Woods Hole Oceanographic INSTITUTION

Course Catalog
2018-2019
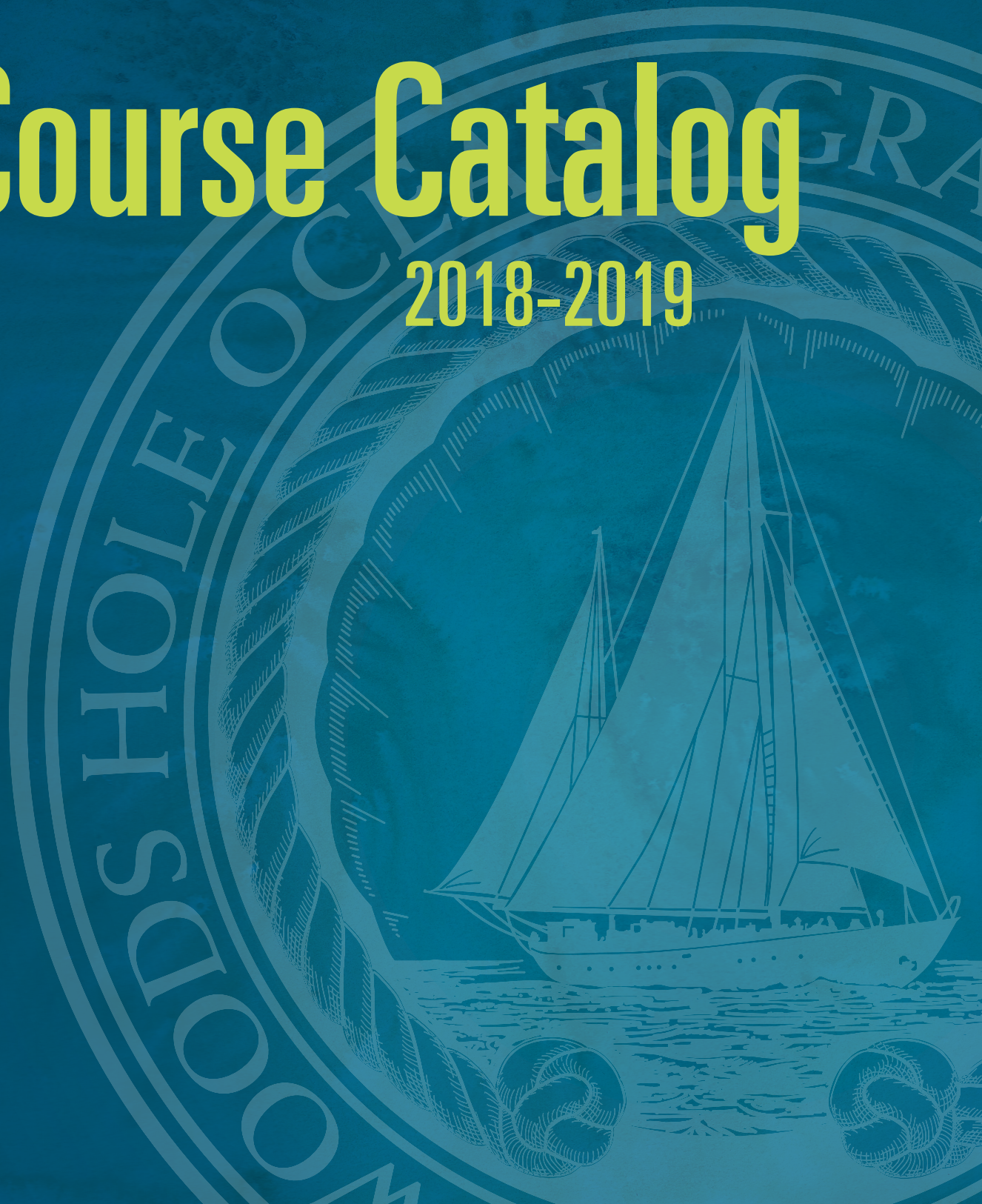
Course Catalog

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HOOD

> The Woods Hole Oceanographic Institution is dedicated to advancing knowledge of the ocean and its connection with the Earth system through a sustained commitment to excellence in science, engineering, and education, and to the application of this knowledge to problems facing society.

Woods Hole Oceanographic Institution (WHOI) is the largest independent oceanographic institution in the world and is dedicated to research and higher education at the frontiers of ocean science. WHOI is located in Woods Hole, Massachusetts and is supported by a mix of grants from federal agencies, private contributions, and endowment income.

The ocean is a defining feature of our planet and crucial to life on Earth, yet it remains one of the planet's last unexplored frontiers. For this reason, WHOI scientists, engineers, and students are committed to understanding all facets of the ocean as well as its complex connections with Earth's atmosphere, land, ice, seafloor, and life—including humanity. This is essential not only to advance knowledge about our planet, but also to ensure society's long-term welfare and to help guide human stewardship of the environment. WHOI researchers are also dedicated to training future generations of ocean science leaders, to providing unbiased information that informs public policy and decision-making, and to expanding public awareness about the importance of the global ocean and its resources.

Academic Programs at WHOI include the Massachusetts Institute of Technology-Woods Hole Oceanographic Institution Joint Program in Oceanography/Applied Ocean Science & Engineering (graduate program), postdoctoral programs (scholars, fellows, and investigators), and non-degree, one-semester or less graduate and undergraduate programs (the Geophysical Fluid Dynamics Program, the Summer Student Fellowship Program, the Semester At WHOI Program, and the Ocean Research Experience for Liberal Arts College Undergraduates Fellowship Program). Each of these programs includes a significant research experience and is central to the Institution's mission of advancing "understanding of the ocean and its interaction with the Earth system, and to communicate this understanding for the benefit of society."

WHOI has a scientific and technical staff of 350 researchers and engineers and an average of 80 Postdoctoral Researchers, approximately 125 Joint Program students, 10 Geophysical Fluid Dynamics Fellows, 30 Summer Student Fellows each year, and numerous graduate and undergraduate guest students in various labs. Our newest program, Semester At WHOI, has enrolled two to five students since its inception in 2015. WHOI offers scientists and students over 85 years of sea-going experience. The Institution boasts a diverse research fleet: two large research vessels operated for the oceanographic community; a small, fast research vessel designed for work close to shore in the Northeast; the submersible *Alvin*; multiple remotely operated and autonomous vehicles; and several small surface crafts. Scientists from this Institution and many other research laboratories use these vessels and vehicles for exploration and research in all the basic marine disciplines.

Semester at WHOI

WHOI offers a semester-long, tuition-supported program for advanced undergraduates majoring in science, engineering, or mathematics that features a significant research experience. The Semester At WHOI (SAW) program is particularly well-suited for students who are planning to obtain an advanced degree in ocean sciences, ocean engineering, or related fields in the geosciences.

The semester features a for-credit research project overseen by a WHOI scientist or engineer. Two courses

(WH.401 Elements of Modern Oceanography and WH.495 Undergraduate Seminar in Ocean Science) are designed specifically at the undergraduate level while others are graduate courses that can be modified for undergraduate credit. With permission of the instructor, students may take courses for graduate credit. SAW participants are required to take at least six credit hours of directed research (WH.490); this is the equivalent of 20 hours per week in the lab. The combination of the research project and course work provides a full semester of credit transferable back to the student's home institution. A full course load is considered to be 12 credits. For undergraduate courses, WHOI follows the U.S. Department of Education, Office of Postsecondary Education guidance regarding a credit hour as defined in the final regulations published on October 29, 2010.

MIT-WHOI Joint Program in Oceanography/ Applied Ocean Science and Engineering

The MIT-WHOI Joint Program provides a high quality education leading to an internationally-recognized doctoral degree awarded by both institutions. The Joint Program is organized within five subdisciplinary areas, each administered by a Joint Committee consisting of MIT faculty and WHOI scientists: Applied Ocean Science and Engineering, Biological Oceanography, Chemical Oceanography, Marine Geology and Geophysics, and Physical Oceanography. Cutting across the Joint Committees are interdisciplinary themes including "climate and climate impacts" and "coastal processes." In addition to the cross-cutting themes, many students choose research topics that overlap two or more of the subdisciplines, and Joint Program leadership works to support and accommodate students with interdisciplinary interests (see http://mit.whoi.edu/interdisciplinary-research for interdisciplinary statement and curriculum examples). Thesis committees involving biologists and engineers, chemists and geologists, physical oceanographers and biologists are common.

