6.931 Development of Inventions and Creative Ideas

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

Role of the engineer as patent expert and as technical witness in court and patent interference and related proceedings. Rights and obligations of engineers in connection with educational institutions, government, and large and small businesses. Various manners of transplanting inventions into business operations, including development of New England and other US electronics and biotech industries and their different types of institutions. American systems of incentive to creativity apart from the patent laws in the atomic energy and space fields. For graduate students only; others see 6.901.
R. H. Rines

6.936 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

6.938 Engineering Risk-Benefit Analysis

Prereq.: 18.02
Acad Year 1996-97: G (Spring)
Acad Year 1997-98: **Not offered**
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.
A. W. Drake, A. R. Odoni, G. Apostolakis

6.946J Variational Mechanics: A Computational Approach

(Same subject as 12.620J, 8.351J)
Prereq.: 8.01, 18.03, 6.001 or equivalent
G (Fall)
3-3-6 H-LEVEL Grad Credit

See description under subject 12.620J.
G. J. Sussman, J. Wisdom

6.951 Graduate VI-A Internship

Prereq.: 6.922
G (Fall, Summer)
0-12-0 [P/D/F]

Provides academic credit for a Graduate Assignment of graduate students at companies affiliated with the Department's VI-A Internship Program. Enrollment limited to graduate students participating in the VI-A Internship Program.
M. Zahn

6.952 Graduate VI-A Internship

Prereq.: 6.951
G (Fall, Spring, Summer)
0-12-0 [P/D/F]

Provides academic credit for graduate students who require an additional term at the company to complete the Graduate Assignment of the Department's VI-A Internship Program. This academic credit is for registration purposes only and cannot be used toward fulfilling the requirements of any degree program. Enrollment limited to graduate students participating in the VI-A Internship Program.
M. Zahn

6.961 Introduction to Research in Electrical Engineering and Computer Science

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

Opportunity to become involved in graduate research, under guidance of a staff member, on a problem of mutual interest to student and supervisor. Recommended for all entering full-time graduate students in the Department of Electrical Engineering and Computer Science. Individual programs subject to approval of professor in charge. Enrollment restricted to regular graduate students in Electrical Engineering and Computer Science. Normal registration is for 12 units.
F. R. Morgenthaler

6.962–6.969 Special Studies in Electrical Engineering and Computer Science

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

Opportunity for study of graduate-level topics related to electrical engineering and computer science but not included elsewhere in the curriculum. Registration under this subject normally used for situations involving individual study (under supervision of a faculty member) of topics of mutual interest to student and supervisor, but may, when appropriate, be used for small study groups. Normal registration is for 12 units. Registration subject to approval of professor in charge.
F. R. Morgenthaler

6.971–6.979 Special Subjects in Electrical Engineering and Computer Science

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

Opportunity for group study of advanced subjects related to electrical engineering and computer science not otherwise included in curriculum. Offerings are initiated by members of EECS faculty on an ad hoc basis, subject to Departmental approval.
F. R. Morgenthaler

6.980 Teaching Electrical Engineering and Computer Science

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

For qualified students interested in gaining teaching experience. Classroom, tutorial, or laboratory teaching under the supervision of a faculty member. Enrollment limited by availability of suitable teaching assignments.
F. C. Hennie

6.981–6.989 Teaching Electrical Engineering and Computer Science

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

For Teaching Assistants in Electrical Engineering and Computer Science, in cases where teaching assignment is approved for academic credit by the Department.
F. C. Hennie

6.991–6.999 Research in Electrical Engineering and Computer Science

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

For Research Assistants in Electrical Engineering and Computer Science, in cases where the assigned research is approved for academic credit by the Department. Hours arranged with research supervisor.
F. R. Morgenthaler

6.UR Undergraduate Research in Electrical Engineering and Computer Science

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

Extended participation in the work of a faculty member or research group, including independent study of the literature, direct involvement in the group's research, and project work under an individual faculty member. Research is arranged by mutual agreement between the student and a member of the faculty of the Department of Electrical Engineering and Computer Science, and may continue over several terms. Forms and instructions for the initial letter of intent and final summary report are available in the Department Undergraduate Office. Grading P/D/F only.
R. D. Thornton

6.ThG Graduate Thesis

Prereq.: —
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 M.Eng., S.M., E.E., E.C.S., Ph.D., or Sc.D. thesis; to be arranged by the student and an appropriate MIT faculty member.
F. R. Morgenthaler

Course 7

Biology

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

7.UR Undergraduate Research

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

7.URG Undergraduate Research

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

Undergraduate research opportunities in the Department of Biology. For further information, consult the Departmental Coordinator: Gene Brown. Permission of department required.

7.012, 7.013, 7.014 Introductory Biology

Prereq.: —
U (Fall, Spring)
5-0-7 BIOLOGY

All three subjects cover the same core material, which includes the fundamental principles of biochemistry, genetics, molecular biology, and cell biology. In addition, each version of the subject has its own distinctive material, described below. The core material focuses on function at a molecular level: the structure and regulation of genes, and the structure and synthesis of proteins; how these molecules are integrated into cells; and how cells are integrated into cells; and how cells are integrated into multicellular systems and organisms.
Coordinators: *U. RajBhandary, P. Matsudaira*
Instructors: *B. White, S. Verghis*
Fall Term: 7.012. Exploration into areas of current research in cell biology, immunology, neurobiology, developmental biology, and evolution. Spring Term: 7.013. Application of the fundamental principles toward an understanding of cells, human genetics and diseases, infectious agents, cancer, the immune system, and evolution. Spring Term: 7.014. Application of the fundamental principles toward an understanding of microorganisms as geochemical agents responsible for the evolution and renewal of the biosphere and of their role in human health and disease.
Fall Term: 7.012: *R. Weinberg, H. Lodish*
Spring Term: 7.013: *D. Page, U. RajBhandary*
Term 2: 7.014: *S. Chisholm, G. Walker*

7.02 Introduction to Experimental Biology

Prereq.: 7.012 or 7.013 or 7.014
U (Fall, Spring)
2-8-5 Institute LAB

Application of experimental techniques in biochemistry, microbiology, and cell biology. Emphasizes integrating factual knowledge with understanding the design of experiments and data analysis to prepare the students for research projects. Concurrent registration with 7.03 or 7.05 is recommended. Restricted to upperclassmen. 12 units may be applied to the General Institute Laboratory Requirement.
Fall Term: *J. King, A. Rich*
Spring Term: *J. Liu, M. Fox*

7.03 Genetics

Prereq.: *7.012 or 7.013 or 7.014*
U (Fall)
4-0-8 REST

The principles of genetics with application to the study of biological function at the level of molecules, cells, and multicellular organisms. Structure and function of genes and chromosomes. Biological variation resulting from recombination, mutation, and selection. Use of genetic methods to analyze protein function, gene regulation, development, and inherited disease.
C. Kaiser, L. Guarente

7.05 General Biochemistry

Prereq.: 5.12; 7.012 or 7.013 or 7.014 or permission of instructor
U (Spring)
5-0-7 REST
Credit cannot also be received for 5.07

Contributions of biochemistry toward an understanding of the structure and functioning of organisms, tissues, and cells. Chemistry and functions of constituents of cells and tissues and the chemical and physical-chemical basis for the structures of nucleic acids, proteins, and carbohydrates. General metabolism of carbohydrates, fats, and nitrogen-containing materials such as amino acids, proteins, and related compounds.
G. M. Brown, P. Schimmel

