SCHOOL OF Ocean and Earth Science and Technology

Administration

Pacific Ocean Science and Technology 802
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General Information

The School of Ocean and Earth Science and Technology (SOEST) was established in 1988. It combines and integrates the Departments of Geology and Geophysics, Meteorology, Ocean and Resources Engineering, and Oceanography, as well as the Hawai'i Institute of Geophysics and Planetology, the Hawai'i Institute of Marine Biology, and the Hawai'i Natural Energy Institute. The Sea Grant and Space Grant College Programs, the Hawai'i Undersea Research Laboratory, and the Joint Institute for Marine and Atmospheric Research, all jointly supported by state and federal funds, are also part of SOEST.

In 1997 the International Pacific Research Center was established in SOEST under the U.S.- Japan Common Agenda. The center is jointly supported by the state, Japanese, and federal funds. In addition, SOEST includes the Marine Option Program.

Although the Department of Ocean and Resources Engineering offers several undergraduate courses, baccalaureate degrees are not offered in this area. The Department of Oceanography offers the BS in global environmental science. Undergraduate students may also pursue ocean-related interests by means of the undergraduate certificate program administered by the Marine Option Program (see the "Certificate Programs" section). Baccalaureate degree programs are offered in the Department of Geology and Geophysics and the Department of Meteorology. Those with long-range plans for graduate work in oceanography or ocean and resources engineering should prepare themselves with an undergraduate course of study that will satisfy the entry requirements for admission to these graduate programs. Information on entrance and degree or certificate requirements for all SOEST graduate programs (MS and PhD in geology and geophysics, meteorology, ocean and resources engineering, and oceanography; and certificates in

Graduate Maritime Archeology and History and Graduate Ocean Policy) is in this Catalog. Candidates for advanced degrees and the graduate certificate programs apply through the Graduate Division of the University. The school has developed a number of interdisciplinary courses at both the undergraduate and the graduate levels, which are listed under OEST within the "Courses" section of the Catalog.

Mission

The mission of SOEST is to make the University of Hawai'i a leading center in ocean and earth science and technology. Scientists of SOEST intend to understand the subtle and complex interrelations of the seas, the atmosphere, and the Earth in order to learn how to preserve the quality of our lives and to bring to Hawai'i an enrichment of intellect and culture along with technological advances well suited to the needs of these islands. To that end, the objectives of SOEST are as follows:

1. Enhance educational opportunities in ocean and earth science and technology for the people of Hawai'i, the nation, and the Pacific Basin;
2. Accelerate the growth of the University of Hawai'i at Mānoa to preeminence in research and development in ocean and earth science and technology;
3. Build the strength of the University for public service and outreach in the Pacific Basin; and
4. Provide a foundation for economic interaction and development of marine-related industries within the state of Hawai'i.

Degrees and Certificates

Bachelor's Degrees: BA in geology, BS in geology and geophysics, BS in meteorology, BS in global environmental science

Master's Degrees: MS in geology and geophysics, MS in meteorology, MS in ocean and resources engineering, MS in oceanography

Doctoral Degrees: PhD in geology and geophysics, PhD in meteorology, PhD in ocean and resources engineering, PhD in oceanography

Certificate Programs: Marine Option Program Certificate, Maritime Archaeology and History Graduate Certificate, Graduate Ocean Policy Certificate

Advising

For general information about the school and its programs, contact the associate dean's office at POST 802, 1680 East-West Road; tel. (808) 956-9109 or Leona Anthony, Student Services Specialist at (808) 956-8763.

For information on specific degree programs, contact the appropriate departments. For information on certificate programs, contact the Marine Option Program (see the "Certificate Programs" section).

Undergraduate Programs

Candidates for the BA degree in geology, the BS degree in geology and geophysics, the BS degree in meteorology, and the BS degree in global environmental science, apply through the undergraduate Admissions Office.

School Requirements

To be entitled to a bachelor's degree offered by the school, students must fulfill these requirements.

1. Basic course work as specified by their degree programs.
2. Completion of requirements for the major, including presentation of goldenrod form to the Student Academic Services Office.
3. Completion of 60 credit hours in non-introductory level courses (i.e., courses numbered 300 and above) or 200-level courses that have an explicit college-level course prerequisite.
4. GPA of 2.0 (C average) for all University of Hawai'i at Mānoa registered credits.
5. GPA of 2.0 (C average) for all courses applied to the major requirements.
6. A degree audit at the Student Academic Services Office in the semester preceding the award of the degree.
7. Application for graduation at the Student Academic Services Office in the semester preceding the award of the degree.

Bachelor of Arts and Bachelor of Science Degrees

Basic Requirements

1. Courses in written communication and in world civilizations as required by the UH Mānoa General Education Core (see the "Mānoa General Education and Graduation Requirements" section of this Catalog).
2. Three semester courses chosen from the three humanities groups in the General Education Core (see the "Mānoa General Education and Graduation Requirements" section of this Catalog).
3. Three semester courses from three different departments in the social sciences group in the General Education Core (see the "Mānoa General Education and Graduation Requirements" section of this Catalog).
4. At least one course in biological sciences chosen from natural sciences group one in the General Education Core (see the "Mānoa General Education and Graduation Requirements" section of this Catalog).

Support science requirements from mathematics, chemistry, and physics vary with degree programs. The following are the minimum required courses (consult departmental adviser for further details).

- Mathematics
  - MATH 241 (BA)
  - MATH 242, 242L (BS, geology and geophysics)
  - MATH 244 (BS, meteorology)
- Chemistry
  - CHEM 161/161L, 162/162L
  - CHEM 171/171L (mandatory for meteorology)

- Physics
  - PHYS 151/151L and 152/152L (BA)
  - PHYS 170/170L and 272/272L (BS)
  - (BS majors may enroll in PHYS 151/151L, 152/152L with permission of departmental adviser)

Note that introductory chemistry and mathematics courses have placement tests.

Students who have not completed a high school course equivalent to pre-calculus should take MATH 140 during the summer session prior to their first semester. All BA and BS degree candidates should consult with the departmental adviser before registering.

Major Requirements

See appropriate departments for specific major requirements leading to a bachelor of arts or a bachelor of science degree.

Graduate Programs

See appropriate departments for specific major requirements leading to MS and PhD degrees.

Certificate Programs

Marine Option Program

The Marine Option Program (MOP) is a unique opportunity for undergraduates with an interest in the ocean. It is open to students in all fields and provides a clearinghouse for marine-oriented experiential education as well as a chance for students with common interests to meet. MOP sponsors a wide variety of marine activities, including field trips, workshops, seminars, symposia, along with credit and noncredit courses.

A certificate is awarded to undergraduates who successfully complete at least 16 credit hours of marine-related courses (including OCN 201, ORE 202, ZOOL 200, or an equivalent survey course; one 3-credit interdisciplinary ocean course; 6 credit hours of marine electives). In addition, within the 16-credit requirement students must complete the MOP Seminar (OEST 100) followed by the MOP skill project. The unique MOP skill project (worth 3 or more credits, e.g. OEST 300V) allows students to design and conduct a personal marine or aquatic project related to their educational goals. Past projects have run from scientific research to endeavors in the arts. Unclassified graduate students are also eligible to enroll in MOP and earn a certificate.

Students interested in MOP or in marine careers and curricula should visit the Marine Option Program offices in Hawai'i Institute of Geophysics, room 214A; tel. (808) 956-8433; e-mail mop@hawaii.edu.

Maritime Archaeology and History

The field of maritime archaeology and history is relatively undeveloped in the Pacific, yet a great potential exists to explore, document, preserve, and interpret the rich heritage of ocean-related culture, history, anthropology, archaeology, science, and technology. The University of Hawai'i is exceptionally well-located, staffed, and equipped to conduct education, research, and service for Pacific Ocean maritime archaeology and history of Polynesians and other Pacific Islanders as well as the maritime peoples of Asia—with expertise spanning from coastal wetlands to the technologies required for deep water exploration. This graduate certificate is offered as a complement to classified graduate students pursuing advanced degrees or as a stand-alone credential. Cooperating faculty from several departments and programs in the UH system are complemented by faculty and professionals from throughout the Pacific and continental United States. Completion of the certificate requires a minimum of 20 credits, including OEST/HIST 489 (3) and ANTH 640F (3) or OEST/ANTH 668 (6), plus a capstone paper and electives from courses in the following areas: history and social science, archaeology, techniques, and natural sciences and engineering. For further information contact the office of the associate dean, SOEST, tel (808) 956-9109; e-mail: cooper@soest.hawaii.edu.

Ocean Policy

The wise use and careful stewardship of the ocean require people with multidisciplinary and interdisciplinary advanced education in the natural and social sciences. This program offered by the School of Ocean and Earth Science and Technology, in collaboration with several other colleges and schools, is designed for classified graduate students, law students, and community professional practitioners who wish to complement their existing degree or curriculum. An advisory committee assists each student in custom-designing a 21-credit (minimum) program that draws on marine-related courses in law, geography, agricultural and resource economics, oceanography, costal management, civil and ocean and resources engineering, geology and geophysics, meteorology, botany and zoology, and includes an interdisciplinary seminar and two practica (one each in natural science and social science). For further information and applications, contact the Department of Oceanography, tel (808) 956-7633; e-mail: ocean@soest.hawaii.edu.

Instructional and Research Facilities

Hawai'i Institute of Geophysics and Planetology

The Hawai'i Institute of Geophysics and Planetology (HIGP) conducts geological, geochemical, geophysical, and oceanographic and atmospheric laser and passive remote sensing research, as well as remote sensing research in earth, space, and marine sciences. Programs embrace research and advanced training in marine geology and geophysics, marine geochemistry, materials science and high-pressure geophysics, oceanic biology, evolution of the solar system, seismology and solid earth geophysics, planetary geology, volcanology, and petrology. The institute maintains various specialized facilities in support of its research endeavors. HIGP includes the Hawai'i Space Grant College, which runs a wide variety of education and fellowship programs at the K–12, undergraduate, and professional levels and also provides outreach to the Hawai'i community.

