A, both with a grade of "C" or better. Corequisite: CHEM 220B, except for students who have previously earned a "C" or better in CHEM 220B.

Upper Division:

Take the following course:

SCED 404 The Nature of Science and Scientific Reasoning (3)

Prerequisites: Minimum of 9 units of science (introductory level or higher) or consent of instructor.

Take at least nine courses totaling at least 26-29 units in the biological sciences including:

All of the following courses:

BIOL 312 Evolutionary Biology (3)

Prerequisites: BIOL 211, BIOL 212, BIOL 213, BIOL 260 all with a grade of "C" or better.

BIOL 340 Molecular Cell Biology (3)

Prerequisites: BIOL 211, BIOL 212, all with a grade of "C" or better.

BIOL 350 General Ecology (3)

Prerequisites: BIOL 211, BIOL 212, BIOL 213, BIOL 260; MATH 119A or MATH 122 all with a grade of "C" or better.

BIOL 370 General Genetics (4)

Prerequisites: BIOL 211, BIOL 212 and either BIOL 260 or CHEM 251 all with a grade of "C" or better.

BIOL 480 Seminars (1)

Prerequisites: Consent of Department of Biological Sciences. (Undergraduates and classified post-baccalaureates enroll in BIOL 480; graduates enroll in BIOL 580). Undergraduates must have filed for graduation and be in their last semester. Graduates must have been admitted to the department as a graduate student. Classified post-baccalaureates must have been admitted to a second baccalaureate or a certificate.

One of the following courses in physiology:

BIOL 345 Comparative Animal Physiology (3)

Prerequisites: BIOL 211, BIOL 212, BIOL 213 all with grade of "C" or better.

BIOL 447 Molecular Plant Physiology (3)

Prerequisites: BIOL 340, BIOL 370, both with grade of "C" or better.

One of the following courses in plant diversity:

BIOL 427 Vascular Plant Systematics (4)

Prerequisite: BIOL 312 or BIOL 370 with a grade of "C" or better.

BIOL 439 Plant Morphology (4)

Prerequisite: BIOL 312 or BIOL 370 with a grade of "C" or better.

One of the following courses in animal diversity:

BIOL 313 Invertebrate Zoology (4)

Prerequisites: BIOL 211, BIOL 212, BIOL 213 all with a grade of "C" or better, and consent of instructor.

BIOL 316 General Entomology (4)

Prerequisites: BIOL 211, BIOL 212, BIOL 213 all with grade of "C" or better.

BIOL 324 Vertebrate Zoology (4)

Prerequisites: BIOL 211, BIOL 212, BIOL 213 all with grade of "C" or better.

The remaining biological sciences course should be

chosen in consultation with an advisor; BIOL 495 is highly recommended. Either CHEM 441A, CHEM 441B or CHEM 448 will count toward this additional required course. Students may use BIOL 496 as one of the nine required upper division courses but only with prior permission of the advisor for this option.

These courses do not meet any specific or elective requirements for this major: BIOL 300, BIOL 301, BIOL 304, BIOL 305; and NSCI 492.

To meet prerequisite standards for courses in this program's requirements, a "C" or better is necessary in the following: BIOL 211, BIOL 212, BIOL 213, BIOL 260, BIOL 312, BIOL 370, CHEM 111A, CHEM 111B, CHEM 220A, CHEM 223A, MATH 119A, MATH 122.

Although SCED 403 and EDSS 300C are not required in the major, the credential does require these courses. Students may want to take some or all of them prior to graduation.

Single Subject Teaching Credential in Biology

The Biological Sciences Concentration meets the subject matter competence requirement for the Single Subject Teaching Credential in Biology. In addition to meeting the subject matter competence requirement for the Teaching Credential, prospective Biology teachers are also required to complete 45 units of professional preparation in the Single Subject Credential Program, including student teaching. Students may begin the professional preparation courses as early as the junior year. With careful planning, it is possible to complete many of the credential program courses as an undergraduate. Courses may also be started as a post-baccalaureate student. Refer to the Single Subject Teacher Education section of this catalog or the Single Subject Credential Program website (www.ced.csulb.edu/single-subject) for a description of the professional preparation requirements, courses, and application procedures.

The Biological Sciences Subject Matter Program is being revised to meet new state standards. When the revised program has been approved by the Commission on Teacher Credentialing, the new course requirements will be in effect and supersede current requirements.

Option in Organismal Biology (120 units)

This option is designed primarily for those interested in careers that involve the biology of animals, plants and the study of organisms in relation to their environment. It is particularly appropriate for those seeking employment in private industry (such as environmental consulting firms), or government service (such as fish and game agencies), as well as those students contemplating graduate work in these fields. This option requires approximately 78-81 units in the major, of which 36-38 units are in lower division and 42-43 units are in upper division.

All students must achieve at least a 2.0 grade-point average in each of the following: 1. the entire college record, 2. all units attempted at CSULB, and 3. all courses in the major.

In addition students must receive a C or better in all upper division major courses.

Degree Progress

Pre-Biology majors must complete the following requirements within the specified time of declaring the pre-major. Some students may need to take courses during Summer Session to meet these requirements. Students who have not met the requirements by the required semester must either declare another major or meet with an Academic Advisor to determine if the student's performance in the courses merits an additional semester to complete.

Freshmen: A grade "C" or better must be achieved in CHEM 111A, BIOL 211, and MATH 119A (or 122) within one and a half calendar years.

Requirements

Lower Division:

Take all of the following courses:

BIOL 211 Introduction to Evolution and Diversity (4)

Prerequisite/Corequisite: CHEM 111A with a grade of "C" or better.

BIOL 212 Intro to Cell and Molecular Biology (4)

Prerequisites: BIOL 211, CHEM 111A with grades of "C" or better.

Prerequisite/Corequisite: CHEM 111B.

BIOL 213 Intro to Ecology and Physiology (4)

Prerequisites: BIOL 211, 212, CHEM 111B, each with a grade of "C" or better.

NOTE: BIOL 111, BIOL 111L, BIOL 212, BIOL 212L, BIOL 213, BIOL 213L are required if courses were taken prior to catalog year 2010-11.

BIOL 260 Biostatistics (3)

Prerequisites: BIOL 201 or BIOL 211 or BIOL 207 or MICR 200; MATH 111 or MATH 113 or MATH 119A or MATH 122 all with a grade of "C" or better.

CHEM 111A General Chemistry (5)

Prerequisite: A passing score on the Chemistry Placement Examination.

Corequisite: MATH 109 or higher.

CHEM 111B General Chemistry (5)

Prerequisites: CHEM 111A and MATH 113 or MATH 115 or MATH 119A or MATH 122 all with a grade of "C" or better.

Take one of the following courses:

MATH 119A Survey of Calculus I (3)

Prerequisite: Appropriate MDPT placement or a grade of "C" or better in MATH 113.

MATH 122 Calculus I (4)

Prerequisite: Appropriate MDPT placement or a grade of "C" or better in MATH 111 and MATH 113.

Take one of the following courses:

PHYS 100A General Physics (4)

Prerequisites: MATH 109 or MATH 113 or MATH 119A or MATH 122.

PHYS 151 Mechanics and Heat (4)

Prerequisite/Corequisite: MATH 122.

Take one of the following courses:

PHYS 100B General Physics (4)

Prerequisite: PHYS 100A.

PHYS 152 Electricity and Magnetism (4)

Prerequisite: PHYS 151; Prerequisite/Corequisite: MATH 123

These courses do not meet any specific or elective requirements for this major: BIOL 100, BIOL 101, BIOL 153, BIOL 153L, BIOL 200, BIOL 200L, BIOL 205, BIOL 205L, BIOL 207, and BIOL 208

Take one of the following course combinations in Organic Chemistry or Biochemistry (Groups A or B):

Group A

CHEM 220A Organic Chemistry I (3)

Prerequisite: CHEM 111B with a grade of "C" or better.

Corequisites: CHEM 224 is required for students repeating course. CHEM 223A must be taken concurrently if required by a degree plan.

CHEM 220B Organic Chemistry II (3)

Prerequisite: CHEM 220A with a grade of "C" or better.

Corequisite: CHEM 223B or CHEM 320L except for students who previously earned a "C" or better in CHEM 223B or CHEM 320L.

CHEM 223A Organic Chemistry Laboratory I (1)

Corequisite: CHEM 220A, except for students who have previously earned a "C" or better in CHEM 220A.

CHEM 223B Organic Chemistry Laboratory II (1)

Prerequisites: CHEM 220A and CHEM 223A, both with a grade of "C" or better. Corequisite: CHEM 220B, except for students who have previously earned a "C" or better in CHEM 220B.

Group B

CHEM 227 Fundamentals of Organic Chemistry (3)

Prerequisite: CHEM 111A with a grade of "C" or better; CHEM 111B is recommended.

CHEM 448 Fundamentals of Biological Chemistry (3)

Prerequisites: CHEM 220B or CHEM 227 either with a grade of "C" or better.

Few, if any, health-related professional schools (e.g. veterinary medicine) will accept CHEM 227. Some graduate programs with masters or doctorates in biology and/or ecology may also not accept CHEM 227. Students interested in these programs might consider taking CHEM 220A,B and CHEM 223A,B. CHEM 227 is not acceptable as a prerequisite for CHEM 441A. CHEM 227 is acceptable toward the Minor in Chemistry.

Upper Division:

Take a minimum of 36 upper division units to include the following:

Take all of the following courses: (11 units)

BIOL 312 Evolutionary Biology (3)

Prerequisites: BIOL 211, BIOL 212, BIOL 213, BIOL 260 all with a grade of "C" or better.

BIOL 350 General Ecology (3)

Prerequisites: BIOL 211, BIOL 212, BIOL 213, BIOL 260; MATH 119A or MATH 122 all with a grade of "C" or better.

BIOL 370 General Genetics (4)

Prerequisites: BIOL 211, BIOL 212 and either BIOL 260 or CHEM 251 all with a grade of "C" or better.

BIOL 480 Seminars (1)

Prerequisites: Consent of Department of Biological Sciences. (Undergraduates and classified post-baccalaureates enroll in BIOL 480; graduates enroll in BIOL 580). Undergraduates must have filed for graduation and be in their last semester. Graduates must have been admitted to the department as a graduate student. Classified post-baccalaureates must have been admitted to a second baccalaureate or a certificate.

Although BIOL 340 is not required for this option, it is a prerequisite for many 400-level courses and may be used as an elective.

Take at least one of the following courses/course pairs: 3-4 units

BIOL 345 Comparative Animal Physiology (3)

Prerequisites: BIOL 211, BIOL 212, BIOL 213 all with grade of "C" or better.

BIOL 345L Lab in Comparative Animal Physiology (1)

Prerequisite/Corequisite: BIOL 345 with a grade of "C" or better.

Or

BIOL 447 Molecular Plant Physiology (3)

Prerequisites: BIOL 340, BIOL 370, both with grade of "C" or

better.

Take at least two of the following courses in organismal diversity, one of which must be BIOL 313, BIOL 316, BIOL 324, BIOL 427, or BIOL 439:

- BIOL 311 General Microbiology (4)
Prerequisites: BIOL 211, BIOL 212; CHEM 111B, all with a grade of "C" or better.
- BIOL 313 Invertebrate Zoology (4)
Prerequisites: BIOL 211, BIOL 212, BIOL 213 all with a grade of "C" or better, and consent of instructor.
- BIOL 316 General Entomology (4)
Prerequisites: BIOL 211, BIOL 212, BIOL 213 all with grade of "C" or better.
- BIOL 324 Vertebrate Zoology (4)
Prerequisites: BIOL 211, BIOL 212, BIOL 213 all with grade of "C" or better.
- BIOL 419, Ichthyology (3)
Prerequisites: BIOL 211, BIOL 212, BIOL 213, BIOL 260 and at least 6 additional units of upper division biological science, all with a grade of "C" or better. Recommended: BIOL 350, BIOL 353, and BIOL 370.
- BIOL 421 Herpetology (3)
Prerequisites: BIOL 260, BIOL 350, and one additional upper division biology course, all with a grade of "C" or better.
Recommended: BIOL 312, BIOL 324, or BIOL 370.
- BIOL 423 Mammalogy (3)
Prerequisite: At least one of BIOL 312, BIOL 324, or BIOL 350, with a grade of "C" or better.
- BIOL 424 Ornithology (3)
Prerequisites: BIOL 211, BIOL 212, BIOL 213, BIOL 260 and three units of upper division BIOL, all with a grade of "C" or better. Recommended: BIOL 350.
- BIOL 427 Vascular Plant Systematics (4)
Prerequisite: BIOL 312 or BIOL 370 with a grade of "C" or better.
- BIOL 439 Plant Morphology (4)
Prerequisite: BIOL 312 or BIOL 370 with a grade of "C" or better.

Select a minimum of two courses from the following (any combination of courses from the two groups is acceptable):

Ecology and Evolution Courses

- BIOL 355 Microbial Ecology (3)
Prerequisites: BIOL 311 or MICR 211 or BIOL 211, BIOL 212, BIOL 213; BIOL 260, all with a grade of "C" or better.
- BIOL 412 Advanced Evolutionary Biology (3)
Prerequisite: BIOL 312 with a grade of "C" or better.
- BIOL 450 Plant Ecology (3)
Prerequisites: BIOL 260, BIOL 350 with a grade of "C" or better. Recommended: BIOL 427, BIOL 447.
- BIOL 451 Wetlands and Mangrove Ecology (3)
Prerequisites: BIOL 260, BIOL 350 both with a grade of "C" or better.
- BIOL 452 Behavioral Ecology (3)
Prerequisites: BIOL 312 or BIOL 350. (Undergraduates enroll in BIOL 452; graduates enroll in BIOL 552.)
- BIOL 454B Research in Tropical Terrestrial Ecology (3)
Prerequisites: BIOL 350 with a grade of "C" or better; and consent of instructor. (Undergraduates enroll in BIOL 454B; graduates enroll in BIOL 554B.)
- BIOL 456 Population Ecology (3)
Prerequisites: BIOL 350, MATH 119B or MATH 123 all with a grade of "C" or better.
- BIOL 457 Field Methods in Ecology (3)
Prerequisites: BIOL 260, BIOL 350 both all with a grade of "C" or better.
- BIOL 459 Conservation Biology (3)
Prerequisites: BIOL 260, BIOL 350 both with a grade of "C" or

better. Recommended: BIOL 370.

- BIOL 472 Molecular Evolution (3)
Prerequisite: BIOL 370 with a grade of "C" or better.
Recommended: BIOL 312.

Physiology Courses

- BIOL 442 Physiology at the Limit (3)
Prerequisites: BIOL 342 or BIOL 345 with a grade of "C" or better.
- BIOL 443 Endocrinology (3)
Prerequisites: BIOL 340; BIOL 342 or BIOL 345, all with a grade of "C" or better. (Undergraduates enroll in BIOL 443; graduates enroll in BIOL 543.)
- BIOL 444 Reproductive Biology (3)
Prerequisite: BIOL 342 or BIOL 345 with a grade of "C" or better.
- BIOL 449 Fish Physio and Endocrinology (3)
Prerequisite: BIOL 345 with grade of "C" or better.
- BIOL 464 Aquatic Toxicology (3)
Prerequisites: BIOL 211, BIOL 212, BIOL 213, BIOL 340; CHEM 220A or CHEM 227, all with a grade of "C" or better. Recommended: BIOL 353 and CHEM 448 or CHEM 441A,B.

Take 2-3 additional upper division courses totaling 6-9 units in the Department of Biological Sciences so that a minimum number of 36 upper division units are completed. At least three of these units must be at the 400 level. Note that many 400 numbered courses require BIOL 340, which can also count as one of these elective courses. Courses outside of BIOL that can also count toward these units include GEOG 481, CHEM 441A, and CHEM 448.

Courses that will not count towards these units are BIOL 300, BIOL 301, BIOL 304, BIOL 305

To meet prerequisite standards for courses in this program's requirements, a "C" or better is necessary in the following: BIOL 211, BIOL 212, BIOL 213, BIOL 260, BIOL 345, CHEM 111A, CHEM 111B, (CHEM 220A, CHEM 223A/ CHEM 227), MATH 119A, MATH 122.

Students contemplating graduate or professional school should consider taking 1-3 units of BIOL 496 in addition to the requirements listed above. With prior permission of the advisor for this option, students may use 3 units of BIOL 496 as an elective.

Option in Molecular Cell Biology and Physiology (120 units)

This option is designed primarily for those interested in careers that involve biology at the cell, molecular and organ system levels and is particularly appropriate for those contemplating graduate work in these fields or entering one of the health professions, such as medicine and physical therapy. Students in this option might also want to pursue the Certificate in Biotechnology described elsewhere in this Catalog. This option requires approximately 76-79 units in the major, of which 43-46 are in lower division and 32-33 are in upper division.

All students must achieve at least a 2.0 grade-point average in each of the following: 1. the entire college record, 2. all units attempted at CSULB, and 3. all courses in the major.

In addition, students must receive a "C" or better in all upper division major courses.

Degree Progress

Pre-Biology majors must complete the following requirements within the specified time of declaring the pre-major. Some students may need to take courses during Summer Session to meet these requirements. Students who have not met the requirements by the required semester must either declare another major or meet with an Academic Advisor to determine if the student's performance in the courses merits an additional semester to complete.

Freshmen: A grade "C" or better must be achieved in CHEM 111A, BIOL 211, and MATH 119A (or 122) within one and a half calendar years.

Requirements

Lower Division:

Take all of the following courses:

- BIOL 211 Introduction to Evolution and Diversity (4)
Prerequisite/Corequisite: CHEM 111A with a grade of "C" or better.
- BIOL 212 Intro to Cell and Molecular Biology (4)
Prerequisites: BIOL 211, CHEM 111A with grades of "C" or better.
Prerequisite/Corequisite: CHEM 111B.
- BIOL 213 Intro to Ecology and Physiology (4)
Prerequisites: BIOL 211, 212, CHEM 111B, each with a grade of "C" or better.

NOTE: BIOL 111, BIOL 111L, BIOL 212, BIOL 212L, BIOL 213, BIOL 213L are required if courses were taken prior to catalog year 2010-11.

- BIOL 260 Biostatistics (3)
Prerequisites: BIOL 201 or BIOL 211 or BIOL 207 or MICR 200; MATH 111 or MATH 113 or MATH 119A or MATH 122 all with a grade of "C" or better.
- CHEM 111A General Chemistry (5)
Prerequisite: A passing score on the Chemistry Placement Examination.
Corequisite: MATH 109 or higher.
- CHEM 111B General Chemistry (5)
Prerequisites: CHEM 111A and MATH 113 or MATH 115 or MATH 119A or MATH 122 all with a grade of "C" or better.
- CHEM 220A Organic Chemistry I (3)
Prerequisite: CHEM 111B with a grade of "C" or better.
Corequisites: CHEM 224 is required for students repeating course. CHEM 223A must be taken concurrently if required by a degree plan.
- CHEM 220B Organic Chemistry II (3)
Prerequisite: CHEM 220A with a grade of "C" or better.
Corequisite: CHEM 223B or CHEM 320L except for students who previously earned a "C" or better in CHEM 223B or CHEM 320L.
- CHEM 223A Organic Chemistry Laboratory I (1)
Corequisite: CHEM 220A, except for students who have previously earned a "C" or better in CHEM 220A.
- CHEM 223B Organic Chemistry Laboratory II (1)
Prerequisites: CHEM 220A and CHEM 223A, both with a grade of "C" or better.
Corequisite: CHEM 220B, except for students who have previously earned a "C" or better in CHEM 220B.

Take one of the following courses:

- MATH 119A Survey of Calculus I (3)
Prerequisites: Appropriate MDPT placement or a grade of "C" or better in MATH 113.
- MATH 122 Calculus I (4)
Prerequisites: Appropriate MDPT placement or a grade of "C" or better in MATH 111 and MATH 113.

Take one of the following courses:

- PHYS 100A General Physics (4)
Prerequisites: MATH 109 or MATH 113 or MATH 119A or MATH 122.
- PHYS 151 Mechanics and Heat (4)
Prerequisite/Corequisite: MATH 122.

Take one of the following courses:

- PHYS 100B General Physics (4)
Prerequisite: PHYS 100A.
- PHYS 152 Electricity and Magnetism (4)
Prerequisite: PHYS 151;
Prerequisite/Corequisite: MATH 123.

Upper Division:

Take all of the following courses:

- BIOL 340 Molecular Cell Biology (3)
Prerequisites: BIOL 211, BIOL 212, all with a grade of "C" or better.
- BIOL 370 General Genetics (4)
Prerequisites: BIOL 211, BIOL 212 and either BIOL 260 or CHEM 251 all with a grade of "C" or better.
- BIOL 480 Seminars (1)
Prerequisites: Consent of Department of Biological Sciences. (Undergraduates and classified post-baccalaureates enroll in BIOL 480; graduates enroll in BIOL 580). Undergraduates must have filed for graduation and be in their last semester. Graduates must have been admitted to the department as a graduate student. Classified post-baccalaureates must have been admitted to a second baccalaureate or a certificate.
- CHEM 441A Biological Chemistry (3)
Prerequisites: CHEM 220B and either CHEM 320L or CHEM 223B all with a grade of "C" or better; a biology or microbiology course is recommended.
- CHEM 441B Biological Chemistry (3)
Prerequisite: CHEM 441A with a grade of "C" or better.

Take one of the following:

- BIOL 312 Evolutionary Biology (3)
Prerequisites: BIOL 211, BIOL 212, BIOL 213, BIOL 260 all with a grade of "C" or better.
- BIOL 350 General Ecology (3)
Prerequisites: BIOL 211, BIOL 212, BIOL 213, BIOL 260; MATH 119A or MATH 122 all with a grade of "C" or better.

Take at least one of the following courses/course pairs:

- BIOL 342 Human/Mammalian Phys (3)
Prerequisites: BIOL 211, BIOL 212, BIOL 213 all with grade of "C" or better.
- And
- BIOL 342L Lab in Human/Mammalian Phys (1)
Prerequisite/Corequisite: BIOL 342 with a grade of "C" or better.
- Or
- BIOL 345 Comparative Animal Phys (3)
Prerequisites: BIOL 211, BIOL 212, BIOL 213 all with grade of "C" or better.

And

- BIOL 345L Lab in Comp Animal Phys (1)
Prerequisite/Corequisite: BIOL 345 with a grade of "C" or better.

Or

- BIOL 440L Molecular Cell Biology Lab (3)
Prerequisites: BIOL 340, BIOL 370, both with a grade of "C" or better, and consent of instructor.

Take four additional courses totaling at least 12 units selected from the following:

- BIOL 311 General Microbiology (4)
Prerequisites: BIOL 211, BIOL 212; CHEM 111B, all with a grade of "C" or better.
- BIOL 431 Biology of Cancer (3)
Prerequisites: BIOL 340, 370 with a grade of "C" or better.

- BIOL 432 Stem Cell Biology (3)
Prerequisite: BIOL 340 and 370 with a grade of "C" or better.
- BIOL 433 Developmental Biology (3)
Prerequisites: BIOL 340; BIOL 370 or BIOL 371 or MICR 371, both with a grade of "C" or better.
- BIOL 440L Molecular Cell Biology Lab (3)
Prerequisites: BIOL 340, BIOL 370, both with a grade of "C" or better, and consent of instructor.
- BIOL 442 Physiology at the Limit (3)
Prerequisites: BIOL 342 or BIOL 345 with a grade of "C" or better.
- BIOL 443 Endocrinology (3)
Prerequisites: BIOL 340; BIOL 342 or BIOL 345, all with a grade of "C" or better. (Undergraduates enroll in BIOL 443; graduates enroll in BIOL 543.)
- BIOL 444 Reproductive Biology (3)
Prerequisites: BIOL 342 or BIOL 345 with a grade of "C" or better.
- BIOL 445 Metabolic Regulation (3)
Prerequisites: BIOL 340, BIOL 342 or BIOL 345; CHEM 441A with grade of "C" or better.
- BIOL 447 Molecular Plant Physiology (3)
Prerequisites: BIOL 340, BIOL 370, both with grade of "C" or better.
- BIOL 448 Principles of Neurobiology (3)
Prerequisites: BIOL 340; BIOL 342 or BIOL 345, all with a grade of "C" or better. (Undergraduates enroll in BIOL 448; graduates enroll in BIOL 548.)
- BIOL 449 Fish Physiology and Endocrinology (3)
Prerequisite: BIOL 345 with grade of "C" or better.
- BIOL 472 Molecular Evolution (3)
Prerequisite: BIOL 370 with a grade of "C" or better.
- BIOL 473 Molecular Genetics (3)
Prerequisites: BIOL 370 or BIOL 371 or MICR 371; CHEM 220A,B and 223A,B, or CHEM 227, all with a grade of "C" or better.
- BIOL 474 Bioinformatics (3)
Prerequisites: BIOL 260; BIOL 370 or BIOL 371 or MICR 371, all with a grade of "C" or better.
- BIOL 477 Biotechnology & Bioinformatics (4)
Prerequisite: BIOL 340 or 370 or CHEM 441A,B; all with a grade of "C" or better.
- BIOL 416 Virology (3)
Prerequisite: BIOL 320 or MICR 320 or BIOL 340 with a grade of "C" or better.
- BIOL 430 Immunology (3)
Prerequisite: BIOL 340 with a grade of "C" or better.

With permission of the appropriate advisor, students may substitute one course in the biological sciences that is not on the above list for one of these four courses.

These courses do not meet any specific or elective requirements for this major: BIOL 300, BIOL 301, BIOL 304, BIOL 305, 309; and NSCI 492.

To meet prerequisite standards for courses in this program's requirements, a "C" or better is necessary in the following: BIOL 211, BIOL 212, BIOL 213, BIOL 260, BIOL 340, BIOL 342, BIOL 345, BIOL 370, CHEM 111A, CHEM 111B, CHEM 220A, CHEM 223A, CHEM 220B/CHEM 223B, CHEM 441A, MATH 119A/MATH 122.

Students contemplating graduate or professional school should consider taking 1-3 units of BIOL 496 in addition to the requirements listed above. With prior permission of the advisor for this option, students may use 3 units of BIOL 496 as an elective.

Bachelor of Science in Marine Biology (120 units)

Marine biology is the study of the biology and ecology of organisms found in the ocean. This degree provides a base to pursue graduate school, along with a variety of careers in environmental consulting, government, teaching, and public aquaria. This major requires approximately 78-85 units in the major, of which 38-44 are in lower division and 41 are in upper division. All students must achieve at least a 2.0 grade-point average in each of the following: 1. the entire college record, 2. all units attempted at CSULB, and 3. all courses in the major. In addition students must receive a "C" or better in all upper division major courses.

Admission Under Impaction

Refer to the following website for additional impaction criteria: http://www.csulb.edu/depts/enrollment/admissions/impacted_major.html.

Requirements

Lower Division:

Take all of the following courses:

- BIOL 153 Introduction to Marine Biology (3)
Prerequisites/Corequisites: Courses that fulfill the A.1 and B.2 GE requirements.
- BIOL 211 Introduction to Evolution and Diversity (4)
Prerequisite/Corequisite: CHEM 111A with a grade of "C" or better.
- BIOL 212 Intro to Cell and Molecular Biology (4)
Prerequisites: BIOL 211, CHEM 111A with grades of "C" or better.
Prerequisite/Corequisite: CHEM 111B.
- BIOL 213 Intro to Ecology and Physiology (4)
Prerequisites: BIOL 211, 212, CHEM 111B, each with a grade of "C" or better.

NOTE: BIOL 111, BIOL 111L, BIOL 212, BIOL 212L, BIOL 213, BIOL 213L are required if courses were taken prior to catalog year 2010-11.

- BIOL 260 Biostatistics (3)
Prerequisites: BIOL 201 or BIOL 211 or BIOL 207 or MICR 200; MATH 111 or MATH 113 or MATH 119A or MATH 122 all with a grade of "C" or better.
- CHEM 111A General Chemistry (5)
Prerequisite: A passing score on the Chemistry Placement Examination.
Corequisite: MATH 109 or higher.
- CHEM 111B General Chemistry (5)
Prerequisites: CHEM 111A and MATH 113 or MATH 115 or MATH 119A or MATH 122 all with a grade of "C" or better.

Take one of the following courses:

- PHYS 100A General Physics (4)
Prerequisites: MATH 109 or MATH 113 or MATH 119A or MATH 122.
- PHYS 151 Mechanics and Heat (4)
Prerequisite/Corequisite: MATH 122.

Take one of the following courses:

- MATH 119A Survey of Calculus I (3)
Prerequisite: Appropriate MDPT placement or a grade of "C" or better in MATH 113.
- MATH 122 Calculus I (4)
Prerequisite: Appropriate MDPT placement or a grade of "C" or better in MATH 111 and MATH 113.

These courses do not meet any specific or elective requirements for this major: BIOL 100, BIOL 101, BIOL 200, BIOL 200L, BIOL 201, BIOL 205, BIOL 205L, BIOL 207, BIOL 208

Take either:

CHEM 227 Fundamentals of Organic Chemistry (3)
Prerequisite: CHEM 111A with a grade of "C" or better;
CHEM 111B is recommended.

or all four of the following courses lower-division courses:

CHEM 220A Organic Chemistry I (3)

Prerequisite: CHEM 111B with a grade of "C" or better.
Corequisites: CHEM 224 is required for students repeating
course. CHEM 223A must be taken concurrently if required
by a degree plan.

CHEM 220B Organic Chemistry II (3)

Prerequisite: CHEM 220A with a grade of "C" or better.
Corequisite: CHEM 223B or CHEM 320L except for
students who previously earned a "C" or better in CHEM
223B or CHEM 320L.

CHEM 223A Organic Chemistry Laboratory I (1)

Corequisite: CHEM 220A, except for students who have
previously earned a "C" or better in CHEM 220A.

CHEM 223B Organic Chemistry Laboratory II (1)

Prerequisites: CHEM 220A and CHEM 223A, both with a
grade of "C" or better.
Corequisite: CHEM 220B, except for students who have
previously earned a "C" or better in CHEM 220B.

Upper Division:

Take all of the following courses:

BIOL 312 Evolutionary Biology (3)

Prerequisites: BIOL 211, BIOL 212, BIOL 213, BIOL 260 all
with a grade of "C" or better.

BIOL 313 Invertebrate Zoology (4)

Prerequisites: BIOL 211, BIOL 212, BIOL 213 all with a
grade of "C" or better, and consent of instructor.

BIOL 340 Molecular Cell Biology (3)

Prerequisites: BIOL 211, BIOL 212, all with a grade of "C"
or better.

BIOL 345 Comparative Animal Physiology (3)

Prerequisites: BIOL 211, BIOL 212, BIOL 213 all with grade
of "C" or better.

BIOL 345L Lab in Comparative Animal Physiology (1)

Prerequisite/Corequisite: BIOL 345 with a grade of "C" or
better.

BIOL 350 General Ecology (3)

Prerequisites: BIOL 211, BIOL 212, BIOL 213, BIOL 260;
MATH 119A or MATH 122 all with a grade of "C" or better.

BIOL 353 Marine Biology (3)

Prerequisites: BIOL 153, BIOL 211, BIOL 212, BIOL 213,
BIOL 260 all with grade of "C" or better.

BIOL 370 General Genetics (4)

Prerequisites: BIOL 211, BIOL 212 and either BIOL 260 or
CHEM 251 all with a grade of "C" or better.

BIOL 419 Ichthyology (3)

Prerequisites: BIOL 211, BIOL 212, BIOL 213, BIOL 260
and at least 6 additional units of upper division biological
science, all with a grade of "C" or better.
Recommended: BIOL 350, BIOL 353, and BIOL 370.

BIOL 425 Phycology (4)

Prerequisite: BIOL 353 with a grade of "C" or better.

BIOL 480 Seminars (1)

Prerequisites: Consent of Department of Biological
Sciences. (Undergraduates and classified post-
baccalaureates enroll in BIOL 480; graduates enroll in
BIOL 580). Undergraduates must have filed for graduation
and be in their last semester. Graduates must have
been admitted to the department as a graduate student.
Classified post-baccalaureates must have been admitted to
a second baccalaureate or a certificate.

Take a minimum of three courses from the following:

BIOL 411 Marine Mammalogy (3)

Prerequisites: BIOL 345, BIOL 350, and BIOL 353, all with
grade of "C" or better, and consent of instructor.

BIOL 415 Marine Microbiology (3)

Prerequisite: BIOL 353 or BIOL 355 or MICR 355 with a grade
of "C" or better.

BIOL 420 Fisheries Ecology and Conservation (3)

Prerequisites: BIOL 260, BIOL 350, 353, and 419, all with
grade of "C" or better.

BIOL 449 Fish Physiology and Endocrinology (3)

Prerequisite: BIOL 345 with grade of "C" or better.

BIOL 451 Wetlands and Mangrove Ecology (3)

Prerequisites: BIOL 260, BIOL 350 both with a grade of "C"
or better.

BIOL 454A Research in Tropical Marine Ecology (3)

Prerequisites: BIOL 350, BIOL 353, and one 400-level marine
biology major course, all with grade of "C" or better, and
consent of instructor.

BIOL 455 Ecology of Marine Communities (3)

Prerequisites: BIOL 260, BIOL 350, BIOL 353 all with a grade
of "C" or better.

BIOL 457 Field Methods in Ecology (3)

Prerequisites: BIOL 260, BIOL 350 both all with a grade of "C"
or better.

BIOL 463 Computer Modeling in Biology (4)

Prerequisites: BIOL 260, BIOL 350 both with a grade of "C"
or better.

BIOL 464 Aquatic Toxicology (3)

Prerequisites: BIOL 211, BIOL 212, BIOL 213, BIOL 340;
CHEM 220A or CHEM 227, all with a grade of "C" or better.

GEOG 481 Geographic Information Science for Natural
Sciences (4)

Prerequisites: Junior/Senior/Graduate standing; GEOG 140
or BIOL 153 or GEOL 102.

GEOL 465 Physical and Chemical Oceanography (3)

Prerequisites: CHEM 111B; PHYS 100A or PHYS 151, and
upper division standing in the College of Natural Sciences
and Mathematics or Engineering.

and

GEOL 466 Oceanography Laboratory and Ocean Studies
(1)

Prerequisite/Corequisite: GEOL 465.

PHYS 100B General Physics (4)

Prerequisite: PHYS 100A.

or

PHYS 152 Electricity and Magnetism (4)

Prerequisite: PHYS 151; Prerequisite/Corequisite: MATH 123.

MATH 119B Survey of Calculus II (3)

Prerequisite: A grade of "C" or better in MATH 119A or MATH
122.

or

MATH 123 Calculus II (4)

Prerequisite: A grade of "C" or better in MATH 122.

and, with prior consent of marine biology advisor for both:

BIOL 490 Selected Topics in Biology (1-3)

Prerequisites: BIOL 211, BIOL 212, BIOL 213 all with a grade
of "C" or better, and consent of instructor.

and 3 units of:

BIOL 496 Undergraduate Directed Research (1-3)

Prerequisites: BIOL 211, 212; one of BIOL 213, BIOL 311 or
MICR 211, BIOL 296 or MICR 296; consent of instructor; and
consent of appropriate undergraduate advisor.

These courses do not meet any specific or elective
requirements for this major: BIOL 300, BIOL 301, BIOL 304,
BIOL 305; and NSCI 492.

To meet prerequisite standards for courses in this
program's requirements, a "C" or better is necessary in the
following: BIOL 153, BIOL 211, BIOL 212, BIOL 213, BIOL
260, BIOL 345, BIOL 353, CHEM 111A, CHEM 111B, CHEM

220A, CHEM 223A, MATH 119A/MATH 122.

Few, if any, health-related professional schools (e.g. veterinary medicine) will accept CHEM 227. Some graduate programs with masters or doctorates in biology and/or marine biology may also not accept CHEM 227. Students interested in these programs might consider taking PHYS 100B or PHYS 152; MATH 119B or MATH 122; CHEM 220A,B and CHEM 223A,B. CHEM 227 is not acceptable as a prerequisite for CHEM 441A. CHEM 227 is acceptable toward the Minor in Chemistry.

Bachelor of Science in Microbiology (120 units)

Microbiology is the study of microorganisms and their interactions with humans, other organisms, and the environment. This degree is appropriate for those contemplating graduate work in microbiology or, with the inclusion of appropriate classes, may be utilized by pre-professional students. Students in this option might also want to pursue the Certificate in Biotechnology described elsewhere in this Catalog. This undergraduate major is recognized by the American Society for Microbiology as meeting their core curriculum for the baccalaureate degree program in microbiology. This major requires 77-78 units in the major, of which 40-41 are lower division and 37 are upper division. All students must achieve at least a 2.0 grade-point average in each of the following: 1. the entire college record, 2. all units attempted at CSULB, and 3. all courses in the major. In addition, students must receive a "C" or better in all upper division major courses.

Admission Under Impaction

Refer to the following website for additional impaction criteria: http://www.csulb.edu/depts/enrollment/admissions/impacted_major.html.

Degree Progress

Pre-Microbiology majors must complete the following requirements within the specified time of declaring the pre-major. Some students may need to take courses during Summer Session to meet these requirements. Students who have not met the requirements by the required semester must either declare another major or meet with an Academic Advisor to determine if the student's performance in the courses merits an additional semester to complete.

Freshmen: A grade "C" or better must be achieved in CHEM 111A, BIOL 211, and MATH 119A (or MATH 122) within one and a half calendar years.

Requirements

Lower Division:

Take all of the following courses:

BIOL 211 Introduction to Evolution and Diversity (4)
Prerequisite/Corequisite: CHEM 111A with a grade of "C" or better.

BIOL 212 Introduction to Cell & Molecular Biology (4)
Prerequisites: BIOL 211, CHEM 111A with grades of "C" or better.

Prerequisite/Corequisite: CHEM 111B..

NOTE: BIOL 111, BIOL 111L, BIOL 212, BIOL 212L, BIOL 213, BIOL 213L are required if courses were taken prior to catalog year 2010-11.

BIOL 260 Biostatistics (3)
Prerequisites: BIOL 201 or BIOL 211 or BIOL 207 or MICR

200; MATH 111 or MATH 113 or MATH 119A or MATH 122 all with a grade of "C" or better.

CHEM 111A General Chemistry (5)
Prerequisite: A passing score on the Chemistry Placement Examination.
Corequisite: MATH 109 or higher.

CHEM 111B General Chemistry (5)
Prerequisites: CHEM 111A and MATH 113 or MATH 115 or MATH 119A or MATH 122 all with a grade of "C" or better.

CHEM 220A Organic Chemistry I (3)
Prerequisite: CHEM 111B with a grade of "C" or better.
Corequisites: CHEM 224 is required for students repeating course. CHEM 223A must be taken concurrently if required by a degree plan.

CHEM 220B Organic Chemistry II (3)
Prerequisite: CHEM 220A with a grade of "C" or better.
Corequisite: CHEM 223B or CHEM 320L except for students who previously earned a "C" or better in CHEM 223B or CHEM 320L.

CHEM 223A Organic Chemistry Laboratory I (1)
Corequisite: CHEM 220A, except for students who have previously earned a "C" or better in CHEM 220A.

CHEM 223B Organic Chemistry Laboratory II (1)
Prerequisites: CHEM 220A and CHEM 223A, both with a grade of "C" or better.
Corequisite: CHEM 220B, except for students who have previously earned a "C" or better in CHEM 220B.

Take one of the following courses:

PHYS 100A General Physics (4)
Prerequisite: MATH 109 or MATH 113 or MATH 119A or MATH 122.

PHYS 151 Mechanics and Heat (4)
Prerequisite/Corequisite: MATH 122.

Take one of the following courses:

PHYS 100B General Physics (4)
Prerequisite: PHYS 100A.

PHYS 152 Electricity and Magnetism (4)
Prerequisite: PHYS 151; Prerequisite/Corequisite: MATH 123.

Take one of the following courses:

MATH 119A Survey of Calculus I (3)
Prerequisite: Appropriate MDPT placement or a grade of "C" or better in MATH 113.

MATH 122 Calculus I (4)
Prerequisites: Appropriate MDPT placement or a grade of "C" or better in MATH 111 and MATH 113.

These courses do not meet any specific or elective requirements for this major: BIOL 100, BIOL 101, BIOL 153, BIOL 153L, BIOL 200, BIOL 200L, BIOL 201, BIOL 205, BIOL 205L, BIOL 207, BIOL 208

Upper Division:

Take one of the following courses:

CHEM 448 Fundamentals of Biological Chemistry (3)
Prerequisites: CHEM 220B or CHEM 227 either with a grade of "C" or better.

CHEM 441A Biological Chemistry (3)
Prerequisite: CHEM 220B and either CHEM 320L or CHEM 223B all with a grade of "C" or better; a biology or microbiology course is recommended.

Take all of the following courses:

BIOL 311 General Microbiology (4)
Prerequisites: BIOL 211, BIOL 212; CHEM 111B, all with a grade of "C" or better.

BIOL 320 Bacterial Pathogenesis (3)
Prerequisite: BIOL 311 with a grade of "C" or better.
Recommended: BIOL 320L.

BIOL 340 Molecular Cell Biology (3)
Prerequisites: BIOL 211, BIOL 212, all with a grade of "C" or better.

BIOL 355 Microbial Ecology (3)
Prerequisites: BIOL 211 or BIOL 311, BIOL 212, BIOL 213; BIOL 260, all with a grade of "C" or better.

BIOL 371 Microbial Genetics (3)
Prerequisite: BIOL 311 with a grade of "C" or better.

BIOL 372 Methods in Microbial Genetics (2)
Prerequisite: BIOL 311 with a grade of "C" or better.
Recommended: BIOL 371.

BIOL 471 Bacterial Physiology (3)
Prerequisites: BIOL 320, CHEM 448 or CHEM 441A; both with a grade of "C" or better.

BIOL 480 Seminars (1)
Prerequisites: Consent of Department of Biological Sciences. (Undergraduates and classified post-baccalaureates enroll in BIOL 480; graduates enroll in BIOL 580). Undergraduates must have filed for graduation and be in their last semester. Graduates must have been admitted to the department as a graduate student. Classified post-baccalaureates must have been admitted to a second baccalaureate or a certificate.

Take four courses totaling at least 12 elective units chosen from the following, one of which must be BIOL 320L, BIOL 322, BIOL 355L, BIOL 415, BIOL 434, BIOL 474, or BIOL 477:

BIOL 320L Bacterial Pathogenesis Laboratory (2)
Prerequisite: BIOL 212 or BIOL 311, with a grade of "C" or better.

BIOL 322 Medical Mycology/Parasitology (4)
Prerequisites: BIOL 211, BIOL 212; BIOL 320, all with a grade of "C" or better.

BIOL 325 Emerging Infectious Diseases (3)
Prerequisites: BIOL 311 with a grade of "C" or better and consent of instructor.

BIOL 355L Microbial Ecology Laboratory (2)
Prerequisite/Corequisite: BIOL 355.

BIOL 415 Marine Microbiology (3)
Prerequisites: BIOL 353 or BIOL 355 with a grade of "C" or better.

BIOL 416 Virology (3)
Prerequisites: BIOL 320 or BIOL 340 with a grade of "C" or better.

BIOL 429 Epidemiology of Infectious Diseases (3)
Prerequisites: BIOL 260; BIOL 320, BIOL 322; all of a grade of "C" or better.

BIOL 430 Immunology (3)
Prerequisite: BIOL 340 with a grade of "C" or better.

BIOL 434 Hematology (4)
Prerequisite: BIOL 340 with a grade of "C" or better.

BIOL 473 Molecular Genetics (3)
Prerequisites: BIOL 370 or BIOL 371 or MICR 371; CHEM 220A,B and CHEM 223A,B, or CHEM 227, all with a grade of "C" or better.

BIOL 474 Bioinformatics (3)
Prerequisites: BIOL 260; BIOL 370 or BIOL 371 or MICR 371, all with a grade of "C" or better.

BIOL 477 Biotechnology: Applications of Molecular Techniques and Bioinformatics (4)
Prerequisites: BIOL 340 or BIOL 370 or CHEM 441A,B; all with a grade of "C" or better.

BIOL 490 Selected Topics in Biology (1-3)
Prerequisites: BIOL 211, BIOL 212, BIOL 213 all with a grade of "C" or better, and consent of instructor.

BIOL 495 Instruction in Laboratory Teaching (1-2)
Prerequisites: Consent of instructor, an "A" in the course in which the student elects to do BIOL 495 (another course with laboratory may be substituted with consent of instructor), and an overall GPA of at least 3.0.

CHEM 441B Biological Chemistry (3)

Prerequisite: CHEM 441A with a grade of "C" or better.

Students may use BIOL 496 towards the additional units but only with prior permission of the advisor for this degree. Those students seeking a career as a Clinical Laboratory Scientist/Medical Technologist are encouraged to take BIOL 320L, BIOL 416, BIOL 423, and BIOL 430.

These courses do not meet any specific or elective requirements for this major: BIOL 300, BIOL 301, BIOL 304, BIOL 305; and NSCI 492.

To meet prerequisite standards for courses in this program's requirements, a "C" or better is necessary in the following: BIOL 211, BIOL 212, BIOL 311, BIOL 320, BIOL 340, CHEM 111A, CHEM 111B, CHEM 220A, CHEM 223A, CHEM 220B/CHEM 223B, MATH 119A/MATH 122

Minor in Biology

This minor may be combined with any major at CSULB except the B.S. in Biology (all options), B.S. in Microbiology, and B.S. in Marine Biology. A minimum of 21 units is required for this minor.

Lower Division:

Take all of the following courses:

BIOL 211 Introduction to Evolution and Diversity (4)

*C or better required.

Prerequisite/Corequisite: CHEM 111A with a grade of "C" or better.

BIOL 212 Intro to Cell and Molecular Biology (4)

*C or better required.

Prerequisites: BIOL 211, CHEM 111A with grades of "C" or better.

Prerequisite/Corequisite: CHEM 111B.

BIOL 213 Intro to Ecology and Physiology (4)

Prerequisites: BIOL 211, 212, CHEM 111B, each with a grade of "C" or better.

NOTE: BIOL 111, BIOL 111L, BIOL 212, BIOL 212L, BIOL 213, BIOL 213L are required if courses were taken prior to catalog year 2010-11.

CHEM 111A and 111B are required if the courses are taken at CSULB.

These courses do not meet any specific or elective requirements for this minor: BIOL 100, BIOL 101, BIOL 153, BIOL 153L, BIOL 200, BIOL 200L, BIOL 201, BIOL 205, BIOL 205L, BIOL 207, BIOL 208

Upper Division:

Take a minimum of nine units selected from upper division biology courses with at least one course selected from the 400 series. The nine units must include at least one course chosen from BIOL 312, BIOL 340, BIOL 350, and BIOL 370. Many of the upper division courses in biology also require either BIOL 260 or organic chemistry.

These courses do not meet any specific or elective requirements for this minor: BIOL 200, BIOL 300, BIOL 301, BIOL 304, BIOL 305 and NSCI 492.

Minor in Physiology

This minor may be combined with any major at CSULB except the B.S. in Biology, Option in Physiology.

A minimum of 18 upper division units.

Twelve units must be selected from the following:

BIOL 341, BIOL 342, BIOL 342L, BIOL 345, BIOL 345L, BIOL 443, BIOL 445, BIOL 448, BIOL 490.

Six units must be selected from other courses in the

above list or from the following:

BIOL 473; CHEM 441A,B, CHEM 443, or CHEM 448.

At least one of the upper division courses taken for this minor must have a laboratory. Most of these upper-division courses require CHEM 111A,B and BIOL 211, BIOL 212, BIOL 213 as prerequisites; some have other prerequisites in addition.

These courses do not meet any specific or elective requirements for this minor: BIOL 100, BIOL 101, BIOL 153, BIOL 153L, BIOL 200, BIOL 200L, BIOL 201, BIOL 205, BIOL 205L, BIOL 207, BIOL 208

These courses do not meet any specific or elective requirements for this minor: BIOL 300, BIOL 301, BIOL 304, BIOL 305, 309; MICR 300; and NSCI 492.

Minor in Microbiology

This minor may be combined with any major at CSULB except the B.S. in Marine Biology. A minimum of 21 units is required for this minor.

Lower Division:

Take all of the following courses:

BIOL 211 Introduction to Evolution and Diversity (4)

Prerequisite/Corequisite: CHEM 111A with a grade of "C" or better.

BIOL 212 Intro to Cell and Molecular Biology (4)

Prerequisites: BIOL 211, CHEM 111A with grades of "C" or better. Prerequisite/Corequisite: CHEM 111B.

BIOL 311 General Microbiology (4)

Prerequisites: BIOL 211, 212; CHEM 111B, all with a grade of "C" or better. CHEM 111A and 111B are required if the courses are taken at CSULB.

The following courses do not meet any specific or elective requirements for this minor: BIOL 100, 101, 153, 153L, 200, 200L, 201, 205, 205L, 207, 208.

Take a minimum of nine units selected from upper division microbiology courses with at least one course chosen from BIOL 320, 355, or 371 and at least 3 units from the 400 series.

The following courses do not meet any specific or electives for this minor: BIOL 300, 301, 304, 305, 308, and NSCI 492.

Certificate Program in Biomedical Art

This is an interdisciplinary program sponsored by the Art and Biological Sciences departments. For requirements, see the Art section of this catalog.

Certificate in Biotechnology

Biotechnology refers to a process which ultimately yields a product that can be loosely subdivided into five categories; biological organisms with novel traits, DNAs, RNAs, proteins, and compounds. The certificate may be earned in conjunction with or subsequent to a baccalaureate degree. Courses offered for the certificate may be used to satisfy, as appropriate, major or minor requirements.

This certificate program is eligible for Financial Aid. Please see the department web site for required Federal disclosure information.

Prerequisites for Admission

Completion of the following courses with a grade of "C" or better (or consent of the biotechnology certificate program director): CHEM 111A,B; CHEM 220A,B and CHEM 223A,B; CHEM 441A,B; BIOL 311, BIOL 340, BIOL 370

These courses do not meet any specific or elective requirements for

this certificate: BIOL 100, BIOL 101, BIOL 153, BIOL 153L, BIOL 200, BIOL 200L, BIOL 201, BIOL 205, BIOL 205L, BIOL 207, BIOL 208

Requirements

1. A baccalaureate degree (can be concurrent);
2. Completion of prerequisites;
3. Approval by the program director;
4. Completion of the core curriculum:

BIOL 477/577 Biotechnology: Applications of Molecular Techniques and Bioinformatics (4)

Prerequisites: BIOL 340 or 370 or CHEM 441A,B; all with a grade of "C" or better. (Undergraduates enroll in BIOL 477; graduates enroll in BIOL 577.)

BIOL 480/580 Seminars (1)

Prerequisites: Consent of Department of Biological Sciences. (Undergraduates and classified post-baccalaureates enroll in BIOL 480; graduates enroll in BIOL 580). Undergraduates must have filed for graduation and be in their last semester. Graduates must have been admitted to the department as a graduate student. Classified post-baccalaureates must have been admitted to a second baccalaureate or a certificate.

One of the following courses:

BIOL 440L. Molecular Cell Biology Laboratory (3)

Prerequisites: BIOL 340, BIOL 370, both with a grade of "C" or better.

or

BIOL 372 Methods in Microbial Genetics (2)

Prerequisite: BIOL 311 with a grade of "C" or better. Recommended: BIOL 371.

or

CHEM 443. Biological Chemistry Laboratory (4)

Prerequisites: CHEM 251, CHEM 441A; and either CHEM 361 or CHEM 466, all with a grade of "C" or better.

One of the following courses:

BIOL 492A./592A. Stem Cell Research Internship (12)

Prerequisites: BIOL 432/532, BIOL 432L/532L, BIOL 440L, BIOL 462/562, BIOL 473/573, BIOL 477/577, all with a grade of "C" or better, and permission of the director of the CSULB Biotechnology Certificate Program, and acceptance in the Stem Cell Training Option within the Biotechnology Certificate. (Undergraduates enroll in BIOL 492A; graduates enroll in BIOL 592A.)

or

NSCI 492 Internships In Natural Science (3)

Prerequisites: Major in the College of Natural Sciences and Mathematics, completion of 9 units of upper division science coursework, a 2.5 GPA overall or 2.75 GPA in the student's major, and consent of instructor prior to registration.

