

11.255 Bargaining, Negotiation, and Dispute Resolution in the Public Sector

Prereq.: —
G (Fall)
4-0-8

Investigates social conflict and distributional disputes in the public sector. While theoretical aspects of conflict are considered, focus is on the practice of dispute resolution. Comparisons between unassisted and assisted negotiation are reviewed along with the techniques of facilitation, negotiation, and nonbinding arbitration.

L. E. Susskind

11.256 Comparative Studies of Negotiation and Dispute Resolution

Prereq.: 11.255 or permission of instructor
G (Fall)
3-0-6 H-LEVEL Grad Credit

Advanced research seminar open only to qualified graduate students. Focus on cross-cultural and cross-group analysis of institutional barriers to effective dispute resolution. Students are expected to prepare detailed comparative case studies.

L. E. Susskind

11.257 Research Seminar on Theory-Building in Negotiation and Dispute Resolution

Prereq.: 11.255 or permission of instructor
G (Spring)
3-0-6 H-LEVEL Grad Credit

Advanced research seminar open only to qualified graduate students. Focus is on cross-disciplinary contributions to the theory of negotiation and dispute resolution. Students are expected to prepare in-depth theory-building case studies.

L. E. Susskind

11.258J Organizations and Environments

(11.512J)
(Same subject as 15.342J)
Prereq.: Permission of instructor
G (Spring)
3-0-9 H-LEVEL Grad Credit

See description under subject 15.342J.
M. A. Scully

Program Group Subjects**Urban Design and Development****11.301J Urban Design and Development**

(Same subject as 4.252J)
Prereq.: Permission of instructor
G (Fall)
3-0-9

Examines both the structure of cities and ways they can be changed. Includes historical forces that have produced cities, models of urban analysis, contemporary theories of urban design, implementation strategies. Core lectures supplemented by discussion group focusing on student work. Speakers present cases involving current projects illustrating the scope and methods of urban design practice.

D. Frenchman

11.302J Urban Design Politics

(Same subject as 4.253J)
Prereq.: Permission of instructor
G (Fall)
3-0-9 H-LEVEL Grad Credit

Examines ways urban design contributes to distribution of political power and resources in cities. Investigates the nature of relations between built form and political purposes through close study of a wide variety of situations where public sector design commissions and planning processes have been clearly motivated by political pressures. Lectures and discussions focus on specific case studies of twentieth-century government-sponsored designs carried out under diverse regimes in the United States, Europe, and elsewhere.

L. Vale

11.303J Design for Urban Development

(Same subject as 4.254J)
Prereq.: 11.447
G (Spring)
2-4-6 H-LEVEL Grad Credit

Focuses on development programming and design and the integration of marketing and finance with physical planning. Two studio projects interspersed with lectures, field trips, and short sketch problems. Offers students a perspective on the role of the architectural designer in the development process.

D. Frenchman, P. Roth

11.304J Site and Urban Systems Planning (Revised Units)

(Same subject as 4.255J)
Prereq.: Permission of instructor
G (Spring)
2-2-8

The planning of sites and the infrastructure systems which serve them. Site analysis, spatial organization of uses on sites, design of roadways and subdivision patterns, grading plans, utility systems, analysis of runoff, parking requirements, traffic and off-site impacts, landscaping. Lectures on analytical techniques and examples of good site-planning practice. Assignments on each aspect of subject.

G. Hack, K. Hill

11.305 Landscape Ecology and Urban Development

Prereq.: —
G (Spring)
3-0-9 [P/D/F]

Presents a framework for current landscape ecological theory, structured to encourage application in physical planning of landscapes. Case studies link theory to practice, and include both urban and rural landscapes. Science and planning are examined as social practices which rely on situated knowledge. Past and present methods of ecological planning are reviewed and critiqued in a student project. Major topics include biodiversity, cyclical processes, assessment of landscape structures, and design for sustainability.

K. Hill

11.306 Impact Assessment Techniques

(11.224)
Prereq.: 11.220
G (Spring)
3-0-6 H-LEVEL Grad Credit

Methods for predicting and evaluating impact of development, stressing predictive techniques for use by public officials without formal training in quantitative methods. Uses both computer-based modeling and non-quantitative techniques as aids in evaluation of alternatives. Includes traffic, fiscal, employment, and visual impacts.

Consult Department Headquarters.

11.329J User Needs Programming

(Same subject as 4.266J)
Prereq.: Permission of instructor
G (Spring)
3-0-6 H-LEVEL Grad Credit

See description under subject 4.266J.
S. C. Howell

11.330J Theory of City Form

(Same subject as 4.241J)
Prereq.: 11.001J or 4.252J or 11.301J
G (Spring)
Units arranged H-LEVEL Grad Credit

See description under subject 4.241J.
J. Beinart

11.331J Advanced Seminar in City Form

(Same subject as 4.242J)
Prereq.: 4.241J, 11.330J
G (Fall)
Units arranged H-LEVEL Grad Credit

See description under subject 4.242J.
J. Beinart

11.332J Urban Design

(Same subject as 4.163J)
Prereq.: Permission of instructor
G (Fall, Spring)
Units arranged H-LEVEL Grad Credit
Can be repeated for credit

See description under subject 4.163J.
J. P. de Monchaux, M. Dennis

**11.333J Urban Design Seminar
(New)**

(Same subject as 4.244J)

Prereq.: —

G (Spring)

2-0-7

Seminar on the basic theories of urban design. Includes morphological, structural, and procedural approaches. Case studies of important urban design efforts. Required for Urban Design certificate students.

*G. Hack***11.335J Cities of Tomorrow**

(Same subject as 4.245J)

Prereq.: Permission of instructor

G (Fall)

3-0-6 H-LEVEL Grad Credit

Research seminar on the future of urban design, to focus on developing a realistic projection of the organization, function, and form of cities, based on an analysis of contemporary trends. Review of historical efforts in the tradition of predicting urban change. Analysis of contemporary urban design projects and proposals. Supplemented by readings and speakers in parallel fields likely to have impact on urban form, including information processing, communications, entertainment.

*D. Frenchman***11.337J Environmental Design Policy and Action**

(Same subject as 4.247J)

Prereq.: —

G (Spring)

3-0-6 H-LEVEL Grad Credit

Seminar on ways that governments influence the quality of environmental design. Focuses on the success and failure of methods for achieving urban design objectives through various public policy mechanisms: incentives, standards and regulations, owning and operating, creation and enforcement of legal rights, and information-based strategies. Students complete a research project.

*J. P. de Monchaux***11.339 Downtown**

(New)

(Subject meets with 21H.234J, 11.026J)

Prereq.: —

G (Spring)

2-0-7

Seminar on downtown in US cities from the late nineteenth century to the late twentieth. Emphasis on downtown as an idea, place, and cluster of interests, on the changing character of downtown, and on recent efforts to rebuild it. Topics considered include subways, skyscrapers, highways, urban renewal, and retail centers. Focus on readings, discussions, and individual research projects. Meets with undergraduate subject 11.026J, but assignments differ.

*R. M. Fogelson, B. J. Frieden***11.340J Legal Issues in the Development Process**

(Same subject as 15.658J)

Prereq.: Permission of instructor

G (Fall)

3-0-9 H-LEVEL Grad Credit

Reviews the legal issues that arise in the course of acquiring, managing, and developing real estate. Topics covered include purchase and sale agreements, organization of the ownership entity, financing, contracting, federal income taxation of real estate, fiduciary relationships, leasing, and workouts.

*L. Bacow***Environmental Policy and Planning****11.360 Community Growth and Land Use Planning**

Prereq.: 11.200

G (Fall)

3-0-9 H-LEVEL Grad Credit

Seminar and fieldwork on strategies of planning and control for growth and land use, chiefly at the municipal level. Growth and its local consequences; land use planning approaches; implementation tools including innovative zoning, subdivision controls, infrastructure systems, and fiscal techniques. Projects arranged with small teams serving municipal clients.

*T. S. Szold***11.361 Environmental Policy and Regulation**

Prereq.: —

G (Fall)

3-0-9

Examines the role of government in environmental protection. Economic analysis is emphasized, but other policy frames are considered. Traces evolution of US environmental policy from command/control, citizen empowerment, to current interest in market manipulation.

*P. Levy***11.362 Environmental Management**

Prereq.: 11.361

G (Spring)

3-0-6 H-LEVEL Grad Credit

Analyzes national, state, and regional efforts to plan for the allocation and use of environmental resources. Discussions focus on strengths and weaknesses of traditional planning and regulatory mechanisms. Political obstacles to plan implementation and strategies for citizens' participation in environmental policy making receive special attention.

*L. E. Susskind***11.363J Chemicals in the Environment: Policy and Management**

(Same subject as TPP.54J)

Prereq.: —

G (Spring)

3-0-6 H-LEVEL Grad Credit

Examines public policy for managing hazardous substances, including old waste cleanup, disposal of new wastes, and current use of hazardous substances. Analyzes use and limits of risk assessment in and roles of different government and non-governmental actors in policy formulation and implementation. Examines policy mechanisms for achieving environmental goals. Focuses on how new approaches can overcome failures of past efforts to reduce toxics in the environment, with emphasis on pollution prevention.

*V. Norberg-Bohm***11.364 International Environmental Negotiation**

Prereq.: 11.361, 11.362, 11.255

G (Fall)

3-0-6 H-LEVEL Grad Credit

This is the fourth subject in the Environmental Policy and Planning sequence. Seminar looks at problems of managing common resources, difficulties of achieving transboundary pollution control, and the dilemmas of regional harmonization of environmental protection standards (particularly in Europe). At the core of these problems are issues of how best to structure international negotiations. Focuses especially on problems of representation voting, linkage, and enforcement.

*L. E. Susskind***11.365J Environmental Management of the Coast**

(Same subject as 13.98J)

Prereq.: Permission of instructor

G (Spring)

3-0-9 H-LEVEL Grad Credit

See description under subject 13.98J.
J. T. Kildow

**11.366 Planning for Sustainable Development
(Revised Content)**

Prereq.: —

G (Fall)

3-0-6

Explores policy and planning for sustainable development. Critically examines concept of sustainability from social, economic, and biogeophysical perspectives. Explores pathways to sustainability through debates on limits to growth; poverty and environmental degradation; technology and financial transfers; and international and intergenerational equity. Applies these analytical and policy frameworks to case-studies on resource management (e.g., soil erosion, water, fisheries) and industrialization (e.g., on energy, hazardous wastes).

V. Norberg-Bohm, O. Razzaz

11.367 The Law and Politics of Land Use

Prereq.: 11.200 or 11.360

G (Spring)

3-0-9 H-LEVEL Grad Credit

Analysis of local and state power to regulate land use and development. Particular emphasis on the evolution of planning and zoning regulations, and the perceived narrowing of the relationship between public improvements requirements and development impact. The ability of regulatory bodies to impose environmental performance standards and limit development activity is explored in relation to recent Supreme Court and State SJC decisions. Development decisions rendered by public agencies are reviewed, critiqued, and discussed.

*T. S. Szold***11.369 Science and Technology in Environmental Policy Making**

Prereq.: —

G (Spring)

2-1-7

Subject analyzes: 1) techniques for using scientific information in environmental problem solving, including risk assessment, technology assessment, uncertainty analysis, materials balances, and life-cycle product analysis; 2) technology as cause of and solution to environmental problems, including concepts of industrial ecology, technology diffusion and transfer, and sustainable development; 3) role of scientific experts in the process of policy formation and implementation.

*V. Norberg-Bohm***11.379J Transportation and Government — Public Policy and Politics**

(Same subject as 1.251J)

Prereq.: —

G (Spring)

3-0-6

See description under subject 1.251J.

*F. Salvucci, R. Gakenheimer***11.380J Urban Transportation Planning**

(Same subject as 1.252J)

Prereq.: Permission of instructor

G (Fall)

3-0-9 H-LEVEL Grad Credit

Various concepts, planning processes, and skills to solve urban transportation problems. Discussion of federal programs. Applications emphasize current concerns for congestion alleviation by various techniques of traffic management and demand management. Introduces geographic information systems-based software. Intelligent vehicle and highway systems. Transportation impacts, intergovernmental problems.

*R. A. Gakenheimer, F. Salvucci, T. Humphrey***11.381J Public Transportation Service and Operations Planning**

(Same subject as 1.258J)

Prereq.: 1.201 or permission of instructor

G (Spring)

3-0-9 H-LEVEL Grad Credit

See description under subject 1.258J.

*N. H. M. Wilson***11.382J Transit Management**

(Same subject as 1.259J)

Prereq.: 1.258J or permission of instructor

G (Fall)

3-0-6 H-LEVEL Grad Credit

See description under subject 1.259J.
N. H. M. Wilson, F. Salvucci

11.385J Strategic Analysis for Environmental Policy Planning, Design, and Implementation

(Same subject as 1.141J, 3.563J, 6.688J, 22.822J, TPP.121J)

Prereq.: 1.146 or 2.192 or 3.56 or 13.62 or 16.861 or TPP.21 or 11.200 or 11.205

G (Spring)

3-0-6 H-LEVEL Grad Credit

See description under subject 1.141J.
D. H. Marks, R. de Neufville, J. Clark, R. Gakenheimer, M. W. Golay, D. Sadoway, R. D. Tabors

Housing, Community, and Economic Development**11.40 Introduction to Housing and Community Development**

Prereq.: —

G (Fall)

3-0-9

Explores how public policy and private markets affect housing, economic development, and the local economy; provides an overview of techniques and specified programs policies and strategies that are (and have been) directed at neighborhood development; gives students an opportunity to reflect on their personal sense of the housing and community development process; emphasizes the institutional context within which public and private actions are undertaken.

*L. C. Keyes***11.41 Discourse on Social Policy**

(11.510)

Prereq.: —

Acad Year 1996-97: G (Spring)

Acad Year 1997-98: Not offered

2-0-7

Explores an alternative to the dominant "rational actor" model of policy analysis and emphasizes the shaping of the policy-making process through the framing and reframing of policy discourse. Attempts to place the dominant model and the alternative in the context of a larger debate on positivism in the social sciences and a varied body of interdisciplinary work on "discourse analysis."

*M. Rein***11.410J The Economics of Cities and Regions**

(Same subject as 14.573J, 1.283J)

Prereq.: 14.03 or 14.04

G (Fall)

3-0-9 H-LEVEL Grad Credit

See description under subject 14.573J.
W. Wheaton

11.420J Housing and Urban Policy

(Same subject as 4.256J)

Prereq.: 11.200 or 4.144

G (Spring)

3-0-6 H-LEVEL Grad Credit

Analysis of housing markets, consumption, investment, and policy. Techniques of neighborhood planning, including such issues as analysis of problem definition, program design, organizational issues, and strategic planning at the neighborhood level. Case studies of housing and neighborhood projects.

*P. Clay***11.421 Housing and Human Services**

Prereq.: 11.40

G (Spring)

2-0-7 H-LEVEL Grad Credit

Focuses on how the housing and human service systems interact: how networks and social capital can build between elements of the two systems. Explores ways in which the differing world views, professional perspectives, and institutional needs of the two systems play out operationally. Part I establishes the nature of the action frames of these two systems. Part II applies these insights to particular vulnerable groups: "at risk" households in transitional housing, the chronically mentally ill, and the frail elderly.

*L. C. Keyes, M. Rein***11.425 Urban Labor Markets**

Prereq.: 11.210

G (Spring)

3-0-9

Focuses on the recent evolution of central city labor markets. Topics include the changing occupational structure of central cities; the occupation/population skills mismatch; education, wages, and urban schooling; the spatial mismatch and mobility strategies; the position of minority groups in central city labor markets; the interaction between welfare programs and labor markets; the potential role of job training.

*A. Cintron, F. Levy***11.426 Massachusetts Economy and Economic Development**

Prereq.: 11.210 or equivalent

G (Fall)

3-0-9

Every state has a relatively unique set of characteristics that shape its development options. In the mid-1990s, Massachusetts is characterized by high wage levels and housing prices, a low rate of population growth, concentrations of high-tech firms, and a steady out-migration of manufacturing jobs. Using theoretical and empirical studies, subject examines whether this base can be developed into an employment structure that benefits most residents — not just the very well-educated.

F. Levy

11.427J Public Policy and Human Resources

(Same subject as 15.677J)

Prereq.: Permission of instructor

G (Spring)

3-0-6 H-LEVEL Grad Credit

See description under subject 15.677J.

*P. Osterman***11.430J Managing the Real Estate Company**

(New)

(Same subject as 15.941J)

Prereq.: 11.431J or 15.412 or 15.415

G (Spring)

4-0-8 H-LEVEL Grad Credit

Focuses on management abilities — to design innovative strategies and organizations, to motivate, to negotiate, and to create and sustain learning environments — which are crucial for success. Case studies from real estate and other industries illustrate management, negotiation, and organization theory and concepts. Topics include: globalization and strategic alliances, strategic planning, industry and organization restructuring, organization design and learning, managing organization change, quality and asset management, international management, international computer networks and implementation of information technology, and ethics. Students are required to participate in field research projects.

*G. Schuck***11.431J Real Estate Finance and Investment**

(Same subject as 15.426J)

Prereq.: 11.447

G (Fall)

4-0-8 H-LEVEL Grad Credit

Concepts and techniques for analyzing financial decisions in property development and investment. Topics: leasing and property income streams, *pro forma* analysis, equity valuation, tax analysis, options, risk, and the financial structuring of real property ownership.

*T. Riddiough***11.432J Real Estate Capital Markets**

(Same subject as 15.427J)

Prereq.: Permission of instructor

G (Spring)

4-0-8 H-LEVEL Grad Credit

The evolving organization and operation of real estate capital markets. Sources of real estate capital. Primary and secondary mortgage markets. The investment behavior of real estate assets. The development of REITs and securitized debt markets. Advanced pricing techniques for complex real estate securities.

T. Riddiough

Centers on current issues in community development: values, ideology, tactics, models, and alternative strategies. Seminar format is organized around students' planning projects, and focuses primarily on problem framing from an interdisciplinary perspective. Designed for the Community Fellows Program; students working on thesis or community-based projects admitted by permission. Consult Department Headquarters.

11.433J Real Estate Economics

(Same subject as 15.021J)

Prereq.: 14.01 or 15.010 or 15.011

G (Spring)

4-0-8 H-LEVEL Grad Credit

Focuses on developing an understanding of the factors that shape and influence markets for real property. Includes demographic analysis, patterns of regional growth, construction cycles, urban location theory, and modeling techniques for predicting demand.

*W. C. Wheaton***11.437 Financing Community Economic Development**

Prereq.: —

G (Fall)

3-0-9

Focuses on financing tools and program models to support local economic development. Includes an overview of (1) private capital markets and financing sources to understand capital market imperfections that constrain economic development, (2) business accounting, (3) financial statement analysis, and (4) federal economic development programs. Program models covered include revolving loan funds, guaranteed programs, venture capital funds, bank holding companies, community development loan funds and credit union, micro enterprise fundings, and the use of the Community Reinvestment Act to leverage bank financing.

*K. Seidman***11.438 Economic Development Planning and Policy**

Prereq.: 11.210, 11.220

G (Spring)

3-0-9

Focuses on the policy tools and planning techniques used to formulate and implement local economic development strategies. Includes an overview of economic development theory, discussion of major policy areas and practices employed to influence local economic development, and detailed review of tools and techniques, to assess local economics and formulate strategy. Coursework includes formulation of an economic development strategy for a locality by the class.

*K. F. Seidman***11.441 Issues in Community Development**

Prereq.: Permission of instructor

G (Fall)

3-2-4

Centers on current issues in community development: values, ideology, tactics, models, and alternative strategies. Seminar format is organized around students' planning projects, and focuses primarily on problem framing from an interdisciplinary perspective. Designed for the Community Fellows Program; students working on thesis or community-based projects admitted by permission. Consult Department Headquarters.

11.442 Strategies in Community Development

Prereq.: 11.441

G (Spring)

3-2-4

Continuation of 11.441. Focuses on alternative intervention strategies in community-based development. Seminar format is organized around students' planning projects, and centers on a review of relevant practice in the field, on formulation of both a detailed intervention strategy, project finding, and effectiveness evaluation plans. Designed for the Community Fellows Program; students working on thesis or community-based projects admitted by permission.

Consult Department Headquarters.

11.447 Housing Finance

(Revised Units)

Prereq.: —

G (Spring)

3-0-3

Considers the debt financing process for residential and multi-family lending. Both the economic and legal aspects of standard and alternative mortgage instruments are considered, then combined to develop an understanding of income property finance. Mortgage securitization and the secondary mortgage market also examined.

*T. Riddiough***11.449 Perspectives on Labor Markets**

Prereq.: —

G (Spring)

2-0-7

Divided into three sections: (1) review of major transformations of labor markets of industrial societies; (2) exploration of main theoretical perspectives for understanding these transformations (neo-classical, Marxist, and institutional); (3) critical review of the capacity of these perspectives to yield an adequate interpretation of changes in the labor market.

*M. Rein***11.450 American Living Standards and Income Inequality**

(Subject meets with 11.022J, 14.65J)

Prereq.: 14.01 or equivalent

G (Spring)

3-0-9

Meets with undergraduate subject 11.022J, but assignments differ. See description under subject 11.022J.

F. S. Levy

International Development and Regional Planning**11.462 Housing Problems and Policies in Developing Countries**

Prereq.: 11.205 or equivalent
 G (Spring)
 3-0-9 H-LEVEL Grad Credit

Focuses on the particular attributes, innovations, and methods of analysis of urban land and housing in developing and transition countries. Includes an overview of theory on supply and demand, tenure, standards, and community participation, detailed review of tools used in the field, and an examination of case studies revealing innovations in the field. Particular emphasis given to affordability and accessibility by the poor. Class format combines lectures, class projects, and presentation.

O. Razzaz

11.463J Structuring Low-Income Housing Projects in Developing Countries

(Same subject as 4.236J)
 Prereq.: Permission of instructor
 G (Spring)
 3-0-9 H-LEVEL Grad Credit

See description under subject 4.236J.
R. Goethert

11.464 The Informal Sector and the Household Economy

Prereq.: 11.205
 Acad Year 1996-97: Not offered
 Acad Year 1997-98: G (Spring)
 3-0-9 H-LEVEL Grad Credit

Examines interrelationships among low-income households, small-scale, income-generating activities, and the urban economy in developing countries. Theories of employment and an analysis of "bazaar economies" looked at. Reviews policy options for enhancing the informal sector's contribution to development. The role of women and the possibilities of nonmonetary activities explored.

B. Sanyal

11.465J Special Interest Group in Urban Settlements: SIGUS Workshops

(Same subject as 4.23J)
 Prereq.: Permission of instructor
 G (IAP, Spring)
 Units arranged [P/D/F] H-LEVEL Grad Credit
 Can be repeated for credit

See description under subject 4.23J.
R. Goethert, R. A. Gakenheimer, B. Sanyal

11.466 Common Property Resources

Prereq.: —
 G (Spring)
 3-0-9

Introduces students to conceptual and practical aspects of managing common resources. Examines the management issues raised by distinctive characteristics of various resources (fisheries, wildlife, water resources, forests, and land), explores the various institutional structures and property rights assignments to such resources, and develops the ability to assess and improve the management of such resources.