7.06 Cell Biology

Prereq.: 7.05
U (Fall)
3-0-9

Biology of cells of higher organisms: structure, function, and biosynthesis of cellular membranes and organelles; cell growth and oncogenic transformation; transport, receptors and cell signaling; the cytoskeleton, the extracellular matrix, and cell movements; chromatin structure and RNA synthesis.
R. A. Young, P. Sorger

7.08 Molecular Biology

Prereq.: 7.03; *7.05*
U (Spring)
4-0-8

Detailed analysis of the biochemical mechanisms that control the maintenance, expression, and evolution of prokaryotic and eukaryotic genomes. Topics covered in lecture and readings of relevant literature include: gene regulation, DNA replication, genetic recombination, and translation.
S. Bell, T. Baker

7.11 Biology Teaching

Prereq.: —
U (Fall, Spring)
Units arranged

For qualified undergraduate students interested in gaining some experience in teaching. Laboratory, tutorial, or classroom teaching under the supervision of a faculty member. Students selected by interview.
Consult Biology Student Office.

7.13 Experimental Microbial Genetics

Prereq.: 7.02, 7.03, 7.05
Acad Year 1996-97: U (Fall)
Acad Year 1997-98: **Not offered**
2-16-6

Laboratory project in microbiology and genetics to address fundamental questions of gene organization, regulation, and expression using *Corynebacterium glutamicum*. Use of advanced genetic and rDNA technology approaches.
A. J. Sinskey

7.15 Experimental Molecular Biology: Biotechnology I

Prereq.: 7.02, 7.03, 7.05
U (Fall)
2-16-6

Molecular genetic technology applied to a contemporary biomedical research problem in the laboratory. Emphasis on recombinant DNA techniques and interpretation and communication of experimental results. Recombinant DNA methods include PCR, gene cloning, and DNA sequencing.
P. W. Robbins, Staff

7.16 Experimental Molecular Biology: Biotechnology II

Prereq.: 7.02, 7.03, 7.05
U (Spring)
2-16-6

Laboratory methodology and theoretical basis for cloning and manipulation of genes in eukaryotic organisms. Mammalian cell culture, biological assays with mammalian cells, isolation of hybridomas that secrete monoclonal antibodies, and cloning and expression of genes in eukaryotic organisms.
D. Housman, J. Chen

7.17 Experimental Molecular Biology: Biotechnology III

Prereq.: 7.02, 7.03, 7.05
U (Spring)
2-16-6

Molecular genetic technology applied to the study of cell biology problems including regulation of the cell cycle and the cytoskeleton. Laboratory emphasizes techniques for cloning and sequencing genes from yeast and studying the function of normal and mutant human genes in yeast.
P. Matsudaira, M. L. Pardue

7.19 Experimental Cellular Structure

Prereq.: 7.06 or 7.08
U (Fall)
2-6-4

Electron microscopic and related techniques for investigating the structure of cells and tissues with a focus on developmental and neurobiological problems. Operation of the transmission and scanning electron microscopes and confocal light microscopes. Fixation, embedding, sectioning, and immunostaining of cells, embryos, and mature organs such as eye and muscle.
S. Penman, P. Reilly

7.20 Human Physiology

Prereq.: 7.05
U (Fall)
5-0-7

Comprehensive subject in human physiology, emphasizing the molecular basis and applied aspects of organ function and regulation in health and disease. Material covered includes a review of cell structure and function, as well as the mechanisms by which the endocrine and nervous systems integrate cellular metabolism. Special emphasis on examining the cardiovascular, pulmonary, gastrointestinal, and renal systems.
R. D. Rosenberg, M. Krieger

7.21 Microbial Physiology

Prereq.: 7.05, 7.03
U (Fall)
4-0-8

Biochemical properties of bacteria and other microorganisms that enable them to grow under a variety of conditions. Interaction between bacteria and bacteriophages. Genetic and metabolic regulation of enzyme action and enzyme formation.
G. C. Walker, B. Magasanik

7.22 Developmental Biology

Prereq.: 7.08
U (Spring)
4-0-8

Principles of embryology and development with emphasis on vertebrates. The experimental approaches discussed include: genetic manipulation of vertebrates by transgenic, micromanipulative, and molecular techniques.
R. Jaenisch, H. Sive

7.23 General Immunology

Prereq.: 7.05
U (Fall)
4-0-8

A comprehensive survey of immunology. Includes antigen-antibody reactions, immunoglobulin structure, organization and expression of immunoglobulin genes, cells and tissues of the immune system, major histocompatibility complex (MHC), genes encoding MHC proteins and T-cell antigen-specific receptors, antibody formation, cell-mediated immunity, complement, hypersensitivity, immunodeficiencies, graft rejection.
L. Steiner, H. Ploegh, J. Chen

7.27 Principles of Human Disease (New)

Prereq.: 7.03, 7.05, 7.06
U (Spring)
4-0-8

Covers current understanding of and modern approaches to human disease, emphasizing the molecular and cellular basis of both infectious and inheritable diseases. Specific topics include the roles of oncogenes and tumor suppressors in signal transduction, cell cycle control, and apoptosis; predisposition to cancer and other genetic diseases; karyoptic analysis and positional cloning; histopathology; animal models of human disease; and disease induction by viral and other pathogenic agents.
T. Jacks, J. A. Lees

7.29J Cellular Neurobiology

(Same subject as 9.09J)
Prereq.: 7.05
U (Spring)
4-0-8

An introduction to the structure and function of the nervous system. Emphasis placed on the cellular properties of neurons and other excitable cells. Includes the structure and biophysical properties of excitable cells, synaptic transmission, neurochemistry, neurodevelopment, and integration of information in simple systems and the visual system.
W. G. Quinn

7.341–7.346 Advanced Undergraduate Seminars

Prereq.: 7.03, 7.05, 7.06, or 7.08
U (Fall, Spring)
2-0-4 [P/D/F]
Can be repeated for credit

Seminars covering topics of current interest in biology. Includes reading and analysis of research papers and student presentations. Fall 1996–97: 7.341: Development and Evolution of the Immune System; 7.342: Regulatory Gene Transcription; 7.343: Unravelling the Mechanisms of DNA Repair by Studying Human Disease. Spring 1996–97: 7.344: Human Gene Hunting; 7.345: Tumor Suppressor Genes; 7.346: T-cell Recognition and Development. Contact Biology Student Office.
Staff

7.37J Molecular and Engineering Aspects of Biotechnology

(Same subject as 10.441J)
Prereq.: 7.03 or 7.05, 5.60
Acad Year 1996-97: **Not offered**
Acad Year 1997-98: U (Spring)
4-0-8

Biological and bioengineering principles for utilization of animal cells and bacteria for production of recombinant protein products: post-translational processing and secretion of proteins; gene cloning and expression in mammalian cells; physiology of cell growth and *in vitro* cultivation; bioreactor design; protein recovery and purification; site-specific mutation of proteins; transgenic animals and plants.
D. I. C. Wang, H. Lodish

7.391 Special Problems for Undergraduates

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

Used for students receiving Advanced Placement credit and transfer credit. Program of study or research to be arranged with a Department faculty member. Written report required. Permission of Department required. Consult Biology Student Office.