Take an additional 6 units selected from the following list:

BIOL 415/515, BIOL 416/516, BIOL 430, BIOL 431/531, BIOL 432/532, BIOL 447/547, BIOL 448/548, BIOL 462/562, BIOL 464/564, BIOL 472/572, BIOL 473/573, BIOL 474/574, or CHEM 480/580.

5. Completion of 2 units consisting of an approved research project in biotechnology to be taken from one or more of the following:
BIOL 496; CHEM 496 (undergraduate students); BIOL 697; CHEM 697 (graduate students);
6. BIOL 300, BIOL 301, and BIOL 304 do not meet any specific or elective requirements for this certificate.
7. Total 18 units required.

Concurrent and/or Summer Enrollment in Another College

Students who wish to take coursework in a community or another college to meet curricular requirements while enrolled as undergraduates in the College of Natural Sciences and Mathematics must petition the appropriate department for prior approval to enroll in specific courses. This policy applies to concurrent enrollment or summer enrollment. University policy must also be met; see 'Concurrent Enrollment' and 'Transfer of Undergraduate Credit' in this catalog. Courses not receiving prior approval will not be accepted for credit by the department.

GRADUATE PROGRAMS

Master of Science in Biology

This degree is available to qualified students preparing for professional careers in industry and government and for further studies at the doctoral level. In addition, a master's degree in biology, combined with appropriate courses in education, can be utilized for a community college teaching credential. This degree requires a thesis based on original scientific research; a list of research areas with the names of faculty specializing in these areas can be obtained from the department's website.

Admission to the Department

Prerequisites

In addition to the prerequisites for entrance into CSULB as a graduate student, stated previously in this catalog under Graduate Degrees and Post Baccalaureate Studies, the Department of Biological Sciences requires:

1. A faculty member in the department must agree to serve as the thesis advisor to the student prior to her/his acceptance into the M.S. program;
2. A bachelor's degree in the biological or related sciences from an accredited institution. Students with alternative undergraduate degrees will be considered;
3. An undergraduate GPA in all completed science and mathematics courses of at least 2.70 OR a GPA of at least 3.00 in the last 40 semester (or 60 quarter) units of science and mathematics courses completed;
4. The GRE General Test must have been taken prior to applying to the Department. The applicant should score in the 50th percentile or better in Verbal and Quantitative sections. If either the GRE Verbal or Quantitative score (but not both) is below the 50th percentile, the student may be considered for acceptance if their respective undergraduate grades in English or Math are a B average or better. The GRE must have been taken within five years prior to the intended admission date.
5. Applicants without a degree within a field of the biological sciences must also take the GRE Biology or Biochemistry, Cell and Molecular Biology Subject Test. A score of 50th percentile or better on the GRE Subject Test in Biology, or Biochemistry, Cell and Molecular

Biology must be achieved.

Students who do not meet the minimum required criteria for acceptance are encouraged to take post-baccalaureate courses to bring up their GPA or GRE scores.

Application

Prospective graduate students in M.S. in Biology, including CSULB graduates, must formally apply for admission to CSULB as described previously in this catalog and must also apply directly to the Department of Biological Sciences. All applicants must submit the following documents directly to the Department no later than the deadline as seen on the Graduate Advising home page (<http://web.csulb.edu/divisions/aa/grad/advising/>) for the fall semester to receive consideration for admission:

1. Departmental Application Form, also available from the Department's Graduate Office;
2. A one page essay describing why the applicant wishes to obtain an M.S. degree in Biology at CSULB and how this relates to her/his career objectives;
3. Unofficial transcripts of all college level academic work, including those completed at CSULB (these are in addition to those transcripts required for general graduate admission to CSULB);
4. Three letters of recommendation from persons familiar with the applicant's academic performance, as well as research and teaching potential; and
5. Official report of the GRE General Test scores. The applicant should have taken this examination prior to applying to the Department, because the official scores must reach the Department by the deadline above.

These materials must be submitted to the Graduate Office, Department of Biological Sciences, California State University, Long Beach, 1250 Bellflower Blvd., Long Beach, CA 90840-9502.

Review by the Graduate Studies Committee

The Graduate Studies Committee will review all completed applications received by the deadlines. Admission into the M.S. Program in Biology is competitive, with an applicant's college GPA, GRE Test scores, one-page essay, and letters of recommendation weighed in the decision to accept or decline. Applicants who are admitted into the program will enter as a Classified Graduate Student, as described below.

Admission to the Department of Biological Sciences as a Classified Graduate Student

The Department of Biological Sciences may admit as a Classified Graduate Student any applicant who:

1. has met all prerequisites,
2. has a complete application folder, and
3. has obtained acceptance by a faculty member to serve as her/his Thesis Advisor.

The Thesis Proposal

After admission to the Department as a Classified Graduate Student, the student in consultation with the Thesis Advisor, must prepare her/his Thesis Proposal and Program of Study, which includes all coursework to be taken. The Thesis Proposal must include a thorough review of relevant primary literature that demonstrates the context of the proposed research, it must clearly define the experiments proposed

for the research to be undertaken, and should include preliminary data, if available. The student and her/his Thesis Advisor will select at least two additional members to serve on the Thesis Committee. In most cases, the Thesis Advisor will serve as Chair of the Thesis Committee. However, if the Thesis Advisor is not eligible, another member of the Thesis Committee will serve as Thesis Committee Chair. The student will then have a formal meeting with the Thesis Committee, at which the student's Thesis Proposal and Program of Study will be presented and evaluated. At this meeting, the Thesis Committee will question the student about her/his Thesis Proposal. At the completion of this meeting, the Thesis Committee will meet briefly, without the student present, to evaluate the Thesis Proposal. Approval is based on whether the student has demonstrated a solid understanding of her/his thesis project. The Thesis Proposal must be prepared, presented to, and approved by the Thesis Committee before the end of the second semester after admission to the Department. Failure to meet this requirement will result in dismissal from the M.S. in Biology program. (Note: In order to satisfy the culminating activity requirement (thesis, project, or comprehensive examination dependent upon the program), students must earn at least three (3) units and no more than six (6) units related to the completion of the culminating activity.

The Program of Study

The Program of Study must include six units of Thesis (BIOL 698), one to three units of Directed Research (BIOL 697), three units of Experimental Design (BIOL 696A), three units of Scientific Communication (BIOL 696B), one unit of Seminar (BIOL 580), and four units from: BIOL 661, BIOL 663, BIOL 664, BIOL 665, BIOL 666; or CHEM 595A; BIOL 661-666 topics must be different. Of the minimum 30 units, no more than six may come from BIOL 661-666 and no more than two units of CHEM 595A; no more than nine may come from transfer credit; and no more than one 300-level course may be included. Any 300-level course on a graduate program of study must be approved by the Thesis Advisor and the Graduate Advisor. BIOL 696A will be taken during the student's initial fall semester; the course will cover experimental design, statistics, and literature research, and help students in preparing their Thesis Proposal. BIOL 696B will be taken during the first spring semester in the program, and will cover both oral and written scientific presentation. BIOL 696B is intended to facilitate manuscript and thesis writing and to help students learn to articulate their findings for their thesis defense. The Program of Study must be prepared, presented to, and approved by the Thesis Committee before the end of the second semester after admission to the Department. Failure to meet this requirement will result in dismissal from the M.S. in Biology program.

Advancement to Candidacy

In addition to the general University requirements stated previously under Post-Baccalaureate and Graduate Degrees in this catalog, the student must complete the following steps before receiving Master's Candidate status in the Department of Biological Sciences:

1. Admission to the Master's Degree program in Biology as a Classified Graduate Student (see above);

2. Acceptance of the Thesis Proposal and Program of Study by the Thesis Committee;
3. Satisfactory academic progress;
4. Satisfactory fulfillment of the Graduation Writing Assessment Requirement (GWAR).

The Thesis Committee will recommend the student for advancement to candidacy by forwarding its recommendation to the Department Graduate Advisor. This should occur at end of second semester after admission. Upon approval by the College's Associate Dean or designee, the student will attain Master's Candidate status.

Requirements for the Master of Science in Biology

In addition to the general University requirements stated previously in this catalog, the student must meet the following requirements before receiving the degree of Master of Science in Biology. The requirements are:

1. Advancement to Master's Candidate status (see above);
2. Maintenance of a 3.00 ("B" average) or better, overall GPA (includes all upper-division and graduate level courses taken since admission to this University and after completion of the baccalaureate degree) and graduate program GPA. If either GPA falls below 3.00, it must be elevated to a 3.00 by the end of the following semester or the student will be dismissed from the M.S. program in Biology;
3. Successful completion of the following: written thesis and public defense followed by a private defense with the Thesis Committee; and
4. Service as a Teaching Assistant or Graduate Assistant. Under some circumstances, this requirement may be waived.

Requests to graduate must be received by Enrollment Services approximately 6 months in advance of the expected graduation date (Check the Schedule of Classes for the date).

These degree requirements must be completed within 7 years from when the first course on the Program of Study was completed, including academic leaves, or the student's degree program will be terminated.

Master of Science in Microbiology

This degree is available to qualified students preparing for professional careers in industry and government and for further studies at the doctoral level. In addition, a master's degree in microbiology, combined with appropriate courses in education, can be utilized for a community college teaching credential. This degree requires a thesis based on original scientific research; a list of research areas with the names of faculty specializing in these areas can be obtained from the department's website.

Admission to the Department

Prerequisites

In addition to the prerequisites for entrance into CSULB as a graduate student, stated previously in this catalog under Graduate Degrees and Post Baccalaureate Studies, the Department of Biological Sciences requires:

1. A faculty member in the department must agree to serve as the thesis advisor for the student prior to her/his acceptance into the M.S. program;
2. A bachelor's degree in the biological or related sciences

from an accredited institution. Students with alternative undergraduate degrees will be considered, but they will likely be assigned deficiency courses by the Thesis Advisor in consultation with the Graduate Advisor;

3. An undergraduate GPA in all completed science and mathematics courses of at least 2.70 OR a GPA of at least 3.00 in the last 40 semester (60 quarter) units of science and mathematics courses completed;
4. The GRE General Test must have been taken prior to applying to the Department. The applicant should score in the 50th percentile or better in Verbal and Quantitative sections. If either the GRE Verbal or Quantitative score (but not both) is below the 50th percentile, the student may be considered for acceptance if their respective undergraduate grades in English or Math are a B average or better. The GRE must have been taken within five years prior to the intended admission date.
5. Applicants without a degree within a field of the biological sciences must also take the GRE Biology or Biochemistry, Cell and Molecular Biology Subject Test. A score of 50th percentile or better on the GRE Subject Test in Biology, or Biochemistry, Cell and Molecular Biology must be achieved.

Students who do not meet the minimum required criteria for acceptance are encouraged to take post-baccalaureate courses to bring up their GPA or GRE scores.

Application

Prospective graduate students in M.S. in Microbiology, including CSULB graduates, must formally apply for admission to CSULB as described previously in this catalog and must also apply directly to the Department of Biological Sciences. All applicants must submit the following documents directly to the Department by the deadline as seen on the Graduate Advising home page (<http://web.csulb.edu/divisions/aa/grad/advising/>) for the fall semester to receive consideration for admission:

1. Departmental Application Form, also available from the Department's Graduate Office;
2. A one page essay describing why the applicant wishes to obtain an M.S. degree in Microbiology at CSULB and how this relates to her/his career objectives;
3. Unofficial transcripts of all college level academic work, including those completed at CSULB (these are in addition to those transcripts required for general graduate admission to CSULB);
4. Three letters of recommendation from persons familiar with the applicant's academic performance, as well as research and teaching potential; and
5. Official report of the GRE General Test scores. The applicant should have taken this examination prior to applying to the Department, because the official scores must reach the Department by the deadline above.

These materials must be submitted to the Graduate Office, Department of Biological Sciences, California State University, Long Beach, 1250 Bellflower Blvd., Long Beach, CA 90840-9502.

Review by the Graduate Studies Committee

The Graduate Studies Committee will review all completed applications received by the deadlines. Admission into the M.S. Program in Microbiology is competitive, with an applicant's college GPA, GRE Test scores, one-page essay, and letters of recommendation weighed in the decision to accept or decline. Applicants who are admitted into the program will enter as a Classified Graduate Student, as described below.

Admission to the Department of Biological Sciences as a Classified Graduate Student

The Department of Biological Sciences may admit as a Classified Graduate Student any applicant who:

1. has met all prerequisites,
2. has a complete application folder, and
3. has obtained acceptance by a faculty member to serve as her/his Thesis Advisor.

The Thesis Proposal

After admission to the Department as a Classified Graduate Student, the student in consultation with the Thesis Advisor, must prepare her/his Thesis Proposal and Program of Study, which includes all coursework to be taken. The Thesis Proposal must include a thorough review of relevant primary literature that demonstrates the context of the proposed research, it must clearly define the experiments proposed for the research to be undertaken, and should include preliminary data, if available. The student and her/his Thesis Advisor will select at least two additional members to serve on the Thesis Committee. In most cases, the Thesis Advisor will serve as Chair of the Thesis Committee. However, if the Thesis Advisor is not eligible, another member of the Thesis Committee will serve as Thesis Committee Chair. The student will then have a formal meeting with the Thesis Committee, at which the student's Thesis Proposal and Program of Study will be presented and evaluated. At this meeting, the Thesis Committee will question the student about her/his Thesis Proposal. At the completion of this meeting, the Thesis Committee will meet briefly, without the student present, to evaluate the Thesis Proposal. Approval is based on whether the student has demonstrated a solid understanding of her/his thesis project. The Thesis Proposal must be prepared, presented to, and approved by the Thesis Committee before the end of the second semester after admission to the Department. Failure to meet this requirement will result in dismissal from the M.S. in Microbiology program. (Note: In order to satisfy the culminating activity requirement (thesis, project, or comprehensive examination dependent upon the program), students must earn at least three (3) units and no more than six (6) units related to the completion of the culminating activity.

The Program of Study

The Program of Study must include completion of a minimum of 30 semester units. At least 21 of these units must be in the 500-600 level courses. If not taken previously, BIOL 371 or an upper division/graduate course in genetics, and BIOL 471 or an upper division/graduate course in cell physiology are required courses for your Program of Study. The rest of your required courses for

your Program of Study include: BIOL 580 (1 unit), BIOL 661 (two enrollments with different topics for a total of 4 units is required), or BIOL 661 and BIOL 663; BIOL 696A (3 units), BIOL 696B (3 units), BIOL 697 (maximum 3 units); and BIOL 698 (6 units). Other elective units included in the graduate program must be 400-600 level courses acceptable to the University and microbiology degree program, no more than nine may come from transfer credit. Up to 5 units of 300-level courses may be included with an approval from the Thesis Chair and Graduate Advisor. BIOL 696A will be taken during the student's initial fall semester; the course will cover experimental design, statistics, and literature research, and help students in preparing their Thesis Proposal. BIOL 696B will be taken during the first spring semester in the program, and will cover both oral and written scientific presentation. BIOL 696B is intended to facilitate manuscript and thesis writing and to help students learn to articulate their findings for their thesis defense.

Advancement to Candidacy

In addition to the general university requirements stated previously under Post-Baccalaureate and Graduate Degrees in this catalog, the student must complete the following steps before receiving Candidate status in the Department of Biological Sciences:

1. Admission to the Department of Biological Sciences' Master's Degree program as a Classified Graduate Student (see above);
2. Acceptance of the Thesis Proposal and Program of Study by the Thesis Committee;
3. Satisfactory academic progress;
4. Satisfactory fulfillment of the Graduate Writing Assessment Requirement (GWAR).

The Thesis Committee will recommend the student for advancement to candidacy by forwarding its recommendation to the department Graduate Advisor. This should occur at end of second semester after admission. Upon approval by the College's Associate Dean or designee, the student will attain Master's Candidate status.

Requirements for the Master of Science in Microbiology

In addition to the general University requirements stated previously in this catalog, the student must meet the following requirements before receiving the degree of Master of Science in Microbiology. The requirements are:

1. Advancement to Master's Candidate status (see above);
2. Maintenance of a 3.00 ("B" average) or better, overall GPA (includes all upper-division and graduate level courses taken since admission to this University and after completion of the baccalaureate degree) and graduate program GPA. If either GPA falls below 3.00, it must be elevated to a 3.00 by the end of the following semester or the student will be dropped from the M.S. in Microbiology program;
3. Successful completion of the following: written thesis and public defense followed by a private defense with the Thesis Committee; and
4. Service as a Teaching Associate or Graduate Assistant. Under some circumstances, this requirement may be waived.

Requests to graduate must be received by Enrollment Services approximately 6 months in advance of the expected graduation date (check the *Schedule of Classes* for the date).

These degree requirements must be completed within 7 years from when the first course on the Program of Study was completed, including academic leaves, or the student's degree program will be terminated.

Single Subject Teaching Credential in Biology

For information, refer to the undergraduate section in this department..

Biology Courses (BIOL)

Students pursuing a major and/or a minor in this department may receive unit credit for courses marked with the symbol '##' as a general elective but may not apply the units toward the specific or elective requirements for any degree or option in this department. Majors in this department may, however, take, for general education purposes, interdisciplinary courses offered by this department. All other courses in this department are open to majors and minors but by letter grade only (A-F).

LOWER DIVISION

100.## Biology of the Human Environment (3)

Prerequisite/Corequisite: One GE Foundation course.

Biological perspective on the interaction between humans and their environment. Specifically designed for non-science majors.

(Lecture 3 hrs.)

101. Introduction to Human Disease (3)

Prerequisite/Corequisite: Course that fulfills the A.1 GE requirement.

Introduction to the study of human disease including moral/ethical and economic issues.

(Lecture 3 hrs.) Not open for credit to students with credit in MICR 101.

153. Introduction to Marine Biology (3)

Prerequisites/Corequisites: Courses that fulfill the A.1 and B.2 GE requirements.

Scientific approach to the study of marine organisms and their relationships to the environment. Emphasis on human interaction with marine ecosystems.

(Lecture 2 hrs., laboratory and field 3 hrs.) Field trips may be required outside of scheduled class time.

153L. Introduction to Marine Biology Laboratory (1)

Prerequisite: Open only to students who have successfully completed the equivalent of the lecture portion of BIOL 153 at another accredited institution and have consent of the Department of Biological Sciences.

Identical to the laboratory portion of BIOL 153. Students enrolled in BIOL 153L will take it in the same room and at the same time as students enrolled in BIOL 153. Not open for credit to students with credit in BIOL 153. (Laboratory 3 hrs.)

200.## General Biology (4)

Prerequisite: GE Foundation requirements.

Brief survey of major areas of biology including cell biology, genetics, evolution, phylogeny, plant and animal anatomy and physiology, ecology, and behavior. Specially designed for non-science majors.

Course fee may be required. (Lecture 3 hrs., laboratory 3 hrs.)

200L.## General Biology Laboratory (1)

Prerequisite: Open only to students who have successfully completed the equivalent of the lecture portion of BIOL 200 at another accredited institution and have consent of the Department of Biological Sciences.

BIOL 200L is identical to the laboratory component of BIOL 200. Students enrolled in BIOL 200L will take it in the same room and at the same time as students enrolled in BIOL 200.

Not open for credit to students with credit in BIOL 200. Course fee may be required. (Laboratory 3 hrs.)

201. General Microbiology for Health Professionals (4)

Prerequisites: CHEM 111A or CHEM 140 with a grade of "C" or better and GE Foundation requirements.

Microbiology for those planning careers in nursing, health care and education, and foods and nutrition. Introduction to microorganisms, including structure, function, metabolism, growth, genetics, diversity, and applied aspects. Special emphasis on human health.

Not open for credit to majors in the biological sciences. (Lecture 2 hrs., laboratory 6 hrs.) Course fee may be required. Not open for credit to students with credit in MICR 200.

205.## Human Biology (4)

Prerequisites: GE Foundation requirements.

Brief survey of human biology focusing on anatomy, physiology, and development of cells, tissues, organs, and organ systems; including molecular biology, genetics, ecology, evolution, and diversity. Specially designed for non-science majors.

Course fee may be required. (Lecture 3 hrs., laboratory 3 hrs.)

205L.## Human Biology Laboratory (1)

Prerequisites: Open only to students who have successfully completed the equivalent of the lecture portion of BIOL 205 at another accredited institution and have consent of the Department of Biological Sciences. Identical to the laboratory portion of BIOL 205. Students enrolled in BIOL 205L will take it in the same room and at the same time as students enrolled in BIOL 205.

Not open for credit to students with credit in BIOL 205. Course fee may be required. (Laboratory 3 hrs.)

207.## Human Physiology (4)

Prerequisites: GE Foundation requirements.

General introduction to the functional integration of human body systems. Designed for majors in biomedical engineering, physical education, and the allied health fields.

(Lecture 3 hrs., laboratory 3 hrs.) Course fee may be required.

208.## Human Anatomy (4)

Prerequisites: Grade of "C" or better in one of the following: ART 372, BIOL 201, BIOL 205, BIOL 207, BIOL 212, BIOL 311, CHEM 140, DANC 261, or MICR 200.

Gross anatomy of humans from the cellular to the systemic levels. Intensive laboratory experience including the use of human cadavers. Designed for majors in kinesiology and the allied health fields. (Lecture 3 hrs., laboratory 3 hrs.) Course fee may be required.

211. Introduction to Evolution and Diversity (4)

Prerequisite/Corequisite: CHEM 111A with a grade of "C" or better.

Intended for natural science majors. First of three semester introductory sequence. Evolution as a process responsible for biological diversity at all levels: molecular, cellular, organismal, population, and community. Phylogenetic and taxonomic survey of life. Science as method of inquiry. Failure of either the lecture or the laboratory component will result in a failing grade for the entire course.

Letter grade only (A-F). (Lecture 3 hrs., laboratory 3 hrs.) Course

fee may be required.

211L. Introduction to Evolution and Diversity Laboratory (1)

Prerequisites: Open only to students who have successfully completed the equivalent of the lecture component of BIOL 211 at another accredited institution and have consent of the Department of Biological Sciences.

Phylogenetic and taxonomic survey of life emphasizing the principles of evolution and science as a method of inquiry. Identical to the laboratory component of BIOL 211. Students enrolled in BIOL 211L will take it in the same room and at the same time as students enrolled in BIOL 211. Letter grade only (A-F). (Laboratory 3 hrs.) Course fee may be required.

212. Introduction to Cell and Molecular Biology (4)

Prerequisites: BIOL 211, CHEM 111A with grades of "C" or better.

Prerequisite/Corequisite: CHEM 111B.

The second of a three semester introductory sequence. Introduction to macromolecular and cellular structure and function and to fundamental genetic principles. Failure of either the lecture or laboratory component will result in a failing grade for the entire course. Letter grade only (A-F). (Lecture 3 hrs., laboratory 3hrs.) Course fee may be required.

212L. Introduction to Cell and Molecular Biology Laboratory (1)

Prerequisites: Open only to students who have successfully completed the equivalent of the lecture component of BIOL 212 at another institution and have consent of the Department of Biological Sciences.

Introduction to methods for studying macromolecular and cellular structure and function and fundamental genetic analyses. Identical to the laboratory component of BIOL 212. Students enrolled in BIOL 212L will take it in the same room and at the same time as students enrolled in BIOL 212.

Letter grade only (A-F). (Laboratory 3 hrs.) Course fee may be required.

213. Introduction to Ecology and Physiology (4)

Prerequisites: BIOL 211, 212, CHEM 111B, each with a grade of "C" or better.

Introduction to the structure and function of organ systems across a variety of taxa, and the ecological interactions among organisms and their environment. Failure of either the lecture or the laboratory component will result in failing grade for the entire course.

Letter grade only (A-F). (Lecture 3 hrs., laboratory 3 hrs.) Course fee may be required.

213L. Introduction to Ecology and Physiology Laboratory (1)

Prerequisites: Open only to students who have successfully completed the equivalent of the lecture component of BIOL 213 at another institution and have consent of the Department of Biological Sciences.

Introduction to methods for studying plant and animal structure and function and the interactions among organisms and their environments. Identical to the laboratory component of BIOL 213. Students enrolled in BIOL 213L will take it in the same room and at the same time as students enrolled in BIOL 213.

Letter grade only (A-F). (Laboratory 3 hrs.) Course fee may be required.

260. Biostatistics (3)

Prerequisites: BIOL 201 or BIOL 211 or BIOL 207 or MICR 200; MATH 111 or MATH 113 or MATH 119A or MATH 122 all with a grade of "C" or better.

Probability and statistics used in the description and analysis of biological data.

Letter grade only (A-F). (Lecture 2 hrs., laboratory 3 hrs.) Course fee may be required.

296. Introduction to Undergraduate Directed Research (1)

Prerequisite: Consent of instructor.

Introduction to research in biology approved and directed by a faculty member in the Department of Biological Sciences. Designed primarily to introduce lower division students to research before taking BIOL 496.

Credit/No Credit only. May be repeated to a maximum of 3 units in different semesters. Same course as MICR 296. Not open for credit to students with credit in MICR 296. Students who have completed one or more units of BIOL/MICR 496 may not enroll in this course. (Conference 1 hr., laboratory 3 hrs.)

UPPER DIVISION

300. Human Immunology: In Self-Defense (3)

Prerequisites: GE Foundation requirements, one or more Explorations courses, and upper-division standing; one laboratory course in a life science. Introductory psychology and a laboratory course in a physical science recommended.

Mechanisms and cells responsible for protecting human body from disease. Normal functions of immune system, diseases involving immune system, and psychological, endocrine and age factors affecting immune system included. Impact of immunology or organ transplantation, immunotherapy, and biotechnology discussed.

Not applicable for credit toward the major in Microbiology. (Lecture 3 hrs.) Not open for credit to students with credit in MICR 300.

301.## Biology of Human Aging (3)

Prerequisites: BIOL 200 or BIOL 205 or BIOL 207 all with a grade of "C" or better.

Biological processes associated with aging in humans. Emphasis on both cellular and organ aging.

Specifically designed for the gerontology program. Not open to students with "C" or better in BIOL 401. (Lecture 3 hrs.)

304.## Pathophysiology (3)

Prerequisites: BIOL 201 or MICR 200, BIOL 207, BIOL 208; CHEM 140 all with a grade of "C" or better.

Pathogenesis and pathophysiology of common disorders of human nervous, musculoskeletal, endocrine, cardiovascular, respiratory, excretory, digestive, and reproductive systems with emphasis on the physiological basis of the disease process and clinical correlations.

Not designed for majors in the College of Natural Sciences and Mathematics. Priority registration given to students who have been accepted into CSULB nursing programs.

(Lecture 3 hrs.)

305.## Pharmacology (2)

Prerequisite/Corequisite: BIOL 304, with a grade of "C" or better.

Systematic study of drugs, their classification, methods and routes of administration, therapeutic and toxic effects with emphasis on nursing implications.

Not designed for majors in the College of Natural Sciences and Mathematics. Not open for credit to students with a "C" or better in BIOL 204. Priority registration given to students who have been accepted into CSULB nursing programs. (Lecture 2 hrs.)

311. General Microbiology (4)

Prerequisites: BIOL 211, BIOL 212; CHEM 111B, all with a grade of "C" or better.

Introduction to biology of microorganisms, including structure, function, metabolism, growth, genetics, diversity, host-parasite relationships, and applied aspects.

Letter grade only (A-F). (Lecture 2 hrs., laboratory 6 hrs.) Course fee may be required. Not open for credit to students with credit in MICR 211.

312. Evolutionary Biology (3)

Prerequisites: BIOL 211, BIOL 212, BIOL 213, BIOL 260 all with a grade of "C" or better.

Survey of evolutionary biology including population genetics, speciation, origin of life, and phylogenetic analysis. Main emphasis is evolutionary mechanisms and methods of analysis on specific of the evolutionary history of life.

Letter grade only (A-F). (Lecture 3 hrs.)

313. Invertebrate Zoology (4)

Prerequisites: BIOL 211, BIOL 212, BIOL 213 all with a grade of "C" or better, and consent of instructor.

Systematics, morphology, and natural history of invertebrate animals, with emphasis on local marine forms.

Letter grade only (A-F). (Lecture 2 hrs., laboratory and field 6 hrs.; weekend field trips may be required.) Course fee may be required.

316. General Entomology (4)

Prerequisites: BIOL 211, BIOL 212, BIOL 213 all with grade of "C" or better.

Characteristics, structure, habits, and life cycles of insects; importance of insects to humans and other organisms.

Letter grade only (A-F). (Lecture 2 hrs., laboratory 6 hrs.) Course fee may be required.

320. Bacterial Pathogenesis (3)

Prerequisite: BIOL 311 or MICR 211 with a grade of "C" or better. Recommended: BIOL 320L.

Nature of host-pathogen interactions in health and disease. Emphasis upon pathogenic bacteria of humans and animals; topics include bacterial ultrastructure, epidemiology, and mechanisms of pathogenesis, host defense mechanisms, and antibiotic therapy.

Letter grade only (A-F). (Lecture 3 hrs.) Not open for credit to students with credit in MICR 320.

320L. Bacterial Pathogenesis Laboratory (2)

Prerequisite: BIOL 311 or MICR 211 or BIOL 212, with a grade of "C" or better. Not open for credit to students with credit in MICR 320L.

Diagnosis of bacterial infections and experimental examination of bacterial pathogenic mechanisms and host defenses using classical and modern techniques including immunofluorescence microscopy, enzyme immunoassay, flow cytometry, mammalian cell culture, phagocytosis, and phagocytic killing assay.

Letter grade only (A-F). (Laboratory 6 hrs) Course fee may be required.

322. Medical Mycology/Parasitology (4)

Prerequisites: BIOL 211, BIOL 212; BIOL 320 or MICR 320, all with a grade of "C" or better.

Survey of parasitic protozoa, helminthes, and fungi of humans; emphasis on identification of fresh and preserved specimens, pathogenesis, host-parasite interactions, epidemiology, prevention, and control.

Letter grade only (A-F). (Lecture 3 hrs., laboratory 6 hrs.) Course fee may be required. Not open for credit to students with credit in MICR 322.

324. Vertebrate Zoology (4)

Prerequisites: BIOL 211, BIOL 212, BIOL 213 all with grade of "C" or better.

Phylogenetic survey of vertebrates (craniates). Lecture concentrates on origin and radiation of vertebrates and their functional morphology. Laboratory concentrates on skeletal and internal anatomy and taxonomy to the ordinal and familial level of living vertebrates.

Letter grade only (A-F). (Lecture 2 hrs., laboratory 6 hrs.) Course fee may be required.

325. Emerging Infectious Diseases (3)

Prerequisites: BIOL 311 or MICR 211 with a grade of "C" or better and consent of instructor.

Explores changes in technology, infectious disease organisms and other factors contributing to emerging and re-emerging infectious diseases, including immunodeficiency, antibiotic and insecticide abuses, climate change, travel and commerce, human demographic and behavioral changes, land use, and breakdown of public health.

Letter grade only (A-F). (Lecture 3 hrs.) Not open for credit to students with credit in MICR 325.

340. Molecular Cell Biology (3)

Prerequisites: BIOL 211, BIOL 212, all with a grade of "C" or better.

Detailed study of the organization and functioning of cells and cellular organelles at the molecular level; emphasis on experimental approaches and structural/functional relationships.

Letter grade only (A-F). (Lecture 3 hrs.)

341. Physiology for Therapists I (4)

Prerequisites: BIOL 211, BIOL 212, BIOL 213; CHEM 111A,B; PHYS 100A,B all with grade of "C" or better; 100 hours of documented exposure to the practice of physical therapy in a variety of settings; and consent of instructor.

Mechanisms of action and interaction of physiological body systems with emphasis on nervous and endocrine systems and skeletal and smooth muscle. Pathological and clinical considerations presented.

Letter grade only (A-F). Course fee may be required. (Lecture 3 hrs., laboratory 3 hrs.)

342. Human/Mammalian Physiology (3)

Prerequisites: BIOL 211, BIOL 212, BIOL 213 all with grade of "C" or better.

Function of various mammalian body systems, primarily of humans. Emphasis on integration of homeostatic mechanisms of nervous, muscular, endocrine, cardiovascular, respiratory, renal, digestive, and reproductive systems.

Letter grade only (A-F). (Lecture 3 hrs.). Not open for credit to students with credit in BIOL 345.

342L. Laboratory in Human/Mammalian Physiology (1)

Prerequisite/Corequisite: BIOL 342 with a grade of "C" or better.

Experiments and exercises designed to provide experience in, and illustration of, physiological principles and mechanisms of interaction among various body systems.

Letter grade only (A-F). Course fee may be required. (Laboratory 3 hrs.) Not open for credit to students with credit in BIOL 345L.

345. Comparative Animal Physiology (3)

Prerequisites: BIOL 211, BIOL 212, BIOL 213 all with grade of "C" or better.

Comparison of fundamental physiological processes of major animal phyla.

Letter grade only (A-F). (Lecture 3 hrs.) Not open for credit to students with credit in BIOL 342.

345L. Laboratory in Comparative Animal Physiology (1)

Prerequisite/Corequisite: BIOL 345 with a grade of "C" or better.

Laboratory course acquaints students with direct observation and measurement of physiological processes in various animal groups, both invertebrate and vertebrate.

Letter grade only (A-F). Course fee may be required. (Laboratory 3 hrs.) Not open for credit to students with credit in BIOL 342L.

350. General Ecology (3)

Prerequisites: BIOL 211, BIOL 212, BIOL 213, BIOL 260; MATH 119A or MATH 122 all with a grade of "C" or better.

Relationships of plants and animals to their physical and biological environment; structure and function of populations, communities and ecosystems.

Letter grade only (A-F). (Lecture 3 hrs.)

353. Marine Biology (3)

Prerequisites: BIOL 153, BIOL 211, BIOL 212, BIOL 213, BIOL 260 all with grade of "C" or better.

Study of pelagic and benthic marine ecosystems, including food resources, mariculture, and pollution. Weekend field trips may be required.

Letter grade only (A-F). (Lecture 2 hrs., laboratory and field 3 hrs.) Course fee may be required.

355. Microbial Ecology (3)

Prerequisites: BIOL 311 or MICR 211, or BIOL 211, BIOL 212, BIOL 213; BIOL 260, all with a grade of "C" or better.

Explores relationships of microorganisms to their environment. Emphasis placed on ecological basis for diversity of prokaryotic forms, metabolic functions and community interactions.

Letter grade only (A-F). Not open for credit to student with credit in MICR 355. (Lecture 3 hrs.)

355L. Microbial Ecology Laboratory (2)

Prerequisite/Corequisite: BIOL 355 or MICR 355.

Provides an understanding of microbes in the environment. Sample and analyze microbes from field trips to different habitats. Analytical techniques learned include enrichment culture methods and modern molecular biology methods to study the diversity and community dynamics of microbes.

Letter grade only (A-F). Course fee may be required. Not open for credit to student with credit in MICR 355L. (Laboratory 6 hrs.)

370. General Genetics (4)

Prerequisites: BIOL 211, BIOL 212 and either BIOL 260 or CHEM 251 all with a grade of "C" or better.

Detailed study of classical transmission genetics and introduction to modern molecular genetics. Includes current observations and concepts of nature, organization, function, and regulation of genetic expression.

Letter grade only (A-F). (Lecture 3 hrs., laboratory 3 hrs.) Course fee may be required.

371. Microbial Genetics (3)

Prerequisite: BIOL 311 or MICR 211 with a grade of "C" or better.

Genetic analysis of biological processes in microbes. Includes gene structure, regulation, and function; isolation/analysis of mutations in haploid/diploid organisms; gene function from mutants; genetic exchange; regulation of host-pathogen interactions; bacteriophages; cloned genes; and genomics.

Letter grade only (A-F). (Lecture 3 hrs.) Not open for credit to students with credit in MICR 371.

372. Methods in Microbial Genetics (2)

Prerequisite: BIOL 311 or MICR 211 with a grade of "C" or better. Recommended: BIOL 371.

Laboratory study of microbial genetics, using classical (non-molecular) and contemporary (molecular) approaches. Includes genetic engineering techniques; microbial genomics.

Not open for credit to students with credit in MICR 451. Letter grade only (A-F). (Laboratory 6 hrs.) Course fee may be required.

Not open for credit to students with credit in MICR 372.

411./511. Marine Mammalogy (3)

Prerequisites: BIOL 345, BIOL 350, and BIOL 353, all with grade of "C" or better, and consent of instructor. (Undergraduates enroll in BIOL 411; graduates enroll in BIOL 511.)

Fundamental biological, ecological, and physiological concepts of marine mammals, including cetaceans, pinnipeds, walruses, sirenians, and polar bears. Information concerning taxonomy, distribution, morphology, physiology, reproduction, and feeding through readings and scientific literature.

Fieldtrips may include weekends and spring recess. Letter grade only (A-F). (Lecture 2 hrs., laboratory and fieldtrips 3 hrs.)

412. Advanced Evolutionary Biology (3)

Prerequisite: BIOL 312 with a grade of "C" or better.

A Writing Intensive Capstone. An advanced survey of topics in evolutionary biology including population and quantitative genetics, allometry, game theory, evolutionary psychology, and evolutionary-developmental biology. Main emphasis on the development of conceptual and mathematical models. Weekly writing assignments and editing.

Letter grade only (A-F). (Lecture 3 hrs.)

415./515. Marine Microbiology (3)

Prerequisite: BIOL 353 or MICR 355 or BIOL 355 with a grade of "C" or better. (Undergraduates enroll in BIOL 415; graduates enroll in BIOL 515.)

Designed to familiarize microbiology and marine biology students with the role of microorganisms in the marine environment. Topics will include ecology, physiology, biogeochemistry and diversity of marine microbes. Laboratory/field component will emphasize examination and cultivation of local marine microbes.

Letter grade only (A-F). Not open for credit to students with credit in MICR 415. Course fee may be required. (Lecture 2 hrs., laboratory and field 3 hrs., weekend field trip may be required.)

416./516. Virology (3)

Prerequisite: BIOL 320 or MICR 320 or BIOL 340 with a grade of "C" or better. (Undergraduates enroll in BIOL 416; graduates enroll in BIOL 516.)

Virology at molecular level including viral replication and molecular basis for viral pathogenesis; survey of human, animal, and plant viral diseases. Current trends for prevention and treatment of viral diseases.

Letter grade only (A-F). Not open for credit to students with credit in MICR 416. (Lecture 3 hrs.)

419. Ichthyology (3)

Prerequisites: BIOL 211, BIOL 212, BIOL 213, BIOL 260 and at least 6 additional units of upper division biological science, all with a grade of "C" or better.

Recommended: BIOL 350, BIOL 353, and BIOL 370.

Systematics, morphology, genetics, and ecology of fishes. Emphasis on local marine forms.

Letter grade only (A-F). (Lecture 2 hrs., laboratory 3 hrs., weekend field trips may be required.) Course fee may be required.

420./520. Fisheries Ecology and Conservation (3)

Prerequisites: BIOL 260, BIOL 350, 353, and 419, all with grade of "C" or better. (Undergraduates enroll in BIOL 420; graduates enroll in BIOL 520.)

Advanced aspects of fish and invertebrate biology and behavior; fisheries economics and conservation; emphasis on state-of-art field/laboratory techniques and contemporary concepts and their application in fishery management.

Letter grade only (A-F). (Lecture 2 hrs., laboratory and field 3 hrs.)

421. Herpetology (3)

Prerequisites: BIOL 260, BIOL 350, and one additional upper division biology course, all with a grade of "C" or better. Recommended: BIOL 312, BIOL 324, or BIOL 370.

Taxonomy, natural history, ecology and distribution of amphibians and reptiles, emphasis on local forms. Weekend field trip required.

Letter grade only (A-F). (Lecture 2 hrs., laboratory and field 3 hrs.)

423. Mammalogy (3)

Prerequisites: At least one of BIOL 312, BIOL 324, or BIOL 350, with a grade of "C" or better.

Explores the biology and diversity of the world's living mammals. Lecture emphasizes radiation of orders; their morphology, physiology, evolutionary history, ecology and behavior. Laboratory emphasizes external and skeletal morphology of these same taxa, identification of California species, and a focus on techniques in mammalogy.

Letter grade only (A-F). (Lecture 2 hrs., laboratory 3 hrs.)

424./524. Ornithology (3)

Prerequisites: BIOL 211, BIOL 212, BIOL 213, BIOL 260 and three units of upper division BIOL, all with a grade of "C" or better. Recommended: BIOL 350. (Undergraduates enroll in BIOL 424; graduates enroll in BIOL 524.)

Ecology, morphology, physiology, behavior, and taxonomy of birds from an evolutionary perspective, also factors influencing recent increase in their extinction risk. Species identification techniques (emphasis on the local avifauna) and methods of surveying avian populations.

Letter grade only (A-F). (Lecture 2 hrs., laboratory/field 3 hrs.) Course fee may be required.

425. Phycology (4)

Prerequisite: BIOL 353 with a grade of "C" or better.

Taxonomy, phylogeny, and physiology of algae, including the physiological ecology of marine macroalgae; emphasis on local marine forms.

Letter grade only (A-F). (Lecture 3 hrs., laboratory and field 3 hrs.)

427. Vascular Plant Systematics (4)

Prerequisite: BIOL 312 or BIOL 370 with a grade of "C" or better.

Principles and methods of plant systematics, including phylogenetics, different types of systematic data, evolutionary history and diversification of vascular plants. Laboratory emphasizes retrieving and analyzing systematic data, using phylogenetic methods, and identifying vascular plants of Southern California.

Letter grade only (A-F). Course fee may be required. (Lecture 2 hrs., laboratory and field 6 hrs.)

429./529. Epidemiology of Infectious Diseases (3)

Prerequisites: BIOL 260; BIOL 320 or MICR 320, BIOL 322 or MICR 322; all of a grade of "C" or better. (Undergraduates enroll in BIOL 429; graduates enroll in BIOL 529.)

Principles of epidemiology and application to health; fundamentals of biomedical statistics; basic factors in classic epidemiological studies and prevention and control of infectious diseases.

Letter grade only (A-F). (Lecture 3 hrs.) Not open for credit to students with credit in MICR 429.

430. Immunology (3)

Prerequisite: BIOL 340 with a grade of "C" or better.

Study of cellular and molecular components of immune system, including how immune system recognizes pathogens, how it functions in various types of immune responses, mechanisms of vaccines, immunodeficiencies, transplantation, allergy, and autoimmunity.

Letter grade only (A-F). Not open for credit to students with credit in MICR 430. (Lecture 3 hrs.)

431./531. Biology of Cancer (3)

Prerequisites: BIOL 340, BIOL 370 with a grade of "C" or better. (Undergraduates enroll in BIOL 431, graduates enroll in BIOL 531.)

Examination of cancer, tumor progression, and treatment at the cellular, molecular, and genetic levels.

Letter grade only (A-F). (Lecture 3 hrs.)

432./532. Stem Cell Biology (3)

Prerequisites: BIOL 340 and 370 with a grade of "C" or better. (Undergraduates enroll in BIOL 432; graduates enroll in BIOL 532.)

Current literature on advances in stem cell research, translational research, and clinical applications of stem cells to alleviate human disease.

Letter grade only (A-F). (Lecture 3 hrs.)

432L./532L. Advanced Stem Cell Laboratory (4)

Prerequisites: BIOL 432/532, BIOL 440L, BIOL 462/562, BIOL 473/573, BIOL 477/577, all with a grade of "C" or better, and consent of the director of the CSULB Biotechnology Certificate Program. (Undergraduates enroll in BIOL 432L; graduates enroll in BIOL 532L.)

Intensive laboratory, offered during a 6-week summer session. Students learn basic and advanced stem cell culture techniques. The sixth week is 40 hours at the Children's Hospital of Orange County Research Institute (CHOC).

Letter grade only (A-F). (Lecture 1 hr., laboratory 9 hrs.)

433./533. Developmental Biology (3)

Prerequisites: BIOL 340; BIOL 370 or BIOL 371 or MICR 371, both with a grade of "C" or better. (Undergraduates enroll in BIOL 433; graduates enroll in BIOL 533.)

Experimental approaches to development in model organisms, mostly animal, at the molecular, genetic, cellular, and tissue levels. Topics include gametogenesis, fertilization, early cleavage, gastrulation, pattern formation, and organogenesis.

Letter grade only (A-F). (Lecture/discussion 3 hrs.)

434./534. Hematology (4)

Prerequisite: BIOL 340 with a grade of "C" or better. (Undergraduates enroll in BIOL 434; graduates enroll in BIOL 534.)

Study of blood and coagulation system. Normal cell structure and function and physiological and morphological changes in inflammation, leukemias, and anemias discussed. Clinical, diagnostic, and research techniques for observing blood and pathologic case-studies included.

Useful for students interested in medical professions. Required for clinical laboratory science (medical technology) internship. Letter grade only (A-F). (Lecture 3 hrs., laboratory 3 hrs.) Course fee may be required. Not open for credit to students with credit in MICR 423.

439. Plant Morphology (4)

Prerequisite: BIOL 312 or BIOL 370 with a grade of "C" or better.

A phylogenetic survey of green plant morphological diversity and analysis of the developmental and genetic mechanisms affecting this diversity. Emphasis in the laboratory is on documenting green plant morphological evolution, bioinformatics, and studying the developmental mechanisms driving morphological diversification.

Letter grade only (A-F). (Lecture 3 hrs., laboratory 3 hrs.) Course fee may be required.

440L. Molecular Cell Biology Laboratory (3)

Prerequisites: BIOL 340, BIOL 370, both with a grade of "C" or better.

Intensive course of modern laboratory techniques used in both cell and molecular biology. Topics include tissue culture, genomics, bioinformatics, proteomics, microscopy, and/or purification and functional characterization of recombinant proteins. Provides extensive laboratory experience for students.

Letter grade only (A-F). (Lecture 1 hr., laboratory 6 hrs.) Course fee may be required. Not open for credit to students with credit in BIOL

340L.

441. Physiology for Therapists II (3)

Prerequisite: BIOL 341 with a grade of "C" or better.

Mechanisms of action and interaction of physiological body systems with emphasis on cardiovascular, renal, and respiratory systems. Pathological and clinical considerations will be presented.

Letter grade only (A-F). (Lecture 3 hrs.)

442./542. Physiology at the Limit (3)

Prerequisites: BIOL 342 or BIOL 345 with a grade of "C" or better. (Undergraduates enroll in BIOL 442; graduates enroll in BIOL 542.)

Survey of biochemical and physiological adaptations of organisms under extreme environmental conditions or performance. Topics include adaptive responses to hypoxia, high-altitude, deep-sea diving, outer space, micro-gravity, exercise, flight, swimming, salt stress, and extreme temperatures. Examples from vertebrates and invertebrates.

Letter grade only (A-F). (Lecture 3 hrs.)

443./543. Endocrinology (3)

Prerequisites: BIOL 340; BIOL 342 or BIOL 345, all with a grade of "C" or better. (Undergraduates enroll in BIOL 443; graduates enroll in BIOL 543.)

Role of endocrines in vertebrate and invertebrate adjustment to changes in internal and external environment.

Letter grade only (A-F). (Lecture 3 hrs.)

444./544. Reproductive Biology (3)

Prerequisite: BIOL 342 or BIOL 345 with a grade of "C" or better. (Undergraduates enroll in BIOL 444; graduates enroll in BIOL 544.)

Topics in comparative reproductive biology from molecular, cellular, organismal, and population levels. Hormones and reproduction, gamete/gonad biology, reproductive lifespan, mating system/strategies, environmental influence on reproductive capabilities, contraception/*in vitro* fertilization. Scientific communication discussed including scientific articles and scientific writing.

Letter grade only (A-F). (Lecture 3 hrs.)

445./545. Metabolic Regulation (3)

Prerequisites: BIOL 340, BIOL 342 or BIOL 345; CHEM 441A with grade of "C" or better. (Undergraduates enroll in BIOL 445; graduates enroll in BIOL 545.)

Study of molecular mechanisms by which intermediary metabolism is regulated in various mammalian tissues with emphasis on mechanisms of hormone action and regulation of some key enzymes of carbohydrate, fat, and protein metabolism.

Letter grade only (A-F). (Lecture 3 hrs.)

447. Molecular Plant Physiology (3)

Prerequisites: BIOL 340, BIOL 370, both with grade of "C" or better.

A Writing Intensive Capstone. Molecular approaches to classical topics including water relations, plant development and photosynthesis. Weekly writing assignments and editing.

Letter grade only (A-F). (Lecture 3 hrs.)

448./548. Principles of Neurobiology (3)

Prerequisites: BIOL 340; BIOL 342 or BIOL 345, all with a grade of "C" or better. (Undergraduates enroll in BIOL 448; graduates enroll in BIOL 548.)

Study of the principles of anatomy, physiology, and function of the nervous system. Topics covered include neuroanatomy, physiology of neuronal signaling (excitable membranes and action potentials), synaptic transmission, neurotransmitters and their receptors, pain processing, special senses, reflexes, and neural circuits.

Letter grade only (A-F). (Lecture 3 hrs.)

449./549. Fish Physiology and Endocrinology (3)

Prerequisite: BIOL 345 with grade of "C" or better. (Undergraduates enroll in BIOL 449; graduates enroll in BIOL 549.)

Fundamentals of physiological systems and strategies in fishes, with emphasis on endocrine regulatory mechanisms. Adaptations in endocrine physiology of fishes considered from evolutionary and ecological perspectives. Impacts of human activities, particularly in context of Southern California's marine environment addressed.

Letter grade only (A-F). (Lecture 3 hrs.)

450./550. Plant Ecology (3)

Prerequisites: BIOL 260, BIOL 350 with a grade of "C" or better. Recommended: BIOL 427, BIOL 447. (Undergraduates enroll in BIOL 450; graduates enroll in BIOL 550.)

Relationship of plants to their environment and principles of plant distribution.

Letter grade only (A-F). (Lecture 2 hrs., laboratory and field 3 hrs.) Course fee may be required.

451./551. Wetlands and Mangrove Ecology (3)

Prerequisites: BIOL 260, BIOL 350 both with a grade of "C" or better. (Undergraduates enroll in BIOL 451; graduates enroll in BIOL 551.)

A comprehensive look at wetland ecology and management. Focuses on physical, biogeochemical, and ecological aspects of major wetland ecosystems with an emphasis on local urban wetlands. Also includes wetland management concepts and approaches worldwide.

Letter grade only (A-F). (Lecture 2 hrs., laboratory and field 3 hrs.)

452./552. Behavioral Ecology (3)

Prerequisites: BIOL 312 or BIOL 350. (Undergraduates enroll in BIOL 452; graduates enroll in BIOL 552.)

Primary objectives are to understand how animal behavior affects survival and reproduction and introduce students to current methodologies to study behavior of animals in lab and field conditions. Emphasizes ecological and evolutionary consequences of behavior across taxa.

Letter grade only (A-F). (Lecture 2 hrs., laboratory/field 3 hrs.)

454A./554A. Research in Tropical Marine Ecology (3)

Prerequisites: BIOL 350, BIOL 353, and one 400-level marine biology major course, all with grade of "C" or better, and consent of instructor. (Undergraduates enroll in BIOL 454A; graduates enroll in BIOL 554A.)

Field and laboratory studies, lectures, and individual research on tropical marine biological problems. Designed to engage students in experimental research, including: recognizing a problem, designing and carrying out a project, statistical data analysis, and oral and written report presentation.

Eight-day field trip to Hawaii required during spring recess at student expense. Enrollment is limited. Letter grade only (A-F). Course fee may be required. (Lecture 2 hrs., 8 day field trip.)

454B./554B. Research in Tropical Terrestrial Ecology (3)

Prerequisites: BIOL 350 with a grade of "C" or better; and consent of instructor. (Undergraduates enroll in BIOL 454B; graduates enroll in BIOL 554B.)

Field-based comparison of tropical lowland deciduous forest and lowland rainforest incorporating basic ecology methodology. Forest structure and diversity of animals emphasized. Students maintain field notebook, submit final paper, and give oral presentation.

Nine-day fieldtrip to Costa Rica required during spring recess at student expense. Enrollment is limited. Letter grade only (A-F). Course fee may be required. (Lecture 2 hr., 9 day field trip.)