O. Razzaz

11.467J Property Rights Under Transition

(Same subject as 4.257J, 17.550J)
 Prereq.: 11.210 or permission of instructor
 G (Fall)
 3-0-9 H-LEVEL Grad Credit

Seminar on different economic, political, and social perspectives of property rights and their policy and planning implications. Each year the theory and applications from two or more key areas, such as land, natural resources, infrastructure, or industrial organization, are covered.

K. R. Polenske

11.469J Infrastructure in Developing Countries

(Subject meets with 1.254J, 11.104)
 Prereq.: —
 G (Fall)
 3-0-9 H-LEVEL Grad Credit

Planning for transport, water supply, sewerage, etc. Summarizes the technologies but emphasizes the planning process and decision points within that are important to planned objectives. Deals with patterns of consumption, strategies of problems analysis, technology choices, equity questions, pricing, finance, building viable public-sector institutions, privatization, relationships between technocrats and politicians, roles of interest groups. Meets with undergraduate subject 11.104, but assignments differ.

R. A. Gakenheimer

11.471 Political Economy of Development Projects: Targeting the Poor

Prereq.: 11.210 or equivalent
 G (Spring)
 3-0-9 H-LEVEL Grad Credit

Covers public-sector policies, programs, and projects that target the poor in developing countries and involve small enterprises, small farmers, cooperatives, nongovernment organizations, employment-creating programs, and social investment funds. Links these programs to the literature on poverty, economic development, and the reform of government. Discusses types of projects, tasks, and environments that are conducive to equitable outcome.

J. Tendler

G (Fall)
 3-0-9 H-LEVEL Grad Credit

See description under subject 14.570J.
I. Whiston

11.480 Theory and Practice of Privatization in Emerging Economies (New)

Prereq.: 11.205 or equivalent
 G (Spring)
 3-0-9 H-LEVEL Grad Credit

Explores the theoretical and practical aspects of privatization in emerging economies (i.e. developing countries and postcommunist nations). Analyzes why privatization became an important policy issue starting in the 1980s; how such programs were designed and implemented in various countries and industries, including infrastructure, manufacturing, and financial services; and the short-term and long-term consequences for productivity growth, fiscal management, structure of business enterprise, business-government relations, and regulation. Also analyzes the opportunities and risks for private investors, including multinational corporations, of participating in privatization transactions.

A. Amsden

11.481J Regional Economic Theories, Accounts, and Techniques

(Same subject as 1.284J)
 Prereq.: 14.03, 14.04
 G (Spring)
 3-0-9 H-LEVEL Grad Credit

Surveys the basic theories, accounting frameworks, and techniques used in regional and multiregional economic analyses. Emphasizes the aspects of each relevant to their use in program impact and distribution studies. Uses problem sets (some microcomputer-based) to illustrate the different concepts.

K. R. Polenske

11.482J Regional Socioeconomic Impact Analyses and Modeling

(Same subject as 1.285J)
 Prereq.: 11.481J or permission of instructor
 G (Fall)
 3-0-9 H-LEVEL Grad Credit

Reviews regional economic theories and models and provides students with experience in using alternative economic impact assessment models on microcomputers. First two problem sets are oriented around infrastructure investments and environmental issues in Massachusetts. Students may select their own set of data and region for the third problem set.

K. R. Polenske

11.484 Project Evaluation and Planning in Developing Countries

Prereq.: 11.205
 G (Spring)
 3-0-9

Examines techniques and procedures relevant for project planning and implementation in developing countries, including project identification, feasibility analysis, design and implementation monitoring. Considers how to evaluate economic and distributive effects of completed or ongoing development projects. Specific attention given to how institutional setting and other practical influences affect the use of conventional analytical tools.

P. Smoke

11.486J Economic Institutions and Growth Policy Analysis

(Same subject as 14.778J, 17.184J)

Prereq.: 11.210

G (Spring)

3-0-6 H-LEVEL Grad Credit

Considers how institutions have been incorporated theoretically into explorations of growth and development. Four sets of institutions are examined in detail: the corporate sector, to study how ownership, strategy, and structure affect growth-related policies; financial institutions, to analyze how they condition savings and investment; labor market institutions, to investigate their impact on the determination of wage and production-related productivity; and the institutions associated with technology, such as universities, research laboratories, and corporate training centers, to consider how skill formulation is accomplished.

*A. Amsden***11.487 Public Finance in Developing Countries**

Prereq.: 11.205 and 11.254 or permission of instructor

G (Spring)

3-0-9 H-LEVEL Grad Credit

Analysis of the structure and operation of government systems in developing countries, with particular emphasis on regional and local governments. Major topics include: the role of decentralization in national economic reform programs; the potential impact of decentralized governments on local economic development; determination of optimal arrangements for sharing fiscal responsibilities among levels of government; evaluation of local revenue and expenditure decisions; and assessment of prospects and options for intergovernmental fiscal reform. Emphasis on basic economic concerns, with consideration given to political, institutional, and cultural factors.

*P. Smoke***11.491J Industrial Development and Policy Analysis**

(Same subject as 17.176J)

Prereq.: 11.205

G (Fall)

3-0-9 H-LEVEL Grad Credit

Analyzes the theoretical and historical reasons why governments in latecomer countries have intervened with a wide array of policies to foster industrial development at various turning points: the initiation of industrial activity; the diversification of the industrial base; the restructuring of major industrial institutions; and the entry into high-technology sectors.

*A. Amsden***Planning Support Systems****11.520 A Workshop on Geographic Information Systems**

Prereq.: 1.201 or 11.220, 1.00 or 11.227

G (Spring)

3-6-3 H-LEVEL Grad Credit

Examines the potential use of Geographic Information Systems in land-use planning, transportation planning, and town government. Subject format is a studio setting with a local town government as a client. Begins with theory and use of GIS technology. Students select one of two middle segments focusing on a) a user-needs assessment and the development of skills in interview techniques, case studies, and unobtrusive measures; or b) the design of appropriate land use and transportation models. The third segment integrates the work of both groups in developing the prototype GIS.

*J. Ferreira, Jr., Q. Shen***11.521 Computer-Based Analysis for Public Management**

Prereq.: 11.227

G (Fall)

3-2-7 H-LEVEL Grad Credit

Extends the computer and analytic skills developed in 11.227 to more advanced topics and problems. Includes advanced database management concepts and applications of SQL (Structured Query Language). Computer-implemented models for improved public management are studied, including decision support and geographic information systems.

*J. Ferreira, Jr., M. Shiffer***11.522 Research Seminar on Planning Support Systems**

Prereq.: 11.227, 11.520, or 11.521

G (Fall)

3-2-7 H-LEVEL Grad Credit

Can be repeated for credit

Advanced seminar extends computer and analytic skills developed in the other subjects in this sequence into a research environment. Students present a structured discussion of a journal article representative of current research in Planning Decision Support Systems, and complete an approved short research project. Suggested research projects include topics related to ongoing research projects of the Computer Resource Laboratory.

*J. Ferreira, Jr., Q. Shen, M. Shiffer***11.525 New and Developing Technologies for Planners**

Prereq.: 11.227 and 11.228 or permission of instructor

G (Spring)

2-2-5 H-LEVEL Grad Credit

Students are familiarized with the changing technologies available for manipulating, organizing, and presenting visually-oriented electronic information for the description of urban environmental phenomena. Students are exposed to cases where these technologies have been used, or are in use, by planning-related agencies. Impacts of these technologies upon public debate and decision making are studied. Specific attention is paid to multimedia and communication technologies and how these have the ability to change the way people plan.

*M. Shiffer***11.526J Logistical and Transportation Planning Methods**

(Same subject as 1.203J, 6.281J, 13.665J, 15.073J, 16.76J)

Prereq.: 6.431, 15.075

G (Fall)

3-0-9 H-LEVEL Grad Credit

See description under subject 1.203J.

*A. I. Barnett, R. C. Larson, A. R. Odoni***Tutorials, Research, and Field Work Subjects****11.800 Doctoral Research Paper**

Prereq.: Permission of instructor

G (Fall, Spring)

3-0-9 H-LEVEL Grad Credit

Can be repeated for credit

Required subject for all entering Ph.D. students. Main focus is on formulating researchable questions. Designed to help students write their first-year papers.

*M. Schuster, M. Rein***11.900 Doctoral Proseminars**

Prereq.: Permission of instructor

G (Fall, Spring)

Units arranged H-LEVEL Grad Credit

Can be repeated for credit

Designed primarily for advanced doctoral candidates. A selection of Proseminars is offered each year for groups of students affiliated with the various research clusters in the Department.

B. Sanyal

11.901 Research Seminar: Topics in Urban Studies and Planning

Prereq.: Permission of instructor
 G (Fall)
 3-0-6 H-LEVEL Grad Credit
 Can be repeated for credit

11.902 Research Seminar: Topics in Urban Studies and Planning

Prereq.: Permission of instructor
 G (Spring)
 3-0-6 H-LEVEL Grad Credit
 Can be repeated for credit

Special research issues in urban planning, selected each term for special study. Open to graduate students with permission of instructor.
B. Sanyal

11.911, 11.912 Supervised Readings in Urban Studies

Prereq.: Permission of instructor
 G (Fall, Spring, Summer)
 Units arranged [P/D/F] H-LEVEL Grad Credit
 Can be repeated for credit

Reading and discussion of special topics in urban studies and planning.
P. Clay

11.921, 11.922 Special Seminars in Real Estate Development

Prereq.: —
 G (Fall, Spring)
 Units arranged H-LEVEL Grad Credit
 Can be repeated for credit

Opportunity for group study by graduate students on current topics related to real estate not otherwise included in the curriculum. Consult W. Wheaton.

11.932 Preparation for Thesis

Prereq.: —
 G (Fall, Spring, Summer)
 Units arranged [P/D/F] H-LEVEL Grad Credit
 Can be repeated for credit

Selection of thesis subject, definition of method of approach, and preparation of preliminary thesis outline. Independent study, supplemented by frequent individual conference with staff members. Restricted to doctoral candidates.

B. Sanyal

11.941–11.955 Special Studies in Urban Studies and Planning

Prereq.: —
 G (Fall, Spring)
 Units arranged H-LEVEL Grad Credit
 Can be repeated for credit

Small-group study of advanced subjects under staff supervision. For graduate students wishing to pursue further study in advanced areas of urban studies and city and regional planning not covered in regular subjects of instruction. 11.941 is taught P/D/F.

B. Sanyal

11.956–11.957 IAP Special Studies in Urban Studies and Planning

Prereq.: Permission of instructor
 G (IAP)
 Units arranged [P/D/F] H-LEVEL Grad Credit
 Can be repeated for credit

Planned subjects of instruction for use during IAP only.
B. Sanyal

11.958–11.959 IAP Special Studies in Urban Studies and Planning

Prereq.: Permission of instructor
 G (IAP)
 Units arranged H-LEVEL Grad Credit
 Can be repeated for credit

Planned subjects of instruction for use during IAP only.

B. Sanyal

11.960, 11.961 IAP Special Studies in Real Estate

Prereq.: —
 G (IAP)
 Units arranged [P/D/F]
 Can be repeated for credit

Planned subjects of instruction for use during IAP only.

W. Wheaton

11.962 Urban Fieldwork and Internships

Prereq.: Permission of instructor
 G (Fall, Spring)
 Units arranged [P/D/F] H-LEVEL Grad Credit
 Can be repeated for credit

Practical application of planning techniques to towns, cities, and regions, including problems of replanning, redevelopment, and renewal of existing communities. Includes internships, under staff supervision, in municipal and state agencies and departments.

J. Ferreira, Jr., G. Hack, L. C. Keyes, L. E. Susskind, J. Tendler

11.981 Graduate Tutorial

Prereq.: —
 G (Fall)
 Units arranged
 Can be repeated for credit

11.982 Graduate Tutorial

Prereq.: —
 G (Spring)
 Units arranged
 Can be repeated for credit

Planned programs of individual instruction. Students and faculty members must make arrangements prior to the beginning of the term.

B. Sanyal

11.ThG Graduate Thesis

Prereq.: —
 G (Fall, IAP, Spring, Summer)
 Units arranged H-LEVEL Grad Credit
 Can be repeated for credit

Program of graduate research and writing of thesis; to be arranged by the student with supervising committee.

Staff

12.006 Chaos and Complexity

Prereq.: 18.03, 8.02

U (Fall)

3-0-9

Introduction to the theory and phenomenology of nonlinear dynamics and chaos in dissipative systems. Forced and parametric oscillators. Phase space. Periodic, quasiperiodic, and aperiodic flows. Sensitivity to initial conditions and strange attractors. Lorenz attractor. Period doubling, intermittency, and quasiperiodicity. Universality. Analysis of experimental data: Fourier transforms, Poincaré sections, fractal dimension, and Lyapunov exponents. Applications drawn from fluid dynamics, physics, geophysics, and chemistry.

*D. H. Rothman***12.090 Special Topics in Earth, Atmospheric, and Planetary Sciences**

Prereq.: Permission of instructor

U (Fall, IAP, Spring)

Units arranged

Can be repeated for credit

12.091 Special Topics in Earth, Atmospheric, and Planetary Sciences

Prereq.: Permission of instructor

U (Fall, IAP, Spring)

Units arranged [P/D/F]

Can be repeated for credit

Laboratory or field work in earth, atmospheric, and planetary sciences. To be arranged with department faculty. Consult with department Education Office.

*EAPS Faculty***12.092 Special Topics in Geology and Geochemistry**

Prereq.: —

U (Fall, IAP, Spring)

Units arranged

Can be repeated for credit

12.093 Special Topics in Geology and Geochemistry

Prereq.: Permission of instructor

U (Fall, IAP, Spring)

Units arranged [P/D/F]

Can be repeated for credit

Laboratory or field work in geology and geochemistry. To be arranged with department faculty. Consult with department Education Office.

*EAPS Faculty***12.094 Special Topics in Geophysics**

Prereq.: Permission of instructor

U (Fall, IAP, Spring)

Units arranged

Can be repeated for credit

12.095 Special Topics in Geophysics

Prereq.: Permission of instructor

U (Fall, IAP, Spring)

Units arranged [P/D/F]

Can be repeated for credit

Laboratory or field work in geophysics. To be arranged with department faculty. Consult with department Education Office.

*EAPS Faculty***12.096 Special Topics in Atmospheric Science and Oceanography**

Prereq.: Permission of instructor

U (Fall, IAP, Spring)

Units arranged

Can be repeated for credit

12.097 Special Topics in Atmospheric Science and Oceanography

Prereq.: Permission of instructor

U (Fall, IAP, Spring)

Units arranged [P/D/F]

Can be repeated for credit

Laboratory or field work in atmospheric science and oceanography. To be arranged with department faculty. Consult with department Education Office.

*EAPS Faculty***12.098 Special Topics in Planetary Science**

Prereq.: Permission of instructor

U (Fall, IAP, Spring)

Units arranged

Can be repeated for credit

12.099 Special Topics in Planetary Science

Prereq.: Permission of instructor

U (Fall, IAP, Spring)

Units arranged [P/D/F]

Can be repeated for credit

Laboratory or field work in planetary science. To be arranged with department faculty. Consult with department Education Office.

*EAPS Faculty***Geology and Geochemistry****12.102 Environmental Earth Science**

Prereq.: —

U (Fall)

3-0-9 REST

The geologic record demonstrates that our environment has changed over a variety of time scales from seconds to billions of years. Subject explores the many ways in which geologic processes control and modify the Earth's environment. Topics include: chemical and physical interactions between the solid Earth, its oceans and atmosphere; the effect of catastrophic events such as volcanic eruptions and earthquakes on the environment; geologic hazards; and our role in modifying the environment through earth resource development. This subject serves as an introduction to subject 12.120, which addresses field applications of these principles in the American Southwest.

*S. A. Bowring, J. B. Southard***12.104 Geochemistry of the Earth and Planets**

Prereq.: 18.02

Acad Year 1996-97: U (Spring)

Acad Year 1997-98: Not offered

3-1-8

Focuses on the processes that create chemical variability in the solid and fluid earth, the moon, and meteorites. Includes nucleosynthesis, cosmochemistry, and basic geochemical concepts. Thermodynamics and phase equilibria are introduced and applied to problems of melting solid planetary interiors and the evolution of the earth's hydrosphere. Radiogenic and stable isotopic systems are used to document the timing of planetary formation and differentiation, formation, and evolution of volcanoes and continental crust, and to understand interactions between the solid and fluid earth.

*J. Edmond, F. A. Frey, T. L. Grove***12.108 Structure of Earth Materials**

Prereq.: —

Acad Year 1996-97: U (Fall)

Acad Year 1997-98: Not offered

3-4-5

Provides a comprehensive introduction to crystalline structure, crystal chemistry, and bonding in rock-forming minerals. Introduces the theory relating crystal structure and crystal symmetry to physical properties such as refractive index, elastic modulus, and seismic velocity. Surveys the distribution of silicate, oxide, and metallic minerals in the interiors and on the surfaces of planets and discusses the processes that led to their formation.

*B. Evans, T. L. Grove***12.109 Petrology**

Prereq.: 12.104, 12.108

Acad Year 1996-97: Not offered

Acad Year 1997-98: U (Fall)

3-6-3

Surveys the distribution, chemical composition, and mineral associations in rocks of the earth's crust and upper mantle, and establishes their relation to tectonic environment. Emphasis is on the use of chemistry and physics to interpret rock forming processes. Topics include: dynamics of crust and mantle melting as preserved in the chemical composition of igneous rocks and minerals, the long-term record of global climate change as preserved in the minerals of sedimentary rocks, and the time-temperature-depth record preserved in minerals of metamorphosed crustal rocks.

J. P. Grotzinger, T. L. Grove, K. V. Hodges

**12.110 Sedimentary Geology
(Revised Content)**

Prereq.: 12.001

Acad Year 1996-97: U (Spring)

Acad Year 1997-98: Not offered

3-3-6

Sediments in the rock cycle. Production of sediments at the Earth's surface. Physics and chemistry of sedimentary materials. Scale and geometry of near-surface sedimentary bodies, including aquifers. Sediment transport and deposition in modern sedimentary environments. Burial and lithification. Survey of major sedimentary rock types. Stratigraphic relationships of sedimentary basins. Evolution of sedimentary processes through geologic time. Two or three weekend days of field trips.

*J. B. Southard, J. P. Grotzinger***12.113 Structural Geology**

Prereq.: 12.001, 12.005

Acad Year 1996-97: Not offered

Acad Year 1997-98: U (Fall)

3-3-6

Introduces mechanics of rock deformation. Discusses recognition, interpretation, and mechanics of faults, folds, structural features of igneous and metamorphic rocks, and superposed deformations. Introduces regional structural geology and tectonics. Laboratory includes techniques of structural analysis, recognition and interpretation of structures on geologic maps, and construction of interpretive cross sections.

*B. C. Burchfiel***12.114 Field Geology I**

Prereq.: 12.108, 12.113, or permission of instructor

Acad Year 1996-97: Not offered

Acad Year 1997-98: U (Fall)

2-2-2

Introduces techniques of geological field study. Several weekend field exercises provide practical experience in preparation for 12.115.

Presents, in addition, introductory material on the regional geology of the locale of 12.115.

*B. C. Burchfiel, J. P. Grotzinger, K. V. Hodges, L. H. Royden***12.115 Field Geology II**

Prereq.: 12.113, 12.114

Acad Year 1996-97: Not offered

Acad Year 1997-98: U (IAP, Spring)

0-18-0 Institute LAB

During January, practices methods of modern geological field study during an intensive four-week excursion. Exercises include geological mapping on topographic and photographic base maps, correlating geochemical and geophysical field measurements with geology, examining and sampling a wide variety of geological features. Following term includes 1) preparation of reports based on field studies conducted during January, and 2) laboratory analysis of samples, interpretation of geological, geophysical, and geochemical data. 12 units may be applied to the General Institute Laboratory Requirement.

*B. C. Burchfiel, J. P. Grotzinger, K. V. Hodges, L. H. Royden***12.119 Analytical Techniques for Studying Environmental and Geologic Samples**

Prereq.: —

U (Spring)

2-6-4 Institute LAB

Focuses on analytical facilities that are used to determine elemental and isotopic abundances in soils, rocks, minerals, and fluids. Emphasis is on isotopic ratios Sr, Nd, and Pb, whose isotopic ratios can be used for age dating, and abundances of trace elements such as Rb, Sr, Cu, Cd, Hg, rare-earths, Pb, Th, and U. Analytical techniques include mass spectrometry, emission spectrometry, atomic absorption, neutron activation, and electron microprobe. A major lab project utilizes these techniques to address specific environmental and geologic problems. Each student generates a report that may be used to satisfy Phase II of the Writing Requirement.

*S. Bowring, E. Boyle, F. Frey, T. Grove***12.120 Environmental Earth Science Field Course**

Prereq.: 12.001 or 12.102

U (IAP)

1-5-0

Introduction to the methods of geologic mapping; practical experience in aspects of environmental geology such as selecting sites for hazardous waste disposal, hazard assessment in seismically and volcanically active areas, and in understanding the three-dimensional character of dissected alluvial deposits.

*S. Bowring***12.130 Structure of Geologic Aquifers**

(Subject meets with 12.465)

Prereq.: 12.110 or permission of instructor

Acad Year 1996-97: U (Fall)

Acad Year 1997-98: Not offered

3-3-6

Meets with graduate subject 12.465, but assignments differ. See description under 12.465.

*J. P. Grotzinger, J. B. Southard, C. J. Marone***12.141 Electron Microprobe Analysis**

Prereq.: —

U (IAP)

1-1-4 [P/D/F]

Introduction to theory of x-ray microanalysis through Electron Microprobe; lab sessions, including analysis of materials with hands-on use of the microprobe; analytical methods include energy and wavelength dispersive spectrometry and backscattered electron imaging.

*T. Grove, N. Chatterjee***12.159 Sedimentary and Surficial Geology Investigations
(New)**

(Subject meets with 12.459)

Prereq.: 12.110 or permission of instructor

U (Spring)

3-6-3

Can be repeated for credit

Meets with graduate subject 12.459, but assignments differ. See description under 12.459.

*J. P. Grotzinger, J. B. Southard, K. X. Whipple***12.163 Surface Processes and Landscape Evolution
(New)**

(Subject meets with 12.463)

Prereq.: 8.01; 18.03

U (Fall)

3-3-6

Meets with graduate subject 12.463, but assignments differ. See description under 12.463.

*K. X. Whipple***Geophysics****12.201 Essentials of Geophysics**

(Subject meets with 12.501)

Prereq.: 8.02, 18.03

U (Fall)

4-0-8

See description under subject 12.501.

*R. D. van der Hilst***12.213 Alternate Energy Sources**

Prereq.: —

U (IAP)

1-4-1 [P/D/F]

Can be repeated for credit

Explores a number of alternative energy sources such as geothermal energy (heat from the Earth's interior), wind, natural gas, and solar energy. Includes a field trip to visit sites where alternative energy is being harvested or generated. Content and focus of subject varies from year to year.

*M. N. Toksöz, F. D. Morgan***12.214 Environmental Geophysics**

(Subject meets with 12.507)

Prereq.: 18.03

U (Spring)

3-3-6

Meets with graduate subject 12.507, but assignments differ. See description under subject 12.507.