7.40 Biotechnology: Engineering of Macromolecules

Prereq.: 7.05
U (Spring)
3-0-6

Fundamentals of genetics and biochemical principles for the synthesis, design, and engineering of biopolymers such as polyesters and polysaccharides. Principles underlying structure-function properties of biopolymers. Topics include conformation analysis and molecular properties of polymer chains in solution.
C. K. Rha, A. J. Sinskey

7.411–7.419 Seminars in Biological Oceanography

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

Selected topics in biological oceanography. Information: A. L. Peirson (Woods Hole Staff).

7.421 Special Problems in Biological Oceanography

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

Advanced problems in biological oceanography with assigned reading and consultation. Information: A. L. Peirson (Woods Hole Staff).

7.431 Topics in Marine Ecology

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

Lectures and discussions on ecological principles and processes in marine populations, communities, and ecosystems. Topics vary from year to year.
H. Caswell, R. Harbison (WHOI)

7.432 Topics in Marine Physiology and Biochemistry

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

Lectures and discussions on physiological and biochemical processes in marine organisms. Topics vary from year to year.
H. Hahn, J. McDowell, J. Stegeman (WHOI)

7.434 Topics in Zooplankton Biology

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

Lectures and discussions on the biology of marine zooplankton. Topics vary from year to year.
L. Madin (WHOI)

7.435 Topics in Benthic Biology

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

Lectures and discussions on the biology of marine benthos. Topics vary from year to year.
L. Mullineaux, R. Scheltema (WHOI)

7.436 Topics in Phytoplankton Biology

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

Lectures and discussion on the biology of marine phytoplankton. Topics vary from year to year.
R. Olson, H. Sosik, D. Anderson (WHOI)

7.437 Topics in Molecular Biological Oceanography

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

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

7.438 Topics in the Behavior of Marine Animals

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

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

7.439 Topics in Marine Microbiology

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

Lectures and discussion on the biology of marine prokaryotes. Topics vary from year to year.
P. Dunlap, J. Waterbury (WHOI)

7.47 Biological Oceanography

Prereq.: Advanced level training in biology
G (Spring)
3-0-9 H-LEVEL Grad Credit

Intensive overview of biological oceanography. Major biological paradigms and processes discussed, and dependence of biological processes in the ocean on physical and chemical aspects of the environment examined. Surveys the diversity of marine habitats, major groups of taxa inhabiting those habitats, and the general biology of the various taxa: the production, consumption, burial, and remineralization of organic material in the ocean, as well as factors controlling those processes. Structure of marine food webs and the flow of energy within different marine habitats detailed and contrasted.
D. Caron (WHOI)

7.491 Research in Biological Oceanography

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

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

7.ThG Graduate Biology Thesis

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

Program of graduate research, leading to the writing of a Ph.D. thesis; to be arranged by the student and an appropriate MIT faculty member.
F. Solomon

7.50 Method and Logic in Molecular Biology

Prereq.: Permission of instructor
G (Fall)
4-0-8 [P/D/F] H-LEVEL Grad Credit

Logic and experimental design: an in-depth discussion and assessment of biochemical, physical, and genetic methods employed in testing hypotheses. Limited to Course VII graduate students.
D. Housman, T. Baker, C. Kaiser, R. Young

7.51 Biochemistry for Graduate Students

Prereq.: Permission of instructor
G (Fall)
5-0-7 H-LEVEL Grad Credit

Fundamental principles of biochemistry. Analysis of the mode of action and structure of regulatory, binding, and catalytic proteins.
R. T. Sauer

7.52 Genetics for Graduate Students

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

Principles of genetics, including Mendelian systems and prokaryotic genetics. Application of principles to biological function, including regulation and development. Mechanisms of recombination, mutation, and evolution. Discussion of original scientific papers and review of problem sets and exams supplement lectures.
H. R. Horvitz, Staff

7.546J Principles and Methodologies of Metabolic Engineering

(Same subject as 10.546J)
Prereq.: —
G (Spring)
3-0-6

See description under subject 10.546J.
Gr. Stephanopoulos, A. J. Sinskey

7.57J Genetics and Molecular Medicine

(Subject meets with HST.181J, HST.180)
Prereq.: 7.012 or 7.013 or 7.014, 7.05
G (IAP)
4-0-8

See description under subject HST.181J.
D. E. Housman, C. Tabin

7.60 Cell Biology I

Prereq.: 7.06 or 7.08
G (Spring)
4-0-8 H-LEVEL Grad Credit

Structure and organization of genes and genomes, nucleic acid biosynthesis, structure and assembly of nuclei and chromosomes, regulation of cell cycle, DNA replication, transposition, recombination and repair; RNA transcription, processing and translation, differentiation of specialized cell types, especially lymphocytes. Literature readings.
P. Sharp, D. Baltimore

7.61 Membranes, Receptors, and Signalling

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

Principles of membrane structure and function and the experimental approaches used to analyze them. Cell surface receptors and signal transduction; transport across membranes; endocytosis, subcellular sorting; cell adhesion and its effects on cellular organization and polarity. Illustrates the principles and methods of cell biology from basic studies to applications to human disease states through lectures and discussion sessions emphasizing literature readings. Limited enrollment.
R. O. Hynes, M. Krieger

7.63 Immunology

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

Principles of immunology, including immunochemistry and molecular and cellular immunology. An in-depth critical analysis of current literature in the field. Particular attention paid to the function of the immune system as a whole as studied by modern methods and techniques. Discussions of original papers supplement lectures.
S. Tonegawa, H. Ploegh, J. Chen

7.64 Advanced Cell Structure and Function

Prereq.: 7.06 or 7.08
Acad Year 1996-97: **Not offered**
Acad Year 1997-98: G (Spring)
3-0-6

Understanding cell function and organization into tissue requires the emerging technologies for ultrastructural analysis. We consider morphological and biochemical techniques for studying cell architecture in major tissues, mechanisms of image formation that influence data interpretation, the biochemistry of cellular substructures and methods of chemical cell dissection. The cells in major body organs will conclude the material.
S. Penman

7.65J Principles of Neuroscience

(Same subject as 9.011J)
Prereq.: Permission of instructor
G (Fall)
6-0-9 H-LEVEL Grad Credit

See description under subject 9.011J.
M. Sur, E. Bizzi, S. Corkin, A. Graybiel, W. Quinn, P. Schiller, R. J. Wurtman, T. Poggio

7.67J Genetic Neurobiology

(Same subject as 9.322J)
Prereq.: —
Acad Year 1996-97: **Not offered**
Acad Year 1997-98: G (Fall)
3-0-6 H-LEVEL Grad Credit

See description under subject 9.322J.
W. G. Quinn, H. Steller

7.70 Regulation of Gene Expression

Prereq.: 7.03, 7.05, 7.08
G (Spring)
3-0-9 H-LEVEL Grad Credit

Studies molecular mechanisms responsible for the regulation of gene expression in prokaryotes and eukaryotes. The control of the cell cycle gene activation and silencing and other topics are examined. Classes involve critical evaluation of primary research papers in a seminar format.
B. Magasanik, Staff

