WOODS HOLE
OCEANOGRAPHIC
INSTITUTION

MIT-WHOI JOINT PROGRAM

Course Catalog

2026-2027

Course Catalog

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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, and the Blue Economy Internship 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 453 researchers and engineers and an average of 70 Postdoctoral Researchers, approximately 140 Joint Program students, 10-12 Geophysical Fluid Dynamics Fellows, 20-30 Summer Student Fellows, and numerous graduate and undergraduate guest students in various labs. WHOI offers scientists and students over 90 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.

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. For example, 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 125 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 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.


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Graduate Courses for the MIT-WHOI Joint Program

MIT and WHOI offer joint doctoral and master's degrees in oceanography and doctoral, professional and master's degrees in applied ocean science and 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 engineering and computer science; with a 7, biology; with a 12, earth, atmospheric, and planetary sciences; and with a 16, aeronautics and astronautics. They are all graduate-level courses.

Some courses are offered every year, some are offered biennially, and others are offered as required. See the Course Cadence 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 an additional approved graduate-level 12-unit oceanography or oceanographic engineering breadth class (1.69, 2.681, 2.682, 2.683, 7.470, 12.742, 12.710, 12.712, 12.800, 12.808, 12.862); also, one fall, spring, or summer term of research conducted at WHOI (1.THG, 2.689, 2.THG, 6.9920, 6.THG, or 16.THG).

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

Biological Oceanography

Required: 7.470 Biological Oceanography, 7.491 or 7.THG (research). A course in foundational statistics (18.05, 1.010, 7.573/7.574, IDS.013, IDS.014), and a course in applied statistics (1.871, 7.440, 9.014, 12.586, 12.715, 12.747, 12.832, MCB112 (Harvard), OEB137 (Harvard)); at least 24 additional units of graduate level oceanography or marine science courses; and no fewer than 96 units of non-research courses within the five years expected to complete the PhD.

Recommended: 12.702 Elements of Modern Oceanography, 12.739 Marine Microbiology & Biogeochemistry, 7.430-7.439 Topics in Biological Oceanography

Common Electives: 7.493, 7.51, 11.373, 17.310

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, 12.739, 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 including: 1.715, 6.100B, 6.380, 12.444, 12.714, 12.747, 12.805, 12.860, 12.864, IDS.131 (Harvard), OEB 137 (Harvard)

Common Electives: 12.752 Marine Geodynamics Seminar, 12.708 Special Topics in Paleoclimatology

Physical Oceanography

Strongly recommended: 12.800 Fluid Dynamics of the Atmosphere and Ocean and 12.808 Introduction to Observational Physical Oceanography.

Four discipline-wide core courses are highly recommended, plus two area-relevant core courses that may vary depending on the focus.

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

At least three Joint Program 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.

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. *D. Plata*

1.83 Environmental Organic Chemistry

(12 units) Prereq: 5.601, 5.602, and 18.03

Focuses on the processes affecting organic compounds in the environment. Uses physical chemical properties to predict chemical transfers between environmental compartments (air, water, sediments, and biota). Uses molecular structure-reactivity relationships to estimate chemical, photochemical, and biochemical transformation rates. Resulting process models are combined to predict environmental concentrations (and related biological exposures) of anthropogenic and natural organic compounds. *P. Gschwend*

2.681 Environmental Ocean Acoustics

(12 units) Prereq: 2.066, 18.075, or permission of instructor

This is a course covering the basic elements of ocean acoustic-wave propagation and scattering apropos of the particular physical, biological, geological, and chemical conditions found in ocean margins and basins, including high latitudes. An introduction will provide an overview of ocean acoustics, especially remote sensing, navigation, and communication applications; analytical tools; and acoustically significant properties of seawater, including the equation of state. The following topics will then be treated: acoustic wave equation from the fundamental principles of fluid dynamics; properties of sound waves; acoustical environment of the ocean; plane-wave reflection and transmission at the sea surface and seabed; geometrical acoustics/ray theory; normal-mode theory; parabolic equation techniques; scattering from rough surfaces; bubbles; numerical methods to solve the wave equation for scattering. *J. Colosi, K. Foote*

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. *J. Colosi, 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. *Staff*

2.688 Principles of Oceanographic Instrument Systems - Sensors and Measurements

(12 units)

Introduces theoretical and practical principles of design of oceanographic sensor systems. Transducer characteristics for acoustic, current, temperature, pressure, electric, magnetic, gravity, salinity, velocity, 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. Lab work includes hands-on experience with sensors and data acquisition, and preparation, deployment and analysis of observations from standard oceanographic instruments. *T. Maksym et al.*

2.689 Projects in Oceanographic Engineering

(units arranged)

Projects in oceanographic engineering, carried out under supervision of Woods Hole Oceanographic Institution staff.