*F. D. Morgan***12.215 Modern Navigation**

Prereq.: —

U (Fall)

3-1-8

Introduces the concepts and applications of navigation techniques using celestial bodies and satellite positioning systems such as the Global Positioning System (GPS). Topics include astronomical observations, radio navigation systems, the relationship between conventional navigation results and those obtained from GPS, and the effects of the security systems, Selective Availability, and anti-spoofing on GPS results. Laboratory sessions cover the use of sextants, astronomical telescopes, and field use of GPS. Application areas covered include ship, automobile, and aircraft navigation and positioning, including very precise positioning applications.

T. A. Herring

12.221 Geophysical Applications of the Global Positioning System

Prereq.: —

U (IAP)

1-4-1 [P/D/F]

Introduction to the science of accurate determination of a position on Earth using radio signals from satellites, or the Global Positioning System (GPS). Uses GPS to address, specifically, earthquake risk and prediction. Includes a field trip of three to four days duration.

*T. A. Herring, B. H. Hager, R. King***Meteorology and Oceanography****12.300 Global Change Science**

Prereq.: 18.03; 5.60

U (Fall)

3-0-9

Introduces the basic relevant principles and concepts in atmospheric chemistry and physics, climate dynamics, biogeochemistry, and environmental policy making, through an examination of two current problems in the global environment: 1) carbon dioxide and global warming, and 2) chlorofluorocarbons and ozone. An introduction to global environmental problems for students in basic sciences and engineering.

*R. G. Prinn, P. H. Stone***12.301 Past and Present Climate**

(Subject meets with 12.840)

Prereq.: 8.02

U (Spring)

3-0-9

Meets with graduate subject 12.840, but assignments differ. See description under subject 12.840.

*R. E. Newell***12.305 Global Atmospheric Pollution**

Prereq.: 8.02

U (Fall)

2-0-4

Increasing industrial activity and biomass burnings have produced pollution patterns now detectable world-wide. In 1996-97, subject concentrates on material reaching the atmosphere from Pacific Rim countries and measured over the Pacific from specially instrumented aircraft in 1991, 1994, and 1996.

Space shuttle measurements on global carbon monoxide also discussed. Atmospheric and oceanic structure necessary to understand the transport processes and photochemical sources and sinks of constituents, which in some cases provide natural removal processes, is presented. Students examine possible sources, including fossil fuel use, volcanic activity, biomass burning, and oceanic biosphere.

*R. E. Newell***12.310 An Introduction to Weather Forecasting**

Prereq.: 8.01, 18.01

U (IAP)

1-1-4 [P/D/F]

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***12.311 Experimental Oceanography**

Prereq.: —

U (IAP)

2-2-2 [P/D/F]

Can be repeated for credit

An intensive introduction to the experimental aspects of oceanography, specifically in the areas of marine geology and geophysics, physical oceanography, and chemical oceanography. Includes participation in a research cruise. Content varies from year to year.

*M. McNutt, J. Marshall, J. Edmond, WHOI Staff***12.312 Climate System Computer Lab**

Prereq.: —

U (IAP)

0-2-4 [P/D/F]

Introduction to climate dynamics and the hands-on use of computer simulation models; investigation of the interaction between atmosphere, oceans, ice, and carbon cycle; applications include greenhouse effect and ice age onset.

*J. Marotzke***12.313 Climate Change: Past, Present, and Future**

Prereq.: —

U (IAP)

2-0-4 [P/D/F]

The human race is now a significant factor influencing global changes in the Earth's environment and climate. Subject provides a historical (as in geological) context within which to think about global climate change. Covers the entire spectrum of climate variations, from the formation of the Earth's early atmosphere 4.6 billion years ago, to the ice ages, to the role of CO₂ variations in natural climate change, to temperature trends in this century.

*M. E. Raymo***12.320J Introduction to Hydrology**

(Same subject as 1.71J)

Prereq.: 1.03, 1.05, or equivalents

U (Fall)

3-0-9

See description under subject 1.71J.

*D. Entekhabi***12.330J Fluid Physics**

(Same subject as 8.292J)

Prereq.: 8.044 or 5.60 or permission of instructor

U (Spring)

3-0-9

A physics-based introduction to the properties of fluids and fluid systems, with examples drawn from a broad range of sciences. Definitions of fluids and the notion of continuum. Equations of state and continuity; conservation of momentum; the stress tensor; ideal fluids and Euler's equation; viscosity and Navier-Stokes equation. Hydrostatics and magnetohydrodynamics. Energy considerations, fluid thermodynamics, and isentropic flow. Compressible vs incompressible and rotational vs irrotational flow; Bernoulli's theorem; steady flow and streamlines. Circulation and vorticity. Thomson's theorem. Boundary layers. Fluid waves and instabilities.

*K. Emanuel, P. Joss***12.331 Fluid Dynamics of the Atmosphere and Ocean**

(Subject meets with 12.800)

Prereq.: 8.03, 18.04

U (Fall)

3-0-9

See description under subject 12.800.
*J. Marshall***12.332 Wave Motions in the Ocean and Atmosphere**

(Subject meets with 12.802)

Prereq.: 12.331

U (Spring)

3-0-9

See description under subject 12.802.
*C. Wunsch***12.333 Atmospheric and Ocean Circulation**

Prereq.: 12.003

U (Spring)

3-0-9

Survey of atmospheric and oceanic phenomena including the discussion of observations and theoretical interpretations. Topics covered include: monsoons; El Niño; planetary waves; atmospheric synoptic eddies and fronts; gulf stream rings; hurricanes; surface and internal gravity waves; tides; the stratosphere and ozone.

R. A. Plumb

12.335 The Ocean in Climate: Physics and Chemistry

Prereq.: 18.03, 5.60, or equivalents

U (Fall)
3-0-9

Provides the background in physical and chemical oceanography necessary to discuss climate problems in light of modern oceanic knowledge. Observations of the ocean and their physical interpretation in terms of turbulent flow. Implications of recent progress in general circulation modeling. Oceanic carbon system and global carbon cycle: chemical equilibrium, biological/nutrient controls, radioactive and stable carbon isotopes. Introduction to chemical modeling. Fate of fossil fuel CO₂. Past variability of circulation and carbon system from ice and sediment cores. Intended for advanced undergraduates and beginning graduates.

*E. Boyle, C. Wunsch***12.337 Tropical Meteorology**

(Subject meets with 12.811)

Prereq.: 12.331
U (Spring)
3-0-9

See description under subject 12.811.
R. A. Plumb

12.338 Introduction to Atmospheric Data and Synoptic Meteorology

(Revised Units)

(Subject meets with 12.818)

Prereq.: 12.003 and 12.330J or 12.331
U (Spring)
3-3-6

See description under subject 12.818.
L. Illari, E. Chang

12.340J Atmospheric Chemistry

(Subject meets with 5.23J, 5.68)

Prereq.: 5.60
U (Spring)
3-0-9

Describes the principles that govern the chemical behavior of terrestrial and planetary atmospheres. Reviews chemical reactions and biogeochemical cycles that control the abundance of trace species in the troposphere and stratosphere. Emphasis is placed on the potentially damaging effects of human activity on the chemical balance of the atmosphere. Covers stratospheric ozone depletion, regional and local photochemical smog, and greenhouse gases.

M. J. Molina, J. I. Steinfield

Course includes case studies involving atmospheric and stratospheric ozone depletion, and other applications of photochemistry for environmental processes, including continental haze, continental pollution, and sources of building materials will be an increasing theme. Tutorials and continents processes using specific examples from around the world.

*S. O. Banday, J. H. Haynes***Planetary Science and Astronomy****12.400 The Solar System**

Prereq.: 8.01

U (Fall)
3-0-9 REST

Introduction to the study of the solar system with emphasis on the latest spacecraft results. Subject covers basic principles rather than detailed mathematical and physical models. Topics include an overview of the solar system, planetary orbits, rings, planetary formation, meteorites, asteroids, comets, planetary surfaces and cratering, planetary interiors, planetary atmospheres, and life in the solar system.

*R. P. Binzel***12.401 Beyond the Solar System**

Prereq.: —

U (Spring)
2-2-5

Our solar system's place in the universe and how we know it, taught by a combination of conventional lectures and hands-on work with small telescopes and computers. The formation, evolution, and death of stars and galaxies. The origins of the chemical elements. Quasars and black holes. Radiation and gravitation. Relativity and cosmology. The physics of modern astronomical observations.

*C. C. Counselman***12.409 Hands-On Astronomy: Observing Stars and Planets**

(New)

Prereq.: —

U (Fall)
0-6-0 [P/D/F]

Background for and techniques of visual observation, astrophotography, electronic imaging, and spectroscopy of the Moon, planets, satellites, stars, and brighter deep-space objects. Weekly observing sessions using 8-inch diameter telescopes outdoors when weather permits. Indoor sessions introduce needed skills. Introduction to contemporary observational astronomy including astronomical computing, image and data processing, and how astronomers work. Student must maintain a careful and complete written log which is graded. (Limited enrollment. Consumes an entire evening each week; attendance mandatory.)

*C. C. Counselman, S. Slivan***12.410J Observational Techniques of Optical Astronomy**

(Same subject as 8.287J)

Prereq.: One subject in Astronomy or Astrophysics
U (Fall)
2-4-6 Institute LAB

Fundamental physical and optical principles used for astronomical measurements at visible wavelengths and practical methods of astronomical observations. Topics: astronomical coordinates, time, geometrical optics, telescopes, photon counting, signal-to-noise ratios, data analysis (including least-squares model fitting), limitations imposed by the Earth's atmosphere on optical observations, CCD, photometry, spectroscopy, and time variability. Project at Wallace Astrophysical Observatory.

*J. L. Elliott***12.411 Astronomy Field Camp**

Prereq.: 12.410J or 8.287J

U (IAP)
0-6-3 [P/D/F]
Can be repeated for credit

Supervised research at Lowell Observatory in Flagstaff, Arizona. Individual projects using the Lowell 1.1 meter and 1.8 meter telescopes. Extensive data analysis. Written report required. Enrollment limited.

*J. L. Elliott***12.412 Advanced Astronomical Techniques**

Prereq.: 12.410J or 8.287J; permission of instructor

Acad Year 1996-97: Not offered
Acad Year 1997-98: U (Spring)
3-0-9

Can be repeated for credit

Students learn advanced astronomical techniques such as image processing of data obtained with charged-coupled device (CCD) detectors and are responsible for developing and carrying out a short-term research project. The primary tool is the IRAF image analysis software package developed by the National Optical Astronomical Observatories. Regular seminar meetings introduce image-processing techniques and include discussion of the progress of research projects. Requires a written report on the project.

*R. P. Binzel***12.421 Exploration of the Solar System**

Prereq.: 8.03; 12.004

Acad Year 1996-97: U (Spring)
Acad Year 1997-98: Not offered
3-0-9

Spacecraft and Earth-based remote sensing techniques used to study the Earth and other planets, satellites, rings, minor planets, and comets. Techniques covered include ultraviolet, optical, and infrared photometry; radar; stellar and radio occultations; spectroscopy, and *in situ* measurements. Recent results from spacecraft emphasized.

R. P. Binzel, J. L. Elliott, C. C. Counselman

Graduate Subjects

12.ThG Graduate Thesis

Prereq.: Permission of instructor
G (Fall, Spring, Summer)
Units arranged H-LEVEL Grad Credit
Can be repeated for credit

Program of graduate research, leading to the writing of an S.M., Ph.D., or Sc.D. thesis; to be arranged by the student and an appropriate MIT faculty member.

Consult Department Headquarters.

Geology and Geochemistry

12.450 Seminar in Geology and Geochemistry

Prereq.: Permission of instructor
Acad Year 1996-97: G (Spring)
Acad Year 1997-98: Not offered
2-0-4 [P/D/F] H-LEVEL Grad Credit
Can be repeated for credit

Seminar on topics of current interest in geology and geochemistry. Required background preparation for students taking pre-doctoral general examinations in these subjects.

T. L. Grove

12.451 Seminar in Regional Tectonics

Prereq.: Permission of instructor
G (Fall, Spring)
3-0-6 [P/D/F] H-LEVEL Grad Credit
Can be repeated for credit

Applies techniques of tectonic synthesis to study the roles of particular orogenic belts in global plate tectonics. Treats different applications in different terms, so that the subject may be taken repeatedly to learn the range of orogenic responses to temporal and spatial variations of activity at plate boundaries.

B. C. Burchfiel, J. P. Grotzinger, K. V. Hodges, L. H. Royden

12.452 Mechanics of Sedimentary Processes

Prereq.: Permission of instructor
Acad Year 1996-97: Not offered
Acad Year 1997-98: G (Spring)
3-0-9 H-LEVEL Grad Credit

Aspects of turbulent-flow mechanics relevant to sediment movement. Mechanics of sediment erosion, transportation, and deposition: modes of particle entrainment and motion in turbulent shear flows; sediment-bed configurations; erosion and deposition of cohesive sediments. Sediment gravity flows; sorting of sediments by particle size and density. Interpretation of primary structures and textures in modern and ancient sedimentary deposits on the basis of sediment-transportation mechanics.

J. B. Southard

12.453 Crosby Lectures in Geology

Prereq.: Permission of instructor
G (Fall, Spring)
3-0-6 [P/D/F] H-LEVEL Grad Credit
Can be repeated for credit

A series of presentations on an advanced topic in the field of geology by the visiting William Otis Crosby lecturer. The Crosby lectureship is awarded to a distinguished international scientist each year to introduce new scientific perspectives to the MIT community. Subject content and structure vary from year to year.

Consult Department Headquarters for additional information.

12.455 Megascopic Strain Analysis in Orogenic Belts

Prereq.: 12.113
Acad Year 1996-97: G (Fall)
Acad Year 1997-98: Not offered
3-0-6 H-LEVEL Grad Credit

Introduction to modern techniques used to estimate the magnitude of strain in orogenic belts. Emphasis on megascopic strain analysis. Includes 1) methods of determining sense of shear in various structural settings; 2) the construction of 2D-balanced structural sections; 3) the construction of 3D structural sections; and 4) graphical reconstruction of 2D and 3D sections to pre-deformational configurations.

K. V. Hodges

12.456 Seminar in Rock Mechanics

Prereq.: Permission of instructor
G (Fall, Spring)
2-0-4 [P/D/F] H-LEVEL Grad Credit
Can be repeated for credit

Discussion of current research or advanced topics in continental tectonics, rock mechanics, or experimental structural geology.

B. Evans

12.457 Sedimentary Basins

Prereq.: 18.03, 12.113
Acad Year 1996-97: G (Spring)
Acad Year 1997-98: Not offered
3-0-6 H-LEVEL Grad Credit

Formation and evolution of basin systems in continental crust (including passive continental margins, foredeep accretionary basins, back-arc type basins, intraplate rifts, etc.) are examined with regard to tectonic settings, structural and sedimentary features, and deep lithospheric processes. Case studies of several sedimentary basins of each type.

L. H. Royden, J. P. Grotzinger

12.459 Sedimentary and Surficial Geology Investigations

(Revised Content)

(Subject meets with 12.159)
Prereq.: Permission of instructor
G (Spring)
3-6-3 H-LEVEL Grad Credit
Can be repeated for credit

In-depth examination of modern and ancient depositional systems, Earth-surface landforms, and surficial processes, utilizing concepts of process sedimentology and geomorphology, sequence stratigraphy, and sedimentary basin analysis.

J. P. Grotzinger, J. B. Southard, K. X. Whipple

12.460–12.461 Special Problems in Geology-Geochemistry

Prereq.: Permission of instructor
G (Fall, Spring, Summer)
Units arranged [P/D/F] H-LEVEL Grad Credit
Can be repeated for credit

For graduate students desiring to perform special investigations, special laboratory work, or special fieldwork in geology, petrology, mineralogy or geochemistry. 12.460 is letter-graded.

Geology and Geochemistry Staff

12.463 Surface Processes and Landscape Evolution

(New)

(Subject meets with 12.163)
Prereq.: 8.01; 18.03
G (Fall)
3-3-6

Examines the interaction of climate, tectonics, and surface processes in the sculpting of the Earth's surface. Quantitative introduction to mechanics of fluvial, hillslope, and glacial processes. Essentials of weathering, soil formation, runoff, erosion, slope stability, sediment transport, river morphology, glacial erosion, and volcanism. System responses to climatic and tectonic forcings, including: glaciation, sea level change, uplift, subsidence, and post-glacial isostatic rebound. Additional instruction in: computer modeling in the study of surface processes, image analysis, and GIS applications in surface hydrology and slope stability.

K. X. Whipple

**12.465 Structure of Geologic Aquifers
(New)**

(Subject meets with 12.130)
Prereq.: 12.110 or permission of instructor
Acad Year 1996-97: G (Fall)
Acad Year 1997-98: Not offered
3-3-6 H-LEVEL Grad Credit

Intended for earth scientists and engineers who require a knowledge of the structure and complexity of shallow to deeply-buried sedimentary aquifers. Content focuses on the analysis of depositional systems and facies and architecture; the nature and origin of geometry and scales of vertical and lateral inhomogeneity; reconstruction of sedimentary basins and their interpretation; quantitative methods of spatial and temporal correlation; numerical forward modeling and use of simulation in characterization of aquifer geometry. Two field trips explore unconsolidated as well as lithified sediments.

J. P. Grotzinger, J. B. Southard, C. J. Marone

**12.467 Seminar in Geomorphology
(New)**

Prereq.: Permission of instructor
G (Spring)
2-0-4 H-LEVEL Grad Credit
Can be repeated for credit

Discussion of current research or advanced topics in landscape evolution, surface hydrology, mechanics of sediment transport, basin analysis, or experimental geomorphology. Advanced instruction in process geomorphology.

K. X. Whipple

12.474 Origin and Evolution of the Earth's Crust

Prereq.: Permission of instructor
Acad Year 1996-97: Not offered
Acad Year 1997-98: G (Spring)
3-0-6 H-LEVEL Grad Credit

Broad overview of the origin and evolution of Earth's crust and mantle with emphasis on the study of the Precambrian rock record. Topics include: processes of crustal growth, stabilization, and reactivation; evaluation of secular change; and use of radiogenic isotopes in geochronology and as tracers of crust forming processes.

S. Bowring

12.475 Global Plate Tectonics

Prereq.: Permission of instructor
Acad Year 1996-97: G (Spring)
Acad Year 1997-98: Not offered
3-0-6 H-LEVEL Grad Credit

First half covers basic elements of plate tectonics, including sea floor spreading, magnetic anomalies, and subduction zone. Second half covers implications of plate tectonics for continental processes, including continental rifting, continental collision, and mountain building. Emphasis will be on correlating plate tectonic and continental processes using specific examples from around the world.

B. C. Burchfiel, L. H. Royden

12.476 Radiogenic Isotope Geology

Prereq.: Permission of instructor
G (Spring)
3-0-9 H-LEVEL Grad Credit

Applications of the variations in the relative abundance of radiogenic isotopes to problems of petrology, geochemistry, and tectonics. Topics: geochronology; isotopic evolution of earth's crust and mantle, petrogenesis, analytical techniques.

S. Bowring

12.478 Pressure-Temperature-Time Evolution of Orogenic Belts

Prereq.: 3.01 or 5.60; 12.109, 18.03
Acad Year 1996-97: Not offered
Acad Year 1997-98: G (Fall)
3-0-6 H-LEVEL Grad Credit

Multidisciplinary introduction to modern techniques used to analyze burial and uplift histories of metamorphic terrains. Includes 1) geochronologic systems; 2) closure temperature theory and the use of geochronologic systems as thermochromometers; 3) geothermometry and geobarometry; 4) thermodynamic modeling of P-T paths; 5) thermal structure of orogenic belts, with emphasis on characteristic length scales and time scales for thermal events; 6) geophysical analysis of burial and uplift trajectories for metamorphic terrains.

K. V. Hodges, L. H. Royden

12.479 Trace-Element Geochemistry

Prereq.: Permission of instructor
Acad Year 1996-97: Not offered
Acad Year 1997-98: G (Fall)
3-0-9 H-LEVEL Grad Credit

Focuses on element distribution in rocks and minerals using data obtained from natural and experimental systems. Emphasizes models describing trace-element partitioning and applications of trace-element geochemistry to problems in igneous geology.

F. A. Frey

12.480 Advanced Igneous Petrology

Prereq.: 5.60 or 3.00
Acad Year 1996-97: G (Spring)
Acad Year 1997-98: Not offered
3-3-6 H-LEVEL Grad Credit

Thermodynamics, experimental phase equilibria, and kinetics combined to infer the physical conditions of igneous rock crystallization and magma production. Uses results of experimental studies to constrain processes that control magma genesis and give rise to the diversity of igneous rocks. Discusses theoretical approaches to thermometry-barometry techniques involving solid/solid and mineral/liquid reactions, kinetic controls on crystallization, and properties of silicate melts.

T. L. Grove

12.481 Advanced Field Geology I

Prereq.: 12.108, 12.113, 12.114, 12.115
Acad Year 1996-97: G (Fall)
Acad Year 1997-98: Not offered
2-2-2 H-LEVEL Grad Credit
Can be repeated for credit

Introduction to the problems to be investigated in 12.482, as well as the regional setting and local geology of the field area. Various special techniques may be introduced and preparatory investigations may be conducted that are specific to the area to be studied in 12.482.

B. C. Burchfiel, J. P. Grotzinger, K. V. Hodges, L. H. Royden

12.482 Advanced Field Geology II

Prereq.: 12.481
Acad Year 1996-97: G (IAP, Spring)
Acad Year 1997-98: Not offered
Units arranged H-LEVEL Grad Credit
Can be repeated for credit

In January, a geological study of a selected field area is conducted during a four-week excursion. The following term includes 1) preparation of maps and report based on field study conducted in January, and 2) laboratory analysis of samples.

B. C. Burchfiel, J. P. Grotzinger, K. V. Hodges, L. H. Royden

12.484 Directed Field Studies

Prereq.: Permission of instructor
G (IAP)
0-6-0
Can be repeated for credit

Intensive training in field geological methods. Includes specific exercises selected to complement the backgrounds of the students enrolled and provides supervised experience in applying field analytical techniques to geological problems. Cannot be taken as a substitute for 12.115.

K. V. Hodges, B. C. Burchfiel

12.485 Advanced Directed Field Studies

Prereq.: 12.484
G (IAP)
0-6-0
Can be repeated for credit

Continuation of 12.484. Designed to provide more advanced training in specific field geological methods. Can be taken during the same IAP period as 12.484.

K. V. Hodges, B. C. Burchfiel

12.490-12.491 Advanced Seminar in Geology and Geochemistry

Prereq.: Permission of instructor
G (Fall, Spring)
Units arranged [P/D/F] H-LEVEL Grad Credit
Can be repeated for credit

Problems of current interest in geology and geochemistry. Subject matter varies from term to term. 12.490 is letter-graded.

Geology and Geochemistry Staff

Geophysics

12.501 Essentials of Geophysics

(Subject meets with 12.201)

Prereq.: 8.02, 18.03

G (Fall)

4-0-8 H-LEVEL Grad Credit

Overview of basic topics in solid-earth geophysics, such as the Earth's rotation, precessions and wobble, gravity and magnetic fields, seismology, and thermal structure. Formulation of physical principles presented in three 1-hour lectures per week. Current applications discussed in an additional 1-hour tutorial each week.