455./555. Ecology of Marine Communities (3)

Prerequisites: BIOL 260, BIOL 350, BIOL 353 all with a grade of "C" or better. (Undergraduates enroll in BIOL 455; graduates enroll in BIOL 555.)

Field studies on ecological principles related to marine communities

discussed. Includes individual field research project and two class projects.

Letter grade only (A-F). (Lecture 2 hrs., field 3 hrs.)

456./556. Population Ecology (3)

Prerequisites: BIOL 350, MATH 119B or MATH 123 all with a grade of "C" or better. (Undergraduates enroll in BIOL 456; graduates in BIOL 556.)

Analysis of animal and plant populations characteristics: population growth and regulation, fluctuation and regulation, competition, predation, parasitism, and other intraspecific and interspecific interactions; spatial patterns.

Letter grade only (A-F). (Lecture 3 hrs.)

457./557. Field Methods in Ecology (3)

Prerequisites: BIOL 260, BIOL 350 both all with a grade of "C" or better. (Undergraduates enroll in BIOL 457; graduates in BIOL 557.)

Design of field research projects, collection, and data analysis, report writings and presentations. Field sampling techniques emphasized. Five weekend fieldtrips required.

Letter grade only (A-F). (Lecture 2 hrs., laboratory and field 3 hrs.)

459./559. Conservation Biology (3)

Prerequisites: BIOL 260, BIOL 350 both with a grade of "C" or better. Recommended: BIOL 370. (Undergraduates enroll in BIOL 459; graduates enroll in BIOL 559.)

Conservation biology concepts including population dynamics, extinction processes, population viability analyses, metapopulations, community-level interactions, island biogeography, biological diversity patterns, habitat fragmentation, reserve design, and landscape-level conservation. Lecture includes group discussions of case studies and relevant primary literature.

Letter grade only (A-F). (Lecture 3 hrs.) 20 hrs. per semester service learning for undergraduates, extra research paper for graduates.

462./562. Bioethics and Public Policy (3)

Prerequisite: BIOL 340 with a grade of "C" or better. (Undergraduates enroll in BIOL 462; graduates enroll in BIOL 562.)

History of bioethics, scientific and medical bases of key bioethical issues, current legislation and appropriations, including legal, social, and ethical implications of stem cell research and other biotechnological advances.

Letter grade only (A-F). (Lecture 3 hrs.)

463./563. Computer Modeling in Biology (4)

Prerequisites: BIOL 260, BIOL 350 both with a grade of "C" or better. (Undergraduates enroll in BIOL 463; graduates enroll in BIOL 563.)

History, modeling theory, different modeling approaches, theoretical, empirical and quantitative modeling. Laboratory uses modeling software and focuses on model construction and quantitative simulation. Applicable to ecology, microbiology, physiology, environmental sciences, etc.

Letter grade only (A-F). (Lecture 3 hrs., laboratory 3 hrs.) Course fee may be required.

464./564. Aquatic Toxicology (3)

Prerequisite: BIOL 211, BIOL 212, BIOL 213, BIOL 340; CHEM 220A or CHEM 227, all with a grade of "C" or better. Recommended: BIOL 353 and CHEM 448 or 441A,B. (Undergraduates enroll in BIOL 464; graduates enroll in BIOL 564.)

In depth study of interactions between anthropogenic chemicals and aquatic ecosystems, including origin, fate, chemical and biological detection, and quantification of pollutants and impact at molecular, biochemical, cellular, physiological, organismal, and community levels of organization. Individual research project required.

Letter grade only (A-F). (Lecture 3 hrs.)

465./565. Experimental Design and Regression Analysis (4)

Prerequisites: BIOL 260; MATH 119B or MATH 123; 6 units of upper division biological science all with a grade of "C" or better. (Undergraduates enroll in BIOL 465; graduates enroll in BIOL 565.)

Experimental design and data analysis techniques applied to problems in biology including analysis of variance and covariance, bivariate and multiple regression, experimental design, bootstrapping and randomization tests, and nonparametric statistics. Experience in analyzing biological data using computerized statistical packages.

Letter grade only (A-F). (Lecture 3 hrs., laboratory 3 hrs.)

466. Research Design and Methods (3)

Prerequisites: BIOL 211, BIOL 212, BIOL 213, either BIOL 260 or CHEM 251, CHEM 220A,B and CHEM 223A,B all with a grade of "C" or better; GE Foundation requirements; a GPA of at least 3.0 in the major; and consent of the instructor. At least one unit of BIOL 496 or CHEM 496.

Corequisites: At least one unit of BIOL 496 or CHEM 496.

Introduction to hypothesis testing, experimental design, methodological and technical procedures for experimentation, grant writing, and techniques for written and oral presentation of research results. Research paper and oral presentation required.

Letter grade only (A-F). Same course as CHEM 466. Not open for credit to students with credit in BIOL 466H or CHEM 466H. (Lecture 3 hours.)

467./567. Multivariate Data Analysis (4)

Prerequisites: BIOL 260; MATH 119B or MATH 123; 6 units of upper division biological science; all with a grade of "C" or better. (Undergraduates enroll in BIOL 467; graduates enroll in BIOL 567.)

Multivariate data analysis techniques applied to biological data. Applied matrix algebra for analyzing and understanding multivariate analysis. Includes principal components analysis, factor analysis, discriminant analysis, cluster analysis and current modern phylogenetic analysis techniques. Analyzing multivariate biological data using computerized statistical packages.

Letter grade only (A-F). (Lecture 3 hrs., laboratory 3 hrs.)

471./571. Bacterial Physiology (3) S

Prerequisites: BIOL 320 or MICR 320, CHEM 441A or CHEM 448; both with a grade of "C" or better. (Undergraduates enroll in BIOL 471; graduates enroll in BIOL 571.)

Cellular physiology at molecular level as related to bacterial growth, reproduction, nutrition, metabolism, and ecology.

Letter grade only (A-F). (Lecture 3 hrs.) Not open for credit to students with credit in MICR 471.

472./572. Molecular Evolution (3)

Prerequisite: BIOL 370 with a grade of "C" or better. Recommended: BIOL 312. (Undergraduates enroll in BIOL 472; graduates enroll in BIOL 572.)

Survey of molecular evolution including but not limited to the history of the field, protein and DNA evolution, neutral and nearly-neutral theory, molecular phylogenetics, molecular population genetics and DNA fingerprinting, genomics, and proteomics. Applicable to ecological, evolutionary, medical, forensic sciences.

Letter grade only (A-F). (Lecture 3 hrs.)

473./573. Molecular Genetics (3)

Prerequisites: BIOL 370 or BIOL 371 or MICR 371; CHEM 220A,B and CHEM 223A,B, or CHEM 227, all with a grade of "C" or better. (Undergraduates enroll in BIOL 473; graduates enroll in BIOL 573.)

Contemporary molecular genetic analysis of model organisms (mouse, worm, flies, yeasts) used in study of human disease, basic biological processes, gene regulation, and global analysis of genomes and proteomes.

Letter grade only (A-F). (Lecture 3 hrs.)

474./574. Bioinformatics (3)

Prerequisites: BIOL 260; BIOL 370 or BIOL 371 or MICR 371, all with a grade of "C" or better. (Undergraduates enroll in BIOL 474; graduates enroll in BIOL 574.)

Survey of biological sequences and prokaryotic genomes. Investigation of DNA, RNA, and protein sequences using statistics and computer science techniques. Computer-based laboratory will familiarize students with bioinformatics tools and programming. Letter grade only (A-F). (Lectures 2 hrs., laboratory 3 hrs.)

477./577. Biotechnology: Applications of Molecular Techniques and Bioinformatics (4)

Prerequisite: BIOL 340 or BIOL 370 or CHEM 441A,B; all with a grade of "C" or better. (Undergraduates enroll in BIOL 477; graduates enroll in BIOL 577.)

Theory and techniques for isolating, amplifying, and analyzing genes, genomes, transcripts, and proteins. Data-mining, the use of computers in experimental design and/or functional analysis, use of microarrays, and future of nanotechnology.

Letter grade only (A-F). Not open for credit to students with credit in MICR 477./577. (Lecture 3 hrs., activity 2 hrs.)

480./580. Seminars (1)

Prerequisites: Consent of Department of Biological Sciences. (Undergraduates and classified post-baccalaureates enroll in BIOL 480; graduates enroll in BIOL 580). Undergraduates must have filed for graduation and be in their last semester. Graduates must have been admitted to the department as a graduate student. Classified post-baccalaureates must have been admitted to a second baccalaureate or a certificate.

Weekly meetings with professional biologists presenting results of their research. Requires participation in organization and critical evaluation of these presentations.

(Seminar 1 hr.) Letter grade only (A-F). May not be repeated for credit towards any single degree.

490./590. Selected Topics in Biology (1-3)

Prerequisites: BIOL 211, BIOL 212, BIOL 213 all with a grade of "C" or better, and consent of instructor. (Undergraduates enroll in BIOL 490; graduates enroll in BIOL 590.)

Topics from selected areas of biology. Course content varies from section to section.

Letter grade only (A-F). May be repeated to a maximum of 6 units with different topics. Topics announced in the *Schedule of Classes*. (Lecture 1-3 hrs.)

490L./590L. Selected Topics in Biology, Laboratory (1-2)

Prerequisites: BIOL 211, BIOL 212, BIOL 213 all with a grade of "C" or better, and consent of instructor. (Undergraduates enroll in BIOL 490L; graduates enroll in BIOL 590L.)

Topics from selected areas of biology. Course content varies from section to section.

Letter grade only (A-F). May be repeated to a maximum of 4 units with different topics. Topics announced in the *Schedule of Classes*. (Laboratory 3 or 6 hrs.)

492A./592A. Stem Cell Research Internship (12)

Prerequisites: BIOL 432/532, BIOL 432L/532L, BIOL 440L, BIOL 462/562, BIOL 473/573, BIOL 477/577, all with a grade of "C" or better, and permission of the director of the CSULB Biotechnology Certificate Program, and acceptance in the Stem Cell Training Option within the Biotechnology Certificate. (Undergraduates enroll in BIOL 492A; graduates enroll in BIOL 592A.)

CIRM-approved institutions train interns in their stem cell research laboratories.

Must be repeated once for credit. Credit/No Credit grading only. (Laboratory 36 hrs.)

495. Instruction in Laboratory Teaching (1-2)

Prerequisites: Consent of instructor, an "A" in the course in which the student elects to do BIOL 495 (another course with laboratory may be substituted with consent of instructor), and an overall GPA of at least 3.0.

Individual instruction in organization and techniques of teaching a biological sciences laboratory.

May be repeated to a maximum of 2 units in different semesters. Any units beyond the two taken for a letter grade in BIOL 495 or MICR 495 or any combination of the two will be taken credit/no credit.

Not open for credit to students with credit in MICR 495. (Conference 1 hr., laboratory 3 hrs. per unit.)

496. Undergraduate Directed Research (1-3)

Prerequisites: BIOL 211, 212; one of BIOL 213, BIOL 296, BIOL 311, MICR 211 or MICR 296; consent of instructor; and consent of appropriate undergraduate advisor.

Research in a specific topic in biological sciences approved and directed by a faculty member in Department of Biological Sciences.

May be repeated for a letter grade and degree credit to a maximum of three units for any single degree or option. Units beyond the three taken for a letter grade in MICR 496 or BIOL 496, or any combination of the two, will be taken credit/no credit.

Not open for credit to student with credit in MICR 496. Students may only have a total of 3 units of BIOL 496 and MICR 496 combined. Not available to graduate students.

GRADUATE LEVEL

511./411. Marine Mammalogy (3)

Prerequisites: BIOL 345, BIOL 350, and BIOL 353, all with grade of "C" or better, and consent of instructor. (Undergraduates enroll in BIOL 411; graduates enroll in BIOL 511.)

Fundamental biological, ecological, and physiological concepts of marine mammals, including cetaceans, pinnipeds, walrus, sirenians, and polar bears. Information concerning taxonomy, distribution, morphology, physiology, reproduction, and feeding through readings and scientific literature. Fieldtrips may include weekends and spring recess.

Letter grade only (A-F). (Lecture 2 hrs., lab and fieldtrips 3 hrs.)

515./415. Marine Microbiology (3)

Prerequisites: BIOL 353 or MICR 355 or BIOL 355 with a grade of "C" or better. (Undergraduates enroll in BIOL 415; graduates enroll in BIOL 515.)

Designed to familiarize microbiology and marine biology students with the role of microorganisms in the marine environment. Topics will include ecology, physiology, biogeochemistry and diversity of marine microbes. Laboratory/field component will emphasize examination and cultivation of local marine microbes.

Letter grade only (A-F). Course fee may be required. Not open for credit to students with credit in MICR 415 or 515. (Lecture 2 hrs., laboratory and field 3 hrs., weekend field trip may be required.)

516./416. Virology (3)

Prerequisites: BIOL 320 or MICR 320 or BIOL 340 with a grade of "C" or better. (Undergraduates enroll in BIOL 416; graduates enroll in BIOL 516.)

Virology at molecular level including viral replication and molecular basis for viral pathogenesis; survey of human, animal, and plant viral diseases. Current trends for prevention and treatment of viral diseases.

Letter grade only (A-F). Not open for credit to students with credit in MICR 416 or 516. (Lecture 3 hrs.)

520./420. Fisheries Ecology and Conservation (3)

Prerequisites: BIOL 260, BIOL 350, BIOL 353, and BIOL 419, all with grade of "C" or better. (Undergraduates enroll in BIOL 420; graduates enroll in BIOL 520.)

Advanced aspects of fish and invertebrate biology and behavior; fisheries economics and conservation; emphasis on state-of-art field/laboratory techniques and contemporary concepts and their application in fishery management.

Letter grade only (A-F). (Lecture 2 hrs., laboratory and field 3 hrs.)

524./424. Ornithology (3)

Prerequisites: BIOL 211, BIOL 212, BIOL 213, BIOL 260 and 3 units of upper division BIOL, all with a grade of "C" or better. Recommended: BIOL 350. (Undergraduates enroll in BIOL 424; graduates enroll in BIOL 524.)

Ecology, morphology, physiology, behavior, and taxonomy of birds from an evolutionary perspective, also factors influencing recent increase in their extinction risk. Species identification techniques (emphasis on the local avifauna) and methods of surveying avian populations.

Letter grade only (A-F). (Lecture 2 hrs., laboratory/field 3 hrs.) Course fee may be required.

529./429. Epidemiology of Infectious Diseases (3)

Prerequisites: BIOL 260; BIOL 320 or MICR 320, BIOL 322 or MICR 322; all of a grade of "C" or better. (Undergraduates enroll in BIOL 429; graduates enroll in BIOL 529.)

Principles of epidemiology and application to health; fundamentals of biomedical statistics; basic factors in classic epidemiological studies and prevention and control of infectious diseases.

Letter grade only (A-F). (Lecture 3 hrs.) Not open for credit to students with credit in MICR 529.

531./431. Biology of Cancer (3)

Prerequisites: BIOL 340, BIOL 370 with a grade of "C" or better. (Undergraduates enroll in BIOL 431, graduates enroll in BIOL 531.)

An examination of cancer, tumor progression, and treatment at the cellular, molecular, and genetic levels.

Letter grade only (A-F). (Lecture 3 hrs.)

532./432. Stem Cell Biology (3)

Prerequisites: BIOL 340 and 370 with a grade of "C" or better. (Undergraduates enroll in BIOL 432; graduates enroll in BIOL 532.)

Current literature on advances in stem cell research, translational research, and clinical applications of stem cells to alleviate human disease.

Letter grade only (A-F). (Lecture 3 hrs.)

532L./432L. Advanced Stem Cell Laboratory (4)

Prerequisites: BIOL 432/532, BIOL 440L, BIOL 462/562, BIOL 473/573, BIOL 477/577, all with a grade of "C" or better, and permission of the director of the CSULB Biotechnology Certificate Program. (Undergraduates enroll in BIOL 432L; graduates enroll in BIOL 532L.)

Intensive laboratory, offered during a 6-week summer session. Students learn basic and advanced stem cell culture techniques. The sixth week is 40 hours at the Children's Hospital of Orange County Research Institute (CHOC).

Letter grade only (A-F). (Lecture 1 hr., laboratory 9 hrs.)

533./433. Developmental Biology (3)

Prerequisites: BIOL 340; BIOL 370 or BIOL 371 or MICR 371, both with a grade of "C" or better. (Undergraduates enroll in BIOL 433; graduates enroll in BIOL 533.)

Experimental approaches to development in model organisms, mostly animal, at the molecular, genetic, cellular, and tissue levels. Topics include gametogenesis, fertilization, early cleavage, gastrulation, pattern formation, and organogenesis.

Letter grade only (A-F). (Lecture/discussion 3 hrs.)

534/434. Hematology (4)

Prerequisite: BIOL 340 with a grade of "C" or better. (Undergraduates enroll in BIOL 434; graduates enroll in BIOL 534.)

Study of blood and coagulation system. Normal cell structure and function and physiological and morphological changes in inflammation, leukemias, and anemias discussed. Clinical, diagnostic, and research techniques for observing blood and pathologic case studies included. Useful for students interested in medical professions. Required for clinical laboratory science (medical technology) internship.

Letter grade only (A-F). (Lecture 3 hrs., laboratory 3 hrs.) Course fee may be required. Not open for credit to students with credit in MICR 523.

540. Advanced Molecular Cell Biology and Physiology (3)

Prerequisites: Graduate standing and consent of instructor.

In depth discussion of cellular processes and their regulation and how they relate to organismal physiology. Includes critical reading and discussion of primary journal articles on pertinent topics.

Letter grade only (A-F). (Lecture 3 hrs.)

542./442. Physiology at the Limit (3)

Prerequisites: BIOL 342 or BIOL 345 with a grade of "C" or better. (Undergraduates enroll in BIOL 442; graduates enroll in BIOL 542.)

Survey of biochemical and physiological adaptations of organisms under extreme environmental conditions or performance. Topics include adaptive responses to hypoxia, high-altitude, deep-sea diving, outer space, micro-gravity, exercise, flight, swimming, salt stress, and extreme temperatures. Examples from vertebrates and invertebrates.

Letter grade only (A-F). (Lecture 3 hrs.)

543./443. Endocrinology (3)

Prerequisites: BIOL 340; BIOL 342 or BIOL 345, all with a grade of "C" or better. (Undergraduates enroll in BIOL 443; graduates enroll in BIOL 543.)

Role of endocrines in vertebrate and invertebrate adjustment to changes in internal and external environment.

Letter grade only (A-F). (Lecture 3 hrs.)

544./444. Reproductive Biology (3)

Prerequisites: BIOL 342 or BIOL 345 with a grade of "C" or better. (Undergraduates enroll in BIOL 444; graduates enroll in BIOL 544.)

Topics in comparative reproductive biology from molecular, cellular, organismal, and population levels. Hormones and reproduction, gamete/gonad biology, reproductive lifespan, mating system/strategies, environmental influence on reproductive capabilities, contraception/*in vitro* fertilization. Scientific communication discussed including scientific articles and scientific writing.

Letter grade only (A-F). (Lecture 3 hrs.)

545./445. Metabolic Regulation (3)

Prerequisites: BIOL 340, BIOL 342 or BIOL 345; CHEM 441A with grade of "C" or better. (Undergraduates enroll in BIOL 445; graduates enroll in BIOL 545.)

Study of molecular mechanisms by which intermediary metabolism is regulated in various mammalian tissues with emphasis on mechanisms of hormone action and regulation of some key enzymes of carbohydrate, fat, and protein metabolism.

Letter grade only (A-F). (Lecture 3 hrs.)

548./448. Principles of Neurobiology (3)

Prerequisites: BIOL 340; BIOL 342 or BIOL 345, all with a grade of "C" or better. (Undergraduates enroll in BIOL 448; graduates enroll in BIOL 548.)

Study of the principles of anatomy, physiology, and function of the nervous system. Topics covered include neuroanatomy, physiology of neuronal signaling (excitable membranes and action potentials), synaptic transmission, neurotransmitters and their receptors, pain

processing, special senses, reflexes, and neural circuits.

Letter grade only (A-F). (Lecture 3 hrs.)

549./449. Fish Physiology and Endocrinology (3)

Prerequisite: BIOL 345 with a grade of "C" or better. (Undergraduates enroll in BIOL 449; graduates enroll in BIOL 549.)

Fundamentals of physiological systems and strategies in fishes, with emphasis on endocrine regulatory mechanisms. Adaptations in endocrine physiology of fishes considered from evolutionary and ecological perspectives. Impacts of human activities, particularly in context of Southern California's marine environment addressed.

Letter grade only (A-F). (Lecture 3 hrs.)

550./450. Plant Ecology (3)

Prerequisites: BIOL 260, BIOL 350 both with a grade of "C" or better. Recommended: BIOL 427, BIOL 447. (Undergraduates enroll in BIOL 450; graduates enroll in BIOL 550.)

Relationship of plants to their environment and principles of plant distribution.

Letter grade only (A-F) (Lecture 2 hrs., laboratory and field 3 hrs.) Course fee may be required.

551./451. Wetlands and Mangrove Ecology (3)

Prerequisites: BIOL 260, BIOL 350 both with a grade of "C" or better. (Undergraduates enroll in BIOL 451; graduates enroll in BIOL 551.)

Comprehensive look at wetland ecology and management. Focuses on physical, biogeochemical, and ecological aspects of major wetland ecosystems with an emphasis on local urban wetlands. Includes wetland management concepts and approaches worldwide.

Letter grade only (A-F). (Lecture 2 hrs., laboratory and field 3 hrs.)

552./452. Behavioral Ecology (3)

Prerequisites: BIOL 312 or BIOL 350. (Undergraduates enroll in BIOL 452; graduates enroll in BIOL 552)

Primary objectives are to understand how animal behavior affects survival and reproduction and introduce students to current methodologies to study behavior of animals in lab and field conditions. Emphasizes ecological and evolutionary consequences of behavior across taxa.

Letter grade only (A-F). (Lecture 2 hrs., laboratory/field 3 hrs.)

554A./454A. Research in Tropical Marine Ecology (3)

Prerequisites: BIOL 350, BIOL 353, and one 400-level marine biology major course, all with grade of "C" or better, and consent of instructor. (Undergraduates enroll in BIOL 454A; graduates enroll in BIOL 554A.)

Field and laboratory studies, lectures, and individual research on tropical marine biological problems. Designed to engage students in experimental research, including: recognizing a problem, designing and carrying out a project, statistical data analysis, and oral and written report presentation.

Eight-day field trip to Hawaii required during spring recess at student expense. Enrollment is limited. Letter grade only (A-F). Course fee may be required. (Lecture 2 hrs., 8 day field trip.)

554B./454B. Research in Tropical Terrestrial Ecology (3)

Prerequisites: BIOL 350 with a grade of "C" or better; and consent of instructor. (Undergraduates enroll in BIOL 454B; graduates enroll in BIOL 554B.)

Field-based comparison of tropical lowland deciduous forest and lowland rainforest incorporating basic ecology methodology. Forest structure and diversity of animals emphasized. Students maintain field notebook, submit final paper, and give oral presentation.

Nine-day fieldtrip to Costa Rica required during spring recess at student expense. Enrollment is limited. Letter grade only (A-F). Course fee may be required. (Lecture 2 hr., 9 day field trip.)

555./455. Ecology of Marine Communities (3)

Prerequisites: BIOL 260, BIOL 350, BIOL 353 all with a grade of "C" or better. (Undergraduates enroll in BIOL 455; graduates enroll in BIOL 555.)

Field studies on ecological principles related to marine communities discussed. Includes individual field research project and two class projects.

Letter grade only (A-F). (Lecture 2 hrs., field 3 hrs.)

556./456. Population Ecology (3)

Prerequisites: BIOL 350; MATH 119B or MATH 123; all with a grade of "C" or better. (Undergraduates enroll in BIOL 456; graduates enroll in BIOL 556.)

Analysis of animal and plant populations characteristics: population growth and regulation, fluctuation and regulation, competition, predation, parasitism, and other intraspecific and interspecific interactions; spatial patterns.

Letter grade only (A-F). (Lecture 3 hrs.)

557./457. Field Methods in Ecology (3)

Prerequisites: BIOL 260, BIOL 350 both with a grade of "C" or better. (Undergraduates enroll in BIOL 457; graduates enroll in BIOL 557.)

Design of field research projects, collection, and data analysis, report writings and presentations. Field sampling techniques emphasized. Five weekend fieldtrips required.

Letter grade only (A-F). (Lecture 2 hrs., laboratory and field 3 hrs.)

559./459. Conservation Biology (3)

Prerequisites: BIOL 260, BIOL 350 both with a grade of "C" or better. Recommended: BIOL 370. (Undergraduates enroll in BIOL 459; graduates enroll in BIOL 559.)

Conservation biology concepts including population dynamics, extinction processes, population viability analyses, metapopulations, community-level interactions, island biogeography, biological diversity patterns, habitat fragmentation, reserve design, and landscape-level conservation. Lecture includes group discussions of case studies and relevant primary literature.

Letter grade only (A-F). (Lecture 3 hrs.) 20 hrs. per semester service learning for undergraduates, extra research paper for graduates.

562./462. Bioethics and Public Policy (3)

Prerequisite: BIOL 340 with a grade of "C" or better. (Undergraduates enroll in BIOL 462; graduates enroll in BIOL 562.)

History of bioethics, scientific and medical bases of key bioethical issues, current legislation and appropriations, including legal, social, and ethical implications of stem cell research and other biotechnological advances.

Letter grade only (A-F). (Lecture 3 hrs.)

563./463. Computer Modelling in Biology (4)

Prerequisites: BIOL 260, BIOL 350 both with a grade of "C" or better. (Undergraduates enroll in BIOL 463; graduates enroll in BIOL 563.)

History, modeling theory, different modeling approaches, theoretical, empirical and quantitative modeling. Laboratory uses modeling software and focuses on model construction and quantitative simulation. Applicable to ecology, microbiology, physiology, environmental sciences, etc.

Letter grade only (A-F). (Lecture 3 hrs., laboratory 3 hrs.) Course fee may be required.

564./464. Aquatic Toxicology (3)

Prerequisites: BIOL 211, BIOL 212, BIOL 213, BIOL 340; CHEM 220A or CHEM 227, all with a grade of "C" or better

Recommended: BIOL 353 and CHEM 448 or 441A,B.

(Undergraduates enroll in BIOL 464; graduates enroll in BIOL 564.)

In depth study of interactions between anthropogenic chemicals

and aquatic ecosystems, including origin, fate, chemical and biological detection, and quantification of pollutants and impact at molecular, biochemical, cellular, physiological, organismal, and community levels of organization. Individual research project required.

Letter grade only (A-F). (Lecture 3 hrs.)

565./465. Experimental Design and Regression Analysis (4)

Prerequisites: BIOL 260; MATH 119B or MATH 123; 6 units of upper division biological science all with a grade of "C" or better. (Undergraduates enroll in BIOL 465; graduates enroll in BIOL 565.)

Experimental design and data analysis techniques applied to problems in biology including analysis of variance and covariance, bivariate and multiple regression, experimental design, bootstrapping and randomization tests, and nonparametric statistics. Experience in analyzing biological data using computerized statistical packages.

Letter grade only (A-F). (Lecture 3 hrs., laboratory 3 hrs.)

567./467. Multivariate Data Analysis (4)

Prerequisites: BIOL 260; MATH 119B or MATH 123; 6 units of upper division biological science all with a grade of "C" or better. (Undergraduates enroll in BIOL 467; graduates enroll in BIOL 567.)

Multivariate data analysis techniques applied to biological data. Applied matrix algebra for analyzing and understanding multivariate analysis. Includes principal components analysis, factor analysis, discriminant analysis, cluster analysis and current modern phylogenetic analysis techniques. Analyzing multivariate biological data using computerized statistical packages.

Letter grade only (A-F). (Lecture 3 hrs., laboratory 3 hrs.)

570. Advanced Genetics (3)

Prerequisites: Graduate standing and consent of instructor.

In depth discussion of various advanced topics in genetics, which may include population genetics, molecular phylogeny, and microbial genetics. Includes critical reading and discussion of primary journal articles on pertinent topics.

Letter grade only (A-F). (Lecture 3 hrs.)

571./471. Bacterial Physiology (3)

Prerequisites: BIOL 320 or MICR 320, CHEM 441A or CHEM 448; both with a grade of "C" or better. (Undergraduates enroll in BIOL 471; graduates enroll in BIOL 571.)

Cellular physiology at molecular level as related to bacterial growth, reproduction, nutrition, metabolism, and ecology.

Letter grade only (A-F). (Lecture 3 hrs.). Not open for credit to students with credit in MICR 571.

572./472. Molecular Evolution (3)

Prerequisite: BIOL 370 with a grade of "C" or better. Recommended: BIOL 312. (Undergraduates enroll in BIOL 472; graduates enroll in BIOL 572.)

Survey of molecular evolution including but not limited to the history of the field, protein and DNA evolution, neutral and nearly-neutral theory, molecular phylogenetics, molecular population genetics and DNA fingerprinting, genomics, and proteomics. Applicable to ecological, evolutionary, medical, forensic sciences.

Letter grade only (A-F). (Lecture 3 hrs.)

573./473. Molecular Genetics (3)

Prerequisites: BIOL 370 or BIOL 371 or MICR 371; CHEM 220A,B and CHEM 223A,B, or CHEM 227, all with a grade of "C" or better. (Undergraduates enroll in BIOL 473; graduates enroll in BIOL 573.)

Contemporary molecular genetic analysis of model organisms (mouse, worm, flies, yeasts) used in study of human disease, basic biological processes, gene regulation, and global analysis of genomes and proteomes.

Letter grade only (A-F). (Lecture 3 hrs.)

574./474. Bioinformatics (3)

Prerequisites: BIOL 260; BIOL 370 or BIOL 371 or MICR 371, all with a grade of "C" or better. (Undergraduates enroll in BIOL 474; graduates enroll in BIOL 574.)

Survey of biological sequences and prokaryotic genomes. Investigation of DNA, RNA, and protein sequences using statistics and computer science techniques. Computer-based laboratory will familiarize students with bioinformatics tools and programming. Letter grade only (A-F). (Lectures 2 hrs., laboratory 3 hrs.)

577./477. Biotechnology: Applications of Molecular Techniques and Bioinformatics (4)

Prerequisite: BIOL 340 or BIOL 370 or CHEM 441A,B; all with a grade of "C" or better. (Undergraduates enroll in BIOL 477; graduates enroll in BIOL 577.)

Theory and techniques for isolating, amplifying, and analyzing genes, genomes, transcripts, and proteins. Data-mining, the use of computers in experimental design and/or functional analysis, use of microarrays, and future of nanotechnology.

Letter grade only (A-F). Not open for credit to student with credit in MICR 577/477. (Lecture 3 hrs., activity 2 hrs.)

580./480. Seminars (1)

Prerequisites: Consent of Department of Biological Sciences. (Undergraduates and classified post-baccalaureates enroll in BIOL 480; graduates enroll in BIOL 580). Undergraduates must have filed for graduation and be in their last semester. Graduates must have been admitted to the department as a graduate student. Classified post-baccalaureates must have been admitted to a second baccalaureate or a certificate.

Weekly meetings with professional biologists presenting results of their research. Requires participation in organization and critical evaluation of these presentations.

(Seminar 1 hr.) Letter grade only (A-F). May not be repeated for credit towards any single degree.

590./490. Selected Topics in Biology (1-3)

Prerequisites: BIOL 211, BIOL 212, BIOL 213 all with a grade of "C" or better, and consent of instructor. (Undergraduates enroll in BIOL 490; graduates enroll in BIOL 590.)

Topics from selected areas of biology. Course content varies from section to section.

Letter grade only (A-F). May be repeated to a maximum of 6 units with different topics. Topics announced in the *Schedule of Classes*. (Lecture 1-3 hrs.)

590L./490L. Selected Topics in Biology, Laboratory (1-2)

Prerequisites: BIOL 211, BIOL 212, BIOL 213 all with a grade of "C" or better, and consent of instructor. (Undergraduates enroll in BIOL 490L; graduates enroll in BIOL 590L.)

Topics from selected areas of biology. Course content varies from section to section.

Letter grade only (A-F). May be repeated to a maximum of 4 units with different topics. Topics announced in the *Schedule of Classes*. (Laboratory 3 or 6 hrs.)

592A./492A. Stem Cell Research Internship (12)

Prerequisites: BIOL 432/532, BIOL 432L/532L, BIOL 440L, BIOL 462/562, BIOL 473/573, BIOL 477/577, all with a grade of "C" or better, and consent of the director of the CSULB Biotechnology Certificate Program, and acceptance in the Stem Cell Training Option within the Biotechnology Certificate. (Undergraduates enroll in BIOL 492A; graduates enroll in BIOL 592A.)

CIRM-approved institutions train interns in their stem cell research laboratories. Must be repeated once for credit.

Credit/No Credit grading only. (Laboratory 36 hrs.)

661. Seminar in Microbiology (2)

Prerequisite: Consent of instructor.

Critical evaluation of literature in this field, including oral and/or written presentation of critiques.

May be repeated to a maximum of 4 units with different topics. Letter grade only (A-F). (Seminar 2 hours). Not open to credit for students with credit in MICR 661.

663. Seminar in Cell and Molecular Biology (2)

Critical evaluation of field's primary literature, including oral and/or written presentation of critiques.

May be repeated to a maximum of 4 units with different topics. Letter grade only (A-F) (Seminar 2 hrs.)

664. Seminar in Marine Biology (2)

Critical evaluation of field's primary literature, including oral and/or written presentation of critiques.

May be repeated to a maximum of 4 units with different topics.

Letter grade only (A-F) (Seminar 2 hrs.)

665. Seminar in Ecology (2)

Critical evaluation of field's primary literature, including oral and/or written presentation of critiques.

May be repeated to a maximum of 4 units with different topics. Letter grade only (A-F) (Seminar 2 hrs.)

666. Seminar in Physiology (2)

Critical evaluation of field's primary literature, including oral and/or written presentation of critiques.

May be repeated to a maximum of 4 units with different topics.

Letter grade only (A-F) (Seminar 2 hrs.)

696A. Research Design and Ethics (3)

Prerequisites: Graduate standing in the Department of Biological Sciences and departmental permission.

Research design, experimental ethics, statistics, literature searches, and thesis proposal writing. Required for all first semester graduate students.

Letter grade only (A-F). (Lecture 2 hrs., laboratory 3 hrs.)

696B. Scientific Communication (3)

Prerequisite: BIOL 696A with a grade of "B" or better.

Presentation/publication skills for communicating biological research to professional and lay audiences: scientific writing, data presentation (posters and oral).

Letter grade only (A-F). (Lecture 2 hrs., laboratory 3 hrs.) Course fee may be required.

697. Directed Research (1-3)

Prerequisite: Consent of instructor.

Research on specific topic approved and directed by a faculty member in the biological sciences. Written report required.

May be repeated for a letter grade and degree credit to a maximum of three units. Any units beyond the three taken for a letter grade in BIOL 697 or MICR 697 or any combination of the two must be taken credit/no credit.

698. Thesis (1-6)

Prerequisites: Advancement to Candidacy for the Master of Science in Biology, and consent of the chair of the thesis committee and the departmental graduate advisor.

Planning, preparation, writing, defense, oral presentation, and completion of a research thesis in the biological sciences.

Letter grade only (A-F).

Students pursuing a major and/or a minor in this department may receive unit credit for courses marked with the symbol '##' as a general elective but may not apply the units toward the specific or elective requirements for any degree or option in this department. Majors in this Department may, however take for general education purposes, interdisciplinary courses offered by this department. All other courses in this department are open to majors and minors but by letter grade only.

CHEMISTRY AND BIOCHEMISTRY

College of Natural Sciences and Mathematics

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Administrative Support Coordinator: Irma Sanchez

Advisors:

Undergraduate: Douglas D. McAbee
Credential: James Kisiel, Tim Williamson
Graduate: Biochemistry: Paul M. M. Weers; Chemistry: Lijuan Li

Graduate Studies Committee: Lijuan Li, Krzysztof Slowinski, Christopher R. Brazier, Young Shen, Paul M. M. Weers

Honors in the Major: Douglas D. McAbee

Students desiring information should contact the undergraduate advisor.

Career Possibilities

Patent Agent • Chemist • Assayer • Water Purification Chemist • Chemical Lab Technician • Biochemist • Quality Control Coordinator • Pharmaceutical or Technical Sales Representative • Public Health Educator • Industrial Hygienist • Health Administrator • Teacher • Food / Drug Inspector • Materials Scientist • Medical Librarian • Environmental Scientist • Criminologist • Pharmacologist • Dentist • Physician • Geochemist • Chemical Oceanographer (Some of these, and other careers, require additional education or experience. For more information, see www.careers.csulb.edu.)

Introduction

The Department of Chemistry and Biochemistry offers three bachelor's degrees, the B.S. in Chemistry, the B.S. in Biochemistry, and the B.A. in Chemistry, and two master's degrees, the M.S. in Chemistry and the M.S. in Biochemistry. These programs combined serve over 700 majors. In addition, the Department offers a Minor in Chemistry.

Degree Programs

The programs in chemistry and biochemistry at the bachelor's degree level are planned to develop background in a specific science, to serve as preparation for graduate work in chemistry or biochemistry, and to provide a foundation for those students seeking careers in the chemical sciences, teaching, law, medicine, dentistry, pharmacy and other health-related professions, and in industrial and governmental scientific occupations. The B.S. degree in Chemistry is certified by the American Chemical Society (American Chemical Society, Committee on

Professional Training, 1155 Sixteenth St., NW, Washington, DC 20036, phone: 202-872-4589).

The B.S. degree in Biochemistry is certified by the American Society for Biochemistry and Molecular Biology (ASBMB department/program accreditation sub-committee, 11200 Rockville Pike, Suite 302, Rockville MD 20852-3110, phone: 240-283-6600).

Transfer Students: A student who transfers to the University must take at least 16 units of upper division chemistry courses here. To receive credit towards the major for courses taken elsewhere in place of CHEM 371A,B and/or 377A,B, consent of the Department Chair is required. Satisfactory performance on appropriate proficiency examinations may also be required.

The Department of Chemistry and Biochemistry offers graduate study leading to research-based master of science degrees in chemistry and biochemistry.

Applicants for the master of science degree programs should apply online both to the university and to the department. Links to the online application forms can be found on the department's web site (<http://chemistry.csulb.edu> – click on "Graduate Programs").

A limited number of teaching associate and graduate and research assistantships are available. Usually, these involve half-time work in the instructional program at the freshman and sophomore level or work in the laboratory. An applicant may apply for a teaching associate or graduate assistant position in the course of completing the online departmental application.

Academic Advising and Facilitated Enrollment into Classes

All entering students who declare a major in a degree program offered by this department need to contact the College of Natural Sciences and Mathematics' (CNSM) Academic Advising Center (HSCI 164) and participate in the College's Science Safari to Success (for first time freshmen) or EONS (Enrollment and Orientation in the Natural Sciences and Mathematics for transfer students) Program. These programs are held in June/July for those starting in the Fall Semester and in January for those starting in the Spring Semester. Department advisors will be available to provide an overview of the students' chosen baccalaureate degree program, to assist with academic advisement, to provide information on the many career opportunities available, and to aid students in enrolling in classes. Contact the CNSM Academic Advising Center, Jensen Student Access to Sciences and Mathematics Center (HSCI 164), or department office for additional information.

Concurrent and/or Summer Enrollment in Another College

Students who wish to take course work in a community or other college to meet curricular requirements while enrolled as undergraduates in the College of Natural Sciences and Mathematics must petition the appropriate department for approval prior to enrolling in specific

courses. This policy applies to concurrent enrollment or summer enrollment. University policy must also be complied with; see "Concurrent Enrollment" and "Transfer of Undergraduate Credit" in this catalog. Courses not receiving prior approval will not be accepted for credit by the Department.

Undergraduate Programs

Bachelor of Science in Chemistry (120 units)

Degree Progress

BS Chemistry majors must complete the following requirements within the specified time of declaring the major. Some students may need to take courses during Summer Session to meet these requirements. Students who have not met the requirements by the required semester must either declare another major or meet with an Academic Advisor to determine if the student's performance in the courses merits an additional semester to complete. Students required to enroll in pre-baccalaureate math may receive one additional semester to meet the requirements.

Freshmen: A grade "C" or better must be achieved in both MATH 122 and CHEM 111A within one calendar year. A grade of "C" or better must be achieved in CHEM 111B and CHEM 220A within two calendar years.

Transfer Students: A grade of "C" or better must be achieved in both CHEM 220A and PHYS 151 within 1 calendar year.

In addition, all BS Chemistry majors must earn a "C" or better in all courses counting toward the major and must maintain major and upper-division major GPAs of 2.0 or higher. A student whose GPA in the major or upper division GPA in the major falls below 2.0 will be advised that they are at risk of being dismissed from the major and granted one semester to raise their major GPA(s) to 2.0. Students who do not successfully raise their major GPA(s) must meet with an advisor to declare another major or submit an appeal to the Department of Chemistry and Biochemistry explaining why they need one additional semester. Students whose major GPAs remain below 2.0 after this additional semester must declare a new major.

Students Desiring Entrance into a Health Professions Program

Students desiring entrance into one of the various health-related professional schools should consult with the Health Professions Advising Office in the College of Natural Sciences and Mathematics, Jensen Student Access to Sciences and Mathematics Center (HSCI-164) for more information. Most of these schools do not require students to major in any particular discipline and many favor applicants who have earned a baccalaureate; rather, they want students who have done well in their major and who also took the prerequisite courses required by that particular school.

Requirements

Lower Division:

Either take all of the following:

BIOL 211 Introduction to Evolution and Diversity (4)
Prerequisite/Corequisite: CHEM 111A with a grade of "C" or better.

BIOL 212 Intro to Cell and Molecular Biology (4)
Prerequisites: BIOL 211, CHEM 111A with grades of "C" or better. Prerequisite/Corequisite: CHEM 111B.

NOTE: BIOL 111, BIOL 111L, BIOL 212, BIOL 212L are required if courses were taken prior to catalog year 2010-11.

Or one of the following:

BIOL 200 General Biology (4)
Prerequisite: GE Foundation requirements.

BIOL 205 Human Biology (4)
Prerequisites: GE Foundation requirements.

BIOL 207 Human Physiology (4)
Prerequisites: GE Foundation requirements.

Take either:

CHEM 111A General Chemistry (5)
Prerequisites: A passing score on the Chemistry Placement Examination.
Corequisite: MATH 109 or higher.

and

CHEM 111B General Chemistry (5)
Prerequisites: CHEM 111A and MATH 113 or MATH 115 or MATH 119A or MATH 122 all with a grade of "C" or better.

or

CHEM 112A Advanced General Chemistry (5)
Prerequisite: Department consent.

and

CHEM 112B Advanced General Chemistry (5)
Prerequisite: CHEM 112A with a grade of "C" or better

Take either:

CHEM 251 Quantitative Analysis (4)
Prerequisite: CHEM 111B with a grade of "C" or better. Strongly recommended for pre-pharmacy students and students planning careers in clinical or analytical laboratory sciences. It is advised that CHEM 251 be taken within one calendar year of CHEM 111B.

or

4 units of electives chosen in consultation with an advisor.

Take all of the following courses:

CHEM 220A Organic Chemistry I (3)
Prerequisites: CHEM 111B with a grade of "C" or better.
Corequisites: CHEM 224 is required for students repeating course. CHEM 223A must be taken concurrently if required by a degree plan.

CHEM 220B Organic Chemistry II (3)
Prerequisites: CHEM 220A with a grade of C or better
Corequisite: CHEM 223B or CHEM 320L except for students who previously earned a "C" or better in CHEM 223B or CHEM 320L

MATH 122 Calculus I (4)
Prerequisite: Appropriate MDPT placement or a grade of "C" or better in MATH 111 and MATH 113.

MATH 123 Calculus II (4)
Prerequisite: A grade of "C" or better in MATH 122.

MATH 224 Calculus III (4)
Prerequisite: A grade of "C" or better in MATH 123 or MATH 222.

PHYS 151 Mechanics and Heat (4)
Prerequisite/Corequisite: MATH 122.

PHYS 152 Electricity and Magnetism (4)
Prerequisite: PHYS 151; Prerequisite/Corequisite: MATH 123.

Upper Division:

Take all of the following courses:

CHEM 320L Organic Chemistry Laboratory for Chemistry & Biochemistry Majors (2) F, S
Prerequisites: CHEM 220A.

Corequisites: CHEM 220B, except for students who have previously earned a "C" or better in CHEM 320B.

CHEM 331 Inorganic Chemistry (3)

Prerequisites: CHEM 111B with a grade of "C" or better.

CHEM 332 Inorganic Chemistry Lab (2)

Prerequisite/Corequisite: CHEM 331.

CHEM 361 Chemical Communications (3)

Prerequisites: GE Foundation requirement. Students must have scored 11 or higher on the GWAR Placement Examination or completed the necessary portfolio course that is a prerequisite for a GWAR Writing Intensive Capstone.
Prerequisite/Corequisite: CHEM 220A.

CHEM 371A Physical Chemistry (3)

Prerequisites: CHEM 111B, MATH 123, PHYS 152 (all with a grade of "C" or better).

Prerequisite/Corequisite: MATH 224.

CHEM 371B Physical Chemistry (3)

Prerequisites: CHEM 111B, MATH 123, PHYS 152 (all with a grade of "C" or better).

Prerequisite/Corequisite: MATH 224.

CHEM 373. Physical Chemistry Laboratory (3)

Prerequisites: CHEM 361, CHEM 371A or 377A, and CHEM 371B or 377B, all with a grade of "C" or better.

CHEM 431 Advanced Inorganic Chemistry (3)

Prerequisite(s): CHEM 331, with a grade of "C" or better.

Prerequisite(s)/Corequisite(s): CHEM 371B.

CHEM 441A Biological Chemistry (3) or CHEM 448 (3)

Prerequisites: CHEM 220B and either CHEM 320L or CHEM 223B all with a grade of "C" or better; a biology or microbiology course is recommended.

CHEM 451 Instrumental Methods of Analysis (5)

Prerequisites: PHYS 152, CHEM 361; CHEM 371B or CHEM 377B; all with a grade of "C" or better.

CHEM 461 Chemistry Capstone (1)

Prerequisite: Department consent.

Take one of the following:

CHEM 420 Advanced Organic Chemistry Lab (3)

Prerequisites: CHEM 220B or CHEM 320L and either CHEM 361 or CHEM 466. (all with a grade of C or better).

CHEM 498 Senior Thesis (3)

Prerequisites: Major GPA 3.0 or higher, 3 units of CHEM 496 with a grade of "A", consent of instructor.

Take an additional 3 units of upper division chemistry electives including at least one unit of CHEM 496. CH E 330, CH E 430, or CH E 475 may be used as chemistry electives.

Students are also advised to take one or more additional courses in mathematics, such as MATH 247, MATH 364A, MATH 370A, MATH 380.

To meet prerequisite standards for courses in this program's requirements, a "C" or better is necessary in the following: BIOL 211, CHEM 111A, CHEM 111B, CHEM 112A, CHEM 220A, CHEM 220B, CHEM 320L, CHEM 331, CHEM 361, CHEM 371A, CHEM 371B, MATH 122, MATH 123, PHYS 151, PHYS 152.

Bachelor of Arts in Chemistry (120 units)

Degree Progress

BA Chemistry majors must complete the following requirements within the specified time of declaring the major. Some students may need to take courses during Summer Session to meet these requirements. Students who have not met the requirements by the required semester must either declare another major or meet with an Academic Advisor to determine if the student's performance in the courses merits an additional semester to complete. Students required to enroll in pre-baccalaureate math may receive one additional semester to meet the requirements.

Freshmen: A grade "C" or better must be achieved in both MATH 122 and CHEM 111A within one calendar year. A grade of "C" or better must be achieved in CHEM 111B and CHEM 220A within two calendar years.

Transfer Students: A grade "C" or better must be achieved in both CHEM 220A and PHYS 151 within one calendar year.

In addition, BA Chemistry majors must earn a "C" or better in all courses counting toward the major and must maintain major and upper-division major GPAs of 2.0 or higher. A student whose GPA in the major or upper division GPA in the major falls below 2.0 will be advised that they are at risk of being dismissed from the major and granted one semester to raise their major GPA(s) to 2.0. Students who do not successfully raise their major GPA(s) must meet with an advisor to declare another major or submit an appeal to the Department of Chemistry and Biochemistry explaining why they need one additional semester. Students whose major GPAs remain below 2.0 after this additional semester must declare a new major.

Requirements

Lower Division:

Take either of the following pairs:

CHEM 111A General Chemistry (5)

Prerequisites: A passing score on the Chemistry Placement Examination.

Corequisite: MATH 109 or higher.

and

CHEM 111B General Chemistry (5)

Prerequisites: CHEM 111A and MATH 113 or MATH 115 or MATH 119A or MATH 122 all with a grade of "C" or better.

or

CHEM 112A Advanced General Chemistry (5)

Prerequisite: Department consent.

and

CHEM 112B Advanced General Chemistry (5)

Prerequisite: CHEM 112A with a grade of "C" or better

Take either:

CHEM 251 Quantitative Analysis (4)

Prerequisite: CHEM 111B with a grade of "C" or better. Strongly recommended for pre-pharmacy students and students planning careers in clinical or analytical laboratory sciences. It is advised that CHEM 251 be taken within one calendar year of CHEM 111B.

or

4 units of electives chosen in consultation with an advisor

Take all of the following courses:

CHEM 220A Organic Chemistry I (3)

Prerequisites: CHEM 111B with a grade of "C" or better.
Corequisites: CHEM 224 is required for students repeating course. CHEM 223A must be taken concurrently if required by a degree plan.

CHEM 220B Organic Chemistry II (3)

Prerequisites: CHEM 220A with a grade of C or better.
Corequisite: CHEM 223B or CHEM 320L except for students who previously earned a "C" or better in CHEM 223B or CHEM 320L.

MATH 122 Calculus I (4)

Prerequisite: Appropriate MDPT placement or a grade of "C" or better in MATH 111 and MATH 113.

MATH 123 Calculus II (4)

Prerequisite: A grade of "C" or better in MATH 122.

PHYS 151 Mechanics and Heat (4)

Prerequisite/Corequisite: MATH 122.

PHYS 152 Electricity and Magnetism (4)

Prerequisite: PHYS 151; Prerequisite/Corequisite: MATH 123.

Upper Division:

Take all of the following courses:

CHEM 320L Organic Chemistry Laboratory for

Chemistry & Biochemistry Majors (2)

Prerequisite: CHEM 220A

Corequisite: CHEM 220B, except for students who have previously earned a "C" or better in CHEM 220B

CHEM 331 Inorganic Chemistry (3)

Prerequisites: CHEM 111B with a grade of "C" or better.

CHEM 361 Chemical Communications (3)

Prerequisites: GE Foundation requirement. Students must have scored 11 or higher on the GVAR Placement Examination or completed the necessary portfolio course that is a prerequisite for a GVAR Writing Intensive Capstone.

Prerequisite/Corequisite: CHEM 220A.

Take one of the following courses:

CHEM 420 Advanced Organic Chemistry Lab (3)

Prerequisites: CHEM 220B or CHEM 320L and either CHEM 361 or CHEM 466, all with a grade of "C" or better.

CHEM 498 Senior Thesis (3)

Prerequisites: major GPA>3, 3 units of CHEM 496 with a grade of "A", consent of instructor

Take all of the following courses:

CHEM 451 Instrumental Methods of Analysis (5)

Prerequisites: PHYS 152, CHEM 361; CHEM 371B or CHEM 377B; all with a grade of "C" or better.

CHEM 461 Chemistry Capstone (1)

Prerequisite: Department consent.

Select one pair from the following:

CHEM 371A Physical Chemistry (3)

Prerequisites: CHEM 111B, MATH 123, PHYS 152 (all with a grade of "C" or better).

Prerequisite/Corequisite: MATH 224.

and

CHEM 371B Physical Chemistry (3)

Prerequisites: CHEM 111B, MATH 123, PHYS 152 (all with a grade of "C" or better).

Prerequisite/Corequisite: MATH 224.

or

CHEM 377A Fundamentals of Physical Chemistry (3)

Prerequisites: CHEM 111B, MATH 123, and PHYS 152 (all with a grade of "C" or better).

and

CHEM 377B Fundamentals of Physical Chemistry (3)

Prerequisites: CHEM 111B, MATH 123, and PHYS 152 (all with a grade of "C" or better).