The Joint Program offers a master's degree program for U.S. Naval Officers, and more than 80 officers have received this degree dating back to the first award in 1970. With the exception of the U.S. Naval Officers program, students are not admitted to the Joint Program for a master's degree. However, a master's degree can be awarded in all programs on the way to the doctoral degree or as a terminal degree.

The Joint Program is an ocean science program in the broadest sense. Student research projects extend beyond ocean science into earth science, hydrology, glaciology, marine conservation, and environmental chemistry, to name a few. Coursework in marine policy is not mandated by any of the Joint Committees, although there are opportunities to take policy courses at MIT and Harvard University. In addition, WHOI has a Marine Policy Center, and its faculty lead informal seminars on marine policy as well as serve on thesis committees.

Joint Program students have access to courses, programs, and resources at one of the top oceanographic research institutions in the world, one of the top research universities in the world as well as the opportunity to take courses at Harvard University through a cross registration agreement. In addition to seminars and lectures by visiting scientists from all over the world, students can expand their intellectual horizons by taking courses or participating in programs well outside their main area of focus. For example, MIT's Technology and Policy Program housed in the Engineering Systems Division offers courses such as Global Environmental Science and Politics.

The Joint Program is committed to providing five years of tuition and stipend support to every student who is admitted, assuming satisfactory progress in the program. The Joint Program also has funds to help students attend scientific meetings, conferences, and special courses and to support student research. The Joint Program provides transportation options between the two campuses as well as housing at MIT and at WHOI for qualified students.

Graduate Courses for the MIT-WHOI Joint Program

MIT and WHOI offer joint doctoral degrees in oceanography and doctoral, professional, and master's degrees in oceanographic engineering. Graduate study in oceanography encompasses virtually all of the basic sciences as they apply to the marine environment: physics, chemistry, geology, geophysics, and biology. Applied ocean science and engineering allows for concentration in the major engineering fields of civil and environmental engineering, mechanical engineering, electrical engineering and computer science, and aeronautics and astronautics.

This catalog lists MIT-WHOI Joint Program courses offered at WHOI. This is not a full listing of courses available to Joint Program students; they are encouraged to take other courses not listed here. Information regarding subjects offered at MIT can be found online in the MIT course catalog at http://student.mit.edu/catalog/index.cgi.

Each graduate subject is assigned a course number. Course numbers starting with a 1 are in the area of civil and environmental engineering; with a 2, mechanical and ocean engineering; with a 6, electrical and ocean engineering; with a 7, biological oceanography; with a 12, earth and atmospheric sciences; and with a 16, aeronautics and astronautics. They are all graduate-level courses.

Some courses are offered every year, some are offered biannually, and others are offered as required. See the Course Schedule on pages 25 and 26 to determine when a course is offered.

Units are assigned to each graduate course. Units are determined by adding the average number of class and recitation hours, lab, design or field hours, and expected outside preparation hours per week. One unit is approximately equal to 14 hours of work per term.

The following are required courses, recommended courses, and common electives for MIT-WHOI Joint Program disciplines. Some of the courses are offered at MIT; more information about those courses can be found at http://student.mit.edu/catalog/index.cgi.

Applied Ocean Science and Engineering

Required for doctoral degree: any MIT department requirements plus 2.688 Principles of Oceanographic Instrument Systems and 12.808 Introduction to Observational Physical Oceanography (or approved substitution); also, one fall, spring, or summer term of research at WHOI (1.699 or 2.689).

Required for Navy students enrolled for master's degree: all of the above except 12.808.

Biological Oceanography

Required: 7.410 Applied Statistics, 7.470 Biological Oceanography, and 7.491 or 7.THG (research)

Recommended: 7.430-7.439 Topics in Biological Oceanography, 12.802 Waves, Instability, and Turbulence, 12.710 Geological Oceanography, 12.742 Marine Chemistry, 12.808 Introduction to Observational Physical Oceanography

Common Electives: 7.440, 7.51, 7.493, 12.756, 17.310, 12.884, 11.373, 12.885

Chemical Oceanography

Required: 12.742 Marine Chemistry, 12.759 Marine Chemistry Seminar (twice)

Recommended: 1.76 Aquatic Chemistry, 12.747 Modeling, Data Analysis, and Numerical Techniques for Geochemistry

Common electives: 1.83, 12.741, 12.743, 12.744, 12.746.

Marine Geology & Geophysics

Required: 12.710 Geological Oceanography, 12.703 Presenting Scientific Research, and one data analysis class (1.715, 12.444, 12.714, 12.747, 12.864, or approved substitution)

Common Elective: 12.753 Marine Geodynamics Seminar

Physical Oceanography

Strongly recommended: 12.800 Rotating Stratified Fluids and 12.808 Introduction to Observational Physical Oceanography.

More detailed information can be found in each discipline handbook: http://mit.whoi.edu/handbooks.

At least three Joint Program or SAW students must be registered for credit for a course to go forward. Rare exceptions to this rule, e.g., for a course that is a degree requirement, are subject to approval by the Dean.

Questions regarding courses, registration, and class schedules should be directed to the WHOI Registrar.

Undergraduate Subjects

WH.401 Elements of Modern Oceanography

(3 credits) Offered every fall semester

The course is structured around a series of crosscutting topics that exemplify current directions in interdisciplinary oceanography. This course aims to help students be aware of current themes in oceanography, their interdisciplinary nature, and the role of ocean sciences in society. Woven into the presentation of these cross-disciplinary topics, or themes, students will be introduced to core concepts across the disciplines of biological, physical, and chemical oceanography as well as marine geology. However, the primary emphasis will be placed on exploring the interdisciplinary aspects of these core concepts, the kinds of approaches and modes of thinking common to all of the disciplines, and the technological developments underpinning current advances. The overall, larger goal of the course will be to expose students to related disciplines, to help them understand the interrelation of their discipline of choice to the others, to build their enthusiasm for oceanography, and to get them thinking like oceanographers.

WH.402 Climate Change Science: Current Topics, Controversies and Communication

Joint Program graduate course (1.5 credits)
Next offered Fall 2019.
Prerequisite: Permission of Instructor

Introduces students to many of the "big questions" driving climate change. Reading and discussion of cutting-edge research papers and synthesis reports. Course will also include readings and discussions related to the processes and methods of critically evaluating and communicating climate science topics. This seminar will give students (1) a fundamental interdisciplinary understanding of many of the most critical issues motivating climate research today and (2) experience with the most important, yet often overlooked, skills one should attain as a scientist: reading, writing, speaking, synthesizing, and critical thinking. *Modified workload for undergraduates.*

WH.403 Climate Variability and Diagnostics

Joint Program graduate course (3 credits)
Offered in odd years, next offered Fall 2019.

Practical insight into characteristics and mechanisms of climate variability from regional to global scale in the modern world with applications to past and future climates. Major emphasis is placed on the salient features of the mean climate system and their dominant modes of natural variability (e.g., seasonality, El Niño–Southern Oscillation, North Atlantic Oscillation, Indian Ocean Dipole, Madden-Julian Oscillation, Southern Annular Mode, Pacific Decadal Oscillation), as well as observed and projected manifestations of anthropogenic climate change. Timescales covered range from synoptic, sub-seasonal, interannual, to decadal and beyond. Learning is driven by exploration of data and supplemented by lectures, textbook, and published literature. Students gain hands-on experience accessing, analyzing, and visualizing a wide range of gridded data including instrumental, satellite, and reanalysis products, as well as Intergovernmental Panel on Climate Change (IPCC) global climate model simulations. *Modified workload for undergraduates.*

WH.411 Marine Microbiology and Biogeochemistry

Joint Program graduate course (3 credits)
Offered in odd years, next offered Fall 2019.
Prerequisite: Permission of Instructor

Integrates the fields of microbiology and biogeochemistry and is centered on elucidating the linkages between microorganisms and geochemical processes in the oceans. The course is broken into modules that first lay the theoretical framework. Next, the course introduces specific and general linkages between the topics and an introduction to the major tools and techniques that have advanced their integrated study. The course concludes with a synthesis module examining the role of microorganisms in the biogeochemical cycles of diverse ocean biomes. *Modified workload for undergraduates.*