Hawai'i Institute of Marine Biology

The Hawai'i Institute of Marine Biology (HIMB) provides facilities and services for faculty members, graduate and undergraduate students and visiting scholars for research and education in marine biology and related topics. The core faculty, plus many from other UH departments, study the life processes of marine organisms including plants, animals, and microbes. Research at HIMB covers a broad range of topics including coral reef biology and ecology, the behavior physiology and sensory systems of marine mammals, tropical aquaculture, the behavior of reef fishes, shark ecology and sensory systems, fish endocrinology, pollution and management of marine ecosystems, coastal biogeochemical processes, fisheries, and bioengineering and genetics.

HIMB is unique in that it has new, state of the art, molecular biology laboratories and immediate access to the reef, Kāne'ohe Bay, and deep ocean waters. It is located on Coconut Island in Kāne'ohe Bay (on the east coast of O'ahu) providing a unique setting for graduate-level topics courses and field-trip demonstration opportunities. Kāne'ohe Bay is filled with healthy coral reefs. The 24 acre island, located within a 30 minute drive distance from the Mānoa campus, is surrounded by a 64 acre coral reef dedicated to scientific research. Facilities at the marine laboratory include research vessels and skiffs, protected harbors, a pelagic fish laboratory; Hawaiian fish ponds, aquaria and tanks; a flow-through seawater system; remote environmental monitoring capabilities; reef microcosm systems; a wide array of computerized analytical and acoustic equipment; a floating marine mammal research complex; and the Barbara Pauley Pagen Library and classrooms.

Hawai'i Natural Energy Institute

The Hawai'i Natural Energy Institute (HNEI) was established by the state Legislature in 1974 as a research institute at the University to provide leadership, focus, and support for natural energy research, development, and demonstration. HNEI works closely with the federal, state, and county governments; private industry; the utilities, community and international organizations; and individuals to initiate and complete renewable energy and ocean resources activities. HNEI attracts government and industrial funds for basic research, demonstration projects, feasibility studies, and field evaluation programs.

Hawai'i Undersea Research Laboratory

The Hawai'i Undersea Research Laboratory (HURL) was established in 1980 by a cooperative agreement between the National Oceanic and Atmospheric Administration (NOAA) and the University of Hawai'i. HURL is one of six National Undersea Research Centers sponsored by NOAA's National Undersea Research Program (NURP). HURL operates the *Pisces IV and Pisces V* research submersibles and the *RCV-150* remotely-operated vehicle to conduct marine research to oceanic depths of 2,000 meters. These underwater vehicles are operated from HURL's dedicated support ship, the 222-foot R/V *Ka'imikai-o-Kanaloa*. Extensive data are archived and available to the scientific and academic community for biology, geology and marine chemistry research from submersible dives dating back to 1980. Principal research projects conducted are those aligned with the mission of NOAA.

James K. K. Look Laboratory

The James K. K. Look Laboratory of Oceanographic Engineering (established 1966), part of the Department of Ocean and Resources Engineering, conducts research on ocean engineering problems related to structures in and physical characteristics of the coastal zone and open ocean, and it provides service to researchers on problems related to ocean resources and the calibration of wind-measuring instruments. The Look Laboratory is also used for instruction of courses involving field measurements of ocean characteristics and hydraulic scale models. Facilities at Look Laboratory include two- and three-dimensional hydraulic scale model spaces, an in-ocean test range, a wet chemistry and biology laboratory, photobioreactors for the Marine Bioproducts Engineering Center (MarBEC) and supporting electronics and machine shops.

Joint Institute for Marine and Atmospheric Research

The Joint Institute for Marine and Atmospheric Research (JIMAR) was formed in 1977 under a memorandum of understanding between the NOAA and the University of Hawai'i. The principal research interests of JIMAR are tsunamis, equatorial oceanography, climate, fisheries oceanography, and tropical meteorology.

International Pacific Research Center

The International Pacific Research Center was established in 1997 under the U.S.- Japan Common Agenda for Cooperation in Global Perspective. Its mission is to provide an international, state-of-the-art research environment to improve understanding of the nature and predictability of climate variability in the Asia-Pacific sector, including regional aspects of global environmental change.

Pacific Mapping Program

The Pacific Mapping Program (PMP) was established in 1990 to facilitate the exploration and development of the Pacific Islands Exclusive Economic Zone (EEZ). It was initially funded by the U. S. Geological Survey (USGS), the National Ocean Service/National Oceanic and Atmospheric Administration (NOS/NOAA), and the Pacific International Center for High Technology Research (PICHTR). It is a self-contained research facility with the state-of-the-art computer hardware and software to conduct research, service and graduate education in ocean mapping and marine geographic information systems (GIS). The principal research interests of the PMP are shallow water mapping, GIS, remote sensing and data integration.

Sea Grant College Program

The Sea Grant College Program develops and administers a multidisciplinary institutional research and extension program dedicated to the wise use and management of the marine environment and its resources. The research is conducted by

UH faculty and staff in 26 departments in 10 colleges and institutes at the Mānoa campus, the Hilo campus, and the Community Colleges; graduate and undergraduate education is supported through the research projects. Results of the research are disseminated to marine agencies, the marine industry, and the general public through the program's extension service and communications program. The program has strong linkages with the 29 Sea Grant programs across the nation and with the United States flag territories and freely associated states of the western Pacific.

Space Grant College Program

The Space Grant College Program is a wide-ranging community educational program supported by the National Aeronautics and Space Administration (NASA) that promotes studies in scientific fields related to space. These fields include astronomy, geology, meteorology, oceanography, mathematics, physics, engineering, computer science, and life sciences. Affiliate campuses are UH Hilo, all seven Community Colleges, and the University of Guam. Some of the programs supported by Space Grant include an Undergraduate Fellowship Program (approximately 20 students per semester are supported); the Future Flight Program for teachers, school students and their parents; teacher workshops; undergraduate remote-sensing class; an undergraduate telescope facility; maintenance of several World Wide Web sites including "Planetary Science Research Discoveries"; and outreach to state and federal agencies related to the use of satellite and aircraft remote-sensing data. A significant goal of the program is to encourage interdisciplinary studies and research and to train future generations of space scientists in the physical sciences. Students, teachers, and researchers in Hawai'i are encouraged to contact the Mānoa Space Grant office at (808) 956-3138 to learn more about the opportunities.

Geology and Geophysics

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Faculty

*P. Wessel, PhD (Chair)—marine geophysics
*J. M. Becker, PhD—geophysical fluid dynamics, nonlinear dynamics
*P. Cooper, PhD—seismology
*F. K. Duennebier, PhD—seismology, marine geophysical instrumentation
*A. I. El-Kadi, PhD—groundwater hydrology
*P. F. Fan, PhD—sedimentary and geothermal mineralogy, geology of Asia
*C. H. Fletcher, PhD—coastal processes
*L. N. Frazer, PhD—theoretical seismology
*M. O. Garcia, PhD—igneous petrology, volcanology
*C. R. Glenn, PhD—sedimentology, diagenesis, paleoceanography
*B. F. Houghton, PhD—physical volcanology
*J. L. Karsten, PhD—petrology
P. D. Lee, MS—paleontology
*J. J. Mahoney, PhD—geochemistry
*S. J. Martel, PhD—engineering geology, geomechanics
*R. Moberly, PhD—marine geology, sedimentology
*G. F. Moore, PhD—exploration seismology, tectonics
*B. N. Popp, PhD—isotopic biogeochemistry
*C. B. Raleigh, PhD—seismology, rock mechanics
*J. M. Resig, Dr. rer. nat.—micropaleontology
*K. H. Rubin, PhD—isotope geochemistry, age dating
*J. M. Sinton, PhD—igneous petrology, marine geology
*K. J. Spencer, PhD—geochemistry, instrumentation
*B. Taylor, PhD—plate tectonics, geology of ocean margin basins

*Graduate Faculty

Cooperating Graduate Faculty

T. B. Appelgate, PhD—marine geology and geophysics, seafloor mapping and plate tectonics
J. Bell, PhD—planetary geosciences
M. G. Bevis, PhD—crustal motion geodesy, GPS, geodynamics
K. A. W. Crook, PhD—sedimentology, tectonics, geoscience policy
E. H. DeCarlo, PhD—marine geochemistry, marine resources
M. H. Edwards, PhD—marine geology and geophysics
F. P. Fanale, PhD—planetary surfaces
L. Flynn, PhD—remote sensing of fires and volcanoes
G. J. Fryer, PhD—seismology, computer modeling, marine geophysics
P. B. Fryer, PhD—marine geology, petrology, tectonics
M. D. Fuller, PhD—paleomagnetism, geomagnetism
A. J. Harris, PhD—volcanology, remote sensing
M. A. Garcés, PhD—infrasound, wave propagation, volcanology
B. R. Hawke, PhD—planetary geosciences
E. Herrero-Bervera, PhD—paleomagnetism, geomagnetism
R. N. Hey, PhD—marine geophysics and tectonics
B. H. Keating, PhD—paleomagnetism
K. Keil, Dr. rer. nat.—meteorites, planetary geosciences
L. S. L. Kong, PhD—seismology
L. W. Kroenke, PhD—marine geology and geophysics
B. R. Lienert, PhD—geophysics
P. G. Lucey, PhD—planetary geosciences
F. Mackenzie, PhD—sedimentary geochemistry, sedimentology
M. H. Manghnani, PhD—high-pressure geophysics, mineral physics
F. Martinez, PhD—marine geophysics
T. B. McCord, PhD—planetary surfaces, remote sensing
F. W. McCoy, PhD—marine geology, sedimentology
L. C. Ming, PhD—high-pressure mineralogy
P. J. Mouginis-Mark, PhD—planetary science, remote sensing
S. K. Rowland, PhD—planetary geosciences
E. R. D. Scott, PhD—planetary geosciences
S. K. Sharma, PhD—raman and IR spectroscopy in geochemistry
G. J. Taylor, PhD—planetary geosciences
D. M. Thomas, PhD—geothermal and volcanic geochemistry
J. S. Tribble, PhD—marine geology and geochemistry