Take an additional 3 additional units chosen with

advisor consultation from the following:

CHEM 332, CHEM 373, CHEM 421, CHEM 431, CHEM 441A, 441B, CHEM 448, CHEM 480, CHEM 496. Only one biochemistry pathway may be used toward this degree program: either CHEM 448 or CHEM 441A and/or 441B.

To meet prerequisite standards for courses in this program's requirements, a "C" or better is necessary in the following: CHEM 111A, CHEM 111B, CHEM 112A, CHEM 220A, CHEM 220B, CHEM 320L, CHEM 361, CHEM 371B, CHEM 377B, MATH 122, MATH 123, PHYS 151, PHYS 152.

Students must consult an advisor to select additional courses to meet the student's individual goals and interests.

Bachelor of Science in Biochemistry (120 units)

Degree Progress

BS and Biochemistry majors must complete the following requirements within the specified time of declaring the major. Some students may need to take courses during Summer Session to meet these requirements. Students who have not met the requirements by the required semester must either declare another major or meet with an Academic Advisor to determine if the student's performance in the courses merits an additional semester to complete. Students required to enroll in pre-baccalaureate math may receive one additional semester to meet the requirements.

Freshmen: A grade "C" or better must be achieved in both MATH 122 and CHEM 111A within one calendar year. A grade of "C" or better must be achieved in CHEM 111B and CHEM 220A within two calendar years.

Transfer Students: A grade of "C" or better must be achieved in both CHEM 220A and PHYS 151 within 1 calendar year.

In addition, BS and Biochemistry majors must earn a C or better in all courses counting towards the major and must maintain major and upper-division major GPAs of 2.0 or higher. A student whose GPA in the major or upper division GPA in the major falls below 2.0 will be advised that they are at risk of being dismissed from the major and granted one semester to raise their major GPA(s) to 2.0. Students who do not successfully raise their major GPA(s) must meet with an advisor to declare another major or submit an appeal to the Department of Chemistry and Biochemistry explaining why they need one additional semester. Students whose major GPAs remain below 2.0 after this additional semester must declare a new major.

Requirements

Lower Division:

Take either:

CHEM 111A General Chemistry (5)

Prerequisites: A passing score on the Chemistry Placement Examination.

Corequisite: MATH 109 or higher.

and

CHEM 111B General Chemistry (5)

Prerequisites: CHEM 111A and MATH 113 or MATH 115 or MATH 119A or MATH 122 all with a grade of "C" or better.

or

CHEM 112A Advanced General Chemistry (5)

Prerequisite: Department consent.

and

CHEM 112B Advanced General Chemistry (5)
Prerequisite: CHEM 112A with a grade of "C" or better

Take either:

CHEM 251 Quantitative Analysis (4)
Prerequisite: CHEM 111B with a grade of "C" or better. Strongly recommended for pre-pharmacy students and students planning careers in clinical or analytical laboratory sciences. It is advised that CHEM 251 be taken within one calendar year of CHEM 111B.

or

4 units of electives chosen in consultation with an advisor

Take all of the following courses:

BIOL 211 Introduction to Evolution and Diversity (4)
Prerequisite/Corequisite: CHEM 111A with a grade of "C" or better.

BIOL 212 Intro to Cell and Molecular Biology (4)
Prerequisites: BIOL 211, CHEM 111A with grades of "C" or better.
Prerequisite/Corequisite: CHEM 111B.

NOTE: BIOL 111, BIOL 111L, BIOL 212, BIOL 212L are required if courses were taken prior to catalog year 2010-11.

CHEM 220A Organic Chemistry I (3)
Prerequisites: CHEM 111B with a grade of "C" or better.
Corequisites: CHEM 224 is required for students repeating course.
CHEM 223A must be taken concurrently if required by a degree plan.

CHEM 220B Organic Chemistry II (3)
Prerequisites: CHEM 220A with a grade of C or better
Corequisite: CHEM 223B or CHEM 320L except for students who previously earned a "C" or better in CHEM 223B or CHEM 320L

MATH 122 Calculus I (4)
Prerequisite: Appropriate MDPT placement or a grade of "C" or better in MATH 111 and MATH 113.

MATH 123 Calculus II (4)
Prerequisite: A grade of "C" or better in MATH 122.

PHYS 151 Mechanics and Heat (4)
Prerequisite/Corequisite: MATH 122.

PHYS 152 Electricity and Magnetism (4)
Prerequisite: PHYS 151; Prerequisite/Corequisite: MATH 123.

Upper Division:

Take all of the following courses:

BIOL 340 Molecular Cell Biology (3)
Prerequisites: BIOL 211, BIOL 212, all with a grade of "C" or better.

CHEM 320L Organic Chemistry Laboratory for Chemistry & Biochemistry Majors (2) F, S
Prerequisite: CHEM 220A.
Corequisite: CHEM 220B, except for students who have previously earned a "C" or better in CHEM 320B.

CHEM 361 Chemical Communications (3)
Prerequisites: GE Foundation requirement. Students must have scored 11 or higher on the GWAR Placement Examination or completed the necessary portfolio course that is a prerequisite for a GWAR Writing Intensive Capstone.
Prerequisite/Corequisite: CHEM 220A.

CHEM 441A Biological Chemistry (3)
Prerequisites: CHEM 220B and either CHEM 320L or CHEM 223B all with a grade of "C" or better; a biology or microbiology course is recommended.

CHEM 441B Biological Chemistry (3)
Prerequisite: CHEM 441A with a grade of "C" or better.

CHEM 443 Biological Chemistry Laboratory (4)
Prerequisites: CHEM 441A and either CHEM 361 or CHEM 466; all with a grade of "C" or better.

CHEM 461 Chemistry Capstone (1)
Prerequisite: Department consent.

Select one of the following:

CHEM 371A Physical Chemistry (3)
Prerequisites: 111B, MATH 123, PHYS 152 (all with a grade of "C"

or better).
Prerequisite/Corequisite: MATH 224.

CHEM 377A Fundamentals of Physical Chemistry (3)
Prerequisites: CHEM 111B, MATH 123, and PHYS 152 (all with a grade of "C" or better).
(CHEM 371A,B is recommended as preparation for graduate studies in biochemistry)

Select one of the following:

CHEM 371B Physical Chemistry (3)
Prerequisites: CHEM 111B, MATH 123, PHYS 152 (all with a grade of "C" or better).
Prerequisite/Corequisite: MATH 224.

CHEM 377B Fundamentals of Physical Chemistry (3)
Prerequisites: CHEM 111B, MATH 123, and PHYS 152 (all with a grade of "C" or better).

Select one course from the following:

CHEM 420 Advanced Organic Chemistry Lab (3)
Prerequisites: CHEM 220B or CHEM 320L and either CHEM 361 or CHEM 466. (all with a grade of C or better).

CHEM 451 Instrumental Methods of Analysis (5)
Prerequisites: PHYS 152, CHEM 361; CHEM 371B or CHEM 377B; all with a grade of "C" or better.

Take at least three units of elective chosen from: :

BIOL 342/342L, BIOL 370, BIOL 416, BIOL 430, BIOL 431, BIOL 432, BIOL 433, BIOL 443, BIOL 445, BIOL 473; CHEM 251, CHEM 331, CHEM 332, CHEM 373, CHEM 420, CHEM 421, CHEM 431, CHEM 451, CHEM 466, CHEM 480, CHEM 496, CHEM 498, CHEM 498H, CHEM 499.

To meet prerequisite standards for courses in this program's requirements, a "C" or better is necessary in the following: BIOL 211, BIOL 212, CHEM 111A, CHEM 111B, CHEM 112A, CHEM 220A, CHEM 220B, CHEM 320L, CHEM 361, CHEM 441A, CHEM 371B, CHEM 377B, MATH 122, MATH 123, PHYS 151, PHYS 152.

Single Subject Chemistry Concentration

The Chemistry Concentration meets the subject matter competence requirement for the Single Subject Teaching Credential in Chemistry. Consult with an adviser in the Department of Science Education early to plan a program.

Requirements

Lower Division:

Take all of the following courses:

ASTR 100 Astronomy (3)
Corequisites: One course from General Education Category B.2 and ASTR 100L.

BIOL 211 Introduction to Evolution and Diversity (4)
Prerequisite/Corequisite: CHEM 111A with a grade of "C" or better.

BIOL 212 Intro to Cell and Molecular Biology (4)
Prerequisites: BIOL 211, CHEM 111A with grades of "C" or better. Prerequisite/Corequisite: CHEM 111B.

BIOL 213 Introduction to Ecology and Physiology (4)
Prerequisites: BIOL 211, BIOL 212, CHEM 111B all with a grade of "C" or better.

NOTE: BIOL 111, BIOL 111L, BIOL 212, BIOL 212L, BIOL 213, BIOL 213L are required if courses were taken prior to catalog year 2010-11.

CHEM 251 Quantitative Analysis (4)
Prerequisite: CHEM 111B with a grade of "C" or better. Strongly recommended for pre-pharmacy students and students planning careers in clinical or analytical laboratory sciences. It is strongly recommended that CHEM 251 be taken within one calendar year of CHEM 111B.

GEOL 102 General Geology (3)

Prerequisites/Corequisites: A course that fulfills the A.1 GE requirement and three years of high school mathematics including algebra, geometry, and intermediate algebra or the equivalent.

GEOL 104 Geology Laboratory (1)

Prerequisites/Corequisites: A course that fulfills the A.1 GE requirement and three years of high school mathematics including algebra, geometry, and intermediate algebra or the equivalent. Prerequisite/Corequisite: GEOL 102.

GEOL 160 Introduction to Oceanography (3)

Prerequisites/Corequisites: A course that fulfills the A.1 GE requirement and three years of high school mathematics including algebra, geometry, and intermediate algebra or the equivalent.

Select one pair from the following:

CHEM 111A General Chemistry (5)

Prerequisites: A passing score on the Chemistry Placement Examination.

Corequisite: MATH 109 or higher.

CHEM 111B General Chemistry (5)

Prerequisites: CHEM 111A and MATH 113 or MATH 115 or MATH 119A or MATH 122 all with a grade of "C" or better.

Or

CHEM 112A Advanced General Chemistry (5)

Prerequisites: Department consent

CHEM 112B Advanced General Chemistry (5)

Prerequisite: CHEM 112A with a grade of "C" or better

Select one pair from the following:

PHYS 100A General Physics (4)

Prerequisite: MATH 109 or MATH 113 or MATH 119A or MATH 122.

PHYS 100B General Physics (4)

Prerequisite: PHYS 100A.

or

PHYS 151 Mechanics and Heat (4)

Prerequisite/Corequisite: MATH 122.

PHYS 152 Electricity and Magnetism (4)

Prerequisite: PHYS 151; Prerequisite/Corequisite: MATH 123.

Select one pair from the following:

MATH 119A Survey of Calculus I (3)

Prerequisite: Appropriate MDPT placement or a grade of "C" or better in MATH 113.

MATH 119B Survey of Calculus II (3)

Prerequisite: A grade of "C" or better in MATH 119A or MATH 122.

or

MATH 122 Calculus I (4)

Prerequisite: Appropriate MDPT placement or a grade of "C" or better in MATH 111 and MATH 113.

MATH 123 Calculus II (4)

Prerequisite: A grade of "C" or better in MATH 122.

Upper Division:

Take all of the following:

CHEM 220A Organic Chemistry I (3)

Prerequisites: CHEM 111B with a grade of "C" or better. Corequisites: CHEM 224 is required for students repeating course. CHEM 223A must be taken concurrently if required by a degree plan.

CHEM 220B Organic Chemistry II (3)

Prerequisite: CHEM 220A with a grade of "C" or better. Corequisite: CHEM 223B or CHEM 320L except for students who previously earned a "C" or better in CHEM 223B or CHEM 320L.

CHEM 451 Instrumental Methods of Analysis (5)

Prerequisites: PHYS 152, CHEM 361; CHEM 371B or

CHEM 377B; all with a grade of "C" or better.

CHEM 496 Special Problems in Chemistry (1-3)

Prerequisite: Consent of instructor.

SCED 403 Integrated Science (3)

Prerequisites: Completion of all credential breadth requirements for the Single Subject Teaching Credential Program in Science, three-fourths of the credential specializations courses, and consent of instructor.

Take one of the following:

CHEM 441A Biological Chemistry (3)

Prerequisites: CHEM 220B and either CHEM 320L or CHEM 223B all with a grade of "C" or better; a biology or microbiology course is recommended.

Or

CHEM 448 Fundamentals of Biological Chemistry (3)

Prerequisites: CHEM 220B or 227 with a grade of "C" or better.

Take one of the following:

CHEM 431 Advanced Inorganic Chemistry (3)

Prerequisite(s): CHEM 331, with a grade of "C" or better.

Prerequisite(s)/Corequisite(s): CHEM 371B.

CHEM 441B Biological Chemistry (3)

Prerequisite: CHEM 441A with a grade of "C" or better.

Single Subject Teaching Credential in Chemistry

In addition, prospective Chemistry teachers are required to complete 45 units of professional preparation in the Single Subject Credential Program, including student teaching. Professional preparation courses may be taken as early as the junior year. With careful planning, it is possible to complete many of the credential program courses, except for student teaching, as an undergraduate. Courses may also be started as a post-baccalaureate student. Refer to the Single Subject Teacher Education section of this catalog or the Single Subject Credential Program website (www.ced.csulb.edu/single-subject) for a description of the professional preparation requirements, courses, and application procedures.

The Chemistry Subject Matter Program is being revised to meet new state standards. When the revised program has been approved by the Commission on Teacher Credentialing, the new course requirements will be in effect and supersede current requirements.

Honors in Biochemistry or Chemistry

Students majoring in the B.S. in Biochemistry, B.S. in Chemistry, or B.A. in Chemistry who would like an enriched academic program including an intensive research experience may be eligible to graduate with Honors in the Major through the University Honors Program. Students may complete General Honors through the University Honors Program as well; in such cases the General Honors thesis requirement is met through Honors in the Major (see University Honors in this catalog).

Requirements for Admission to Honors in the Major

The requirements for Honors in the Major also satisfies the requirements of a college-wide program, Honors in Biological Sciences, created with the support of a grant from the Howard Hughes Medical Institute. While Honors in the Major requires junior or senior standing, the college-wide program offers an enriched curriculum. Interested students

should contact the Honors in the Major director or the Jensen Student Access to Sciences and Mathematics Center.

1. Junior or senior standing with at least one year remaining before graduation.
2. Declared major of B.S. in Biochemistry, B.S. in Chemistry, or B.A. in Chemistry.
3. Submission of an application detailing interest in the program and willingness to commit to a year-long research experience.
4. Letter of recommendation from a CSULB faculty member familiar with the student's work.
5. Completion of CHEM 220A,B and one upper division chemistry lecture course. Students may apply during the semester in which they expect to complete these courses.
6. GPA of at least 3.00 in all courses in the major and in all upper division courses in the major.

Requirements for Graduation with Honors in the Major

1. GPA of at least 3.30 in all upper division courses in the major and in Honors courses.
2. Completion of all requirements for the B.S. in Biochemistry, B.S. in Chemistry, or B.A. in Chemistry.
3. Completion of one 500-level lecture course or 400/500 dual level course in chemistry (3 units).
4. Completion of 3 units CHEM 496, Undergraduate Directed Research.
5. Completion of 3 units of CHEM 498H, Senior Thesis - Honors.
6. Presentation of research results in a public forum. This requirement may be met by presentation at a scientific conference or at a local venue; consult the Honors in the Major advisor for additional information.

Substitutions to this program must be approved by the Honors in the Major Advisor.

Minor in Chemistry

Requirements

The Minor in Chemistry is available to any non-Chemistry or non-Biochemistry major. Students must earn a "C" or better in every course counted towards the minor.

A minimum of 19 units of chemistry coursework which must include a minimum of six units of upper division chemistry courses and the following:

CHEM 111A General Chemistry (5)

Prerequisites: A passing score on the Chemistry Placement Examination.

Corequisite: MATH 109 or higher.

CHEM 111B General Chemistry (5)

Prerequisites: CHEM 111A and MATH 113 or MATH 115 or MATH 119A or MATH 122 all with a grade of "C" or better.

If students choose to take Organic Chemistry, then they must use courses from only one of the two Organic Chemistry paths to meet the requirements of the minor:

CHEM 227 Fundamentals of Organic Chemistry (3)

Prerequisite: CHEM 111A with a grade of "C" or better; CHEM 111B is recommended.

or

CHEM 220A Organic Chemistry I (3)

Prerequisites: CHEM 111B with a grade of "C" or better.
Corequisites: CHEM 224 is required for students repeating course. CHEM 223A must be taken concurrently if required

by a degree plan.

CHEM 220B Organic Chemistry II (3)

Prerequisites: CHEM 220A with a grade of C or better

Corequisite: CHEM 223B or CHEM 320L except for students who previously earned a "C" or better in CHEM 223B or CHEM 320L

If students choose to take Physical Chemistry, then they must use courses from only one of the three Physical Chemistry paths to meet the requirements of the minor:

CHEM 371A Physical Chemistry: Thermodynamics and Kinetics (3)

Prerequisites: CHEM 111B, MATH 123, PHYS 152 (all with a grade of "C" or better).

Prerequisite/Corequisite: MATH 224.

CHEM 371B Physical Chemistry: Quantum Mechanics and Spectroscopy (3)

Prerequisites: CHEM 111B, MATH 123, PHYS 152 (all with a grade of "C" or better).

Prerequisite/Corequisite: MATH 224.

or

CHEM 375 Physical Chemistry for Engineers (3)

Prerequisites: MATH 123; PHYS 151 and either PHYS 152 or EE 210/EE 210L; CH E 220; CHEM 111A/B; and CHEM 220A or CHEM 227, all grades of "C" or better. CH E 310 is strongly recommended.

or

CHEM 377A Fundamentals of Physical Chemistry (3)

Prerequisites: CHEM 111B, MATH 123, and PHYS 152 (all with a grade of "C" or better).

CHEM 377B Fundamentals of Physical Chemistry (3)

Prerequisites: CHEM 111B, MATH 123, and PHYS 152 (all with a grade of "C" or better).

If students choose to take Biochemistry, then they must use courses from only one of the two Biochemistry paths to meet the requirements of the minor:

CHEM 441A Biological Chemistry (3)

Prerequisites: CHEM 220B and either CHEM 320L or CHEM 223B all with a grade of "C" or better; a biology or microbiology course is recommended.

CHEM 441B Biological Chemistry (3)

Prerequisites: CHEM 441A with a grade of "C" or better.

Or

CHEM 448 Fundamentals of Biological Chemistry (3)

Prerequisites: CHEM 220B or 227 either with a grade of "C" or better

In addition to the courses listed above the following courses may be used to complete the minor in chemistry: CHEM 223A, CHEM 223B, CHEM 251, CHEM 296, CHEM 320L, CHEM 331, CHEM 332, CHEM 373, CHEM 420, CHEM 421, CHEM 431, CHEM 443, CHEM 449, CHEM 451, CHEM 466, CHEM 480, CHEM 496.

The following courses are not acceptable toward the minor: CHEM 90, CHEM 100, CHEM 101, CHEM 140, CHEM 224, CHEM 302, CHEM 361

Graduate Credit Earned as an Undergraduate Chemistry or Biochemistry Major

Graduate credit usually may not be earned in advance of the baccalaureate degree. However, based upon the recommendation of the Department Chairman and the Chairman of the Department Graduate Studies Committee, academic performance (a grade point average of 3.00 overall and 3.00 in the major), and promise of academic

achievement in postgraduate study, a student in his/her senior year may be granted approval to earn a maximum of 12 units of course work in the 400 and 500 level taken at this University toward his/her prospective graduate program, subject to the following conditions:

1. The course work must be in addition to that required by the Department for the B.A. or B.S. degree in Chemistry or the B.S. degree in Biochemistry.

2. The undergraduate student must have a "Petition to Earn Credit in the Senior Year" approved by the appropriate Department Graduate Advisor, the Associate Dean for Graduate Accountability in the College of Natural Sciences and Mathematics, and the Dean of Graduate Studies.

Graduate Programs

Master of Science in Chemistry

Prerequisites

1. Acceptance as a graduate student by the Department of Chemistry and Biochemistry;
2. A bachelor's degree with a major in chemistry; or a bachelor's degree with undergraduate preparation in chemistry, physics and mathematics equivalent to that required for the bachelor's degree with a major in chemistry at this University. A student deficient in any of these courses must complete the course(s) as a graduate student. The courses that must be taken to make up those deficiencies will be determined by the Graduate Adviser in consultation with the Graduate Studies Committee. Students with majors in other areas may be considered for admission at the discretion of the Graduate Adviser.
3. Entering graduate students are required to take a minimum of two placement examinations (more exams may be required by Graduate Committee) as follows:
 - at the beginning of the first semester of the M.S. program: student chooses to take one placement examination in analytical, inorganic, organic, physical or biochemistry.
 - at the beginning of the second semester of the M.S. program, student takes any additional placement examination(s) required by the Thesis Committee to a minimum of two.

Under some circumstances with the approval of the Graduate Adviser, students may take 2 or more placement examinations at the beginning of the first semester.

Any student failing to pass a placement examination is required to complete with a minimum grade of "B" or better an appropriate course recommended by the Graduate Studies Committee. Usually the recommended courses are:

CHEM 251 and/or CHEM 451

if the subject is analytical chemistry;

CHEM 331 and/or CHEM 431

if the subject is inorganic chemistry;

CHEM 220A and/or CHEM 220B

if the subject is organic chemistry;

CHEM 371A and/or CHEM 371B

if the subject is physical chemistry;

CHEM 441A and/or CHEM 441B

if the subject is biochemistry.

4. The placement examinations are usually given on the Monday of the week preceding the first day of instruction. The Graduate Studies Committee evaluates the examination results and recommends appropriate courses to correct any deficiencies in chemistry.
5. Entering students must select a research advisor by the ninth week of the first semester. The thesis advisor will select two additional faculty members to serve on the Thesis Committee by the 13th week of the first semester. The Thesis Committee will prepare a degree program including the following: (1) additional placement examination(s) the student will take at the beginning of the second semester, (2) a list of graduate courses to be completed in the course of the program. The degree program must be finalized and forwarded to Graduate Advisor by the end of the first semester in residence. Any change in the approved degree program must be preauthorized by Graduate Advisor.
6. Each student shall prepare a thesis proposal in collaboration with the research advisor, stating the specific topic of the research and its significance, the specific objectives of the research, and the methods to be used. The thesis proposal must be approved by the Thesis Committee. The student must make a public presentation of the proposal by the end of the second semester in the MS program. Any major change in direction during the course of the research shall be subject to the approval of the Thesis Committee.

Advancement to Candidacy

The Department Graduate Studies Committee recommends advancement to candidacy after the graduate student has:

1. Either passed all the required placement examinations including those recommended by the Thesis Committee or achieved a grade of "B" or better in each course recommended by the Graduate Studies Committee for correcting the deficiencies;
2. Completed at least 6 units of courses on the proposed Graduate Program;
3. While in residence as a graduate student at this University, earned at least a 3.0 ("B") average in all upper division and graduate work, a 3.0 gpa in all CHEM courses, and a 3.0 GPA in all courses on the graduate program.
4. Fulfilled the Graduation Writing Assessment Requirement (GWAR);
5. Obtained approval of a graduate degree program by the Thesis Committee, the Graduate Adviser, the Department Chair (in consultation with the Graduate Studies Committee), and the Associate Dean or designee responsible for graduate studies in the College of Natural Sciences and Mathematics.
6. Make a public presentation of their thesis proposal and made appropriate progress in their proposed research as determined by the Thesis committee.

The criteria above should be met by the beginning of the third semester of graduate study. Deficient students may continue at the discretion of the Department Graduate Studies

Committee. Students should be advanced to candidacy as soon as they are eligible.

Requirements

1. Advancement to candidacy;
2. Complete a minimum of 30 units including:
 - A. Take a minimum of 12 units in chemistry lecture courses in the 500 series (excluding CHEM 595);
 - B. Take CHEM 595 Colloquium for a total of 2 or 3 units
Prerequisite: Graduate standing or consent of instructor.
 - C. Take CHEM 660 Seminar in Chemistry (1-3)
Prerequisite: None
 - D. Take CHEM 697 Directed Research (4-6)
Prerequisite: Arrangement with instructor.
 - E. Take CHEM 698 Thesis (4-6)
Prerequisites: Advancement to candidacy for M.S. in Chemistry or M.S. in Biochemistry and arrangement with instructor.
 - F. Additional courses (excluding CHEM 595 and required courses in the BS Chemistry degree program) as approved by Thesis Committee with concurrence of Graduate Advisor.Changes in the above pattern of course requirements may be made only by the Graduate Studies Committee and the Graduate Advisor subject to approval by the College's Associate Dean.
3. Completion of a written thesis, of publication quality, acceptable to the members of the thesis committee and a public presentation of the thesis research. The public presentation must be completed before the thesis is signed by the committee members.
4. A record of regular attendance at departmental seminars, poster sessions, thesis proposal presentations, and thesis defenses.
5. While not a requirement for the degree, students in the MS program normally gain experience teaching laboratory sections of Chemistry courses, as preparation for professionally related teaching activities in their future careers.

Master of Science in Biochemistry

Prerequisites

1. Acceptance as a graduate student by the Department of Chemistry and Biochemistry;
2. A bachelor's degree with a major in chemistry or biochemistry or one of the biological sciences. Students with majors in other areas may be considered for admission at the discretion of the Graduate Advisor. Prerequisite courses include CHEM 220A,B, CHEM 377A,B, CHEM 441A,CHEM 441B, CHEM 443; MATH 122, MATH 123; PHYS 100A,B or their equivalents and courses in general biology and cell/molecular biology. A student deficient in any of these courses must complete the course(s) as a graduate student.
3. Entering graduate students are required to take a placement examination in biochemistry at the beginning of the first semester of the MS program. A second placement examination in either organic chemistry or physical chemistry must be taken by the beginning of the second semester. Any student failing to pass a placement examination, is required to complete an appropriate course recommended by the

Graduate Studies Committee with a minimum grade of "B" or better. Usually the recommended courses are:

CHEM 220A and/or CHEM 220B

if the subject is organic chemistry.

(CHEM 371A or CHEM 377A) and/or (CHEM 371B or CHEM 377B)

if the subject is physical chemistry.

CHEM 441A and/or CHEM 441B

if the subject is biochemistry.

Under some circumstances, with the approval of the Graduate Advisor, students may take both placement examinations at the beginning of the first semester.

4. The placement examinations are usually given on the Monday of the week preceding the first day of instruction. The Graduate Studies Committee evaluates the examination results and recommends appropriate courses to correct any deficiencies in chemistry. 5. Entering students must select a research advisor by the ninth week of the first semester. The advisor will select two additional faculty members to serve on the Thesis Committee by the end of the 13th week of the first semester. The Thesis Committee will prepare a degree program including the following (1) the second placement examinations (in organic or physical chemistry) the student will take at the beginning of the second semester, (2) a list of graduate courses to be completed in the course of the program. The degree program must be finalized and forwarded to the Graduate Advisor by the end of the first semester in residence. Any changes in the approved degree program must be preauthorized by the Graduate Advisor.
5. Each student shall prepare a thesis proposal in collaboration with the thesis advisor, stating the specific topic of the research and its significance, the specific objectives of the research, and the methods to be used. The thesis proposal must be approved by the Thesis Committee. The student must make a public presentation of the proposal by the end of the second semester in the MS program. Any major change in direction during the course of the research shall be subject to the approval of the Thesis Committee.

Advancement to Candidacy

The Department's Graduate Studies Committee recommends advancement to candidacy after the graduate student has:

1. Either passed all the required placement examinations including those recommended by the Thesis Committee or achieved a grade of B or better in courses recommended by the Graduate Studies Committee for correcting the deficiencies;
2. Completed at least 6 units of courses on the proposed Graduate Program;
3. While in residence as a graduate student at this University, earned at least a 3.0 ("B") average in all upper division and graduate work, a 3.0 gpa in all CHEM courses, and a 3.0 gpa in all courses on the graduate program.
4. Fulfilled the Graduation Writing Assessment Requirement (GWAR);

5. Obtained approval of a graduate degree program by the Thesis Committee, the Graduate Adviser, the Department Chair (in consultation with the Graduate Studies Committee), and the Associate Dean responsible for graduate studies in the College of Natural Sciences and Mathematics.
6. Made a public presentation of their thesis proposal and made appropriate progress in their proposed research as determined by the Thesis committee.

The criteria above should be met by the beginning of the third semester of graduate study. Deficient students may continue at the discretion of the Department Graduate Studies Committee. Students should be advanced to candidacy as soon as they are eligible.

Requirements

1. Advancement to candidacy;
2. Complete a minimum of 30 units including:
 - A. Take a minimum of 12 units in chemistry lecture courses in the 500 series that must include CHEM 541 (excluding CHEM 595);
 - B. Take BIOL 540. In some circumstances, 3 units of another 500-level biology lecture course may be substituted with the approval of the Graduate Advisor.
 - C. Take CHEM 595 Colloquium for a total of 2 units
Prerequisite: Graduate standing or consent of instructor.
 - D. Take CHEM 660 Seminar in Chemistry (1-3)
Prerequisite: None
 - E. Take CHEM 697 Directed Research (3) and CHEM 697C Directed Research (1-3)
Prerequisite: Arrangement with instructor.
 - F. Take CHEM 698 Thesis (4-6)
Prerequisites: Advancement to candidacy for M.S. in Chemistry or M.S. in Biochemistry and arrangement with instructor.
 - G. Additional 400- and 500-level science courses (excluding CHEM 595 and required courses in the BS Biochemistry degree program) as recommended by the Thesis Committee and approved by the Graduate Advisor and the College's Associate Dean.
Changes in the above pattern of course requirements may be made only at the discretion of the Graduate Studies Committee and the Graduate Advisor subject to approval by the College's Associate Dean or designee.
3. Completion of a written thesis, of publication quality, acceptable to the members of the Thesis Committee and a public presentation of the thesis research. The public presentation must be completed before the thesis is signed by the committee members.
4. A record of regular attendance at departmental seminars, poster sessions, thesis proposal presentations and thesis defenses.
5. While not a requirement for the degree, students in the MS program normally gain experience teaching laboratory sections of Chemistry courses, as preparation for professionally related teaching activities in their future careers.

Single Subject Teaching Credential in Chemistry

For information, refer to the undergraduate section in this department.

Chemistry and Biochemistry Courses (CHEM)

PREBACCALAUREATE

90. Introduction to General Chemistry (4)

Prerequisite/Corequisite: MATH 109 or higher.

Preparatory course for CHEM 111A. Recommended for students who have not achieved a satisfactory score on the Chemistry Placement examination. Basic principles and concepts including atomic structure, nomenclature, and chemical calculations with emphasis on problem solving.

Credit/No Credit grading only. Cannot be taken for credit toward a university degree. Credit in CHEM 90 or CHEM 101 does not substitute for a passing score on the Chemistry Placement Test. Not open to students with credit in CHEM 101. (Lecture 3 hrs., activity 2 hrs.) May be offered in a hybrid format.

LOWER DIVISION

100. Chemistry and Today's World (4)

Prerequisite: One GE Foundation course (GE categories A1, A2, A3, or B2).

Introduction to basic principles of chemistry and a consideration of the benefits and problems arising from applications of chemistry. Discussions of foods and food additives, drugs, plastics, and other materials of everyday life, fuel sources, the atmosphere, and fresh water. Suitable for general education credit.

Not open for credit to chemistry or biochemistry majors or students with credit in CHEM 111A or CHEM 140. (Lecture 3 hrs., laboratory 3 hrs.) Course fee may be required.

111A. General Chemistry (5)

Prerequisites: A passing score on the Chemistry Placement Examination.

Corequisite: MATH 109 or higher.

Students not planning to continue onto CHEM 111B may be concurrently enrolled in MATH 109.

Other students need to be concurrently enrolled in MATH 113 or MATH 115 or MATH 119A or MATH 122.

One year of high school chemistry is strongly recommended.

(This course is recommended for those intending to pursue careers in science or engineering.)

First semester of a two-semester sequence (CHEM 111A and CHEM 111B). Introduction to principles of chemistry including chemical reactions, stoichiometry, thermochemistry, electronic structure, bonding, and properties of solids, liquids, gases, and solutions.

Letter grade only (A-F). Credit in CHEM 90 or CHEM 101 does not substitute for a passing score on the Chemistry Placement Examination.

(Lecture 3 hrs., lab and problem solving session 6 hrs.) Course fee may be required.

111B. General Chemistry (5)

Prerequisites: CHEM 111A and MATH 113 or MATH 115 or MATH 119A or MATH 122 all with a grade of "C" or better.

Second semester of a two-semester sequence (CHEM 111A and CHEM 111B). Continuation of chemical principles, chemical equilibrium, kinetics, thermodynamics, electrochemistry, elements of qualitative and quantitative inorganic analysis. Solving aqueous equilibrium problems are emphasized.

Letter grade only (A-F). (Lecture 3 hrs., lab and problem solving sessions 6 hrs.) Course fee may be required.

112A. Advanced General Chemistry (5)

Prerequisite: Department consent.

First semester of a two-semester advanced general chemistry sequence (CHEM 112A and CHEM 112B). Introduction to principles of chemistry including chemical reactions, stoichiometry, thermochemistry, electronic structure, bonding, and properties of solids, liquids, gases, and solutions, kinetics, and equilibrium.

Letter grade only (A-F). (Lecture 3 hrs., lab and problem session 6 hrs.)

112B. Advanced General Chemistry (5)

Prerequisite: CHEM 112A with a grade of "C" or better.

Second semester of a two-semester advanced general chemistry sequence (CHEM 112A and CHEM 112B). Continuation of chemical principles, electrochemistry, applications of bonding theories of inorganic molecules, trends and reactivities of elements and their compounds, elements of qualitative and quantitative inorganic analysis, introduction to coordination chemistry, solid-state chemistry, and reactions of transition metals. Solving aqueous equilibrium problems is emphasized.

Letter grade only (A-F). (Lecture 3 hrs., lab and problem session 6 hrs.).

140. General, Organic, and Biochemistry (5)

Prerequisites: Restricted to Pre-Nursing majors. A grade of "C" or better in MATH 109 or MATH 113 or MATH 117 or MATH 119A or MATH 122 or STAT 108; high school chemistry or equivalent.

This one-semester course encompasses general chemistry, organic chemistry, and biochemistry. Meets chemistry requirement for pre-nursing curriculum.

Letter grade only (A-F). (Lecture 3 hrs; problem solving session 1 hr., and laboratory 3 hrs.) Course fee may be required.

220A. Organic Chemistry I (3)

Prerequisites: CHEM 111B with a grade of "C" or better.

Corequisites: CHEM 224 is required for students repeating course. CHEM 223A must be taken concurrently if required by a degree plan.

First semester of two-semester sequence (CHEM 220A, CHEM 220B; and CHEM 223A and CHEM 223B or CHEM 320L). Sequence meets requirements for medical and dental schools. Emphasis is upon application of modern principles of structure, reactivity, methods of synthesis, physical properties and spectroscopy. Not open to students with credit in CHEM 320A or CHEM 322A.

Letter grade only (A-F). (Lecture 3 hrs.)

220B. Organic Chemistry II (3)

Prerequisite: CHEM 220A with a grade of "C" or better.

Corequisite: CHEM 223B or CHEM 320L except for students who previously earned a "C" or better in CHEM 223B or CHEM 320L.

Second semester of two-semester sequence (CHEM 220A, CHEM 220B; CHEM 223A and CHEM 223B or CHEM 320L). Continuation of study of organic chemistry including chemistry or compounds containing more than one functional group, bioorganic molecules, and special topics. Not open to students with credit in CHEM 320B or CHEM 322B. Letter grade only (A-F). (Lecture 3 hrs.)

223A. Organic Chemistry Laboratory I (1)

Corequisite: CHEM 220A, except for students who have previously earned a "C" or better in CHEM 220A.

Introduction to organic laboratory techniques. First semester of a two-semester sequence (CHEM 223A, CHEM 223B). Not applicable to a degree in chemistry or biochemistry. Not open to students with credit in CHEM 320L or CHEM 323A.

Letter grade only (A-F). (Laboratory 3 hrs.)

223B. Organic Chemistry Laboratory II (1)

Prerequisites: CHEM 220A and CHEM 223A, both with a grade of "C" or better. Corequisite: CHEM 220B, except for students who have previously earned a "C" or better in CHEM 220B.

Synthesis and characterization of organic and bioorganic compounds. Second semester of a two-semester sequence (CHEM 223A, CHEM 223B). Not applicable to a degree in chemistry or biochemistry. Not open to students with credit in CHEM 320B, or CHEM 320L, or CHEM 323B.

Letter grade only (A-F). (Laboratory 3 hrs)

224. Organic Chemistry Recitation (1)

Corequisite: CHEM 220A.

Problem solving session emphasizing principles learned in first semester organic chemistry.

Credit/No Credit grading only. May be repeated to a maximum of 3 units in different semesters. (Problem solving session 1 hr.) Does not count for General Education credit.

227. Fundamentals of Organic Chemistry (3)

Prerequisite: CHEM 111A with a grade of "C" or better; CHEM 111B is recommended.

Lecture course in chemistry of the carbon compounds.

Letter grade only (A-F). Not applicable to a degree in chemistry. (Lecture 3 hrs.) Not open for credit to students with credit in CHEM 327.

251. Quantitative Analysis (4)

Prerequisite: CHEM 111B with a grade of "C" or better. Strongly recommended for pre-pharmacy students and students planning careers in clinical or analytical laboratory sciences. It is strongly recommended that CHEM 251 be taken within one calendar year of CHEM 111B.

Introduction to techniques and theory of gravimetric and volumetric analysis, spectrophotometry, potentiometry, and chromatography.

Letter grade only (A-F). (Lecture 2 hrs., laboratory 6 hrs.) Course fee may be required.

296. Research Methods (1)

Prerequisites: CHEM 111A or CHEM 112A (grade of "B" or better) or consent of Instructor

Introduction to research methods in chemistry. Mixed course designed primarily to introduce lower division students to research before they take CHEM 496.

Letter grade only (A-F). (Lecture/seminar based course only)

UPPER DIVISION

302. Survey of Biochemistry (3)

Prerequisites: A minimum of 3 units of university-level general and organic chemistry with grade of "C" or better.

Study of the chemistry, structures, metabolic reactions and functions of the major classes of biochemical compounds. Does not meet the requirements of medical or dental schools.

Letter grade only (A-F). Does not count for General Education credit. (Lecture 2 hrs., discussion 1 hr.)

320L. Organic Chemistry Laboratory (2)

Prerequisite: CHEM 220A.

Corequisite: CHEM 220B, except for students who have previously earned a "C" or better in CHEM 220B.

Introduction to organic laboratory techniques, synthesis and characterization of organic and bioorganic compounds.

Letter grade only (A-F). Not open for credit to students with credit in CHEM 320B. (Laboratory 6 hrs). Course fee may be required.

331. Inorganic Chemistry (3)

Prerequisites: CHEM 111B with a grade of "C" or better.

Introduction to coordination chemistry, solid-state chemistry, and reactions of transition metals.

Letter grade only (A-F). (Lecture 3 hrs.)

332. Inorganic Chemistry Laboratory (2)

Prerequisite/Corequisite: CHEM 331.

Synthesis, characterization, and manipulation of inorganic compounds and materials.

Letter grade only (A-F). (Laboratory 3 hrs.)

361. Chemical Communications (3)

Prerequisites: GE Foundation requirement. Students must have scored 11 or higher on the GEAR Placement Examination or completed the necessary portfolio course that is a prerequisite for a GEAR Writing Intensive Capstone.

Prerequisite/Corequisite: CHEM 220A.

Using the chemical literature. Writing technical reports for various purposes. Oral presentation of chemical information. Includes extensive writing. Fulfills the GE Writing Intensive Capstone requirement.

Letter grade only (A-F). (Seminar 3 hrs.)

371A. Physical Chemistry: Thermodynamics and Kinetics (3) F

Prerequisites: CHEM 111B, MATH 123, PHYS 152 (all with a grade of "C" or better).

Prerequisite/Corequisite: MATH 224.

Half of the two semester physical chemistry package. The two courses, CHEM 371A,B, may be taken in either order. Principles and applications of classical thermodynamics; introduction to chemical kinetics.

Letter grade only (A-F). (Lecture 3 hrs.)

371B. Physical Chemistry: Quantum Mechanics and Spectroscopy (3)

Prerequisites: CHEM 111B, MATH 123, PHYS 152 (all with a grade of "C" or better).

Prerequisite/Corequisite: MATH 224.

Half of the two semester physical chemistry package. The two courses CHEM 371A,B may be taken in either order. Principles and applications of quantum chemistry, spectroscopy, and statistical thermodynamics.

Letter grade only (A-F). (Lecture 3 hrs.)

373. Physical Chemistry Laboratory (3)

Prerequisites: CHEM 361, CHEM 371A or 377A, and CHEM 371B or 377B, all with a grade of "C" or better.

Introduction to basic physico-chemical experimental techniques with applications to principles discussed in CHEM 371A,B and CHEM 377A,B.

Letter grade only (A-F). (Lecture 1 hr., laboratory 6 hrs.)

375. Physical Chemistry for Engineers (3)

Prerequisites: MATH 123; PHYS 151 and either PHYS 152 or EE 210/EE 210L; CH E 220; CHEM 111A/B; and CHEM 220A or CHEM 227, all grades of "C" or better. CH E 310 is strongly recommended.

Principles and applications of real gases, liquids, and solutions; intra- and intermolecular interactions; kinetic theory and chemical kinetics; quantum chemistry, chemical bonding, and spectroscopy.

Letter grade only (A-F). (Lecture 3 hrs)

377A. Fundamentals of Physical Chemistry (3)

Prerequisites: CHEM 111B, MATH 123, and PHYS 152 (all with a grade of "C" or better).

Half of the two semester physical chemistry package with a biochemical emphasis. The two courses CHEM 377A,B may be taken in either order. Principles of physical chemistry emphasizing thermodynamics and chemical kinetics. Biological and environmental science examples used to illustrate principles.

Letter grade only (A-F). (Lecture 3 hrs.)

377B. Fundamentals of Physical Chemistry (3)

Prerequisites: CHEM 111B, MATH 123, and PHYS 152 (all with a grade of "C" or better).

Half of the two semester physical chemistry package with a biochemical emphasis. The two courses CHEM 377 A,B may be taken in either order. Principles of physical chemistry with emphasis on molecular structure and spectroscopy.

Letter grade only (A-F). (Lecture 3 hrs.)

385. Materials Science (3)

Prerequisite: CHEM 111A and PHYS 152 and (CHEM 111B or PHYS 320), completion of CHEM 111B is strongly recommended.

Introduction to general principles of energy materials including catalytic, photovoltaic, and thermoelectric materials based on nanostructural and/or nanoporous systems. Students will be required to complete preparatory modules on Kinetics (reaction dynamics), Electrochemistry, Fermi statistics, and Diodes.

Letter grade only (A-F). Same course as PHYS 385. Not open for credit to students with credit in PHYS 385.

385C. Materials Science Colloquium (1)

Prerequisite: CHEM 111A and PHYS 152 and (CHEM 111B or PHYS 320), completion of CHEM 111B is strongly recommended

Discussion of advances as reported in recent literature related to energy materials. Provides experience in library use, organization, presentation, and critical evaluation of the literature.

Letter grade only (A-F). Same course as PHYS 385C. Not open for credit to students with credit in PHYS 385C.

385L. Materials Science Laboratory (2)

Prerequisite: CHEM 111A and PHYS 152 and (CHEM 111B or PHYS 320), completion of CHEM 111B is strongly recommended

Introduction to synthesis, characterization methods, and property measurement of advanced materials

Letter grade only (A-F). Course fee may be required. (Laboratory 6 hours). Same course as PHYS 385L. Not open for credit to students with credit in PHYS 385L.

420. Advanced Organic Chemistry Laboratory (3)

Prerequisites: CHEM 220B or CHEM 320L and either CHEM 361 or CHEM 466, all with a grade of "C" or better.

Synthesis and characterization of organic compounds. Organic structures analyzed through interpretation of spectral data. Emphasis on use of high field NMR, mass spectrometry, IR, and UV. Applications of modern separation techniques.

In addition to regularly scheduled lectures, students are expected to attend three hours of lecture on use of chemical literature. Letter grade only (A-F). Course fee may be required. (Lecture 1 hr., laboratory 6 hrs.)

421./521. Physical Organic Chemistry (3) F

Prerequisites: CHEM 220B with a grade of "C" or better.

Prerequisite/Corequisite: CHEM 371B or CHEM 377B.

Undergraduates enroll in CHEM 421; graduates in CHEM 521.

Theoretical interpretation of chemical and physical properties of organic compounds: mathematical derivations of rate equations from experimental results, quantitative comparison of organic compounds reactivities, mathematical correlations of structure and properties. Solving problems relating to reaction mechanisms to described factors.

Letter grade only (A-F). (Lecture 3 hrs.)

431. Advanced Inorganic Chemistry (3) F

Prerequisite(s): CHEM 331, with a grade of "C" or better.

Prerequisite(s)/Corequisite(s): CHEM 371B.

Quantitative study of chemical bonding in inorganic molecules emphasizing on molecular orbital theory. Transition metal chemistry including coordination chemistry, ligand field theory, spectroscopy applications to structural analysis of inorganic molecules, and review of properties and reactivities of elements and their compounds.

Letter grade only (A-F). (Lecture 3 hrs.)

441A. Biological Chemistry (3)

Prerequisites: CHEM 220B and either CHEM 320L or CHEM 223B all with a grade of "C" or better; a biology or microbiology course is recommended.

First semester of a two-semester sequence (CHEM 441A and 441B) in biochemistry. Chemical and mathematical treatment of energetics and kinetics of reactions in living systems, including chemistry and metabolism of carbohydrates and chemistry of proteins.

Letter grade only (A-F). (Lecture 3 hours)

441B. Biological Chemistry (3)

Prerequisite: CHEM 441A with a grade of "C" or better.

Second semester of two-semester sequence (CHEM 441A and CHEM 441B) in biochemistry. Metabolism of lipids, proteins, and nucleic acids, and other advanced topics in metabolism.

Letter grade only (A-F). (Lecture 3 hours)

443. Biological Chemistry Laboratory (4)

Prerequisites: Prerequisites: CHEM 441A and either CHEM 361 or CHEM 466; all with a grade of "C" or better.

Theory and practice of laboratory techniques used in biochemical research.

Letter grading only (A-F). (Lecture 1 hr., laboratory 9 hrs.) Course fee may be required.

448. Fundamentals of Biological Chemistry (3)

Prerequisites: CHEM 220B or CHEM 227 either with a grade of "C" or better.

Major principles of biochemistry including metabolic processes, biological control and regulatory processes, nutrition and chemical energetics and kinetics of animals, plants and microorganisms. Emphasis on major concepts and problem solving.

Not open to chemistry majors. Not open for credit to students with credit in CHEM 441A,B. Letter grade only (A-F). (Lecture 3 hrs.)

449. Nutritional Biochemistry Laboratory (1)

Prerequisite: CHEM 448 with a grade of "C" or better. May be taken concurrently with CHEM 448.

Analytical and biochemical analyses of foodstuffs and other compounds of biochemical interest.

Letter grade only (A-F). (Laboratory 3 hrs.) Course fee may be required.

451. Instrumental Methods of Analysis (5)

Prerequisites: PHYS 152, CHEM 361; CHEM 371B or CHEM 377B; all with a grade of "C" or better.

Theory and application of instrumental methods to chemical problems. Includes measurement basics, atomic and molecular spectroscopy, electroanalytical chemistry, separation methods, surface analysis, and statistical evaluation of analytical data.

Letter grade only (A-F). (Lecture 3 hrs., laboratory 6 hrs.) Course fee may be required.

461. Chemistry Capstone (1) F,S

Prerequisite/Corequisite: Department consent.

The capstone course for chemistry and biochemistry seniors integrating knowledge and skills from different disciplines of chemistry and biochemistry. Includes discussion of regulatory affairs, ethics in research, and seminars on research topics in chemistry and biochemistry.

Letter grade only (A-F). (Seminar 1 hr)

466. Research Design and Methods (3) S

Prerequisites: BIOL 211, BIOL 212, BIOL 213, either BIOL 260 or CHEM 251, CHEM 220A,B and CHEM 223A,B all with a grade of "C" or better; GE Foundation requirement; a GPA of at least 3.0 in the major; and consent of the instructor. At least one unit of BIOL 496 or CHEM 496.

Corequisites: At least one unit of BIOL 496 or CHEM 496.

Introduction to hypothesis testing, experimental design, methodological and technical procedures for experimentation, grant writing, and techniques for written and oral presentation of research results. Research paper and oral presentation required.

Letter grade only (A-F). Same course as BIOL 466. (Lecture 3 hours). Not open for credit to students with credit in BIOL 466, BIOL 466H or CHEM 466H.

480./580. Biomolecular Modeling and Simulation (3)

Prerequisites: CHEM 220A, MATH 123 (may be taken concurrently), and PHYS 100B or PHYS 152, all with a grade of "C" or better.

The study of biomolecular phenomena using computer-based modeling and simulation techniques with varying degrees of resolution, including development and validity of molecular models.

Letter grade only (A-F). (Lecture 3 hrs.)

485. Special Topics in Materials Chemistry (3)

Prerequisite: CHEM 220B and CHEM 331 and CHEM 385 or consent of instructor

Areas of current interest in materials chemistry with introduction to principles of materials synthesis, characterization, and application.

Letter grade only (A-F)

496. Undergraduate Directed Research (1-3)

Prerequisite: Consent of instructor.

Research in a specific topic in chemistry or biochemistry approved and directed by faculty. Written report required.

May be repeated to a maximum of 6 units. (Independent Study).

498H. Senior Thesis – Honors (1-3)

Prerequisites: CHEM 466; at least one unit of CHEM 496 with a grade of "A"; admission into the Honors in Chemistry program, and consent of instructor.

Planning, preparation, and completion of thesis based on a research project in chemistry or biochemistry.

Letter grade only (A-F). Not available to graduate students.

498. Senior Thesis (3)

Prerequisites: Major GPA 3.0 or higher, 3 units of CHEM 496 with a grade of "A", consent of instructor.

Continuation of research in chemistry and biochemistry, planning, preparation, and completion of thesis based on original research project. Submission of acceptable thesis meeting the guidelines for research reports issued by the Committee on Professional Training American Chemical Society is required.

Letter grade only (A-F). Not available for graduate students.

499. Directed Reading (1)

Survey of chemical literature on some topic of current interest under supervision of a faculty member. Preparation of a written report based on readings.

Letter grade only (A-F). Not open for credit to graduate students.

GRADUATE LEVEL

521./421. Physical Organic Chemistry (3) F

Prerequisites: CHEM 220B with a grade of "C" or better.
Prerequisite/Corequisite: CHEM 371B or CHEM 377B.
Undergraduates enroll in CHEM 421; graduates in CHEM 521.

Theoretical interpretation of chemical and physical properties of organic compounds: mathematical derivations of rate equations from experimental results, quantitative comparison of organics compounds reactivities, mathematical correlations of structure and properties. Solving problems relating to reaction mechanisms to described factors.

Letter grade only (A-F). (Lecture 3 hrs.)

522. Selected Topics in Organic Chemistry (3)

Prerequisite: CHEM 421 or CHEM 521 or consent of instructor.

Areas of current interest in organic chemistry.

Letter grade only (A-F). May be repeated to a maximum of 6 units with different topics. Topics announced in the *Schedule of Classes*. (Lecture 3 hrs.)

523. Synthetic Methods (3)

Prerequisites: CHEM 220B with a grade of "C" or better; CHEM 521 recommended

Introduction to current methods of synthetic transformations; topics may include, but not limited to the following: Retrosynthetic analysis, protecting groups, functional group transformations, enolate chemistry, organometallics, stereochemistry and conformational analysis, pericyclic reactions, alkene functionalization and reactions of carbon nucleophiles.

Letter grade only (A-F). (Lecture 3 hrs.)