WH.412-414 Biological Oceanography Topics Courses

Joint Program graduate course (1.5 credits)
Offered every fall semester.
Prerequisite: Permission of Instructor

Topics courses in Biological Oceanography vary each term; some recent Topics courses include Ecology and Systematics of Marine Fishes; Recent Advances in Microbial Biogeochemistry; Structured Population Models; Food Webs: Structure, Dynamics and Ecosystem Function; and Effects of Noise on Aquatic Animals. (With permission of the instructor.) *Modified workload for undergraduates.*

WH.421 Geological Oceanography

Joint Program graduate course (3 credits)
Offered every fall semester.
Prerequisite: Permission of Instructor

Introduction to marine geology and geophysics. Topics include: deposition and preservation of marine sediments, climate proxies, Cenozoic to Holocene climate history, paleoceanography, marine stratigraphy and geochronology, structure of the earth, structure of oceanic crust, evolution of the oceanic lithosphere, mantle geodynamics, plate tectonics, ocean altimetry, and coastal sediment processes. *Modified workload for undergraduates.*

WH.431 Marine Chemistry

Joint Program graduate course (3 credits)
Offered every fall semester.
Prerequisite: Permission of Instructor

An introduction to chemical oceanography. Reservoir models and residence time. Major ion composition of seawater. Inputs to and outputs from the ocean via rivers, the atmosphere, and the sea floor. Biogeochemical cycling within the oceanic water column and sediments, emphasizing the roles played by the formation, transport, and alteration of oceanic particles and the effects that these processes have on seawater composition. Cycles of carbon, nitrogen, phosphorus, oxygen, and sulfur. Uptake of anthropogenic carbon dioxide by the ocean. Material presented through lectures and student-led presentation and discussion of recent papers. *Modified workload for undergraduates.*

WH.441 Introduction to Observational Physical Oceanography

Joint Program graduate course (3 credits)
Offered every fall semester.
Prerequisite: Permission of Instructor

Results and techniques of observations of the ocean in the context of its physical properties and dynamical constraints. Emphasis on large-scale steady circulation and the time-dependent processes that contribute to it. Includes the physical setting of the ocean, atmospheric forcing, application of conservation laws, description of wind-driven and thermohaline circulation, eddy processes, and interpretive techniques. (Appropriate for physics majors, with permission of the instructor.) *Modified workload for undergraduates.*

WH.452 Principles of Oceanographic Instrument Systems

Joint Program graduate course (3 credits)
Offered every fall semester.
Prerequisite: Permission of Instructor

Introduces theoretical and practical principles of design of oceanographic sensor systems. Transducer characteristics for acoustic, current, temperature, pressure, electric, magnetic, gravity, salinity, velocity, heat flow, and optical devices. Limitations on these devices imposed by ocean environment. Signal conditioning and recording; noise, sensitivity, and sampling limitations; standards. Principles of state-of-the-art systems being used in physical oceanography, geophysics, submersibles, acoustics discussed in lectures by experts in these areas. Day cruises in local waters during which the students will prepare, deploy and analyze observations from standard oceanographic instruments constitute the lab work for this subject. (Appropriate for engineering and physics majors, with permission of the instructor.) *Modified workload for undergraduates.*

WH.490 Directed Research

(credits arranged) Offered every fall semester

Course credit given for research project conducted under the supervision of a WHOI scientist or engineer.

A written report following the format of a scientific manuscript is required, and the results presented orally to the advisor and other WHOI scientists. The research is graded according to an evaluation rubric which includes the methodology, data notebook, data presentation and analysis, and the final paper.

WH.495 Undergraduate Seminar in Ocean Science

(1 credit) Offered every fall semester

One or more sections of a reading and discussion course with topics chosen based on student backgrounds and interests.

Graduate Subjects

1.69 Introduction to Coastal Engineering
(12 units) Prereq: 1.061B

Basic hydrodynamics of waves in deep and shallow water. Linear theory, dispersion, superposition, and spectral representation. Energy, energy transport, and dissipation by bottom friction. Refraction and diffraction by breakwaters. Some nonlinear aspects and wave breaking. Emphasizes physical interpretation of mathematical results and their engineering application. Storm surges, coastal circulation, and forecasting of wind-wave characteristics. Wind-wave statistics, wave forces on piles, and breakwater stability. *M. Scully*

1.76 Aquatic Chemistry
(12 units) Prereq: 5.11 or 5.111 or 5.112 or 5.60

Quantitative treatment of chemical processes in aquatic systems such as lakes, oceans, rivers, estuaries, groundwaters, and wastewater. A brief review of chemical thermodynamics is followed by discussion of acid-base, precipitation-dissolution, coordination, and reduction-oxidation reactions. Emphasis is on equilibrium calculations as a tool for understanding the variables that govern the chemical composition of aquatic systems and the fate of inorganic pollutants. *MIT Faculty*

2.681 Environmental Ocean Acoustics
(12 units) Prereq: 2.066, 18.075, or permission of instructor

Fundamentals of underwater sound, and its application to mapping and surveillance in an ocean environment. Wave equations for fluid and elastic media. Reflection and transmission of sound at plane interfaces. Wave theory representation of acoustic source radiation and propagation in shallow and deep ocean waveguides. Interaction of underwater sound with elastic waves in the seabed and an Arctic ice cover, including effects of porosity and anisotropy. Numerical modeling of the propagation of underwater sound, including spectral methods, normal mode theory, and the parabolic equation method, for laterally homogeneous and inhomogeneous environments. Doppler effects. Effects of oceanographic variability and fluctuation - spatial and temporal coherence. Generation and propagation of ocean ambient noise. Modeling and simulation of signals and noise in traditional sonar systems, as well as modern, distributed, autonomous acoustic surveillance systems. *H. Schmidt, E. Fischell*

2.682 Acoustical Oceanography
(12 units) Prereq: 2.681

Course will begin with brief overview of what important current research topics are in oceanography (physical, geological, and biological) and how acoustics can be used as a tool to address them. Three typical examples are climate, bottom geology, and marine mammal behavior. Will then address the acoustic inverse problem, reviewing inverse methods (linear and nonlinear) and the combination of acoustical methods with other measurements as an integrated system. Last part of course will concentrate on specific case studies, taken from current research journals. *J. Lynch*

2.683 Marine Bioacoustics and Geoacoustics
(12 units) Prereq: 2.681

Both active and passive acoustic methods of measuring marine organisms, the seafloor, and their interactions are reviewed. Acoustic methods of detecting, observing, and quantifying marine biological organisms are described, as are acoustic methods of measuring geological properties of the seafloor, including depth, and surficial and volumetric composition. Interactions are also described, including effects of biological scatterers on geological measurements, and effects of seafloor scattering on measurements of biological scatterers on, in, or immediately above the seafloor. Methods of determining small-scale material properties of organisms and the seafloor are outlined. Operational methods are emphasized, and corresponding measurement theory is described. Case studies are used in illustration. Principles of acoustic-system calibration are elaborated. *K. Foote*

2.684 Wave Scattering by Rough Surfaces and Randomly Inhomogenous Media
(12 units) Prereq: 2.066

An advanced-level subject designed to give the student working knowledge of current techniques in scattering and wave propagation through random media theory. Major application of theory presented is to ocean acoustics, but can be used in other acoustic and electromagnetic applications. Includes basics of wave propagation through random media theory, volume scattering by discrete scatterers (aerosols), scattering by rough surfaces, and acoustic propagation through ocean internal waves and mesoscale eddies. *T. Stanton, A. Lavery*

2.685 Numerical Methods in Scattering
(12 units) Prereq: 18.06 , 2.066

Fundamental equations for acoustic and electromagnetic waves are derived from first principles. Boundary, or interface, conditions are introduced. The course emphasizes the development of numerical methods to solve wave equations in interior or exterior domains using boundary-element and finite-element techniques. Spectral techniques are also developed. A number of technical computational issues are addressed: discretization of geometry, order of approximation, efficiency, and analysis of numerical schemes. Validation is an essential exercise. Validation examples are drawn from analytical solutions for separable shapes. Applications of numerical methods are presented for acoustic scattering by marine organisms of complex shape and structure, and optical scattering by dielectric bodies. Assignments will entail code development. *K. Foote*