R. D. van der Hilst

12.507 Environmental Geophysics (New)

(Subject meets with 12.214)

Prereq.: 18.03

G (Spring)

3-3-6

Introduction to basic geophysical methods that can be used for environmental site characterization and shallow geological investigations. Techniques include seismic, electrical, and electromagnetic sounding; ground-penetrating radar, magnetics, gravity, and borehole geophysics. Lectures emphasize basic principles and a physical understanding of the geophysical methods with environmental applications in mind. Some specific case histories are included. A few weekends of field measurements at representative local sites are included. A weekly lab session covers modeling and interpretation of geophysical field data.

F. D. Morgan

12.509 Earthquakes and Faulting

Prereq.: 12.005, 18.03

Acad Year 1996-97: Not offered

Acad Year 1997-98: G (Spring)

3-0-9 H-LEVEL Grad Credit

Multidisciplinary introduction to the principles of fault and earthquake mechanics. Overview of brittle fracture, macroscopic failure criteria, effective stress laws, friction laws. Fault mechanics. Fault development and the state of stress, fault nucleation, and growth. Fault rocks and structures, the strength and rheology of faults. Seismotectonics. Introduction to the physics of earthquake rupture. Instability conditions, dynamic energy balance, quantification of earthquakes, earthquake source parameters and scaling laws. The seismic cycle, earthquake prediction.

C. J. Marone

12.510 Elements of Seismology

Prereq.: 18.075 or 18.085

G (Fall)

3-1-8 H-LEVEL Grad Credit

A basic subject in seismology and the utilization of seismic waves for the study of the Earth's interior. Introduces techniques necessary for understanding of elastic wave propagation in layered media. Seismic-ray theory and interpretation of travel times. Surface-wave dispersion and layered media. Seismicity, earthquake magnitude, moment, and source properties.

M. N. Toksöz

12.511 Low-Frequency Seismology

Prereq.: 8.033, 18.076

Acad Year 1996-97: G (Spring)

Acad Year 1997-98: Not offered

3-0-9 H-LEVEL Grad Credit

Seismological theory and methods based on the representation of the displacement field as a superposition of normal modes. Equations of motion; Rayleigh's Principle; perturbation theory; attenuation. Excitation formulae; the inverse problem of source structure. Traveling-wave representation; asymptotic expansions; surface and body waves. Free oscillations of a rotating, laterally heterogeneous earth; the inverse problem for 3-D Earth structure.

T. H. Jordan

12.512 High-Frequency Seismology

Prereq.: 8.033, 18.076

Acad Year 1996-97: Not offered

Acad Year 1997-98: G (Spring)

3-0-9 H-LEVEL Grad Credit

Seismological theory and methods based on high-frequency approximations to transient displacement fields. Elastodynamic equations; representation theorems; moment-tensor representation; radiation patterns. Propagator and reflectivity methods; WKBJ and Langer approximations. Ray theory; Fermat's Principle; travel-time curves for spherically symmetric media. Radon transforms; inversion of travel times for Earth structure; seismic tomography.

T. H. Jordan

12.515 Data Analysis: Model Parameter Estimation

Prereq.: 18.075 or 18.085

G (Fall)

3-0-9 H-LEVEL Grad Credit

Surveys a number of methods of inverting data to obtain model parameter estimates. Topics include review of matrix theory and statistics, random and grid-search methods, linear and non-linear least squares, maximum-likelihood estimation, ridge regression, stochastic inversion, sequential estimation, singular value decomposition, solution of large systems, genetic and simulated annealing inversion, regularization, parameter error estimates, solution uniqueness and resolution. Students are required to develop the appropriate algorithms on the computer.

F. D. Morgan

12.517 Dynamics of Complex Physical Systems

Prereq.: 18.03, 8.02

G (Spring)

3-0-9 H-LEVEL Grad Credit

An introduction to theoretical studies of natural systems of many interacting components, the individual dynamics of which may be simple, but the collective dynamics of which are complex. Topics include scaling, fractals, percolation theory, surface growth, cellular automata. Methods for obtaining macroscopic dynamics from microscopic interactions. Applications to problems of geological/geophysical interest: interfacial and other complex flows, geomorphology and other aspects of natural pattern formation, dynamical aspects of rock physics.

D. H. Rothman

12.518J Sonar, Radar and Seismic Signal Processing I

(Same subject as 13.741J, 6.455J)

Prereq.: 2.02 or 2.003 or 6.003, 6.041, 18.075 or 18.085

G (Fall)

3-0-9 H-LEVEL Grad Credit

See description under subject 13.741J.

A. B. Bagheroer, J. R. Fricke

12.519J Sonar, Radar and Seismic Signal Processing II

(Same subject as 13.742J, 6.456J)

Prereq.: 13.741J

G (Spring)

3-1-8 H-LEVEL Grad Credit

See description under subject 13.742J.

A. B. Bagheroer, J. R. Fricke

12.520 Geodynamics

Prereq.: 12.005; 18.075 or 18.085

G (Fall)

3-0-9 H-LEVEL Grad Credit

Mechanics of deformation of the crust and mantle, with emphasis on the importance of different rheological descriptions. Coupling between mantle convection and crustal deformation.

B. H. Hager

12.522 Geological Fluid Mechanics

Prereq.: 8.03; 18.076 or 18.085

G (Fall)

3-0-9 H-LEVEL Grad Credit

Treats heat transfer and fluid mechanics in the Earth. Low Reynolds number flows, convection instability, and 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, and the mantle convection problem.

(Woods Hole Staff): J. A. Whitehead

12.524 Mechanical Properties of Rocks

Prereq.: 8.03, 18.03

Acad Year 1996-97: G (Fall)

Acad Year 1997-98: Not offered

3-0-9 H-LEVEL Grad Credit

A survey of the mechanical behavior of rocks in natural geologic situations. Topics: brief survey of field evidence of rock deformation, physics of plastic deformation in minerals, brittle fracture and sliding, and pressure-solution processes. Results of field petrologic and structural studies compared to data from experimental structural geology.

*B. Evans***12.533 Rock Physics**

Prereq.: Permission of instructor

G (Spring)

3-3-6 H-LEVEL Grad Credit

Fundamentals of experimental and theoretical rock physics taught at an advanced level.

Rocks viewed as complex composite media with behavior dependent both on the physical and chemical properties of the constituent phases, and on their geometries. Electrical, fluid transport, and seismic properties covered in detail. Other topics such as magnetic, mechanical, and thermal responses briefly discussed. Weekly laboratory.

*F. D. Morgan***12.540 Principles of Global Positioning System**

Prereq.: 8.01, 18.02, 18.06

Acad Year 1996-97: Not offered

Acad Year 1997-98: G (Spring)

3-1-8 H-LEVEL Grad Credit

The principles and applications of the Global Positioning System (GPS) and other space geodetic systems, including very-long-baseline interferometry (VLBI) and satellite laser ranging (SLR). The nature and uses of the course acquisition (CA), the precise positioning (P) codes, and the differential carrier phase observable. Techniques for estimating geodetic and geophysical quantities from these data. Other topics include: atmospheric refraction modeling, effects of Selective Availability (SA), estimation techniques (including Kalman filtering). Statistical and spectral analysis of data.

T. A. Herring

Prereq.: Permission of instructor

G (Fall, Spring, Summer)

Units arranged [P/D/F] H-LEVEL Grad Credit Can be repeated for credit

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

*Geophysics Staff***12.550 Geosystems I (New)**

Prereq.: 8.02, 18.03, and permission of instructor

G (Fall)

3-3-9 H-LEVEL Grad Credit

Modeling of complex systems in all areas of geoscience, with emphasis on general theoretical principles and numerical tools for describing system behaviors. Subject matter organized into a sequence of teaching modules, each focusing on a specific geosystem. Lectures introduce key physical and chemical processes that operate within each geosystem. Laboratory sessions include the use of simple table-top and computer-based models, as well as introductions to advanced numerical simulations, with a strong focus on scientific inference through numerical experimentation.

*T. H. Jordan, J. Marotzke***12.551 Geosystems II (New)**

Prereq.: 12.550

G (Spring)

3-3-9 H-LEVEL Grad Credit

Continuation of Geosystems I (2 semester sequence)

*T. H. Jordan, J. Marotzke***12.560-12.561 Special Seminar in Exploration Geophysics**

Prereq.: Permission of instructor

G (Fall, IAP, Spring)

2-0-4 [P/D/F] H-LEVEL Grad Credit

Can be repeated for credit

Advanced seminar focusing on areas of current interest in exploration geophysics and seismology. Taught by visiting lecturers.

12.560 is letter-graded.

*Geophysics Staff***12.563 Seminar in Earthquake Source Physics (New)**

Prereq.: Permission of instructor

Acad Year 1996-97: G (Spring)

Acad Year 1997-98: Not offered

2-0-4 [P/D/F] H-LEVEL Grad Credit

Can be repeated for credit

Theoretical models, laboratory data, and seismic observations relevant to earthquake source physics. Topics include: earthquake nucleation, dynamic rupture processes, instability criteria and the transition from quasi-static to dynamic rupture, the influence of fault zone rheology on source processes, fracture mechanics and friction. This is a reading seminar. Participants read, discuss, and critically analyze papers from the literature. Detailed focus varies from year to year.

C. Marone

Geophysics Staff

12.570-12.571 Seminar in Geophysics

Prereq.: Permission of instructor

G (Fall, IAP, Spring)

Units arranged [P/D/F] H-LEVEL Grad Credit Can be repeated for credit

Problems of current interest in geophysics; subject matter varying from term to term.

12.570 is letter-graded.

*Geophysics Staff***12.580-12.581 Special Problems in Geophysics**

Prereq.: Permission of instructor

G (Fall, Spring, Summer)

Units arranged [P/D/F] H-LEVEL Grad Credit Can be repeated for credit

For graduate students desiring to perform special investigations, special laboratory work, or special fieldwork in geophysics. 12.580 is letter-graded.

*Geophysics Staff***Planetary Science****12.601 Essentials of Planetary Science**

Prereq.: 8.03, 18.03

G (Fall)

3-0-9 H-LEVEL Grad Credit

Reviews fundamental physical concepts pertaining to the study of the solar system, and highlights recent spacecraft results. Topics include: meteorites, orbital dynamics, asteroids, impact craters, surfaces, atmospheres, atmospheric dynamics, interiors, magnetospheres, rings, comets, formation of the solar system.

*T. Dowling***12.602 Asteroids and Small Bodies**

Prereq.: 8.02, 18.03

Acad Year 1996-97: G (Spring)

Acad Year 1997-98: Not offered

3-0-9 H-LEVEL Grad Credit

Introduction to the study of asteroids and the ground-based and space-based techniques used to explore them. Topics include asteroid orbital properties, surface structure, physical properties, classifications, as well as their origin, thermal and collisional evolution, and interrelationships with meteorites and comets. Subject also covers the near-earth asteroids, the probabilities and consequences of terrestrial collisions, and the possible utilization of asteroids as space resources.

R. P. Binzel

Geophysics Staff

12.603 Solar System Dynamics

Prereq.: Permission of instructor
 Acad Year 1996-97: **Not offered**
 Acad Year 1997-98: G (Fall)
 3-0-9 H-LEVEL Grad Credit
 Can be repeated for credit

Introduction to chaotic behavior in conservative systems, with examples drawn primarily from the rotation and orbital dynamics of planets and satellites. Includes surfaces of section, Lyapunov exponents, perturbation theory, KAM theorem, resonances, onset of chaos, double pendulum, Henon-Heiles problem, restricted three-body problem, spin-orbit coupling, orbital resonances, adiabatic invariants, adiabatic chaos, tidal evolution, capture into resonance, stability of the solar system.

J. Wisdom

12.611 Advanced Planetary Observations

Prereq.: Permission of instructor
 G (IAP)
 0-6-3 [P/D/F] H-LEVEL Grad Credit
 Can be repeated for credit

Astronomical observations involving several techniques are carried out at a major observatory, with focus on a particular set of objectives that change from year to year. Work includes 1) critical planning of the observations, 2) acquiring the data, 3) calibrating the data, and 4) on-site data reduction.

J. L. Elliot

12.616 Occultation Studies of the Solar System (New)

Prereq.: 8.03, 18.03 or 18.034
 Acad Year 1996-97: **Not offered**
 Acad Year 1997-98: G (Spring)
 3-0-9 H-LEVEL Grad Credit

Basic principles underlying the techniques of occultations by solar system bodies, observed throughout the electromagnetic spectrum from spacecraft and Earth-based platforms. The interaction of electromagnetic radiation with planetary atmospheres and rings. Astrometric methods used to predict occultations. Physical models for atmospheres and rings that have been developed from occultation data.

J. L. Elliot

12.620J Variational Mechanics: A Computational Approach

Same subject as 6.946J, 8.351J)
 Prereq.: 8.01, 18.03, 6.001 or equivalent
 G (Fall)
 3-3-6 H-LEVEL Grad Credit

Classical mechanics in a computational framework. Lagrangian formulation. Action, variational principles. Hamilton's principle. Conserved quantities. Hamiltonian formulation. Surfaces of section. Chaos. Liouville's theorem and Poincaré integral invariants. Poincaré-Birkhoff and KAM theorems. Invariant curves. Cantori. Nonlinear resonances. Resonance overlap and transition to chaos. Properties of chaotic motion. Transport, diffusion, mixing. Symplectic integration. Adiabatic invariants. Many-dimensional systems, Arnold diffusion. Extensive use of computation to capture methods, for simulation, and for symbolic analysis.

J. Wisdom, G. J. Sussman

12.650 Current Topics in Planetary Science

Prereq.: Permission of instructor
 G (Spring)
 3-0-9 H-LEVEL Grad Credit
 Can be repeated for credit

In-depth discussion of current and classic literature on selected topics in planetary science. Topics vary from year to year.

J. Wisdom

12.690-12.691 Special Problems in Planetary Science

Prereq.: —
 G (Fall, Spring, Summer)
 Units arranged [P/D/F] H-LEVEL Grad Credit
 Can be repeated for credit

For graduate students desiring to perform special investigations, special laboratory work, or special fieldwork in planetary science. 12.690 is letter-graded.

Planetary Science Staff

Geological, Geophysical, and Chemical Oceanography**12.707 Pre-Pleistocene Paleoceanography and Paleoclimatology**

Prereq.: Permission of instructor
 Acad Year 1996-97: G (Spring)
 Acad Year 1997-98: **Not offered**
 3-0-9 H-LEVEL Grad Credit

Climate history of the Earth from the formation of the early atmosphere and ocean to the present. Evaluation of geochemical, sedimentological, and paleontological evidence for changes in ocean circulation, global temperatures, and atmospheric carbon dioxide levels. Theories and models of Phanerozoic climate change. Long-term history of the global carbon cycle.

M. E. Raymo

12.708 Special Topics in Paleoceanography

Prereq.: Permission of instructor
 G (Fall)
 Units arranged [P/D/F] H-LEVEL Grad Credit
 Can be repeated for credit

Advanced seminar focusing on areas of current interest in paleoceanography and paleoclimatology. Includes discussion of current and classic literature. Topics vary from year to year.

M. E. Raymo

12.710 Marine Geology and Geophysics I

Prereq.: Permission of instructor
 G (Fall)
 3-2-7 H-LEVEL Grad Credit

An introduction to marine geology and geophysics intended as part of a two-semester sequence for first-year MIT-WHOI Joint Program students in marine geology and geophysics. Topics covered include the theory of plate tectonics, processes of deep-sea sedimentation, paleoceanography, and the evolution of the Mesozoic-Cenozoic global oceans.

R. Detrick, M. Raymo, G. Giese, R. Stephen

12.711 Marine Geology and Geophysics II

Prereq.: 12.710
 G (Spring)
 3-2-7 H-LEVEL Grad Credit

An introduction to marine geology and geophysics intended as part of a two-semester sequence for first-year MIT-WHOI Joint Program students in marine geology and geophysics. Topics covered this semester include lithosphere evolution and mantle dynamics, the structure and composition of the oceanic crust and mantle, tectonic and magmatic processes at mid-ocean ridges, hotspot volcanism, subduction and arc magmatism, and the crustal structure and sedimentation history of continental margins.

R. Detrick, N. Shimizu, R. Stephen

12.712 Advanced Marine Seismology

Prereq.: 12.711
 Acad Year 1996-97: G (Fall, Spring)
 Acad Year 1997-98: **Not offered**
 3-0-6 H-LEVEL Grad Credit
 Can be repeated for credit

Advanced subject on theory and practice of marine seismology. Topics: seismic wave propagation; marine reflection and refraction seismology, including seismic data processing, modeling, and inversion of multichannel data. Extensive readings of geophysical literature. (Woods Hole Staff): *R. Stephen, R. Detrick*

12.714 Computational Data Analysis

Prereq.: 18.03

G (Spring)

3-0-9 H-LEVEL Grad Credit

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 covered 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, M. K. McNutt)

12.716 Igneous Processes at Oceanic Margins

Prereq.: 12.710, 12.711, or permission of instructor

Acad Year 1996-97: Not offered

Acad Year 1997-98: G (Fall)

3-2-4 H-LEVEL Grad Credit

Can be repeated for credit

Quantitative analysis of melting, melt transport, and igneous crustal accretion at oceanic spreading centers, rifted continental margins, and subduction-related arcs, applied to understanding variation in composition and volume of the Earth's crust in different tectonic environments. Theoretical methods for calculation of melt volume and composition, solid-liquid equilibria and reaction rates, and liquid density and viscosity combined with field, petrographic, geochemical, and computational techniques. Topics vary from year to year.

(Woods Hole Staff): P. Kelemen

12.718 Kinetics and Mass Transport

Prereq.: Permission of instructor

Acad Year 1996-97: Not offered

Acad Year 1997-98: G (Spring)

3-0-6 H-LEVEL Grad Credit

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.

(Woods Hole Staff): G. Hirth, S. Hart

12.721 Special Problems in Marine Geology and Geophysics at Woods Hole

Prereq.: Permission of instructor

G (Fall, Spring, Summer)

Units arranged [P/D/F] H-LEVEL Grad Credit

Can be repeated for credit

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

(Woods Hole Staff)

12.722 Special Problems in Chemical Oceanography at Woods Hole

Prereq.: Permission of instructor

G (Fall, Spring, Summer)

Units arranged [P/D/F] H-LEVEL Grad Credit
Can be repeated for credit

For graduate students desiring to perform special investigations, special laboratory work, or special fieldwork in chemical oceanography. (Woods Hole Staff)

12.730-12.731 Special Problems in Marine Geology and Geophysics at MIT

Prereq.: Permission of instructor

G (Fall, Spring, Summer)

Units arranged [P/D/F] H-LEVEL Grad Credit
Can be repeated for credit

For graduate students in the MIT/WHOI Joint Program desiring to perform special investigations, special laboratory work, or special fieldwork in marine geology and geophysics under the supervision of a faculty member in residence at MIT. 12.730 is letter-graded.

(Marine Geology and Geophysics Staff)

12.735-12.736 Special Problems in Chemical Oceanography at MIT

Prereq.: Permission of instructor

G (Fall, Spring, Summer)

Units arranged [P/D/F] H-LEVEL Grad Credit
Can be repeated for credit

For graduate students in the MIT/WHOI Joint Program desiring to perform special investigations, special laboratory work, or special fieldwork in chemical oceanography under the supervision of a faculty member in residence at MIT. 12.735 is letter-graded.

(Chemical Oceanography Staff)

12.740 Quaternary Paleoceanography

Prereq.: Permission of instructor

Acad Year 1996-97: Not offered

Acad Year 1997-98: G (Spring)

3-0-9 H-LEVEL Grad Credit

History of the earth-surface environment during the past 2 million years as deduced from the records preserved in deep-sea sediments, ice cores, and corals. Uses micropaleontological, isotopic, geochemical, and mineralogical changes to infer changes in seawater composition, atmospheric chemistry, and climate. These changes are used to infer changes in the temperature and current field of the ocean. Discussion of processes proposed to account for glacial/interglacial cycles (orbital forcing and internal oscillations) and abrupt century-scale climate changes. Evaluation of theories of environmental change in view of the paleoclimatic record of climate change.

(E. A. Boyle)

12.741 Marine Geochemistry

Prereq.: 5.11 or 3.091; 5.60

G (Spring)

3-0-9 H-LEVEL Grad Credit

Geochemical cycle of the elements. Continental weathering processes; oceanic hydrothermal systems and fluxes; physical and chemical processes in the oceanic water column and in lakes; static versus dynamic models of the chemistry of the atmosphere and oceans over geologic time; authigenic sediments and the control of seawater composition. Emphasizes development of problems and topics by students.

(J. M. Edmond)

12.742 Marine Chemistry

Prereq.: Permission of instructor

G (Fall)

3-0-9 H-LEVEL Grad Credit

Introduction to chemical processes operating in the oceans (i.e., biogeochemical cycles). Includes oceanic particles; cycling of organic carbon, phosphorous and nitrogen; carbonate and silica systems; upwelling and low-oxygen systems; iron and manganese redox systems. Designed for first- or second-year chemistry, biology, and geology students.

(Woods Hole Staff): O. Zafiriou, Staff

12.743 Geochemistry of Marine Sediments

Prereq.: 5.11 or 3.091; 5.60

Acad Year 1996-97: G (Fall)

Acad Year 1997-98: Not offered

3-0-9 H-LEVEL Grad Credit

Factors influencing the chemical and mineralogical composition of deep-sea sediments and chemical fluxes across the sediment-water interface, and their spatial and temporal variability. Carbonate, silicic, and detrital sediments: sources and reactivity. Pore water: diffusion, reaction, and fluxes. Ferromanganese sediments and manganese nodule geochemistry. Trace element sedimentary geochemistry. Sediment dating and accumulation rate estimation. Stable isotopes and natural-series radioisotopes. Effect of climate change on sedimentary processes. Mathematical techniques and modeling in sedimentary systems.

(E. A. Boyle)

12.744 Marine Isotope Chemistry

Prereq.: 12.742 or 12.741

Acad Year 1996-97: Not offered

Acad Year 1997-98: G (Spring)

3-0-9 H-LEVEL Grad Credit

Treats important aspects of radionuclides and stable isotopes as applied to the oceans. Includes introduction to radioactivity, natural-series radionuclides (i.e., ^{210}Pb , ^{210}Po , Th, U), artificial radionuclides (i.e., ^{14}C , ^3H , ^{137}Cs , ^{90}Sr , $^{239,240}\text{Pu}$), and systematics of several stable isotopes (e.g., Nd, Sr, C, N, O).

(Woods Hole Staff): K. Buesseler, W. Jenkins, M. Kurz

12.745 Ore Deposition at Submarine Ridge Axes

Prereq.: Permission of instructor
G (Fall)
3-0-6 H-LEVEL Grad Credit

Ridge crest hot springs; description of currently active systems. Geologic and tectonic setting and exploration strategies. Hydrothermal chemistry of sediment-starved and sediment-covered spreading centers and seamounts. Thermodynamic modeling of water-rock interactions using EQ3/6. Description and classification of ore deposits formed on the sea floor. Chemical and physical mechanisms of ore localization. Formation of metalliferous sediments.