524. Catalysis in Organic Chemistry (3)

A study of catalysis beginning with a general theory of catalysis. The course also covers catalysis in synthetic organic chemistry centered on metals and ligated metals and catalysis centered on organic molecules as the catalytic species.

Letter grade only (A-F). (Lecture 3 hrs.)

525. Introduction to Supramolecular Chemistry (3)

Prerequisites: Proficiency in any of the following as demonstrated by ACS placement exam: Organic, Biochemistry or Inorganic

Introduction to non-covalent interactions will be presented in the context of molecular recognition and self-assembly. Synthetic and biological examples will be used to understand these principles and how they can be applied to the preparation of new materials.

Letter grade only (A-F). (Lecture 3 hrs.)

531. Advances in Inorganic Chemistry (3)

Prerequisite: CHEM 431 or consent of instructor.

Current topics and advances in inorganic chemistry.

May be repeated to a maximum of 6 units with different topics.

Letter grade only (A-F). (Lecture 3 hrs.)

532. Inorganic Materials Chemistry (3)

Prerequisite: CHEM 431 or consent of instructor.

Advanced studies in bonding in solids, crystal structure variations, band theory and electronic structure, crystal structure-electronic structure-physical properties relationship, electron transport properties, magnetic materials, materials by design for technological applications.

Letter grade only (A-F). (Lecture 3 hrs.)

533. Physical Techniques in Inorganic Chemistry (3)

Prerequisite: CHEM 431 or consent of instructor.

An introduction to physical techniques commonly used in inorganic chemistry with focus on the magnetic resonance spectroscopic techniques: EPR and multinuclear NMR.

Letter grade only (A-F). (Lecture 3 hrs.)

534. Crystal Structure Analysis (3)

Prerequisite: CHEM 431 or consent of instructor.

An introduction to structural methods commonly used in inorganic chemistry with focus on single crystal and powder X-ray diffraction.

Letter grade only (A-F). (Lecture 3 hrs.)

541. Biochemistry Core for Graduate Study (3)

Prerequisites: CHEM 441A,B

The course is divided into three topics: (i) structure and evolution of proteins and their complexes with nucleic acids, lipids and carbohydrates, including structure determination methods; (ii) metabolic regulation from mechanistic and physiological viewpoints; (iii) applications of biochemical methodologies.

Letter grade only (A-F). (Lecture 3 hrs.)

542. Selected Topics in Biochemistry (3)

Prerequisites: CHEM 441B and CHEM 541 all with a grade of "C" or better; or consent of instructor.

Intensive discussion of a limited aspect of biochemistry with reference to current literature. Course content will vary from year to year.

May be repeated to a maximum of 6 units with different topics in different semesters. Topics announced in the *Schedule of Classes*. (Lecture 3 hrs.) Letter grade only (A-F).

544. Physical Biochemistry (3)

Prerequisites: Either CHEM 371A,B or CHEM 377A,B; CHEM 441B; CHEM 541 all with the grade of "C" or better; or consent of instructor.

Physical chemical aspects of protein and nucleic acid chemistry and related analytical methods.

Letter grade only (A-F). (Lecture 3 hrs.)

546. Protein Structure and Function (3)

Prerequisites: Either CHEM 371B or CHEM 377B; and both CHEM 441A and CHEM 541 with the grade of "C" or better; or consent of instructor.

Principles of protein structure, folding, and function. Includes techniques used for the production, isolation and characterization of proteins.

Letter grade only (A-F). (Lecture 3 hrs.)

547. Biochemistry of Nucleic Acids (3)

Prerequisites: CHEM 441B, CHEM 541 with the grade of "C" or better; or consent of instructor.

Gene expression with emphasis on regulatory mechanisms. Analytical techniques for isolation, purification, and characterization of nucleic acids.

Letter grade only (A-F). (Lecture 3 hrs.)

548. Cell Membranes (3)

Prerequisites: BIOL 340, BIOL 370, CHEM 441A, CHEM 541 with the grade of "C" or better; or consent of instructor.

Examination of modern membrane biochemistry. May include membrane structure and transport, phospholipids sorting, vesicular transport, membrane coat protein structure and function, and membrane-dependent signal transduction.

Letter grade only (A-F). (Lecture 3 hrs.)

549. Biochemistry of Lipids and Lipoproteins (3)

Prerequisites: BIOL 340, CHEM 441B, CHEM 541 all with the grade of "C" or better; or consent of instructor.

Current topics on the biochemistry of lipids and lipoproteins in health and disease. Lipid absorption, synthesis and transport; Cellular uptake of lipoproteins, lipid storage and mobilization; lipid signaling; cellular lipid efflux.

Letter grade only (A-F). (Lecture 3 hrs.)

552. Selected Topics in Analytical Chemistry (3)

Prerequisite: CHEM 451 or consent of instructor.

Including electrochemical measurements, chromatographic techniques, spectroscopic techniques, radiochemical analysis and basic electronic components of instrumentation. Emphasizing the chemical principles involved, utility and limitations of each method. Includes trace analysis of water and air.

Letter grade only (A-F). May be repeated to a maximum of 6 units with different topics. Topics announced in the *Schedule of Classes*. (Lecture 3 hrs.)

553. Fundamentals of Electroanalytical Chemistry (3)

In-depth description of electrochemical processes and research techniques. Voltammetric, potentiometric, and impedance methods. Scanning probe techniques. Analysis of current research literature related to electroanalytical chemistry and surface science.

Letter grade only (A-F). (Lecture 3 hrs.)

572. Advanced Physical Chemistry (3)

Prerequisite: CHEM 371B or consent of instructor.

Special topics in physical chemistry.

May be repeated to a maximum of 6 units with different topics.

Letter grade only (A-F). (Lecture 3 hrs.)

573. Molecular Spectroscopy (3)

Prerequisite: CHEM 371B or consent of instructor.

The interaction of electromagnetic radiation with atoms and molecules. Symmetry properties of molecules and the Hamiltonian. Angular momentum and the spectra of atoms and molecules. Pure rotational, vibrational, Raman, and electronic spectra of molecules. Understanding and predicting molecular spectra.

Letter grade only (A-F). (Lecture 3 hrs.)

574. Kinetics and Dynamics (3)

Prerequisite: CHEM 371A or consent of instructor.

Reaction rates for chemical systems; dependence on concentration and temperature. Derivation of the mechanisms of chemical reactions. Kinetic theory and analysis of experimental results for different systems. Dynamics of chemical reactions; transition state theory, potential-energy surfaces, and reaction pathways.

Letter grade only (A-F). (Lecture 3 hrs.)

580./480. Biomolecular Modeling and Simulation (3)

Prerequisites: CHEM 220A; MATH 123 (may be taken concurrently); PHYS 100B or PHYS 152, all with a grade of "C" or better.

The study of biomolecular phenomena using computer-based modeling and simulation techniques with varying degrees of resolution, including development and validity of molecular models.

Letter grade only (A-F). (Lecture 3 hrs.)

581. Biological Performance of Materials (3)

Advance studies of the chemical and mechanical interactions between materials used in medical devices and implants and living organisms. The course content includes materials response to biological system and host response to biomaterials.

Letter grade only (A-F). (Lecture 3 hrs.)

595A. Colloquium in Biochemistry (1)

595B. Colloquium in Organic Chemistry (1)

595C. Colloquium in Analytical, Physical and Inorganic Chemistry (1)

Prerequisite: Graduate standing or consent of instructor.

Discussion of advances as reported in recent literature. Provides experience in library use, organization, presentation, and critical evaluation of the chemical literature.

May be repeated to a maximum of 3 units (not more than a total of 3 units may be earned in any combination of CHEM 595 courses). Letter grade only (A-F). (Seminar 1 hr.)

660. Seminar in Chemistry (1)

Weekly meetings for presentation and discussion of advanced work in special fields including original research by faculty and graduate students.

Credit/No Credit grading only. (Seminar 1 hr.) May be repeated to a maximum of 3 units.

695. Directed Reading (1)

Survey of information in chemical literature on a current research topic, under direction of a faculty member. Written report prepared from these readings.

Letter grade only (A-F).

697. Directed Research (1-6)

Prerequisite: Arrangement with instructor.

Laboratory work supervised on an individual basis. A written report will be required.

Letter grade only (A-F). May be repeated to a maximum of 3 units.

697C. Directed Research (1-3)

Prerequisite: Arrangement with Instructor

Continuation of laboratory work supervised on an individual basis. A written report will be required.

Credit/No Credit grading only. May be repeated to a maximum of 3 units.

698. Thesis (1-6)

Prerequisites: Advancement to candidacy for M.S. in Chemistry or M.S. in Biochemistry and arrangement with instructor.

Planning, preparation and completion of a thesis in chemistry or biochemistry.

Letter grade only (A-F).

GEOLOGICAL SCIENCES

College of Natural Sciences and Mathematics

Department Chair: Stanley C. Finney

Department Office: Hall of Science (HSCI) 322
Telephone/FAX: (562) 985-4809 / (562) 985-8638
Website: www.csulb.edu/depts/geology/index.shtml

Faculty: Matthew Becker, Richard J. Behl, Stanley C. Finney, Robert D. Francis, Roswitha B. Grannell, K. Benjamin Hagedorn, Gregory J. Holk, Thomas Kelty, Nathan Onderdonk, Lora Stevens

Administrative Support Coordinator: Margaret Costello

Advisors:

Undergraduate: Thomas Kelty
Credential: James Kisiel, Tim Williamson
Graduate: Lora Stevens-Landon

Students desiring information should contact the Department Office for referral to one of the faculty advisors.

Career Possibilities

Geologist • Geophysicist • Hydrologist • Mineralogist • Paleontologist • Seismologist • Geophysical Prospector • Laboratory Assistant • Soils Engineer • Stratigrapher • Crystallographer • Geodesist • Environmental Analyst • Oceanographer • Teacher • Petrologist • Ecologist • Geochemist (Some of these, and other careers, require additional education or experience. For more information, see www.careers.csulb.edu.) Various entry-level trainee positions in business and industry are available for graduates regardless of academic discipline.

Introduction

The Geological Sciences includes the study of the solid earth, the hydrosphere, and the atmosphere. All Earth Science and Geology majors must contact the Undergraduate Advisor prior to the first semester in residence.

The Geological Sciences Department participates in the Southern California Marine Institute for marine geology, oceanography, and seismic studies. See the Ocean Studies Institute section of this *Catalog* for additional information.

Academic Advising and Facilitated Enrollment into Classes

All entering students who declare a major in a degree program offered by this department need to contact the College of Natural Sciences and Mathematics' (CNSM) Academic Advising Center (HSCI 164) and participate in the College's Science Safari to Success (for first time freshmen) or EONS (Enrollment and Orientation in the Natural Sciences and Mathematics for transfer students) Program. These programs are held in June/July for those starting in the Fall Semester and in January for those starting in the Spring Semester. Department advisors will be available to provide an overview of the students' chosen baccalaureate degree program, to assist with academic advisement, to provide information on the many career opportunities available, and to aid students in enrolling in classes. Contact the CNSM Academic Advising Center, Jensen Student Access to Sciences and Mathematics Center (HSCI 164), or department office for additional information.

Concurrent and/or Summer Enrollment at Another College

Students who wish to take course work at a community or another college to meet curricular requirements while enrolled as undergraduates in the College of Natural Sciences and Mathematics must petition the appropriate Department for prior approval to earn credit for specific courses. This policy applies to concurrent enrollment or summer enrollment. University policy must also be complied with; see 'Concurrent Enrollment' and 'Transfer of Undergraduate Credit' in this *Catalog*. Courses not receiving prior approval will not be accepted for credit by the Department.

Undergraduate Programs

Bachelor of Science in Geology (120 units)

The bachelor of science degree program provides training in the geological sciences for those planning to pursue professional careers in industry or enter a graduate degree program. Students explore fundamental geological processes, cultivate skills in integrative three-dimensional geological thinking, and engage in laboratory and field experience, and pursue interests in the many subdisciplines of the geological sciences. Students interested in pursuing a career in geophysics must consult the undergraduate advisor to construct an appropriate program.

Geology majors must receive a grade of "C" or better in all courses required for the major. A minimum of 120 units is required for the Bachelor of Science degree. Transfer students should attempt to fulfill, prior to transferring, the appropriate lower division curricular requirements as outlined below. In particular students should take prior to transferring the equivalent of GEOL 102 and 104, and at least three of the following four: CHEM 111A, CHEM 111B, MATH 122, and MATH 123.

GEOL 420 (Geological Writing) and GEOL 450 (Summer Field), both required courses for the major, are also capstone General Education courses, and GEOL 420 fulfills the GWAR requirement for a writing intensive course. Geology majors should take these two courses, and one other course to fulfill their upper division GE and GWAR requirements.

Lower Division:

Take all of the following:

GEOL 102 General Geology (3)

Prerequisites/Corequisites: A course that fulfills the A.1 GE requirement and three years of high school mathematics including algebra, geometry, and intermediate algebra or the equivalent.

GEOL 104 Geology Laboratory (1)

Prerequisites/Corequisites: A course that fulfills the A.1 GE requirement and three years of high school mathematics including algebra, geometry, and intermediate algebra or the equivalent, and concurrent or prior enrollment in GEOL 102.

GEOL 240 Historical Geology (4)

Prerequisite: GEOL 106 or both GEOL 102, GEOL 104.

GEOL 250 Introduction to Field Petrology and Geological Field Techniques (3)

Prerequisites: GEOL 102 with GEOL 104 or GEOL 105; or GEOL 106; all with grades of "C" or better. Corequisite: GEOL 240.

CHEM 111A General Chemistry (5)

Prerequisites: A passing score on the Chemistry Placement Examination.

Corequisite: MATH 109 or higher.

CHEM 111B General Chemistry (5)

Prerequisites: CHEM 111A and MATH 113 or MATH 115 or MATH 117 or MATH 119A or MATH 122 all with a grade of "C" or better.

MATH 122 Calculus I (4)

Prerequisite: Appropriate MDPT placement or a grade of "C" or better in MATH 111 and MATH 113.

MATH 123 Calculus II (4)

Prerequisite: A grade of "C" or better in MATH 122.

PHYS 151 Mechanics and Heat (4)

Prerequisite/Corequisite: MATH 122.

PHYS 152 Electricity and Magnetism (4)

Prerequisite: PHYS 151; Prerequisite/Corequisite: MATH 123.

Upper Division:

Take all of the following:

GEOL 322 Crystallography and Mineralogy (3)

Prerequisites: GEOL 250; CHEM 101 or CHEM 111A.

GEOL 326 Optical Mineralogy (2)

Prerequisite: GEOL 250; A passing score on the Chemistry Placement Examination or CHEM 111A;

Prerequisite/Corequisite: GEOL 322

GEOL 322 and GEOL 326 must be taken concurrently unless the undergraduate advisor approves otherwise.

GEOL 341 Paleontology and Biostratigraphy (4)

Prerequisites: GEOL 240 and GE Life Science requirement B.1.a.

GEOL 350 Spring Field Geology (2)

Prerequisites: GEOL 250 and GEOL 443 with grades of "C" or better. Prerequisite/Corequisite: GEOL 433.

GEOL 420 Geological Writing (3)

Prerequisites: GE Foundation completed, upper division standing, GEOL 102, GEOL 104, GEOL 240, GEOL 250; and at least 6 units of Geology courses at 300-level or above. Students must have scored 11 or higher on the GEAR Placement Examination or completed necessary portfolio course that is a prerequisite for a GEAR Writing Intensive Capstone.

GEOL 426 Igneous Metamorphic Petrography Laboratory (1)

Prerequisites: GEOL 322 and GEOL 326

Prerequisite/Corequisite: GEOL 428

GEOL 428 Igneous and Metamorphic Petrology and Petrography (3)

Prerequisites: GEOL 322; CHEM 111A, B.

GEOL 428 and GEOL 426 must be taken concurrently unless the undergraduate advisor approves otherwise.

GEOL 433 Structural Geology (4)

Prerequisites: GEOL 250, GEOL 322; PHYS 151.

GEOL 443 Stratigraphy/Sedimentology (4)

Prerequisites: GEOL 240, GEOL 322.

GEOL 450 Summer Field Geology (4)

Prerequisites: GEOL 350, GEOL 428, GEOL 433, and GEOL 443.

GEOL 460 Introduction to Geophysics (3)

Prerequisites: PHYS 151, PHYS 152; and MATH 123, all with a grade of "C" or better.

GEOL 461 Introduction to Geochemistry (3)

Prerequisites: CHEM 111A,B and MATH 123.

In addition, nine units of electives (normally at upper division) approved in advance by the undergraduate advisor.

Minor in Geology

The Minor in Geology is available to any non-Geology major.

Twenty units in geology courses that must include:

Lower Division:

Take all of the following:

GEOL 102 General Geology (3)

Prerequisites/Corequisites: A course that fulfills the A.1 GE requirement and three years of high school mathematics including algebra, geometry, and intermediate algebra or the equivalent.

GEOL 104 Geology Laboratory (1)

Prerequisites/Corequisites: A course that fulfills the A.1 GE requirement and three years of high school mathematics including algebra, geometry, and intermediate algebra or the equivalent, and concurrent or prior enrollment in GEOL 102.

GEOL 240 Historical Geology (4)

Prerequisite: GEOL 106 or both GEOL 102, GEOL 104.

Upper Division:

Take at least 9 additional units of geology approved in advance by the Undergraduate Advisor.

Bachelor of Science in Earth Science (120 units)

The bachelor of science degree in Earth Science is designed for those students considering a professional career in environmental, geotechnical, or engineering geology. The program also provides a fundamental education in geology that prepares students for graduate studies in the geological sciences. The required curriculum includes surficial geology courses (geomorphology, hydrology) not required as part of the B.S. in Geology. Students interested in pursuing a career in geophysics must consult the undergraduate advisor to construct an appropriate program.

Earth Science majors must receive a grade of "C" or better in all courses required for the major. A minimum of 120 units is required for the bachelor of science degree. Transfer students should attempt to fulfill, prior to transferring, the appropriate lower division curricular requirements as outlined below. In particular students should take prior to transferring the equivalent of GEOL 102 and 104, and at least three of the following four: CHEM 111A, CHEM 111B, MATH 122, and MATH 123.

GEOL 420 (Geological Writing) and GEOL 450 (Summer Field), both required courses for the major, are also capstone General Education courses, and GEOL 420 fulfills the GEAR requirement for a writing intensive course. Earth Science majors should take these two courses, and one other course to fulfill their upper division GE and GEAR requirements.

Lower Division:

Take all of the following:

GEOL 102 General Geology (3)

Prerequisites/Corequisites: A course that fulfills the A.1 GE requirement and three years of high school mathematics including algebra, geometry, and intermediate algebra or the equivalent.

GEOL 104 Geology Laboratory (1)

Prerequisites/Corequisites: A course that fulfills the A.1 GE requirement and three years of high school mathematics including algebra, geometry, and intermediate algebra or the equivalent, and concurrent or prior enrollment in GEOL 102.

GEOL 240 Historical Geology (4)

Prerequisite: GEOL 106 or both GEOL 102, GEOL 104.

GEOL 250 Introduction to Field Petrology and

Geological Field Techniques (3)

Prerequisites: GEOL 102 with GEOL 104 or GEOL 105; or GEOL 106; all with grades of "C" or better. Corequisite: GEOL 240.

CHEM 111A General Chemistry (5)

Prerequisites: A passing score on the Chemistry Placement Examination.

Corequisite: MATH 109 or higher.

CHEM 111B General Chemistry (5)

Prerequisite: CHEM 111A with a grade of "C" or better.

MATH 122 Calculus I (4)

Prerequisite: Appropriate MDPT placement or a grade of "C" or better in MATH 111 and MATH 113.

MATH 123 Calculus II (4)

Prerequisite: A grade of "C" or better in MATH 122.

PHYS 151 Mechanics and Heat (4)

Prerequisite/Corequisite: MATH 122.

PHYS 152 Electricity and Magnetism (4)

Prerequisite: PHYS 151; Prerequisite/Corequisite: MATH 123.

Upper Division:

Take all of the following:

GEOL 322 Crystallography and Mineralogy (3)

Prerequisites: GEOL 250; CHEM 101 or CHEM 111A.

GEOL 339 Geomorphology (3)

Prerequisites: GEOL 102 with GEOL 104 or GEOL 105; or GEOL 106; or GEOG 140.

GEOL 350 Spring Field Geology (2)

Prerequisites: GEOL 250 and GEOL 443 with grades of "C" or better. Prerequisite/Corequisite: GEOL 433.

GEOL 420 Geological Writing (3)

Prerequisites: GE Foundation completed, upper division standing, GEOL 102, GEOL 104, GEOL 240, GEOL 250; and at least 6 units of Geology courses at 300-level or above. Students must have scored 11 or higher on the GWAR Placement Examination or completed necessary portfolio course that is a prerequisite for a GWAR Writing Intensive Capstone.

GEOL 428 Igneous and Metamorphic Petrology and Petrography (3)

Prerequisites: GEOL 322; CHEM 111A, B.

GEOL 433 Structural Geology (4)

Prerequisites: GEOL 250, GEOL 322; PHYS 151.

GEOL 443 Stratigraphy/Sedimentology (4)

Prerequisites: GEOL 240, GEOL 322.

GEOL 450 Summer Field Geology (4)

Prerequisites: GEOL 350, GEOL 428, GEOL 433, and GEOL 443.

GEOL 460 Introduction to Geophysics (3)

Prerequisites: PHYS 151, PHYS 152; and MATH 123, all with a grade of "C" or better.

GEOL 461 Introduction to Geochemistry (3)

Prerequisites: CHEM 111A, CHEM 111B and MATH 123.

GEOL 474 Physical Hydrology (3)

Prerequisites: GEOL 102, Math 122; PHYS 151

In addition, nine units of electives (normally at upper division) approved in advance by the undergraduate

advisor. At least one elective must be chosen from the following list:

GEOL 477./577. Hydrogeology (4)

Prerequisites: GEOL 102, 104; CHEM 111B; PHYS 152; MATH 123. (Undergraduates enroll in GEOL 477; graduates enroll in GEOL 577).

MATH 370A. Applied Mathematics I (3)

Prerequisites: MATH 123. Not open to Freshmen.

Geoscience Concentration

The Geosciences Concentration meets the subject matter competence requirement for the Single Subject Teaching Credential in Geosciences. Prospective students should consult the Single Subject Science Education Advisor in the Department of Science Education early to plan their program.

Requirements

Lower Division:

Take all of the following

ASTR 100 Astronomy (3)

Corequisites: One course from General Education Category B.2 and ASTR 100L.

BIOL 211 Introduction to Evolution and Diversity (4)

Prerequisite/Corequisite: CHEM 111A with a grade of "C" or better.

BIOL 212 Intro to Cell and Molecular Biology (4)

Prerequisites: Completion of BIOL 211 and CHEM 111A with grades of "C" or better.

Prerequisite/Corequisite: CHEM 111B

BIOL 213 Introduction to Ecology and Physiology (4)

Prerequisites: BIOL 211, 212, CHEM 111B all with a grade of "C" or better.

CHEM 111A General Chemistry (5)

Prerequisites: A passing score on the Chemistry Placement Examination.

Corequisite: MATH 109 or higher.

CHEM 111B General Chemistry (5)

Prerequisites: CHEM 111A and MATH 113 or MATH 115 or MATH 117 or MATH 119A or MATH 122 all with a grade of "C" or better.

MATH 122 Calculus I (4)

Prerequisite: Appropriate MDPT placement or a grade of "C" or better in MATH 111 and MATH 113.

MATH 123 Calculus II (4)

Prerequisite: A grade of "C" or better in MATH 122.

PHYS 151 Mechanics and Heat (4)

Prerequisite/Corequisite: MATH 122.

PHYS 152 Electricity and Magnetism (4)

Prerequisite: PHYS 151; Prerequisite/Corequisite: MATH 123.

GEOL 102 General Geology (3)

Prerequisites/Corequisites: A course that fulfills the A.1 GE requirement and three years of high school mathematics including algebra, geometry, and intermediate algebra or the equivalent.

GEOL 104 Geology Laboratory (1)

Prerequisites/Corequisites: A course that fulfills the A.1 GE requirement and three years of high school mathematics including algebra, geometry, and intermediate algebra or the equivalent, and concurrent or prior enrollment in GEOL 102.

GEOL 160 Introduction to Oceanography (3)

Prerequisites/Corequisites: A course that fulfills the A.1 GE requirement and three years of high school mathematics including algebra, geometry, and intermediate algebra or the equivalent.

NOTE: BIOL 111, BIOL 111L, BIOL 212, BIOL 212L, BIOL 213, BIOL 213L are required if courses were taken prior to catalog year 2010-11.

Upper Division:

Take all of the following

GEOL 341 Paleontology and Biostratigraphy (4)

Prerequisites: GEOL 240 and GE Life Science requirement B.1.a.

GEOL 428 Igneous and Metamorphic Petrology and Petrography (3)

Prerequisites: GEOL 322; CHEM 111A, B.

GEOL 433 Structural Geology (4)

Prerequisites: GEOL 250, GEOL 322; PHYS 151.

GEOL 443 Stratigraphy/Sedimentology (4)

Prerequisites: GEOL 240, GEOL 322.

GEOL 450 Summer Field Geology (4)

Prerequisites: GEOL 350, GEOL 428, GEOL 433, and GEOL 443.

SCED 403 Integrated Science (3)

Prerequisites: Completion of all credential breadth requirements for the Single Subject Teaching Credential Program in Science, three-fourths of the credential specializations courses, and consent of instructor.

Single Subject Teaching Credential in Geosciences

In addition to meeting the subject matter competence requirement for the Teaching Credential, prospective Geosciences teachers are also required to complete 45 units of professional preparation in the Single Subject Credential Program, including student teaching. Students may begin the professional preparation courses as early as the junior year. With careful planning, it is possible to complete many of the credential program courses, except for student teaching, as an undergraduate. Courses may also be started as a post-baccalaureate student. Refer to the Single Subject Teacher Education section of this catalog or the Single Subject Credential Program website (www.ced.csulb.edu/single-subject) for a description of the professional preparation requirements, courses, and application procedures.

The Geosciences Subject Matter Program is being revised to meet new state standards. When the revised program has been approved by the Commission on Teacher Credentialing, the new course requirements will be in effect and supersede current requirements.

GRADUATE PROGRAMS

Master of Science in Geology

The Department of Geological Sciences offers a comprehensive program of courses coupled with appropriate thesis projects leading to the Master of Science in Geology. Within geology, students specialize in any of a number of sub-disciplines including paleoclimatology, environmental geochemistry, geophysics, hydrogeology, mineralogy and petrology, tectonic geomorphology, paleontology, petroleum geology, sedimentology, stratigraphy, structural and field geology. In addition, a formal emphasis in geophysics is available. Students may include in their studies courses offered by other departments at CSULB with the approval of their principal thesis advisor (or their Thesis Committee).

Offshore Resources

The Department has access to an ocean-going research vessel, support staff, and dockside facilities of the Southern California Marine Institute (SCMI), a consortium of several California State University campuses, University of Southern California, and Occidental College.

Admission to the Program

The basic requirement for admission to the graduate program is possession of a bachelor's degree or equivalent in geological sciences, or a closely related field. The final curriculum requirements for the Master of Science Degree are set by the Thesis Committee at Advancement to Candidacy, but the following undergraduate courses are considered an essential foundation for the program: (1) two courses in calculus, (2) two courses in general chemistry, (3) two courses in calculus-based physics, (4) a course in physical geology, (5) a course in historical geology, (6) mineralogy, (7) sedimentology/stratigraphy, (8) structural geology, (9) a course in field methods or a field camp. Students who are missing some of this course work may be admitted conditionally to the program but will be expected to remove deficiencies or present acceptable alternatives prior to Advancement to Candidacy. Courses taken to remove deficiencies cannot be used towards satisfying the minimum requirements of the Graduate Program. Students who are missing the general science and math requirements are recommended to complete an undergraduate degree in Geological Sciences or a closely related field before applying to the Graduate Program.

In addition to the above course work requirements, students are required to take the General test of the Graduate Record Examination and to submit three letters of recommendation prior to entry.

Prospective graduate students in the geological sciences, including CSULB graduates, must formally apply for admission to CSULB (CSUMentor) as described previously in this Catalog and must also apply directly to the Department of Geological Sciences. All applicants must submit all required documents directly to the Department by February 1 to receive full consideration for admission and financial support. Applications completed as late as April 1 may be considered on a case by case basis for any remaining positions. Required documents include:

1. Department Application Form, available on the Department's website;
2. Personal Statement/Letter of Intent
3. Official transcripts of all college level academic work including that done at CSULB, in addition to those transcripts required for general graduate admission to CSULB;
4. Three letters of recommendation from persons familiar with the applicant's academic performance and research potential. Instructions, including forms to be used for these letters, are included in the Department application form, available from the Department's website;
5. Official reports of scores on the General test of the Graduate Record Examination.

A limited number of teaching and research assistantships are available to fund graduate studies in the Department of

Geological Sciences. Applicants wishing to secure research assistantships must discuss the possibility directly with their intended advisor.

Johnson-Conrey Graduate Fellowship

The Johnson-Conrey Graduate Fellowship is awarded to the most highly qualified incoming Geological Sciences graduate students each year. The Fellowship, which provides \$15,000 per year for two years, is competitive, and is awarded by the Department based on students' application materials and a separate essay. Up to two Fellowships are awarded each year. (Note that former CSULB students are ineligible to apply.)

Initiation of Graduate Study

Students are responsible for all University and Department regulations governing master's degrees as outlined in this *Catalog* and the Department Graduate Student Handbook. All applicants must be matched to a potential thesis advisor prior to acceptance. This advisor will provide academic advising. Administrative advising is carried out by the graduate advisor, who explains the requirements of the program.

All entering students must take GEOL 500 (Introductory Graduate Seminar) during their first Fall semester. This course consists of lectures and activities to help students focus their research projects and goals and work effectively toward the Advancement to Candidacy.

Students are required to maintain a GPA of 3.0 or higher at all times. If at any time a student's GPA drops below 3.0, that student will immediately be placed on academic probation for a maximum of two semesters. If the student does not bring the GPA back up to 3.0 during the probationary period, he/she will not be allowed to continue as a graduate student in this Department. In order for a student to regain status in the Department after failing to maintain this academic standard, he/she must formally reapply for Department admission.

Advancement to Candidacy

A student must have been advanced to candidacy before the beginning of their third semester. International students must have fulfilled the Graduation Writing Assessment Requirement (GWAR) or taken ENG 301B prior to Advancement to Candidacy. All students must Advance to Candidacy prior to enrollment in GEOL 698: Thesis Units. Requests to graduate must be received during the preceding May for Spring/Summer graduation or preceding December for Fall graduation. Filings after the deadlines are not accepted.

Prior to Advancement, a thesis topic, thesis committee, and graduate program consisting of at least 30 units (see below) must be established by the student and the prospective thesis committee chair. In addition, the following requirements must be met:

1. Completion of all deficiencies and incompletes. This includes courses required in the undergraduate major for the emphasis in which the student is pursuing graduate research, as well as additional courses specified by the thesis advisor.
2. Completion of six units of graduate level courses with

- a 3.0 or higher grade point average and attainment of a 3.0 or higher grade point average in all upper division and graduate work attempted, as well as in courses to be listed in the student's graduate academic program (see below).
3. A passing grade in GEOL 500.

Advancement to Candidacy includes a successful completion of an oral presentation given by the student to their thesis committee, and acceptance of a written proposal for the thesis research. The student's thesis topic will be the subject of the examination.

Once the above requirements are met, Advancement to Candidacy proceeds with approval of the thesis committee followed by the Department Graduate Advisor, and Associate Dean of Graduate Studies in the College of Natural Sciences and Mathematics. After the student has been advanced, no course work in addition to that specified in the graduate program may be required of the student. In order for a student to change thesis chair/director, topic, committee members, or courses in the graduate program, approvals must be obtained. Under some circumstances this may mean that additional courses are required.

Requirements of Graduate Academic Program

The graduate academic program consists of at least 30 units of courses and is established when the student Advances to Candidacy. The program proposed by the thesis committee chair and the student must be approved by the thesis committee, Graduate Advisor and Associate Dean of Graduate Studies. Six units of GEOL 698 (Thesis) must be taken as part of the program, GEOL 695 (Directed Reading) may account for up to four units). Directed Research, GEOL 697, may account for up to three units, but normally cannot be taken before the student completes 12 units of the graduate program with a grade point average of 3.0 or higher.

A minimum of 21 units of 500 or 600 level courses, including Thesis, must be completed; the remaining units (9 or less) may be 300, 400, 500, or 600 level courses, although courses at 300 level in the Department may not be used in the program. Up to 9 units may be taken at other universities if suitable courses are not offered at CSULB. Appropriate courses from related areas in science, mathematics, or engineering may be substituted within limits with consent of the Department.

Thesis Defense

All M.S. students are required to submit a thesis that conforms to the University and Department guidelines. The thesis should document the systematic study of a significant geological problem; evidence originality and critical, independent thinking; and conform to appropriate and accepted organization, format, and writing style. Each student should discuss thesis format with his/her thesis committee chair.

All M.S. students are also required to present the results of their research orally to members of the department. The student must schedule his/her presentation at least two weeks in advance, and with the approval of the thesis committee. The date of the presentation must precede the semester's thesis submission deadline for which the student plans to graduate.

Single Subject Teaching Credential in Geosciences

For information, refer to the undergraduate section in this department.

Courses (GEOL)

LOWER DIVISION

102. General Geology (3)

Prerequisites/Corequisites: A course that fulfills the A.1 GE requirement and three years of high school mathematics including algebra, geometry, and intermediate algebra or the equivalent. Recommended: Concurrent enrollment in GEOL 104 or 105.

Broad based introductory study of geology. Broad based introductory study of geology. Structure, composition, distribution, and modification of earth materials and elementary geologic history of the Earth.

(Lecture, demonstration 3 hrs.)

104. Geology Laboratory (1)

Prerequisites/Corequisites: A course that fulfills the A.1 GE requirement and three years of high school mathematics including algebra, geometry, and intermediate algebra or the equivalent, and concurrent or prior enrollment in GEOL 102.

Laboratory study of earth materials.

(Laboratory 3 hrs.)

105. Geology Field Laboratory (1)

Prerequisites/Corequisites: A course that fulfills the A.1 GE requirement and three years of high school mathematics including algebra, geometry, and intermediate algebra or the equivalent, and concurrent or prior enrollment in GEOL 102.

Field trips to areas of geologic significance and field study of earth materials.

May be repeated to a maximum of 3 units with consent of instructor. (Field trips, 6 days per unit.) Course fee may be required for bus trips.

106. Earth Science for Teachers (4)

Prerequisites/Corequisites: A course that fulfills the A.1 GE requirement and three years of high school mathematics, including algebra, geometry, and intermediate algebra or the equivalent.

Introduction to earth science including geology, oceanography, meteorology, solar system and astronomy. Scientific method addressed. Methods of teaching science to K-8 pupils.

Letter grade only (A-F). (Lecture, demonstration 3 hours., laboratory 3 hrs., field trips.)

110. Natural Disasters (3)

Prerequisites/Corequisites: Courses that fulfill the GE A.1 and B.2 requirements.

Recommended: Concurrent enrollment in GEOL 110L.

Introductory study of Earth's natural processes that severely impact humans. Includes study of processes causing natural disasters such as earthquakes, volcanic eruptions, landslides, floods, tornadoes, hurricanes, tsunamis, and asteroid impacts.

(Lecture 3 hrs.)

110L. Natural Disasters Laboratory (1)

Prerequisites/Corequisites: Courses that fulfill the GE A.1 and B.2 requirements.

Corequisite: GEOL 110.

Laboratory analysis of geological data and field observations of geologic features associated with natural disasters.

Course fee may be required. (Laboratory 3 hrs, field trips).

160. Introduction to Oceanography (3)

Prerequisites/Corequisites: A course that fulfills the A.1 GE requirement and three years of high school mathematics including algebra, geometry, and intermediate algebra or the equivalent.

Origin and extent of oceans, nature of ocean floor, and cause and effect of currents, tides, and waves; and life in the ocean.

(Lecture, discussion 3 hrs.)

160L. Introduction to Oceanography Laboratory (1)

Prerequisites/Corequisites: A course that fulfills the A.1 GE requirement and three years of high school mathematics including algebra, geometry, and intermediate algebra (MAPB 7) or the equivalent; and previous credit or concurrent registration in GEOL 160.

Field and laboratory study of marine environment. Analysis of maps, plus shore and on-water trips for experience in use of oceanographic instruments. Analysis and interpretation of results.

(Laboratory-field 3 hrs.) Course fee may be required.

190. Environmental Geology (3)

Prerequisites/Corequisites: A course that fulfills the A.1 GE requirement and three years of high school mathematics including algebra, geometry, and intermediate algebra or the equivalent.

Interrelationships between humans and hazards: landslides, floods, erosion, subsidence, volcanism, earthquakes, and seismic sea waves. Origin of resources and impacts of resource development: water, soils, and energy. Waste and waste disposal.

(Lecture 3 hrs.)

191. Air and Water Pollution (3)

Prerequisites/Corequisites: A course that fulfills the A.1 GE requirement and three years of high school mathematics including algebra, geometry, and intermediate algebra or the equivalent.

Survey course dealing with the causes and nature of pollution in the air, groundwater, fresh water lakes and streams, and the ocean. Effects of air and water pollution on the environment.

(Lecture 3 hrs.)

240. Historical Geology (4)

Prerequisite: GEOL 106 or both GEOL 102, GEOL 104.

History of earth and evolution of animals and plants.

(Lecture 3 hrs., laboratory 3 hrs., field trips.)

250. Introduction to Field Petrology and Geological Field Techniques (3)

Prerequisites: GEOL 102 with GEOL 104 or GEOL 105; or GEOL 106; all with grades of "C" or better.

Corequisite: GEOL 240.

Identification and description of igneous, sedimentary, and metamorphic rocks in the field. Development of fundamental geological field techniques: recording, collection, and interpretation of geological field data. Creation and interpretation of geological maps, writing technical reports, and construction of geological illustrations.

Letter grade only (A-F). (Lecture 1 hour, weekend field trips.)

280. Water Resources and Society (3)

Prerequisites: GEOL 102, GEOL 104. Four years of high school mathematics.

Hydrologic, geologic, and other factors controlling groundwater and surface water occurrence, movement, quality, and contamination. Environmental effects of groundwater and surface water contamination.

(Lecture 3 hours; field trips)

UPPER DIVISION

300. Earth Systems and Global Change (3)

Prerequisites: GE Foundation requirement, upper division standing, and CHEM 100 or CHEM 111A or GEOL 102 or GEOL 106 with a grade of "C" or better.

Interaction of Earth's systems (biosphere, lithosphere, hydrosphere, cryosphere, and atmosphere) and links between life, oceans, climate, and the solid earth. This approach is used to understand important issues confronting society regarding climatic and environmental change.

Letter grade only (A-F). (Lecture 3 hrs.)

322. Crystallography and Mineralogy (3)

Prerequisites: GEOL 250; CHEM 111A.

Morphological and structural crystallography, crystal structure, chemistry, classification, origin, occurrence, and association of minerals reviewed. Analysis and identification of minerals by megascopic, qualitative, chemical, and instrumental means.

(Lecture 2 hrs., laboratory 3 hrs., field trip)

326. Optical Mineralogy (2)

Prerequisites: GEOL 250; a passing score on the Chemistry Placement Examination or CHEM 111A;

Corequisite/Prerequisite: GEOL 322.

Review of morphological and optical properties of minerals including basics of the nature of light. Use of petrographic microscope in rock and mineral examination.

Letter grade only (A-F).

339. Introduction to Geomorphology (3)

Prerequisites: GEOL 102 with GEOL 104 or GEOL 105; or GEOL 106; or GEOG 140.

Study of landforms and processes producing and modifying them. Emphasis on mechanics of geomorphic processes and relationships between properties of earth materials and forces applied to them by gravity, wind, ice, water, waves, and humans. Conceptual basis of geomorphology addressed.

Designed for Geology, Geography, Biology, Anthropology, and Civil Engineering majors. Letter grade only (A-F). (Lecture 2 hrs., laboratory 3 hrs., field trips)

341. Paleontology and Biostratigraphy (4)

Prerequisite: GEOL 240 and GE Life Science requirement B.1.a.

Morphologic, systematic, and ecologic aspects of invertebrate fossils; methods and techniques in collection, preparation, illustration, and description of fossils; uses of fossils in stratigraphic work; principles of biostratigraphy.

(Lecture 3 hrs., laboratory 3 hrs., fieldtrips) Course fee may be required.

350. Spring Field Geology (2)

Prerequisites: GEOL 250 and GEOL 443 with grades of "C" or better. Prerequisite/Corequisite: GEOL 433.

Development of proficiency in geological mapping skills. Construction of stratigraphic columns and structural cross sections.

Letter grade only (A-F). (Field trips, 5 days per unit)

370. Geology for Engineers (2)

Prerequisite: CE 200

Earth processes and materials which influence the design, construction and operation of engineering works, construction materials. Not open for credit to geology majors.

(Lecture 2 hrs., field trips.)

420. Geologic Writing (3)

Prerequisites: GE Foundation completed, upper division standing, GEOL 102, GEOL 104, GEOL 240, GEOL 250; and at least 6 units of Geology courses at 300-level or above. Students must have scored 11 or higher on the GVAR Placement Examination or completed necessary portfolio course that is a prerequisite for a GVAR Writing Intensive Capstone.

A writing-intensive capstone. Writing for a geological audience; writing scientific/geological content at an advanced level emphasized. Journal articles and abstracts reviewed. Includes handling scientific data, distinction between data and interpretation, logic and argument, clarity of style, and types of writing (abstracts, proposals, articles, etc.). Library search methods. Extensive writing, editing, and peer review. Enrollment limited.

Letter grade only (A-F). (Lecture 1 hr. and laboratory (6 hrs.))

426. Igneous Metamorphic Petrography Laboratory (1)

Prerequisites: GEOL 322 and GEOL 326;

Prerequisite/Corequisite: GEOL 428

Laboratory microscopic analysis of igneous and metamorphic rocks, including fabric and mineral content.

Letter grade only (A-F). (Laboratory 3 hrs.)

428. Igneous and Metamorphic Petrology and Petrography (3)

Prerequisites: GEOL 322; CHEM 111A, B.

Magmatic and metamorphic rock bodies and systems characteristics, including mineralogical and chemical aspects. Fabrics' origin, evolution of igneous and metamorphic rocks, modeling of magma genesis. Microscopic, hand specimen and x-ray analysis of rocks, including fabric and mineral content.

Letter grade only (A-F). (Lecture 2 hrs., laboratory 3 hrs., field trips)

433. Structural Geology (4)

Prerequisites: GEOL 250, GEOL 322; PHYS 151.

Theories/principles of structural geology, orogenesis, and tectonics. Planar/linear structures in naturally deformed rocks. Description, classification, interpretation, and kinematic and dynamic analysis of faults/folds. Field measurement, analysis and mapping of structures. Deformation, strength, fracture, and rheological properties of rocks.

Letter grade only (A-F). (Lecture 3 hrs., laboratory 3 hrs., required field trips)

443. Stratigraphy/Sedimentology (4)

Prerequisites: GEOL 240, GEOL 322.

Introduction to sedimentology and stratigraphy, flow mechanics and sedimentary structures, laboratory and field methods for the description and classification of sedimentary rocks, depositional systems, sequence stratigraphy, subsurface stratigraphic methods, sedimentation and tectonics, and preparation of sedimentologic field reports.

Not open for credit to students with credit in GEOL 343. Letter grade only (A-F). (Lecture 3 hrs., laboratory 3 hrs., required field trips)

444. Engineering Geology (4)

Prerequisites: GEOL 250, GEOL 433; MATH 122, MATH 123; PHYS 151, PHYS 152.

In depth study of the fundamentals of engineering geology and related hazards. Topics covered include rock and soil mechanics, active faulting, landslides, coastal and fluvial processes.

Letter grade only (A-F). (Lecture 3 hrs., laboratory 3 hrs.; field trips.)

445. Paleoclimatology (4)

Prerequisites: ESP 200 or GEOG 340 and GEOG 200 (or equivalent) or consent of instructor.

Methods and theories used in reconstructing and dating climates of the past 2 million years, using such proxies as sediment sequences, packrat middens, ice cores, tree rings, corals, and documentary data. Causes of environmental change and human interactions are analyzed.

Letter grade only (A-F). Same course as GEOG 445. Not open for credit to students with credit in GEOG 445. (Lecture 3 hours, lab activities 2 hours)

450. Summer Field Geology (4)

Prerequisites: GEOL 350, GEOL 428, GEOL 433, and GEOL 443.

An integrative learning capstone. Four weeks of geological field mapping at a selected area. Preparation of geological reports of the field problems.

(Lecture as needed, daily field work)

460. Introduction to Geophysics (3)

Prerequisites: PHYS 151, PHYS 152; and MATH 123, all with a grade of "C" or better.

Introduction to geophysics; principles and processes; methods of investigation.

Letter grade only (A-F). (Lecture 2 hrs., laboratory 3 hrs., field trips.)

461. Introduction to Geochemistry (3)

Prerequisites: CHEM 111A,B and MATH 123.

Abundance and migration of elements in the earth; chemical processes in evolution of earth and its crust including geochemistry of organic compounds.

Letter grade only (A-F). (Lecture 2 hrs., laboratory 3 hrs.)

462. Physics and Chemistry of the Earth's Interior (3)

Prerequisites: GEOL 240, GEOL 428; PHYS 152.

Structure and composition of the Earth's interior. Origin and evolution of the Earth. Review of geophysical data, petrologic analyses, and other types of evidence for Earth structure and compositional models.

Letter grade only (A-F). (Lecture 3 hrs.)

465. Physical and Chemical Oceanography (3)

Prerequisites: CHEM 111B; PHYS 100A or PHYS 151, and upper division standing in the College of Natural Sciences and Mathematics or Engineering.

Physics and chemistry of the oceans, carbon cycle; minor and trace elements in sea water, nutrients, water masses and currents; physical concepts and interpretative theories related to ocean circulation.

Letter grade only (A-F). (Lecture 3 hrs.)

466. Oceanography Laboratory and Ocean Studies (1)

Prerequisite/Corequisite: GEOL 465.

Analysis and interpretation of oceanographic data, acquisition of data at sea on field trip, and post-cruise analysis and presentation of results.

Not open for credit to students with credit in GEOL 462. (Laboratory 3 hrs., sea trips.)

474./574. Physical Hydrology (3)

Prerequisites: GEOL 102, MATH 122; PHYS 151. (Undergraduates enroll in GEOL 474; graduates enroll in GEOL 574.)

Quantitative study of the terrestrial water cycle; prediction and measurement of precipitation, surface water, soil water, and groundwater.

Letter grade only (A-F). (Lecture 2 hrs, lab/field trips 3 hrs)

477./577. Hydrogeology (4)

Prerequisites: GEOL 102, GEOL 104; CHEM 111B; PHYS 152; MATH 123. (Undergraduates enroll in GEOL 477; graduates enroll in GEOL 577.)

Groundwater flow, occurrence, development, chemistry, and contamination. Elementary groundwater flow theory. Well hydraulics.

Letter grade only (A-F). (Lecture 3 hrs., laboratory 3 hrs.)

489. Current Topics in Geological Sciences (3)

Prerequisite: Consent of instructor.

Topics of current interest in the geological sciences selected for intensive development.

May be repeated to a maximum of 6 units. Field trips may be required. (Lecture 2 hrs., laboratory 3 hrs.)

490. Current Topics in Geological Sciences (1-3)

Prerequisite: Consent of instructor.

Topics of current interest in the geological sciences selected for intensive development.

May be repeated to a maximum of 6 units. Field trips may be required.

496. Investigations in Geology and Other Earth Sciences (1-4)

Prerequisites: Senior standing in geology, earth science or related fields, completion of an upper division course in geology or earth science in the area of the topics chosen and approval of the topic chosen by the Geological Sciences faculty.

Supervised research in geology or the other earth sciences. Field trips may be required.

GRADUATE LEVEL

500. Introductory Graduate Seminar (1)

Prerequisite: Graduate standing.

Introduction to graduate policies and faculty research in Geological Sciences. Abstracts on faculty presentation required of all students.

Course cannot be counted for program requirements for the M.S degree in Geology. Credit/No Credit grading only. May be repeated to a maximum of 3 units. (Seminar 1 hr.)

510. Biogeochemical Cycles (3)

Study of carbon, nitrogen, phosphorus, iron, and sulfur cycles among the bio-, hydro-, and geospheres with an emphasis on transfer rates, mass balance, and residence times. Evaluation of processes and interactions among key ecosystems (wetlands, rivers, ocean, lakes, estuaries).

Letter grade only (A-F). (Lecture 3 hrs.)

524. Sedimentary Petrology (4)

Prerequisites: GEOL 322 and GEOL 443.

Microscopic and macroscopic study of the origin and diagenesis of sedimentary rocks. Identification of grain types, textures, structures, and cements emphasizing provenance, paleotectonics, paleoenvironmental reconstructions, and post-depositional alteration.

Letter grade only (A-F). (Lecture 3 hrs., laboratory 3 hrs.)

530. Seminar in Structural Geology and Tectonics (3)

Prerequisite: GEOL 433.

Review of analysis, interpretation and origin of geologic structures, mechanics of rock deformation and of large scale crustal deformation.

(Lecture 2 hrs., laboratory 3 hrs.; field trips.)

531. Tectonic Geomorphology (4)

Prerequisite: GEOL 433.

Observation and analysis of Earth surface processes, and development of landforms and landscape. Interaction between surficial processes and tectonic, biologic, hydrologic, climatic, and atmospheric processes. Tectonic generated landforms, earthquake hazards evaluated, and geomorphic assessment. Assessing problems including landforms and environmental hazards.

Letter grade only (A-F). (Lecture 2 hrs., laboratory 6 hrs., field trips).

537. California Geology (3)

Prerequisites: GEOL 433, GEOL 450.

Examination of recent theories concerning evolution of California's geological provinces; geological, geochemical, and geophysical evidence for these theories.

Letter grade only (A-F). (Lecture 3 hrs., field trips.)

541. Seminar on Mass Extinctions (3)

Prerequisites: GEOL 341, 443, 461.

Study of the nature, causes, and stratigraphic record of mass extinction events in Earth history.

Letter grade only (A-F). (seminar 3 hrs.)

543. Seminar on Integrated Stratigraphy (3)

Prerequisites: GEOL 341, 443, 461.

Study of all stratigraphic subdisciplines and their integrated use for effecting high-resolution stratigraphic correlations.

Letter grade only (A-F). (Seminar 3 hrs.)

554. Environmental Geochemistry (3)

Prerequisites: CHEM 111B and consent of instructor.

Geochemical cycles. Human interference with cycles. Trace elements, health and agriculture. Clay mineral reactions. Groundwater chemistry. Reading and discussion of research articles; projects in environmental geochemistry.

Letter grade only (A-F). (Lecture 3 hrs., field trips)

555. Stable Isotopes (3)

Prerequisites: GEOL102, CHEM 111B.

Fractionation of stable isotopes, mass spectrometry, application of stable isotopes to geologic, ecologic, and archaeological studies such as paleoclimatology, petrologic studies, paleodiet analysis.

Letter grade only (A-F). Lecture 3 hrs.

570. Special Topics in Geology (3)

Prerequisite: Consent of instructor.

Investigation of selected topics in geology. May be repeated to a maximum of 9 units toward any single degree with different topics. Seminars with field trips as appropriate.

Letter grade only (A-F). (Seminar, 3 hrs.) May be repeated to a maximum of 9 units with different topics in different semesters.

571. Contaminant Hydrogeology (3)

Prerequisites: GEOL 102, GEOL 104, GEOL 477/577; CHEM 111B; PHYS 152; MATH 123.

Study and prediction of groundwater pollution transport, reaction, and remediation.

Letter grade only (A-F). (Lecture 2 hrs., laboratory 3 hrs.)

574./474. Physical Hydrology (3)

Prerequisites: GEOL 102, MATH 122; PHYS 151. (Undergraduates enroll in GEOL 474; graduates enroll in GEOL 574.)