6.7020 Array Processing

(12 units) Prereq: 6.700 and (2.687 or (6.301 and 18.06)

Adaptive and non-adaptive processing of signals received at arrays of sensors. Deterministic beamforming, space-time random processes, optimal and adaptive algorithms, and the sensitivity of algorithm performance to modeling errors and limited data. Methods of improving the robustness of algorithms to modeling errors and limited data are derived. Advanced topics include an introduction to matched field processing and physics-based methods of estimating signal statistics. Homework exercises providing the opportunity to implement and analyze the performance of algorithms in processing data supplied during the course. *G. Averbuch, Y. Park*

6.9920 Introductory Research in EECS

(units arranged)

Enrollment restricted to first-year graduate students in Electrical Engineering and Computer Science who are doing introductory research leading to an SM, EE, ECS, PhD, or ScD thesis. Opportunity to become involved in graduate research, under guidance of a staff member, on a problem of mutual interest to student and advisor. Individual programs subject to approval of professor in charge.

7.411–7.419 Seminars in Biological Oceanography

(units arranged)

Selected topics in biological oceanography.

7.421 Special Problems in Biological Oceanography

(units arranged)

Advanced problems in biological oceanography with assigned reading and consultation.

7.430 – 7.439 Topics Courses

(6 units)

Topics courses in Biological Oceanography vary each term; some recent Topics courses include Salty Symbiosis, Marine Molecular Ecology, Polar Biology & Ecology, Effects of Noise on Marine Animals, Biophysical Interactions in Pelagic Ecosystems, Partial Differential Equations in Population Ecology, Bioeconomic Theory & Methods for Renewable Resource Management, Marine Policy & Ocean Management, and Data Savvy Oceanographer.

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. *H. Alexander, J. Pineda*

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.

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. *J. Pineda, M. Andres*

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. *A. Cross, K. Costa*

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 Orbital Theory of Climate Change, Paleoclimate Perspectives of Greenland and Antarctic Ice Sheets, and Temperature over Past Millennium. *K. Costa, S. Shackleton*

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. *F. Horton, A. Ashton, O. Marchal, D. Lizarralde*

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. *Staff*

12.715 Environmental Bioinformatics

(12 units)

An intensive introduction to computational skills and a survey of modern computational theory and approaches for the manipulation and analysis of genomic data in environmental and non-model systems. Designed to synthesize theory (both biological and computational) and programming to equip students with the ability to understand and carry out hypothesis testing with genomic data. Topics include: introduction to programming and biological algorithms; genomic and transcriptomic data; environmental metagenomics; intraspecific diversity; and best practices in data science and reproducibility. *H. Alexander, C. Tepolt, M. Pachiadaki*

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*

12.739 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. *S. Wankel, T. Horner*

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. *K. Costa, M. Long*

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. *S. Wankel , V. Galy, B. Peucker-Ehrenbrink*

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. *V. Galy*

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.

H. Kim, D. Nicholson


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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. *Staff*

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 Climate Change Science. 12.753, 12.754, 12.755 and 12.756 are letter-graded. *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. *W. Kang*

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, Y. Kwon*

12.802 Waves, Instability and Turbulence at Small Scales

(12 units) Prereq: 12.800

Covers basic concepts of wave motion, flow instability, and turbulence in rotating and stratified fluids with emphasis on small scales. Presents wave properties, including the dispersion relation, phase and group velocities, and wave kinematics, and uses these concepts to study the dynamics of surface and internal gravity waves, Poincare waves, Kelvin waves, and topographic waves. Includes flow instability. Explores general concepts of linear instability in small-scale stratified shear flows (Rayleigh and Kelvin-Helmholtz instabilities); examines non-rotating stratified turbulence resulting from these instabilities. Also discusses wave-mean flow interaction, hydraulic control, the entrainment assumption, and the interpretation of microstructure observations. *G. Flierl*

12.803 Advanced Geophysical Fluid Dynamics

(9 units) Prereq: 12.843

Further development of topics covered in 12.843, with a more mathematical treatment. Covers current topics of interest in rotating stratified flows of oceans and atmospheres. *G. Flierl, W. Kang*