J. M. Edmond

12.746 Marine Organic Geochemistry

Prereq.: Permission of instructor
Acad Year 1996-97: G (Spring)
Acad Year 1997-98: Not offered
3-0-6 H-LEVEL Grad Credit

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.

(Woods Hole Staff): D. Repeta, W. R. Martin

12.747 Modeling, Data Analysis, and Numerical Techniques for Geochemistry (New)

Prereq.: Permission of instructor
Acad Year 1996-97: G (Fall)
Acad Year 1997-98: Not offered
3-0-9 H-LEVEL Grad Credit

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.

(Woods Hole Staff): D. Glover, W. Jenkins

12.751–12.759 Seminar in Oceanography at Woods Hole

Prereq.: Permission of instructor
G (Fall, Spring)
Units arranged [P/D/F] H-LEVEL Grad Credit
Can be repeated for credit

Topics in marine geology and geophysics, physical, dynamical, and chemical oceanography. Content varies from term to term. 12.755 is letter-graded.
(Woods Hole Staff)

12.760–12.761 Seminar in Marine Geology and Geophysics at MIT

Prereq.: Permission of instructor
G (Fall, Spring)
Units arranged [P/D/F] H-LEVEL Grad Credit
Can be repeated for credit

Topics in marine geology and geophysics taught at MIT. Content varies from term to term. 12.760 is letter-graded.

Marine Geology and Geophysics Staff

12.770–12.771 Seminar in Chemical Oceanography at MIT

Prereq.: Permission of instructor
G (Fall, Spring)
Units arranged [P/D/F] H-LEVEL Grad Credit
Can be repeated for credit

Topics in chemical oceanography taught at MIT. Content varies from term to term. 12.770 is letter-graded.

Chemical Oceanography Staff

Meteorology and Oceanography**12.800 Fluid Dynamics of the Atmosphere and Ocean**

(Subject meets with 12.331)
Prereq.: 8.03, 18.04
G (Fall)
3-0-9 H-LEVEL Grad Credit

Introductory subject for first-year graduate students in meteorology and oceanography. Eulerian and Lagrangian kinematics. Equations of mass, momentum, and energy in Eulerian form in rotating frame of reference. Vorticity and divergence. Scaling and geostrophic approximation. Potential vorticity. Rossby waves. Ekman layers. Wave motion and instability. Vortex motion.
J. Marshall

12.801 Steady Circulation of the Oceans

Prereq.: 12.800
G (Spring)
3-0-9 H-LEVEL Grad Credit

Fundamental principles in modeling steady flows in the ocean and their analogues in the atmosphere. Illustrates general methods that apply to either fluid and the contrasts between them. Includes quasi-geostrophy on the beta plane and sphere, Ekman pumping, wind- and thermally driven ocean circulation models, western-boundary current dynamics, upwelling systems.

(Woods Hole Staff): J. Pedlosky

12.802 Wave Motions in the Ocean and Atmosphere

(Subject meets with 12.332)
Prereq.: 12.800 or equivalent
G (Spring)
3-0-9 H-LEVEL Grad Credit

Basic ideas of geophysical wave motion in rotating, stratified, and rotating-stratified fluids, with a theoretical focus but with coverage of salient observations. Begins with general wave concepts, including the dynamics and kinematics of gravity waves: dispersion, energy flux, initial value problems, etc. This foundation is then used to study internal and inertial waves, Kelvin, Poincare, and Rossby waves in homogeneous and stratified fluids. Laplace tidal equations are used generically, and applied to actual tides. Other topics include resonant interactions, potential vorticity, wave-mean flow interactions, etc.
C. Wunsch

12.803 Quasi-balanced Circulations in Oceans and Atmospheres

Prereq.: 12.800, 12.804
G (Fall)
3-0-9 H-LEVEL Grad Credit

Dynamics of large-scale circulations in oceans and atmospheres, taken concurrently with the laboratory subject 12.804. Conservation and balance principles for large-scale flows; geostrophic adjustment, potential vorticity and invertibility; shallow water equations, quasi-geostrophy; nonlinear balance equations. Dispersion and propagation of Rossby waves; topographic waves. Generation and dissipation of large-scale eddies, including baroclinic and barotropic instability as described by Eady, Charney, and two-layer models; the Rayleigh, Fjørtoft, Charney-Stern, and Arnol'd theorems; effects of surface friction and phase change of water; the superposition principle; quasi-geostrophic turbulence, fronts and frontogenesis.

G. Flierl, P. Rizzoli, E. Chang

12.804 Large-scale Flow Dynamics Laboratory

Prereq.: 12.800, 12.803
G (Fall)
0-3-6 H-LEVEL Grad Credit

Laboratory component of subject 12.803. Analysis of observations of oceanic and atmospheric quasi-balanced flows, computational models, and rotating tank experiments. Illustrates the basic principles of potential vorticity conservation and inversion, Rossby wave propagation, baroclinic instability, and the behavior of isolated vortices.

L. Illari, G. Flierl, P. Rizzoli, E. Chang

12.805 Laboratory in Physical Oceanography

Prereq.: 12.808

G (Spring)

2-2-5 H-LEVEL Grad Credit

An introduction to standard data analysis methods including time series analysis, objective mapping, empirical orthogonal functions, and dynamic analysis of hydrographic data. Emphasis on working with data in a computer laboratory setting using packaged software. Where appropriate, comparison is made with simple models. Some attention given to the instruments and algorithms used to acquire the data.

(Woods Hole Staff): *B. Owens***12.806 Atmospheric Physics and Chemistry I**

Prereq.: 5.61, 18.075

G (Fall)

3-0-9 H-LEVEL Grad Credit

Introduces atmospheric physics and chemistry. Transfer of solar and thermal radiation and radiative heating. Atmospheric thermal structure, differential heating, and energy budget. Atmospheric chemistry including kinetics, continuity, transport, and chemical-radiative-dynamical feedbacks. Application to ozone layer and Antarctic ozone hole.

*R. G. Prinn, M. J. Molina***12.807 Atmospheric Physics and Chemistry II**

Prereq.: 12.806

G (Spring)

3-0-9 H-LEVEL Grad Credit

Radiative transfer including Mie theory scattering and non-grey effects. Physics of greenhouse effect, chemistry of greenhouse gases and models for warming. Physics and chemistry of clouds. Chemistry of the troposphere on urban, regional, and global scales. Satellite remote sensing and inversion methods.

*M. J. Molina, R. G. Prinn***12.808 Introduction to Observational Physical Oceanography**

Prereq.: Permission of instructor

G (Fall)

3-0-6 H-LEVEL Grad Credit

An introduction to the 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.

(Woods Hole Staff): *N. Hogg*This course is P/D/F. H-LEVEL Grad Credit
Can be repeated for credit.Handing, consultation, and original investigation
in oceanographic problems. 12.870 is required.
Woods Hole Staff**12.810 Dynamics of the Atmosphere**

Prereq.: 12.800

G (Spring)

3-0-9 H-LEVEL Grad Credit

Review of equations of motion. Zonally averaged budgets of heat, momentum, and water vapor. Review of historical understanding of the maintenance of zonal winds. Symmetric models of the general circulation. Introduction to waves and eddies in nonrotating and rotating fluids: specifically internal gravity waves, tides, Rossby waves, barotropic and baroclinic instabilities. The interaction of these asymmetric components of atmospheric motion with the zonally averaged circulation discussed. Emphasis on specific observed phenomena.

*R. S. Lindzen***12.811 Tropical Meteorology**

(Subject meets with 12.337)

Prereq.: 12.803

G (Spring)

3-0-9 H-LEVEL Grad Credit

A description of the large-scale circulation systems of the tropical atmosphere and analysis of the dynamics of such systems. Topics include: interaction between the convective scales and the large-scale flow; importance of moisture and latent heat release; equatorial waves; the Hadley circulation; monsoons; theory of the response of the tropical atmosphere to localized sea-surface temperature anomalies; the Walker circulation; mechanisms coupling tropics with midlatitudes; intraseasonal oscillations; El Niño/Southern Oscillation; easterly waves; tropical cyclones.

*R. A. Plumb***12.812 General Circulation of the Earth's Atmosphere**

Prereq.: 12.810 or 12.803

G (Fall)

3-0-9 H-LEVEL Grad Credit

Diagnostic studies and discussion of their implications for the theory of the structure and general circulation of the Earth's atmosphere. Includes some discussion of the validation and use of general circulation models as atmospheric analogs.

*P. H. Stone, R. D. Rosen***12.813 Atmospheric Convection**

Prereq.: 12.800

Acad Year 1996-97: G (Spring)

Acad Year 1997-98: Not offered

3-3-9 H-LEVEL Grad Credit

Introduction and theory of dry convection over isolated heat sources. Basic theory of Rayleigh convection. Extensive treatment of the thermodynamics of moist and cloudy air. Observations and dynamics of isolated convective clouds; turbulence in saturated and partly saturated mixtures. Moist- and dry-convective boundary layers. Organization of moist convection on larger scales and interaction of convective ensembles with the large-scale environment.

*K. A. Emanuel***12.814 Global Transport Modeling**

Prereq.: Permission of instructor

Acad Year 1996-97: Not offered

Acad Year 1997-98: G (Fall)

3-0-9 H-LEVEL Grad Credit

The theory and practice of modeling global-scale transport of trace gases is reviewed, primarily through reading and discussing the relevant literature. Taught in two parts: two-dimensional (longitudinally averaged) models, mostly but not exclusively concentrating on models of stratospheric ozone, and three-dimensional models of tropospheric gases. Emphasizes transport rather than chemistry, and the conceptual basis for and application of such models, rather than their detailed numerics.

*R. A. Plumb***12.816 Numerical Modeling of the Atmosphere**

Prereq.: 12.803, 12.810

Acad Year 1996-97: Not offered

Acad Year 1997-98: G (Spring)

3-0-9 H-LEVEL Grad Credit

Presentation of the numerical methods used in atmospheric models: grid point methods, time differencing schemes, spectral transform methods, solution to elliptic and parabolic equations. Hierarchy of numerical prediction models. Representation of physical processes in atmospheric models. Objective analysis and initialization. Discussions on the use of numerical models in weather and climate prediction.

*E. Chang***12.818 Introduction to Atmospheric Data and Synoptic Meteorology**

(Revised Units)

(Subject meets with 12.338)

Prereq.: 12.800

G (Spring)

3-3-6 H-LEVEL Grad Credit

Provides a general introduction to meteorological data and analysis techniques, and their use in the MIT Synoptic Laboratory to study the phenomenology and dynamics of large-scale atmospheric flow. Balance concepts as applied to the dynamics of frontal and synoptic scales are illustrated using real-time upper air and surface station data and gridded analyzed fields. Advanced meteorological software packages are used to access, manipulate, and graphically display the data. Statistical methods such as optimal interpolation, EOF, and time series analyses are discussed.

L. Illari, E. Chang

12.820 Instability and Turbulence in Geophysical Systems

Prereq.: 12.803

G (Fall)

3-0-9 H-LEVEL Grad Credit

Comprehensive introduction to the methodology of stability theory as applied to problems of interest in geophysical fluid dynamics. Emphasizes problems governed by quasi-geostrophic dynamics. Topics in linear theory include baroclinic-barotropic instability, numerical methods for eigenvalue problems, Rossby wave instability, symmetric instability, and solution of initial-value problems. Nonlinear instability.

(Woods Hole Staff): L. Pratt, K. Helfrich

12.822 Nonlinear Waves and Vortices

Prereq.: 18.305, 12.803

Acad Year 1996-97: Not offered

Acad Year 1997-98: G (Spring)

3-0-6 H-LEVEL Grad Credit

The dynamics of nonlinear waves in geophysical systems. Linear dispersion, nonlinear steepening, and solitary waves. Wave groups. Modulational instability. Particle motions in waves. Point vortices, vortex patches, and modons. Interactions between vortices and wave fields. Nonlinear instability, bifurcations, chaotic behavior.

G. Flierl

12.823 Ocean Modeling

Prereq.: Permission of instructor

Acad Year 1996-97: Not offered

Acad Year 1997-98: G (Spring)

3-0-9 H-LEVEL Grad Credit

Can be repeated for credit

Students engage in hands-on research directed at a central problem of contemporary physical oceanography by using numerical models that they build themselves. Meets at a weekly workshop where progress is reviewed and priorities for the next week are set out. Outstanding issues of the chosen problem are reviewed and the theory and models required to understand them developed. Formal lectures are kept to a minimum; the chosen theme varies from year to year.

J. Marshall

12.826J Land-Atmosphere Interaction

(Same subject as 1.713J)

Prereq.: 1.71J or 1.714 or permission of instructor

Acad Year 1996-97: Not offered

Acad Year 1997-98: G (Spring)

3-0-9 H-LEVEL Grad Credit

See description under subject 1.713J.

D. Entekhabi

12.830 Topics in Waves and Instability

Prereq.: 12.803; 12.802 or 12.810

Acad Year 1996-97: Not offered

Acad Year 1997-98: G (Fall)

3-0-9 H-LEVEL Grad Credit

A detailed presentation of selected advanced topics in waves and instability in the atmosphere. The precise selection varies from year to year. Topics have included wave-mean flow interaction, the quasi-biennial oscillation, sudden warmings, critical-level behavior, wave overreflection, nonlinear equilibration, wave breaking, tropical waves, and stationary waves.

R. S. Lindzen

12.831 Dynamics of the Middle Atmosphere

Prereq.: 12.810 or permission of instructor

Acad Year 1996-97: G (Fall)

Acad Year 1997-98: Not offered

3-0-9 H-LEVEL Grad Credit

Observed characteristics of the stratosphere and mesosphere. Climatological heat budget. Wave transport theory. Tides. Gravity waves. Gravity wave breaking. Traveling planetary waves. Quasi-stationary ultralong waves; propagation in winter and impact on the mean circulation. Potential vorticity diagnostics; wave breaking. Dynamics of the disturbed polar vortex; "warmings." Equatorial waves in the stratosphere. Theory of the quasi-biennial oscillation. Transport of trace constituents. Ozone: observed climatology; production and loss processes; effects of transport. Ozone depletion.

R. A. Plumb

12.840 Past and Present Climate

(Subject meets with 12.301)

Prereq.: 8.02

G (Spring)

3-0-9 H-LEVEL Grad Credit

Properties of climate systems. Physics of climatic fluctuations on time scales from past century up to 100 million years. Phenomena of drought, biennial oscillation, Southern Oscillation and El Niño, and other interannual fluctuations. Review of evidence for global warming and possible temperature limits. Role of volcanoes, water vapor, ozone, and carbon dioxide changes, solar variations, and surface changes in altering climate. Reconstruction of ice-age climate from ocean-bed cores, pollen records, isotope ratios in ice cores. Theories of ice ages. Large-scale ocean-atmosphere interactions. Suitable for undergraduate students with little or no previous background in meteorology. Meets with undergraduate subject 12.301, but assignments differ.

R. E. Newell

(Woods Hole Staff): J. Marshall
See description under subject 1.713J.
D. Entekhabi

12.841 Climate Modeling

Prereq.: 12.801, 12.803 or 12.810

Acad Year 1996-97: Not offered

Acad Year 1997-98: G (Spring)

3-0-9 H-LEVEL Grad Credit

Develops parameterizations for atmospheric and oceanic processes important in determining climate and applies them in simple models of climate and climate change. Discussion of General Circulation Model studies of climate and climate change.

P. H. Stone, J. Marotzke

12.862 Dynamics of Shelf Circulation I

Prereq.: 12.800

G (Fall)

3-0-9 H-LEVEL Grad Credit

General introduction to the dynamics of flow over the continental shelf. An overview of surface and bottom boundary layer physics. Theory and observations of tides over the continental shelf.

(Woods Hole Staff): R. Beardsley, J. Trowbridge

12.863 Dynamics of Shelf Circulation II

Prereq.: 12.862 or permission of instructor

G (Spring)

3-0-6 H-LEVEL Grad Credit

More specialized topics in the dynamics of flow over the continental shelf, including coastal-trapped waves, wind-driving, and mean flows. Emphasis on the relationship between theory and observations. Instrumentation and the application of statistical techniques also covered.

(Woods Hole Staff): D. Chapman

12.864 Ocean Data and Ocean Models I

Prereq.: 18.075 or 18.086

Acad Year 1996-97: Not offered

Acad Year 1997-98: G (Fall)

3-0-6 H-LEVEL Grad Credit

12.865 Ocean Data and Ocean Models II

Prereq.: 12.864

Acad Year 1996-97: Not offered

Acad Year 1997-98: G (Spring)

3-0-6 H-LEVEL Grad Credit

Fundamental methods used for exploring the information content of observations related to theoretical ideas about how the ocean moves. Basic statistics and linear algebra for inverse and assimilation methods including singular value decompositions, control theory, sequential estimation (Kalman filters and smoothing algorithms), adjoint/Pontryagin principle methods, etc. Second part focuses on stationary processes, including Fourier methods, z-transforms, sampling theorems, spectra, coherences, filtering, etc. Directed at the quantitative combinations of models, with realistic, i.e. sparse and noisy observations

C. I. Wunsch

12.866 Theory of the General Circulation of the Ocean

Prereq.: 12.800, 12.801, 12.802

Acad Year 1996-97: G (Fall)

Acad Year 1997-98: Not offered

3-0-9 H-LEVEL Grad Credit

A review of wind-driven, homogeneous, ocean circulation theory. Quasi-geostrophic layer models of the circulation. Open and closed geostrophic contours. Potential vorticity homogenization. The ventilated thermocline. Combined ventilated and homogenized circulations. Inter-gyre communication. Buoyancy-forced circulation. Inertial models of the equatorial undercurrent. Stommel-Arons theory for the abyssal circulation. Effects of topography.

(Woods Hole Staff): J. Pedlosky

12.870 Air-Sea Interaction: Boundary Layers

Prereq.: Permission of instructor

G (Fall)

2-1-6 H-LEVEL Grad Credit

Examines the interaction of the atmosphere and ocean on time scales from hours to months, with emphasis on effects within the boundary layers. Methods for measuring and computing air/sea fluxes are reviewed, and students who participate in the optional laboratory subject at WHOI can build and use the relevant instruments. Modification of boundary layers by air/sea exchange, radiation and turbulent mixing is treated using a hierarchy of boundary layer models that are available on Athena for student use.

(Woods Hole Staff): J. Price, J. Edson

12.950-12.951 Seminar in Physical Oceanography at MIT

Prereq.: Permission of instructor

G (Fall, Spring)

Units arranged [P/D/F] H-LEVEL Grad Credit Can be repeated for credit

Topics in physical and dynamical oceanography. Content varying from term to term. 12.950 is letter-graded.

Physical Oceanography Staff

12.960-12.961 Special Problems in Physical Oceanography at MIT

Prereq.: Permission of instructor

G (Fall, Spring, Summer)

Units arranged [P/D/F] H-LEVEL Grad Credit Can be repeated for credit

Special investigations, special laboratory work, or special fieldwork in oceanography. 12.960 is letter-graded.

Physical Oceanography Staff

12.970-12.971 Special Problems in Physical Oceanography at Woods Hole

Prereq.: Permission of instructor

G (Fall, Spring, Summer)

Units arranged [P/D/F] H-LEVEL Grad Credit Can be repeated for credit

Reading, consultation, and original investigation on oceanographic problems. 12.970 is letter-graded.

(Woods Hole Staff)

12.980-12.981 Special Problems in Meteorology

Prereq.: Permission of instructor

G (Fall, Spring, Summer)

Units arranged [P/D/F] H-LEVEL Grad Credit Can be repeated for credit

Reading, consultation, and original investigations on meteorological problems. 12.980 is letter-graded.

Meteorology Staff

12.990-12.991 Special Subjects in Meteorology

Prereq.: Permission of instructor

G (Fall, IAP, Spring)

Units arranged [P/D/F] H-LEVEL Grad Credit Can be repeated for credit

Organized lecture or laboratory subject on some aspect of meteorology not normally covered in regularly scheduled subjects.

12.990 is letter-graded.

Consult Department Headquarters.

12.990-12.991 Special Subjects in Meteorology

Prereq.: Permission of instructor

G (Fall, IAP, Spring)

Units arranged [P/D/F] H-LEVEL Grad Credit Can be repeated for credit

Reading, consultation, and original investigations on meteorological problems. 12.990 is letter-graded.

Consult Department Headquarters.

12.990-12.991 Special Subjects in Meteorology

Prereq.: Permission of instructor

G (Fall, IAP, Spring)

Units arranged [P/D/F] H-LEVEL Grad Credit Can be repeated for credit

Organized lecture or laboratory subject on some aspect of meteorology not normally covered in regularly scheduled subjects.

12.990 is letter-graded.

Consult Department Headquarters.

12.990-12.991 Special Subjects in Meteorology

Prereq.: Permission of instructor

G (Fall, IAP, Spring)

Units arranged [P/D/F] H-LEVEL Grad Credit Can be repeated for credit

Reading, consultation, and original investigations on meteorological problems. 12.990 is letter-graded.

Consult Department Headquarters.

12.990-12.991 Special Subjects in Meteorology

Prereq.: Permission of instructor

G (Fall, IAP, Spring)

Units arranged [P/D/F] H-LEVEL Grad Credit Can be repeated for credit

Reading, consultation, and original investigations on meteorological problems. 12.990 is letter-graded.

Consult Department Headquarters.

12.990-12.991 Special Subjects in Meteorology

Prereq.: Permission of instructor

G (Fall, IAP, Spring)

Units arranged [P/D/F] H-LEVEL Grad Credit Can be repeated for credit

Reading, consultation, and original investigations on meteorological problems. 12.990 is letter-graded.

Consult Department Headquarters.

12.990-12.991 Special Subjects in Meteorology

Prereq.: Permission of instructor

G (Fall, IAP, Spring)

Units arranged [P/D/F] H-LEVEL Grad Credit Can be repeated for credit

Reading, consultation, and original investigations on meteorological problems. 12.990 is letter-graded.

Consult Department Headquarters.

12.990-12.991 Special Subjects in Meteorology

Prereq.: Permission of instructor

G (Fall, IAP, Spring)

Units arranged [P/D/F] H-LEVEL Grad Credit Can be repeated for credit

Reading, consultation, and original investigations on meteorological problems. 12.990 is letter-graded.

Consult Department Headquarters.

Descriptions of Subjects 419

Course 13**Ocean Engineering**

For degree requirements, see listing in Chapter VII under the School of Engineering.

13.UR Undergraduate Research

Prereq.: —
U (Fall, Spring, Summer)
Units arranged [P/D/F]
Can be repeated for credit

Research in engineering for the ocean environment, including naval architecture, wave energy, seakeeping, ocean exploration, ocean transportation, ocean vehicles, utilization of resources, marine economics, systems analysis, marine policy, marine hydrodynamics, ocean acoustics, ocean structures, sailing yachts, and some aspects of marine-related management. Hands-on experimental research in modern laboratory facilities.

D. K.-P. Yue

13.010 Introduction to Ocean Science and Technology

Prereq.: 8.01, 18.02
U (Fall)
3-0-9 REST

Introductory subject for students majoring or minoring in ocean engineering and others desiring introductory knowledge in the field. Physical oceanography including distributions of salinity, temperature, and density; heat balance; major ocean circulations and geostrophic flows; and influence of wind stress. Surface waves including wave velocities, propagation phenomena, and descriptions of real sea waves. Acoustics in the ocean including influence of water properties on sound speed and refraction, sounds generated by ships and marine animals, fundamentals of sonar, types of sonar systems and their principles of operation.