2.687 Time Series Analysis and System Identification

(12 units) Prereq: 18.06, 6.003, and 6.431 (or equivalent courses within the ME department)

Matched filtering, power spectral estimation and adaptive signal processing and system identification algorithms are introduced. Algorithm development is framed as an optimization problem, and methods of finding both optimal and approximate solutions are described. Course includes an introduction to time-varying systems, first and second moment characterizations of stochastic processes, and state-space models. Algorithm derivation, performance analysis and robustness to modeling errors are covered for matched filter and power spectral estimation algorithms, stochastic gradient algorithms (LMS and its variants), Least Squares algorithms (RLS, order- recursive approaches), and the discrete-time Kalman Filter and its derivatives. Course includes laboratory exercises involving working with experimental data from a variety of fields, and a term paper/project is required. *J. Preisig*

2.688 Principles of Oceanographic Instrument Systems - Sensors and Measurements

(12 units) Prereq: 2.671, 18.075

Introduces theoretical and practical principles of design of oceanographic sensor systems. Transducer characteristics for acoustic, current, temperature, pressure, electric, magnetic, gravity, salinity, velocity, heat flow, and optical devices. Limitations on these devices imposed by ocean environment. Signal conditioning and recording; noise, sensitivity, and sampling limitations; standards. Principles of state-of-the-art systems being used in physical oceanography, geophysics, submersibles, acoustics discussed in lectures by experts in these areas. Day cruises in local waters during which the students will prepare, deploy and analyze observations from standard oceanographic instruments constitute the lab work for this subject. *A. Michel, S. Laney*

2.689J Special Projects in Oceanographic Engineering
(units arranged)

Special problems in oceanographic engineering. *WHOI Staff*

6.456 Array Processing
(12 units) Prereq: 2.004 or 6.003; 6.041; 18.075 or 18.085

Signal processing used in sonar, radar, and geophysical data analysis. Active sonar and radar systems: matched filters and ambiguity functions, signal design of range/doppler resolution, second moment characterizations of random processes with correlation functions and power density spectra, deconvolution, spectral estimation by Fourier techniques and adaptive methods, beam forming. *E. Fischell*

7.410 Applied Statistics
(12 units) Prereq: Permission of instructor

This course serves as an introduction to modern applied statistics. Topics include likelihood-based methods of estimation, confidence intervals, and hypothesis-testing; bootstrapping; time series modeling; linear models; nonparametric regression; and model selection. The course is organized around examples drawn from the recent literature. *A. Solow*

7.411–7.419 Seminars in Biological Oceanography
(units arranged)

Selected topics in biological oceanography. *Information: R. Gast*

7.421 Special Problems in Biological Oceanography
(units arranged)

Advanced problems in biological oceanography with assigned reading and consultation. *Information: R. Gast*

7.430 – 7.439 Topics Courses
(6 units)

Topics courses in Biological Oceanography vary each term; some recent Topics courses include Ecology and Systematics of Marine Fishes; Recent Advances in Microbial Biogeochemistry; Structured Population Models; Food Webs: Structure, Dynamics and Ecosystem Function; and Effects of Noise on Aquatic Animals.

7.430 Topics in Quantitative Marine Science
(6 units)

Lectures and discussions on quantitative marine ecology. Topics and instructors vary from year to year.

7.431 Topics in Marine Ecology
(6 units)

Lectures and discussions on ecological principles and processes in marine populations, communities, and ecosystems. Topics and instructors vary from year to year.

7.432 Topics in Marine Physiology and Biochemistry
(6 units)

Lectures and discussions on physiological and biochemical processes in marine organisms. Topics and instructors vary from year to year.

7.433 Topics in Biological Oceanography
(6 units)

Lectures and discussions on biological oceanography. Topics and instructors vary from year to year.

7.434 Topics in Zooplankton Biology
(6 units)

Lectures and discussions on the biology of marine zooplankton. Topics and instructors vary from year to year.

7.435 Topics in Benthic Biology
(6 units)

Lectures and discussions on the biology of marine benthos. Topics and instructors vary from year to year.

7.436 Topics in Phytoplankton Biology
(6 units)

Lectures and discussion on the biology of marine phytoplankton. Topics and instructors vary from year to year.

7.437 Topics in Molecular Biological Oceanography
(6 units)

Lectures and discussion on molecular biological oceanography. Topics and instructors vary from year to year.

7.438 Topics in the Behavior of Marine Animals
(6 units)

Lectures and discussion on the behavioral biology of marine animals. Topics and instructors vary from year to year.

7.439 Topics in Marine Microbiology
(6 units)

Lectures and discussion on the biology of marine prokaryotes. Topics and instructors vary from year to year.

7.440 An Introduction to Mathematical Ecology
(12 units) Prereq: 18.01, 1.018 or permission of instructor)

Covers the basic models of population growth, demography, population interaction (competition, predation, mutualism), food webs, harvesting, and infectious disease, and the mathematical tools required for their analysis. Because these tools are also basic to the analysis of models in biochemistry, physiology, and behavior, subject also broadly relevant to students whose interests are not limited to ecological problems. *M. Neubert*

7.470 Biological Oceanography
(12 units)

Intensive overview of biological oceanography. Major paradigms discussed, and dependence of biological processes in the ocean on physical and chemical aspects of the environment examined. Surveys the diversity of marine habitats, major groups of taxa inhabiting those habitats, and the general biology of the various taxa: the production and consumption of organic material in the ocean, as well as factors controlling those processes. Species diversity, structure of marine food webs, and the flow of energy within different marine habitats detailed and contrasted. *J. Pineda, M. Johnson*

7.491 Research in Biological Oceanography
(units arranged)

Directed research in biological oceanography not leading to graduate thesis and generally done before the qualifying examination. Possible areas include population dynamics, physiology, and cytology of marine microorganisms; physiology, nutrition, and productivity of phytoplankton; influence of organisms on the composition of seawater; systematics, physiology, and ecology of pelagic larvae, zooplankton, benthos, and mesopelagic fishes; physiology and migration of large fishes; diving physiology; and use of sound by marine mammals. *WHOI Staff*

12.521 Computational Geophysical Modeling
(12 units) Prereq: Permission of Instructor

An introduction to theory, design, and practical methods of computational modeling in geodynamics. Covers the most effective and widely used numerical modeling approaches and emphasizes problem-solving skills through illustrative examples of heat and mass transfer in the mantle, mechanisms of lithosphere deformation, and other meso-scale geodynamical topics. Students acquire experience with various numerical methods through regularly assigned computational exercises and a term-long modeling project of each student's choice. *J. Lin, O. Marchal*

12.522 Geological Fluid Mechanics
(12 units) Prereq: 8.03; 18.076 or 18.085

Treats heat transfer and fluid mechanics in the Earth, low Reynolds number flows, convection instability, double diffusion, Non-Newtonian flows, flow in porous media, and the interaction of flows with accreting and deforming boundaries. Applications include: the flow under plates, postglacial rebound, diapirism, magma dynamics, and the mantle convection problem. *C. Cenedese*

12.701 Classic Papers in Physical Oceanography
(6 units) Prereq: permission of instructor

Provides a historical perspective on fundamental topics in oceanography by considering individual works which, when pieced together, contribute to the more cohesive description of how the ocean works. In class discussions, students consider various aspects of the work in question, including motivation, approach, and implications for the broader context. They also synthesize information and make oral presentations. Develops basic analytical and critical skills in paper reading and writing. *I. Rypina*

12.702 Elements of Modern Oceanography
(12 Units)

Structured around a series of crosscutting topics that exemplify current directions in inter-disciplinary oceanography, this course aims to help students begin their graduate school career with a strong awareness of current themes in oceanography, their inter-disciplinary nature, and the role of ocean sciences in society. Woven into the presentation of these cross-disciplinary topics, or themes, students will be introduced to core concepts across the disciplines of biological, physical, and chemical oceanography as well as marine geology. However, the primary emphasis will be placed on exploring the inter-disciplinary aspects of these core concepts, the kinds of approaches and modes of thinking common to all of the disciplines, and the technological developments underpinning current advances. *A. Kirincich, S. Laney*