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, C. Piecuch*

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. *I. LeBras, X. Yang*

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). *C. Cenedese*

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, D. McGillicuddy*

12.843 Large-scale Atmosphere and Ocean Dynamics

(15 units) Prereq: 12.801, 12.810, or permission

Project-based with lectures covering the relevant theory. Students work in groups on four projects. Each of these comprises a numerical part, to illuminate and illustrate the theory, and a data part (drawn from laboratory tank experiments, atmospheric, or ocean observations), to illustrate the phenomena. Topics include: barotropic vorticity dynamics including inversion and evolution, geostrophic and higher order balance, baroclinic dynamics and the evolution of balanced flows, and stability with emphasis on the mutual interaction of disturbances. Projects include a verbal presentation and writeup covering both the numerical and geophysical parts plus additional derivations as needed. *R. Ferrari, G. Flierl*

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, A. Bodner*

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 cryosphere offer insight into connections across a range of disciplines and time scales with applications to past and future climates. Students will learn various statistical methods, and gain hands-on experience accessing and analyzing instrumental data, reanalysis products, and climate model output toward a practical understanding of the mechanisms governing the climate system from regional to global scales. Emphasis will be placed on salient features of the mean climate system (e.g., Earth's energy balance, Walker Circulation, Hadley Circulation), as well as dominant modes of variability spanning from synoptic (e.g., storms) and intraseasonal (e.g., Madden-Julian Oscillation) via interannual (e.g., El Niño-Southern Oscillation, North Atlantic Oscillation), to (multi) decadal variability (e.g., Atlantic Multidecadal Variability, Interdecadal Pacific Oscillation). The course will also cover important aspects of observed and projected manifestations of anthropogenic climate change, including the implications to extreme events and induced hazards. Learning will be driven by project-based data analysis and supplemented by examples from the published literature. *A. Gonzalez*

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. *D. Ralston, K. Chen*

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. *T. Farrar, M. Hell*

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 college or university and in a supervised elementary school classroom. The undergraduate lesson is arranged in consultation with the institution's faculty. Outreach in local school classrooms involves one session observing and several sessions teaching. Class meets twice a week for 11 sessions and episodically thereafter.
L. Mullineaux

12.951 Seminar in Physical Oceanography: Polar Physical Oceanography

(6 units) Pass/D/Fail grading

Introduction to the physical oceanography of polar regions. The focus will be on oceanography topics unique to high latitudes or ice-covered oceans, from both a theoretical and observational perspective. Mean fields, recent changes, and projected future changes of the polar oceans will be discussed. Students will read and present selected classic and current papers. The setting is very informal and group discussion is expected throughout. Students will also develop basic analytical and critical skills in paper reading and writing, and practice synthesizing information and making oral presentations. *S. Cole*

12.980 Current Research in Joint Program at MIT

(units arranged) Letter graded

Original investigations on problems in oceanography. *Staff*

12.981 Current Research in Joint Program at MIT

(units arranged) Pass/D/Fail grading

Original investigations on problems in oceanography. *Staff*

12.982 Current Research in Joint Program at WHOI

(units arranged) Letter graded

Original investigations, laboratory work, or fieldwork in oceanography. *Staff*

12.983 Current Research in Joint Program at WHOI

(units arranged) Pass/D/Fail grading

Original investigations, laboratory work, or fieldwork in oceanography. *Staff*


TERORO
II

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.