T. F. Ogilvie

13.012 Fluid Mechanics for Ocean Engineers

Prereq.: 13.010, 18.03
U (Spring)
4-3-8

Development of the fundamental equations of fluid mechanics and their simplifications for several areas of marine hydrodynamics. Application of these equations to a wide variety of problems of interest to ocean engineers ranging from local boundary layer flows on a small underwater vehicle to global oceanic flows; ocean tides. Hydrostatic behavior of floating and submerged bodies, lift and drag forces, water waves and wave forces on ships and platforms.

T. F. Ogilvie

13.013J Systems Modeling and Dynamics II

(Same subject as 2.004J, 2.03J)
Prereq.: 2.001 and 2.003 or 13.015
U (Fall, Spring)
4-0-5

See description under subject 2.004J.
J. H. Williams, Jr., J. K. Vandiver

13.014 Marine Structures and Materials

Prereq.: 2.001, 18.03
U (Fall)
3-0-9

Fundamentals of solid mechanics and materials science needed for design and fabrication of marine structures. Topics related to solid mechanics include advanced beam theory, beam buckling, plastic beam response, and structural failure. Topics related to materials science include atomic structures of materials, phase diagrams, mechanical properties, cutting and joining techniques.

K. Masubuchi, H. Schmidt

13.015 Mathematical Methods in Ocean Engineering

Prereq.: 18.03
U (Spring)
3-0-9

Mathematical methods are developed for the solution of physical problems arising in ocean engineering. Model problems from hydrodynamics, wave propagation, vibrations, structural mechanics, and signal processing are formulated and solved using the theory of ordinary differential equations, complex variables and complex contour integration, Laplace and Fourier transforms, convolution, impulse response functions, and Fourier series.

P. D. Sclavounos

13.016 Introduction to Geometric Modeling and Computation

Prereq.: 8.01, 18.02
U (Fall)
3-0-9 REST

Development of mathematical representations of curves and surfaces for use in computer-aided design and engineering analysis, from simple polynomials to general non-uniform rational B-splines. Numerical integration and differentiation. Software engineering concepts. Code design, development, debugging and maintenance. Fortran 77 syntax, data types, subroutines. Emphasis on engineering modelling and design in computational environment. Homework projects developed around ocean engineering applications include writing Fortran 77 programs and using software developed under Project Athena.

J. E. Kerwin

13.017 Design of Ocean Systems I

Prereq.: 2.001, 6.071, 13.016, 13.012
U (Spring)
3-4-5 Institute LAB

13.018 Design of Ocean Systems II

Prereq.: 13.017
U (Fall)
1-4-7 Institute LAB

A two-semester subject sequence that demonstrates the design process through application to small-scale ocean systems. Emphasis on carrying out the design and implementation of a system, including demonstration of its operation in the marine environment. Fall Term: Introduction to the design process and its application in the marine environment. Design project with students developing system definition and completing its preliminary design. Students are instructed in the use of the machine shop and are required to implement mechanical, electrical, and electronic components of the systems. Spring Term: Students work in small groups to design and implement system defined in 13.017, including demonstration of its operation in the laboratory or marine environment. Students design, plan, construct, and operate a small-scale ocean system, or plan, develop experimental apparatus, acquire data, and report the analysis of an experiment in the ocean or the laboratory. Subject varies from year to year. The specific topic is made available to students during IAP before the first term of the subject sequence. Each of these subjects satisfies six units of the General Institute Laboratory Requirement.

M. S. Triantafyllou

13.020 Introduction to Fluid Mechanics for Naval Architecture

Prereq.: 18.089

G (Summer)

3-0-5

Kinematics and dynamics of fluid motion; applications to water waves, lifting surfaces, boundary layers; dimensional analysis and model testing.

T. F. Ogilvie

13.021 Marine Hydrodynamics I

Prereq.: 13.012 or 2.20 or 1.05

G (Fall)

4-1-7 H-LEVEL Grad Credit

The fundamentals of fluid mechanics are developed in the context of naval architecture and ocean science and engineering. Transport theorem and conservation principles. Navier-Stokes' equation. Dimensional analysis. Ideal and potential flows. Vorticity and Kelvin's theorem. Hydrodynamic forces in potential flow, D'Alembert's paradox, added-mass, slender-body theory. Viscous-fluid flow, laminar and turbulent boundary layers. Model testing, scaling laws. Application of potential theory to surface waves, energy transport, wave/body forces. Linearized theory of lifting surfaces. Experimental project in the towing tank or propeller tunnel.

D. K.-P. Yue

13.022 Marine Hydrodynamics II

Prereq.: 13.021, 18.075

G (Spring)

4-0-8 H-LEVEL Grad Credit

Continuation of 13.021, emphasizing analytical and computational methods. Ideal flows in two and three dimensions. Lifting-surface theory for steady, unsteady, and cavitating hydrofoils. Water waves, loads and motions of bodies in waves, and ship wave resistance.

Hydrodynamics of slender bodies, maneuvering, strip theory of ship motions. Use of panel programs for computations.

J. N. Newman

13.03 Responses of Marine Structures to Sea Loads

Prereq.: 18.075, 13.022

G (Spring)

3-0-6 H-LEVEL Grad Credit

Hydrodynamic and statistical models describing the responses of marine structures in random seas. Linear wave-body interactions. Nonlinear wave loads on ships, semisubmersibles, and tension-leg platforms. Effects of wind and current. Linear response statistics. Gaussian and Rayleigh processes. Extreme statistics. Stochastic models for nonlinear responses. Markovian processes and Volterra Series. Nonstationary responses and memory effects. Case studies include the slamming of ships and slow-drift oscillation of compliant structures.

P. D. Sclavounos

13.04 Hydrofoils and Propellers

Prereq.: 18.076, 13.021

G (Spring)

3-0-9 H-LEVEL Grad Credit

Theory and design of hydrofoil sections; lifting and thickness problems for sub-cavitating sections, unsteady flow problems. Computer-aided design of low drag, cavitation free sections. Lifting line and lifting surface theory with applications to hydrofoil craft, rudder, and control surface design. Propeller lifting line and lifting surface theory; computer-aided design of wake adapted propellers, unsteady propeller thrust and torque. Flow about axially symmetric bodies and low-aspect ratio lifting surfaces. Experimental projects in the variable pressure water tunnel.

J. E. Kerwin

13.06 Numerical Methods in Marine Hydrodynamics

Prereq.: 13.021, 13.50, 18.075

Acad Year 1996-97: Not offered

Acad Year 1997-98: G (Spring)

3-0-9 H-LEVEL Grad Credit

Formulation, methodology, and techniques of numerical solutions of problems in marine hydrodynamics. Rudiments of finite-difference, finite-element, boundary-integral-equation, and spectral methods with illustrations of applications to this field. Special emphases on treatment of free-surface and open boundaries, and the characteristics and efficacy of the different approaches. Projects involve hands-on development of simple computer programs.

D. K.-P. Yue

13.07 Free Surface Hydrodynamics

Prereq.: 13.022, 18.076

Acad Year 1996-97: Not offered

Acad Year 1997-98: G (Fall)

3-0-6 H-LEVEL Grad Credit

Water wave phenomena pertinent to problems in naval architecture and ocean engineering. Generation, propagation, and diffraction of plane progressive waves. Exciting and restoring forces on floating and submerged bodies. Ship waves and wave resistance. Use of panel methods to compute wave forces on ships and offshore platforms. Some background in water waves equivalent to that covered in 13.022 assumed. Alternates with 13.09.

J. N. Newman

13.09 Potential Flows

Prereq.: 13.022, 18.076

Acad Year 1996-97: G (Fall)

Acad Year 1997-98: Not offered

3-0-6 H-LEVEL Grad Credit

Develops and applies potential theory to the flow past marine vehicles. Review of ideal fluid theory. Simple potential flows. Two-dimensional flows based on complex variable theory. Three-dimensional flows based on separation of variables and Green's theorem.

Hydrodynamic pressure forces and the added-mass tensor. Description of numerical methods, matched asymptotic expansions, and slender-body theory. Alternates with 13.07. Second half of subject includes mini-seminars by students on relevant research topics.

J. N. Newman

13.10J Introduction to Structural Mechanics

(Same subject as 1.573J)

Prereq.: 2.001, 18.03

G (Fall)

4-0-8 H-LEVEL Grad Credit

Fundamental concepts of structural mechanics with applications to marine and civil structures. Governing equations of continuum mechanics. Analysis of beams, columns, and shafts. Exact and approximate methods for analysis of statically indeterminate structures, energy methods, principle of virtual work. Elastic buckling of columns. Examples from trusses, buildings, ships, and cables.

N. M. Patrikalakis, J. J. Connor, Jr.

13.111 Structural Mechanics

Prereq.: 13.10J or permission of instructor

G (Spring)

3-0-9 H-LEVEL Grad Credit

Concept of deformation and equilibrium in continuum mechanics and plate and shell structures. Derivation of elastic stress-strain relations for plate and shell elements. Bending and buckling of rectangular plates. Nonlinear geometric effects. Post-buckling and ultimate strength of typical stiffened panels used in naval architecture. General theory of elastic shells and axisymmetric shells. Buckling and crushing strength of cylindrical shells.

T. Wierzbicki

13.112 Safety of Marine Systems

Prereq.: 13.014 or 13.410, 13.111, 13.42

G (Spring)

3-1-8 H-LEVEL Grad Credit

Marine safety regulation with historical perspective. Ship grounding and collision including damage case studies, methods for protection, and residual strength of damaged ships. Extreme wave loads, slamming, and ice damage. Statistical analysis of ship intact stability, subdivision, and damaged stability. Decision-making methods necessary to consider engineering, maintenance, and operational alternatives affecting environmental impact of tanker oil spills. Capstone for Marine Safety concentration, Program in Marine Environmental Systems.

A. J. Brown, T. Wierzbicki

13.122 Ship Structural Analysis and Design

Prereq.: 13.111, 13.14J or 13.410

G (Spring)

3-2-7 H-LEVEL Grad Credit

Ship longitudinal strength and hull primary stresses. Ship structural design concepts. Effect of superstructures and dissimilar materials on primary strength. Transverse shear stresses and thermal stresses in the hull girder. Torsional strength of ships. Design limit states including plate bending, column and panel buckling, panel ultimate strength, and plastic analysis. Matrix stiffness, grillage, and finite element analysis. Computer projects on the structural design of a midship module.

A. J. Brown

13.14J Structural Mechanics in Nuclear Power Technology

(Same subject as 22.314J, 1.56J, 2.084J)

Prereq.: Permission of instructor

Acad Year 1996-97: Not offered

Acad Year 1997-98: G (Spring)

3-0-9 H-LEVEL Grad Credit

See description under subject 22.314J.

O. Buyukozturk, J. E. Meyer

13.15 Materials for Ocean Engineering

Prereq.: —

G (Spring)

3-0-8

Properties of metals used for the construction of ships and ocean engineering structures. Microstructures, processing, heat treatment, service behavior, and failures with special emphasis on corrosion resistance of ferrous and nonferrous metals.

K. Masubuchi

13.16J Fracture of Structural Materials

(Same subject as 3.90J, 1.591J)

Prereq.: 2.30 or 3.11 or 13.15

G (Fall)

3-0-6 H-LEVEL Grad Credit

See description under subject 3.90J.

K. Masubuchi, F. J. McGarry

13.21 Ship Power and Propulsion

Prereq.: 2.40

G (Fall)

3-1-8 H-LEVEL Grad Credit

Examines ship power and propulsion systems for commercial and naval ships. Considers steam, diesel, and gas-turbine power plants, together with speed reducers and propulsors. Project study and economic evaluation of the propulsion system for a commercial or a naval ship.

A. D. Carmichael

13.25J Thermal Power Engineering

(Same subject as 2.41J)

Prereq.: 2.005

U (Spring)

3-0-9

See description under subject 2.41J.

A. D. Carmichael, E. G. Cravalho

13.26J Design of Thermal Power Systems

(Same subject as 2.601J)

Prereq.: 2.005, 2.006, 2.51

G (Spring)

3-0-9 H-LEVEL Grad Credit

See description under subject 2.601J.

A. D. Carmichael, L. R. Glicksman

13.39 Analysis of Techniques for Fabricating Structures

Prereq.: 3.13 or 13.15

G (Spring)

2-0-4 H-LEVEL Grad Credit

Analyzes problems related to fabrication of structures, such as ships, aircraft, rockets, pressure vessels, buildings, and ocean engineering structures by various joining processes including welding, riveting, and adhesive bonding. Discusses problem areas such as fracture characteristics of welded structures; residual stress, distortion, and stress relieving; advanced welding metallurgy; nondestructive testing of structural welds. Laboratory demonstrations of some tests.

K. Masubuchi

13.410 Introduction to Naval Architecture

Prereq.: —

G (Summer)

3-0-9

Introduction to principles of naval architecture, ship geometry, hydrostatics, calculation and drawing of displacement and other curves, intact and damaged stability, hull structure strength calculations, and ship resistance. Projects include computer-aided ship design and analysis tools.

M. Welsh

13.411 Methods of Naval Ship-System Design

Prereq.: 13.410

G (Summer)

3-0-9 H-LEVEL Grad Credit

Overview of naval ship design and acquisition process; mechanics of designing a ship system, formulation of a systematic design plan, requirements and constraints, design philosophy and design elements; selection/optimization criteria; design trade-offs; analysis of ship design trends; marginal cost factors.

Design exercises and projects in application of principles.

A. J. Brown

13.412 Principles of Naval Ship Design

Prereq.: 13.410; 13.21; 13.021; 13.411;

13.122; 13.49

G (Fall)

3-3-6 H-LEVEL Grad Credit

Design of surface ship platforms for naval applications; formal design optimization procedures; mathematical and computer models of ship design process; engineering and economic principles governing selection of dimensions and coefficients; influence of hull form and dimensions on seakeeping and maneuvering in calm water and rough seas; internal subdivisions for efficient arrangement and maximum survivability; damage stability. Design exercises in applications of principles.

A. J. Brown, M. Welsh

13.413 Projects in Naval Ships Conversion Design

Prereq.: 13.411, 13.412, 13.21

G (Fall, Spring, Summer)

Units arranged H-LEVEL Grad Credit

Can be repeated for credit

Project studies focus on conversion design of a naval ship. A new mission requirement is defined, requiring significant ship modification. Design plan formulation. Technical aspects addressed in sufficient detail to demonstrate feasibility and desirability. Requires formal written and verbal reports. Encourages participation by several students in a single project.

A. J. Brown, M. Welsh

13.414 Projects in New Construction Naval Ship Design

Prereq.: 13.411, 13.412, 13.21 and 13.413

G (Fall, Spring, Summer)

Units arranged H-LEVEL Grad Credit

Can be repeated for credit

Project studies focus on preliminary design of a new naval ship, fulfilling a given set of mission requirements. Design plan formulation. System level trade-off studies. Emphasizes achieving a balanced design and total system integration. Requires formal written and oral reports. Encourages participation by several students in a single project extending over two terms.

A. J. Brown, M. Welsh

13.42 Design Principles for Ocean Vehicles

Prereq.: 13.014; 13.021; 13.013J

G (Spring)

3-3-6 H-LEVEL Grad Credit

Linear systems and random processes; ocean spectra and their selection; short-term and long-term statistics. Inertia vs drag dominated flows; seakeeping and sensitivity of seakeeping performance. Maneuvering of surface and underwater vehicles; equations of motion; motion stability; control surfaces. Design exercises in application of principles.

M. S. Triantafyllou, M. Grosenbaugh

13.43 Design of Ocean Engineering Systems

Prereq.: 13.42

Acad Year 1996-97: Not offered

Acad Year 1997-98: G (Fall)

3-0-9 H-LEVEL Grad Credit

Advanced topics in designing ocean engineering systems. Wave, current, and wind forces; statistics of drift forces. Separation, oscillatory flow around bluff bodies. Vortex-induced vibrations. Galloping and flutter. Cable statics and dynamics; dynamics and design of multileg mooring systems. Riser statics and dynamics; flexible risers; towed arrays. Dynamic positioning of vehicles; modeling issues and control system design. Applications to floating structures include moored semisubmersibles and ships, and tension-leg platforms.

*M. S. Triantafyllou, M. Grosenbaugh***13.462 Projects in Ocean Engineering System Design**

Prereq.: 13.412 or 13.42 or 13.43

G (Fall, Spring, Summer)

Units arranged H-LEVEL Grad Credit

Can be repeated for credit

Determines design criteria for ocean-based systems such as ships, submersibles, platforms, and their control systems derived from a set of system mission requirements specified by the student in consultation with the instructor. Preparation of preliminary design of system fulfilling selected criteria. Students intending to take 13.462 should plan a two-term sequence, preferably beginning in the first term. Participation by several students in a single project encouraged. Primarily for graduate students in Ocean Engineering; others admitted by permission of instructor.

*C. Chrysostomidis, M. S. Triantafyllou***13.465 Ocean Instrument Field Laboratory**

Prereq.: 13.951

G (IAP)

1-4-1 H-LEVEL Grad Credit

Field experience subject at Woods Hole Oceanographic Institution. Classroom background and field laboratory with hands-on experience. Emphasis on modern oceanographic instrumentation including the operation of side-scan sonar, conductivity, temperature, depth, and optical backscatter systems; modern underwater acoustic navigation and tracking techniques; underwater systems for coastal research and monitoring; and underwater vehicle operation.

*J. H. Milgram, C. von Alt (Woods Hole Staff)***13.470J Computer Aided Engineering I**

(Same subject as 1.124J, 2.159J)

Prereq.: 1.00 and knowledge of C

G (Fall)

3-3-6 H-LEVEL Grad Credit

See description under subject 1.124J.

J. R. Williams

Engineering School-Wide Elective Subject
Description given at end of this chapter in
SWE section on page 162
J. R. Williams

13.471J Design and Implementation of Computer-Aided Engineering Systems

(Same subject as 2.157J, 1.127J)

Prereq.: Permission of instructor

G (Fall)

3-2-7 H-LEVEL Grad Credit

See description under subject 2.157J.

*N. M. Patrikalakis, D. C. Gossard***13.472J Computational Geometry**

(Same subject as 1.128J, 2.158J)

Prereq.: 13.471J/2.157J or 6.837

Acad Year 1996-97: Not offered

Acad Year 1997-98: G (Spring)

3-0-9 H-LEVEL Grad Credit

Topics in surface modeling: b-splines, non-uniform rational b-splines, physically based deformable surfaces, sweeps and generalized cylinders, offsets, blending and filleting surfaces. Non-linear solvers and intersection problems. Solid modeling: constructive solid geometry, boundary representation, non-manifold and mixed-dimension boundary representation models, octrees. Robustness of geometric computations. Interval methods. Finite and boundary element discretization methods for continuum mechanics problems. Scientific visualization. Variational geometry. Tolerances. Inspection methods. Feature representation and recognition. Shape interrogation for design, analysis, and manufacturing. Involves analytical and programming assignments in C.

*N. M. Patrikalakis, D. C. Gossard***13.49 Maneuvering and Control of Surface and Underwater Vehicles**

Prereq.: 13.42

G (Fall)

3-0-9 H-LEVEL Grad Credit

Maneuvering motions of surface and underwater vehicles. Derivation of equations of motion, hydrodynamic coefficients. Memory effects. Linear and nonlinear forms of the equations of motion. Control surfaces; modeling and design of control surfaces. Environmental forces, simulation of a maneuvering vehicle. Towed vehicles and their motion. Stability of motion. Principles of multivariable automatic control; effect of delays. Applications include autopilots for surface vehicles; towing in open seas; remotely operated vehicles; and single point moorings.

M. S. Triantafyllou, M. Grosenbaugh

Acad Year 1996-97: Not offered
Acad Year 1997-98: G (Fall)

See description under subject 2.158J (SWE)
3-0-9 H-LEVEL Grad Credit

Acad Year 1996-97: Not offered
Acad Year 1997-98: G (Fall)

See description under subject 2.158J (SWE)

13.50 Numerical Methods with Applications to Marine Problems

Prereq.: 18.03, 13.016 or 1.00

G (Fall)

3-0-9

Introduces numerical methods useful in the solution of engineering problems. Representation of numbers on the computer. Round-off error. Solution of linear systems. Nonlinear equations. Eigenvalues of dynamical systems. Singular-value decomposition. Optimization methods. Fast Fourier Transforms. Differential equations. Solution of model problems from ocean engineering by finite-difference, finite-element, and spectral methods. Assigned computer problems requiring familiarity with FORTRAN.

*P. D. Sclavounos***13.51 Computer Models of Physical and Engineering Systems**

Prereq.: 18.03 or 18.034, 1.00

U (Spring)

3-1-8

Engineering School-Wide Elective Subject.
Description given at end of this chapter in
SWE section on page 999.

*F. Peña-Mora***13.52 Management in Engineering**

Prereq.: —

U (Fall)

3-0-9

Engineering School-Wide Elective Subject.
Description given at end of this chapter in
SWE section on page 562.

*J.-H. Chun***13.60 Ship Production (New)**

Prereq.: 13.410, 13.122, 13.17J

G (Summer)

3-1-8 H-LEVEL Grad Credit

Presents and applies modern ship production methods in a total ship system and concurrent engineering context. Reviews basic fabrication and material handling processes. Major topics include design/production integration, build strategy, group technology zone construction, shipyard layout, CAD/CAM, accuracy control, process planning, and scheduling. Examines design concepts to enhance producibility and reduce cost/environment impact. Uses case studies and projects.

A. J. Brown

13.61 Project Management

Prereq.: Permission of instructor
G (Fall)
3-0-9 H-LEVEL Grad Credit

Review of project and development economics. Project identification and demand forecast techniques. Study of project design and planning methods such as network planning techniques, technological forecasting and evaluation methods, capital budgeting and project control, and scheduling techniques. Technical, operational, economic, and financial project analyses reviewed. Methods for selection from among project alternatives discussed. Study of procurement or contracting process. Approaches to project supervision, test, and acceptance.

E. G. Frankel

13.615J Project Control (New)

(Same subject as 1.432J)
Prereq.: Permission of instructor
G (Fall)
3-0-9 H-LEVEL Grad Credit

See description under subject 1.432J.
F. Peña-Mora, H. S. Marcus

13.62 Engineering Systems Analysis

Prereq.: Permission of instructor
G (Fall)
3-0-6 H-LEVEL Grad Credit

Engineering School-Wide Elective Subject. Description given at end of this chapter in SWE section on page 562.
R. de Neufville, J. P. Clark, F. Field

13.621 Engineering Risk-Benefit Analysis

Prereq.: 18.02
G (Spring)
3-0-6 H-LEVEL Grad Credit

Engineering School-Wide Elective Subject. Description given at end of this chapter in SWE section on page 562.
G. Apostolakis, A. W. Drake, A. R. Odoni

13.64 Projects in Ocean Systems Management

Prereq.: Permission of instructor
G (Spring)
Units arranged H-LEVEL Grad Credit

An applied problem-solving subject where students work in multidisciplinary teams to solve current ocean systems problems. Designed to train students how to think about large marine systems, identify problems, formulate and carry out research plans, perform rigorous analyses, and seek alternative solutions. Combines analytical skills and knowledge in marine management, ocean engineering technologies, and marine sciences. Projects change yearly, and include topics such as ocean transport systems, oil and other marine pollution, dredging and port systems, wastewater management, and ocean resources management. Primarily for students in Ocean Systems Management and Marine Environmental Systems Programs; others admitted by permission of instructor.