7.71 Biophysical Chemistry

(Subject meets with 5.64)
Prereq.: 5.60, 7.05 or 5.07
G (Fall)
3-0-9

Principles of biophysical chemistry introduced while discussing the structure, folding, stability, and interactions of proteins and nucleic acids. Topics include: an overview of protein and nucleic acid structure; introductions to X-ray crystallography, spectroscopy, and 2D NMR; thermodynamic and kinetic aspects of protein folding; and principles of protein-nucleic acid interactions. Molecular mechanics introduced as a unifying tool that relates structure, molecular forces, and thermodynamic quantities. Meets with undergraduate subject 5.64. Students who take 5.64 cannot also receive credit for 7.71.
C. O. Pabo, J. R. Williamson

7.72 Development

Prereq.: 7.51 or 7.52
G (Fall)
3-0-9 [P/D/F]

Graduate discussion seminar examining in-depth fundamental aspects of development and differentiation. In addition, particular attention paid to the critical appraisal of current published research in important areas of the field.
H. Sive

7.73 Human and Mouse Genetics

Prereq.: 7.52
Acad Year 1996-97: **Not offered**
Acad Year 1997-98: G (Spring)
3-0-9 [P/D/F] H-LEVEL Grad Credit

Seminar covering advanced applications of the tools of genetics to biological problems in mammals, focusing on experimental approaches in the mouse and principles of population genetics and pedigree analysis in the human. Topics include: construction of genetic maps; genetic mapping of simply-inherited traits and gene cloning by position; somatic mutation and cancer; genetic imprinting; quantitative genetics. Alternate years.
E. S. Lander

7.75J Topics in Metabolic Biochemistry

(Same subject as 5.77J)
Prereq.: 7.05 or 5.07
G (Fall)
4-0-8 H-LEVEL Grad Credit

Special topics include major metabolic pathways for the biosynthesis of certain cellular constituents and oxidative metabolism. Emphasis is on enzymology and methods used to understand metabolism and enzymatic processes.
G. M. Brown, J. Liu

7.76 Topics in Protein Biochemistry

Prereq.: Permission of instructor
Acad Year 1996-97: **Not offered**
Acad Year 1997-98: G (Fall)
2-0-7

In-depth analysis and discussion of classic and current literature with emphasis on the relationship between protein structure and function. Topics include binding specificity; cooperativity and allostery; protein folding, evolution and macromolecular assembly; sequence homology and prediction of structure; and protein engineering and design. Undergraduates should have taken 7.71 or 5.64.
P. Kim, R. Sauer

7.77 Workshop on Nucleic Acids and Their Interactions with Proteins
(Revised Units)

Prereq.: 7.05 or 7.51
G (Spring)
3-0-6 H-LEVEL Grad Credit

Interactive discussions, lectures, and student presentations, including in-class problem solving. Chemistry, structure, and function of DNA and RNA. Biochemical, physical, and genetic approaches to understanding nucleic acids. Forces stabilizing nucleic acid structures. Structural motifs in RNA molecules including pseudoknots and tetraloops. Transfer RNAs. Prediction of structures of large RNAs. Superhelical and bent DNA and thermodynamic analysis of special DNA conformations. Selection system for generating novel RNA and DNA structures for ligand interactions. Analysis of protein-nucleic acid interactions with examples including repressors and activators, nucleosomes, restriction enzymes, aminoacyl tRNA synthetases, and RNA binding proteins. Analysis of methods of transcription. RNA and protein evolution in relation to the development of peptide synthesis and the genetic code.
P. Schimmel

7.81 Frontiers in Modern Plant Biology

Prereq.: 7.03, 7.05
Acad Year 1996-97: **Not offered**
Acad Year 1997-98: G (Fall)
2-0-7 [P/D/F] H-LEVEL Grad Credit

Intensive analysis of key original literature, both classical and current, with emphasis on experimental approaches and analysis of primary data. Topics include regulation of cell, tissue, and organ growth; control of gene expression; fertility, embryogenesis, and seed development; transformation and transgenic plants; transposable elements and genetic structure; function and genetics of organelles; pathogenesis and disease resistance. Student reports and class presentations.
E. R. Signer, G. R. Fink

7.82 Selected Topics of Mammalian Development and Genetics

Prereq.: —
G (Fall)
2-0-4 [P/D/F]

Seminar covering biological, genetic, and molecular approaches to mouse development. Topics include preimplantation development; postimplantation development; cell lineage studies; embryonic stem cells and gene targeting; transgenic technology; genomic imprinting; tissue interactions and induction; X-inactivation; sex determination; genetic basis of coat color; muscle development.
R. Jaenisch, D. Page

7.84 Topics in Bacteriology

Prereq.: 7.21, permission of instructor
G (Fall)
2-0-6 [P/D/F] H-LEVEL Grad Credit

Recent developments in bacteriology: regulatory mechanisms and membrane phenomena.
Consult Biology Student Office.

7.85 Topics in Cell Biology

Prereq.: Permission of instructor
G (Spring)
3-0-9

Seminar on aspects of cell cycle regulation — mechanisms and control of DNA replication, chromosome structure, and chromosome segregation — using classic and current literature and emphasizing multiple approaches.
S. Bell, P. Sorger

7.87 X-Ray Crystallography of Proteins and Nucleic Acids

Prereq.: 7.71 or permission of instructor
Acad Year 1996-97: **Not offered**
Acad Year 1997-98: G (Spring)
2-0-7 H-LEVEL Grad Credit

Overview of the major theoretical and practical problems involved in x-ray crystallographic studies of macromolecules. Topics include discussion of basic diffraction theory, crystallization and space group determination, data collection, heavy atom derivative methods, anomalous scattering, molecular replacement, model-building and refinement.
Staff

7.88J The Protein Folding Problem

(Same subject as 5.48J, 10.543)
Prereq.: 5.07 or 7.05 or equivalent
G (Spring)
3-0-9 H-LEVEL Grad Credit

Seminar analyzing the mechanisms by which the amino acid sequence of polypeptide chains determines their three-dimensional conformation. Topics include: sequence determinants of secondary structure; folding of newly synthesized polypeptide chains within cells; unfolding and refolding of proteins *in vitro*; folding intermediates aggregation and competing off-pathway reactions; role of chaperonins, isomerases, and other helper proteins; protein recovery problems in the biotechnology industry; diseases associated with protein folding defects.
J. A. King

7.89J Seminar on Pharmaceutical and Biotechnology Industry Management

(Same subject as 15.138J, 10.940J)
Prereq.: Permission of instructor
G (Fall)
3-0-6 H-LEVEL Grad Credit
Can be repeated for credit

See description under subject 15.138J.
T. J. Allen, C. L. Cooney, S. N. Finkelstein, A. Sinskey

7.91 Topics in Genomics
(New)

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

Seminars and readings in genomics. Topics covered include infomatics, genetic and molecular biology strategies and techniques, and hardware systems design.
E. Lander, P. Matsudaira, Staff

7.92J Neurology, Neuropsychology, and Neurobiology of Aging
(New)

(Same subject as 9.110J)
Prereq.: Permission of instructor
G (Spring)
3-0-9 H-LEVEL Grad Credit

Lectures and discussion explore the clinical, behavioral, and molecular aspects of brain aging processes in humans. Topics include: loss of sensory and motor function and loss of memory and other cognitive abilitites in normal aging; neurodegenerative conditions, such as Parkinson's, Alzheimer's, and Huntington's diseases, and Down's syndrome. Based on lectures, readings taken from the primary literature, and discussions. Students are expected to present topics based on their readings. One written mid-term test and one final paper.
S. Corkin, V. Ingram

7.93 Selected Topics in Biology

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

Classwork in various fields of biology not covered by the regular subjects of instruction. Consult Biology Student Office.

