Courses Taken by Recent Joint Program Naval Officers

Civil Engineering

1.813 Technology, Globalization, and Sustainable Development
Graduate (Fall)
Prereq: Permission of instructor, Units: 12
Investigates sustainable development, taking a broad view to include not only a healthy economic base, but also a sound environment, stable employment, adequate purchasing power, distributional equity, national self-reliance, and maintenance of cultural integrity. Explores national, multinational, and international political and legal mechanisms to further sustainable development through transformation of the industrial state. Addresses the importance of technological innovation and the financial crisis of 2008. N. Ashford

Mechanical Engineering

2.062[J] Wave Propagation
Graduate (Spring)
Prereq: 2.003, 18.075, Units: 12
Theoretical concepts and analysis of wave problems in science and engineering with examples chosen from elasticity, acoustics, geophysics, hydrodynamics, blood flow, nondestructive evaluation, and other applications. Progressive waves, group velocity and dispersion, energy density and transport. Reflection, refraction and transmission of plane waves by an interface. Mode conversion in elastic waves. Rayleigh waves. Waves due to a moving load. Scattering by a two-dimensional obstacle. Reciprocity theorems. Parabolic approximation. Waves on the sea surface. Capillary-gravity waves. Wave resistance. Radiation of surface waves. Internal waves in stratified fluids. Waves in rotating media. Waves in random media.
T. R. Akylas, R. R. Rosales

2.066 Acoustics and Sensing
Graduate (Spring)
Prereq: 2.003, 2.04B, 6.003, 8.03, 16.003, or permission of instructor, Units: 12
Introduces the fundamental concepts of acoustics and sensing with waves. Provides a unified theoretical approach to the physics of image formation through scattering and wave propagation in sensing. The linear and nonlinear acoustic wave equation, sources of sound, including musical instruments. Reflection, refraction, transmission and absorption. Bearing and range estimation by sensor array processing, beamforming, matched filtering, and focusing. Diffraction, bandwidth, ambient noise and reverberation limitations. Scattering from objects, surfaces and volumes by Green's Theorem. Forward scatter, shadows, Babinet's principle, extinction and attenuation. Ray tracing and waveguides in remote sensing. Applications to acoustic, radar, seismic, thermal and optical sensing and exploration. Students taking the graduate version of the subject complete additional assignments.
N. C. Makris

2.096[J] Introduction to Numerical Simulation
Same subject as 6.336[J], 16.910[J] Prereq: 18.03 or 18.06 G (Fall) 3-0-9 units
See description under subject 6.336[J].

2.160 Identification, Estimation, and Learning
Prereq: 2.151, Units: 12
Provides a broad theoretical basis for system identification, estimation, and learning. Least squares estimation and its convergence properties, Kalman filter and extended Kalman filter, noise dynamics and system representation, function approximation theory, neural nets, radial basis functions, wavelets, Volterra expansions, informative data sets, persistent excitation, asymptotic variance, central limit theorems, model structure selection, system order estimate, maximum likelihood, unbiased estimates, Cramer-Rao lower bound, Kullback-Leibler information distance, Akaike's information criterion, experiment design, and model validation. H. Asada, J.-J. E. Slotine

2.290 Numerical Fluid Mechanics
Prereq: 2.006, 2.06, 2.016, 2.20, or 2.25; 18.075k, Units: 12
Introduction to numerical methods and MATLAB: errors, condition numbers and roots of equations. Navier-Stokes. Direct and iterative methods for linear systems. Finite differences for elliptic, parabolic and hyperbolic equations. Fourier decomposition, error analysis and stability. High-order and compact finite-differences. Finite volume methods. Time marching methods. Navier-Stokes solvers. Grid generation. Finite volumes on complex geometries. Finite element methods. Spectral methods. Boundary element and panel methods. Turbulent flows. Boundary layers. Lagrangian Coherent Structures. Includes a final research project. P. F. J. Lermusiaux

2.680 Unmanned Marine Vehicle Autonomy, Sensing, and Communication
Prereq: Permission of instructor, Units: 12
Focuses on software and algorithms for autonomous decision making (autonomy) by underwater vehicles operating in ocean environments. Discusses how autonomous marine vehicles (UMVs) adapt to the environment for improved sensing performance. Covers sensors for acoustic, biological and chemical sensing and their integration with the autonomy system for environmentally adaptive undersea mapping and observation. Introduces students to the underwater acoustic communication environment and various options for undersea navigation, highlighting their relevance to the operation of collaborative undersea networks for environmental sensing. Labs involve the use of the MOOP-IvP autonomy software for the development of integrated sensing, modeling and control solutions. Solutions modeled in simulation environments and include field tests with small autonomous surface and underwater vehicles operated on the Charles River. Limited enrollment. H. Schmidt, J.J. Leonard, M. Benjamin

2.681 Environmental Ocean Acoustics
Prereq: 2.066, 18.075 or Permission of instructor, Units: 12
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

2.682 Acoustical Oceanography
Prereq: 2.681, Units: 12
Provides 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. Addresses the acoustic inverse problem, reviewing inverse methods (linear and nonlinear) and the combination of acoustical methods with other measurements as an integrated system. Concentrates on specific case studies, taken from current research journals. J. F. Lynch, Woods Hole Staff

2.688 Principles of Oceanographic Instrument Systems -- Sensors and Measurements
Prereq: 18.075, 2.671, Units: 12
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. H. Singh, R. Geyer, A. Michel

2.689[J] Projects in Oceanographic Engineering
Prereq: Permission of instructor, 24 units
Projects in oceanographic engineering, carried out under supervision of Woods Hole Oceanographic Institution staff. Given at Woods Hole Oceanographic Institution.
J. Preisig, Woods Hole Staff