H. S. Marcus, J. T. Kildow, J. D. Nyhart

13.661 Economics of Marine Transportation and Environment

Prereq.: 14.01 or permission of instructor
G (Fall)
2-0-4 H-LEVEL Grad Credit

Studies the economics of the principal markets related to marine transportation, environment, and natural resources. Structures of the markets and industries involved; competition; impacts of policies and regulations. Analysis of the interrelationships among economic infrastructures, technologies, and national policies. Introduces new concepts of national income accounts, sustainability, and intergenerational equity and their relationship to current economic practice. Meets first half of term.

J. T. Kildow, H. S. Marcus

13.665J Logistical and Transportation Planning Methods

(Same subject as 1.203J, 6.281J, 11.526J, 15.073J, 16.76J)
Prereq.: 6.431, 15.075
G (Fall)
3-0-9 H-LEVEL Grad Credit

See description under subject 1.203J.
A. I. Barnett, R. C. Larson, A. R. Odoni

13.68 Management of Marine Systems

Prereq.: Permission of instructor
G (Fall)
2-0-4 H-LEVEL Grad Credit

Analyzes current technological, market, and regulatory trends in various segments of the marine industry and government development programs such as liner trades, vessel chartering, shipbuilding, defense systems, and coastal facilities; description of resources and constraints involved; impact of trends on management decisions; analysis of problems actually existing in the field. Meets during second half of term.

H. S. Marcus

13.685J Manufacturing/Technology Interface

(Same subject as 15.365J)
Prereq.: Permission of instructor
G (Spring)
3-0-6 H-LEVEL Grad Credit

See description under subject 15.365J.
J. M. Utterback

13.69 International Shipping

Prereq.: 13.68
G (Spring)
3-0-6 H-LEVEL Grad Credit

Explores internal operating, financial, and marketing issues as well as external market and technological factors that define the international shipping environment. Includes effect of world energy prices and changing trade patterns upon demand for shipping; evaluation of shipping capacity requirements in terms of capital needs; new ship and terminal technologies; and effect of changing international relationships. Other students admitted by permission of the instructor.

H. S. Marcus

13.690–699 Special Problems in Ocean Engineering

Prereq.: —
U (Fall, IAP, Spring, Summer)
Units arranged [P/D/F]
Can be repeated for credit

13.700–13.709 Special Problems in Ocean Engineering

Prereq.: —
U (Fall, IAP, Spring, Summer)
Units arranged
Can be repeated for credit

Special reading, study, design, and/or investigation under supervision of a qualified member of the staff. Topics in ocean engineering, naval architecture, or marine engineering individually arranged to suit interests of the student. Consult Department Student Administration Office for subject number that will be assigned in accordance with the technical area of the topic selected.

D. K.-P. Yue

13.710–13.719 Special Problems in Ocean Engineering

Prereq.: —
G (Fall, IAP, Spring, Summer)
Units arranged H-LEVEL Grad Credit
Can be repeated for credit

Special reading, study, design, and/or investigation under supervision of a member of the staff. Topics in ocean engineering, naval architecture, or marine engineering individually arranged to suit interests of the student. Consult Department Student Administration Office for subject number that will be assigned by the Department in accordance with the technical area of the topic selected.

A. D. Carmichael

13.720–729 Special Problems in Ocean Engineering

Prereq.: Permission of instructor
G (Fall, IAP, Spring, Summer)
Units arranged [P/D/F] H-LEVEL Grad Credit
Can be repeated for credit

13.730–13.739 Seminar in Ocean Engineering

Prereq.: Permission of instructor
G (Fall, Spring)
Units arranged
Can be repeated for credit

Weekly lectures on new topics in ocean engineering by members of the MIT staff. Consult Department Student Administration Office for subject number assigned in accordance with the technical area of the topic selected. Consult Department Headquarters.

13.741J Sonar, Radar and Seismic Signal Processing I

(Same subject as 6.455J, 12.518J)

Prereq.: 2.02 or 2.003 or 6.003, 6.041, 18.075 or 18.085

G (Fall)

3-0-9 H-LEVEL Grad Credit

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.

A. B. Baggeroer

13.742J Sonar, Radar and Seismic Signal Processing II

(Same subject as 6.456J, 12.519J)

Prereq.: 13.741J

G (Spring)

3-1-8 H-LEVEL Grad Credit

Continuation of 13.741J emphasizing array processing in sonar, radar, and seismics. Arrays, beamformers and frequency-wave number filters, space-time process characterization, bearing estimation for single and multiple sources, directional and frequency wavenumber spectra estimation, adaptive arrays, matched field processing, multichannel deconvolution, velocity spectra estimation, common depth point stacking, migration.

A. B. Baggeroer

13.771 Engineering Internship

Prereq.: —

U (Summer)

0-6-0 [P/D/F]

13.774 Advanced Engineering Internship

Prereq.: 13.771

G (Fall, Spring, Summer)

0-6-0

Enrollment restricted to students registered in Course XIII-C Program. Provides academic credit for assignments affiliated with XIII-C Program. Students register for 13.771 during their first and second company assignments, accumulating a total of 12 units. Students register for 13.774 during their seven-month company assignment (after admission to graduate school), accumulating a total of 12 graduate units (six units per term). Credit for above given upon satisfactory completion of company assignments, receipt of favorable evaluation by company supervisor, and receipt of favorable evaluation of student's report about company assignment by faculty advisor.

C. Chrysostomidis

13.78 Entrepreneurship

Prereq.: —

G (Spring)

4-0-5

Engineering School-Wide Elective Subject.

Description given at end of this chapter in SWE section on page 562.

T. G. Gutowski

13.80J Mechanical Vibration (Revised Units)

(Subject meets with 2.06J, 13.801)

Prereq.: 13.013J

U (Spring)

3-1-8

Concepts of mechanical vibration, including free and forced vibration of single- and multi-degree of freedom systems. Modal analysis and matrix formulation of vibration problems. Approximate solution techniques. Vibration and modal analysis of continuous systems: beams, rods, and strings. Introduction to the response of linear systems to random excitation. Numerous examples and applications of vibration measurement and analysis, including vibration isolation and dynamic absorbers, ships, offshore structures, engines, and rotating machinery. Elective unit distribution: Advanced disciplinary, 9; Lab, 3.

F. Feng, J.K. Vandiver

13.801 Mechanical Vibration (Revised Units)

(Subject meets with 13.80J, 2.06J)

Prereq.: 13.013J

U (Spring)

3-1-8

Meets with undergraduate subject 13.80J, but assignments differ. See description under subject 13.80J.

F. Feng, J. K. Vandiver

13.81J Principles of Acoustics

(Same subject as 2.060J)

Prereq.: 13.013J or 2.03J or 16.040, 18.075

G (Fall)

3-0-9 H-LEVEL Grad Credit

See description under subject 2.060J.

Staff

13.82J Sound and Structural Vibration

(Same subject as 2.063J)

Prereq.: 2.03J or 16.040 or 18.075

G (Spring)

3-0-9 H-LEVEL Grad Credit

See description under subject 2.063J.

Staff

13.83J Structural Acoustics

(Same subject as 2.067J)

Prereq.: —

Acad Year 1996-97: Not offered

Acad Year 1997-98: G (Fall)

3-0-9 H-LEVEL Grad Credit

See description under subject 2.067J.

Staff

13.851 Fundamentals and Applications of Underwater Sound

Prereq.: 18.075

G (Spring)

3-0-9 H-LEVEL Grad Credit

Fundamentals of underwater sound systems as controlled by physical principles and properties of the ocean and its boundaries. Analyzes sonar systems. Absorption in sea water. Transmitting and receiving arrays. Scattering and reflection. Refraction and propagation loss. Noise and reverberation. Sonar design principles. Applications in charting, navigation, station keeping, target detection, fishing, petroleum exploration, telemetry.

I. Dyer

13.861 Ocean and Seabed Acoustics I

Prereq.: Permission of instructor

Acad Year 1996-97: Not offered

Acad Year 1997-98: G (Fall)

3-0-9 H-LEVEL Grad Credit

Surveys properties of the ocean and seabed and of predictive models of sound propagation, in relation to sonar and seismic system design and/or to the use of sound to uncover oceanic properties. Ray and wave theories of propagation in vertically stratified media. Approximate propagation theories for a horizontally varying ocean. Reflection and transmission of sound by a stratified ocean bottom. Scattering from a random sea surface and seafloor. Introductory knowledge of Fourier analysis, probability, and wave propagation necessary. (Woods Hole Staff): G. Frisk

13.862 Ocean and Seabed Acoustics II

Prereq.: 13.861, permission of instructor

Acad Year 1996-97: Not offered

Acad Year 1997-98: G (Spring)

3-0-9 H-LEVEL Grad Credit

Continuation of 13.861, treating ray and normal mode theory in greater depth, and introducing new topics. Emphasizes "state-of-the-art" level in ocean acoustics. Includes ray theory corrections, coupled normal-mode theory, adiabatic approximation, continuum and virtual modes, rough-surface scattering in mode theory, ray-mode picture connections, parabolic equation, and perturbative inversions for both water column and ocean bottom properties.

(Woods Hole Staff): J. F. Lynch

13.863 Ocean Seismo-Acoustics

Prereq.: 13.851 or permission of instructor

Acad Year 1996-97: G (Fall)

Acad Year 1997-98: Not offered

3-0-9 H-LEVEL Grad Credit

Low-frequency propagation in ocean environments with special emphasis on the interaction of the acoustic field in the water column with seismic waves in seabed and ice cover. Fundamentals of ocean waveguide propagation. Stress wave propagation in isotropic elastic solids. The fluid-solid interface. Fluid-elastic waveguides. Effects of seismic waves on ocean sound propagation. Seismic interface and surface waves in a stratified seabed. Seismic waves in ice cover. Propagation over anisotropic and porous seabeds.

H. Schmidt

13.871 Wave Scattering by Rough Surfaces and Randomly Inhomogenous Media

Prereq.: Permission of instructor
 Acad Year 1996-97: G (Spring)
 Acad Year 1997-98: Not offered
 3-0-9 H-LEVEL Grad Credit

An advanced-level subject designed to give the student working knowledge of current techniques in scattering theory as applied to rough surfaces and randomly inhomogenous media. Major application of theory presented is to ocean acoustics, but can be used in other acoustic and electromagnetic applications. Includes basics of scattering theory, volume scattering by discrete scatters (aerosols), scattering by rough surfaces, satellite remote sensing using rough-surface scattering, and acoustic scattering from ocean internal waves.
(Woods Hole Staff): J. F. Lynch, D. J. Tang, T. Stanton

13.92 Marine Policy

Prereq.: Permission of instructor
 G (Fall)
 3-0-3 H-LEVEL Grad Credit

Features major ocean uses and their associated national and international policy issues through the vehicles of (a) policy analysis and (b) case studies demonstrating relationships among ocean uses and technologies, and their relationship to politics and economic infrastructure. Cases focus on living and non-living resource management problems, and pollution and conservation issues of environmental management. Taught first half of term in coordination with 13.94.

J. T. Kildow

13.94 Law for Ocean Systems

Prereq.: Permission of instructor
 G (Fall)
 3-0-3 H-LEVEL Grad Credit

Legal framework for managing ocean resources and systems, combining public law of the sea, admiralty, and the US regulatory law. OCS, tanker, shipping, and environmental regimes. Law for new ocean technologies. Questions of jurisdiction and implementation arising from new economic zones or unilateral extensions. Principles governing applicability of civil and criminal law offshore. Focus on relationship of law and technology. Taught second half of term in coordination with 13.92.
J. D. Nyhart

13.951 Transport, Fate, and Effects of Ocean Pollutants

Prereq.: 13.012 or equivalent
 G (Fall)
 3-0-9 H-LEVEL Grad Credit

Provides the background for quantitatively predicting and estimating the distribution of pollution, its by-products, and some of its effects on marine ecosystems, starting with information about the pollution source. Topics include: equations of motion for ocean flows, ocean currents, molecular and turbulent diffusion, fluid mechanical transport models, seawater properties and chemistry, important chemicals in the ocean, sediment-chemical interactions, chemical-biological interactions, ocean contaminations and their biological consequences.
J. H. Milgram; Woods Hole Staff

13.98J Environmental Management of the Coast

(Same subject as 11.365J)
 Prereq.: Permission of instructor
 G (Spring)
 3-0-9 H-LEVEL Grad Credit

Methods and concepts introduced through case studies of management options for meeting coastal environmental challenges. Includes background in physical and ecological coastal processes to provide foundation for understanding natural process change and the implications of human interventions which stretch or alter natural limitations. Cases focus on institutional and regulatory frameworks for three environmental themes: 1) impacts of global climate change, 2) coastal pollution and biodiversity, 3) conflicting uses.
J. T. Kildow

13.990J Oceanographic Systems I

(Same subject as 1.697J)
 Prereq.: —
 G (Summer)
 2-4-6

Orientation subject for students entering the MIT-Woods Hole Oceanographic Institution program in oceanographic engineering. Oceanographic experiments of research interest in Cape Cod waters carried through experiment design, instrumentation design, construction and testing, deployment, data taking and interpretation of results. Research teams made up of students in 13.990J and 13.991J together. Participation in summer seminars at WHOI. Given at Woods Hole Oceanographic Institution.
(Woods Hole Staff), J. F. Lynch

13.991J Oceanographic Systems II

(Same subject as 1.698J)
 Prereq.: —
 G (Summer)
 2-4-6

Continuation of 13.990J during second summer term in the MIT-WHOI Joint Program in Oceanographic Engineering. Given at Woods Hole Oceanographic Institution.
(Woods Hole Staff)

Relationships. Other students admitted by permission of the instructor.
H. S. Marcus

13.998 Principles of Oceanographic Instrument Systems — Sensors and Measurements

Prereq.: 2.03J/13.013J, 18.075
 Acad Year 1996-97: G (Spring)
 Acad Year 1997-98: Not offered
 3-3-6 H-LEVEL Grad Credit

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. Laboratory project required.
(Woods Hole Staff): A. Williams, J. Irish, C. Mazel (MIT)

13.999J Special Projects in Oceanographic Engineering

(Same subject as 1.699J)
 Prereq.: Permission of instructor
 G (Fall, Spring, Summer)
 Units arranged H-LEVEL Grad Credit
 Can be repeated for credit

Special problems in oceanographic engineering, carried out under supervision of members of the staff of the Woods Hole Oceanographic Institution. Given at Woods Hole Oceanographic Institution.
(Woods Hole Staff)

13.ThG Graduate Thesis

Prereq.: —
 G (Fall, IAP, Spring, Summer)
 Units arranged H-LEVEL Grad Credit
 Can be repeated for credit

Program of graduate research, leading to the writing of an S.M., Ph.D., or Sc.D. thesis; to be arranged by the student and an appropriate MIT faculty member. Consult Department Headquarters.
Staff

Course 14**Economics**

For degree requirements, see listing in Chapter VII under the School of Humanities and Social Science.

General Economics and Theory**14.UR Undergraduate Research**

Prereq.: 14.02

U (Fall, Spring)

Units arranged [P/D/F]

Can be repeated for credit

14.URG Undergraduate Research

Prereq.: 14.02

U (Fall, Spring)

Units arranged

Can be repeated for credit

Participation in research with an individual faculty member or research group, independent research or study under the guidance of a faculty member. Admission by arrangement with individual faculty member.

Consult L. Smith.

14.01 Principles of Microeconomics

Prereq.: —

U (Fall, Spring)

3-0-9 HASS

Introduces microeconomic concepts and analysis. Supply and demand analysis, theories of the firm and of individual behavior, competition and monopoly, welfare economics. Applications to problems of current economic policy.

Fall Term: J. Harris

Spring Term: F. Fisher

14.02 Principles of Macroeconomics

Prereq.: —

U (Fall, Spring)

3-0-9 HASS

Provides an overview of macroeconomic issues: the determination of output, employment, unemployment, interest rates, and inflation. Monetary and fiscal policies are discussed, as are the public debt and international economic issues. Introduces basic models of macroeconomics and illustrates principles with the experience of the US and foreign economies.

Fall Term: O. Blanchard

Spring Term: R. Caballero

14.03 Intermediate Applied Microeconomics

Prereq.: 14.01

U (Fall, Spring)

4-0-8 HASS

Credit cannot also be received for 14.04

Presents basic theory and applications of consumer and producer behavior and welfare analysis at an intermediate level. Emphasizes applications, including the measurement of productivity, rationing, insurance markets, and intertemporal behavior.

Fall Term: D. Genesove

Spring Term: S. Athey

14.04 Intermediate Microeconomic Theory

Prereq.: 14.01, 18.02, 18.06

U (Fall)

4-0-8

Credit cannot also be received for 14.03

Basic theory of consumer behavior, production and costs, partial equilibrium analysis of pricing in competitive and monopolistic markets, general equilibrium, welfare, and externalities. Credit not given for both 14.03 and 14.04. May not count toward HASS Requirement. Recommended for students planning to apply to graduate school in economics, accounting, or finance.

L. Smith

14.05 Intermediate Applied Macroeconomics

Prereq.: 14.02

U (Fall)

4-0-8 HASS

Uses the tools of macroeconomics to study two or three macroeconomic policy problems in depth. Possible topics include long-run economic growth, the macroeconomics of the transition to a modern capitalist society, federal government deficits, Social Security, the distribution of earnings and income, and the Great Depression.

P. Temin

14.06 Intermediate Macroeconomic Theory

Prereq.: 14.02

U (Spring)

4-0-8 HASS

Thorough review of models of economic growth and business cycles with applications in fiscal, monetary, and commercial policy. Recommended for students planning to apply to graduate school in economics.

J. Ventura

14.09 Reading Seminar in Economics

Prereq.: 14.04, 14.06

U (Fall, Spring, Summer)

Units arranged [P/D/F]

Can be repeated for credit

Reading and discussion of particular topics in economics. Open to undergraduate students by arrangement with individual faculty members. Consult Department Headquarters.

J. Gruber

14.10 Reading Seminar in Economics

Prereq.: 14.04, 14.06

U (Fall, Spring)

Units arranged

Can be repeated for credit

Reading and discussion of particular topics in economics. Open to undergraduate students by arrangement with individual faculty members. Consult Department Headquarters.

J. Gruber

14.102 Mathematics for Economists (New)

Prereq.: 18.01, 18.02, 18.06

G (Fall)

4-0-8

Covers some topics in mathematics that are frequently used in economic theory and in applications. Topics include: i) optimization theory (including optimal control and recursive methods); ii) probability theory; iii) topology (continuity, compactness); iv) dynamical systems (including stability); v) convex analysis; vi) fixed point theory. Presentation of each topic self-contained.

A. Bisin, L. Smith

14.103 Dynamic Optimization and Economic Applications (New)

Prereq.: 14.102

Acad Year 1996-97: Not offered

Acad Year 1997-98: G (Fall)

2-0-4 H-LEVEL Grad Credit

Stochastic processes, including Markov chains, stochastic stability, stochastic calculus and integration. Stochastic optimization, including dynamic programming, stopping times, regulated Brownian motion. Applications include growth, natural resources, asset pricing, learning, investment.

Staff

14.111J Economics of Project Evaluation

(Same subject as 1.148J)

Prereq.: 14.03

Acad Year 1996-97: Not offered

Acad Year 1997-98: G (Spring)

3-0-6 H-LEVEL Grad Credit

Economic concepts of costs and benefits: consumers' and producers' surplus; shadow prices; and valuation of nonmarket costs and benefits. Investment criteria and the discount rate: static and dynamic; treatment of risk and uncertainty. Pricing policies and investment rules. Case studies in developed and underdeveloped countries.

Consult P. Joskow.

14.12 Economic Applications of Game Theory

Prereq.: 14.01

U (Fall)

4-0-8 HASS

Analysis of strategic behavior in multi-person economic settings. Introduction to Nash equilibrium and its refinements: subgame-perfect equilibrium and sequential equilibrium. Applications drawn from labor economics, the economics of organization, industrial organization, international trade, and macroeconomics.

D. Acemoglu

14.121 Microeconomic Theory I

Prereq.: 14.04 and permission of instructor

G (Fall)

2-0-4 H-LEVEL Grad Credit

Individual choice and production, including competitive markets and monopoly. Class size limited.

S. Athey

14.122 Microeconomic Theory II

Prereq.: 14.121 and permission of instructor

G (Fall)

2-0-4 H-LEVEL Grad Credit

Introduction to game theory. Class size limited.

G. Ellison

14.123 Microeconomic Theory III

Prereq.: 14.121, 14.122, and permission of instructor

G (Spring)

2-0-4 H-LEVEL Grad Credit

General equilibrium, capital theory, incomplete markets, externalities, public goods. Class size limited.

P. A. Diamond

14.124 Microeconomic Theory IV

Prereq.: 14.123 and permission of instructor

G (Spring)

2-0-4 H-LEVEL Grad Credit

Information economics, externalities, public goods and incentives. Market equilibria and contract design. Class size limited.

B. Holmstrom

14.125 General Equilibrium

Prereq.: 14.04

Acad Year 1996-97: Not offered

Acad Year 1997-98: G (Spring)

4-0-8 H-LEVEL Grad Credit

Topics include Arrow-Debreu economies, general equilibrium economies with incomplete markets, informational asymmetries, increasing returns, imperfect competition. Mathematical techniques to study existence, regularity, welfare properties of equilibria. Applications provided with special emphasis on financial markets, fiscal policy, and regulation.

Consult A. Bisin.

14.126 Game Theory

Prereq.: 14.122

G (Spring)

3-0-9 H-LEVEL Grad Credit

How should economic agents act when their optimal decisions depend on what they expect other agents to do? We study various models of equilibrium, which correspond to different ways that the agents might make their decisions, and various kinds of games — static games, dynamic games, and games of incomplete information.

A. Banerjee, G. Ellison

14.127 Economics of Uncertainty

Prereq.: 14.124

G (Fall)

3-0-9 H-LEVEL Grad Credit

Part I: Fundamentals of information theory, with applications to social learning, individual experimentation, and search theory. Part II: Models of decentralized trading with search, models of trading with imperfect information.

D. Acemoglu, L. Smith

14.128 Dynamic Optimization and Economic Applications

Prereq.: 14.101

Acad Year 1996-97: Not offered

Acad Year 1997-98: G (Spring)

4-0-8 H-LEVEL Grad Credit

Deterministic optimization: maximum principle, dynamic programming, calculus of variations, optimal control, dynamic games. Stochastic optimization: stochastic optimal control and dynamic programming, Markov processes, Ito calculus, Markov games. Applications. Dynamical systems: local and global analysis and chaos.

Consult A. Bisin.

14.129 Contract Theory

Prereq.: 14.121, 14.451

G (Fall)

4-0-8 H-LEVEL Grad Credit

Recent developments in contract theory. Includes hidden action and hidden information models, dynamic agency issues, incomplete contracts, and applications of contract theory to theories of the firm and corporate financial structure.