7.941 Research Problems

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

7.942 Research Problems

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

Directed research in a field of biological science, but not contributory to graduate thesis. Consult Biology Student Office.

7.95 Cancer Biology
(Revised Units)

Prereq.: 7.03, 7.06, 7.08
G (Spring)
3-0-9 H-LEVEL Grad Credit
Can be repeated for credit

Intensive analysis of historical and current developments in cancer biology. Topics covered in lecture and through critical reading of relevant literature include: principles of transformation, viral and cellular oncogenes, tumor suppressor genes, tumor cell growth, and apoptosis.
T. Jacks, J. Lees

7.96 Cell-Cell Signaling

Prereq.: —
G (Spring)
3-0-9 [P/D/F]

A seminar focusing on recent research in the area of intercellular communication. Topics include intracellular signal transduction by cell surface tyrosine and serine/theonine kinase receptors, cytokine receptors, and cell adhesion (integrin) receptors. Emphasis on techniques used in receptor research, including mutants, and on alterations in receptor function in various pathophysiologic states.
H. Lodish, R. Rosenberg

7.97 Topics in Evolution

Prereq.: 7.05 and permission of instructor
Acad Year 1996-97: **Not offered**
Acad Year 1997-98: G (Spring)
2-0-7 H-LEVEL Grad Credit

Seminar considering the role of evolutionary thought in modern science. Topics include: discussion of Darwin's *The Origin of Species*; molecular studies of protein evolution; roles of neutral mutation, recombination, and sex in evolution; the RNA world and the origin of life: *in vitro* selection and "test tube evolution"; and the interplay between biological thought and computer science, with reference to complexity theory, neural networks, genetic programming, and artificial life.
C. Pabo

7.98J Neural Plasticity in Learning and Development

(Same subject as 9.301J)
Prereq.: Permission of instructor
G (Spring)
3-0-9 H-LEVEL Grad Credit

Roles of neural plasticity in learning and memory and in development of invertebrates and mammals. An in-depth critical analysis of current literature of molecular, cellular, genetic, electrophysiological, and behavioral studies. Discussion of original papers supplemented by introductory lectures.
S. Tonegawa, W. Quinn, M. Wilson, H. Steller

7.99 Disease Intervention Through Biotechnology

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

Analyzes the flow of scientific principles from the laboratory to the diseased patient. Concentrates on the biotechnology industry past, present, and future. Considers science in academia and industry and the regulatory hurdles required to bring scientific developments to humans.
M. Gefter

Course 8

Physics

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

General Undergraduate Subjects

8.UR Undergraduate Research

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

Undergraduate research opportunities in physics. For further information, contact the Departmental UROP Coordinator.
D. E. Pritchard

8.01 Physics I

Prereq.: —
U (Fall, Spring)
5-0-7 PHYSICS I
Credit cannot also be received for 8.012 or 8.01X

Introduces classical mechanics. Space and time: straight-line kinematics; motion in a plane; forces and equilibrium; experimental basis of Newton's laws; particle dynamics; universal gravitation; collisions and conservation laws; work and potential energy; vibrational motion; conservative forces; inertial forces and non-inertial frames; central force motions; rigid bodies and rotational dynamics.
Fall Term: *W. Busza and Staff*
Spring Term: *B. Wyslouch*

8.012 Physics I

Prereq.: —
U (Fall)
5-0-7 PHYSICS I
Credit cannot also be received for 8.01 or 8.01X

Elementary mechanics, presented at greater depth than in 8.01. Newton's laws, concepts of momentum, energy, angular momentum, rigid body motion, non-inertial systems. Uses elementary calculus freely. Concurrent registration in a math subject more advanced than 18.01 is recommended. In addition to the theoretical subject matter, several experiments in classical mechanics are performed by the students in the laboratory.
W. Ketterle

8.01X Physics I

Prereq.: —
U (Fall)
5-0-7 PHYSICS I
Credit cannot also be received for 8.01 or 8.012

An introduction to basic topics in physics, supported by take-home experiments. The sequence of topics includes space and time; force, work, and mechanical energy; heat and mechanical/thermal energy conversions; electrical and chemical energy; atomicity and kinetic theory of gases; introduction to wave motion; Newtonian mechanics and gravitation; simple harmonic motion in mechanical systems. Kits of equipment are provided for the performance of a relevant take-home experiment as part of the homework each week. Many of the experiments involve simple electrical and electronic instrumentation.
P. Dourmashkin, H. V. Bradt

8.01L Physics I

Prereq.: —
U (Fall)
3-0-9 PHYSICS I

Introduction to classical mechanics (see description under 8.01). Material is covered over a Longer interval, so that the subject is completed by the end of the Independent Activities Period. During the first month of classes, substantial emphasis is given to reviewing and strengthening pre-calculus mathematics, basic physics concepts, and problem-solving skills. Delay in the use of calculus permits students more exposure to 18.01 before the material is used in the physics. Overall content, depth, and difficulty is otherwise identical to that of 8.01. Enrollment is limited to 100 freshmen. Students receive credit for 8.01 on their transcripts. Credit cannot also be received for 8.012 or 8.01X.
G. Stephans

8.02 Physics II

Prereq.: 8.01 or 8.01X or 8.01L or 8.012; 18.01
U (Fall, Spring)
5-0-7 PHYSICS II
Credit cannot also be received for 8.022

Introduction to electromagnetism and electrostatics: electric charge, Coulomb's law, electric structure of matter; conductors and dielectrics. Concepts of electrostatic field and potential, electrostatic energy. Electric currents, magnetic fields and Ampere's law. Magnetic materials. Time-varying fields and Faraday's law of induction. Basic electric circuits. Electromagnetic waves and Maxwell's equations. Credit cannot also be received for 8.02X.
Fall Term: *D. Kleppner*
Spring Term: *J. L. Tonry*

8.022 Physics II

Prereq.: 8.012, *18.02*
U (Fall, Spring)
5-0-7 PHYSICS II
Credit cannot also be received for 8.02

Parallel to 8.02, but more advanced mathematically. Some knowledge of vector calculus assumed. Maxwell's equations, in both differential and integral form. Electrostatic and magnetic vector potential. Properties of dielectrics and magnetic materials. In addition to the theoretical subject matter, several experiments in electricity and magnetism are performed by the students in the laboratory. Credit cannot also be received for 8.02X.
Fall Term: *R. Ashoori*
Spring Term: *P. Fisher*

8.02X Physics II

Prereq.: 8.01, 8.01X, or 8.012
U (Spring)
5-0-7 PHYSICS II

Designed as a sequel to 8.01X, which is the recommended but not required prerequisite. Main emphasis on electricity and magnetism. Topics include currents and DC circuits; capacitance, resistance, and nonsteady currents; Coulomb's Law and electrostatic fields; Gauss's Law; electric potential; magnetic fields of currents; electromagnetic induction; magnetism and matter; AC circuits and resonance; Maxwell's equations; electromagnetic fields in space; electromagnetism and relativity; electromagnetic radiation as waves and photons. Kits of equipment are provided for the performance of a relevant take-home experiment as part of the homework each week. Credit cannot also be received for 8.02 or 8.022.
J. L. Matthews