12.703 Presenting Scientific Research
(6 Units)

The goal of this class is to help students improve skills at presenting scientific research. As such, all students will be asked to give several presentations geared toward a scientific audience. Each student will give one 30-minute talk, one AGU-style 15-minute talk, and one poster presentation. Students are encouraged to present their on-going research and use the class as a forum to practice for upcoming talks in more formal settings. Abstracts will be prepared for each presentation and discussed in class. *G Edgcomb, A. Ashton*

12.708 Special Topics in Paleoclimatology
(Units arranged) Prereq: Permission of instructor

Advanced seminar focusing on areas of current interest in paleoceanography and paleoclimatology. Includes discussion of current and classic literature. Topics vary; recent topics include Paleoclimate Perspectives of Greenland and Antarctic Ice Sheets, Temperature over Past Millennium, and Monsoons: Past, Present and Future. *O. Marchal, A. Condron*

12.710 Geological Oceanography
(12 units)

An introduction to marine geology and geophysics suitable for any student interested in the ocean sciences. Also intended as part of a two-semester sequence for first-year MIT-WHOI Joint Program students in marine geology and geophysics (MG&G). Topics include: deposition and preservation of marine sediments, climate proxies, Cenozoic to Holocene climate history, paleoceanography, marine stratigraphy and geochronology, structure of the earth, structure of oceanic crust, evolution of the oceanic lithosphere, mantle geodynamics, plate tectonics, ocean altimetry, and coastal sediment processes. *D. Lizarralde, O. Marchal, A. Soule, L. Giosan*

12.712 Advanced Marine Seismology

(12 units) Prereq: 12.710, 12.711

Focuses on synthetic seismograms, ocean bottom refraction seismology, and multi-channel reflection seismology as applied to studies of the ocean sediments, crust, and lithosphere. Topics include: the wave equations for elastic/anelastic, isotropic/anisotropic, homogeneous/heterogeneous and fluid/solid media; ray theory and WKBJ approximations; the Sommerfeld/Weyl integrals, asymptotic analysis, and Lamb's problem for a fluid/solid interface; reflectivity and related methods; finite difference and finite element methods; and special topics of interest to the class. Extensive readings of geophysical and seismological literature. *R. Stephen*

12.714 Computational Data Analysis
(12 units) Prereq: 18.03

An introduction to the theory and practice of analyzing discrete data such as are normally encountered in geophysics and geology. Emphasizes statistical aspects of data interpretation and the nonparametric discrete-time approach to spectral analysis. Topics include: elements of probability and statistics, statistical inference, robust and nonparametric statistics, the method of least squares, univariate and multivariate spectral analysis, digital filters, and aspects of multidimensional data analysis. *A. Chave, T. Herring (MIT)*

12.716 Essentials of Oceanic Petrology
(9 units) Prereq: 12.710, 12.711 or permission of instructor

Qualitative interpretation and quantitative analysis of melting, melt transport, melt-rock reactions, igneous crustal accretion, metamorphism and hydrothermalism at oceanic spreading centers and subduction-related arcs applied to understanding the variations in the composition of the Earth's (oceanic) mantle and crust and accretionary processes at mid-ocean ridges. Theoretical methods will be combined with field, petrographic, geochemical, and computational techniques. Topics vary from year to year. *H. Dick, G. Gaetani*

12.717 Coastal Geomorphology
(12 units)

Explores mechanisms behind the formation and reshaping of coastal environments. The focus will be on a process-based understanding of both the fluid dynamic and sediment transport aspects of coastal landforms, and, most importantly, the importance of feedbacks between the two. Coastal evolution at many scales will be investigated, from ripples to coastline formation, with an emphasis on the behavior of coastal environments over integrated timescales of days and years to centuries and millennia. Will investigate the effect of storms, sea-level rise, and interactions with biological and anthropogenic influences. Course covers a broad array of coastal environments, including beaches, barrier islands, spits, inlets, tidal flats, deltas, rocky coasts, arctic shores, and carbonate atolls. *A. Ashton*

12.718 Kinetics and Mass Transport
(9 units) Prereq: Permission of instructor

Offers a broad overview of various kinetic and transport processes in geology, including volume and grain boundary solid-state diffusion, defects in minerals, rates of mineral reaction and transformation, crystal nucleation and growth, advective transport in porous media and partially molten aggregates, and percolation theory. Emphasis on processes in crystalline rocks. Covers theoretical, phenomenological, and experimental constraints, with a consistent application to "real-world" settings and actual case histories. *G. Gaetani*

12.721 Current Research in Marine Geology and Geophysics at Woods Hole
(units arranged) Pass/D/Fail grading

For graduate students desiring to perform special investigations, special laboratory work, or special fieldwork in marine geology and geophysics. *WHOI Staff*

12.722 Current Research in Chemical Oceanography at Woods Hole
(units arranged) Pass/D/Fail grading

For graduate students desiring to perform special investigations, special laboratory work, or special fieldwork in chemical oceanography. *WHOI Staff*

12.723 Current Research in Biological Oceanography at Woods Hole

(units arranged) Pass/D/Fail grading

For graduate students desiring to perform special investigations, special laboratory work, or special fieldwork in biological oceanography. *WHOI Staff*

12.724 Current Research in Marine Geology and Geophysics at Woods Hole

(units arranged) Letter graded

For graduate students desiring to perform special investigations, special laboratory work, or special fieldwork in marine geology and geophysics. *WHOI Staff*

12.725 Current Research in Chemical Oceanography at Woods Hole

(units arranged) Letter graded

For graduate students desiring to perform special investigations, special laboratory work, or special fieldwork in chemical oceanography. *WHOI Staff*

12.726 Current Research in Biological Oceanography at Woods Hole

(units arranged) Letter graded

For graduate students desiring to perform special investigations, special laboratory work, or special fieldwork in biological oceanography. *WHOI Staff*

12.739 Marine Microbiology and Biogeochemistry

(12 units)

This course is an integration of the fields of microbiology and biogeochemistry and is centered on elucidating the linkages between microorganisms and geochemical processes in the ocean. The course is broken into modules that first lay the theoretical framework to familiarize students of diverse backgrounds (biologists, chemists, physical oceanographers). Next, the course introduces specific and general linkages between the topics and an introduction to the major tools and techniques that have advanced their integrated study. The course concludes with a synthesis module examining the role of microorganisms in the biogeochemical cycles of divers ocean biomes. *A. Apprill, S. Sievert*

12.741 Marine Bioinorganic Chemistry

(12 units) Prereq: Permission of instructor

Provides an overview of trace element biogeochemistry and marine bioinorganic chemistry. Topics include controls on oceanic trace metal distributions; co-evolution of biological metal requirements and metal availability during early Earth history; chemical speciation and its influence on microbial bioavailability; applications of metal isotopes; roles of metalloenzymes and metal proteins in biogeochemical cycles; and biogeochemical applications of metagenomics, metaproteomics, and bioinformatics. *M. Saito*

12.742 Marine Chemistry

(12 units) Prereq: Permission of instructor

An introduction to chemical oceanography. Reservoir models and residence time. Major ion composition of seawater. Inputs to and outputs from the ocean via rivers, the atmosphere, and the sea floor. Biogeochemical cycling within the oceanic water column and sediments, emphasizing the roles played by the formation, transport, and alteration of oceanic particles and the effects that these processes have on seawater composition. Cycles of carbon, nitrogen, phosphorus, oxygen, and sulfur. Uptake of anthropogenic carbon dioxide by the ocean. Material presented through lectures and student-led presentation and discussion of recent papers. *B. Van Mooy, E. Kujawinski*

12.743 Geochemistry of Marine Sediments

(12 units) Prereq: 5.11 or 5.111 or 5.112 or 3.091; 5.60

Factors influencing the composition of deep-sea sediments and their spatial and temporal variability. Carbonate, silicic, organic, and detrital phases: sources and reactivity. Pore water: diffusion, reaction, and chemical fluxes across the sediment-water interface. Sediment dating and accumulation rate and mixing rate estimates. Stable isotopes, natural-series radioisotopes, and trace elements. Effect of climate change on sedimentary processes. Mathematical techniques and modeling in sedimentary systems. *D. McCorkle, A. Wang, M. Long, W. Martin*

12.744 Marine Isotope Chemistry

(12 units)

Focuses on isotope systematics applied to important problems in marine chemistry, specifically isotope systematics of light stable isotopes and intermediate mass stable isotope systematics. *B. Peucker-Ehrenbrink, S. Ono (MIT), T. Horner, V. Galy*