S. Athey, B. Holmstrom

14.141 Disequilibrium Foundations of Equilibrium Economics

Prereq.: 14.122

G (Spring)

2-0-4 H-LEVEL Grad Credit

Does a competitive economy, with rational agents taking advantage of disequilibrium opportunities for arbitrage, tend to approach equilibrium? Is that equilibrium competitive?

Importance of the subject for the foundations of usual economic analysis and the theory of value. Historical review and modern theory of stability in relation to above questions. Half-term subject.

F. Fisher

14.191 Independent Research Paper

Prereq.: Permission of instructor

G (Fall, Spring)

0-12-0 H-LEVEL Grad Credit

Can be repeated for credit

Under supervision of a faculty member approved by Graduate Registration Officer, student writes a substantial, probably publishable research paper. Must be completed by the end of a student's second year to satisfy the departmental minor requirement.

P. Temin

14.192 Supervised Research

Prereq.: Permission of instructor

G (Fall, Spring)

Units arranged [P/D/F] H-LEVEL Grad Credit

Can be repeated for credit

Student participates in research with an individual faculty member, with approval of Graduate Registration Officer.

P. Temin

14.193 Seminar: Topics in Economics

Prereq.: 14.121, 14.451

G (Fall)

Units arranged H-LEVEL Grad Credit

Can be repeated for credit

14.194 Seminar: Topics in Economics

Prereq.: 14.121, 14.451

G (Spring)

Units arranged H-LEVEL Grad Credit

Can be repeated for credit

Reading and discussion of special topics in economics. Open to advanced graduate students by arrangement with individual members of the staff.

Consult Department Headquarters.

14.195, 14.196 Reading Seminar in Economics

Prereq.: 14.121

G (Fall, Spring)

Units arranged [P/D/F] H-LEVEL Grad Credit

Can be repeated for credit

Reading and discussion of special topics in economics. Open to advanced graduate students by arrangement with individual members of the staff.

Consult Department Headquarters.

14.198, 14.199 Teaching Introductory Economics

Prereq.: —

G (Fall, Spring)

2-0-2 [P/D/F]

Can be repeated for credit

Required of teaching assistants in introductory economics (14.01 and 14.02), under supervision of the faculty member in charge of the subject.

14.198: *J. Harris, F. Fisher*14.199: *O. Blanchard, R. Caballero***Industrial Organization****14.20 Industrial Organization and Public Policy**

Prereq.: 14.01

U (Spring)

3-0-9 HASS

Analyzes the structure, behavior, and performance of industrial markets in the US economy. Topics include the measurement of monopoly power, behavior of firms in oligopoly markets, static and dynamic measures of market performance, antitrust, research and development, consumer protection policy, and theory of the firm.

*D. Genesove***14.21J Health Economics**

(Same subject as HST.901J)

Prereq.: 14.01

U (Fall)

3-0-9 HASS

Applies theoretical and empirical tools of economics to problems of health and medical care delivery. Concentrates on selected problems such as the welfare economics of "health" as a commodity, hospitals and the nonprofit sector, human capital and medical manpower, and innovation in medicine.

*J. E. Harris***14.23 Government Regulation of Industry (Revised Units)**

Prereq.: 14.01

U (Spring)

4-0-8 HASS

Examines government regulation of prices, entry, and product quality from a normative and positive perspective. Theoretical analyses of regulatory mechanisms and empirical analyses of regulatory behavior and performance are included. Regulatory reform, industry restructuring, and deregulation in industries such as telecommunications, electric power, airlines, and pharmaceuticals in the US and abroad are covered.

P. Temin

Prereq.: 14.01, permission of instructor
G (Fall)
3-0-8 H-LEVEL Grad Credit

Methods of economic growth: old and new. How
from subject. Class size limited.
J. Verdun

14.24 Law and Economics

Prereq.: 14.01

U (Fall)

4-0-8 HASS

Analysis of the role of the legal system in providing an appropriate framework for market transactions and in encouraging efficient resource allocation. Contracts, torts, and property law emphasized. Cases considered along with general theory.

*P. Diamond***14.25J Aerospace Economics**

(Same subject as 16.800J)

Prereq.: 14.01

U (Fall)

3-0-9 HASS

See description under subject 16.800J.

*P. P. Belobaba***14.271 Industrial Organization I**

Prereq.: 14.04

G (Fall)

4-0-8 H-LEVEL Grad Credit

Covers theoretical and empirical work dealing with the structure, behavior, and performance of firms and markets and core issues in antitrust. Topics include the organization of the firm, monopoly, price discrimination, oligopoly, monopolistic competition, product selection, and advertising. Theoretical and empirical work are integrated in each area.

*G. Ellison, D. Genesove***14.272 Industrial Organization II**

Prereq.: 14.271

G (Spring)

4-0-8 H-LEVEL Grad Credit

A continuation of 14.271. Focuses on public policy issues in industrial organization including topics in antitrust policy, economic and social regulation, deregulation and privatization, patent and R & D policies, and the political economy of regulation. Theoretical and empirical work is integrated in each area.

*P. Joskow, N. Rose***14.28 Competition in Telecommunications**

(Subject meets with 15.020)

Prereq.: 14.03 or 14.04

U (Fall)

3-0-9 HASS

Provides an introduction to the economics and technology of telecommunications markets, including markets for exchange and information services, cellular telephone, long-distance services, and both carrier and customer equipment. The shifting roles of technology, Federal and state government policies, and business strategies in shaping these rapidly changing markets are studied, with particular emphasis on the roles of regulation and competition and the likely evolution of technology, public policy, and market structures over the next decade. Undergraduates expected to complete an extra assignment in order to receive the additional units of credit.

*J. Hausman***14.286J Health Economics Seminar**

(Same subject as HST.903J)

Prereq.: 14.04, permission of instructor

G (Spring)

3-0-9 H-LEVEL Grad Credit

Can be repeated for credit

Advanced subject in economics of health-care sector. Considers selected topics in depth, such as design and financing of health insurance, behavior of nonprofit hospitals, role of competition in the medical care market, determinants of technological change, and effects of government regulations.

*J. E. Harris***14.29 Topics in Political Economy (New)**

Prereq.: 14.03 or 14.04

U (Fall)

4-0-8 HASS

Reviews recent theoretical advances in the field of political economy. Is politics mainly about conflicting interests or about information? Positive and normative analysis of political institutions in terms of mechanism design. Theory and empirical data about party positioning, polarization, coalition formation, and stability. Political-economic cycles, competing explanations of the size of countries. Voting as aggregating information, voting vs. the market. Should one expect efficient outcomes? Application to taxation and trade liberalization.

*D. Spector***14.294 Seminar in Political Economy**

Prereq.: 14.121, 14.122, and permission of instructor

G (Fall, Spring)

3-0-6 H-LEVEL Grad Credit

Political economics is the study of group or collective decision-making processes and the institutions that evolve to implement them. Includes collective choice theory, interest group competition, theories of economic regulation, legislative behavior, bureaucracy, and behavior of administrative agencies. Both theoretical and empirical work are discussed.

*P. Joskow, J. Poterba***14.295J Theory of Collective Choice: Empirical Tests**

(Same subject as 17.808J)

Prereq.: 17.806J

Acad Year 1996-97: G (Spring)

Acad Year 1997-98: Not offered

3-0-9 H-LEVEL Grad Credit

See description under subject 17.808J.

*S. Ansolabehere***14.296J Theory of Collective Choice: Institutions and Positive Political Theory**

(Subject meets with 17.806J, 17.805)

Prereq.: —

G (Spring)

3-0-9

See description under subject 17.806J.

J. M. Snyder, Jr.

Statistics and Econometrics

14.30 Introduction to Statistical Method in Economics

Prereq.: 18.02
U (Fall, Spring)
4-0-8 REST

Self-contained introduction to statistics with economic applications. Elements of probability theory, sampling theory, statistical estimation, regression analysis, and hypothesis testing. Elementary econometrics and other applications of statistical tools to economic data. May not count toward HASS Requirement.

Fall Term: *S. Ellison*
Spring Term: *J. Bai*

14.31 Econometrics

Prereq.: 14.30
U (Fall, Spring)
3-4-5 Institute LAB

Introduces basic econometric techniques, emphasizing the application of least squares to cross section and time series data. Examples include applications to labor economics, monetary economics, and financial economics. Advanced topics covered include two stage least squares, panel data methods, and limited dependent variable models. May not count toward HASS Requirement.

Fall Term: *D. Costa*
Spring Term: *J. Angrist*

14.381 Statistical Method in Economics

Prereq.: 18.02, permission of instructor
G (Fall)
4-0-8 H-LEVEL Grad Credit

Self-contained introduction to probability and statistics as background for advanced econometrics. Elements of probability theory; sampling theory; asymptotic approximations; decision-theory approach to statistical estimation focusing on regression, hypothesis testing, and maximum-likelihood methods. Illustrations from economics and application of these concepts to economic problems. Class size limited.
J. Bai

14.382 Econometrics I

Prereq.: 14.101, 14.381, permission of instructor
G (Spring)
4-0-8 H-LEVEL Grad Credit

Specification and estimation of the linear regression model. Departures from the standard Gauss-Markov assumptions include heteroskedasticity, serial correlation, and errors in variables. Advanced topics include generalized least squares, instrumental variables, nonlinear regression, and limited dependent variable models. Economic applications are discussed. Class size limited.
J. Hausman, W. Newey

14.383 Econometrics II

Prereq.: 14.382, permission of instructor
G (Fall)
4-0-8 H-LEVEL Grad Credit

Covers identification and estimation of linear and nonlinear simultaneous equations models. Requires econometrics paper due at the end of IAP. Class size limited.
J. Hausman

14.384 Time Series Analysis

Prereq.: 14.382 or 14.388
G (Fall)
2-0-4 H-LEVEL Grad Credit

Theory and application of time series methods in econometrics, including representation theorems, decomposition theorems, prediction, spectral analysis, estimation with stationary and nonstationary processes, VARs, and method of moments procedures.
J. Bai

14.385 Nonlinear Econometric Analysis

Prereq.: 14.382 or permission of instructor
G (Fall)
2-0-4 H-LEVEL Grad Credit

Nonlinear econometric models, including large sample theory for estimation and hypothesis testing, generalized method of moments, estimation of censored and truncated specifications and duration models, and nonparametric and semiparametric estimation. Methods illustrated with economic applications.
W. Newey

14.386 Advanced Topics in Applied Econometrics

Prereq.: 14.383
G (Spring)
4-0-8 H-LEVEL Grad Credit

Focuses on recent applications of econometric tools. Topics include structural change, Markov switching, stochastic volatility, threshold auto-regression, models for duration data, discrete choice models, nonparametric methods, quantile regression and other robust methods. Applications will be drawn from labor economics, financial economics, industrial organization, and public finance.
W. Newey

14.389 Econometrics Paper

Prereq.: 14.382 or 14.31
G (Fall)
0-0-3 H-LEVEL Grad Credit

Paper in econometrics required of all Ph.D. candidates who do not take 14.383. Paper due at the end of IAP.
J. Hausman

14.391 Workshop in Economic Research

Prereq.: 14.124, 14.454
G (Fall)
2-0-10 [P/D/F] H-LEVEL Grad Credit
Can be repeated for credit

14.392 Workshop in Economic Research

Prereq.: 14.124, 14.454
G (Spring)
2-0-10 [P/D/F] H-LEVEL Grad Credit
Can be repeated for credit

Develops research ability of students through intensive discussion of dissertation research as it proceeds, individual or group research projects, and critical appraisal of current reported research. Workshops divided into various fields, depending on interest and size. Consult P. Temin.

For additional related subjects in Statistics, see:

Civil and Environmental Engineering: 1.03, 1.151, 1.155, 1.202, 1.203J, 1.205, and 1.732

Electrical Engineering and Computer Science: 6.041, 6.231, 6.245, 6.262, 6.264J, 6.430J, 6.431, 6.432, and 6.435

Management: 15.034, 15.061, 15.065, 15.070, 15.074, 15.075, 15.076, 15.078, 15.098, 15.306, and 15.832

Mathematics: 18.05, 18.175, 18.177, 18.313, 18.440, 18.441, 18.443, 18.445, 18.446, 18.457, 18.458, 18.465, and 18.466

See also: 2.061, 2.830, 2.870, 5.70, 5.72, 7.02, 8.044, 8.08, 10.816, 11.220, 11.221, 16.322, 17.842, 17.846, 22.38, HST.191, and MAS.622J.

National Income and Finance

14.40 Advanced Macroeconomics

Prereq.: 14.05 or 14.06; 14.31 recommended
U (Spring)
3-0-9 HASS

Topics in advanced macroeconomics, possibly including but not limited to models of economic growth, term structure of interest rates, money and overlapping generations, time-inconsistency, consumption, and investment. Emphasis on relating theory to testable implications.
A. Bernard

14.41 Public Economics

Prereq.: 14.03 or 14.04

U (Fall)

4-0-8 HASS

The study of government expenditure and taxation policies. Externalities and the environment; public goods such as education; social insurance programs such as social security; health and welfare policy; optimal taxation policy; taxation and economic behavior.

*J. Gruber***14.416J Introduction to Financial Economics**

(Same subject as 15.416J)

Prereq.: 14.121, 14.122

G (Spring)

4-0-8 H-LEVEL Grad Credit

See description under subject 15.416J.

*J. Wang***14.440J Advanced Financial Economics I**

(Same subject as 15.440J)

Prereq.: 15.416J

G (Spring)

3-0-9 H-LEVEL Grad Credit

See description under subject 15.440J.

Information: D. Scharfstein.

14.441J Advanced Financial Economics II

(Same subject as 15.441J)

Prereq.: 14.121, 14.122, or 15.416J

G (Spring)

3-0-9 H-LEVEL Grad Credit

See description under subject 15.441J.

*D. Gromb***14.442J Advanced Financial Economics III**

(Same subject as 15.442J)

Prereq.: 14.382, 15.415, 15.416J, and permission of instructor

G (Spring)

3-0-9 H-LEVEL Grad Credit

See description under subject 15.442J.

*A. W. Lo***14.451 Macroeconomic Theory I**

Prereq.: 14.06, permission of instructor

G (Spring)

2-0-4 H-LEVEL Grad Credit

The basic machines of macroeconomics. Ramsey, Solow, Samuelson-Diamond, RBCs, ISLM, Mundell-Fleming, Fischer-Taylor. How they work, what shortcuts they take, and how they can be used. Half-term subject. Class size limited.

*O. Blanchard***14.452 Macroeconomic Theory II**

Prereq.: 14.451, permission of instructor

G (Spring)

2-0-4 H-LEVEL Grad Credit

Models of economic growth, old and new. Half-term subject. Class size limited.

*J. Ventura***14.453 Macroeconomic Theory III**

Prereq.: 14.452, permission of instructor

G (Fall)

2-0-4 H-LEVEL Grad Credit

Consumption and savings decisions under certainty and uncertainty. Aggregate savings, wealth, and fiscal policy. Portfolio choice and asset pricing. Investment and finance decisions. Half-term subject. Class size limited.

*R. Caballero***14.454 Macroeconomic Theory IV**

Prereq.: 14.453, permission of instructor

G (Fall)

2-0-4 H-LEVEL Grad Credit

The macroeconomic implications of imperfections in labor markets, goods markets, credit and financial markets. The role of nominal rigidities. Half-term subject. Class size limited.

*M. Hammour***14.461 Advanced Macroeconomics I**

Prereq.: 14.122, 14.452

G (Fall)

4-0-8 H-LEVEL Grad Credit

Topics change from year to year. In 1996-97, the main topics are complete markets and business cycles, representative agent models, incomplete markets and business cycles, financial markets, restructuring and reallocation, sunk costs and incomplete contracts, private information and herd behavior.

*A. Bisin, R. Caballero***14.462 Advanced Macroeconomics II**

Prereq.: 14.461

G (Spring)

4-0-8 H-LEVEL Grad Credit

Topics change from year to year. In 1996-97, the main topics are (1) search and efficiency wage models, unions and European unemployment, human capital and income distribution, increasing returns and imperfect competition. (2) Issues in monetary and fiscal policy. Sources of economic fluctuations.

*D. Acemoglu, O. Blanchard***14.471 Public Economics I**

Prereq.: 14.04

G (Fall)

4-0-8 H-LEVEL Grad Credit

Theory and evidence on government taxation policy. Topics include tax incidence; optimal tax theory; the effect of taxation on labor supply and savings; corrective taxes for externalities; taxation and corporate behavior; and tax expenditure policy.

*J. Poterba***14.472 Public Economics II**

Prereq.: 14.04

G (Spring)

3-0-9 H-LEVEL Grad Credit

Theory and evidence on government expenditure policy. Topics include the theory of public goods; education; state and local public goods; political economy; redistribution and welfare policy; social insurance programs such as social security and unemployment insurance; and health care policy.

*P. Diamond, J. Gruber***14.473 Income Distribution, Growth, and Public Finance**

Prereq.: 14.124

Acad Year 1996-97: Not offered

Acad Year 1997-98: G (Fall)

3-0-9 H-LEVEL Grad Credit

Reviews recent theoretical advances in the field of income distribution and growth, as well as the economics and politics of public finance in these models. Topics include income and wealth distribution with asymmetric information, models of social and intergenerational mobility, optimal dynamic taxation, growth and unemployment, politico-economic models. Also covers long-run empirical evidence on income distribution, inequality, social mobility, and growth.

Consult T. Piketty.

14.474 Advanced Topics in Public Economics (Revised Units)

Prereq.: 14.124

G (Spring)

4-0-8 H-LEVEL Grad Credit

Introduction to current research in one or several sub-fields of public economics. Topics may include the design and evaluation of social insurance programs, the effect of income taxes on firm and individual behavior, the political economy of taxation and expenditure programs.

*J. Gruber, J. Poterba***International, Interregional, and Urban Economics****14.54 International Trade**

Prereq.: 14.03 or 14.04

U (Spring)

4-0-8 HASS

Introduction to the theory of international trade and finance with applications to current policy issues.

Consult J. Ventura.

14.573J The Economics of Cities and Regions

(Same subject as 1.283J, 11.410J)

Prereq.: 14.03 or 14.04

G (Fall)

3-0-9 H-LEVEL Grad Credit

The theory of urban land and housing markets, and the spatial development of cities. The roles played by transportation systems and local governments in shaping urban location patterns. Interregional competition, economic development, and the migration of labor and capital.

*W. Wheaton***14.581 International Economics I**

Prereq.: 14.04

G (Fall)

4-0-8 H-LEVEL Grad Credit

Theory of international trade and foreign investment with applications in commercial policy.

*J. Ventura***14.582 International Economics II**

Prereq.: 14.06, 14.581

G (Spring)

4-0-8 H-LEVEL Grad Credit

Adjustment in international economic relations, with attention to foreign exchange markets, balances of payments, and the international monetary system.

*R. Dornbusch***Labor Economics and Industrial Relations****14.63 Labor in Industrial Society**

Prereq.: —

U (Spring)

3-0-9 HASS-D, Category 4

Examines the role of technology, class, gender, race, and law through a historical discussion of the three most important changes in the US economy this century: 1) the rise and decline of unions; 2) the entrance of women into the paid labor force; and 3) the migration of African Americans into the industrial labor markets of the Northern cities. Economic studies integrated with insights from other social sciences. Readings are supplemented by documentary films and guest speakers from outside MIT.

*P. Osterman***14.64 Labor Economics and Public Policy**

Prereq.: 14.01 or permission of instructor

U (Spring)

3-0-9 HASS

Theory and evidence concerning the functioning of the labor market. Particular emphasis on the roles played by government and institutions. Topics include minimum wages, labor market effects of social insurance and welfare programs, the collective bargaining relationship, discrimination, and unemployment.

*S. Pischke***14.65J American Living Standards and Income Inequality**

(Subject meets with 11.022J, 11.450)

Prereq.: 14.01 or equivalent

U (Spring)

3-0-9 HASS

See description under subject 11.022J.
F. S. Levy

14.671J Labor Economics I

(Same subject as 15.671J)

Prereq.: 14.64 or 15.660

G (Spring)

3-0-6 H-LEVEL Grad Credit

An introduction to labor economics, stressing various approaches to labor market analysis. Special attention devoted to theories of worker motivation and behavior, the structure of labor markets, the determinants of wage levels and unemployment, and the historical evolution of labor market institutions.

*M. Piore***14.672J Labor Economics II**

(Same subject as 15.672J)

Prereq.: 14.04

G (Fall)

3-0-6 H-LEVEL Grad Credit

Neoclassical analysis of the labor market and its institutions. A systematic development of the theory of labor supply, labor demand, and human capital theory. Topics discussed also include theories of wage and employment determination, turnover, search, unemployment, equalizing differences, and union behavior. Particular emphasis on the interaction of theoretical and empirical modeling.

*J. Angrist, S. Pischke***14.674J Managing People and Organizations in a Changing World Economy**

(Same subject as 15.674J)

Prereq.: Permission of instructor

Acad Year 1996-97: Not offered

Acad Year 1997-98: G (Fall)

3-0-6 H-LEVEL Grad Credit

See description under subject 15.674J.
Consult R. M. Locke.

14.691J Research Seminar in Industrial Relations

(Same subject as 15.691J)

Prereq.: —

G (Fall)

3-0-6 H-LEVEL Grad Credit

Can be repeated for credit

14.692J Research Seminar in Industrial Relations

(Same subject as 15.692J)

Prereq.: —

G (Spring)

3-0-6 H-LEVEL Grad Credit

Can be repeated for credit

See description under subject 15.692J.
Information: T. A. Kochan.

Economic History**14.71 Historical Perspectives on Current Economic Issues**

Prereq.: 14.01, 14.02

U (Spring)

3-0-9 HASS

Provides a historical perspective on the determinants and consequences of economic growth. Changes in population, education, technology, institutions, business organization, financial markets, labor markets, and government regulation are examined. Focus is primarily on the US.

*D. Costa***14.72 Capitalism and Its Critics**

Prereq.: —

U (Fall)

3-0-9 HASS-D, Category 4

This subject addresses the evolution of the modern capitalist economy and evaluates its current structure and performance. Various paradigms of economics are contrasted and compared (neoclassical, Marxist, socioeconomic, and neocorporate) in order to understand how modern capitalism has been shaped and how it functions in today's economy. Readings include classics in economic thought as well as contemporary analyses. Subject stresses general analytic reasoning and problem formulation rather than specific analytic techniques. May not be used for Economics concentration. One economics HASS-D subject may be used as an economics elective for the economics major and minor.

*M. Piore***14.731 Economic History**

Prereq.: 14.04, 14.06

G (Fall)

3-0-9 H-LEVEL Grad Credit

A survey of world economic history, designed to introduce economics graduate students to the subject matter and methodology of economic history. Topics chosen to show a wide variety of historical experience and illuminate the process of industrialization. Term paper due at the end of IAP.

*D. Costa, P. Temin***Economic Development****14.74 Economic Growth and Development**

Prereq.: 14.02

Acad Year 1996-97: Not offered

Acad Year 1997-98: U (Fall)

3-0-9 HASS

Analysis of the problems of economic growth and development, both microeconomic and macroeconomic, including peasant agriculture, demographic change, urbanization, and international trade. Considers policy measures to promote development and growth.

Consult M. Kremer