2.S981 Graduate Special Subject in Mechanical Engineering
Prereq: Permission of instructor, 12 Units

2.S997 Graduate Special Subject in Mechanical Engineering
Prereq: Permission of instructor, Units: 9

Electrical Engineering and Computer Science

6.003 Signals and Systems
Prereq: Physics II (GIR); 2.087 or 18.03, Units: 12
Presents the fundamentals of signal and system analysis. Topics include discrete-time and continuous-time signals, Fourier series and transforms, Laplace and Z transforms, and analysis of linear, time-invariant systems. Applications drawn broadly from engineering and physics, including audio and image processing, communications, and automatic control.
D. M. Freeman, Q. Hu, J. S. Lim

6.011 Signals, Systems and Inference
Units: 12
Covers signals, systems and inference in communication, control and signal processing. Topics include input-output and state-space models of linear systems driven by deterministic and random signals; time- and transform-domain representations in discrete and continuous time; and group delay. State feedback and observers. Probabilistic models; stochastic processes, correlation functions, power spectra, spectral

factorization. Least-mean square error estimation; Wiener filtering. Hypothesis testing; detection; matched filters. A. V. Oppenheim, G. C. Verghese

6.336[J] Introduction to Numerical Simulation
Same subject as 2.096[J], 16.910[J] Prereq: 18.03 or 18.06 G (Fall) 12 units
Introduction to computational techniques for the simulation of a large variety of engineering and engineered systems. Applications drawn from aerospace, mechanical, electrical, and chemical engineering, biology, and materials science. Topics: mathematical formulations; network problems; sparse direct and iterative matrix solution techniques; Newton methods for nonlinear problems; discretization methods for ordinary, time-periodic and partial differential equations; fast methods for partial differential equations and integral equations, techniques for model order reduction of dynamical systems and approaches for molecular dynamics. L. Daniel, J. K. White

6.431 Introduction to Probability I
Prereq: Calculus II (GIR), Units: 6
An introduction to probability theory, and the modeling and analysis of probabilistic systems. Probabilistic models, conditional probability. Discrete and continuous random variables. Expectation and conditional expectation. Limit Theorems. An introduction to probability theory, and the modeling and analysis of probabilistic systems. Probabilistic models, conditional probability. Discrete and continuous random variables. Expectation and conditional expectation. Limit Theorems. Students taking graduate version complete additional assignments. P. Jaillet, J. N. Tsitsiklis

6.437 Inference and Information
Prereq: 6.008, 6.041, or 6.436[J] G (Spring) 12 units
Introduction to principles of Bayesian and non-Bayesian statistical inference. Hypothesis testing and parameter estimation, sufficient statistics; exponential families. EM agorithm. Log-loss inference criterion, entropy and model capacity. Kullback-Leibler distance and information geometry. Asymptotic analysis and large deviations theory. Model order estimation; nonparametric statistics. Computational issues and approximation techniques; Monte Carlo methods. Selected special topics such as universal prediction and compression. P. Golland, G. W. Wornell

6.431B Introduction to Probability II
Graduate
Prereq: 6.431A, Units: 6
Further topics in probability. Bayesian estimation and hypothesis testing. Elements of statistical inference. Bernoulli and Poisson processes. Markov chains. Students taking graduate version complete additional assignments. P. Jaillet, J. N. Tsitsiklis

6.456 Array Processing
Prereq: 6.341; 2.687, or 6.011 and 18.06, Units: 12
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. J. Preisig

6.869 Advances in Computer Vision
Subject meets with 6.819 Prereq: 6.041 or 6.042[J]; 18.06 G (Fall) 12 units
Advanced topics in computer vision with a focus on the use of machine learning techniques and applications in graphics and human-computer interface. Covers image representations, texture models, structure-from-motion algorithms, Bayesian techniques, object and scene recognition, tracking, shape modeling, and image databases. Applications may include face recognition, multimodal interaction, interactive systems, cinematic special effects, and photorealistic rendering. Covers topics complementary to 6.866. Students taking graduate version complete additional assignments. W. T. Freeman, A. Torralba

Earth, Atmosphere and Planetary Science

12.310 An Introduction to Weather Forecasting
Prereq: Physics I (GIR), Calculus I (GIR), Units: 6
Basic principles of synoptic meteorology and weather forecasting. Analysis of hourly weather data and numerical weather prediction models. Regular preparation of weather forecasts. L. Illari

12.714 Computational Data Analysis
Prereq: 18.0312, 12 Units
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. D. Chave, T. A. Herring

12.800 Fluid Dynamics of the Atmosphere and Ocean
Prereq: 8.03, 18.04, 12 Units
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 courses in atmospheric science, physical oceanography, ocean engineering, climate science, etc. Emphasizes fluid fundamentals, with an atmosphere/ocean twist. J. Marshall

12.808 Introduction to Observational Physical Oceanography
Prereq: Permission of instructor, 12 Units
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. M. Andres, G. Gebbie (WHOI)

Political Science

17.910 Reading Seminar in Social Science
Units: 3
Reading and discussion of special topics in the fields of social science. Open to advanced undergraduates by arrangement with individual staff members. 17.909 is taught P/D/F. Staff

Mathematics

18.0851 and 18.085 Computational Science and Engineering I
Graduate
Prereq: Calculus II (GIR); 18.03 or 18.034
Units: 12
Review of linear algebra, applications to networks, structures, and estimation, finite difference and finite element solution of differential equations, Laplace's equation and potential flow, boundary-value problems, Fourier series, discrete Fourier transform, convolution. Frequent use of MATLAB in a wide range of scientific and engineering applications. Students in Course 18 must register for the undergraduate version, 18.085. Fall: G. Strang. Spring: P. Saenz