8.03 Physics III

Prereq.: 8.02 or 8.022; 18.02
U (Fall, Spring)
5-0-7 REST

Mechanical vibrations and waves; simple harmonic motion, superposition, forced vibrations and resonance, coupled oscillations and normal modes; vibrations of continuous systems; reflection and refraction; phase and group velocity. Optics; wave solutions to Maxwell's equations; polarization; Snell's Law, interference, Huygens's principle, Fraunhofer diffraction, gratings.
Fall Term: *F. Rasio*
Spring Term: *H. V. Bradt*

8.033 Special Relativity and Classical Mechanics
(Revised Content)

Prereq.: 8.01, 18.02
U (Fall)
5-0-7

Normally taken by physics majors in their sophomore year. Topics in relativity: Einstein's postulates; consequences for simultaneity, time dilation, length contraction, clock synchronization; Lorentz transformation; relativistic effects and paradoxes; invariants and four-vectors; momentum, energy and mass; particle collisions; principle of equivalence. Topics in mechanics: review of 8.01, conservative force fields, one-dimensional motion; central forces; celestial mechanics; scattering cross sections; accelerated coordinate systems; Lagrange's equations and applications; conservation laws; rigid body motion. Credit cannot be received for 8.20 if credit for 8.033 is or had been received in the same or prior terms.
M. Baranger

8.04 Quantum Physics I

Prereq.: 8.03 or 6.014; 18.03
U (Fall, Spring)
5-0-7 REST

Experimental basis of quantum physics: photoelectric effect, Compton scattering, photons, Franck-Hertz experiment, the Bohr atom, electron diffraction, deBroglie waves, wave-particle duality of matter and light. Introduction to wave mechanics: Schroedinger's equation, wave functions, wave packets, probability amplitudes, stationary states, the Heisenberg uncertainty principle and zero-point energies. Solutions to Schroedinger's equation in one dimension: transmission and reflection at a barrier, barrier penetration, potential wells, the simple harmonic oscillator. Schroedinger's equation in three dimensions: central potentials, introduction to hydrogenic systems.
Fall Term: *U. Wiese*
Spring Term: *T. A. Arias*

8.044 Statistical Physics I

Prereq.: 8.03, 18.03
U (Spring)
5-0-7

Introduction to probability, statistical mechanics, and thermodynamics. Random variables, joint and conditional probability densities, functions of a random variable. Concepts of macroscopic variables and thermodynamic equilibrium, fundamental assumption of statistical mechanics, microcanonical and canonical ensembles. First, second, and third laws of thermodynamics. Numerous examples illustrating a wide variety of physical phenomena such as magnetism, polyatomic gases, thermal radiation, electrons in solids, and noise in electronic devices. Concurrent enrollment in 8.04 is recommended.
T. J. Greytak

8.05 Quantum Physics II

Prereq.: 8.04
U (Fall, Spring)
5-0-7

General formalism of quantum mechanics: state space, Dirac notation, representations, matrix mechanics. Angular momentum, magnetic moments, time-independent perturbation theory. Applications to atomic, molecular, and condensed-matter systems. Perturbation theory and the hydrogen atom: fine/hyperfine structure, Stark effect, Zeeman and Paschen-Back effects, Rydberg atoms. Vibrational-rotational spectrum of a diatomic molecule using Born-Oppenheimer approximation. Van der Waals interaction in the H_2 molecule. The electron in a one-dimensional periodic potential: Bloch's theorem, band structure.
Fall Term: *R. L. Jaffe*
Spring Term: *T. Imai*

8.059 Quantum Physics III

Prereq.: 8.05
U (Spring)
5-0-7

Further development of quantum mechanics and applications to physical systems. Scattering theory: Rutherford scattering, inelastic scattering, optical theorem. Identical particles: fermions and bosons. Degenerate Fermi matter: collapsed stars, quark matter, metals, insulators, and semiconductors. Thomas-Fermi model of atoms. Hartree-Fock method: helium atom, atomic shell model, periodic table. Models of nuclei and hadrons. Time-dependent perturbation theory: sudden and harmonic perturbations, Fermi's golden rule, electric and magnetic multipole transitions, radiative decay, Mössbauer effect. Superconductivity and the Josephson effect.
R. L. Jaffe

8.07 Electromagnetism II

Prereq.: 8.03, 18.03
U (Fall)
4-0-8

Survey of basic electromagnetic phenomena: electrostatics, magnetostatics; electromagnetic properties of matter. Time-dependent electromagnetic fields and Maxwell's equations. Electromagnetic waves, emission, absorption, and scattering of radiation. Relativistic electrodynamics and mechanics.
L. Rosenberg

8.08 Statistical Physics II

Prereq.: 8.05
U (Spring)
4-0-8

Probability distributions for classical and quantum systems. Microcanonical, canonical, and grand canonical partition-functions and associated thermodynamic potentials. Conditions of thermodynamic equilibrium for homogenous and heterogenous systems. Applications: noninteracting Bose and Fermi gases; mean field theories for real gases, binary mixtures, magnetic systems, polymer solutions; phase and reaction equilibria, critical phenomena. Fluctuations, correlation functions and susceptibilities, Kubo formulae. Evolution of distribution functions: Boltzmann and Smoluchowski equations.
K. Huang

Undergraduate Laboratory and Special Project Subjects

8.12 Physics Project Laboratory

Prereq.: —
U (Spring)
1-6-5 Institute LAB

Offers an opportunity for students to carry out experimental projects based on their own curiosity, interests, and ideas to study physical phenomena, including optics, acoustics, magnetism, and quantum effects. Faculty help students to determine the feasibility of proposed projects and provide guidance in experimental techniques, data acquisition, error analysis and physical interpretation of results. Prior experience in a laboratory environment is not required. Not usable as a restricted elective by Physics majors.
R. K. Yamamoto

8.122 Advanced Project Laboratory

Prereq.: 8.02
U (IAP)
1-5-3

Laboratory subject that offers students the opportunity to carry out experimental physics projects of their own design. Emphasizes contemporary ideas in laboratory techniques and the use of on-line data acquisition, whenever possible. Projects designed by students are based on physics phenomena they have encountered in coursework or on their own. Faculty teach students how to use various laboratory instruments, how to cope with possible systematic errors in their results, and how to determine statistical errors from numerical data.
R. K. Yamamoto

8.13 Experimental Physics I

Prereq.: 8.04
U (Fall)
0-6-12 Institute LAB

8.14 Experimental Physics II

Prereq.: *8.05*, 8.13
U (Spring)
0-6-12 Institute LAB

About five fundamental laboratory experiments carried out each term, covering most aspects of modern physics relating to names such as Rutherford, Franck-Hertz, Hall, Ramsauer, Doppler, Fraunhofer, Faraday, Mossbauer, Compton, Stern-Gerlach. Stresses basic experimental techniques and data analyses, and written and oral presentation of experiment results. Second term requires knowledge of quantum mechanics at the 8.05 level. 12 units may be applied to the General Institute Laboratory Requirement.
G. W. Clark

8.18 Special Problems in Undergraduate Physics

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

Opportunity for undergraduates to engage in experimental or theoretical research under the supervision of a staff member. Specific approval required in each case.
Information: J. W. Belcher.