12.746 Marine Organic Geochemistry

(9 units) Prereq: Permission of instructor

Provides an understanding of the distribution of organic carbon (OC) in marine sediments from a global and molecular-level perspective. Surveys the mineralization and preservation of OC in the water column and within anoxic and oxic marine sediments. Topics include: OC composition, reactivity and budgets within, and fluxes through, major reservoirs; microbial recycling pathways for OC; models for OC degradation and preservation; role of anoxia in OC burial; relationships between dissolved and particulate (sinking and suspended) OC; methods for characterization of sedimentary organic matter; application of biological markers as tools in oceanography. Both structural and isotopic aspects are covered. *D. Repeta*

12.747 Modeling, Data Analysis, and Numerical Techniques for Geochemistry

(12 units) Prereq: Permission of instructor

Emphasizes the basic skills needed for handling and assimilating data as well as the basic tool-set for numerical modeling. Uses MATLAB as its computation engine; begins with an introduction to MATLAB to ensure familiarity with software. Topics include: probability distributions, error propagation, least squares and regression techniques, principle component and factor analysis, objective mapping, Fourier and spectral analysis, numerical solutions to ODEs and PDEs, finite difference techniques, inverse models, and scientific visualization. *D. Glover, D. Nicholson*

12.749 Solid Earth Geochemistry
(12 units)

This course is aimed at integrating methods in mineralogy, petrology (both igneous and metamorphic), trace element geochemistry and isotope geochemistry to address scientific issues of the solid earth. It is thematic; it begins with processes in the solar nebula, accretion and early differentiation of the earth, and discusses topics in three representative geodynamic environments: mid-ocean ridges, subduction zones and mantle plumes. For each, lectures on the physical framework will be followed by those on petrological/geochemical aspects. *N. Shimizu, S. Nielsen, G. Gaetani*

12.751–12.759 Seminar in Oceanography at Woods Hole
(Units arranged)

Topics in marine geology and geophysics, physical, dynamical, and chemical oceanography; content varies from term to term. Recent seminars include Marine Geodynamics, Marine Chemistry Seminar, and Classic Papers in Physical Oceanography. 12.754, 12.755 and 12.756 are letter-graded. *WHOI Staff*

12.800 Fluid Dynamics of the Atmosphere and Ocean
(12 units) Prereq: 8.03 and 18.04

Introduction to fluid dynamics. Students acquire an understanding of some of the basic concepts of fluid dynamics that are needed as a foundation for advanced coursework in atmospheric science, physical oceanography, ocean engineering, climate science, etc. Emphasizes fluid fundamentals, with an atmosphere/ocean twist. Students taking graduate version complete additional assignments. *C. Cenedese, A. Mahadevan*

12.801 Large-Scale Ocean Dynamics
(12 units) Prereq: 12.800

Applies fundamental principles of geophysical fluid dynamics to understand the general patterns of the ocean circulation and stratification. Includes the mid-latitude wind-driven circulation, the Southern Ocean circulation, and the global overturning circulation. Uses a combination of theory, numerical simulations, and observations to illustrate the concepts. *J. Yang*

12.805 Data Analysis in Physical Oceanography
(9 units) Prereq: 12.808

Directed at making scientifically sensible deductions from physical oceanography data (both observations and models). Introduces linear inverse methods including regression, singular value decomposition, objective mapping, and data assimilation. Connects these methods to time series analysis, including Fourier methods, spectra, coherence, and filtering. Focuses on working with data in a computer laboratory setting. Emphasizes how statistical information can be used to improve experimental design. Gives some attention to the instruments and algorithms used to acquire the data. *G. Gebbie, T. Farrar*

12.808 Introduction to Observational Physical Oceanography
(12 units) Prereq: Permission of instructor

Results and techniques of observations of the ocean in the context of its physical properties and dynamical constraints. Emphasis on large-scale steady circulation and the time-dependent processes that contribute to it. Includes the physical setting of the ocean, atmospheric forcing, application of conservation laws, description of wind-driven and thermohaline circulation, eddy processes, and interpretive techniques. *L. Pratt, H. Seo, J. Toole*

### 12.809 Hydraulic Phenomena in Geophysical Fluid Flows
(9 units) Prereq: Permission of instructor

Examination of the hydraulics of non-rotating flows (Long's experiments, hydraulic control, upstream influence, nonlinear wave steepening, hydraulic jump and bores, application to severe downslope winds). Other topics may include: non-rotating stratified flows (two-layer hydraulics, virtual and approach controls, maximal and sub-maximal flow, application to the Strait of Gibraltar and the Bab al Mandab); and deep ocean straits and sills (steady theories for rotating channel flow, nonlinear Kelvin and frontal waves, rotating hydraulic jumps, geostrophic adjustment in a rotating channel, and applications to the Denmark Strait and other deep passages). *L. Pratt*

12.823 Modeling the Biology and Physics of the Ocean
(9 units) Prereq: 18.075 or 18.085

Principles and examples of the construction of physical/ biological models for oceanic systems. Individual-based and continuum representations. Food webs and structured population models. Fluid transport, stirring, and mixing. Effects of rotation and stratification. Advection, diffusion, reaction dynamics. Oceanic examples of physical-biological dynamics: surface mixed layer, upwelling regimes, mesoscale eddies, and oceanic gyres. *G. Flierl (MIT), D. McGillicuddy*
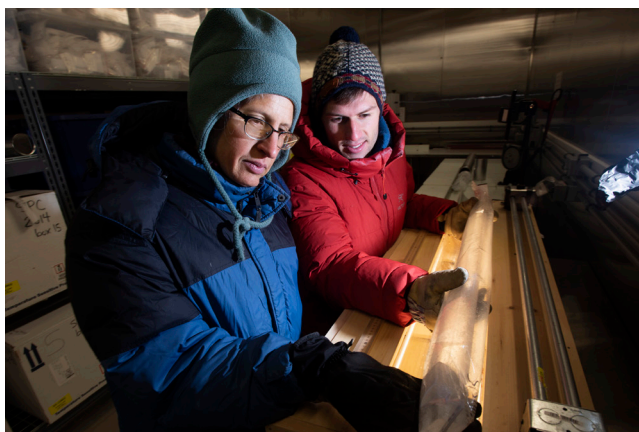
12.850 Numerical Ocean Modeling
(12 units) Prereq: Permission of instructor

The course is designed to teach numerical modeling in oceanography and environmental fluid mechanics. It focuses on the building of computational models that describe processes such as transport (advection, diffusion), reaction, and boundary forcing, of relevance in natural water systems. Models will be developed in a hierarchical manner, starting from the simple (zero-dimensional in space), and incrementally advancing toward more complex, time-evolving systems in one-, two- and three-dimensions. The students will acquire the skills to build their own models using a finite volume approach, and gain an appreciation and understanding of the working of general circulation models. *A. Mahadevan, W. Zhang*

12.860 Climate Variability and Diagnostics
(12 units) Prereq: Permission of instructor

The perspective and techniques used in diagnosing variability in the modern atmosphere, ocean, land, and crysosphere offer insight into connections across a range of disciplines and time scales. Students will gain hands-on experience accessing and analyzing instrumental data sets and climate model outputs toward a practical understanding of the mechanisms governing the climate system from regional to global scales. Emphasis will be placed on dominant modes of interannual variability (*e.g.*, the El Niño-Southern Oscillation [ENSO], Indian Ocean Dipole [IOD], North Atlantic Oscillation [NAO], Southern Annular Mode [SAM]), decadal variability (*e.g.,* Atlantic Multidecadal Oscillation [AMO], Pacific Decadal Oscillation [PDO]), as well as observed and projected manifestations of anthropogenic climate change. Learning will be driven by data, and supplemented by examples from the published literature.
C. Ummenhofer

12.862 Coastal Physical Oceanography
(12 units) Prereq: 12.800

Introduction to the dynamics of flow over the continental shelf, emphasizing both theory and observations. Content varies somewhat according to student and staff interests. Possible topics include fronts, buoyant plumes, surface and bottom boundary layers, wind-driven upwelling, coastal-trapped waves, internal waves, quasi-steady flows, high-latitude shelf processes, tides, and shelf-open ocean interactions. *R. Todd, D. Ralston*