Quantitative study of the terrestrial water cycle; prediction and measurement of precipitation, surface water, soil water, and ground water.

Letter grade only (A-F). (Lecture 2 hrs, lab/field trips 3 hrs)

575. Advanced Topics in Sedimentology (3)

Prerequisite: Consent of instructor.

Investigation of topics in sedimentology such as depositional facies analysis, basin evolution, coastal processes, fluvial processes, advanced stratigraphic analysis, and tectonics and sedimentation.

Content varies form year to year. May be repeated to a maximum of 9 units toward any single degree with different topics in different semesters. Letter grade (A-F). Seminars with field trips as appropriate. (Seminar 3 hrs.)

577./477. Hydrogeology (4)

Prerequisites: GEOL 102, GEOL 104; CHEM 111B; PHYS 152; MATH 123. (Undergraduates enroll in GEOL 477; graduates enroll in GEOL 577.)

Groundwater flow, occurrence, development, chemistry, and contamination. Elementary groundwater flow theory. Well hydraulics.

Letter grade only (A-F). (Lecture 3 hrs., laboratory 3 hrs.)

579. Applied Groundwater Modeling (4)

Prerequisites: GEOL 102, GEOL 104, GEOL 477/577; PHYS 152; MATH 123. Recommended: MATH 370A.

Numerical modeling of groundwater flow and mass transport. Emphasis is on creation of numerical models from conceptual models of geology derived from geologic mapping and sampling.

Letter grade only (A-F). (Lecture 3 hrs., laboratory 3 hrs.)

582. Petroleum Geology and Well Log Analysis (4)

Prerequisites: GEOL 240, GEOL 443.

Geological application in exploration and production of petroleum, including uses of surface and subsurface techniques. Basic well logging techniques employed, including data collection, reduction, interpretation, and integration among various logging methods as well as with surface geology and geophysical data.

(Lecture 2 hrs., laboratory 6 hrs., field trips.)

586. Engineering Geophysics (3)

Prerequisite/Corequisite: GEOL 460.

Applying geophysical techniques to geology and hydrogeology problems. Geophysical techniques, and identification and utilization of specialized techniques. Case histories in site evaluations, subsiding areas, basement topography mapping, seawater problems, water table mapping, groundwater contamination, and subsurface cavities detection.

Letter grade only (A-F). (Lecture 2 hrs., laboratory 3 hrs.; field trips.) Course fee may be required.

695. Directed Reading (1-3)

Survey of information in published or unpublished geological literature or databases on a designated topic, under the direction of a faculty member. Written reports prepared from these readings.

May be repeated to a maximum of 4 units toward any single degree with different topics in different semesters. Limited to 3 units per semester. Letter grade only (A-F).

697. Directed Research (1-3)

Prerequisite: Consent of instructor.

Research on a specific subject in geology. Topic for study to be approved and directed by a faculty member in geological sciences.

Letter grade only (A-F).

698. Thesis (1-6)

Prerequisites: Advanced to candidacy for M.S. in Geology, consent of Graduate Committee and graduate advisor.

Either laboratory or field investigations, or both, for a total of six semester units to culminate in an approved thesis.

Letter grade only (A-F).

MATHEMATICS AND STATISTICS

College of Natural Sciences and Mathematics

Department Chair: Tangan Gao

Undergraduate Associate Chair: Kent G. Merryfield

Department Office: Faculty Offices (FO) 3 - 120

Telephone / FAX: (562) 985-4721 / (562) 985-8227

Website: www.csulb.edu/depts/math/

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Administrative Support Coordinator: Linda Dixon

Student Services Coordinator: Sofia Aguilera

ELM Coordinator: Larry Brownson

Advisors:

Undergraduate:

General - William L. Murray

Applied Math - Melvin D. Lax

Statistics - Olga Korosteleva

K-9th Teaching - Norma Noguera

Honors in the Major: Kent G. Merryfield

Credential: Angelo Segalla

Graduate:

General - John O. Brevik

Applied - Eun Heui Kim

Mathematics Education - Joshua D. Chesler

Statistics - Hojin Moon

Students desiring information should contact the department office for referral to one of the faculty advisors.

Career Possibilities

Mathematician • Statistician • Operations Research Analyst • Computer Programmer • Wage/Salary Analyst • Teacher • Systems Analyst • Financial Analyst • Corporate Accountant • Actuary • Surveyor • Information Scientist • Econometrist • Securities Analyst • Efficiency Engineer • Meteorologist • Technical Writer • Demographer (Some of these, and other careers, require additional education or experience. For more information, see www.careers.csulb.edu/.) Various entry-level trainee positions in business and industry are available for graduates regardless of academic discipline.

Introduction

Mathematics is fundamental to all scientific knowledge, including not only the traditional natural sciences but increasingly the social and economic sciences. Mathematics is also a vital aid to critical and philosophical thinking.

The Department offers instruction for students at all levels beyond high school mathematics. Its courses provide the computational and analytic skills needed for a variety of majors, as well as the advanced theoretical topics for specialists in mathematics.

Academic Advising and Facilitated Enrollment into Classes

All entering students who declare a major in a degree program offered by this department need to contact the College of Natural Sciences and Mathematics' (CNSM) Academic Advising Center (HSCI 164) and participate in the College's Science Safari to Success (for first time freshmen) or EONS (Enrollment and Orientation in the Natural Sciences and Mathematics for transfer students) Program. These programs are held in June-July for those starting in the Fall Semester and in January for those starting in the Spring Semester. Department advisors will be available to provide an overview of the students' chosen baccalaureate degree program, to assist with academic advisement, to provide information on the many career opportunities available, and to aid students in enrolling in classes. Contact the CNSM Academic Advising Center, Jensen Student Access to Sciences and Mathematics Center (HSCI 164), or department office for additional information.

Concurrent and/or Summer Enrollment at Another College

Students who wish to take coursework at a community college or other college to meet curricular requirements while enrolled as undergraduates in the College of Natural Sciences and Mathematics must petition the appropriate department for prior approval to earn credit for specific courses. This policy applies to concurrent enrollment or summer enrollment. University policy must also be complied with; see 'Concurrent Enrollment' and 'Transfer of Undergraduate Credit' in this catalog. Courses not receiving prior approval will not be accepted for credit by the department.

Undergraduate Programs

Bachelor of Science in Mathematics (120 units)

This program requires a selection of fundamental courses in algebra, statistics, and analysis be taken. It is the most flexible program, in which the greatest number of electives may be chosen. Elective upper division mathematics courses are available which meet the needs of students preparing careers in industry and government, secondary teaching, and graduate study. Students who do not wish to complete the requirements for a declared option in applied mathematics or statistics may wish to elect courses in one or both of these areas as part of this degree program.

Requirements

Lower Division:

Take all the following courses:

MATH 122 Calculus I (4)

*C or better required.

Prerequisite: Appropriate MDPT placement or a grade of "C"

or better in MATH 111 and MATH 113.

MATH 123 Calculus II (4)

*C or better required.

Prerequisite: A grade of "C" or better in MATH 122.

MATH 224 Calculus III (4)

*C or better required.

Prerequisite: A grade of "C" or better in MATH 123.

MATH 233 Fundamental Concepts for Adv Math (3)

*C or better required

Prerequisite: A grade of "C" or better in MATH 123.

MATH 247 Introduction to Linear Algebra (3)

Prerequisite: MATH 123.

CECS 174 Introduction to Programming and Problem Solving (3)

Prerequisite: CECS 100 and MATH 113 (or equivalent).

PHYS 151 Mechanics and Heat (4)

Prerequisite/Corequisite: MATH 122.

Take the following course:

ENGL 317 Technical Communication (3)

Prerequisites: GE Foundation requirements, upper-division standing, and a previous composition course, i.e., ENGL 100, ENGL 102, ENGL 300, or equivalents.

Upper Division:

Take a minimum of 30 units of MATH or STAT courses to include the following (but not MATH 303, MATH 309, MATH 370A, MATH 370B, or MATH 409):

Take one of the following courses: (*C" or better required).

MATH 341 Number Theory (3)

Prerequisite: A grade of "C" or better in MATH 233.

MATH 347 Linear Algebra (3)

Prerequisites: MATH 233 and MATH 247.

Take all of the following courses:

MATH 361A Introduction to Mathematical Analysis I (3)

*C" or better required.

Prerequisites: MATH 224, and MATH 233 or MATH 247.

MATH 361B Introduction to Mathematical Analysis II (3)

Prerequisite: A grade of "C" or better in MATH 361A.

MATH 364A Ordinary Differential Equations I (3)

Prerequisites: MATH 224; Prerequisite/Corequisite: MATH 247.

MATH 380 Probability and Statistics (3)

Prerequisite: MATH 224.

MATH 444 Introduction to Abstract Algebra (3)

Prerequisites: MATH 233 and MATH 247 and a grade of "C" or better in at least one of MATH 341 or in MATH 347.

To allow flexibility, only 18 of the required 30 units are specified. Students should choose the remaining 12 units after discussing career goals and interests with an advisor.

Option in Applied Mathematics (120 units)

This option emphasizes mathematics frequently used in applications. The student may choose one of two suboptions: the first is aimed at applications in science and engineering, the second at applications in economics and management. Students are prepared for careers in industry, business, and government and for graduate study in applied mathematics.

Requirements

Suboption I: Application in Science and Engineering

Lower Division:

Take all the following courses:

MATH 122 Calculus I (4)

*C or better required.

Prerequisite: Appropriate MDPT placement or a grade of "C" or better in MATH 111 and MATH 113.

MATH 123 Calculus II (4)

*C or better required.

Prerequisite: A grade of "C" or better in MATH 122.

MATH 224 Calculus III (4)

Prerequisite: A grade of "C" or better in MATH 123.

MATH 247 Introduction to Linear Algebra (3)

Prerequisite: MATH 123.

CECS 174 Introduction to Programming and Problem Solving (3)

Prerequisite: CECS 100 and MATH 113 (or equivalent).

PHYS 151 Mechanics and Heat (4)

Prerequisite: None.

PHYS 152 Electricity and Magnetism (4)

Prerequisite: PHYS 151; Prerequisite/Corequisite: MATH 123.

Take the following course:

ENGL 317 Technical Communication (3)

Prerequisites: GE Foundation requirements, upper-division standing, and a previous composition course, i.e., ENGL 100, ENGL 102, ENGL 300, or equivalents.

Take one of the following courses:

PHYS 254 Applied Modern Physics (3)

Prerequisite: PHYS 152 or EE 210; Prerequisite/Corequisite: MATH 224.

EE 211 Electric and Electronic Circuits (3)

Prerequisites: (EE 210/210L or PHYS 152) and (MATH 123 or equivalent).

CE 205 Analytical Mechanics I (Statics) (3)

Prerequisite: PHYS 151. Prerequisite/Corequisite: MATH 123.

Upper Division:

Take all the following courses:

MATH 323 Introduction to Numerical Analysis (4)

Prerequisites: MATH 224, and a course in computer programming.

MATH 361A Introduction to Mathematical Analysis I (3)

*C" or better required.

Prerequisites: MATH 224, and MATH 233 or MATH 247.

MATH 361B Introduction to Mathematical Analysis II (3)

Prerequisite: A grade of "C" or better in MATH 361A.

MATH 364A Ordinary Differential Equations I (3)

Prerequisites: MATH 224, and prerequisite or corequisite MATH 247.

MATH 364B Ordinary Differential Equations II (3)

Prerequisite: MATH 364A or MATH 370A.

MATH 380 Probability and Statistics (3)

Prerequisite: MATH 224.

MATH 470 Intro to Partial Differential Equations (3)

Prerequisite: MATH 364A or MATH 370A.

A minimum of 9 units from the following:

MATH 423, MATH 461, MATH 463, MATH 472, MATH 473, MATH 474, MATH 479, MATH 485; STAT 381, STAT 482.

A minimum of 9 units from one of the following groups:

A. PHYS 310, PHYS 340A, PHYS 340B, PHYS 350, PHYS 410, PHYS 422, PHYS 450;

B. EE 310, EE 370, EE 382, EE 460, EE 482;

C. CE 335, CE 359, CE 437, CE 438, CE 458; MAE 371, MAE 373

Suboption II: Application in Economics and Management

Lower Division:

Take all the following courses:

MATH 122 Calculus I (4)

*C or better required.

Prerequisite: Appropriate MDPT placement or a grade of "C" or better in MATH 111 and MATH 113.

MATH 123 Calculus II (4)

*C or better required.

Prerequisite: A grade of "C" or better in MATH 122.

MATH 224 Calculus III (4)

Prerequisite: A grade of "C" or better in MATH 123.

MATH 247 Introduction to Linear Algebra (3)

Prerequisite: MATH 123.

CECS 174 Introduction to Programming and Problem

Solving (3)

Prerequisite: CECS 100 and MATH 113 (or equivalent).

Take the following course:

ENGL 317 Technical Communication (3)

Prerequisites: GE Foundation requirements, upper-division standing, and a previous composition course, i.e., ENGL 100, ENGL 102, ENGL 300, or equivalents.

Take one of the following groups:

1. ECON 100 Principles of Macroeconomics (3)

Prerequisites: MATH 103 or higher and one GE Foundation course.

ECON 101 Principles of Microeconomics (3),

Prerequisite/Corequisite: MATH 103 or higher.

or

2. ECON 300 Fundamentals of Economics (3)

Prerequisites: GE Foundation requirements.

Upper Division:

Take all the following courses:

MATH 323 Introduction to Numerical Analysis (4)

Prerequisites: MATH 224, and a course in computer programming.

MATH 361A Introduction to Mathematical Analysis I (3)

*C or better required.

Prerequisites: MATH 224, and MATH 233 or MATH 247.

MATH 361B Introduction to Mathematical Analysis II (3)

Prerequisite: A grade of "C" or better in MATH 361A.

MATH 364A Ordinary Differential Equations I (3)

Prerequisites: MATH 224, and prerequisite or corequisite MATH 247.

MATH 380 Probability and Statistics (3)

*C or better required.

Prerequisite: MATH 224.

STAT 381 Mathematical Statistics (3)

Prerequisites: MATH 247 and a grade of "C" or better in MATH 380.

Take a minimum of 12 units from the following courses:

MATH 364B, MATH 423, MATH 463, MATH 470, MATH 473, MATH 474, MATH 479, MATH 485; STAT 410, STAT 482, including at least one of MATH 474 or MATH 485.

Take a minimum 15 units from one of the following groups:

A. Take both of the following courses:

ECON 310 Microeconomic Theory (3)

Prerequisites: ECON 100, ECON 101, and either MATH 115 or MATH 122, with grades of "C" or better in all prerequisite courses.

ECON 311 Macroeconomic Theory (3)

Prerequisites: ECON 100, ECON 101, and either MATH 115 or MATH 122, with grades of "C" or better in all prerequisite courses.

Take 9 units selected from the following:

ECON 333, ECON 410, ECON 411, ECON 420, ECON 485, ECON486

B. Take both of the following courses:

ECON 333 Managerial Economics (3)

Prerequisites: ECON 100, ECON 101 and either MATH 115, MATH 119A, or MATH 122.

SCM 410 Logistics Management (3)

Prerequisites: MGMT 300, IS 301.

Take 9 units selected from the following:

SCM 411, SCM 414; MGMT 412, MGMT 413,

Option in Statistics (120 units)

This option provides a foundation in statistical methods. The courses required ensure that the student understands how the techniques are mathematically derived and how they are applied. Statistical analysis is an essential part of any scientific investigation and is a vital tool in monitoring the quality of products and services and in forecasting.

Requirements

Lower Division:

Take all the following courses:

MATH 122 Calculus I (4)

*C or better required.

Prerequisite: Appropriate MDPT placement or a grade of "C" or better in MATH 111 and MATH 113.

MATH 123 Calculus II (4)

*C or better required.

Prerequisite: A grade of "C" or better in MATH 122.

MATH 224 Calculus III (4)

Prerequisite: A grade of "C" or better in MATH 123.

MATH 247 Introduction to Linear Algebra (3)

Prerequisite: MATH 123.

CECS 174 Introduction to Programming and Problem

Solving (3)

Prerequisite: CECS 100 and MATH 113 (or equivalent).

Take the following course:

ENGL 317 Technical Communication (3)

Prerequisites: GE Foundation requirements, upper-division standing, and a previous composition course, i.e., ENGL 100, ENGL 102, ENGL 300, or equivalents.

Upper Division:

Take a minimum of 34 units of MATH or STAT courses to include the following (but not MATH 303, MATH 309, MATH 370A, MATH 370B, or MATH 409):

MATH 323 Introduction to Numerical Analysis (4)

Prerequisites: MATH 224, and a course in computer programming.

MATH 361A Introduction to Mathematical Analysis I (3)

Prerequisites: MATH 224, and MATH 233 or MATH 247.

MATH 380 Probability and Statistics (3)

*C or better required.

Prerequisite: MATH 224

STAT 381 Mathematical Statistics (3)

Prerequisites: MATH 247 and a grade of "C" or better in MATH 380.

STAT 410 Regression Analysis (3)

Prerequisite: STAT 381.

STAT 450 Multivariate Statistical Analysis (3)
Prerequisite: STAT 381; Prerequisite/Corequisite STAT 410.

STAT 475 Data Analysis with SAS (3)
Prerequisite: STAT 381 or consent of instructor.

Three units of the elective upper-division MATH or STAT courses may be replaced by MATH 233.

Option in Mathematics Education (120 units)

This option is for students preparing to teach mathematics at the secondary school level. Completion of this option meets subject matter competence requirements for the Single Subject Teaching Credential Mathematics. Consult the department's Mathematics Education Advisor early to plan the program.

Requirements

Lower Division:

Take all the following courses:

MATH 122 Calculus I (4)

*C or better required.

Prerequisite: Appropriate MDPT placement or a grade of "C" or better in MATH 111 and MATH 113.

MATH 123 Calculus II (4)

*C or better required.

Prerequisite: A grade of "C" or better in MATH 122.

MATH 224 Calculus III (4)

Prerequisite: A grade of "C" or better in MATH 123.

MATH 233 Fundamental Concepts for Adv Math (3)

Prerequisite: A grade of "C" or better in MATH 123.

MATH 247 Introduction to Linear Algebra (3)

Prerequisite: MATH 123.

Take one of the following courses:

ENGL 300 Advanced Composition (3)

Prerequisites: GE Foundation requirements and upper-division standing. Students must have scored 11 or higher on the GEAR Placement Examination or completed the necessary portfolio course that is a prerequisite for a GEAR Writing Intensive Capstone.

ENGL 317 Technical Communication (3)

Prerequisites: GE Foundation requirements, upper-division standing, and a previous composition course, i.e., ENGL 100, ENGL 102, ENGL 300, or equivalents.

Take one of the following sequences:

PHYS 151 Mechanics and Heat (4)

Prerequisite: None

PHYS 152 Electricity and Magnetism (4)

Prerequisite: PHYS 151; Prerequisite/Corequisite: MATH 123.

or

PHIL 170 Critical Reasoning (3)

Prerequisite/Corequisite: GE Foundation requirements Category A.1 (Written English).

PHIL 270 Symbolic Logic I (3)

Prerequisite: None.

or

Eight units of a foreign language.

Upper Division:

Take all the following courses:

MATH 310 History of Early Mathematics (3)

Prerequisite/Corequisite: At least one of MATH 224 or MATH 233 or MATH 247.

MATH 341 Number Theory (3)

*C or better required.

Prerequisite: A grade of "C" or better in MATH 233.

MATH 355 College Geometry (3)

Prerequisite: MATH 247.

MATH 380 Probability and Statistics (3)

*C or better required.

Prerequisite: MATH 224.

MATH 410 History of Modern Mathematics (3)

Prerequisites: MATH 247, MATH 310 and at least three of the following: MATH 233, MATH 341, MATH 355, MATH 361A, MATH 380.

MATH 444 Introduction to Abstract Algebra (3)

Prerequisites: MATH 233 and MATH 247 and a grade of "C" or better in at least one of MATH 341 or in MATH 347.

STAT 381 Mathematical Statistics (3)

Prerequisites: MATH 247 and a grade of "C" or better in MATH 380.

MTED 301 Computer Applications in Mathematics for Teachers (3)

Prerequisites: MTED 110 or MATH 122 or EDSS 300M or concurrent enrollment in EDSS 300M.

MTED 411 Topics and Issues in Secondary School Mathematics (3)

Prerequisites: MATH 310, MATH 341, MATH 355, MATH 380, MATH 410, MATH 444; EDSS 300M or consent of the instructor.

EDSS 300M. Introduction to Teaching -

Mathematics (3)

Prerequisite: Advanced sophomore or junior standing.

Take one of the following courses:

MATH 361A Introduction to Mathematical Analysis I (3)

Prerequisites: MATH 224, and MATH 233 or MATH 247.

MATH 364A Ordinary Differential Equations I (3)

Prerequisites: MATH 224, and prerequisite or corequisite MATH 247.

Take 3 additional upper division mathematics units *excluding*: MATH 303, MATH 309, MATH 370A, MATH 370B, MATH 409.

Single Subject Teaching Credential Mathematics

Subject matter competence for the Single Subject Teaching Credential may be demonstrated by completion of the Option in Mathematics Education with (1) a 2.75 GPA or higher in required MATH, MTED, and STAT courses, and (2) no grade lower than a C in those courses. There are alternative means of demonstrating subject matter competence; consult with the Single Subject Mathematics Education Advisor for specific academic advisement. Note that the above demonstration of subject matter competence is required for a Teaching Credential, but is not a requirement of the BS degree.

In addition to meeting the subject matter competence requirement for the Teaching Credential, prospective Math teachers are also required to complete 45 units of professional preparation in the Single Subject Credential Program, including student teaching. Students may begin the professional preparation courses as early as the junior year. With careful planning, it is possible to complete all of the credential program courses, except for student teaching, as an undergraduate. Courses may also be completed as a post-baccalaureate student. Refer to the Single Subject Teacher Education section of this catalog or the Single Subject Credential Program website (www.ced.csulb.edu/single-subject) for a description of the professional preparation requirements, courses, and application procedures.

Honors in Mathematics

Students majoring in the B.S. in Mathematics (all options) who would like an enriched academic program that includes a thesis may complete the Honors in the Major program described here. May also complete General Honors through the University Honors Program, in which case the thesis requirement may be met through the Honors in the Major.

Admission Requirements

Admission to the Honors in the Major program will be determined by the Honors in the Major Advisor.

1. Junior or senior standing with at least one year remaining before graduation.
2. Declared major of B.S. in Mathematics or any of its options.
3. Completion of the following:
 - MATH 122 Calculus I (4)
Prerequisite: Appropriate MDPT placement or a grade of "C" or better in MATH 111 and MATH 113.
 - MATH 123 Calculus II (4)
Prerequisite: A grade of "C" or better in MATH 122.
 - MATH 224 Calculus III (4)
Prerequisite: A grade of "C" or better in MATH 123.
 - MATH 247 Introduction to Linear Algebra (3)
Prerequisite: MATH 123.

And at least two upper division MATH courses at the time of entry with grades of at least "C" in each course. Students may apply during the semester in which they expect to complete these courses.

4. GPA's of at least 3.500 in all courses in the major and in all upper division courses in the major at the time of application.
5. Submission of an application describing the student's academic background, reasons for applying, and willingness to commit to completion of the requirements, including a thesis.
6. Letter of recommendation from a CSULB faculty member familiar with the student's work and abilities.

Graduation Requirements

1. GPA of at least 3.500 in all upper division courses in the major and in all courses in Items 3, 4, and 5, below.
2. Completion of all requirements for the chosen option of the B.S. in Mathematics.
3. Completion of at least one of the following courses: MATH 347, MATH 423, MATH 451, MATH 461, MATH 463, MATH 472, MATH 479.
These courses may be included among the upper division units for the major, in item 2, if allowed in the student's major.
4. Completion of at least three units of any combination of: MATH 491 and/or MATH 496.
5. Completion of 3 units of MATH 498H, Senior Thesis-Honors.
6. It is a requirement for this Honors in the Major program that the 6 units of MATH 491, MATH 496, and MATH 498H be in addition to the Department of Mathematics and Statistics course requirements for the B.S.
7. Presentation of thesis results in a public forum.

This forum could be at a meeting of a scientific or professional organization or a campus or departmental forum, subject to the approval of the Honors in the Major Advisor.

Substitutions to this program must be approved by the Honors in the Major Advisor.

Minor in Mathematics

Requirements

The Minor in Mathematics is available to any student not majoring in Mathematics or Applied Mathematics.

The student must complete 24 or more semester units as follows:

MATH 122 Calculus I (4)

*C or better required.

Prerequisite: Appropriate MDPT placement or a grade of "C" or better in MATH 111 and MATH 113.

MATH 123 Calculus II (4)

*C or better required.

Prerequisite: A grade of "C" or better in MATH 122.

MATH 224 Calculus III (4)

Prerequisite: A grade of "C" or better in MATH 123.

MATH 247 Introduction to Linear Algebra (3)

Prerequisite: MATH 123.

And take 9 units of upper-division MATH or STAT courses to include MATH 361A but not MATH 303, 309, 370A, or 409.

Minor in Applied Mathematics

Requirements

The Minor in Applied Mathematics is available to any student not majoring in Mathematics or Applied Mathematics.

The student must complete 27 or more semester units as follows:

Lower Division:

Take all of the following courses:

MATH 122 Calculus I (4)

*C or better required.

Prerequisite: Appropriate MDPT placement or a grade of "C" or better in MATH 111 and MATH 113.

MATH 123 Calculus II (4)

*C or better required.

Prerequisite: A grade of "C" or better in MATH 122.

MATH 224 Calculus III (4)

Prerequisite: A grade of "C" or better in MATH 123.

MATH 247 Introduction to Linear Algebra (3)

Prerequisite: MATH 123.

Upper Division:

Take all of the following courses:

MATH 323 Introduction to Numerical Analysis (4)

Prerequisites: MATH 224, and a course in computer programming.

MATH 380 Probability and Statistics (3)

Prerequisite: MATH 224.

Take one of the following courses:

MATH 364A Ordinary Differential Equations I (3)

Prerequisites: MATH 224, and prerequisite or corequisite MATH 247.

MATH 370A Applied Mathematics I (3)

Prerequisites: A grade of "C" or better in MATH 123. Not

open to Freshmen.

Take one course from the following:

MATH 364B, MATH 370B, MATH 423, MATH 470,
STAT 381, or STAT 482.

Minor in Statistics

Requirements

The Minor in Statistics is available to any non-Mathematics major. The student must complete 26 or more semester units as follows:

Take all of the following courses:

MATH 122 Calculus I (4)

*C or better required.

Prerequisite: Appropriate MDPT placement or a grade of "C" or better in MATH 111 and MATH 113.

MATH 123 Calculus II (4)

*C or better required.

Prerequisite: A grade of "C" or better in MATH 122.

MATH 224 Calculus III (4)

Prerequisite: A grade of "C" or better in MATH 123.

MATH 247 Introduction to Linear Algebra (3)

Prerequisite: MATH 123.

MATH 380 Probability and Statistics (3)

*C or better required.

Prerequisite: MATH 224.

STAT 381 Mathematical Statistics (3)

Prerequisites: MATH 247 and a grade of "C" or better in MATH 380.

Take any two of the following:

MATH 323, STAT 410, STAT 450, STAT 475, STAT 482,
STAT 484, STAT 485

Graduate Programs

How to Apply

See department's website: www.csulb.edu/depts/math/

To apply for admission to a graduate program in the Department of Mathematics and Statistics, you must apply to the department and to the university.

To apply to the department, send one of the following appropriate prerequisite worksheet (available online at above website or from the department office) to the Graduate Advisor by June 1 for fall admission or November 1 for spring admission:

- Pure Mathematics Prerequisite Worksheet;
- Applied Mathematics Prerequisite Worksheet;
- Applied Statistics Prerequisite Worksheet;
- Mathematics Education for Secondary Teachers Prerequisite Worksheet.

Master of Science in Mathematics

Prerequisites

1. A bachelor's degree in mathematics, or a bachelor's degree with a minimum of 24 upper division units in mathematics from an accredited college or university;
2. A grade of "C" or better in MATH 247, 361A-B, 364A and 444, or their equivalents. Deficiencies will be determined

by the Graduate Advisor.

Advancement to Candidacy

In addition to University requirements, the student must have completed all prerequisite courses listed above with no grade less than "C". Students must have fulfilled the Graduation Writing Assessment Requirement (GWAR) and should file for Advancement upon completion of at least six units (and no more than nine units) on the Program, with at least a 3.0 GPA. Program of study must be approved by the appropriate Graduate Advisor, Department of Mathematics and Statistics Chair, Associate Dean in the College of Natural Sciences and Mathematics or designee, and Dean of Graduate Studies.

Requirements

1. A minimum of 30 graduate and approved upper-division units in mathematics including:
 - A. MATH 540
 - B. Two additional courses selected from MATH 550, MATH 561, MATH 562.
 - C. Two additional courses selected from MATH 545, MATH 555, MATH 565, and MATH 566.
 - D. An additional 3 units of 500-level mathematics courses.

Three units must be in a course designated as fulfilling the program requirement in geometry; these courses include MATH 451, MATH 456, and MATH 542.

2. Complete one of the following culminating activities. (Note: In order to satisfy the culminating activity requirement (thesis, project, or comprehensive examination dependent upon the program), students must earn at least three (3) units and no more than six (6) units related to the completion of the culminating activity:
 - A. Pass a comprehensive written examination in two areas of Pure Mathematics. Specific requirements for passing of the comprehensive examinations can be found on the Department of Mathematics and Statistics website at www.csulb.edu/depts/math.
 - B. Subject to the approval of the Pure Mathematics Committee in the Department of Mathematics and Statistics, write a thesis in mathematics and defend it orally.

Option in Applied Mathematics

Prerequisites

1. A bachelor's degree in mathematics, physics, or engineering, or a bachelor's degree with at least 24 upper division units in mathematics from an accredited college or university.
2. A grade of "C" or better in MATH 247, MATH 323, MATH 361A/B, MATH 364A, and 380, or their equivalents. Deficiencies will be determined by the Graduate Advisor.

Advancement to Candidacy

In addition to University requirements, the student must have completed all prerequisite courses listed above, with no grade less than "C". Students must have fulfilled the Graduation Writing Assessment Requirement (GWAR) and should file for Advancement upon completion of at least six units (and no more than nine units) on the program, with at

least a 3.0 GPA. Program of study must be approved by the appropriate Graduate Advisor, Department of Mathematics and Statistics Chair, Associate Dean in the College of Natural Sciences and Mathematics or designee.

Requirements

1. A minimum of 30 graduate and upper division units approved by the Graduate Advisor, and including:
 - A. Three of the following courses:
MATH 563, MATH 570, MATH 576 and MATH 579.
 - B. Three additional courses selected from:
MATH 520, MATH 521, MATH 564, MATH 573, MATH 574, MATH 575, MATH 577, MATH 578, and the course in 1.A not used to satisfy that requirement.
2. Complete one of the following (Note: In order to satisfy the culminating activity requirement (thesis, project, or comprehensive examination dependent upon the program), students must earn at least three (3) units and no more than six (6) units related to the completion of the culminating activity.):
 - A. Pass a comprehensive written examination in two subjects of Applied Mathematics. Specific requirements for passing of the comprehensive examinations can be found on the Department of Mathematics and Statistics website at www.csulb.edu/depts/math.
 - B. Subject to the approval of the Applied Mathematics Committee in the Department of Mathematics and Statistics, write a thesis in applied mathematics and defend it orally.
 - C. Subject to the approval of the Applied Mathematics Committee in the Department of Mathematics and Statistics, complete a non-proprietary applied mathematics thesis project with a local company under the guidance of a faculty advisor in applied mathematics and a project leader from the company. Write a final report on the thesis project and its outcomes, and defend it orally. Specific requirements for completion of the thesis project can be found on the Department of Mathematics and Statistics website at www.csulb.edu/depts/math.

Option in Mathematics Education for Secondary School Teachers

Option in Mathematics Education for Secondary School Teachers is designed for people holding a California Single Subject Teaching Credential in Mathematics and teaching in middle, junior high, or high schools. This option will give students greater expertise in mathematics and mathematics education (curriculum, teaching, learning, assessment and research). The program includes a blend of courses from pure and applied mathematics, statistics, mathematics education, and also may include coursework from the College of Education.

Prerequisites

1. A bachelor's degree in mathematics or mathematics education, or a bachelor's degree with at least 24 upper division units in mathematics from an accredited college or university.
2. A California Single Subject Credential in Mathematics.
3. Course work in mathematics should include MATH 247,

MATH 310, MATH 341, MATH 355, MATH 361A or MATH 364A and 380 or equivalent with a grade of "C" or better.

Advancement to Candidacy

In addition to University requirements stated elsewhere in this catalog, must have completed prerequisites above and must have satisfied the Graduation Writing Assessment Requirement (GWAR). Must file for Advancement to Candidacy after completion of at least 6 units (and recommend filing before completing 9 units) on Program of Study, with an overall 3.0 grade-point average. Program of Study must be approved by Mathematics Education Graduate Advisor, Department of Mathematics and Statistics Chair and Associate Dean in the College of Natural Sciences and Mathematics or designee.

Requirements

1. A minimum of 30 units of graduate level or approved upper division coursework which includes the following:
 - A. A minimum of 9 graduate or approved upper-division units of mathematics, including at least one 500-level mathematics course. If not previously taken for BS or credential, this course of study must include:
MATH 410 History of Modern Mathematics (3)
Prerequisites: MATH 247, MATH 310 and at least three of the following: MATH 233, MATH 341, MATH 355, MATH 361A, MATH 380.
MATH 444 Introduction to Abstract Algebra (3)
Prerequisites: MATH 233 and MATH 247 and a grade of "C" or better in at least one of MATH 341 or in MATH 347.
B. A minimum of 15 graduate units of mathematics education including:
 - 1) Take both of the following:
MTED 511 Mathematics Teaching and Learning (3)
Prerequisite: Consent of instructor.
MTED 512 Curriculum and Assessment in Math (3)
Prerequisite: MTED 511 or consent of instructor.
 - 2) At least 9 units in mathematics education chosen in consultation with the Mathematics Education Graduate Advisor from the following courses:
MTED 540, MTED 550, MTED 560, MTED 580, MTED590
 - C. A minimum of 6 units of approved upper division or graduate electives from mathematics, mathematics education, or approved College of Education courses, chosen in consultation with the Mathematics Education Graduate Advisor. If the student plans to teach at the Community College level, she/he must take at least 18 units of graduate or approved upper division mathematics from Parts A and C. If the student intends to do a thesis he/she must take EDP 520 or the equivalent.
2. Complete one of the following two options:
 - A. Pass two comprehensive written examinations in mathematics education (one representing MTED 511/512 and one in a selected area - MTED 540, MTED 550, MTED 560, or MTED 580);
 - B. Subject to the approval of the Mathematics Education Committee of the Department of Mathematics and Statistics, write a thesis in mathematics education and defend it orally (MTED 698).

Mathematics Education Thesis

Students choosing the thesis option must consult with the Mathematics Education Graduate Advisor to select a thesis advisor. A proposal is then written in consultation with the mathematics education faculty advisor who will guide the student in choosing the thesis topic and supervise the writing process. After a thesis topic is chosen, it must be approved by the Mathematics Education Committee. A thesis committee of three faculty members, including the thesis advisor, is then chosen to approve the final work. During the writing of the thesis report, students must enroll in MTED 698.

Master of Science in Applied Statistics

Prerequisites

1. A bachelor's degree from an accredited college or university.
2. A grade of "B" or better in MATH 247, MATH 380, and STAT 381 or their equivalents.

Advancement to Candidacy

In addition to University requirements, the student must have completed all prerequisite courses listed above, with no grade less than "B". Students must have satisfied the Graduation Writing Assessment Requirement (GWAR) and should file for Advancement upon completion of at least six units (and no more than nine units) of the Program, with at least a 3.0 GPA. Program of study must be approved by the appropriate Graduate Advisor, Department of Mathematics and Statistics Chair and Associate Dean in the College of Natural Sciences and Mathematics or designee.

Requirements

1. A minimum of 30 graduate and 400 level units in statistics (STAT) and could include upper division/graduate non-statistics units approved by the statistics graduate advisor, and including:
 - A. STAT 510, STAT 520, STAT 530.
 - B. Four additional courses selected from 500 level STAT courses or 400 level STAT courses.
 - C. A minimum of 21 units at the 500/600 level, including at least 15 units of graduate courses in statistics (STAT) other than STAT 697 or STAT 698.
2. Complete one of the following:
 - A. Pass two comprehensive written examinations in Statistical Inference (STAT 520) and Experimental Design (STAT 530). (Note: In order to satisfy the culminating activity requirement (thesis, project, or comprehensive examination dependent upon the program), students must earn at least three (3) units and no more than six (6) units related to the completion of the culminating activity.)
 - B. Subject to the approval of the Statistics Committee in the Department of Mathematics and Statistics, write a thesis in statistics and defend it orally. A letter grade of B or better in each of STAT 510, 520 and 530 is required. A student's highest grade in a class (not the average of the two grades) is used for the purposes of the thesis requirement.
 - C. Subject to the approval of the Statistics Committee

in the Department of Mathematics and Statistics, complete a non-proprietary statistical project with an industrial company under the guidance of a faculty advisor in statistics. Write a final report and give an oral presentation of the project and its outcomes to the department. Specific requirements for completion of the project can be found on the department's statistics webpage at www.csulb.edu/depts/math. A letter grade of B or better in each of STAT 510, 520 and 530 is required. A student's highest grade in a class (not the average of the two grades) is used for the purposes of the project requirement. A student must be a full-time or part-time employee with an industrial company and the project topic must be related and benefitted to the current job.

Single Subject Teaching Credential in Mathematics

For information, refer to the undergraduate section in this department.

Early Start Mathematics Courses (ESM)

1. Early Start - Basic Algebra (1)

Prerequisite: ELM score of 38 or less.

Arithmetic review, elementary algebra and geometry.

This course will satisfy the Early Start Program requirement for CSULB bound students. Cannot be taken for credit toward a university degree. Not open to students who are exempt from the ELM.

Credit/No Credit grading only. (Seminar 15 hrs)

3. Early Start - Elem Algebra-Geometry (3)

Prerequisite: Prerequisite: ELM Score of 38 or less.

Arithmetic review, elementary algebra, and some basic geometry concepts. Cannot be taken for credit toward a university degree. Credit/No Credit grading only. Not open to students who are exempt from the ELM or who have not yet taken the ELM but are required to do so.

Credit/No Credit grading only. (Seminar 45 hrs).

11. Early Start - Enhanced Algebra (1)

Prerequisite: ELM score between 40 and 48 inclusive.

Intermediate algebra and geometry.

This course is designed to satisfy the Early Start Program requirement for CSULB bound students. Cannot be taken for credit toward a university degree. Not open to students who are exempt from the ELM

Credit/No Credit grading only. (Seminar 15 hrs).

21. Early Start - Basic Intermediate Algebra (3)

Prerequisite: Prerequisite: MAPB 1 or ELM Score between 40 and 48 inclusive.

Linear functions, their graphs, applications; proportions and percent change, applications to geometry and life; operations on radicals; rational exponents and scientific notation; dimensional analysis; sets, Venn diagrams, basic counting principles; combinations, permutations, probability; elementary data analysis; logarithmic, exponential functions, applications.

For students who will not need to take MATH 113, MATH 114 or MATH 115 or MTED 110. Cannot be taken for credit toward a university degree. Not open to students who are exempt from the ELM or who have not yet taken the ELM but are required to do so. Credit/No Credit grading only. (Lecture 3 hrs.)

33. Early Start - Enhanced Intermediate Algebra (3)

Prerequisite: Prerequisite: MAPB 1 or ELM Score between 40 and 48 inclusive.

Polynomial, rational, radical expressions, equations; rational exponents, complex numbers; solutions, graphs of linear, quadratic equations, functions; linear systems; graphs of and operations on functions; including the difference quotient and inverses; logarithmic and exponential functions. Applications to science and business emphasized.

For students that intend to take MATH 113 or MATH 115. Cannot be taken for credit toward a university degree. Not open to students who are exempt from the ELM or who have not yet taken the ELM but are required to do so. Credit/No Credit grading only. (Lecture 4 hrs)

Mathematics Prebaccalaureate Courses (MAPB)

1. Elementary Algebra and Geometry (4)

Prerequisite: Appropriate ELM Score.

Arithmetic review, elementary algebra, and some basic geometry concepts. Cannot be taken for credit toward a university degree.

Not open to students who are exempt from the ELM or who have not yet taken the ELM but are required to do so. Credit/No Credit grading only. (Lecture 4 hrs.)

7. Basic Intermediate Algebra (3)

Prerequisite: MAPB 1 or appropriate ELM Score.

Linear functions, their graphs, applications; proportions and percent change, applications to geometry and life; operations on radicals; rational exponents and scientific notation; dimensional analysis; sets, Venn diagrams, basic counting principles; combinations, permutations, probability; elementary data analysis; logarithmic, exponential functions, applications.

Cannot be taken for credit toward a university degree. Not open to students who are exempt from the ELM or who have not yet taken the ELM but are required to do so. For students who will not need to take MATH 113 or MATH 115. Credit/No Credit grading only. (Lecture 3 hrs.)

11. Enhanced Intermediate Algebra (4)

Prerequisite: MAPB 1 or appropriate ELM Score.

Polynomial, rational, radical expressions, equations; rational exponents, complex numbers; solutions, graphs of linear, quadratic equations, functions; linear systems; graphs of and operations on functions, including the difference quotient and inverses; logarithmic and exponential functions. Applications to science and business emphasized.

Cannot be taken for credit toward a university degree. Not open to students who are exempt from the ELM or who have not yet taken the ELM but are required to do so. For students that intend to take MATH 113 or MATH 115. Credit/No Credit grading only. (Lecture 2 hrs., activity 2 hrs.)

Mathematics Courses (MATH)

Satisfying the Entry-Level Math (ELM) requirement (see "Undergraduate Programs" section of this catalog) is a prerequisite for all mathematics courses and mathematics education courses. Please contact the ELM Coordinator in the Department of Mathematics and Statistics for details regarding the ELM test score.

LOWER DIVISION

103. Mathematical Ideas (3)

Prerequisite: Appropriate ELM score, ELM exemption, or MAPB 7 or MAPB 11.

Surveys variety of concepts in undergraduate mathematics. Includes elementary logic, numeration systems, rational and real numbers, modular number systems, elementary combinatorics, probability and

statistics, using real world examples.

Not open for credit to students with credit in any MATH or MTED course numbered greater than 103, or the equivalent. (Lecture 3 hrs.)

109. Modeling with Algebra (3)

Prerequisite: Appropriate ELM score, ELM exemption, or MAPB 7 or MAPB 11.

Data, functions, domain, range, representations of functions (verbal, numerical, graphical, algebraic), visualizing functions (increasing, decreasing, maximum, minimum, concave up, concave down). Linear functions, rate of change, slope, modeling data, systems of linear equations, linear inequalities. Exponentials, logs, growth decay, semi log plots for modeling.

Not open for credit to students with credit in any MATH or MTED course numbered greater than 103, or the equivalent. (Lecture 3 hrs.)

111. Precalculus Trigonometry (3)

Prerequisite: Appropriate ELM score, ELM exemption, or MAPB 11.

Trigonometric functions and applications. Arithmetic and graphical representation of complex numbers, polar form, DeMoivre's Theorem.

Not open for credit to students with credit in MATH 101, MATH 117 or MATH 122. (Lecture 3 hrs.)

113. Precalculus Algebra (3)

Prerequisite: Appropriate ELM score, ELM exemption, or MAPB 11.

Equations, inequalities. Functions, their graphs, inverses, transformations. Polynomial, rational functions, theory of equations. Exponential, logarithmic functions, modeling. Systems of equations, matrices, determinants. Sequences, series.

Not open for credit to students with credit in MATH 112, MATH 115, MATH 117, MATH 119A, MATH 120, or MATH 122. For students who will continue to MATH 115, MATH 119A, or MATH 122. (Lecture 3 hrs.)

114. Finite Mathematics (3)

Prerequisite: Appropriate ELM score, ELM exemption, or MAPB 11.

Combinatorial techniques and introduction to probability. Equations of lines and systems of linear equations, matrices, introduction to linear programming.

Not open for credit to students with credit in MATH 233 or MATH 380. (Lecture 3 hrs.)

115. Calculus for Business (3)

Prerequisite: Appropriate ELM score, ELM exemption, or MAPB 11.

Functions, derivatives, optimization problems, graphs, partial derivatives. Applications to business and economics. Emphasis on problem-solving techniques.

(Lecture 2 hrs., Activity 2 hrs) Not open for credit to students with credit in MATH 119A, MATH 120, or MATH 122.

115Z. Calculus for Business (3)

Prerequisites: ELM or ELM exemption or MAPB 11 or 12.

Functions, derivatives, optimization problems, graphs, partial derivatives. Lagrange multipliers, intergration of functions of one variable. Applications to business and economics. Emphasis on problem-solving techniques.

Only students with contracts through SB 1440 (the STAR Act) may enroll in this class. (Seminar 3 hours.)

119A. Survey of Calculus I (3)

Prerequisite: Appropriate MDPT placement or a grade of "C" or better in MATH 113.

Functions, limits and continuity, differentiation and integration of functions of one variable including exponential, logarithmic, and trigonometric functions. Graphing, optimization, parametric equations, integration by substitution and by parts, numerical integration. Applications to the life sciences. Emphasis on problem solving.

Not open for credit to students with credit in MATH 115, MATH 120 or MATH 122. (Lecture 3 hrs.)

119B. Survey of Calculus II (3)

Prerequisite: A grade of "C" or better in MATH 119A or MATH 122.

Functions of several variables, partial derivatives, optimization. First order differential equations, second order linear homogeneous differential equations, systems of differential equations. Probability, random variables, difference equations. Introduces matrices, Gaussian elimination, determinants. Life science applications. Emphasis on problem solving.

Not open for credit to students with credit in MATH 123 or MATH 224. (Lecture 3 hrs.)

122. Calculus I (4)

Prerequisite: Appropriate MDPT placement or a grade of "C" or better in MATH 111 and MATH 113.

Continuous functions. Derivatives and applications including graphing, related rates, and optimization. Transcendental functions. L'Hospital's Rule. Antiderivatives. Definite integrals. Area under a curve.

(Lecture 3 hrs., problem session 2 hrs.)

123. Calculus II (4)

Prerequisite: A grade of "C" or better in MATH 122.

Applications of the integral. Techniques of integration. Infinite series including convergence tests and Taylor series. Parametric equations. Polar coordinates. Introduces differential equations.

Not open for credit to students with credit in MATH 222. (Lecture 3 hrs., problem session 2 hrs.)

173. Programming in Mathematical Software (3)

Prerequisite: MATH 113 or equivalent.

Introduction to basic concepts and fundamental techniques for solving mathematical and scientific problems by using software MatLab and Maple. Structured problem solving and programming. (Lecture 2 hrs, problem session, 2 hrs.) Letter grade only (A-F).

224. Calculus III (4)

Prerequisite: MATH 123 with a grade of "C" or better.

Vectors and three-dimensional analytic geometry. Partial derivatives and Lagrange multipliers. Multiple integrals. Vector calculus, line and surface integrals. Green's Theorem, Stokes' Theorem, and the Divergence Theorem.

(Lecture 3 hrs., problem session 2 hrs.)

233. Fundamental Concepts for Advanced Mathematics (3)

Prerequisite: MATH 123 with a grade of "C" or better.

Fundamentals of logic and set theory, counting principles, functions and relations, induction and recursion, introduction to probability, elementary number theory, congruences. Introduces writing proofs.

(Lecture 3 hrs.)

247. Introduction to Linear Algebra (3)

Prerequisite: MATH 123.

Matrix algebra, solution of systems of equations, determinants, vector spaces including function spaces, inner product spaces, linear transformations, eigenvalues, eigenvectors, quadratic forms, and applications. Emphasis on computational methods.

(Lecture 3 hrs.)

297. Directed Study (1-6)

Prerequisite: Consent of instructor.

For students who wish to undertake special study, at the lower division level, which is not a part of any regular course, under the direction of a faculty member. Individual investigation, studies or surveys of selected problems.

UPPER DIVISION

303. Reflections in Space and Time (3)

Prerequisites: GE Foundation requirements, at least one GE Exploration course, upper-division standing.

An experimentally-driven investigation of the mathematical nature of symmetry and patterns. Considers the pervasive appearance and deep significance of symmetry and patterns in art and science.

(Lecture 3 hrs.)

309. Complexity and Emergence (3)

Prerequisites: GE Foundation requirements, at least one GE Exploration course, upper-division standing.

Introduction to complexity science. Qualitative and computational exploration of emergent properties in dynamical systems, fractals, algorithms, networks, self-organizing behavior and selected topics.

Letter grade only (A-F)

310. History of Early Mathematics (3)

Prerequisite/Corequisite: At least one of MATH 224 or MATH 233 or MATH 247.

History of mathematics through seventeenth century, including arithmetic, geometry, algebra, and beginnings of calculus. Interconnections with other branches of mathematics. Writing component; strongly recommended students enrolling have completed the G.E. A.1 requirement.

(Lecture 3 hrs.)

323. Introduction to Numerical Analysis (4)

Prerequisites: MATH 224, and a course in computer programming.

Numerical solution of nonlinear equations, systems of linear equations, and ordinary differential equations. Interpolating polynomials, numerical differentiation, and numerical integration. Computer implementation of these methods.

(Lecture-discussion 3 hrs., problem session 2 hrs.)

341. Number Theory (3)

Prerequisite: A grade of "C" or better in MATH 233

Divisibility, congruences, number theoretic functions, Diophantine equations, primitive roots, continued fractions. Writing proofs.

(Lecture 3 hrs.)

347. Linear Algebra (3)

Prerequisites: MATH 233 and MATH 247.

In-depth study of linear transformations, vector spaces, inner product spaces, quadratic forms, similarity and the rational and Jordan canonical forms. Writing proofs.

(Lecture 3 hrs.)

355. College Geometry (3)

Prerequisite: MATH 247.

Transformations, motions, similarities, geometric objects, congruent figures, axioms of geometry and additional topics in Euclidean and non-Euclidean geometry. Writing proofs.

(Lecture 3 hrs.)

361A. Introduction to Mathematical Analysis I (3)

Prerequisites: MATH 224, and MATH 233 or MATH 247.

Rigorous study of calculus and its foundations. Structure of the real number system. Sequences and series of numbers. Limits, continuity and differentiability of functions of one real variable. Writing proofs.

(Lecture 3 hrs.)

361B. Introduction to Mathematical Analysis II (3)

Prerequisite: A grade of "C" or better in MATH 361A.

Riemann integration. Topological properties of the real number line. Sequences of functions. Metric spaces. Introduction to calculus of several variables. Writing proofs.

(Lecture 3 hrs.)

364A. Ordinary Differential Equations I (3)

Prerequisites: MATH 224.

Prerequisite/Corequisite: MATH 247.

First order differential equations; undetermined coefficients and variation of parameters for second and higher order differential equations, series solution of second order linear differential equations; systems of linear differential equations; applications to science and engineering.

(Lecture 3 hrs.)

364B. Ordinary Differential Equations II (3)

Prerequisite: MATH 364A or MATH 370A.

Existence-uniqueness theorems; Laplace transforms; difference equations; nonlinear differential equations; stability, Sturm-Liouville theory; applications to science and engineering.

(Lecture 3 hrs.)

370A. Applied Mathematics I (3)

Prerequisite: A grade of "C" or better in MATH 123. Excludes freshmen.

First order ordinary differential equations, linear second order ordinary differential equations, numerical solution of initial value problems, Laplace transforms, matrix algebra, eigenvalues, eigenvectors, systems of differential equations, applications.

Not open for credit to mathematics majors. (Lecture 3 hrs.)

370B. Applied Mathematics II (3)

Prerequisite: MATH 364A or MATH 370A

Arithmetic of complex numbers, functions of a complex variable, contour integration, residues, conformal mapping; Fourier series; separation of variables for partial differential equations. Applications.

Not open for credit to mathematics majors. .

Not open for credit to mathematics majors. (Lecture 3 hrs.)