8.19 Readings in Physics

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

Supervised reading and library work. Choice of material and allotment of time according to individual needs. For students who want to do work not provided for in the regular subjects. Specific approval required in each case.
Information: J. W. Belcher.

Undergraduate Elective Subjects

8.20 Introduction to Special Relativity

Prereq.: 8.01, *8.02*, 18.01
U (IAP)
2-0-7 REST

Reviews nineteenth-century science leading to special relativity, Einstein's approach to science and postulates of relativity, Lorentz transformation, length contraction and time dilation, four vectors and transformations of four vectors, Lorentz invariants, relativistic energy and momentum, relativisitic kinematics and collisions, massless particles, Doppler shift, space-time diagrams, relativity paradoxes, the impact of relativity. This subject is aimed at the freshman and sophomore level. Not usable as a restricted elective by Physics majors. Credit cannot be received for 8.20 if credit for 8.033 is or has been received in the same or prior terms.
S. A. Rappaport

8.21 Classical Mechanics II
(Revised Content)

Prereq.: 8.033, 18.02
U (IAP)
2-0-4

Continuation of 8.033, containing the more theoretical topics. Normally taken by physics majors in their sophomore year. Hamilton's Principle. Linear mechanics with applications to continuous media. Hamiltonian formulation. Liouville's theorem. Action-angle variables in one dimension. Poisson brackets. Canonical transformations. Noether's theorem. Integrable vs non-integrable systems.
M. Baranger

8.231 Physics of Solids I

Prereq.: 8.044, 8.211 or 8.05
U (Fall)
4-0-8

Introduction to the basic concepts of the quantum theory of solids. Topics: periodic structure and symmetry of crystals; diffraction; reciprocal lattice; chemical bonding; lattice dynamics, phonons, thermal properties; free electron gas; model of metals; Bloch theorem and band structure, nearly free electron approximation; tight binding method; Fermi surface; semiconductors, electrons, holes, impurities; optical properties, excitons; magnetism.
T. J. Greytak

8.235 Superconductivity

Prereq.: 8.04, 8.044
Acad Year 1996-97: **Not offered**
Acad Year 1997-98: U (IAP)
2-0-4

Experiments and phenomenology. A qualitative introduction to perfect conductance and perfect diamagnetism; thermodynamics and the energy gap; electron (Cooper) pairing; Bardeen-Cooper-Schrieffer theory; quasiparticles; phase transition and free energy; suppression of Coulomb repulsion; Type I and II superconductors; vortices, coherence, and penetration lengths; lower and upper critical fields; Landau theory; critical phenomena; Ginzburg criterion; liquid crystal analogs; high T_c superconductivity.
A. N. Berker

8.242 Quantum Electronics and Laser Spectroscopy

Prereq.: 8.04 or 6.017
Acad Year 1996-97: **Not offered**
Acad Year 1997-98: U (Spring)
3-1-8

Fundamental processes in lasers and their applications to studying physical properties of atoms and molecules. Interaction of classical and quantum systems with electromagnetic radiation. The physics of two-level atoms. Laser oscillators. Techniques in nonlinear spectroscopy, such as stimulated Raman effect, free induction decay, optical nutation, photon echoes, and CARS. As part of the curriculum, each student is required to carry out a laboratory project. Familiarity with Maxwell's equations and the Schroedinger equation is required.
M. S. Feld

8.243 Modern Optics

Prereq.: 8.03
Acad Year 1996-97: **Not offered**
Acad Year 1997-98: U (Fall)
3-0-9

Nature of light, wave/particle duality. Polarization. Propagation of plane waves in isotropic and anisotropic media, optical constants. Magneto- and electro-optical effects. Reflection and refraction at an interface between two media. Fresnel equations. Interference, Michelson, and Fabry-Perot interferometers, Fourier transform spectroscopy. Multilayer thin films. Fresnel and Fraunhofer diffraction, diffraction gratings. Ray optics. Optical resonators, Gaussian beams. Lasers, threshold condition, common laser systems. Fourier optics, spatial filtering. Holography, binary optics, micro-optics. Nonlinear optics, effects of second- and third-order nonlinear susceptibility. Fiber optics. Optical detectors. Optical instruments.
R. Aggarwal

8.276 Nuclear and Particle Physics

Prereq.: 8.05
Acad Year 1996-97: **Not offered**
Acad Year 1997-98: U (Spring)
4-0-8

A modern view of the fundamental structure of matter. Starting from a model that views "quarks" as basic building blocks of mesons and baryons, the properties and interactions of these particles are established. Quantum numbers and multiplet structure of particle families. Nuclei as multibaryon systems: stability, radioactive decay, reactions. Current topics in nuclear and particle physics research at MIT.
J. L. Matthews

8.282 Introduction to Astrophysics and Astronomy

Prereq.: 8.01
U (Spring)
3-0-6 REST

Quantitative introduction to physics of the galaxy and the universe, as determined from a variety of astronomical observations and from cosmic ray and neutrino experiments. Topics: the sun and "normal" stars, supernovae, pulsars, globular clusters, compact objects (white dwarfs, neutron stars, black holes), optical and X-ray stellar binary systems, interstellar medium and star formation, galaxies, quasars, and cosmology. Prior knowledge of astronomy not necessary. Not usable as a restricted elective by physics majors.
B. F. Burke

8.284 Modern Astrophysics

Prereq.: 8.04, *8.05*
U (Fall)
3-0-9

Applications of physics (Newtonian, statistical, and quantum mechanics) to fundamental processes that occur in celestial objects. Includes main-sequence stars, collapsed stars (white dwarfs, neutron stars, and black holes), pulsars, supernovae, the interstellar medium, galaxies, and as time permits, active galaxies, quasars, and cosmology. Observational data discussed. No prior knowledge of astronomy is required.
P. Schechter

8.286 The Early Universe

Prereq.: 18.03, 8.02
Acad Year 1996-97: **Not offered**
Acad Year 1997-98: U (Spring)
3-0-9 REST

Introduction to modern cosmology. First half deals with the development of the big-bang theory from 1915 to 1980, and latter half with recent impact of particle theory. Topics: special relativity and the Doppler effect, Newtonian cosmological models, introduction to non-Euclidean spaces, thermal radiation and early history of the universe, big-bang nucleosynthesis, introduction to grand unified theories and other recent developments in particle theory, baryogenesis, the inflationary universe model, and the evolution of galactic structure.
A. H. Guth

8.287J Observational Techniques of Optical Astronomy

(Same subject as 12.410J)
Prereq.: One subject in Astronomy or Astrophysics
U (Fall)
2-4-6 Institute LAB

See description under subject 12.410J.
J. L. Elliot

8.289 Techniques of Radio Astronomy

(New)

Prereq.: 8.04, 8.044
U (IAP)
1-3-2

Instruments and data analysis methods used in radio astronomy: including antennas, receivers, calibration, signal processing, and image processing. Emphasis on relating radio measurements to the study of astrophysical phenomena. Includes a project to be carried out with Haystack Observatory's 37-meter radio telescope.
J. N. Hewitt, Haystack Observatory staff

8.292J Fluid Physics

(Same subject as 12.330J)
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. See description under subject 12.330J.
K. Emanuel, P. Joss

8.299 Physics Teaching

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

For qualified undergraduate students interested in gaining some experience in teaching. Laboratory, tutorial, or classroom teaching under the supervision of a faculty member. Students selected by interview.
Information: J. W. Belcher.