R. Wilkens, PhD—rock and sediment properties, bore-hole research
C. J. Wolfe, PhD—seismology, marine geophysics

Affiliate Graduate Faculty

D. Clague, PhD—marine geology, volcanology
A. L. Clark, PhD—economic geology, resources
J. Gradie, PhD—planetary sciences
C. J. Johnson, PhD—resource systems
K. T. M. Johnson, PhD—marine geology and geophysics
J. P. Kauahikaua, PhD—volcanology
J. P. Lockwood, PhD—volcanology
J. K. Morgan, PhD—sediment mechanics, convergent margin processes, numerical modeling of granular materials
P. G. Okubo, PhD—geophysics
S. Self, PhD—volcanology, petrology
G. H. Sutton, PhD—seismology, marine geophysics
C. R. Thornber, PhD—geochemistry, volcanology
G. W. Tribble, PhD—geochemistry, coral reef geology
D. A. Walker, PhD—seismology
C. G. Wheat, PhD—low-temperature geochemistry
S. Zisk, PhD—planetary geosciences

Degrees Offered: BA in geology, BS in geology and geophysics, MS in geology and geophysics, PhD in geology and geophysics

The Academic Program

Geology and geophysics (GG) are important branches of the geosciences, which encompass the scientific study of Earth and other bodies in our solar system. Thus, the scope of the geosciences is extremely broad, and includes important ties to meteorology and oceanography. The Earth and other planets are highly dynamic; geoscientists study the internal and surface changes that occur to decipher the fundamental causes of these changes. In turn, these studies shed light on the origin and evolution of Earth processes, the other planets, and, indeed, the entire solar system. The range of interest in the Earth and planetary sciences is from submarine volcanism to understanding our environment, from coastal erosion and sea level change to past oceanic, biotic, and climatic changes, from the origins of life to monitoring the earthquakes of active volcanoes, and from the composition of meteorites and Mars to the distribution of petroleum and water resources. The geosciences offer a richness in variety and unrivaled opportunity for multidisciplinary research on problems of great intellectual and practical importance.

Geology and geophysics have much to offer students curious about humankind's place in nature. Undergraduate majors can look forward to expanding opportunities in the private and public sectors (e.g., the environment, hydrogeology). Such jobs offer incredible variety, the opportunity to work outdoors, and many opportunities for travel. Prospective undergraduates are strongly encouraged to build communication skills and a solid background of understanding in chemistry, physics, and mathematics as these disciplines are essential for solving the basic question about how Earth and other planets work. Students with graduate degrees (both MS and PhD) can look forward to interesting research careers in industry, government, or in colleges and universities. The intellectual rewards of basic geosciences research are comparable to such other exciting fields as biomedical research, particle physics, and cosmology. Geosciences have many exciting frontiers and challenges for the future including learning to predict earthquakes and volcanic eruptions, discovering the history of Mars, understanding the forces that move the surface plates of Earth, and unraveling the history of Earth's surficial processes both on land and in its oceans.

At the University of Hawai'i at Mānoa, the department offers outstanding programs of study at the graduate and undergraduate levels. The faculty is large (about 24 teaching and research faculty and about 38 additional graduate faculty) and diverse, so there are strong programs in all major subdisciplines. The geographic location in the midst of the Pacific Ocean and the rich geologic setting provide a natural focus for research programs in seismology, volcanology, marine geology and geophysics, planetary science, sedimentology, hydrogeology, geochemistry, paleoceanography, meteorites, and many other fields. The quality of the school's research vessels, submersibles, and analytical and computing facilities reflects its commitment to the excellence in field studies, and well as in theoretical and modeling studies. The quality of the faculty, research facilities, and opportunities is difficult to match.

Advising

Students contemplating a major or minor in geology and geophysics should visit an undergraduate adviser at the earliest opportunity. Inquire at the department's student services office, POST 701C.

Undergraduate Study

BA in Geology

Requirements

The BA degree in geology is appropriate for students interested in the study of the Earth but who do not necessarily intend to pursue graduate work or employment in traditional geology fields. It is more flexible than the BS program and is suitable for students who are considering, for example, a double major, teaching, or not considering employment as a professional geologist.

The BA degree requires completion of 124 credit hours of coursework, the equivalent of four years of full-time work. The BA program requires 34 credits in the geology and geophysics curriculum. This includes one introductory level GG course with a lab, seven non-introductory GG courses, and a one-credit research seminar (GG 410). A minimum of 6 credits of approved upper division science electives is also required; these courses can be in geology and geophysics or in other natural sciences, mathematics, or engineering. Students are encouraged to consider taking a mainland summer field course as an elective. Required support mathematics and science classes include physics, chemistry, biological sciences, and one semester

of college calculus; these total 20-21 credits and should be taken as early as possible.

Geology and Geophysics Courses

- Required Courses (28 credits)
  - GG 101 Dynamic Earth or GG 103 Geology of the Hawaiian Islands (3)
  - GG 101L Dynamic Earth Laboratory (1)
  - GG 200 Geological Inquiry (4)
  - GG 301 Mineralogy (3)
  - GG 302 Igneous and Metamorphic Petrology (3)
  - GG 303 Structural Geology (3)
  - GG 305 Geological Field Methods (3)
  - GG 308 Earth History (3)
  - GG 309 Sedimentology and Stratigraphy (4)
  - GG 410 Research Seminar (1)

- Upper Division Science Electives (6 credits)
  - GG 300 Volcanology (3)
  - GG 312 Geomathematics (3)
  - GG 313 Geological Data Analysis I (3)
  - GG 325 Fundamentals of Geochemistry (3)
  - GG 399 Directed Reading (V)
  - GG 401 Introduction to Mineral Physics (3)
  - GG 402 Hawaiian Geology (3)
  - GG 407 Energy and Mineral Resources (3)
  - GG 420 Quaternary Geology (3)
  - GG 423 Marine Geology (3)
  - GG 425 Environmental Geochemistry (3)
  - GG 426 Sedimentary Isotope Geochemistry (3)
  - GG 430 Geology and Mineral Resources of Asia (3)
  - GG 444 Plate Tectonics (3)
  - GG 450 Geophysical Methods (4)
  - GG 451 Earthquakes (3)
  - GG 454 Engineering Geology (3)
  - GG 455 Hydrogeology (4)
  - GG 460 Geological Remote Sensing (3)
  - GG 466 Planetary Geology (3)
  - GG 491 Teaching Geology (4)
  - GG 499 Undergraduate Thesis (3)

- Support Courses (20-21 credits)
  - General Chemistry (CHEM 161, 161L, 162, 162L)
  - Calculus I (MATH 241)
  - College Physics (PHYS 151, 151L, 152, 152L)
  - Biological Science (a 3-credit course listed under the University's General Education and Core requirements)

BS in Geology and Geophysics

Requirements

The BS degree in geology and geophysics is strongly recommended for students who intend to pursue graduate work or employment in geology or geophysics. The BS degree provides substantial grounding in computational and analytical skills needed for a practicing geologist. It places added emphasis on applications of chemistry, physics, and mathematics to studying the Earth.

The BS degree requires completion of 124 credit hours of coursework, the equivalent of four years of full-time work. The BS program requires 47 credits in the geology and geophysics curriculum. This includes one introductory level GG course with a lab, ten non-introductory GG courses, a one-credit research seminar (GG 410), and nine credits of electives in GG. With advice and consent of an undergraduate adviser, courses in other natural sciences, mathematics, or engineering may be substituted as electives. Students are encouraged to consider taking a mainland summer field course as an elective. Required support mathematics and science classes include physics, chemistry, biological sciences, and two semesters of college calculus; these total between 24 and 25 credits and should be taken as early as possible.

Geology and Geophysics Courses

- Required Courses (38 credits)
  - GG 101 Dynamic Earth or GG 103 Geology of the Hawaiian Islands (3)
  - GG 101L Dynamic Earth Laboratory (1)
  - GG 200 Geological Inquiry (4)
  - GG 301 Mineralogy (3)
  - GG 302 Igneous and Metamorphic Petrology (3)
  - GG 303 Structural Geology (3)
  - GG 304 Physics of Earth and Planets (4)
  - GG 305 Geological Field Methods (3)
  - GG 308 Earth History (3)
  - GG 309 Sedimentology and Stratigraphy (4)
  - GG 313 Geological Data Analysis I (3)
  - GG 325 Fundamentals of Geochemistry (3)
  - GG 410 Research Seminar (1)

- Upper Division GG Electives (9 credits)

  See the Upper Division Science Electives listing under the BA program.

- Support Courses (24-25 credits)
  - General Chemistry (CHEM 161, 161L, 162, 162L)
  - Calculus I and II (MATH 241 and 242, 242L)
  - General Physics (PHYS 170, 170L, 272, 272L) or College Physics (PHYS 151, 151L, 152, 152L)
  - Biological Science (a 3-credit course listed under the University's General Education and Core require ments)

Minor

Requirements

The minor requires GG 101 (or 103), 101L, 200, and 11 credits of non-introductory courses at the 300-level or higher. A "C" average is required in these courses. The minor is flexible and can provide either an introductory survey of geology or emphasize areas of particular interest to the student. A student interested in a minor in geology and geophysics should consult with an adviser from the department to tailor a plan best suited to the student's interest.

Graduate Study

Admission Requirements

All applicants must take the GRE General Test. All students are urged to have completed a course in C++ or similar computer programming language before entrance. U.S. applications are due by January 15 for admission in the fall semester or by September 1 for the spring semester. International applications are due January 1 and August 15, respectively.

Undergraduate deficiencies will be listed on the basis of the student's transcripts and intended field of study. Courses may be added to the list or removed from it as a result of questioning during the preliminary conference and the general examination. Course GG 611 is intended for students entering from a non-geoscience field to prepare them for graduate studies in geosciences.

Master's Degree

Intended candidates will be accepted from undergraduate majors in the natural sciences, mathematics, and engineering, and they normally would be expected to have completed at least one year each of college mathematics, geology, physics, and chemistry. Adequacy of each applicant's additional preparation will depend on the particular branch of geology and geophysics being pursued. At the time of application the student should state the field in which he or she intends to study

Requirements

For MS students, the graduate studies committee of the department will determine suitability of Plan A (thesis) or Plan B (non-thesis) at the preliminary conference. Virtually all students are required to follow Plan A. Plan A requires a minimum of 30 credits, including 6 credits of GG 700 Thesis Research and at least 24 credits of course work (up to 6 course work credits may be in GG 699). Plan B requires a minimum of 30 credit hours of course work and a final exam.