380. Probability and Statistics (3)

Prerequisite: MATH 224.

Frequency interpretation of probability. Axioms of probability theory. Discrete probability and combinatorics. Random variables. Distribution and density functions. Moment generating functions and moments. Sampling theory and limit theorems.

Letter grade only (A-F). (Lecture 3 hrs.) Not open for credit to student with credit in STAT 380.

409. Strategies for Graduate Admission (1)

Prerequisite: Senior or graduate standing.

The nature and expectations of doctoral programs in Mathematics and related fields. Intensive preparation for GRE mathematics subject exams.

Credit/No Credit grading only. Does not satisfy Mathematics major requirements. (Lecture-discussion 1 hr.)

410. History of Modern Mathematics (3)

Prerequisites: MATH 247, MATH 310 and at least three of the following: MATH 233, MATH 341, MATH 355, MATH 361A, MATH 380.

History of mathematics from seventeenth century onward. Development of calculus, analysis, and geometry during this time period. Other topics discussed may include history of probability and statistics, algebra and number theory, logic, and foundations.

(Lecture 3 hrs.)

423. Intermediate Numerical Analysis (3)

Prerequisites: MATH 247 and MATH 323.

Numerical solutions of systems of equations, calculation of eigenvalues and eigenvectors, approximation of functions, solution of partial differential equations. Computer implementation of these methods.

(Lecture 3 hrs.)

444. Introduction to Abstract Algebra (3)

Prerequisites: MATH 233 and MATH 247 and a grade of "C" or better in at least one of MATH 341 or MATH 347.

Groups, subgroups, cyclic groups, symmetric groups, Lagrange's theorem, quotient groups. Homomorphisms and isomorphisms of groups. Rings, integral domains, ideals, quotient rings, homomorphisms of rings. Fields. Writing proofs.

(Lecture 3 hrs.)

451. Differential Geometry (3)

Prerequisite: MATH 364A or MATH 370A.

Structure of curves and surfaces in space, including Frenet formulas of space curves; frame fields and connection forms; geometry of surfaces in Euclidean three space; Geodesics and connections with general theory of relativity.

(Lecture 3 hrs.)

456. Dynamics and Geometry of Chaos (3)

Prerequisites: MATH 247, MATH 361A, or consent of instructor.

An introduction to discrete dynamical systems in one and two dimensions. Theory of iteration: attracting and repelling periodic points, symbolic dynamics, chaos, and bifurcation. May include a computer lab component.

(Lecture 3 hrs.)

461. Introduction to Complex Analysis (3)

Prerequisite: MATH 361A.

Theory and applications of complex variables. Analytic functions, integrals, power series and applications.

(Lecture 3 hrs.)

463. Multivariable Calculus (3)

Prerequisites: MATH 224, MATH 247, and MATH 361B.

Topology of Euclidean spaces. Partial derivatives. Derivatives as linear transformations. Inverse and implicit function theorems. Jacobians, vector calculus, Green's and Stokes' theorems. Variational problems.

(Lecture 3 hrs.)

470. Introduction to Partial Differential Equations (3)

Prerequisite: MATH 364A or MATH 370A.

First and second order equations, characteristics, Cauchy problems, elliptic, hyperbolic, and parabolic equations. Introduction to boundary and initial value problems and their applications.

(Lecture 3 hrs.)

472. Fourier Analysis (3)

Prerequisite: MATH 364A or MATH 370A.

Theory of Fourier series and Fourier transforms. Physics and engineering applications. Parseval's and Plancherel's identities. Convolution. Multi-dimensional transforms and partial differential equations. Introduction to distributions. Discrete and fast Fourier transforms.

(Lecture 3 hrs.)

473. Scientific Computing (3)

Prerequisites: MATH 323 and MATH 364A or MATH 370A.

Introduction to programming languages. Analysis and implementation of numerical algorithms for linear systems, linear and nonlinear regression, differentiation, integration, optimization and fast convolution using FFT. Basic algorithms for differential equations. Letter grade only (A-F).

474. Mathematics of Financial Derivatives (3)

Prerequisites: MATH 364A or MATH 370A, MATH 380, or consent of instructor.

Options, futures, and other financial derivatives; arbitrage; risk-neutral valuation; binomial trees; the log-normal hypothesis; the Black-Scholes-Merton formula and applications; the Black-Scholes-Merton partial differential equation; American options; exotic options; bond models and interest rate derivatives; credit risk and credit derivatives.

479. Mathematical Modeling (3)

Prerequisites: MATH 247, MATH 323; MATH 364A or MATH 370A; and consent of instructor.

Introduction to mathematical modeling in the applied sciences, including validation and practical use of various modeling methodologies. Mathematical models in physics, chemistry, biology, and other natural sciences. Applications of computational mathematics in computer science, engineering, finance, and related disciplines. Letter grade only (A-F).

485. Mathematical Optimization (3)

Prerequisites: MATH 247 and at least one of MATH 323, MATH 347 or MATH 380.

Linear and nonlinear programming: simplex methods, duality theory, theory of graphs, Kuhn-Tucker theory, gradient methods and dynamic programming.

(Lecture 3 hrs.)

491. Honors Seminar in Problem Solving (1)

Prerequisite: Consent of instructor.

Challenging problems from many fields of mathematics, taken largely from national and worldwide collegiate and secondary school competitions. Students required to participate in at least one national competition.

May be repeated to a maximum of 3 units. (Lecture-discussion 1 hr.)

495. Topics in Modern Mathematics (3)

Prerequisite: Consent of instructor.

Topics of current interest from mathematics literature.

496. Special Problems (1-3)

Prerequisite: Consent of instructor.

Student investigations in mathematics, applied mathematics, mathematics education, or statistics. May include reports and reviews from the current literature, as well as original investigations.

May be repeated to a maximum of 3 units. Letter grade only (A-F).

497. Directed Studies (1-6)

Prerequisites: Junior or senior standing and consent of instructor.

Readings in areas of mutual interest to student and instructor which are not a part of any regular course. A written report or project may be required.

May be repeated to a maximum of 6 units.

498H. Senior Thesis - Honors (3)

Prerequisites: Admission to Honors in the Major in Mathematics or to the University Honors Program, and consent of instructor.

Planning, preparation, completion, and oral presentation of a written thesis in mathematics, applied mathematics, mathematics education, or statistics.

Not available to graduate students. Letter grade only (A-F).

GRADUATE LEVEL

520. Finite Element Method (3)

Prerequisite: MATH 323, MATH 361A, MATH 364A.

Recommended: MATH 470.

Variational forms and weak solutions of partial differential equations, Galerkin method, construction of elements, numerical algorithms for matrix equations and for one-dimensional and two-dimensional problems. Convergence analysis and error estimate. Numerical implementations of algorithms.

Letter grade only (A-F). (Lecture 3 hrs.)

521. Matrix Method in Data Analysis and Pattern Recognition (3)

Prerequisite: MATH 423 or MATH 576.

Vector spaces and linear transformations, optimal orthogonal projections, eigenvalues, eigenvectors, SVD, generalized SVD, Fourier and wavelet transforms, convolution, tangent distance. Implementations include object recognition, handwritten digit classification, digital image processing, feature extraction, image deblurring, text mining.

Letter grade only (A-F). (Lecture 3 hrs.)

540. Elements of Abstract Algebra (3)

Prerequisite: MATH 444.

Group theory including symmetric groups; group actions on sets; Sylow theorems and finitely generated abelian groups; ring theory including polynomial rings, division rings, Euclidean domains, principal ideal domains, and unique factorization domains.

Letter grade only (A-F). (Lecture 3 hours).

542. Algebraic Geometry (3)

Prerequisite: Consent of instructor.

An introduction to algebraic geometry: Algebraic sets; affine and projective varieties. Additional topics at the discretion of the instructor may include: Algebraic Curves; Intersection Theory; Invariant Theory; Computational Approaches.

Letter grade only (A-F). (Lecture 3 hrs.)

545. Topics in Abstract Algebra (3)

Prerequisite: MATH 540.

Selected topics in algebra that build upon the material of MATH 540. Content will vary by semester. May be taken for credit more than once with the consent of the graduate advisor

Letter grade only (A-F). (Lecture 3 hours).

550. Elements of Topology (3)

Prerequisite: MATH 361B.

Fundamentals of point-set topology: metric spaces and topological spaces; bases and neighborhoods; continuous functions; subspaces, product spaces and quotient spaces; separation properties, countability properties; compactness, compactification; connectedness; convergence of sequences; other topics, such as nets, filters and metrizable, as time permits. Letter grade only (A-F). (Lecture 3 hours).

555. Topics in Topology (3)

Prerequisite: MATH 550.

Selected topics in topology that build upon the material of MATH 550. Content will vary by semester. May be taken for credit more than once with the consent of the graduate advisor

Letter grade only (A-F). (Lecture 3 hours).

560. Functional Analysis (3)

Prerequisites: MATH 247, MATH 361B.

Linear spaces, metric and topological spaces, normed linear spaces; four principles of functional analysis: Hahn-Banach, Open Mapping, Uniform Boundedness, and Closed Graph theorems; adjoint spaces; normed space convergence, conjugate spaces, and operator spaces; Banach Fixed Point theorem; Hilbert spaces..

Letter grade only (A-F). (Lecture 3 hours).

561. Elements of Real Analysis (3)

Prerequisite: MATH 361B.

Theory of measure and integration, focusing on the Lebesgue integral on Euclidean space, particularly the real line. Modes of convergence. Fatou's Lemma, the monotone convergence theorem and the dominated convergence theorem. Fubini's theorem.

Letter grade only (A-F). (Lecture 3 hours)

562. Elements of Complex Analysis (3)

Prerequisite: MATH 361B.

Axiomatic development of real and complex numbers; elements of point set theory; differentiation and analytic functions, classical integral theorems; Taylor's series, singularities, Laurent series, calculus of residues.

Letter grade only (A-F). (Lecture 3 hours).

563. Applied Analysis (3)

Prerequisites: MATH 361B and either MATH 364A or MATH 370A.

Hilbert Spaces, L_p spaces, Distributions, Fourier Transforms, and applications to differential and integral equations from physics and engineering.

Letter grade only (A-F). (Lecture 3 hrs.)

564. Applied Nonlinear Ordinary Differential Equations (3)

Prerequisites: MATH 361B; MATH 364A or MATH 370A.

Stability and asymptotic analysis, Perturbation methods, Phase plane analysis, Bifurcation, Chaos, Applications to science and engineering.

(Lecture 3 hrs.)

565. Topics in Real Analysis (3)

Prerequisite: MATH 561.

Selected topics in real analysis that build upon the material of MATH 561. Content will vary by semester. May be taken for credit more than once with the consent of the graduate advisor

Letter grade only (A-F). (Lecture 3 hours).

566. Topics in Complex Analysis (3)

Prerequisite: MATH 562.

Selected topics in real analysis that build upon the material of MATH 562. Content will vary by semester. May be taken for credit more than once with the consent of the graduate advisor

Letter grade only (A-F). (Lecture 3 hours).

570. Partial Differential Equations (3)

Prerequisites: MATH 364A and MATH 463.

Cauchy's problem; classification of second order equations; methods of solution of hyperbolic, parabolic, and elliptic equations.

Letter grade only (A-F). (Lecture 3 hrs.)

573. Advanced Scientific Computing (3)

Prerequisites: MATH 323 and MATH 364A or MATH 370A.

Analysis and implementation of numerical algorithms for linear systems, linear and nonlinear regression, differentiation, integration, optimization and fast convolution using FFT. Numerical solutions for differential equations.

Letter grade only (A-F).

574. Stochastic Calculus and Applications (3)

Prerequisites: MATH 361B, MATH 364A or MATH 370A, MATH 380.

Review of probability theory. Markov processes. Wiener processes. Stochastic integrals. Stochastic differential equations. Applications to Finance and Engineering.

(Lecture 3 hrs.)

575. Calculus of Variations (3)

Prerequisites: MATH 361B and either MATH 364A or MATH 370A

Solution methods for variational problems. First variation, Euler-Lagrange equation, variational principles, problems with constraints, boundary conditions, applications to physics and geometry. May include multiple integral problems, eigenvalue problems, convexity, and second variation.

Letter grade only (A-F). (Lecture 3 hrs.)

576. Numerical Analysis (3)

Prerequisites: MATH 323, MATH 361B, MATH 364A.

Advanced numerical methods. Introduction to error analysis, convergence, and stability of numerical algorithms. Topics may include solution of ordinary differential equations, partial differential equations, systems of linear and nonlinear equations, and optimization theory.

Letter grade only (A-F). (Lecture 3 hrs.)

577. Numerical Solution of Partial Differential Equations (3)

Prerequisite: MATH 423 or MATH 576 or consent of instructor.

Finite difference methods solving hyperbolic, parabolic, elliptic PDE'S; accuracy, convergence, and stability analysis. Selected initial-value boundary-value problems, characteristics, domain of dependence, matrix and von Neumann's methods of stability analysis. Solutions of large sparse linear systems. Finite element method.

(Lecture 3 hrs.)

578. Numerical Linear Algebra (3)

Prerequisites: MATH 247 and MATH 323 or consent of instructor.

Numerical solutions of linear systems, least squares problems, eigenvalue problems. Matrix factorization: LU, QR, SVD, iterative methods. Error analysis. Applications with attention to linear algebra problems arising in numerical solutions of partial differential equations. Numerical implementation of algorithms.

Letter grade only (A-F). (Lecture 3 hrs.)

579. Advanced Mathematical Modeling (3)

Prerequisites: MATH 247, MATH 323; MATH 364A or MATH 370A; one additional graduate level mathematics course, and consent of instructor.

Application of mathematics to develop models of phenomena in science, engineering, business, and other disciplines. Evaluation of benefits and limitations of mathematical modeling.

Letter grade only (A-F).

590. Selected Topics in Mathematics (3)

Prerequisite: Consent of Instructor

Specialized and advanced topics in mathematics.

May be repeated to a maximum of 9 units in different or same semester. (3 hours lecture)

695. Seminar in Mathematics (3)

Prerequisite: Consent of instructor.

Presentation and discussion of advanced work, including original research by faculty and students. Topics announced in the *Schedule of Classes*.

May be repeated to a maximum of 6 units. Letter grade only (A-F).

697. Directed Studies (1-6)

Prerequisite: Consent of instructor.

Research on a specific area in mathematics. Topics for study to be approved and directed by faculty advisor in the Department of Mathematics and Statistics.

Letter grade only (A-F).

698. Thesis or Project (1-6)

Prerequisite: Advancement to candidacy.

Formal report of research or project in mathematics.

May be repeated to a maximum of six units. Letter grade only (A-F).

Mathematics Education Courses (MTED)

Satisfying the Entry-Level Math (ELM) requirement (see "Undergraduate Programs" section of this catalog) is a prerequisite for all mathematics education courses.

LOWER DIVISION

110. The Real Number System for Elementary and Middle School Teachers (3)

Prerequisite: ELM or ELM exemption or MAPB 11.

Introduction to problem solving processes and strategies. Development and analysis of structure, properties, and operations of real number system. Concept and process development using appropriate models, manipulatives, and activities.

Not open for credit to Mathematics majors. (Lecture 2 hrs., activity 2 hrs.)

205. Activity Based Probability and Statistics for Elementary and Middle School Teachers (3)

Prerequisites: ELM or ELM exemption or MAPB 11 and MTED 110.

Activity-based exploration of randomization, data representation, measures of central tendency and dispersion. Analysis of experiments requiring hypothesizing, experimental design and data gathering. Basic laws of probability and set theory, combinations, permutations, and simulations.

Letter grade only (A-F). (Lecture 2 hrs., activity 2 hrs.) Not open for credit to mathematics (all options) and statistics majors or for students with credit in MTED 105.

211. Geometry and Measurement for Elementary Teachers (3)

Prerequisites: MTED 110 with a grade of "C" or better and one year of high school geometry.

Problem solving and hands-on modeling of real-world geometry situations focusing on patterning, informal geometry, congruence, similarity, constructions, transformations, tessellations, measurement in 1, 2, and 3 dimensions (English and Metric units). Computer applications are integrated into the course.

Not open for credit to Mathematics majors or any student with credit in MTED 312. (Lecture 2 hrs., activity 2 hrs.)

UPPER DIVISION

301. Computer Applications in Mathematics for Teachers (3)

Prerequisite(s)/Corequisite(s): MTED 110 or MATH 122 or EDSS 300M or concurrent enrollment in EDSS 300M

Designed for pre-service or inservice teachers. Software evaluation; teacher tools (spreadsheets, databases, email, collaborative tools, and applications); mathematics using technology; programming; technology use issues in schools.

Satisfies California Level I teaching credential computer technology standard. Open for credit to pre-service or in-service teaching credential students only. (Lecture 2 hrs., activity 2 hrs.)

303. Number Systems, Probability and Statistics for Elementary and Middle School Teachers (3)

Prerequisite: California Teaching Credential.

Introduction to problem solving, development, analysis of the structure, properties and operations of the real number system. Concept and process development using appropriate models, manipulatives, and activities. Statistics including data representation, measures of central tendency and dispersion. Basic laws of probability and set theory, combinations, permutations, and simulations.

Letter grade only (A-F). (Lecture 2 hours, Activity 2 hours)

312. Geometry and Measurement for Mathematics Specialists in Elementary and Middle Schools (4)

Prerequisites: MTED 110 and one year of high school geometry.

Exploration, conjecture, justification of geometric relationships, applications relevant to teaching geometry (K-10). Problem solving, informal geometry, proof, non-Euclidean geometry, congruency, similarity, constructions, transformations, tessellations, measurement (English and Metric) in 1, 2, and 3 dimensions. Computer construction utility used.

Not open for credit to Mathematics majors. Letter grade only (A-F). (Lecture 2 hrs., activity 2 hrs.)

402. Problem Solving Applications in Mathematics for Elementary and Middle School Teachers (3)

Prerequisite(s): (include complete list of course prerequisites) "C" or better in MTED 110, MTED 205, and either MTED 211 or 312 or the equivalent and a course in Critical Thinking.

Problem solving processes and strategies; interrelates and applies content from many mathematics areas (real number system, algebra, number theory, geometry, measurement, probability and statistics); develops questioning strategies, fostering understanding of algebra and geometry. Technology integrated throughout.

Not open for credit to Mathematics majors. (Lecture 2 hrs., activity 2 hrs.)

411. Topics and Issues in Secondary School Mathematics (3)

Prerequisites: MATH 310, MATH 341, MATH 355, MATH 380, MATH 410, MATH 444; EDSS 300M or consent of the instructor.

Analysis of topics and issues in secondary school mathematics curriculum. Problem solving, mathematical connections, communication, structures, conjecture, proof, manipulatives, technology, assessment. Observations/interview experiences and portfolio assemblage required. Intended for students preparing to enter Single Subject Credential Program in mathematics.

(Lecture 2 hrs., laboratory 3 hrs.)

415. History of Mathematics for Elementary and Middle School Teachers (4)

Prerequisite: MTED 312 with a grade of "C" or better.

Mathematics ideas throughout history with orientation toward various civilizations and cross-cultural views. Covers origins and interrelationships of areas of K-9 mathematics curriculum, including arithmetic, algebra, geometry, statistics and probability, cryptography, and other mathematics topics.

Not open for credit to mathematics (all options) or statistics majors or for students with credit in MATH 310 or MTED 315. Letter grade only (A-F). (Lecture 2 hrs; activity 2 hrs.)

420. Number Theory for Elementary and Middle School Teachers (4)

Prerequisite: MTED 312 with a grade of "C" or better.

Concepts and justification involving basic properties of natural numbers, mathematics induction, Euclidean algorithm, and the Fundamental Theorem of Arithmetic. Topics include proofs and problem-solving with divisibility, primes and composites, and prime factorization; congruences and other examples.

Not open for credit to mathematics (all options) or statistics majors or for students with credit in MATH 341 or MTED 320. Letter grade only (A-F). (Lecture 2 hrs; activity 2 hrs.)

424. Algebraic Structures for Elementary and Middle School Teachers (4)

Prerequisite: MTED 312 with a grade of "C" or better.

Properties of real and complex numbers, groups, rings, reals and complex fields; polynomial equations and inequalities; polynomial, rational, radical, absolute value, exponential, and logarithmic functions; matrices and vectors.

Not open for credit to mathematics (all options) or statistics majors or for students with credit in MATH 444 or MTED 324. Letter grade only (A-F). (Lecture 2 hrs; activity 2 hrs.)

425. Functions, Models and Concepts of Calculus for Elementary and Middle School Teachers (4)

Prerequisite: MTED 312 with a grade of "C" or better.

Numeric, symbolic, graphical, verbal representation of functions; sequences and sums. Intuitive development of concepts of limit, continuity, derivative, integral. Applications, including differential equations. Algebraic methods and technology emphasized in context of learning calculus. Not open for credit to mathematics (all options) or statistics majors or for students with credit in MTED 325. Letter grade only (A-F). (Lecture 2 hrs; activity 2 hrs.)

495. Special Topics in Mathematics Education (1-3)

Prerequisite: Consent of instructor.

Topics of interest in Mathematics Education.

May be repeated to a maximum of 9 units with different topics in different semesters. Letter grade only (A-F).

GRADUATE LEVEL

500. Advanced Perspectives of Concepts Foundational to Algebra for Teachers (3)

Prerequisite: Multiple Subjects Credential, or consent of instructor.

Analytic investigation of foundational algebra concepts using representations, reasoning and proof, and problem solving. Topics include: number theory, properties of real numbers, proportional reasoning, algebra, discrete mathematics, and functions.

This course will not count toward any M.S. degree options in the Department of Mathematics and Statistics. Letter grade only (A-F). (Lecture 3 hrs.)

511. Mathematics Teaching and Learning (3)

Prerequisite: Consent of instructor.

Theories of mathematics teaching and learning. Key issues in mathematics and mathematics education. Historical development and contemporary views of various theoretical perspectives for teaching and learning mathematics, including the roles of standards and various mathematics and education organizations.

Letter grade only (A-F). (Lecture and Discussion, 3 hrs.)

512. Curriculum and Assessment in Mathematics (3)

Prerequisite: MTED 511 or consent of instructor.

Theories of mathematics curriculum and forms of assessment. Introduces major philosophies, issues, resources, and technologies pertaining to curricula and assessment of mathematics. Relevant histories and contemporary practices of design and implementation of curriculum and assessment of mathematics.

Letter grade only (A-F). (Lecture and Discussion, 3 hrs.)

540. Algebra in the School Curriculum (3)

Prerequisite: MTED 511; prerequisite or corequisite: MTED 512 or consent of instructor.

Issues/topics concerning algebraic learning using curricular standards. Examining texts, curricula, algebraic thinking, and teaching research. Common errors and possible remedies, algebra for mathematizing situations. Relationship of K-12 algebra curriculum to modern algebra and its structures. Fundamental theorem of algebra.

Letter grade only (A-F). (Lecture and Discussion, 3 hrs.)

550. Geometry and Measurement in the School Curriculum (3)

Prerequisite: MTED 511; prerequisite or corequisite: MTED 512 or consent of instructor.

Content, curriculum, standards, and research in learning and teaching geometry, spatial sense and measurement in K-12. Justification and proof, applications and abstraction, tools and technology in geometry teaching and learning. Current issues in teaching and learning of geometry and measurement.

Letter grade only (A-F). (Lecture and Discussion, 3 hrs.)

560. Analysis in the Secondary Curriculum (3)

Prerequisites: MTED 511 and MATH 361A; prerequisite or corequisite: MTED 512 or consent of instructor.

Fundamental concepts of calculus, functions, mappings, related topics and proofs in real and complex analysis, relating mathematics analysis to secondary curriculum. Issues and techniques in teaching and learning of mathematical analysis. Examination of mathematics education research and mathematics frameworks.

Letter grade only (A-F). (Lecture and Discussion, 3 hrs.)

580. Probability and Statistics in the School Curriculum (3)

Prerequisite: MTED 511; prerequisite or corequisite: MTED 512 or consent of instructor.

Content, curriculum, and research in learning and teaching probability and statistics in K-12 schools. Includes role of applications, abstraction, tools and technology in probability and statistics teaching and learning.

Letter grade only (A-F). (Lecture and Discussion, 3 hrs.)

590. Special Topics in Mathematics Education (1-3)

Prerequisite: Consent of instructor.

Advanced study of special topics in the field of mathematics education.

May be repeated for a total of six units with different topics. Letter grade only (A-F). (Seminar 1-3 hrs.)

697. Directed Studies in Mathematics Education (1-6)

Prerequisites: MTED 511, MTED 512; EDP 520; Advancement to Candidacy; consent of instructor.

Research project in mathematics education.

Letter grade only (A-F).

698. Thesis in Mathematics Education (1-6)

Prerequisites: MTED 511, MTED 512; EDP 520; Advancement to Candidacy; consent of instructor.

Research in mathematics education culminating in a formal report.

Letter grade only (A-F).

Statistics Courses (STAT)

Satisfying the Entry-Level Math (ELM) requirement (see "Undergraduate Programs" section of this catalog) is a prerequisite for all statistics courses.

108. Statistics for Everyday Life (3)

Prerequisite: Appropriate ELM score, ELM exemption, or MAPB 7 or MAPB 11 or MAPB 12.

Exploratory data analysis, methods of visualizing data, descriptive statistics, misuse and manipulation of data in statistical analysis, probability, binomial and normal distributions, hypothesis testing, correlation and regression, contingency tables.

Not open for credit to students with credit in MATH 108, MATH 180, MATH 380; or MTED 105, 205. (Lecture 3 hrs.)

118. Introductory Business Statistics (3)

Prerequisite: Appropriate ELM score, ELM exemption, or MAPB 11.

Sampling methods, data collection, organizing and visualizing, descriptive statistics, random variables, probability distributions, point and interval estimation, hypothesis testing, correlation, regression, contingency tables, applications in business, finance, econometrics, and marketing research.

(Lecture 3 hours)

381. Mathematical Statistics (3)

Prerequisites: MATH 247 and a grade of "C" or better in MATH 380.

Estimation and hypothesis testing. Maximum likelihood and method of moments estimation. Efficiency, unbiasedness, and asymptotic distribution of estimators. Neyman-Pearson Lemma. Goodness-of-fit tests. Correlation and regression. Experimental design and analysis of variance. Nonparametric methods.

Letter grade only (A-F). (Lecture 3 hrs.) Not open for credit to students with credit in MATH 381.

410./510. Regression Analysis (3)

Prerequisite: STAT 381. (Undergraduates register in STAT 410; graduates enroll in STAT 510.)

Simple linear regression: estimation and inference, prediction, analysis of residuals, detection of outliers, use of transformations. Multiple linear regression: influence diagnostics, multi-collinearity, selection of variables, simultaneous estimation and inference, validation techniques. Statistical software for data analysis used.

Letter grade only (A-F). (Lecture 3 hrs.) Not open for credit to students with credit in MATH 480 or MATH 590.

450./550. Multivariate Statistical Analysis (3)

Prerequisite: STAT 381; Prerequisite/Corequisite STAT 410. (Undergraduates register in STAT 450; graduates enroll in STAT 550.)

Discriminate analysis, principal components, factor analysis, cluster analysis, logistic regression, canonical correlation, multidimensional scaling, and some nonlinear techniques. Statistical software used.

Letter grade only (A-F). (Lecture 3 hrs.) Not open for credit to students with credit in MATH 483 or MATH 593.

475. Data Analysis with SAS (3)

Prerequisite: STAT 381 or consent of instructor.

Topics include: Statistical analysis including extraction, presentation of data in graphical form, creation, modification of datasets, interpretation of output, writing of reports. Provides SAS programming techniques for aforementioned topics preparation for SAS base certification.

Letter grade only (A-F). (Lecture 3 hrs.) Not open for credit to students with credit in MATH 489.

482. Random Processes (3)

Prerequisites: MATH 247 and MATH 380.

Further topics in probability. Markov processes. Renewal theory. Random walks. Queueing theory. Poisson processes. Brownian motion.

Letter grade only (A-F). (Lecture 3 hrs.) Not open for credit to students with credit in MATH 382.

484. Actuarial Science: Models (3)

Prerequisite: STAT 381 or consent of instructor.

Statistical techniques applied to risk management. Expected utility theory, individual risk models, compound Poisson distributions and processes, ruin probability and first surplus, stop-loss and proportional reinsurance, statistical survival distributions and life tables, life annuity, actuarial present values, and premiums determination.

Letter grade only (A-F). (Lecture 3 hrs.) Not open for credit to students with credit in MATH 484.

485. Actuarial Science: Financial Mathematics (3)

Prerequisite: STAT 381.

Simple and compound interests, stochastic approaches to interest and annuities, stochastic models of stock, Black-Scholes arbitrage pricing of options and other derivative securities, Markowitz portfolio optimization theory, Ito financial calculus, filtrations and martingales.

Letter grade only (A-F). (Lecture 3 hrs.)

495./595. Topics in Modern Statistics (3)

Prerequisite: Consent of instructor. (Undergraduates register in STAT 495; graduates enroll in STAT 595.)

Topics of current interest from statistics literature.

Letter grade only (A-F). Course may be repeated to a maximum of 6 units with different topics. (Lecture 3 hrs)

497. Directed Studies (1-6)

Prerequisite: Consent of instructor.

Junior or senior standing and consent of instructor. Not open to graduate students.

Letter grade only (A-F).

GRADUATE LEVEL

510./410. Regression Analysis (3)

Prerequisite: STAT 381. (Undergraduates register in STAT 410; graduates enroll in STAT 510.)

Simple linear regression: estimation and inference, prediction, analysis of residuals, detection of outliers, use of transformations. Multiple linear regression: influence diagnostics, multi-collinearity, selection of variables, simultaneous estimation and inference, validation techniques. Statistical software for data analysis used.

Letter grade only (A-F). (Lecture 3 hrs.) Not open for credit to students with credit in MATH 480 or MATH 590.

520. Statistical Inference (3)

Prerequisite: STAT 381 or consent of instructor.

Properties of a random sample, convergence in probability, law of large numbers, sampling from the normal distribution, the central limit theorem, principles of data reduction, likelihood principle, point estimation, Bayesian estimation, methods of evaluating estimators, hypothesis testing, decision theory, confidence intervals.

Letter grade only (A-F). (Lecture 3 hrs.) Not open for credit to students with credit in MATH 580.

530. Experimental Design (3)

Prerequisite: STAT 381 or consent of instructor.

Design of experiments to permit efficient analysis of sources of variation with application to quality assurance. Factorial and fractional factorial designs; block designs; confounding. Fixed and random effect models. Effects of departure from assumptions; transformations. Response surface techniques. Taguchi methods.

Letter grade only (A-F). (Lecture 3 hrs.) Not open for credit to students with credit in MATH 581.

532. Statistical Quality Control (3)

Prerequisite: STAT 381 or consent of instructor.

Introduction to methods of statistical quality control. Includes control charts, acceptance sampling, process capability analysis, and aspects of experimental design.

Letter grade only (A-F). (Lecture 3 hrs.) Not open for credit to students with credit in MATH 584.

540. Survey Sampling (3)

Prerequisite: STAT 381 or consent of instructor.

Theory and practice of sampling from finite populations. Simple random sampling, stratified random sampling, systematic sampling, cluster sampling, properties of various estimators including ratio, regression, and difference estimators. Error estimation for complex samples.

Letter grade only (A-F). (Lecture 3 hrs.) Not open for credit to students with credit in MATH 583.

544. Statistical Consulting (3)

Prerequisites: STAT 381 and STAT 410/510 or consent of instructor.

The methodology of statistical consulting: guidelines for client-consultant communications, presentations to clients, basics of writing final technical reports, thorough case studies involving advanced statistical analysis, invited client presentations, real-life projects, group discussions, written and oral statistical reports by students.

Letter grade only (A-F). (Lecture 3 hrs.)

550./450. Multivariate Statistical Analysis (3)

Prerequisite: STAT 381; Prerequisite/Corequisite STAT 410. (Undergraduates register in STAT 450; graduates enroll in STAT 550.)

Discriminate analysis, principal components, factor analysis, cluster analysis, logistic regression, canonical correlation, multidimensional scaling, and some nonlinear techniques. Statistical software used.

Letter grade only (A-F). (Lecture 3 hrs.) Not open for credit to students with credit in MATH 483 or MATH 593.

560. Nonparametric Statistics (3)

Prerequisite: STAT 410 or STAT 510, or consent of instructor.

Alternatives to normal-theory statistical methods, analysis of categorical and ordinal data, methods based on ranks, measures of association, goodness of fit tests, order statistics.

Letter grade only (A-F). (Lecture 3 hrs.) Not open for credit to students with credit in MATH 585.

572. Computational Statistics (3)

Prerequisite: STAT 381 or consent of instructor.

Random number generation, sampling and subsampling, exploratory data analysis, Markov chain Monte Carlo methods, density estimation and EM algorithm. Topics of current interest.

Letter grade only (A-F). (Lecture 3 hrs.)

574. Data Mining (3)

Prerequisite: STAT 410, or STAT 510, or consent of instructor.

Basics of data mining algorithms with emphasis on industrial applications. Prediction and classification techniques such as decision trees, neural networks, Multivariate Adaptive Regression Splines, and other methods. Several software packages utilized.

Letter grade only (A-F). (Lecture 3 hrs.) Not open for credit to students with credit in MATH 586.

576. Data Informatics (3)

Prerequisite: STAT 410/510 or consent of instructor.

Genetic algorithms, fuzzy logic, discrete choice analysis, online analytical processing, structured query language, statistical database management, and text and web mining. Topics of current interest.

Letter grade only (A-F). (Lecture 3 hrs.)

580. Time Series (3)

Prerequisite: STAT 381 or consent of instructor.

Includes moving averages, smoothing, Box-Jenkins (ARIMA) models, testing for nonstationarity, model fitting and checking, prediction and model selection, seasonal adjustment, ARCH, GARCH, cointegration, state-space models. Statistical packages used throughout the course.

Letter grade only (A-F). (Lecture 3 hrs.) Not open for credit to students with credit in MATH 582.

590. Statistical Analysis of Medical Data (3)

Prerequisite: STAT 381 or consent of instructor.

Lifetime distributions, hazard and survival functions, censoring and truncation, Kaplan Meier and Nelson-Aalen estimators, Cox proportional hazard models, m-sample tests, goodness-of-fit tests, Bayesian survival analysis, analysis of multivariate survival data, exploring longitudinal data designs and models, clinical trials.

Letter grade only (A-F). (Lecture 3 hrs.)

595./495. Topics in Modern Statistics (3)

Prerequisite: Consent of instructor. (Undergraduates register in STAT 495; graduates enroll in STAT 595.)

Topics of current interest from statistics literature.

Letter grade only (A-F). Course may be repeated to a maximum of 6 units with different topics. (Lecture 3 hrs)

695. Seminar in Applied Statistics (3)

Prerequisite: Consent of instructor.

Presentation and discussion of advanced work in applied statistics.

May be repeated to a maximum of six units. Letter grade only (A-F).

697. Directed Studies in Applied Statistics (1-3)

Prerequisite: Consent of instructor.

Research on a specific area in applied statistics. Topic for study to be approved and directed by a statistics faculty member.

Credit/No Credit only.

698. Thesis or Project (1-6)

Prerequisite: Advancement to candidacy.

Formal report of research or project in mathematics.

Letter grade only (A-F). May be repeated to a maximum of 6 units.

OCEAN STUDIES INSTITUTE

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Introduction

The Ocean Studies Institute was created in 1972 to coordinate teaching, research and community service in ocean studies on member campuses. Members include Dominguez Hills, Fullerton, Long Beach, Los Angeles, Northridge, Pomona, San Bernardino, and San Marcos. The Institute does not offer degrees, but it serves as an administrative liaison to facilitate degree programs offered on member campuses.

The Institute operates a 76-foot research vessel for teaching and research purposes, obtains research grants and contracts, performs research, and is responsible for curriculum planning and facilities acquisition. Presently the Institute serves over 35 departments across eight campuses.

The courses and research in which the Institute is actively engaged reflect the broad applied approach of interdisciplinary, mission-oriented projects in harbors and the coastal zone.

Courses (OSI)

UPPER DIVISION

417./517. Marine Benthic Invertebrates of Santa Catalina Island (4)

Prerequisite: Consent of instructor. (Undergraduates enroll in OSI 417; graduates enroll in OSI 517)

Topics include benthic community structure and function, benthic-pelagic coupling, animal-sediment relationships, animal interactions, and marine pollution ecology. Laboratory emphasis will be on identification of local forms.

Letter grade only (A-F). (Lecture 2 hrs., laboratory and field 6 hrs.)

419./519. Marine Ichthyology (4)

Prerequisite: Consent of instructor. (Undergraduates enroll in OSI 419; graduates enroll in OSI 519)

Taxonomy, morphology, physiology, and ecology of fishes. Emphasis on local marine fishes.

Letter grade only (A-F). (Lecture 2 hrs., laboratory and field 6 hrs.)

425./525. Marine Phycology (4)

Prerequisite: BIOL 211, BIOL 212, BIOL 213. (Undergraduates enroll in OSI 425; graduates enroll in OSI 525)

Taxonomy, phylogeny, ecology, and physiology of marine algae; emphasis on local marine forms.

Letter grade only (A-F). (Lecture 2 hrs., laboratory and field 6 hrs.)

455./555. Marine Ecological Processes (4)

Prerequisite: BIOL 350 and consent of instructor; statistics recommended. (Undergraduates enroll in OSI 455; graduates enroll in OSI 555)

Discussion of field studies on ecological principles related to marine communities. Includes an individual field research project

and class projects.

Letter grade only (A-F). (Lecture 2 hrs., field 6 hrs.)

490./590. Selected Topics in Ocean Studies (1-3)

Prerequisite: Consent of instructor. (Undergraduates enroll in OSI 490; graduates enroll in OSI 590)

Topics from selected areas of Ocean Studies. Topic content will vary from section to section.

Letter grade only (A-F). May be repeated to a maximum of 6 units with the consent of instructor. Maximum credit for OSI 490/590 and/or 490L/590L limited to 6 units. Topics announced in the *Schedule of Classes*. (Lecture 1-3 hrs.)

490L./590L. Selected Topics in Ocean Studies Laboratory (1-3)

Prerequisite: Consent of instructor. (Undergraduates enroll in OSI 490L; graduates enroll in OSI 590L)

Topics from selected areas of Ocean Studies.

Letter grade only (A-F). May be repeated to a maximum of 6 units with the consent of instructor. Maximum credit for OSI 490/590 and/or 490L/590L limited to 6 units. Topics announced in the *Schedule of Classes*. (Laboratory 3-9 hrs.)

496. Undergraduate Directed Research (1-3)

Prerequisite: Consent of instructor. Not available to graduate students.

Independent research to be conducted under the supervision of a Catalina Semester instructor. Students develop their ideas during the first 12 weeks of the semester, prepare a research proposal, complete their studies, and present their findings in a mini-symposium and a report.

Letter grade only (A-F).

GRADUATE LEVEL

517./417. Marine Benthic Invertebrates of Santa Catalina Island (4)

Prerequisite: Consent of instructor. (Undergraduates enroll in OSI 417; graduates enroll in OSI 517)

Topics include benthic community structure and function, benthic-pelagic coupling, animal-sediment relationships, animal interactions, and marine pollution ecology. Laboratory emphasis will be on identification of local forms.

Letter grade only (A-F). (Lecture 2 hrs, laboratory and field 6 hrs.)

519./419. Marine Ichthyology (4)

Prerequisite: Consent of instructor. (Undergraduates enroll in OSI 419; graduates enroll in OSI 519)

Taxonomy, morphology, physiology, and ecology of fishes. Emphasis on local marine fishes.

Letter grade only (A-F). (Lecture 2 hrs., laboratory and field 6 hrs.)

525./425. Marine Phycology (4)

Prerequisite: BIOL 211, BIOL 212, BIOL 213. (Undergraduates enroll in OSI 425; graduates enroll in OSI 525)

Taxonomy, phylogeny, ecology, and physiology of marine algae; emphasis on local marine forms.

Letter grade only (A-F). (Lecture 2 hrs., laboratory and field 6 hrs.)

555./455. Marine Ecological Processes (4)

Prerequisite: BIOL 350 and consent of instructor; statistics recommended. (Undergraduates enroll in OSI 455; graduates enroll in OSI 555)

Discussion of field studies on ecological principles related to marine communities. Includes an individual field research project and class projects.

Letter grade only (A-F). (Lecture 2 hrs., laboratory and field 6 hrs.)

590./490. Selected Topics in Ocean Studies (1-3)

Prerequisite: Consent of instructor. (Undergraduates enroll in OSI 490; graduates enroll in OSI 590)

Topics from selected areas of Ocean Studies. Course content will vary from section to section.

Letter grade only (A-F). May be repeated to a maximum of 6 units with consent of instructor. Maximum credit for OSI 490/590 and/or 490L/590L limited to 6 units. Topics announced in the *Schedule of Classes*. (Lecture 1-3 hrs.)

590L./490L. Selected Topics in Ocean Studies Laboratory (1-3)

Prerequisite: Consent of instructor. (Undergraduates enroll in OSI 490L; graduates enroll in OSI 590L)

Topics from selected areas of Ocean Studies. Course content will vary from section to section.

Letter grade only (A-F). May be repeated to a maximum of 6 units with consent of instructor. Maximum credit for OSI 490/590 and/or 490L/590L limited to 6 units. Topics announced in the *Schedule of Classes*. (Laboratory 3-9 hrs.)

697. Directed Research (1-3)

Prerequisite: Consent of instructor and graduate standing.

Independent research to be conducted under the supervision of a Catalina Semester instructor. Students develop their ideas during the first 12 weeks of the semester, prepare a research proposal, complete their studies, and present their findings in a mini-symposium and a report.

Letter grade only (A-F).

PHYSICS AND ASTRONOMY

College of Natural Sciences and Mathematics

Department Chair: Chuhee Kwon

Department Office: Hall of Science (HSCI) 220
Telephone / FAX: (562) 985-4925 / (562) 985-7924
Website: www.csulb.edu/depts/physics/

Faculty: Andreas Bill, Thomas Gredig, Jiyeong Gu, Paul Hintzen, Zvonimir Hlousek, Prashanth Jaikumar, Patrick F. Kenealy (Emeritus), Chuhee Kwon, Claudia Ojeda-Aristizabal, Zoltan Papp, Michael Peterson, Galen T. Pickett, Subhash Rajpoot

Advisors:

Undergraduate: Jiyeong Gu
Credential: James Kisiel, Tim Williamson
Graduate: Andreas Bill

Administrative Support Coordinator: Irene Howard

Students desiring information should contact the Department Office for referral to one of the faculty advisors.

Career Possibilities

Physicist • Teacher • Medical Physicist • Astrophysicist • Computer Scientist • Electro-Optical Engineer • Computer Engineer • Meteorologist • Metallurgist • Industrial Health Engineer • Aerospace Engineer • Geophysicist • Financial Analyst • Technical Writer • Astronomer • Teacher • Oceanographer • Systems Analyst • Mathematician • Materials Researcher • Quality Control Specialist • Food and Drug Inspector • Scientific Apparatus Salesperson • Nuclear Engineer • Physicist Technician (Some of these, and other careers, require additional education or experience. For more information, see www.careers.csulb.edu and www.aps.org/careers.) Various entry-level trainee positions in business and industry are available for graduates regardless of academic discipline.

Degree Programs

The Bachelor of Science degree is designed for students interested in immediate employment in industry or wishing to continue on to a Master's or Ph.D. degree in physics or a related field. The Bachelor of Arts degree is appropriate for those preparing for teaching careers in the physical sciences at the secondary level as well as those whose goal is a liberal art education with an emphasis on physics.

The Department also offers graduate study leading to the Master of Science degree. This degree is available in both a general option and an option in applied physics. A limited number of teaching associateships and graduate assistantships are available to students working on the master's degree. Application should be made to the Chair of the Department.

Academic Advising and Facilitated Enrollment into Classes

All entering students who declare a major in a degree program offered by this department need to contact the College of Natural Sciences and Mathematics' (CNSM) Academic Advising Center (HSCI 164) and participate in the College's Science Safari to Success (for first time freshmen) or EONS (Enrollment and Orientation in the Natural Sciences and Mathematics for transfer students) Program. These programs are held in July for those starting

in the Fall Semester and in January for those starting in the Spring Semester. Department advisors will be available to provide an overview of the students' chosen baccalaureate degree program, to assist with academic advisement, to provide information on the many career opportunities available, and to aid students in enrolling in classes. Contact the CNSM Academic Advising Center, Jensen Student Access to Sciences and Mathematics Center (HSCI 164), or department office for additional information.

All entering graduate students need to contact the graduate advisor of the department. An orientation for graduate students is held during the week prior to start of classes.

Concurrent and/or Summer Enrollment at Another College

Students who wish to take course work at a community college or another college or university to meet curricular requirements while enrolled as undergraduates in the College of Natural Sciences and Mathematics must petition the appropriate Department for prior approval to earn credit for specific courses. This policy applies to concurrent enrollment or summer enrollment. Please see "Concurrent Enrollment" and "Transfer of Undergraduate Credit" in this catalog. Courses not receiving prior approval will not be accepted for credit by the Department.

Undergraduate Programs

Bachelor of Science in Physics (120 units)

Requirements

Lower Division:

Take all of the following courses:

PHYS 151 Mechanics and Heat (4)
Prerequisite/Corequisite: MATH 122.

PHYS 152 Electricity and Magnetism (4)
Prerequisite: PHYS 151;
Prerequisite/Corequisite: MATH 123.

PHYS 254 Modern Physics and Light (3)
Prerequisite: PHYS 152 or EE 210;
Prerequisite/Corequisite: MATH 224.

PHYS 255 Laboratory on Light & Modern Physics (1)
Prerequisite/Corequisite: PHYS 254.

MATH 122 Calculus I (4)
Prerequisite: Appropriate MDPT placement or a grade of "C" or better in MATH 111 and MATH 113.

MATH 123 Calculus II (4)
Prerequisite: A grade of "C" or better in MATH 122.

MATH 224 Calculus III (4)
Prerequisite: A grade of "C" or better in MATH 123 or MATH 222.

MATH 247 Introduction to Linear Algebra (3)
Prerequisite: MATH 123 or MATH 222.

Select one from the following three courses:

BIOL 200 General Biology (4)
Prerequisite: GE Foundation requirements.

Or

BIOL 211 Introduction to Evolution and Diversity (4)
Prerequisite/Corequisite: CHEM 111A with a grade of "C" or better.

Or

CHEM 111A General Chemistry (5)
Prerequisites: A passing score on the Chemistry Placement Examination.
Corequisite: MATH 109 or higher.

NOTE: BIOL 111, BIOL 111L are required if courses were taken prior to catalog year 2010-11.

Upper Division:

Take the following courses:

MATH 364A Ordinary Differential Equations I (3)
Prerequisites: MATH 222 or MATH 224, and prerequisite or corequisite MATH 247.

Take one other upper-division mathematics course:

Note: students interested in completing a minor in mathematics or applied mathematics should consult the appropriate advisor.

Take all of the following:

PHYS 310 Analytic Mechanics (3)
Prerequisite: PHYS 151. Corequisite: MATH 364A or MATH 370A.

PHYS 320 Thermodynamics (3)
Prerequisite: PHYS 152. Prerequisite/Corequisite, PHYS 254.

PHYS 340A Electricity and Magnetism I (3)
Prerequisites: PHYS 152, PHYS 310. Prerequisite/
Corequisite: MATH 370A or MATH 364A.

PHYS 340B Electricity and Magnetism II (3)
Prerequisite: PHYS 340A.

PHYS 350 Modern Physics (3)
Prerequisites: PHYS 310; MATH 370A or MATH 364A.

PHYS 360 Physics with Symbolic Algebra Software (3)
Prerequisite: PHYS 254. Prerequisite/Corequisite: MATH 247.

PHYS 380 Electronics (4)
Prerequisite: PHYS 152.

PHYS 450 Quantum Physics I (3)
Prerequisites: PHYS 310, PHYS 340A, PHYS 350.

Take one laboratory course chosen from:

PHYS 445, PHYS 446, PHYS 476 and PHYS 480

6 units of upper-division physics electives

Grade Requirements

Physics majors must have a "C" average in the major. Physics students must achieve a grade of "C" or better in each required course in the major. The following schedule is typical for a major who is a full-time student.

Sophomore Year

Fall: PHYS 254, PHYS 255; MATH 224.
Spring: PHYS 360, PHYS 380; MATH 247.

Junior Year

Fall: PHYS 310, PHYS 320; MATH 364A.
Spring: PHYS 340A, PHYS 350; Upper division MATH elective.

Senior Year

Fall: PHYS 340B, PHYS 450.
Spring: Three upper division physics electives (one of

which is a laboratory).

Bachelor of Arts in Physics (120 units)

Requirements

All required courses must be passed with a grade of "C" or better

Lower Division:

Take all of the following courses:

PHYS 151 Mechanics and Heat (4)
Prerequisite/Corequisite: MATH 122.

PHYS 152 Electricity and Magnetism (4)
Prerequisite: PHYS 151; Prerequisite/Corequisite: MATH 123.

PHYS 254 Modern Physics and Light (3)
Prerequisite: PHYS 152 or EE 210; Prerequisite/
Corequisite: MATH 224.

MATH 122 Calculus I (4)
Prerequisite: Appropriate MDPT placement or a grade of "C" or better in MATH 111 and MATH 113.

MATH 123 Calculus II (4)
Prerequisite: A grade of "C" or better in MATH 122.

MATH 224 Calculus III (4)
Prerequisite: A grade of "C" or better in MATH 123 or MATH 222.

Upper Division:

Take the following:

A minimum of 24 units selected in consultation with Physics Department Undergraduate Advisor, at least 12 units of which must be in physics. The remaining units can be chosen from EDSS 300C, EDSS 300M, any courses in the College of Engineering, or any courses in the College of Natural Sciences and Mathematics.

Physics Concentration

The Physics Concentration meets the subject matter competence requirement for the Single Subject Teaching Credential in Physics. Prospective students should consult the Single Subject Science Education Advisor in the Department of Science Education early to plan their program.

Requirements

Lower Division:

Take all of the following:

PHYS 151 Mechanics and Heat (4)
Prerequisite/Corequisite: MATH 122.

PHYS 152 Electricity and Magnetism (4)
Prerequisite: PHYS 151;
Prerequisite/Corequisite: MATH 123.

PHYS 254 Modern Physics and Light (3)
Prerequisite: PHYS 152 or EE 210; Prerequisite/
Corequisite: MATH 224.

PHYS 255 Laboratory on Light & Modern Physics (1)
Prerequisite/Corequisite: PHYS 254.

MATH 122 Calculus I (4)
Prerequisite: Appropriate MDPT placement or a grade of "C" or better in MATH 111 and MATH 113.

MATH 123 Calculus II (4)
Prerequisite: A grade of "C" or better in MATH 122.

MATH 224 Calculus III (4)
Prerequisite: A grade of "C" or better in MATH 123 or MATH 222.

ASTR 100 Astronomy (3)
Corequisites: One course from General Education Category B.2 and ASTR 100L.

CHEM 111A General Chemistry (5)
Prerequisites: A passing score on the Chemistry Placement Examination.
Corequisite: MATH 109 or higher.

CHEM 111B General Chemistry (5)
Prerequisites: CHEM 111A and MATH 113 or MATH 115 or MATH 117 or MATH 119A or MATH 122 all with a grade of "C" or better.

GEOL 102 General Geology (3)
Prerequisites/Corequisites: A course that fulfills the A.1 GE requirement and three years of high school mathematics including algebra, geometry, and intermediate algebra or the equivalent.

GEOL 104 Geology Laboratory (1)
Prerequisites/Corequisites: A course that fulfills the A.1 GE requirement and three years of high school mathematics including algebra, geometry, and intermediate algebra or the equivalent, and concurrent or prior enrollment in GEOL 102.

GEOL 160 Introduction to Oceanography (3)
Prerequisites/Corequisites: A course that fulfills the A.1 GE requirement and three years of high school mathematics including algebra, geometry, and intermediate algebra or the equivalent.

BIOL 211 Introduction to Evolution and Diversity (4)
Prerequisite/Corequisite: CHEM 111A with a grade of "C" or better.