Joint Program Course Cadence

Course #	Title	Units	Last taught	Anticip. offering	Annual (1) Biennial (2)
1.69	Introduction to Coastal Engineering	12	FA 25	FA 27	2
1.76	Aquatic Chemistry	12	FA 24	FA 27	2
1.83	Environmental Organic Chemistry	12	FA 24	FA26	2
2.681	Environmental Ocean Acoustics	12	FA 25	FA 27	
2.682	Acoustical Oceanography	12	SP 12		Varies
2.683	Marine Bioacoustics & Geoacoustics	12	SP 24	SP 27	2
2.684	Wave Scattering by Rough Surfaces & Inhomogeneous Media	12	SP 25		
2.687	Time Series Analysis & System Identification	12	SP 13		Varies
2.688	Principles of Oceanographic Instrument Systems	12	FA 25	FA 26	1
6.7020	Array Processing	12	SP 26		2
7.411–.419	Seminars in Biological Oceanography	Arr.			Varies
7.421	Special Problems in Biological Oceanography	Arr.			Varies
7.430	Topics in Quantitative Marine Science	6	FA 25	FA 26	Varies
7.431	Topics in Marine Ecology	6	FA 25		Varies
7.432	Topics in Marine Physiology and Biochemistry	6	SP 20		Varies
7.433	Topics in Biological Oceanography	6	SP 26	FA 26	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	SP 26		Varies
7.439	Topics in Marine Microbiology	6	FA 20		Varies
7.440	An Introduction to Mathematical Ecology	12	SP 26	SP 28	2
7.470	Biological Oceanography	12	SP 26	SP 27	1
12.521	Computational Geophysical Modeling	12	SP 16		Varies
12.522	Geological Fluid Mechanics	12	FA 12		Varies
12.525	Mechanisms of Faulting & Earthquakes	12	SP 16		Varies
12.701	Classic Papers in Physical Oceanography	6	SP 25	SP 27	1
12.702	Elements of Modern Oceanography	12	FA 24	FA 26	2
12.703	Presenting Scientific Research	6	FA 25	FA 26	1
12.708	Special Topics in Paleoclimatology	6	FA 25	FA 26	1
12.710	Geological Oceanography	12	FA 25	FA 26	1
12.712	Advanced Marine Seismology	9	FA 15		Varies
12.714	Computational Data Analysis	12	SP 16		Varies
12.715	Environmental Bioinformatics (formerly 12.756)	12	FA 25	FA 27	2
12.716	Essentials of Oceanic Petrology	9	SP 18		Varies
12.717	Coastal Geomorphology	12	SP 24		Varies
12.718	Kinetics and Mass Transport	9	FA 15		Varies
12.739	Marine Microbiology & Geochemistry	12	FA 25	FA 27	2

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

Joint Program Course Cadence

Course #	Title	Units	Last taught	Anticip. offering	Annual (1) Biennial (2)
12.741	Marine Bioinorganic Chemistry	9	SP 26	SP 28	2
12.742	Marine Chemistry	12	FA 25	FA 26	1
12.743	Geochemistry of Marine Sediments	12	SP 25	SP 27	2
12.744	Marine Isotope Chemistry	12	SP 25	SP 27	2
12.746	Marine Organic Geochemistry	9	SP 24	FA 26	2
12.747	Modeling, Data Analysis & Numerical Techniques for Geochemistry	12	SP 25	SP 27	2
12.749	Solid Earth Geochemistry	12	SP 16		Varies
12.752*	Oceanic Faulting & Earthquakes	6	FA 11		Varies
12.752*	Marine Geodynamics Seminar (P/D/F)	6	SP 26	SP 27	1
12.753*	Marine Geodynamics Seminar (letter-graded)	6	SP 26	SP 27	1
12.754*	Active Source Marine Seismology	12	FA 06		Varies
12.754*	Collecting Marine Geophysical Data	6	FA 17		--
12.757*	The Arctic System: An Interdisciplinary Approach	6	FA 18		Varies
12.757*	Climate Change Science	6	FA 25	FA 26	1
12.757*	Science & Society	6	FA 08		Varies
12.759*	Marine Chemistry Seminar	6	SP 26	SP 27	1
12.800	Fluid Dynamics of the Atmosphere & Ocean	12	FA 25	FA 26	1
12.801	Large-Scale Ocean Dynamics	12	SP 26	SP 27	1
12.802	Waves, Instability & Turbulence at Small Scales	12	SP 26	SP 27	1
12.805	Data Analysis in Physical Oceanography	12	FA 25	FA 27	2
12.808	Introduction to Observational Physical Oceanography	12	FA 25	FA 26	1
12.809	Hydraulic Phenomena in Geophysical Flows	12	FA 17		Varies
12.820	Turbulence in Ocean & Atmosphere	12	SP 26		Varies
12.823	Modeling the Biology & Physics of the Ocean	9	SP 25		2
12.843	Large-Scale Atmosphere & Ocean Dynamics	15	FA 25	FA 26	1
12.850	Computational Ocean Modeling	12	SP 26	SP 28	2
12.860	Climate Variability & Diagnostics	12	FA 24	FA 26	2
12.862	Coastal Physical Oceanography	12	FA 24	FA 26	2
12.870	Air-Sea Interaction: Boundary Layers	12	SP 25	SP 27	2
12.910	Communicating Ocean Science	9	SP 24	FA 26	2
12.951	Seminar in Physical Oceanography	6	FA 24	SP 27	Varies

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

** 12.751-12.759: Various Seminars in Oceanography at Woods Hole for CO, MGG, and PO; 12.753, 12.754, 12.755, and 12.756 are letter graded; all others are Pass/D/Fail. Topics may vary from term to term.*

Academic Calendar

2026 Fall Term

The fall term runs from Wednesday, September 9th through Thursday, December 10th for a total of 63 class days (13 Mondays, 12 Tuesdays, 13 Wednesdays, 13 Thursdays, 12 Fridays).