Doctoral Degree

Students wishing to bypass the MS degree and advance directly into PhD candidacy must pass a qualifying examination during the second semester in residence.

Requirements

PhD candidates are accepted with either a BS or MS degree. Students without an MS must pass a qualifying examination given at the beginning of their second semester in residence. All PhD candidates must pass a comprehensive examination no later than at the end of the fourth semester of residence for students without an MS degree or at the end of the second semester of residence for students with an MS degree. The comprehensive exam includes oral and written parts that cover in-depth subjects in the student's field of interest and also the breadth of several areas in this and other departments that bear on the field. A final examination in defense of the dissertation is required. Space and aid for the program are limited, so each student's progress will be reviewed annually.

Areas of Interest

The four areas of interest listed below are active fields of research in the department. For each, a brief description and the required undergraduate preparation is listed. Students with backgrounds other than these may be accepted in a field if their records and recommendations are good, but advancement to candidacy may be delayed. A complete statement of the courses and other work in each field necessary for the MS or to prepare for the PhD comprehensive examination will be given to the entering student.

The department can provide further information on research opportunities and financial aid in each of the areas of interest.

Geophysics and Tectonics. This program takes advantage of the University of Hawai'i's mid-Pacific setting to investigate a wide variety of geodynamic, tectonic, and geophysical phenomena that operate over a broad range of scales. Studies in geophysics and tectonics at the University of Hawai'i are interdisciplinary and include experimental and theoretical developments, field-based observations, and computer simulations. Together, they provide students with a background that combines both geology and geophysics for technical and professional work at industrial, governmental, and academic institutions. Current research areas include:

Plate Kinematics and Evolution. Studies of rift propagation and plate break-up; initiation and evolution of continental margins and back-arc basins; relative and absolute motion of plates; thermo-mechanical properties of oceanic lithosphere; mantle flow and the driving forces of plate tectonics.

Seismology. Theory and analysis of seismic waves from active and passive sources; ocean-bottom geophysical instrumentation (HUGO); multichannel seismic imaging of subduction zones, accretionary prisms, and submarine volcano flanks.

Geophysical Fluid Dynamics. Mantle flow and plume-plate interaction; plate generation and rheology from mantle flow; ocean/shore dynamics and nonlinear waves.

Rock Fracture Mechanics. Coupled field, theoretical, and laboratory analyses of the mechanics of fault growth, rock fracture, dike propagation, landslides, and crustal deformation; these topics are relevant to plate tectonics, structural geology, and engineering geology.

Entrance may be through majors in geophysics, geology, mathematics, physics, or engineering. Students need a background in geology (which can be obtained in graduate school) together with supporting mathematics and physics.

Marine and Environmental Geology. The Marine and Environmental Geology program (MEG) is focused on the dynamic physical, biological and chemical interactions that characterize earth surface environments. The program provides instructional and research opportunities in a wide range of topics related to tropical insular environments. Because of our unique geographic location and diverse ethnic population, Hawai'i is an excellent natural laboratory to study the interaction of humans with natural environmental systems. Special areas of emphasis include carbonate geology, coastal geology,

geomechanics, groundwater hydrology, paleoclimatology, marine biogeochemistry, and sedimentology/stratigraphy. Although much of our research is done within the Hawaiian Islands, we also study other Pacific islands, Asia, and modern environments around the world. The MEG program consists of three main areas of research:

Coastal Geology. Hawai'i's beaches and reefs are world-renowned for their beauty. Understanding the processes which shape them will help us to preserve their splendor; this is an important motivation for research in this field. Volcanic islands provide platforms for reef community development and a unique chronicle of past sea level changes. Studies in this program have a particular emphasis on nearshore processes, coastal sedimentation and erosion, remote sensing of reefs, geologic history of Hawaiian reefs, Pacific basin sea level history, and submarine landslides. Research also focuses on carbonate petrology and petrography to derive clues to past environmental changes as well as post-depositional geochemical changes to island limestones.

Deep-Sea Sedimentary Environments. Hawai'i's central location within the Pacific allows easy access to a wealth of deep-sea environments, where sediments record the history of changes in ocean chemistry and productivity and their relationships to tectonic movements and climate change. Deep-sea studies are focused on micropaleontology, paleoceanography, organic isotope biogeochemistry, marine authigenesis, carbonate sedimentology and the physical properties of sediments and crustal rocks.

Hydrogeology of Tropical Volcanic Islands. Almost all types of hydrologic environments are found in the Hawaiian Islands, ranging from near-desert conditions with annual rainfalls of less than 25 cm to Mt. Waialeale on Kaua'i, which is one of the wettest gauged spots on Earth with annual rainfall of over 10 m, and from sea level tropical rain forests to snow and permafrost conditions at the top of Mauna Kea at 4.2 km above sea level. Human activities related to tourism and agriculture introduce additional complexities into this delicately balanced environmental system. This unique setting presents important opportunities to study groundwater transport and contaminant fate processes, groundwater modeling, and the hydrogeology of Pacific islands and atolls.

Many research efforts in this program involve participation in several marine expeditions each year. Graduate students in our program are encouraged to participate in these voyages as a part of their career training. The program is multidisciplinary with cooperating faculty and courses from several other departments including civil engineering, soil sciences, oceanography and geography. The diverse research and teaching interests of the faculty make it possible to tailor graduate degree work to fit the needs and desires of the student.

Typically an undergraduate major in geology or one of the other natural sciences along with basic courses in physics, chemistry, and mathematics would be sufficient for entrance. The student should be prepared to commence or continue course work in (1) structural or tectonic geology (2) exploration geophysics, and (3) any one or more of sedimentology, paleontology, geochemistry, and petrology, as applied to marine research. The student should be prepared for additional work in whatever combination of geology, geophysics, civil engineering, and geochemistry is appropriate for his or her optimum development.

Volcanology, Geochemistry, and Petrology. The University of Hawai'i is uniquely situated to study all major aspects of volcanic systems. Active Hawaiian volcanoes are natural laboratories of intraplate volcanism and hydrothermalism; eroded fossil volcanic systems on the older islands provide windows into deeper volcanic structures; and Hawai'i is at the center of the Pacific "Ring of Fire." Also, we study submarine volcanoes with our research vessel, and we remotely monitor volcanoes on Earth and other planets from ground-based and space-borne observatories. The Hawai'i Center for Volcanology is housed at SOEST; it includes scientists from the USGS Hawaiian Volcano Observatory and the Center for the Study of Active Volcanoes at UH Hilo, facilitating collaborative projects to monitor active volcanoes. Additionally, the Volcanology, Geochemistry, and Petrology (VGP) program has a wide range of modern, well-equipped analytical laboratories that provide data on the chemical composition and physical properties of igneous materials. Current research areas include:

Ocean Spreading Center Processes. Petrologic, geochemical and isotopic variations along and across mid-ocean ridges and back-arc basin spreading centers; geometry and dynamics of mantle flow, melt generation and magma chambers beneath spreading centers; near axis seamount genesis; hot spot-spreading center interactions; magmatic systems at propagating rifts; geochronology of submarine volcanism, elemental fluxes from erupting mid-ocean ridge volcanoes.

Physical Volcanology. The rise, degassing and fragmentation of magma in conduits; transport and deposition from volcanic plumes and pyroclastic density currents; flood basalts and the eruption and emplacement of lavas; caldera volcanoes and ignimbrites; volatile degassing and retention in magma chambers; environmental impact and social consequences of eruptions; origin of dike complexes and rift zones; and volcanic processes on extraterrestrial bodies.

Intraplate Volcanism and Volcano Monitoring. Petrologic, geochemical, isotopic, and geologic evolution of Hawaiian and other oceanic islands and seamounts; petrologic, seismic, and geodetic monitoring of magmatic systems at active Hawaiian volcanoes, including a fiber optic-linked observatory on Loihi Seamount; satellite monitoring of volcanic hazards and eruption clouds; remote-sensing observation of extraterrestrial volcanoes. Relationship of hot spots to flood basalt and oceanic plateau formation; geochemistry of active hydrothermal systems.

In addition to basic courses in chemistry, physics, and mathematics, the well-prepared student would have had training in mineralogy, optical mineralogy, petrology, structural geology, and, in some cases, geological field methods and remote sensing techniques.

Planetary Geoscience and Remote Sensing. The principal objective of this program is to study the geology and composition of objects (planets, asteroids, moons, and meteorites) in the solar system in order to understand their origin and evolution. It involves research in planetary and terrestrial geology, cosmochemistry, planetary astronomy, and scientific instrumentation. Current research areas include:

Meteoritics and Cosmochemistry. Research on extraterrestrial materials (from asteroids, the Moon, and Mars) focuses on the vast array of processes that formed and modified planets and asteroids. Central themes of our research are: (1) processes in the solar nebula (2) alteration processes in asteroids (3) the effects of shock on mineralogy, textures, and isotopic systems (4) igneous processes, and (5) planetary crustal compositions and evolution.

Inner Planets and the Moon. Several HIGP faculty are involved in a number of remote sensing and petrology projects that have as their focus deriving a better understanding the composition of the crust and mantle of the Moon, which is crucial to understanding lunar origin and differentiation. Mars has numerous large volcanoes that have a similar morphology to Kilauea and Mauna Loa volcanoes in Hawai'i. New high resolution images and topographic data from the Mars Global Surveyor mission allow us to quantify the eruption processes on Mars, based on the knowledge of volcanism in Hawai'i.

Outer Planet Satellites. One group of planetary scientists is doing extensive research on the compositions of the outer planets' satellites. They are studying the surface compositions of the icy moons of Jupiter using data from the Galileo spacecraft and laboratory experiments. The research has implications for the nature of primitive bodies in the solar system and the possibility for life in icy satellites. This group is also heavily involved with the Cassini mission to Saturn and its moons.

Terrestrial Remote Sensing. Several faculty within HIGP are involved with the analysis of volcanic thermal anomalies, using spacecraft (Landsat 7, Terra, GOES), aircraft, and ground observations. These data allow studies of the flux of lava through volcanic systems and evaluation of eruption precursors. Similar work on thermal anomalies focuses on the study of forest fires. Data from the GOES geostationary satellite are made available on the HIGP web site (hotspot1.pgd.hawaii.edu/goes/). Remote sensing studies of volcanoes also include the use of radar interferometry to measure the deformation of volcanoes, crucial for understanding magma emplacement and volcanic tectonics.