12.870 Air-Sea Interaction: Boundary Layers
(9 units) Prereq: Permission of instructor

Examines the interaction of the atmosphere and ocean on time scales from minutes to months, with emphasis on effects within the near-surface boundary layers in both the air and water. Topics include the dynamics of the wave field and its role in mediating air-sea coupling, the scaling of surface layer turbulence, the effects of temperature stratification, and the mechanics of energy and momentum exchange across the interface. Methods for measuring and computing air/sea fluxes are reviewed. Modification of boundary layers by air/sea exchange, radiation, and turbulent mixing is treated using a hierarchy of boundary layer models made available for student use. *J. Trowbridge, C. Clayson*

12.910 Communicating Ocean Science
(9 units)

For students interested in improving their ability to teach science, the focus is on inquiry-based instructional methods and applications to various audiences. Includes an opportunity to teach in a course at a local state university and in a supervised elementary school classroom. Class meets twice a week for 11 sessions and episodically thereafter. The undergraduate lesson is arranged in consultation with Bridgewater State University faculty. Outreach in local school classrooms involves one session observing and three sessions teaching. *L Mullineaux, A. Michel*

12.970 Current Research in Physical Oceanography in Woods Hole
(units arranged) Letter graded

Original investigations, laboratory work, or field work on oceanographic problems. *WHOI Staff*

12.971 Current Research in Physical Oceanography in Woods Hole
(units arranged) Pass/D/Fail grading

Original investigations, laboratory work, or field work on oceanographic problems. *WHOI Staff*

Thesis Research

1.THG Graduate Thesis

(units arranged)

Program of research leading to the writing of a Masters of Engineering, Civil Engineer, Doctor of Philosophy or Doctor of Science thesis in Civil and Environmental Engineering/AOSE, Biological Oceanography, or Chemical Oceanography; to be arranged by the student and an appropriate faculty member.

2.THG Graduate Thesis

(units arranged)

Program of research leading to the writing of a Master of Science, Doctor of Philosophy or Doctor of Science thesis in Mechanical Engineering/Applied Ocean Science and Engineering; to be arranged by the student and an appropriate faculty member.

6.THG Graduate Thesis

(units arranged)

Program of research leading to the writing of a Master of Science, Environmental Engineer, Doctor of Philosophy or Doctor of Science thesis in Electrical Engineering and Computer Science/ AOSE; to be arranged by the student and an appropriate faculty member.

7.THG Graduate Thesis

(units arranged)

Program of research leading to the writing of a Master of Science, Doctor of Philosophy, or Doctor of Science thesis in Biological Oceanography; to be arranged by the student and an appropriate faculty member.

12.THG Graduate Thesis

(units arranged)

Program of research leading to the writing of a Master of Science, Doctor of Philosophy, or Doctor of Science thesis in Earth, Atmospheric, and Planetary Sciences/Chemical Oceanography, Marine Geology and Geophysics, or Physical Oceanography; to be arranged by the student and an appropriate faculty member.

16.THG Graduate Thesis

(units arranged)

Program of research leading to an SM, EAA, PhD, or ScD thesis; to be arranged by the student with an appropriate MIT faculty member, who becomes thesis supervisor. Restricted to students who have been admitted into the department.

Graduate Course Schedules

Subject #	Title	Units	Last Taught*	Annual (1) Biannual (2)
1.69	Introduction to Coastal Engineering	12	FA 17	2
1.76	Aquatic Chemistry	12	SP 17	2
2.682	Acoustical Oceanography	12	SP 12	2
2.683	Marine Bioacoustics & Geoacoustics	12	SP 09	2
2.684	Wave Scattering by Rough Surfaces & Inhomogeneous Media	12	SP 09	2
2.686	Sonar, Radar & Seismic Signal Processing	12	FA 08	2
2.687	Time Series Analysis & System Identification	12	SU 13	2
2.688	Principles of Oceanographic Instrument Systems	12	FA 17	1
6.456	Adaptive Array Processing	12	FA 17	2
7.410	Applied Statistics	12	SP 18	1
7.411	Seminar in Biological Oceanography	Arranged		As needed
7.421	Special Problems in Biological Oceanography	Arranged		As needed
7.430	Topics in Quantitative Marine Science	6	FA 17	Varies
7.431	Topics in Marine Ecology	6	SP 16	Varies
7.432	Topics in Marine Physiology and Biochemistry	6	FA 15	Varies
7.433	Topics in Biological Oceanography	6	SP 18	Varies
7.434	Topics in Zooplankton Biology	6	FA 06	Varies
7.435	Topics in Benthic Biology	6	FA 11	Varies
7.436	Topics in Phytoplankton Biology	6	FA 12	Varies
7.437	Topics in Molecular Biological Oceanography	6	SP 16	Varies
7.438	Topics in the Behavior of Marine Animals	6	FA 16	Varies
7.439	Topics in Marine Microbiology	6	SP 18	Varies
7.440	An Introduction to Mathematical Ecology	9	SP 18	2
7.470	Biological Oceanography	12	SP 18	1
12.521	Computational Geophysical Modeling	9	SP 16	2
12.522	Geological Fluid Mechanics	12	FA 12	2
12.525	Mechanisms of Faulting & Earthquakes	12	FA 16	2
12.701	Classical Papers in Physical Oceanography	6	SP 18	1
12.702	Elements of Modern Oceanography	12	FA 17	1
12.703	Presenting Scientific Research	6	FA 17	1
12.708	Special Topics in Paleoclimatology	9	FA 17	1
12.710	Geological Oceanography	12	FA 17	1
12.712	Advanced Marine Seismology	9	FA 15	2
12.714	Computational Data Analysis	12	SP 16	2
12.716	Essentials of Oceanic Petrology	9	SP 18	As Needed

*Last Taught: FA=Fall term; SP=Spring term **Seminar numbers – topics may vary from term to term

Subject #	Title	Units	Last Taught*	Annual (1) Biannual (2)
12.717	Coastal Geomorpology	12	SP 17	2
12.718	Kinetics and Mass Transport	9	FA 15	2
12.739	Marine Microbiology & Geochemistry	12	FA 17	2
12.741	Marine Bioinorganic Chemistry	9	SP 18	2
12.742	Marine Chemistry	12	FA 17	1
12.743	Geochemistry of Marine Sediments	12	SP 17	2
12.744	Marine Isotope Chemistry	12	SP 17	2
12.746	Marine Organic Geochemistry	9	SP 18	2
12.747	Modeling, Data Analysis & Numerical Techniques for Geochemistry	12	FA 16	2
12.749	Solid Earth Geochemistry	12	SP 16	2
12.752**	Oceanic Faulting & Earthquakes	6	FA 11	As Needed
12.752**	Marine Geodynamics Seminar (for pregenerals students)	6	SP 18	1
12.753**	Marine Geodynamics Seminar (for postgeneratls students)	3	SP 18	1
12.754**	Active Source Marine Seismology	12	FA 06	As Needed
12.757**	The Arctic System: An Interdisciplinary Approach	6	FA 07	As Needed
12.757**	Climate Change Science	6	SP 13	2
12.757**	Science & Society (formerly Science & Communication)	6	FA 08	As Needed
12.759**	Marine Chemistry Seminar	6	SP 18	1
12.800	Fluid Dynamics of the Atmosphere and Ocean	12	FA 17	1
12.801	Large Scale Ocean Dynamics	12	SP18	1
12.802	Wave Motions in the Ocean & Atmosphere	12	SP 16	1
12.805	Data Analysis in Physical Oceanography (formerly Lab in PO)	9	SP 16	1
12.808	Introduction to Observational Physical Oceanography	9	FA 17	1
12.809	Hydraulic Phenomena in Geophysical Flows	9	FA 17	2
12.823	Modeling the Biology & Physics of the Ocean	9	SP 15	2
12.850	Computational Ocean Modeling	12	SP 18	2
12.860	Climate Variability & Diagnostics	12	FA 17	2
12.862	Coastal Physical Oceanography	12	FA 17	2
12.870	Air-Sea Interaction: Boundary Layers	9	SP 08	2
12.910	Communicating Ocean Science	9	SP 17	2

*Last Taught: FA=Fall term; SP=Spring term **Seminar numbers – topics may vary from term to term