August		
7	Friday	Thesis due* for September degree candidates
14	Friday	Last day to go off September degree list
20	Thursday	Fall Pre-registration closes @ 5pm
24	Monday	Summer Session Grade deadline
		Fall Registration opens (deadline 9/11)
September		
7	Monday	Labor Day – Holiday
8	Tuesday	MIT-WHOI shuttle service begins
9	Wednesday	First day of classes
11	Friday	Fall registration deadline;
		Degree application deadline for February degrees
18	Friday	WHOI Convocation (tentative)
October		
9	Friday	Add Date – Last day to add subjects to registration or change from listener to credit
12	Monday	Indigenous Peoples' Day – No classes
13	Tuesday	**Monday schedule of classes to be held**
November		
11	Wednesday	Veterans' Day – Holiday
18	Wednesday	Drop date - Last day to drop subjects or change from credit to listener
26-27	Thursday, Friday	Thanksgiving Recess – No classes
December		
1	Tuesday	Spring Pre-Registration begins (deadline 1/4)
10	Thursday	Last day of classes
14-18	Monday-Friday	Final Exam Period (for subjects with final exams scheduled through MIT)
15	Tuesday	Fall Term Grade deadline (for subjects without final exams scheduled through MIT)
17	Thursday	MIT-WHOI shuttle service ends
25	Friday	Christmas Day - Holiday

2027

January		
1	Friday	New Year's Day - Holiday
4	Monday	Spring Pre-Registration deadline @ 5pm
		First day of Independent Activities Period (IAP)
6	Wednesday	Fall Term Grade deadline (for subjects with final exams scheduled through MIT)
8	Friday	Thesis due* for February doctoral degrees
14	Thursday	Spring Pre-Registration closes @ 5pm
15	Friday	Thesis due* for February SM degrees
		Last day to go off February degree list
18	Monday	Martin Luther King Jr. Day – Holiday
25	Monday	Spring Registration opens (deadline 2/5)

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

2027 Spring Term

The spring term runs from Monday, February 1st through Tuesday, May 11th for a total of 65 class days (13 Mondays, 13 Tuesdays, 13 Wednesdays, 13 Thursdays, 13 Fridays).

February		
1	Monday	First day of classes
2	Tuesday	MIT-WHOI shuttle service begins
5	Friday	Spring registration deadline;
		Degree application deadline for May degrees
15	Monday	Presidents' Day – Holiday
16	Tuesday	**Monday schedule of classes to be held**
March		
5	Friday	Add Date: last day to add subjects or change from listener to credit
22-26	Monday-Friday	MIT Spring Break – no classes
April		
19	Monday	Patriots' Day – No Classes
20	Tuesday	Drop Date: last day to cancel subjects or change from credit to listener
30	Friday	Thesis due * for May doctoral degrees
May		
3	Monday	Summer & Fall Pre-Registration begins (deadlines: Summer 5/27, Fall 6/11)
7	Friday	Thesis due* for May SM degrees
11	Tuesday	Last day of classes
13	Thursday	MIT-WHOI shuttle service ends (tentative)
14	Friday	Last day to go off the May degree list;
		Spring Term Grade deadline (for subjects without final exams scheduled through MIT)
14-19	Friday-Wednesday	Final Exam Period (for subjects with final exams scheduled through MIT)
21	Friday	Spring Term Grade deadline (for subjects with final exams scheduled through MIT)
26-28	Wednesday-Friday	MIT Commencement Activities
27	Thursday	Summer Pre-Registration deadline
28	Friday	WHOI Graduate Reception (tentative)
31	Monday	Memorial Day – Holiday
June		
1	Tuesday	Summer Registration opens (deadline 6/11)
7	Monday	Summer Session begins
11	Friday	Summer Registration deadline
		Fall Pre-Registration deadline
		Degree application deadline for September degrees
18	Friday	Juneteenth - Holiday (observed)
July		
5	Friday	U.S. Independence Day (observed) – Holiday

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