Instrument Development. The Hawai'i Institute of Geophysics and Planetology has a many years of experience in developing instruments for use in studying global problems in earth and planetary science. One group is developing hyperspectral thermal infrared imagers for use in lithologic mapping. A new instrument is also in the planning stage, potentially for flight on the International Space Station. Another group is developing a synthetic aperture sonar system. A third group built the HIGP Acoustic Wide Angle Imaging Instrument, Mapping Researcher 1 (HAWAII MR1).

Typically, an undergraduate major in geology, astronomy, physics, or engineering along with basic courses in chemistry, physics, and mathematics would be sufficient for entrance. The student should be prepared to commence or continue course work in whatever combination of geology, geophysics, geochemistry, planetary science, spectroscopy, or remote sensing is appropriate to optimum development in the field.

Global Environmental Science

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Web: www.soest.hawaii.edu/oceanography/GES/

Faculty

F. T. Mackenzie, PhD (Program Coordinator)—geochemistry, biogeochemical cycling, global environmental change

J. M. Becker, PhD—geophysical fluid dynamics, nonlinear waves and stability, coastal processes, general ocean circulation

R. R. Bidigare, PhD—bio-optical oceanography, pigment biochemistry, plankton metabolism

S. Businger, PhD—mesoscale and syntopic meteorology

A. D. Clarke, PhD—physical and chemical properties of aerosol in remote troposphere, aircraft studies of aerosol in free troposphere

J. P. Cowen, PhD—microbial geochemistry, particle aggregation dynamics, hydrothermal systems

E. H. DeCarlo, PhD—aquatic chemistry; metals and their anthropogenic inputs, transformations, fate and transport

S. Dollar, PhD—biogeochemistry, nearshore processes and effects of human activity on the coastal zone

A. El-Kadi, PhD—hydrogeology, modeling groundwater systems

R. C. Ertekin, PhD—hydrodynamics, computational methods, offshore and coastal engineering, oil-spill spreading, fishpond circulation

P. J. Flament, PhD—surface ocean layer dynamics, mesoscale circulation structures of the ocean, remote sensing of the sea surface

C. H. Fletcher, PhD—quaternary and coastal marine geology, sea-level history, coastal sedimentary processes

P. Fryer, PhD—marine geology, petrology, tectonics

M. O. Garcia, PhD—volcanology, igneous petrology, geochemistry

T. W. Giambelluca, PhD—interactions between the atmosphere and the land surface, including influences of land use and land cover change on climate and surface hydrology and effects of global climate change on hydrologic processes and terrestrial ecology

C. R. Glenn, PhD—paleoceanography, marine geology, sedimentology, sediment diagenesis

E. G. Grau, PhD—environmental physiology and comparative endocrinology of fish

R. W. Grigg, PhD—ecology and paleoecology of coral reefs, precious corals

B. J. Huebert, PhD—air pollution, climate change, atmospheric aerosols, global elemental cycles
M. C. Jarman, LLM—environmental law, administrative law, ocean and coastal law, legal writing; the public trust doctrine, land use, the intersection of indigenous peoples' rights and environmental law, and community empowerment through the law
D. E. Konon, PhD—international trade, microeconomics, computational economics
M. R. Landry, PhD—zooplankton, population dynamics, marine ecosystem modeling
E. A. Laws, PhD—phytoplankton ecology, aquatic pollution, aquaculture
Y. H. Li, PhD—marine geochemistry, environmental pollution
K. Lowry, PhD—design, planning and evaluation of ocean and coastal management programs. Experience in Hawai'i, Indonesia, Sri Lanka, Philippines and Thailand
R. Lukas, PhD—physical oceanography, interannual and decadal climate variability
D. Luther, PhD—observational physical oceanography, circulation variability and dynamics, mesoscale fluctuations, waves in the ocean
J. J. Mahoney, PhD—isotope geochemistry of oceanic and continental crust and mantle
A. Malahoff, PhD—submarine volcanic processes and the geophysical monitoring of submarine volcanoes, processes of formation of ocean floor minerals
S. J. Martel, PhD—engineering and structural geology
G. M. McMurtry, PhD—geochemistry, geology and geophysics
C. Measures, PhD—trace element geochemistry, hydrothermal systems, elemental mass balances
P. Menon, PhD—environmental and occupational health standards
M. A. Merrifield, PhD—physical oceanography; coastal circulation; sea level variability; current flows and mixing in the vicinity of coral reefs, islands and seamounts
J. N. Miller, MS—marine and land environmental management, environmental assessment
G. F. Moore, PhD—marine geophysics, structural geology
M. J. Mottl, PhD—hydrothermal processes, geochemical cycles
P. Mouginis-Mark, PhD—volcanology from space, remote sensing of natural hazards
P. K. Muller, PhD—ocean circulation, waves and turbulence
B. N. Popp, PhD—isotope biogeochemistry, organic geochemistry
J. N. Porter, PhD—atmospheric science, use of satellites to study aerosol and cloud forcing, ship measurements of aerosol and cloud optical properties
R. L. Radtke, PhD—fisheries oceanography, migrations and history
M. A. Ridgley, PhD—resource management and human-environment system analysis
J. Roumasset, PhD—environmental economics and sustainable growth
K. Rubin, PhD—isotope geochemistry, chronology
F. J. Sansone, PhD—suboxic/anoxic diagenesis in sediments, hydrothermal geochemistry, lava-seawater interactions, trace gas geochemistry
T. Schroeder, PhD—mesometeorology, tropical meteorology
S. K. Sharma, PhD—atmospheric instrumentation and remote sensing; Lidar, Raman, and infrared spectrometry and fiber-optic environmental sensors
C. R. Smith, PhD—seafloor ecology, deep-ocean food webs, sediment geochemistry
S. V. Smith, PhD—global biogeochemistry; carbon, nitrogen, and phosphorus cycling, particularly in the coastal zone; behavior of the global carbon cycle
K. J. Spencer, PhD—isotope geochemistry, petrology, environmental geochemistry
M. E. Tiles, PhD—logic, history, and philosophy of mathematics, science, and technology
J. S. Tribble, PhD—sedimentary geochemistry and diagenesis
H. K. Van Tilburg, MA—nautical archaeology, maritime history, submerged cultural resource management
B. Wang, PhD—atmospheric and climate dynamics
D. W. Woodcock, PhD—vegetation and climate, paleoenvironmental reconstruction, use of fossil wood as a paleoenvironmental indicator, and the terrestrial carbon cycle

Degree Offered: BS in global environmental science

The Academic Program

Global environmental science is a holistic, scientific approach to the study of the Earth system and its physical, chemical, biological, and human processes. It is a bold new academic program designed to educate leaders and citizenry to become wise stewards of our planet. Global environmental science focuses on the global reservoirs of hydrosphere (water, primarily oceans), biosphere (life and organic matter), atmosphere (air), lithosphere (land, sediments, and rocks), and cryosphere (ice); their interfaces; and the processes acting upon and within this interactive system, including human activities. In the course of their scientific studies, global environmental science students are able to investigate natural as well as economic, policy, and social systems and their response and interaction with the Earth system. Global environmental science has important ties to the more classical sciences of geology and geophysics, meteorology and climatology, oceanography, and ecology as well as to the social sciences. Thus, the scope of global environmental science is extremely broad. This breadth is reflected in the interdisciplinary nature of the faculty, which is primarily drawn from numerous departments and research institutions within the School of Ocean and Earth Science and Technology.

Global environmental science has much to offer the student who is interested in the environment and the effect of humans on the environment. The skills developed in global environmental science can be brought to bear on local, regional, and global environmental issues. Many of the critical environmental problems confronting humankind involve large-scale processes and interactions among the atmosphere, oceans, biosphere, cryosphere, shallow lithosphere, and people. Some of the problems derive from natural causes; others are a result of human activities. Some of the issues that global environmental science students deal with are: climatic changes from anthropogenic inputs to the atmosphere of CO_2 and other greenhouse

gases; human interventions and disruptions in the biogeochemical cycles of carbon, nitrogen, phosphorus, sulfur, trace metals, and other substances; emissions of nitrogen and sulfur oxide gases and volatile organic compounds to the atmosphere and the issues of acid deposition and photochemical smog; depletion of the stratospheric ozone layer and associated increase in the flux of ultraviolet radiation to Earth's surface; increasing rates of tropical deforestation and other large-scale destruction of habitat, with potential effects on climate and the hydrologic cycle; disappearance of biotic diversity through explosive rates of species extinction; global consequences of the distribution and application of potentially toxic chemicals in the environment and biotechnology; interannual and interdecadal climate variability, e.g., El Ni˜ no/ Southern Oscillation; eutrophication; water and air quality; exploitation of natural resources with consequent problems of waste disposal; earthquakes, tsunamis, and other natural hazards and prediction; and waste disposal: municipal, toxic chemical, and radioactive. In all cases, the student is encouraged to understand and appreciate the social, economic, and ultimately the policy decisions associated with these and other environmental issues.

Specifically with respect to learning objectives, the students develop competency in understanding how the physical, biological, and chemical worlds are interconnected in the Earth system. They obtain skills in basic mathematics, chemistry, physics, and biology that enable them to deal with courses in the derivative geological, oceanographic, and atmospheric sciences at a level higher than that of qualitative description. In turn, these skills enable the students to learn the subject matter of global environmental science within a rigorous context. The students develop an awareness of the complexity of the Earth system and how it has changed during geologic time and how human activities have modified the system and led to a number of local, regional, and global environmental issues. They become competent in using computers and dealing with environmental databases and with more standard sources of information in the field. They are exposed to experimental, observational, and theoretical methodologies of research and complete a senior research paper in environmental studies using one or more of these methodologies. Field work is encouraged for the senior thesis and, depending on the topic chosen by the student, can be carried out at the Hawai'i Institute of Marine Biology's Coconut Island facility, E. W. Pauley Laboratory, and associated He'eia ahupua'a or elsewhere.