Academic Calendar

2018			
Fall Term: 65 Class Days (9/5-12/12): 12 Mondays, 13 Tuesdays, 15 Wednesdays, 13 Thursdays, 12 Fridays			
August			
26	Monday	Online registration open (deadline: 7 September)	
September			
3	Monday	Labor Day – Holiday	
4	Tuesday	Registration Day – Fall term; Semester at WHOI (SAW) orientation	
5	Wednesday	First day of classes	
7	Friday	Registration deadline; Degree application deadline for February degrees	
20	Thursday	Application Deadline – Postdoctoral Programs	
21	Friday	Student Holiday – No classes	
October			
5	Friday	Add date – Last day to add subjects to registration Cross-registration deadline	
8, 9	Monday, Tuesday	Columbus Day – Holiday (Joint Program and SAW students) – no classes	
November			
12	Monday	Veterans' Day – No classes	
21	Wednesday	Last day to drop subjects from registration	
22, 23	Thursday, Friday	Thanksgiving Day – Holiday	
December			
3	Monday	On-line preregistration for spring term begins (12/27 deadline) Course evaluation period begins (until 9 AM December 19)	
12	Wednesday	Last day of classes; MIT-WHOI shuttle service ends	
13	Thursday	Last day to submit or change advanced degree thesis title	
15	Saturday	Application deadline – Joint Program (EECS and Aero/Astro only)	
17	Monday	Course evaluation period ends at 9 AM	
18	Tuesday	Grade deadline (unless course has final exam scheduled through MIT)	
25	Tuesday	Christmas Day - Holiday	
27	Thursday	Spring preregistration deadline	
2019			
January			
1	Tuesday	New Year's Day - Holiday	
5	Saturday	Application deadline – Joint Program (EAPS, Biology, ME, CEE)	
7	Monday	First day of Independent Activities Period	
11	Friday	Thesis due for doctoral degrees*	
18	Friday	Thesis due for engineer's and master's degrees* Last day to go off February degree list	
21	Monday	Martin Luther King Jr. Day – Holiday	
28	Monday	Online registration open (deadline February 8)	
*Joint Program students are advised to check with their MIT departments regarding thesis deadlines.			

2019			
Spring Term: 65 Class Days (2/5-5/16): 12 Mondays, 12 Tuesdays, 14 Wednesdays, 14 Thursdays, 13 Fridays			

February

1	Friday	Last day of Independent Activities Period
4	Monday	Registration Day – Spring Term
5	Tuesday	First day of classes
8	Friday	Registration deadline; Degree application deadline for June degrees
15	Friday	Application deadline – Geophysical Fluid Dynamics & Summer Student Programs
18	Monday	President's Day – Holiday
19	Tuesday	Monday schedule of classes to be held

March

8	Friday	Add date – Last day to add subjects to registration; Cross-registration deadline
11, 12	Monday, Tuesday	Joint Program Open House at MIT and WHOI
25-29	Monday-Friday	Spring Break (Joint Program students) – no classes or T/Th bus

April

5	Friday	Last day to submit or change advanced degree thesis title
15, 16	Monday, Tuesday	Patriots' Day – Vacation (Joint Program students) – no classes
25	Thursday	Drop date – Last day to cancel subjects from registration

May

1	Wednesday	On-line preregistration begins (deadlines: Summer-30 May, Fall-14 June)
3	Friday	Thesis due for doctoral degrees*
6	Monday	Course evaluation period begins (until 9 AM May 20)
10	Friday	Thesis due for engineer's and master's degrees*
16	Thursday	Last day of classes; MIT-WHOI shuttle service ends
20	Monday	Course evaluation period ends at 9 AM
21	Tuesday	Grade deadline (unless course has final exam scheduled through MIT)
24	Friday	Last day to go off the June degree list
29	Monday	Memorial Day – Holiday
30	Thursday	Summer preregistration deadline

June

5	Wednesday	WHOI Graduate Reception
6	Thursday	MIT Doctoral Hooding Ceremony and Doctoral Commencement
10	Monday	Joint Program summer session begins
14	Friday	Summer registration deadline; deadline for September degree application
17	Monday	Fall preregistration deadline Geophysical Fluid Dynamics Program

July

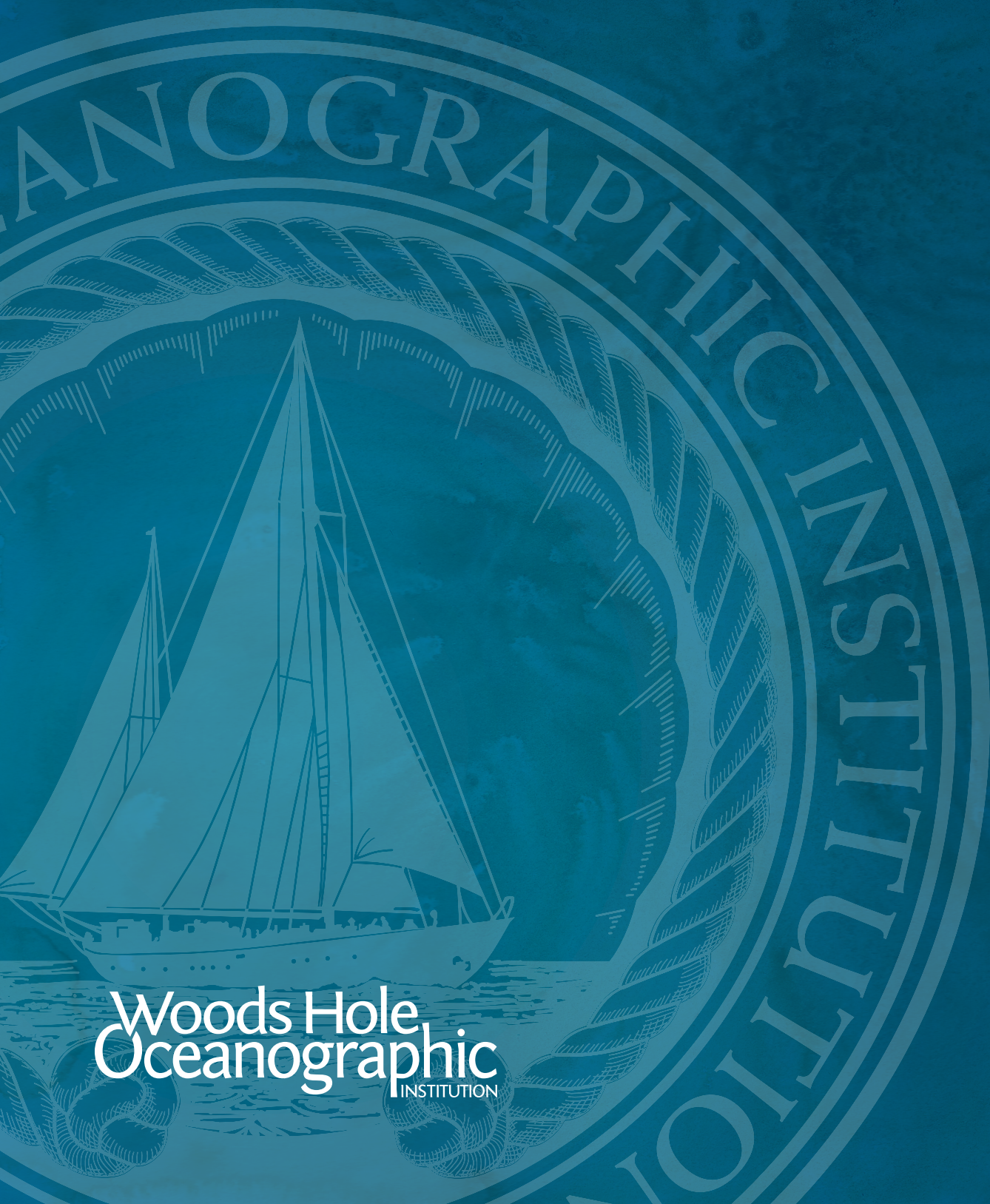|		
4	Thursday	Independence Day– Holiday

August

9	Friday	Thesis due for all September degree candidates*
16	Friday	Last day to go off September degree list; last day of classes
22	Thursday	Geophysical Fluid Dynamics Program ends
26	Monday	Grades for summer session due

*Joint Program students are advised to check with their MIT departments regarding thesis deadlines.