BIOL 212 Introduction to Cell and Molecular Biology (4)
Prerequisites: Completion of BIOL 211 and CHEM 111A with grades of "C" or better.
Prerequisite/Corequisite: Chem 111B

BIOL 213 Introduction to Ecology and Physiology (4)
Prerequisites: BIOL 211, BIOL 212, CHEM 111B with a grade of "C" or better.

NOTE: BIOL 111, BIOL 111L, BIOL 212, BIOL 212L, BIOL 213, BIOL 213L are required if courses were taken prior to catalog year 2010-11.

Upper Division:

Take all of the following:

PHYS 310 Analytic Mechanics (3)
Prerequisite: PHYS 151. Corequisite: MATH 364A or MATH 370A.

PHYS 340A Electricity and Magnetism I (3)
Prerequisites: PHYS 152, PHYS 310. Prerequisite/ Corequisite: MATH 370A or MATH 364A.

PHYS 476 Modern Optics Laboratory (1)
Prerequisite: PHYS 340A.

SCED 403 Integrated Science (3)
Prerequisites: Completion of all credential breadth requirements for the Single Subject Teaching Credential Program in Science, three-fourths of the credential specializations courses, and consent of instructor.

SCED 404 Nature of Science Scientific Reasoning (3)
Prerequisites: Minimum of 9 units of science (introductory level or higher) or consent of instructor.

EDSS 300C Introduction to Teaching - Science (3)
Prerequisite: Advanced sophomore or junior standing.

EDSS 450C Curriculum and Methods in Teaching Science (3)

Prerequisite: EDSS 300C; admission to the Single Subject Credential Program or permission of the Single Subject Credential Program University Coordinator. Required prior to student teaching.

EDSE 435 U.S. Secondary Schools: Interculture Educ (3)

Prerequisite: EDSS 300 (A, C, D, F, G, H, M, N, P, or S); or admission in the Single Subject Credential Program; or permission of University Coordinator of the Single Subject Credential Program. Required course in the Single Subject Credential Program.

EDSE 436 Curriculum, Instruction, Assessment and Classroom Management (3)

Prerequisite: EDSS 300 (A, C, D, F, G, H, M, N, P, or S); or admission in the Single Subject Credential Program; or permission of the University Coordinator of the Single Subject Credential Program. Required course in the Single Subject Credential Program.

EDSE 457 Reading & Writing in Secondary School (3)

Prerequisite: EDSS 300 (A, C, D, F, G, H, M, N, P, or S); or admission in the Single Subject Credential Program; or permission of the University Coordinator of the Single Subject Credential Program. Required course in the Single Subject Credential Program.

Select one course from each of the following pairs:

1. MATH 364A Ordinary Differential Equations I (3)
Prerequisites: MATH 222 or MATH 224, and prerequisite or corequisite MATH 247.

MATH 370A Applied Mathematics I (3)
Prerequisites: A grade of "C" or better in MATH 123. Not open to Freshmen.

2. PHYS 320 Thermodynamics (3)
Prerequisite: PHYS 152. Prerequisite/Corequisite, PHYS 254.

PHYS 422 Statistical Physics (3)
Prerequisites: PHYS 310, PHYS 320, PHYS 350.

3. PHYS 380 Electronics (3)
Prerequisite: PHYS 152.

PHYS 496 Special Problems in Physics (3)
Prerequisites: Consent of instructor and senior standing.

Single Subject Teaching Credential in Physics

In addition to meeting the subject matter competence requirement for the Teaching Credential, prospective Physics teachers are also required to complete 45 units of professional preparation in the Single Subject Credential Program, including student teaching. Students may begin the professional preparation courses as early as the junior year. With careful planning, it is possible to complete many of the credential program courses, except for student teaching, as an undergraduate. Courses may also be started as a post-baccalaureate student. Refer to the Single Subject Teacher Education section of this catalog or the Single Subject Credential Program website (www.ced.csulb.edu/single-subject) for a description of the professional preparation requirements, courses, and application procedures.

The Physics Subject Matter Program is being revised to meet new state standards. When the revised program has been approved by the Commission on Teacher Credentialing, the new course requirements will be in effect and supersede current requirements.

Minor in Physics

Requirements

The Minor in Physics is available to any non-Physics major. A minimum of 20 units which must include the following.

Lower Division:

Take all of the following:

PHYS 151 Mechanics and Heat (4)

Prerequisite/Corequisite: MATH 122.

PHYS 152 Electricity and Magnetism (4)

Prerequisite: PHYS 151; Prerequisite/Corequisite: MATH 123.

PHYS 254 Modern Physics and Light (3)

Prerequisite: PHYS 152 or EE 210; Prerequisite/Corequisite: MATH 224.

Upper Division:

A minimum of 9 units in physics.

Graduate Programs

Master of Science in Physics

This is a comprehensive physics master's degree with options in General Physics or Computational Physics.

Prerequisites

1. A bachelor's degree with a major in physics; or
2. A bachelor's degree with at least 24 units of upper division physics. Students deficient in undergraduate preparation must take courses to remove these deficiencies without credit toward the degree at the discretion of graduate advisor.

Requirements

Take all of the following:

PHYS 510 Graduate Mechanics (3)

Prerequisite: PHYS 310.

PHYS 522 Statistical Physics (3)

Prerequisites: PHYS 310, PHYS 320, PHYS 350.

PHYS 540A Graduate Electrodynamics I (3)

Prerequisite: PHYS 340B.

PHYS 550A Quantum Mechanics I (3)

Prerequisite: PHYS 450.

PHYS 560A Mathematical Methods of Physics (3)

Prerequisites: MATH 370A,B or equivalent.

Take one of the following:

PHYS 595 Colloquium (1)

Prerequisite: Consent of instructor

PHYS 695 Colloquium (1)

Prerequisite: Graduate standing.

Take one of the following:

PHYS 545 Experimental Methods in Physics I (3)

Prerequisites: PHYS 254; PHYS 450 or consent of instructor.

PHYS 546 Experimental Methods in Physics II (3)

Prerequisites: PHYS 254; PHYS 450 or consent of instructor.

PHYS 575 Modern Optics (3)

Prerequisite: PHYS 340A or consent of instructor.

PHYS 580 Computer Interfacing in Experimental Physics (3)

Prerequisite: PHYS 380 or consent of instructor.

In addition, students may opt for one of two plans:

General Physics Plan

Take the following course:

PHYS 550B Quantum Mechanics II (3)

Prerequisite: PHYS 550A.

Take one of the following two choices after consultation with the graduate advisor:

1. Completion of at least 2 additional units of graduate-level PHYS courses, 6 units of PHYS 698, a written thesis approved by the student's thesis committee consisting of a thesis chair (a Physics/Astronomy faculty member) and at least two more members, one of which must be a member of the Department, and an oral presentation of the thesis research. Note: Students must be advanced to candidacy before enrolling in PHYS 698.
2. With the permission of the Graduate committee, an additional 8 units of 500-level PHYS courses, and satisfactorily complete a comprehensive examination.

Computational Physics Plan

Take the following courses:

PHYS 550B Quantum Mechanics II (3)

Prerequisite: PHYS 550A.

PHYS 562 Computational Methods in Theoretical Physics (3)

Prerequisite: PHYS 450

Take 6 units of the following:

PHYS 698 Thesis (6)

Prerequisite: Advancement to candidacy for the M.S. in Physics.

A written thesis approved by the student's thesis committee consisting of a thesis chair (a Physics/Astronomy faculty member) and at least two more members, one of which must be a member of the Department, and an oral presentation of the thesis research.

Note: Students must be advanced to candidacy before enrolling in PHYS 698.

Advancement to Candidacy

1. Students must fulfill the University requirements for advancement to candidacy.
2. A student must have a "B" average or better in six units of physics applicable toward the master's degree, of which at least three units are at the graduate level.
3. Recognizing that effective organization and verbal communication of physics are a necessary part of a successful graduate program, the Department of Physics and Astronomy normally requires that a graduate student serve at least one semester as a teaching associate or a graduate assistant as part of the M.S. program. Exceptions may be granted by the Graduate Advisor.
4. Approval of the degree program by the graduate advisor, the Department Chair, Associate Dean in the College of Natural Sciences and Mathematics or designee.

Option in Applied Physics

The Option in Applied Physics provides a master's degree program that emphasizes concepts and techniques particularly appropriate for applied physics. It is intended for students having a background in physics, engineering, or a related field.

Prerequisites

1. A bachelor's degree with a major in physics, or
2. A bachelor's degree with a major in engineering with upper division physics substantially equivalent to PHYS 310, PHYS 340A,B, and PHYS 450, as determined by the graduate advisor, or
3. A bachelor's degree with upper division physics and mathematics courses essentially equivalent to PHYS 310, PHYS 340B, PHYS 450; and MATH 370A,B; as determined by the graduate advisor.

Students deficient in undergraduate preparation must take courses to remove deficiencies as determined by the graduate advisor.

Requirements

Take all of the following:

PHYS 510 Graduate Mechanics (3)

Prerequisite: PHYS 310.

PHYS 522 Statistical Physics (3)

Prerequisites: PHYS 310, PHYS 320, PHYS 350.

PHYS 540A Graduate Electrodynamics I (3)

Prerequisite: PHYS 340B.

PHYS 550A Quantum Mechanics I (3)

Prerequisite: PHYS 450.

PHYS 560A Mathematical Methods of Physics (3)

Prerequisites: MATH 370A,B or equivalent.

PHYS 695 Colloquium (1)

Prerequisite: Graduate standing.

Take two courses of the following (one must be 545 or 546):

PHYS 545 Experimental Methods in Physics I (3)

Prerequisites: PHYS 254; PHYS 450 or consent of instructor.

PHYS 546 Experimental Methods in Physics II (3)

Prerequisites: PHYS 254; PHYS 450 or consent of instructor.

PHYS 576 Modern Optics with Laboratory (3)

Prerequisite: PHYS 340A.

PHYS 580 Computer Interfacing in Experimental Physics (3)

Prerequisite: PHYS 380 or consent of instructor.

Completion of the following:

Take 2 additional units of graduate-level PHYS course;

Take 6 units of the following:

PHYS 698 Thesis (6)

Prerequisite: Advancement to candidacy for the M.S. in Physics.

A written thesis approved by the student's thesis committee consisting of a thesis chair (a Physics/Astronomy faculty member) and at least two more members, one of which must be a member of the Department. An oral presentation of the thesis research is also required.

Note: Students must be advanced to candidacy before enrolling in PHYS 698.

Advancement to Candidacy

1. Students must fulfill the University requirements for advancement to candidacy.
2. A student must have a "B" average or better in six units of physics applicable toward the master's degree, of which at least three units are at the graduate level.
3. Recognizing that effective organization and verbal communication of physics are a necessary part of a successful graduate program, the Department of Physics and Astronomy normally requires that a graduate student serve at least one semester as a teaching associate or a graduate assistant as part of the M.S. program. Exceptions may be granted by the Graduate Advisor.
4. Approval of the degree program by the graduate advisor, the Department Chair and Associate Dean in the College of Natural Sciences and Mathematics.

Master of Science in Professional Physics

This is a terminal physics master's degree intended for students pursuing industrial professional careers.

Prerequisites

- 1) A bachelor's degree with a major in physics; or
- 2) A bachelor's degree with at least 24 units of upper division physics. Students deficient in upper division undergraduate preparation must take courses to remove these deficiencies without credit toward the degree at the discretion of the graduate advisor.

Requirements

Take all of the following:

- PHYS 510 Graduate Mechanics (3)
Prerequisite: PHYS 310.
- PHYS 522 Statistical Physics (3)
Prerequisites: PHYS 310, 320, 350.
- PHYS 540A Graduate Electrodynamics I (3)
Prerequisite: PHYS 340B.
- PHYS 550A Quantum Mechanics I (3)
Prerequisite: PHYS 450.
- PHYS 560A Mathematical Methods of Physics (3)
Prerequisites: MATH 370A,B or equivalent.
- One elective from 500-level PHYS courses (3)

Take three of the following:

- NSCI 501 Project Management for Scientists (3)
- NSCI 502 Leadership and Management for Scientists (3)
- NSCI 503 Accounting and Finance for Scientists (3)
- NSCI 504 Introduction to Regulatory Science (3)
- NSCI 505 Professional Ethics (3)
- PHYS 692 Internship (3)

Take 4 units of the following:

- PHYS 699 Professional Project (4)

Prerequisite: Advancement to candidacy for the MS in Professional Physics.

Culminating Experience:

The program culminates with a professional project. The professional project is a significant undertaking that aims to apply fundamental physics methods and business-professional skills to situations relevant to the industry environment. Students are to demonstrate professional attributes expected in industry and to communicate the findings to a diverse audience. The project plan must be prepared by the student before advancing to candidacy. The project plan includes a specific set of advanced skills to be demonstrated and a specific timeline for the activities that must be completed. Students will engage the equivalent of 4-units of work on the professional project. The project report must demonstrate core competencies developed through the curriculum and reflect how the student integrates this knowledge into a project in industry. The completed project will include a written project report and oral defense.

Advancement to Candidacy

- 1) Attainment of classified status as a student in a graduate program at CSULB;
- 2) Fulfillment of the Graduation Writing Assessment Requirement (GWAR);
- 3) Approval of the program of study by the Graduate Advisor, the Department Chair, and the Associate Dean in the College of Natural Sciences and Mathematics;
- 4) Completion with a minimum GPA of 3.0 of at least six units of courses required on the student's program of study;
- 5) A cumulative, graduate, grade-point average of at least 3.0 calculated on all upper-division and graduate-level coursework attempted by the student at CSULB after completion of a baccalaureate degree.

Single Subject Teaching Credential in Physics

For information, refer to the undergraduate section in this department.

Physics Courses (PHYS)

LOWER DIVISION

100A,B. General Physics (4,4) F,S

Prerequisite: PHYS 100A: MATH 109 or MATH 113 or MATH 119A or MATH 122.

PHYS 100B: PHYS 100A.

Year course in introductory physics. First semester considers properties of matter, mechanics, wave motion, and heat. Second semester considers electricity, light, and atomic and nuclear physics.

Letter grade only (A-F). (Lecture 3 hrs, laboratory 3 hrs.)

151. Mechanics and Heat (4) F,S

Prerequisite/Corequisite: MATH 122.

Kinematics, Newton's Laws, rotational motion, fluid statics, laws of thermodynamics.

Letter grade only (A-F). (Lecture 3 hrs., laboratory 3 hrs.)

152. Electricity and Magnetism (4) F,S

Prerequisite: PHYS 151; Prerequisite/Corequisite: MATH 123.

Mechanical waves, Coulomb's law, electrostatics, electric circuits, introductory electronics, magnetic fields, induction and Maxwell's equations.

Letter grade only (A-F). (Lecture 3 hrs., laboratory 3 hrs.)

254. Applied Modern Physics (3) F,S

Prerequisite: PHYS 152 or EE 210; Prerequisite/Corequisite: MATH 224.

Geometrical and physical optics, models of atomic and condensed matter systems.

Not open for credit to students with a "C" or better in PHYS 153 or PHYS 154. Letter grade only (A-F). (Lecture 3 hrs.)

255. Laboratory on Modern Physics (1)

Prerequisite/Corequisite: PHYS 254.

Experimental work in optics and modern physics.

Not open for credit to students with a "C" or better in PHYS 153 or PHYS 155. PHYS 255 is equivalent to PHYS 155. Letter grade only (A-F). (Laboratory 3 hrs.)

UPPER DIVISION

310. Analytic Mechanics (3) F

Prerequisite: PHYS 151. Corequisite: MATH 364A or MATH 370A.

Kinematics and dynamics of mass points and systems of particles. Conservation laws. Harmonic motion. Central force problem. Noninertial frames of reference. Lagrangian and Hamiltonian formulation of laws of mechanics.

Letter grade only (A-F). (Lecture 3 hrs.)

320. Thermodynamics (3) F

Prerequisite: PHYS 152. Prerequisite/Corequisite, PHYS 254.

Laws of thermodynamics, thermodynamic potentials, kinetic theory methods, phase transitions, equilibrium ensembles and related formalism with applications to classical and quantum systems.

Letter grade only (A-F). (Lecture 3 hrs.)

340A. Electricity and Magnetism I (3) S

Prerequisites: PHYS 152, PHYS 310. Prerequisite/Corequisite: MATH 370A or MATH 364A.

Vector calculus, electrostatics, and magnetostatics. Formulation of Maxwell's equations in vector analytic form.

Letter grade only (A-F). (Lecture-discussion 3 hrs.)

340B. Electricity and Magnetism II (3) F

Prerequisite: PHYS 340A.

Special relativity. Applications of Maxwell's equations: Plane electromagnetic waves, guided waves, radiation, interaction of electromagnetic waves and matter.

(Lecture-discussion 3 hrs.)

350. Modern Physics (3) S

Prerequisites: PHYS 310; MATH 370A or MATH 364A.

Physical phenomena and models leading to development of quantum mechanics. Schrodinger equation, one-dimensional quantum mechanical problems, uncertainty principle, one-electron atoms, elementary applications of quantum mechanics.

(Lecture-discussion 3 hrs.)

360. Physics With Symbolic Algebra Software (3)

Prerequisite: PHYS 254. Prerequisite/Corequisite: MATH 247.

Learning symbolic algebra programming (e.g. Mathematica) to enhance the problem-solving abilities of students in physics, engineering and mathematics. Interpolation and fitting of experimental data. Sophisticated graphics, animations, analytic calculations, and numerical solutions for a variety of physics problems.

Letter grade only (A-F). (Lecture-discussion 3 hrs.)

380. Electronics (4) S

Prerequisite: PHYS 152.

Network analysis and complex impedance, transistor circuits, operational amplifiers, active filters and oscillators, digital electronics, analog-digital interfacing, microprocessors.

Letter grade only (A-F). (Lecture 3 hrs., laboratory 3 hrs.)

385. Materials Science (3)

Prerequisite: CHEM 111A and PHYS 152 and (CHEM 111B or PHYS 320), completion of CHEM 111B is strongly recommended.

Introduction to general principles of energy materials including catalytics, photovoltaic, and thermoelectric materials based on nanostructural and/or nanoporous systems. Students will be required to complete preparatory modules on Kinetics (reaction dynamics), Electrochemistry, Fermi statistics, and Diodes.

Letter grade only (A-F). Same course as CHEM 385. Not open for credit to students with credit in CHEM 385.

385L. Materials Science Laboratory (2)

Prerequisite: CHEM 111A and PHYS 152 and (CHEM 111B or PHYS 320), completion of CHEM 111B is strongly recommended

Introduction to synthesis, characterization methods, and property measurement of advanced materials

Letter grade only (A-F), Course fee may be required. (Laboratory 6 hours). Same course as CHEM 385L. Not open for credit to students with credit in CHEM 385L.

385C. Materials Science Colloquium (1)

Prerequisite: CHEM 111A and PHYS 152 and (CHEM 111B or PHYS 320), completion of CHEM 111B is strongly recommended.

Discussion of advances as reported in recent literature related to energy materials. Provides experience in library use, organization, presentation, and critical evaluation of the literature.

Letter grade only (A-F). Same course as CHEM 385C. Not open for credit to students with credit in CHEM 385C.

390. Exploring Physics Teaching (3)

Prerequisite: PHYS 151 and consent of instructor.

Exploration of teaching physics as a learning assistant in secondary physics classrooms and in the lower-level laboratories and tutorials of the college physics curriculum. An exploration of the profession of teaching physics at many levels.

(Lecture, 3 hrs)

410./515. Relativity (3)

Prerequisite: PHYS 340A. Prerequisite/Corequisite: MATH 370A or MATH 364A. (Undergraduates enroll in PHYS 410; graduates enroll in PHYS 515.)

Lorentz transformation, relativistic kinematics and dynamics, 4-vectors and tensors, transformation of electric and magnetic fields, covariant form of Maxwell's equations, introduction to general relativity.

Letter grade only (A-F). (Lecture-discussion 3 hrs.)

422./522. Statistical Physics (3) S

Prerequisites: PHYS 310, PHYS 320, PHYS 350. (Undergraduates enroll in PHYS 422; graduates enroll in PHYS 522.)

Entropy and temperature, Boltzmann distribution and Helmholtz free energy, thermal radiation, chemical potential, Gibbs distribution, ideal gas, Fermi and Bose gases, heat and work, Gibbs free energy and chemical reactions, phase transformations and kinetic theory.

Letter grade only (A-F). (Lec-discussion 3 hrs)

434./534. Astrophysics (3)

Prerequisites: PHYS 310, PHYS 320, and PHYS 340A or consent of the instructor. (Undergraduates enroll in PHYS 434; graduates enroll in PHYS 534.)

Topics in astrophysics. A particular semester schedule might include one or two topics from: Stellar interiors and evolution, radiative transfer and stellar atmospheres, relativistic cosmology, galaxy formation, accretion disk physics and quasars.

Letter grade only (A-F). (Lecture 3 hrs)

445./545. Experimental Methods in Physics I (3)

Prerequisites: PHYS 254; PHYS 450 or consent of instructor. (Undergraduates enroll in PHYS 445; graduates enroll in PHYS 545.)

Modern physical measurement techniques including scanning probe microscopy and pulsed nuclear magnetic resonance. Noise and fluctuations in physical measurements. Low noise measurement techniques including lock-in amplifier, gated integrator and boxcar averager, bridge circuits, convolution, auto- and cross-correlation and FFT.

Letter grade only (A-F). (Lecture 2 hrs., laboratory 3 hrs.)

446./546. Experimental Methods in Physics II (3)

Prerequisites: PHYS 254; PHYS 450 or consent of instructor. (Undergraduates enroll in PHYS 446; graduates enroll in PHYS 546.)

Modern physical measurement techniques in condensed matter physics in high magnetic fields and low temperatures. Examples are temperature and magnetic field effects in magnetic materials, Meissner effect and superconducting transition temperature in superconductors, and mobility and Hall effect in semiconductors.

Letter grade only (A-F). (Lecture 2 hrs., laboratory 3 hrs.)

450. Quantum Physics I (3) F

Prerequisites: PHYS 310, PHYS 340A, PHYS 350.

Schrodinger equation, atomic physics, harmonic oscillator, scattering, perturbation theory, Heisenberg and Dirac representations, spin, symmetries (angular momentum, time reversal, and parity), applications.

(Lec-discussion 3 hrs.)

451. Quantum Physics II (3)

Prerequisite: PHYS 450.

Measurement processes, atomic physics, identical particles, quantum statistics, numerical methods, many-body systems, density matrix, applications.

Letter grade only (A-F). (Lecture-discussion 3 hrs.)

470./569. Introduction to Solid State Physics (3)

Prerequisite: PHYS 450. (Undergraduates enroll in PHYS 470; graduates enroll in PHYS 569.)

Study of properties of solids from quantum theoretical viewpoint. Includes lattice vibrations, elastic constants, and thermal, electric, and magnetic properties.

Letter grade only (A-F). (Lecture 3 hrs.)

476./576. Modern Optics with Laboratory (3)

Prerequisite: PHYS 340A. (Undergraduates enroll in PHYS 476; graduates enroll in PHYS 576.)

Propagation of electromagnetic waves, optical resonators, laser spectroscopy and operation, optical phase conjugation, nonlinear optics and selected application. Experiments illustrating principles and techniques of electro-optics and laser physics. Applications include optical methods in communications, atomic spectroscopy, and nonlinear optics.

Letter grade only (A-F). (Lecture 2 hrs., laboratory 3 hrs.)

480./580. Computer Interfacing in Experimental Physics (3)

Prerequisite: PHYS 380 or consent of instructor. (Undergraduates enroll in PHYS 480; graduates enroll in PHYS 580.)

Modern data acquisition and analysis methods using computer-based equipment and high level software. Physics experiments performed with standard personal computers, research-quality data acquisition hardware, and programmable instruments. Computer use as tool in execution and interpretation of experiments.

Letter grade only (A-F). (Lecture 2 hrs., laboratory 3 hrs.)

490./590. Selected Topics in Physics (3)

Prerequisite: Consent of instructor. (Undergraduates enroll in PHYS 490; graduates enroll in PHYS 590.)

Physics topics selected from such areas as atomic and nuclear physics, astrophysics, physics of materials, low temperature physics, acoustics, and theoretical physics.

May be repeated to a maximum of 6 units. Topics announced in the *Schedule of Classes*. (Lecture 3 hrs.)

491A. Pedagogical Content Knowledge in Physics - Force and Motion (3)

Prerequisite: Consent of instructor.

Physics content and pedagogy aimed at supporting secondary education. Force and Motion.

Letter grade only (A-F). (Seminar 3 hrs)

491B. Pedagogical Content Knowledge in Physics - Energy and Momentum (3)

Prerequisite: Consent of instructor.

Physics content and pedagogy aimed at supporting secondary education. Energy and Momentum.

Letter grade only (A-F). (Seminar 3 hrs)

491C. Pedagogical Content Knowledge in Physics - Waves and Optics (3)

Prerequisite: Consent of instructor.

Physics content and pedagogy aimed at supporting secondary education. Waves and Optics.

Letter grade only (A-F). (Seminar 3 hrs)

491D. Pedagogical Content Knowledge in Physics - Electricity and Magnetism (3)

Prerequisite: Consent of instructor.

Physics content and pedagogy aimed at supporting secondary education. Electricity and Magnetism.

Letter grade only (A-F). (Seminar 3 hrs)

491E. Pedagogical Content Knowledge in Physics - Nuclear and Thermal (3)

Prerequisite: Consent of instructor.

Physics content and pedagogy aimed at supporting secondary education. Nuclear, Thermal.

Letter grade only (A-F). (Seminar 3 hrs)

495./595. Colloquium (1)

Prerequisite: Consent of instructor.

Weekly meetings for presentation and discussion of current research in physics.

Credit /No credit grading only. (Seminar 1 hr) (Undergraduates enroll in PHYS 495; graduate students enroll in PHYS 595)

496. Special Problems in Physics (1-3)

Prerequisites: Consent of instructor and senior standing.

Physics problems selected by instructor for considered and mature analysis. Written and 10-minute oral reports required.

GRADUATE LEVEL

510. Graduate Mechanics (3) F

Prerequisite: PHYS 310.

Variational principles, Lagrange's equations, Hamilton's equations, canonical transformations, Hamilton-Jacobi theory, relativistic mechanics and small oscillation theory.

Letter grade only (A-F). (Lecture 4 hrs.)

515./410. Relativity (3)

Prerequisite: PHYS 340A. Prerequisite/Corequisite: MATH 370A or MATH 364A. (Undergraduates enroll in PHYS 410; graduates enroll in PHYS 515.)

Lorentz transformation, relativistic kinematics and dynamics, 4-vectors and tensors, transformation of electric and magnetic fields, covariant form of Maxwell's equations, introduction to general relativity.

Letter grade only (A-F). (Lecture-discussion 3 hrs.)

522./422. Statistical Physics (3) S

Prerequisites: PHYS 310, PHYS 320, PHYS 350. (Undergraduates enroll in PHYS 422; graduates enroll in PHYS 522.)

Entropy and temperature, Boltzmann distribution and Helmholtz free energy, thermal radiation, chemical potential, Gibbs distribution, ideal gas, Fermi and Bose gases, heat and work, Gibbs free energy and chemical reactions, phase transformations and kinetic theory.

Letter grade only (A-F). (Lecture-discussion 3 hrs.)

534./434. Astrophysics (3)

Prerequisites: PHYS 310, PHYS 320, and PHYS 340A or consent of the instructor. (Undergraduates enroll in PHYS 434; graduates enroll in PHYS 534.)

Topics in astrophysics. A particular semester schedule might include one or two topics from: Stellar interiors and evolution, radiative transfer and stellar atmospheres, relativistic cosmology, galaxy formation, accretion disk physics and quasars.

Letter grade only (A-F). (Lecture 3 hrs)

540A. Graduate Electrodynamics (3) S

Prerequisite: PHYS 340B.

Boundary-value problems, applications of special functions to electro/magnetostatics, Green's function techniques, multipole expansion of electrostatic field, dielectric media, Maxwell's equations, electromagnetic waves.

Letter grade only (A-F). (Lecture 3 hrs.)

545./445. Experimental Methods in Physics I (3)

Prerequisites: PHYS 254; PHYS 450 or consent of instructor. (Undergraduates enroll in PHYS 445; graduates enroll in PHYS 545.)

Modern physical measurement techniques including scanning probe microscopy and pulsed nuclear magnetic resonance. Noise and fluctuations in physical measurements. Low noise measurement techniques including lock-in amplifier, gated integrator and boxcar averager, bridge circuits, convolution, auto- and cross-correlation and FFT.

Letter grade only (A-F). (Lecture 2 hrs, laboratory 3 hrs)

546./446. Experimental Methods in Physics II (3)

Prerequisites: PHYS 254; PHYS 450 or consent of instructor. (Undergraduates enroll in PHYS 446; graduates enroll in PHYS 546.)

Modern physical measurement techniques in condensed matter physics in high magnetic fields and low temperatures. Examples are temperature and magnetic field effects in magnetic materials, Meissner effect and superconducting transition temperature in superconductors, and mobility and Hall effect in semiconductors. Letter grade only (A-F). (Lecture 2 hrs., laboratory 3 hrs.)

550A. Quantum Mechanics I (3) F

Prerequisite: PHYS 450.

Mathematical and postulational basis of quantum mechanics, one-dimensional problems, two-level systems, angular momentum, central potentials, time independent and time dependent perturbation theory.

Letter grade only (A-F). (Lecture 3 hrs.)

550B. Quantum Mechanics II (3) S

Prerequisite: PHYS 550A.

Scattering, rotation group and irreducible tensor operations, identical particles, semi-classical radiation theory, atoms, path integral formalism, and other selected topics.

Letter grade only (A-F). (Lecture 3 hrs.)

554. Nuclear Physics (3)

Prerequisite: PHYS 550A.

Deuteron problem, nucleon-nucleon potential, shell model, nuclear models, nuclear reactions, elementary particles, weak interactions, strong interactions.

Letter grade only (A-F). (Lecture 3 hrs.)

555. Elementary Particle Physics (3)

Prerequisites: PHYS 310, PHYS 340B, PHYS 450.

Feynman diagram language of scattering and decay, space-time symmetries, relativistic kinematics, hadron quantum numbers and quark models, QED, QCD and gluons, weak interactions.

Letter grade only (A-F). (Lecture 3 hrs.)

560A. Mathematical Methods of Physics (3,3)

Prerequisites: MATH 370A,B or equivalent.

Linear vector spaces, eigenvalue problem, functions of complex variable, special functions, properties and methods of solving partial differential equations of physics, integral equations, tensor analysis, and group theory.

Letter grade only (A-F). (Lecture 4,3 hrs.)

562. Advanced Computational Methods in Physics (3)

Prerequisite: PHYS 450

Computational methods applied to study advanced physics problems such as symbolic and numerical programming, and their applications in various fields (e.g. quantum mechanics, electrodynamics, statistical physics, condensed matter physics, astrophysics, atomic and subatomic physics, etc.)

Letter grade only (A-F). (Lecture 3 hrs.)

569./470. Introduction to Solid State Physics (3)

Prerequisite: PHYS 450. (Undergraduates enroll in PHYS 470; graduates enroll in PHYS 569.)

Study of the properties of solids from a quantum theoretical viewpoint. Topics include lattice vibrations, elastic constants, and thermal, electric and magnetic properties.

Letter grade only (A-F). (Lecture 3 hrs.)

576./476. Modern Optics with Laboratory (3)

Prerequisite: PHYS 340A. (Undergraduates enroll in PHYS 476; graduates enroll in PHYS 576.)

Propagation of electromagnetic waves, optical resonators, laser spectroscopy and operation, optical phase conjugation, nonlinear optics and selected application. Experiments illustrating principles and techniques of electro-optics and laser physics. Applications include optical methods in communications, atomic spectroscopy, and nonlinear optics.

Letter grade only (A-F). (Lecture 2 hrs laboratory 3 hrs)

580./480. Computer Interfacing in Experimental Physics (3)

Prerequisite: PHYS 380 or consent of instructor. (Undergraduates enroll in PHYS 480; graduates enroll in PHYS 580.)

Modern data acquisition and analysis methods using computer-based equipment and high level software. Physics experiments performed with standard personal computers, research-quality data acquisition hardware, and programmable instruments. Computer use as tool in execution and interpretation of experiments.

Letter grade only (A-F). (Lecture 2 hrs., laboratory 3 hrs.)

590./490. Selected Topics in Physics (3)

Prerequisite: Consent of instructor. (Undergraduates enroll in PHYS 490; graduates enroll in PHYS 590.)

Physics topics selected from such areas as atomic and nuclear physics, astrophysics, physics of materials, low temperature physics, acoustics, and theoretical physics.

May be repeated to a maximum of 6 units. Topics announced in the *Schedule of Classes*. (Lecture 3 hrs.)

595./495. Colloquium (1)

Prerequisite: Consent of instructor

Weekly meetings for presentation and discussion of current research in physics. (Undergraduates enroll in PHYS 495; graduate students enroll in PHYS 595) Credit /No credit grading only. (Seminar 1 hr)

691. Directed Study (1)

Intensive study of advanced topics in physics.

May be repeated to a maximum of 2 units. Letter grade only (A-F).

692. Professional Physics Internship (1-4)

Prerequisite: Graduate standing in physics.

Internship in an industrial setting using advanced professional physics skills. An oral presentation is required. May be repeated to a maximum of 4 units in different semesters.

Credit/ No Credit grading only. (1-4 hours contact)

694. Seminar in Special Topics (1)

Prerequisite: Graduate standing.

Study of research papers and research methods in selected topics. If demand for more than one subject exists, multiple sections may be given in any one semester.

May be repeated to a maximum of 2 units; only 1 unit may be applied to the master's degree. Letter grade only (A-F). (Seminar 1 hr.)

695. Colloquium (1)

Prerequisite: Graduate standing.

Weekly meetings for presentation and discussion of current research in physics. Even though only 1 unit is for M.S. degree, graduate students are expected to attend each semester they are enrolled in University.

Credit/No Credit grading only. (Seminar 1 hr.)

697. Directed Research (1-3)

Theoretical and experimental problems in physics requiring intensive analysis.

Letter grade only (A-F).

698. Thesis (1-6)

Prerequisite: Advancement to candidacy for the M.S. in Physics.

Planning, preparation, and completion of acceptable thesis in partial fulfillment of requirements for master's degree. A half-hour seminar presenting and defending results of the thesis required. Credit obtained upon formal acceptance of thesis.

699. Professional Project (1-4)

Prerequisite: Advancement to candidacy in the Masters of Science in Professional Physics degree program.

A significant project undertaken to gain and demonstrate fluency with advanced methods of physics as it is used professionally. The project will demonstrate the acquisition of skills. An oral presentation is required.

Credit/No Credit grading only. May be repeated to a maximum 4 units in different semesters.

Astronomy Courses (ASTR)

LOWER DIVISION

100. Astronomy (3) F,S

Corequisites: One course from General Education Category B.2 and ASTR 100L.

Introductory course in astronomy. The earth moon system and the planets, the stars and their constitution. Survey of the methods of astronomical observation.

(Lecture 3 hrs.)

100L. Introductory Astronomy Laboratory (1) F,S

Prerequisites/Corequisites: One course from Category B.2 of GE requirements; ASTR 100.

Astronomical coordinates, star maps, magnitude, spectral classification, ages of stars, distance to star clusters.

Not open for credit to students with credit in ASTR 101.

(Laboratory 3 hrs.)

UPPER DIVISION

370. Planetary Environments (3)

Prerequisites: GE Foundation requirements and GE B.1.b category; upper division standing.

Planets and moons analyzed as to surface geology, interiors, atmospheres, etc. Methodologies and scientific reasoning about nature and origins of features. Origin of terrestrial life, including role of extinction events, and probable requirements for life elsewhere in universe.

(Lecture 3 hrs.)

Physical Science Courses (PHSC)

LOWER DIVISION

112. Introduction to the Physical Sciences (3) F,S

Prerequisite/Corequisite: One course from Category B.2 of GE Foundation.

Selected processes which illustrate some basic principles used by scientists to interpret modern ideas of matter and energy in physical universe.

Not open for credit to majors in any of the physical sciences. (Lecture 2 hrs., laboratory 3 hrs.)

SCIENCE EDUCATION

College of Natural Sciences and Mathematics

Department Chair: Lisa Martin-Hansen

Department Office: Hall of Science (HSCI) 205

Telephone/FAX: (562) 985-4801/985-7164

Website: www.cnsm.csulb.edu/depts/scied

Faculty: Alan Colburn, Susan Gomez-Zwiep, Laura Henriques, Thomas Kelty, James Kisiel, Lisa Martin-Hansen, William Straits

Advisors:

Single Subject Science Credential: Tim Williamson

Graduate Advisor: Alan Colburn, James Kisiel

Administrative Support Coordinator: Natalia Mora

Introduction

The department maintains close ties with teachers, schools and informal science institutions in the greater Long Beach area. It undertakes projects aimed at pre-K through university students. From the Head Start on Science project which develops a "sense of wonder" and excitement preschool and Kindergarten children, their teachers and parents to outreach and professional development for inservice elementary and secondary teachers, and support for preservice teachers and informal science educators, the department hosts a wide variety of grants and projects impacting the entire preK-16 and informal science education community. The department sponsors the Young Scientists' Camp programs, research seminars and the Association of Future Science Educators (AFSE) which is student chapter of California Science Teachers Association/National Science Teachers Association.

Graduate Programs

Master of Science in Science Education

The M.S. in Science Education is designed primarily for credentialed K-12 teachers and experienced informal educators.

Application

Prospective graduate students in M.S. in Science Education, including CSULB graduates, must formally apply for admission to CSULB as described previously in this catalog and must also apply directly to the Department of Science Education. All applicants must submit the following documents directly to the department office:

1. Completed departmental application form, including personal statement. The application form is available in the Department of Science Education office and on the internet [<http://www.scienceteaching.org>], click on "Masters Info".
2. Two confidential recommendation letters, sent under separate cover, including one from an administrator or supervisor at a school/institution where the applicant is (or was) employed.

Prospective graduate students must also receive a

positive recommendation following an interview with graduate faculty.

Review by the Graduate Studies Committee

The Graduate Studies Committee will review all completed applications and recommend either accepting the applicant as a Classified or Conditionally Classified graduate student, or denying admission. All accepted students should contact the departmental graduate advisor before their first semester for advisement and orientation.

Classified Graduate Student

The Department of Science Education will recommend for admission as a Classified graduate student any applicant who has met all prerequisites and been accepted by the Graduate Studies Committee.

Conditionally Classified Graduate Student

An applicant who fails to meet the criteria for Classified admission to the department may be considered by the Graduate Studies Committee for admission as a Conditionally Classified graduate student. The Graduate Studies Committee will determine what deficiencies each applicant has and specify what the individual must do to make up those deficiencies. The applicant must make up all such deficiencies before attaining Classified status.

Admission to the Department Prerequisites

In addition to the prerequisites for entrance into CSULB as a graduate student stated in this *Catalog*, the Science Education department requires:

- California Multiple Subject or science teaching credential, or the equivalent;
- GPA of at least 3.0 for the last 60 units of study completed.
- Those students participating in the informal science option may substitute one or more years experience working as an educator in an informal learning setting; a letter of support is required.

Students are expected to exhibit high standards of writing proficiency. Students missing any admission criteria may only be admitted after receiving the approval of a department graduate faculty committee.

Option in Elementary and Middle School Science Education

This option is designed for teachers who are K-8 generalists. It may also be appropriate for Single Subject teachers interested in increasing the breadth of their scientific knowledge.

Program of Study

The Program of Study (30 units) includes successful completion of:

1. Take all the following Science Education core courses:
SCED 550 Current Issues and Research in Science Education (3)
Prerequisite: Admission to M.S. in Science Education program.

SCED 551 Science Teaching, Learning and Curriculum Models (3)

Prerequisites: Admission to M.S. in Science Education program and SCED 550 or prior consent of instructor.

SCED 552 Nature of Science (3)

Prerequisites: Admission to M.S. in Science Education program and SCED 550.

SCE 560 Science Education Research Methods (3)

Prerequisites: Admission to the M.S. in Science Education Program.

SCED 697 Directed Research (1-3)

Prerequisites: Consent of instructor and admission to M.S. in Science Education program.

2. Take all the following science courses:

SCED 500 Life Science Applications for K-8 Teachers (3)

Prerequisites: Admission to M.S. in Science Education program; BIOL 200.

SCED 501 Earth Sciences Applications for K-8 Teachers (3)

Prerequisites: Admission to the M.S. in Science Education program and GEOL 102+GEOL 104 or GEOL 106.

SCED 502 Physical Science Applications for K-8 Teachers (3)

Prerequisites: Admission to M.S. in Science Education program; PHSC 112.

3. Take the following course:

SCED 698 Thesis (1-3)

Prerequisites: Advancement to Candidacy for the M.S. in Science Education, 18 units of coursework required for M.S. Science Education completed, and consent of the chair of the thesis committee.

4. Take 3 elective units (chosen in consultation with advisor)

Option in Secondary Science Education

This option is aimed at teachers with a Single Subject credential in Science. Graduate students complete 9 units of graduate work in a Science discipline.

Program of Study

The Program of Study (30 units) includes successful completion of:

1. Take all the following Science Education core courses:

SCED 550 Current Issues and Research in Science Education (3)

Prerequisite: Admission to M.S. in Science Education program.

SCED 551 Science Teaching, Learning and Curriculum Models (3)

Prerequisites: Admission to M.S. in Science Education program and SCED 550 or prior consent of instructor.

SCED 552 Nature of Science (3)

Prerequisites: Admission to M.S. in Science Education program and SCED 550.

SCED 560 Science Education Research Methods (3)

Prerequisites: Admission to the M.S. in Science Education Program.

SCED 697 Directed Research (1-3)

Prerequisites: Consent of instructor and admission to M.S. in Science Education program.

2. Take 9 units of graduate level science (chosen in consultation with advisor)

3. Take the following course:

SCED 698 Thesis (1-3)

Prerequisites: Advancement to Candidacy for the M.S. in Science Education, 18 units of coursework required for

M.S. Science Education completed, and consent of the chair of the thesis committee.

4. Take 3 elective units (chosen in consultation with advisor)

Option in Informal Science Education

This option is aimed at educators currently working in non-classroom settings such as museums, zoos, and nature centers, as well as those charged with fostering the public understanding of science.

Program of Study

The Program of Study (33 units) includes the successful completion of:

1. Take all the following Science Education core courses:

SCED 550 Current Issues and Research in Science Education (3)

Prerequisite: Admission to M.S. in Science Education program.

SCED 551 Science Teaching, Learning and Curriculum Models (3)

Prerequisites: Admission to M.S. in Science Education program and SCED 550 or prior consent of instructor.

SCED 552 Nature of Science (3)

Prerequisites: Admission to M.S. in Science Education program and SCED 550.

SCED 553 Science Learning in Informal Settings (3)

Prerequisite: Admission to Science Education M.S. program; consent of instructor.

SCED 560 Science Education Research Methods (3)

Prerequisites: Admission to the M.S. in Science Education Program.

SCED 697 Directed Research (1-3)

Prerequisites: Consent of instructor and admission to M.S. in Science Education program.

2. Take 6 units of science courses from the following:

SCED 500, SCED 501, SCED 502, or other graduate-level science courses chosen in consultation with an advisor

3. Take 3 units non-profit management or other related course from the following:

REC 521, REC 528, or other courses in consultation with an advisor

4. Take 3 units elective, chosen in consultation with advisor

5. Take the following course:

SCED 698 Thesis (1-3)

Prerequisites: Advancement to Candidacy for the M.S. in Science Education, 18 units of coursework required for M.S. Science Education completed, and consent of the chair of the thesis committee.

Advancement to Candidacy

1. A student must be designated as a Classified Student in good standing prior to advancing to candidacy.

2. A student must satisfy the general requirements of the University, including fulfilling the Graduation Writing Assessment Requirements (GWAR).

3. The student's M.S. program must be approved by a faculty graduate advisor, the department graduate advisor, the department chair, and the Associate Dean in the College of Natural Sciences and Mathematics or designee.

4. Advancement to candidacy may take place upon satisfactory completion of six units in the M.S. program. A student must have been advanced to candidacy before

initiating formal thesis research necessary to complete the M.S. degree.

Courses (SCED)

Lower Division

100. An Introduction to Scientific and Spatial Reasoning (3)

Course Description: Students develop essential and critical thinking skills that help them 'think outside of the box' and recognize the role of spatial reasoning, perception and creativity in the practices of science. Letter grade or credit/no credit. The course may not be repeated. (3 hours activity.)

UPPER DIVISION

401. A Process Approach to Science (3)

Prerequisite: BIOL 200; PHSC 112; GEOL 106, or both GEOL 102 and GEOL 104; all with a "C" or better grade.

Processes of science as they relate to life, earth, and physical sciences. Practical approaches to integration of science and engineering practices, disciplinary core ideas, and cross-cutting concepts of science integrated and modeled throughout the course for students.

Letter grade only (A-F). (Lecture 2 hrs., laboratory 3 hrs.) Course fee may be required.

403. Integrated Science (3)

Prerequisites: All credential breadth requirements for the Single Subject Teaching Credential Program in Science, three-fourths of the credential specializations courses, and consent of instructor. Enrollment limited to students who intend to pursue a Single Subject Credential in Science.

Focuses on NGSS integration of science and engineering practices, disciplinary core ideas, and cross-cutting concepts of science. Requires presentations, discussions, critical evaluation by students on selected interdisciplinary topics in sciences, and field work in integrated science assignments.

Letter grade only (A-F). (Lecture 3 hrs.)

404. The Nature of Science and Scientific Reasoning (3)

Prerequisites: Minimum of 9 units of science (introductory level or higher) or consent of instructor.

Course introduces the nature of science – its history, philosophy, and sociology. Common misconceptions related to science practices and critical evaluation of scientific investigations (in research literature and popular media) are examined. Implications for science communication and teaching will be addressed.

Letter grade only (A-F). (Lecture 3 hrs.)

475. Teaching and Learning Science, K-8 (3)

Prerequisites: Admission to the Multiple Subject Credential Program. SCED 401 or a bachelor's degree.

Methods for teaching elementary school science. Development of sequenced, Common Core integrated, NGSS-based science lessons addressing the needs of all learners to be STEM ready.

Letter grade only (A-F). Course fee may be required. (Lec 2 hrs., activity 2 hrs.) 60 contact hours, however, actual contact hours vary as course is offered with an on-line distance component (see *Schedule of Classes* footnote). 10 hours minimum of fieldwork in classrooms where at least 25% of students are classified as English learners, or concurrent enrollment in EDEL 482.

490A. Selected Topics in Science Education (1-3)

Prerequisite: Consent of instructor.

Topics in science education.

May be repeated to a maximum of 6 units with different topics in different semesters. (Lecture 1-3 hrs)

490B. Selected Topics in Life Science Education (1-3)

Prerequisite: Consent of instructor.

Topics in life science education.

May be repeated to a maximum of 6 units with different topics in different semesters. Letter grade only (A-F). (Lecture 1-3 hrs)

490C. Selected Topics in Earth/Space Science Education (1-3)

Prerequisite: Consent of instructor.

Topics in earth and space science education.

May be repeated to a maximum of 6 units with different topics in different semesters. Letter grade only (A-F). (Lecture 1-3 hrs)

490D. Selected Topics in Physical Science Education (1-3)

Prerequisite: Consent of instructor.

Topics in physical science education.

May be repeated to a maximum of 6 units with different topics in different semesters. Letter grade only (A-F). (Lecture 1-3 hrs)

496. Directed Studies in Science Education (1-3)

Prerequisites: Consent of instructor.

Supervised study of current topics in science education.

Letter grade only (A-F). May be repeated to a maximum of 3 units with different topics in different semesters.

GRADUATE LEVEL

500. Life Science Applications for K-8 Teachers (3)

Prerequisites: Admission to M.S. in Science Education program; BIOL 200.

Emphasizes major themes and processes in life sciences, focusing on deepening understanding of concepts and approaches to teaching material in K-8. Approaches to developing/teaching inquiry-based/experiential learning units in biology modeled and integrated throughout course.

Letter grade only (A-F). (Seminar 3 hrs.)

501. Earth Sciences Applications for K-8 Teachers (3)

Prerequisites: Admission to the M.S. in Science Education program and GEOL 102+GEOL 104 or GEOL 106.

Investigates earth science topics with focus on deepening connections between concepts in earth science and matter and energy cycling, providing applications of earth science concepts and activities in K-8 classrooms and schools.

Letter grade only (A-F). (Seminar 3 hrs.)

502. Physical Science Applications for K-8 Teachers (3)

Prerequisites: Admission to M.S. in Science Education program; PHSC 112.

Investigates physical science topics with focus on deepening students' science understanding while showcasing applications of physical science for students' personal lives and their K-8 classrooms and schools.

Letter grade only (A-F). (Seminar 3 hrs.)

550. Current Issues and Research in Science Education (3)

Prerequisite: Admission to M.S. in Science Education program. SCED 550 is a core course in the M.S. in Science Education.

Introduces students to body of research and practical knowledge shared by science education community from the early 1900s through today (including recent reforms such as NGSS). Includes choosing, studying, and discussing articles from science education literature relevant to key issues in science education.

Letter grade only (A-F). (Seminar 3 hrs.)

551. Science Teaching, Learning and Curriculum Models (3)

Prerequisites: Admission to M.S. in Science Education program and SCED 550 or prior consent of instructor.

Introduces students to professional literature about science teaching and learning. Traces historical development of elementary/secondary science curriculum models more specifically, and STEM education efforts more broadly. Students examine role science and education organizations played in reforming science curriculum (including standards movements and NGSS), and analyze curricula from variety of teaching/learning perspectives.

Letter grade only (A-F). (Seminar 3 hrs.)

552. Nature of Science (3)

Prerequisites: Admission to M.S. in Science Education program and SCED 550.

A core course in the M.S. in Science Education. Looks at science from historical, philosophical, psychological, and sociological perspectives. Examines perceptions of science and scientists, especially views of science in different cultures and times. Discusses using these perspectives to teach students about nature of science.

Letter grade only (A-F). (Seminar 3 hrs.)

553. Science Learning in Informal Settings (3)

Prerequisite: Admission to Science Education M.S. program; consent of instructor. SCED 553 is a core course required of all Science Education M.S. candidates who have declared an option in informal science learning.

Examines characteristics of non-school learning settings (e.g., science museums, zoos, aquaria, nature centers, homes) and how they promote (or hinder) scientific understanding. Multiple theoretical perspectives examined. Authentic evaluation/research project with local institution.

Letter grade only (A-F). (Seminar 3 hrs.)

560. Science Education Research Methods (3)

Prerequisites: Admission to the M.S. in Science Education program.

Examination and application of science education research methodology including various types of qualitative and quantitative methods, research designs, sampling methods, inferential statistics and hypothesis testing, interpretation and use of science education research instruments and development of a research proposal.

Letter grade only (A-F). (Seminar 3 hrs.)

580. Introduction to College Science Teaching - 1 (1)

Prerequisite: Admission to Master's-level program in CNSM.

Addresses the fundamentals of college science instruction with an emphasis on immediate classroom application. Strategies for active learning, student assessment, and teacher development are introduced.

Letter grade only (A-F). (Seminar 1 hr)

590. Selected Topics in Science Education (1-3)

Prerequisite: Consent of instructor. (Undergraduates enroll in SCED 490; graduate students enroll in SCED 590).

Topics in Science Education. Course content will vary from section to section.

May be repeated to a maximum of 6 units with different topics

in different semesters. Topics announced in the Schedule of Classes. Letter grade only (A-F). (Seminar 1-3 hrs.)

697. Directed Research (1-3)

Prerequisites: Consent of instructor and admission to M.S. in Science Education program.

Independent investigation of a research problem or directed project, under the direction of a faculty member.

May be repeated to a maximum of 3 units with different topics in the same semester. Letter grade only (A-F).

698. Thesis (1-3)

Prerequisites: Advancement to Candidacy for the M.S. in Science Education, 18 units of coursework required for M.S. Science Education completed, and consent of the chair of the thesis committee.

Planning, preparation, and completion of the thesis project in Science Education. Enrollment in more than 2 units in a given semester requires departmental approval.

Letter grade only (A-F).