The ultimate objective of the global environmental science program is to produce a student informed in the environmental sciences at a rigorous level who is able to go on to graduate or professional school; enter the work force in environmental science positions in industry, business, or government; enter or return to teaching with knowledge of how the Earth system works; or enter the work force in another field as an educated person with the knowledge required to become a wise environmental steward of the planet.

Advising

Students contemplating a major in global environmental science should visit the program coordinator at the earliest opportunity. Inquire at the global environmental science office, Marine Science 205C; tel. (808) 956-7932, fax (808) 956-9225; e-mail: ges@soest.hawaii.edu

BS in Global Environmental Science Requirements

Aside from core University requirements, the global environmental science program has core requirements of two basic types: basic sciences and derivative sciences. The former provides the foundation to understand and appreciate the latter in the context of basic skills in mathematics, biology, chemistry, and physics. Both global environmental science core requirements provide the necessary cognitive skills to deal with the higher academic level courses within the global environmental science curriculum. These include required foundation courses in global environmental science and coupled systems courses. It is within this latter category of course work that the formal course program will be tailored to the individual student's needs. For example, we anticipate that most students will follow closely a natural science track of study, perhaps concentrating on the terrestrial, marine, or atmospheric environment. However, because of the human dimensions issues involved in the subject matter of environmental change, some students may wish to expand their academic program into the social sciences that bear on the issues of global change.

Core University Requirements (69 credit hours total; 56 credit hours exclusive of science and mathematics)

Maximum of 69 credit hours of core requirement course work minus 13 credit hours of mathematics and natural sciences equals 56 credit hours of work, up to 15 credit hours of which can also be in science provided that these hours (or others elsewhere in the curriculum) meet the writing intensive requirement. This leaves 68 to 83 hours of science and mathematics for a 4-year program.

Core Basic Sciences Requirement (39 hours)

- BIOL 171/171L, 172/172L
- CHEM 161/161L, 162/162L
- MATH 241, 242/242L, 243 (or GG 312), 244 (or ECON 321)
- PHYS 170/170L, 272/272L

Core Derivative Sciences Requirement (10 hours)

- GG 101/101L
- MET 200
- OCN 201

The global environmental science core requirement represents 49 hours of work. This requirement plus the University General Education Core requirement of 41 to 56 hours leaves 19 to 34 credit hours for other courses for a 4-year program. This is equivalent to six to eleven 3-credit courses

*Graduate Faculty

that can be taken from the foundation and coupled systems courses and from senior research.

Foundation Course Requirements (17 hours)

- GEOG 411 Human Dimensions of Global Environmental Change
- OCN 310/310L Global Environmental Change
- OCN 363 Earth System Sciences Databases
- OCN 401 Biogeochemical Systems
- PHIL 315 (OCN 315) Modeling Natural Systems

Coupled Systems Courses (Examples)

- AREC 432 Natural Resource Economics
- ASTR 240 Foundations of Astronomy
- BIOC 241 Fundamentals of Biochemistry
- BIOL 265 Ecology and Evolutionary Biology
- BIOL 360 Island Ecosystems
- BIOL 410 Human Role in Environmental Change
- ECON 321 Introduction to Statistics
- ECON 358 Environmental Economics
- ECON 638 Environmental Resource Economics
- GEOG 300 Climatology
- GEOG 402 Agricultural Climatology
- GEOG 405 Water in the Environment
- GG 301 Mineralogy
- GG 309 Sedimentology and Stratigraphy
- GG 324 Low temperature and Environmental Geochemistry
- GG 455 Hydrogeology
- GG 466 Planetary Geology
- MET 302 Atmospheric Physics
- MET 303 Introduction to Atmospheric Dynamics
- OCN 320 Aquatic Pollution
- OCN 330 Mineral and Energy Resources of the Sea
- OCN 331 Living Resources of the Sea
- OCN 620 Physical Oceanography
- OCN 621 Biological Oceanography
- OCN 622 Geological Oceanography
- OCN 623 Chemical Oceanography
- PHIL 316 Science, Technology, and Society
- PLAN 310 Introduction to Planning
- SOC 412 Analysis in Population and Society
- SOIL 304 Fundamentals of Soil Science
- SOIL 430 Soil Chemistry
- SOIL 461 Soil Erosion and Conservation

The student may also wish to take additional courses in fundamental physics, chemistry, biology, or mathematics. Global environmental science currently has three optional tracks (or combination of electives):

1. Marine science and environment: In this track, the student concentrates his/her studies in marine/ocean science and the application of their work to environmental problems related to the ocean. The student is encouraged to take as many oceanography courses as practical and to have a senior thesis problem that is related to ocean studies. It is within this track that a student's program can be designed so that the student is able to apply to graduate school in oceanography.
2. Policy/economics and environment: this track enables the student, after satisfying the GES science core, to concentrate further course work and the senior thesis in environmental economics, policy, and law. This is probably the best route for a student to take who is going directly into the work place or is simply interested in becoming a wise environmental steward of the planet.
3. Climate and environment: this track enables the student to concentrate academic studies and the senior thesis topic on the interactions between climate and the environment, on human impacts on climate, and the causes of climatic change. The student is encouraged to take coupled systems courses in meteorology and climatology.

Majors should consult with their adviser as early as possible to devise a curriculum suited to their particular goals.

Senior Research Paper (3-6 hours)

- OCN 499 Undergraduate Thesis

Each student is required to complete a senior thesis based on research conducted with one or more chosen advisers.

Meteorology

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Web: lumahai.soest.hawaii.edu

Faculty

*T. A. Schroeder, PhD(Chair)—mesometeorology - severe local storms, flash flood meteorology, interactions of island with synoptic environments

*G. M. Barnes, PhD—mesometeorology, hurricanes, and boundary layer meteorology

*S. Businger, PhD—mesoscale and synoptic meteorology, satellite meteorology, storm structure and dynamics

*Y. L. Chen, PhD—mesoscale meteorology, heavy rainfall

*P. S. Chu, PhD—climate variability and natural hazards, tropical cyclones, climate prediction

*P. A. Daniels, PhD—physical meteorology, atmospheric pollution, wind-energy meteorology, instrumentation

*K. P. Hamilton, PhD—dynamical meteorology and climate dynamics

*F. F. Jin, PhD—atmospheric dynamics, numerical weather prediction

*T. Li, PhD—climate dynamics and coupled atmosphere-ocean modeling

*D. E. Stevens, PhD—atmospheric dynamics

*B. Wang, PhD—climate dynamics, geophysical fluid dynamics, and tropical meteorology

*Graduate Faculty

*S. P. Xie, PhD—large scale ocean-atmosphere interaction, climate dynamics
*J. Zhao, PhD—atmospheric chemistry and aerosols

Cooperating Graduate Faculty

A. D. Clarke, PhD—marine aerosols, biogeochemical cycles, optical properties
B. J. Huebert, PhD—atmospheric chemistry
J. Porter, PhD—satellite and ground-based optical sensing of atmospheric aerosols

Affiliate Graduate Faculty

P. G. Black, PhD—aircraft analysis of hurricanes
Y. H. (Bill) Kuo, PhD—mesometeorology
W. C. Lee, PhD—radar and mesoscale meteorology
F. D. Marks, ScD—tropical cyclones
J. O. Roads, PhD—mesoscale model applications

Degrees Offered: BS in meteorology, MS in meteorology, PhD in meteorology

The Academic Program

Meteorology (MET) is the study of phenomena in the Earth's atmosphere. These phenomena include the daily weather and climate. Students pursuing the BS in meteorology receive preparation for professional employment in meteorology and are qualified for employment in the federal meteorological agencies. The meteorology major must be well-grounded in the fundamentals of mathematics and physics. Thus BS graduates are qualified to pursue graduate studies both in meteorology and other applied sciences, such as oceanography or computer sciences. Graduate degrees prepare students to pursue research careers both with government and in academia.

The meteorology program at the University of Hawai'i at Mānoa is unique in its focus on tropical meteorology. The tropics comprise 50 percent of Earth's surface and exert critical controls on the global atmosphere. BS students receive comprehensive training in tropical weather analysis and forecasting. Graduate students often pursue thesis research in tropical meteorology, some study topics that take advantage of Hawai'i's unique natural laboratory. Some students pursue graduate thesis research with funding from the National Weather Service, whose Honolulu Weather Forecast Office is housed in the same building as the meteorology department. Meteorology faculty cooperate actively with physical oceanography faculty through the Joint Institute for Marine and Atmospheric Research in the study of air-sea interaction and climate variability. Students also have access to both research databases and cooperative employment opportunities at the Joint Typhoon Warning Center, Pearl Harbor.

Affiliations

The University of Hawai'i is an active member of the University Corporation for Atmospheric Research.

Advising

The department has one undergraduate adviser, who may be contacted through the department office (808) 956-8775. Graduate students are assigned individual faculty advisers by the graduate chair after their preliminary conference.

Undergraduate Study

Bachelor's Degree

Requirements

Students must complete 124 credit hours, including:

- General Education Core (see the "Mānoa General Education and Graduation Requirements" section of this Catalog).
- MET 101L and 200
- 21 credit hours in meteorology courses numbered 300 and above, including MET 302, 303, 305, and 402; and MET 412 or 416 (Students planning careers with federal meteorological agencies should take both 412 and 416.)
- 15 additional credit hours from physical and mathematical sciences (e.g., engineering, geography, geology and geophysics, information and computer sciences, mathematics, oceanography, physics, and soil science) including (but not limited to) MET 405, 406, and 600; MET 412 or 416; AGRN 661; CE 424 and 626; GEOG 300, 302, 402, and 412; GG 412 and 455; ICS 211, 311, and 442; MATH 311, 371, 373, 402, 403, and 405; OCN 620; OEST 310; PHYS 274/274L and 400; and HIST 394 or 395
- CHEM 171/171L
- ICS 111/111L
- MATH 243 and 244 (Students planning careers with federal meteorological agencies should take MATH 405.)
- PHYS 170/170L and 272/272L

Minor

Requirements

Students must complete 15 credit hours of non-introductory courses, including:

- MET 200, 302, and 303
- 6 credits of electives from MET 305, 405, 406, 412, 416, and OEST 310

Graduate Study

The department offers MS and PhD degrees. Through courses in dynamic, synoptic, and physical meteorology, students develop a strong foundation in tropical meteorology, the department's special field, and are prepared to do research in the atmospheric sciences.

Candidates should have a thorough preparation in physics (with calculus), chemistry, and mathematics through differential equations. Undergraduate courses in dynamic and synoptic meteorology are expected, but they can be taken in the first year.

All students in the program must complete two seminar

*Graduate Faculty

courses of MET 765 (Alpha) involving active participation as speaker and listener.

Master's Degree

Requirements

At the master's level, only Plan A (thesis) is available, requiring a minimum of 24 credit hours of course work and 6 credit hours of thesis. A minimum of 18 credit hours, exclusive of research methods must be earned for the MS degree. All students must complete MET 600, 610, 620, and a synoptic analysis course (MET 412 or MET 416) with a minimum GPA of 3.0 for those courses. A thesis examination is required.

Doctoral Degree

The PhD student exhibits a higher level of independence and originality of thought than that required of the MS student.

Requirements

In order to acquire and demonstrate a breadth of knowledge in atmospheric science, each student is required to pass at least eight graduate level courses with a grade of B or higher in the fields of dynamic, synoptic, physical, and tropical meteorology. At least four of these courses must be taken at the Mānoa campus.

The comprehensive examination is taken after the completion of these eight courses, but no later than the student's 24th month in the PhD program. The purpose of this exam is to ascertain the student's comprehension of the broad field of study (meteorology) so that he/she is well prepared for PhD research. The first part is a set of written exercises composed by the student's committee members. The student writes the exam on a single day. Within three to seven days after the written exam, the student sits for the oral portion with his/her committee.

No later than 12 months after successful completion of the comprehensive examination, the student is required to submit a written research proposal to the dissertation committee. The committee must approve the proposal by a majority vote.

In addition to meteorology courses listed in this Catalog, students may take courses in related disciplines such as engineering, information and computer sciences, geography, mathematics, oceanography, and physics, with the concurrence of the academic adviser.

Ocean and Resources Engineering

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Faculty

*A. Malahoff, PhD (Chair)—ocean resources engineering, ship submersible–ROV integration

*K. F. Cheung, PhD—coastal and offshore engineering, hydrodynamics, computational methods, water wave mechanics

*R. C. Ertekin, PhD—naval architecture, offshore engineering, hydrodynamics, computational methods

J. W. Kim, PhD—hydrodynamics, hydroelasticity, nonlinear wave theory, computational fluid dynamics

*H. J. Krock, PhD—environmental engineering, mixing and transport, water quality, ocean thermal energy conversion, hydrogen

*J. C. Radway, PhD—marine resources, photobioreactors and bioremediation

*L. H. Seidl, PhD—offshore engineering, naval architecture, SWATH ships, mooring systems and ship hydrodynamics

Cooperating Graduate Faculty

J. M. Becker, PhD—nonlinear hydrodynamic stability, general ocean circulation

K. A. W. Crook, PhD—sedimentology, tectonics, geoscience policy

B. D. Greeson, PhD—offshore engineering

R. H. Knapp, PhD—structural engineering

S. H. Masutani, PhD—ocean resources engineering

M. A. Merrifield, PhD—coastal and near-shore processes, internal waves and mixing, oceanography

H. R. Riggs, PhD—structural engineering

J. R. Smith, PhD—marine survey

J. C. Wiltshire, PhD—marine minerals

Affiliate Graduate Faculty

G. Nihous, PhD—ocean resources engineering

E. Noda, PhD—coastal and ocean engineering

D. Rezachek, PhD—ocean energy and engineering design

J. van Ryzin, PhD—mechanical and ocean engineering

D. Vithanage, PhD—coastal engineering, nearshore circulation

Degrees Offered: MS in ocean and resources engineering, PhD in ocean and resources engineering

The Academic Program

Ocean and resources engineering (ORE) is the application of ocean science and engineering design to the challenging conditions found in the ocean environment. Wave and current motion and forces, high pressure, and temperature variations,

as well as chemical and biological effects, are among the considerations that set ocean and resources engineering apart from conventional land-based engineering. Ocean and resources engineering in the tropical, mid-ocean location of Hawai'i has the advantage of year-round access to explore research subjects related to oceanic island coastal processes, ocean energy development, deep-ocean mining, ocean instrumentation, ocean transportation, large floating platforms, and marine bioproducts.

Ocean and resources engineering, as an integral part of the School of Ocean and Earth Science and Technology, allows the complete coverage of questions involving ocean processes. Not only can the problem be defined scientifically, but engineering solutions can be devised.

Career opportunities for graduates in ocean and resources engineering exist in various areas. Depending on the student's individual interest, employment may be sought with industry, government, or universities. Government positions are usually with the U.S. Army Corps of Engineers, the U.S. Naval Facilities Command, or with state, city, or county public works departments. Jobs in private industry are with large oil companies, shipyards, consulting and contracting firms, environmental services firms or laboratories, offshore mining companies, large systems design companies and bioproducts firms. Graduates with the PhD degree in ocean and resources engineering have found jobs in research-oriented positions in higher education, government, and the private sector.

Accreditation

The master's program in ocean and resources engineering is accredited by the Accreditation Board of Engineering and Technology (ABET).

Preliminary Conference

Upon entering the ocean and resources engineering program, students are assigned a faculty adviser generally according to the option or area of interest selected by the student. Initial conference participants review the academic background of the student and advise the student on which courses are required and what, if any, deficiencies must be made up.

Graduate Study

The graduate program in ocean and resources engineering is intended to channel the student's previous engineering or scientific experience to ocean-related work. Students may pursue their studies in coastal engineering, offshore engineering, or ocean-resources engineering.

Departmental interests in the coastal area include design of coastal and harbor structures, beach and surf parameters, nearshore and estuary hydrodynamics, hydraulic and numerical modeling, and tsunami wave studies.

In the offshore engineering area, analysis and design of fixed and floating structures, submersible and semi-submersible platforms, offshore ports, mooring systems, ship and platform motions in waves, and stability in waves are addressed.

In the ocean-resources engineering area, ocean thermal energy conversion (OTEC), ocean mining, wave energy extraction, ocean living resources, waste disposal in the ocean, marine bioproducts and environmental response are addressed.

Master's Degree

The MS program in ocean and resources engineering is aimed at training professional engineers.

Admission Requirements

An intended candidate for the master's program is expected to have a bachelor's degree in engineering, applied mathematics, physics, or applied sciences.

In order to satisfy ABET requirements, candidates with degrees other than in engineering will be required to make up deficiencies in engineering. All students must satisfy minimum undergraduate engineering requirements, consisting of 16 credit hours in natural sciences, 16 credit hours in mathematics, 32 credit hours in engineering science, and 16 credit hours in engineering design. Official scores in the GRE General Test must be submitted.

Generally the student's first semester is devoted to basic courses in the field of ocean and resources engineering; then, the student specializes in coastal, offshore, or ocean-resources engineering.

Degree Requirements

The MS degree in ocean and resources engineering may be earned under either Plan A (thesis) or Plan B (non-thesis).

Both degree plans require a balance between engineering science and advanced design. At least 24 credit hours must be earned in advanced courses numbered 600 and above. No more than 5 credit hours of 400-level courses can be counted toward the MS degree requirements.

Ten credits of core courses are required of all students in ocean and resources engineering, and a minimum of 12 credit hours must come from the list of courses identified as basic courses for the option area chosen by the student. As part of the course work requirements, the students must be competent in at least one scientific programming language.

One credit of seminar is required. Students may attend 15 seminars of their choice in ocean-engineering-related areas. They register before the semester in which they plan to fulfill this requirement. The remaining credits are to be chosen so as to form a coherent plan of study.

During the first semester of full-time enrollment, the student must take an examination (general exam) to qualify for admission to candidacy. During the last semester of residence, an oral examination (final exam) is given. This consists of a presentation of the thesis or Plan B paper and provides the faculty with an opportunity to test the student's understanding of the chosen field and ability to integrate theory and design at the master's level. The general and final examinations may be repeated once. The general exam must be taken earlier than the semester in which the final exam is taken.

Plan A (Thesis) Requirements

The thesis option requires a minimum of 30 credit hours, including 6 credit hours of thesis and a minimum of 24 credit

hours of course work, including at least 3 credit hours of advanced design or engineering science. No more than 2 credit hours of directed reading (699) may be used to fulfill the minimum requirements. The thesis can be scientifically and/or technologically oriented and requires independent work by the student. A verbal presentation and defense of the thesis are part of the final exam. The subject of the thesis must receive prior faculty approval.

Plan B (Non-thesis) Requirements

The non-thesis option requires a minimum of 30 credit hours, including at least 12 credit hours of engineering science and 12 credit hours of advanced design. Students are required to write and submit a paper on a technical subject prepared under faculty guidance. An oral presentation of the paper is part of the final exam. The subject of the paper must receive prior faculty approval.

Doctoral Degree

A student pursuing the doctoral program is required to achieve a broad understanding of the principal areas of ocean and resources engineering, as well as a thorough understanding of a specific area. The student may give proof of mastering the subject matter in a selected area by passing a number of related courses offered in the department, as specified by the graduate faculty, or by examination of the material contained in these various courses.

Admission Requirements

Students seeking admission to the doctoral program should normally have an MS degree in engineering, applied mathematics, physics, or applied sciences. Exceptionally well-qualified students with a BS degree in these disciplines may petition to be admitted to the PhD program directly. Applicants must submit the GRE General Test score. Submission of the relevant subject test score is recommended.

All students must satisfy minimum undergraduate engineering requirements, consisting of 16 credit hours in natural sciences, 16 credit hours in mathematics, 32 credit hours in engineering science, and 16 credit hours in engineering design. The student must also satisfy the minimum course work requirements or equivalence of an MS degree in ocean and resources engineering, which consists of 10 credits of core courses and 12 credits of basic courses in the major area chosen by the student. As part of the course work requirements, the student must be competent in at least one scientific programming language.

All intended candidates for the PhD degree must take a qualifying examination. This examination is given during the student's first semester.

Requirements

After being advanced to candidacy, all students must take a comprehensive examination, which will cover the student's general preparation in the area of specialty and pertinent minor fields. An approved minor subject with at least 9 credits must be completed prior to the comprehensive examination. The results of the examination will determine whether the candidate will be allowed to pursue the dissertation.

The dissertation topic must be approved by the doctoral committee. After the dissertation is completed, it will be reviewed by the committee and a final oral examination will follow. The oral examination includes an oral presentation, announced University-wide, of the dissertation by the candidate.

The qualifying and comprehensive examinations may each be repeated only once. The final examination may not be repeated, except with approval of the graduate faculty involved and the dean of the Graduate Division.

Oceanography

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Faculty

*E. A. Laws, PhD(Chair)—phytoplankton ecology, aquatic pollution, aquaculture
*M. J. Atkinson, PhD—coral reef biogeochemistry, solid-state sensor technology
*C. Benitez-Nelson, PhD—global climate change, biogeochemistry, nutrient cycling, radionuclides
*R. Bidigare, PhD—bio-optical oceanography, pigment biochemistry, biogeochemical cycling
*A. D. Clarke, PhD—marine aerosols, biogeochemical cycles, precipitation chemistry
*J. P. Cowen, PhD—deep-sea hydrothermal vent biogeochemistry, microbial geochemistry, particle aggregation
*E. H. DeCarlo, PhD—geochemistry of marine mineral deposits, fundamental chemistry of scavenging processes at the aqueous particle interface, hydrothermal processes
*E. Firing, PhD—equatorial circulation, ocean currents and current profiling methods
*P. J. Flament, PhD—dynamics of the surface layer, mesoscale structures, remote sensing
*R. Grigg, PhD—coral reef ecology, paleoceanography, fisheries management
*B. J. Huebert, PhD—atmospheric chemistry
*D. M. Karl, PhD—microbiological oceanography, oceanic productivity, biogeochemical fluxes
*M. R. Landry, PhD—zooplankton ecology, population dynamics, marine ecosystem modeling
*Y. H. Li, PhD—marine geochemistry, marine pollution studies
*R. Lukas, PhD—equatorial circulation, air-sea interaction and climate
*D. S. Luther, PhD—observational physical oceanography
*F. Mackenzie, PhD—geochemistry, sedimentology, greenhouse effect, biogeochemical cycles and global environmental change
*L. Magaard, DrRerNat—physical oceanography, oceanic waves and turbulence

* Graduate Faculty

*A. Malahoff, PhD—geological and geophysical oceanography, submarine volcanism, hydrothermal and mineral formation processes
*J. P. McCreary, Jr., PhD—equatorial dynamics, coupled ocean-atmosphere climate models, ecosystem modeling
*G. McMurtry, PhD—marine sediment geochemistry, marine mineral formation and resources, submarine hydrothermal processes, radiochemistry
*C. Measures, PhD—trace element geochemistry, elemental mass balance, geochemical effects of dust deposition
*M. A. Merrifield, PhD—coastal and near-shore processes, internal waves and mixing
*M. J. Mottl, PhD—submarine hydrothermal processes, geochemical cycles, sea-water–sea-floor chemical interaction
*P. Muller, DrRerNat—theoretical physical oceanography, analysis and interpretation of geophysical data
*B. Qiu, PhD—numerical modeling
*F. J. Sansone, PhD—gas geochemistry, reef and sediment diagenesis, hydrothermal geochemistry and lava-seawater interactions
*C. R. Smith, PhD—benthic biological oceanography, bioturbation, deep-sea carbon flux
*S. V. Smith, PhD—mass balance in ecosystems, dynamics of calcification and community metabolism
*J. S. Tribble, PhD—sedimentary geochemistry and diagenesis, sedimentation and diagenesis at accretionary plate margins
*R. E. Young, PhD—ecology of midwater animals, especially cephalopod mollusca

Cooperating Graduate Faculty

S. Atkinson, PhD—ecophysiology of marine mammals, conservation biology
W. L. Au, PhD—marine bioacoustics and echolocation
J. M. Becker, PhD—geophysical fluid dynamics, coastal processes, general ocean circulation
T. A. Clarke, PhD—marine fish ecology
K. A. W. Crook, PhD—sedimentology, tectonics, geoscience policy
W. C. Dudley, PhD—marine geology
P. Fryer, PhD—marine geology, petrology, tectonics
L. Herman, PhD—behavior and ecology of marine mammals, animal cognition
R. N. Hey, PhD—plate tectonics
R. C. Kloosterziel, PhD—geophysical fluid dynamics
B. Popp, PhD—isotope biogeochemistry
R. L. Radtke, PhD—population dynamics, fish biology, calcification
J. R. Sibert, PhD—population dynamics, fisheries, modeling
L. M. Tupas, PhD—marine microbial ecology, isotope geochemistry of dissolved particulate organics
J. C. Wiltshire, PhD—geology and geochemistry of marine mineral deposits, marine mining and processing, minerals policy issues, research-submersible technology

Affiliate Graduate Faculty

P. K. Bienfang, PhD—phytoplankton ecology
L. Campbell, PhD—microbial and phytoplankton ecology, population dynamics, immunochemistry and flow cytometry
G. T. Mitchum, PhD—tropical ocean dynamics
*D. W. Moore, PhD—geophysical fluid dynamics, equatorial oceanography
F. Mitsudera, PhD—dynamics of western boundary currents and jets, marginal seas, geostrophic turbulence and eddies
W. C. Patzert, PhD—ocean remote sensing
J. J. Polovina, PhD—larval recruitment, dynamics of exploited populations, fisheries, satellite remote sensing
L. M. Rothstein, PhD—physical oceanography, analytical modeling of equatorial ocean dynamics
E. W. Vetter, PhD—benthic ecosystem and community ecology
C. D. Winn, PhD—marine microbiology, organic chemistry, biogeochemistry

* Graduate Faculty

Degrees Offered: MS in oceanography, PhD in oceanography

The Academic Program

Oceanography (OCN) is the study of the physics, chemistry, and geology of the ocean and the ecology of organisms that live within the sea. Physical oceanography is concerned with ocean circulation, waves, tides, upwelling, air-sea interactions, and the effect of the oceans on climate. Chemical oceanographers study the distribution of dissolved substances in the ocean and the mechanisms, both natural and anthropogenic, that control their form and abundance. Geological oceanography includes the study of sea-floor spreading, submarine vulcanism, beach formation, deep-seabed mineral resources, sediments, and paleoceanography. Biological oceanographers study the interactions of marine organisms with one another and the environment. Topics include coral reef ecology, marine fisheries, hydrothermal-vent communities, plankton ecology, and near-shore and deep-sea benthic communities.

Because Hawai‘i is located near the middle of the largest ocean on Earth, oceanography has a special significance for the state and the University. At Mānoa, the oceanography facilities are among the best in the United States and include three ocean-going research vessels and two research submarines. Biological studies are facilitated by the presence of the Hawai‘i Institute of Marine Biology on Coconut Island in Kāne‘ohe Bay. Computing facilities are based on a growing network of nearly 300 Sun workstations, Macintosh, and personal computers. Graphic peripherals include black/white and color laser printers, a 36-inch inkjet printer, film printers, and pen plotters. Precision instruments include mass spectrometers, gas and liquid chromatographs, liquid scintillation counters, a CHN analyzer, a flow cytometer, and a series of atomic spectroscopy-based instruments. The world-class faculty is actively involved in both teaching and research. The University ranks third among universities in the nation in terms of National Science Foundation research funding for oceanographic research. The location, the facilities, and the faculty all make the Mānoa campus an ideal place to study oceanography.

About 40 percent of marine scientists are employed by the U.S. government, especially by the defense, commerce, and interior departments. Another 40 percent teach and do research at academic institutions. About 20 percent are employed by industry.

The MS and PhD in oceanography are recognized WICHE regional graduate programs. Residents of Alaska, Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, North Dakota, Oregon, Utah, Washington, and Wyoming are eligible, upon admission, to enroll at Hawai'i-resident tuition rates.

Advising

Each student admitted to the oceanography department is assigned an advisory committee by the department chair. The committee initially consists of three graduate faculty members from at least two of the subdisciplines of oceanography. When formed, the student's MS or PhD committee becomes the student's advisory committee. A student must meet with his or her advisory committee at least twice per year. A written report summarizing each meeting must be signed by the student and his or her committee and a copy placed in the student's file.

Graduate Study

The department offers master's and doctoral programs with areas of specializations in biological, chemical, geological, and physical oceanography.

Oceanography courses listed in this Catalog may be taken for credit in the degree program. Additional courses may be selected from the fields of botany, chemistry, engineering, geology, mathematics, meteorology, physics, and zoology.

Admission Requirements

Applicants must have intensive, rigorous training in one of the basic sciences or engineering. Regardless of major, an applicant must have completed mathematical training, including calculus through first-order ordinary differential equations (equivalent to Calculus IV at the University). An applicant must also have a year each of physics and chemistry. The well-prepared student will also have covered classical thermodynamics and applied differential equations and will have had a semester each of biology and geology. GRE test scores (General Test only) are required. Interested students should write to the department chair for a brochure and further information. For U.S. applicants, the deadline for application for admission is February 1 for the fall semester and September 1 for the spring semester. For foreign applicants, the corresponding deadlines are January 15 and August 1.

Major Requirements

All students pursuing a degree program must take OCN 620, 622, and 623. For non-biological students, the sequence is completed by taking OCN 621. Biological students complete the sequence by taking OCN 626, 627, and 628. Students may be admitted to the MS program upon successful completion of the appropriate sequence. To be admitted to the PhD program, a student must receive a positive recommendation from a PhD-qualifying committee.

Degree Requirements

Both the MS and PhD programs require a minimum of 36 credit hours, including 24 credit hours of course work and 12 credit hours of thesis or dissertation research. The 24 semester hours of course work must be in courses numbered 600 or above (excluding OCN 699 and 700 and seminar courses). At least 12 of those semester hours must consist of courses taken from three of the following groups: biological oceanography, geological oceanography, chemical oceanography, physical oceanography, mathematical methods and statistics, and meteorology. All students must complete a seminar requirement, demonstrate computer competency, and accumulate at least 30 days of field experience. PhD candidates must also pass a comprehensive examination and qualify in one foreign language. All students must pass a final oral examination in defense of their thesis/dissertation.