8.ThU Undergraduate Physics Thesis

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

Program of undergraduate research, leading to the writing of an S.B. thesis; to be arranged by the student under approved supervision.
J. L. Matthews

Graduate Subjects

General and Mathematical Physics

8.311 Electromagnetic Theory

Prereq.: 8.07
G (Fall)
4-0-8 H-LEVEL Grad Credit

Basic principles of electromagnetism: experimental basis, electrostatics, magnetic fields of steady currents, motional e.m.f. and electromagnetic induction, Maxwell's equations, propagation and radiation of electromagnetic waves, electric and magnetic properties of matter, conservation laws. This is a graduate level subject which uses appropriate mathematics but whose emphasis is on physical phenomena and principles.
L. Levitov

8.312 Electromagnetic Theory

Prereq.: 8.311
G (Spring)
4-0-8 H-LEVEL Grad Credit

Continuation of 8.311 followed by an introduction to classical field theory. Special relativity Liénard-Wiechert potentials, special topics (may include bremsstrahlung, virtual photons, Cerenkov radiation, multipole radiation, etc.). Lagrangian and Hamiltonian field theory: a choice among the electromagnetic field, the gravitational field (general relativity), non-Abelian gauge fields, and the Dirac electron field.
L. Levitov

8.321 Quantum Theory I

Prereq.: 8.05, 8.21
G (Fall)
4-0-8 H-LEVEL Grad Credit

8.322 Quantum Theory II

Prereq.: 8.07, 8.321
G (Spring)
4-0-8 H-LEVEL Grad Credit

A two-semester subject on quantum theory, stressing principles: uncertainty relation, observables, eigenstates, eigenvalues, probabilities of the results of measurement, transformation theory, equations of motion, constants of motion. Symmetry in quantum mechanics, representations of symmetry groups. Variational and perturbation approximations. Systems of identical particles and applications. Time-dependent perturbation theory. Scattering theory: phase shifts, Born approximation. The quantum theory of radiation. Second quantization and many-body theory. Relativistic quantum mechanics of one electron.
J. Negele

8.323 Relativistic Quantum Field Theory I

Prereq.: 8.321
G (Spring)
4-0-8 H-LEVEL Grad Credit

8.324 Relativistic Quantum Field Theory II

Prereq.: 8.322, 8.323
G (Fall)
4-0-8 H-LEVEL Grad Credit

8.325 Relativistic Quantum Field Theory III

Prereq.: 8.324
G (Spring)
4-0-8 H-LEVEL Grad Credit

A three-semester subject sequence on quantum field theory stressing the relativistic quantum field theories relevant to the physics of the Standard Model. 8.323 is a one-semester self-contained subject in quantum field theory. Concepts and basic techniques are developed through applications in elementary particle physics and condensed matter physics. Includes the basic tools of field theory required for phenomenological studies. Topics: Functional integral formulation of quantum mechanics and many-particle systems. Classical field theory, symmetries, and Noether's theorem. Quantization of scalar fields. Feynman graphs, analytic properties of amplitudes and unitarity of the S-matrix. Renormalization and renormalization group. Spinors and the Dirac equation. Quantization of Dirac fields. Supersymmetry. Quantization of abelian gauge fields. Calculations in quantum electrodynamics. Classical Yang-Mills fields. The Higgs phenomenon and a description of the Standard Model. 8.324 is the second term of the quantum field theory sequence. Develops in depth some of the topics discussed in 8.323 and introduces some advanced material. Topics: Quantization of nonabelian gauge theories. BRST symmetry. Perturbation theory anomalies. Renormalization and symmetry breaking. The renormalization group. Critical exponents and scalar field theory. Conformal field theory. 8.325 is the third and last term of the quantum field theory sequence. Its aim is the proper theoretical discussion of the physics of the standard model. Topics: Quantum chromodynamics. Deep-inelastic scattering and structure functions. Basics of lattice gauge theory. Operator products and effective theories. Detailed structure of the standard model; spontaneously broken gauge theory and its quantization. Instantons and θ-vacua. Topological defects.
8.323: *K. Johnson*, 8.324: *J. Goldstone*
8.325: *L. Randall*

8.333 Statistical Mechanics I

Prereq.: 8.044, 8.05
G (Fall)
4-0-8 H-LEVEL Grad Credit

8.334 Statistical Mechanics II

Prereq.: 8.333
G (Spring)
4-0-8 H-LEVEL Grad Credit

A two-semester course on statistical mechanics. Basic principles are examined in 8.333: the laws of thermodynamics and the concepts of temperature, work, heat, and entropy. Postulates of classical statistical mechanics, microcanonical, canonical, and grand canonical distributions; applications to lattice vibrations, ideal gas, photon gas. Quantum statistical mechanics; Fermi and Bose systems. Interacting systems: cluster expansions, van der Waal's gas, mean-field theory. Topics from modern statistical mechanics are explored in 8.334: the hydrodynamic limit and classical field theories. Phase transitions and broken symmetries: universality, correlation functions and scaling theory. The renormalization approach to collective phenomena. Dynamic critical behavior. Random systems.
N. Berker

8.351J Variational Mechanics: A Computational Approach

(Same subject as 12.620J, 6.946J)
Prereq.: 8.01, 18.03, 6.001 or equivalent
G (Fall)
3-3-6 H-LEVEL Grad Credit

See description under subject 12.620J.
J. Wisdom, G. J. Sussman

8.361 Quantum Theory of Many-Particle Systems

Prereq.: 8.322, 8.333
Acad Year 1996-97: **Not offered**
Acad Year 1997-98: G (Fall)
3-0-9 H-LEVEL Grad Credit

Introduces general many-body theory applicable to low temperature, nuclear, and solid-state physics. Reviews occupation number representation and classical Mayer expansion. Perturbation theory: diagrammatic expansions and linked-cluster theorem for zero or finite temperature systems of fermions or bosons. Green's functions: analytic properties, equations of motion, relation to observables, approximations, linear response theory, random phase approximation. Superconductivity: electron-phonon interaction, instability of normal state, BCS ground state, perturbation theory.
T. W. Donnelly

8.381, 8.382 Selected Topics in Theoretical Physics

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

Topics of current interest in theoretical physics, varying from year to year. Subject not routinely offered; given when sufficient interest is indicated.
Information: G. F. Koster.

8.391, 8.392 Special Problems in Graduate Physics

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

Advanced problems in any area of experimental or theoretical physics, with assigned reading and consultations.
Information: G. F. Koster.

8.399 Physics Teaching

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

For qualified graduate students interested in gaining some experience in teaching. Laboratory, tutorial, or classroom teaching under the supervision of a faculty member. Students selected by interview.
Information: G. F. Koster.

Physics of Atoms, Radiation, Solids, Fluids, and Plasmas

8.421 Atomic and Optical Physics I

Prereq.: 8.05
Acad Year 1996-97: G (Fall)
Acad Year 1997-98: **Not offered**
3-0-9 H-LEVEL Grad Credit

The first of a two-semester subject sequence that provides the foundations for contemporary research in selected areas of atomic and optical phsyics. The interaction of radiation with atoms: resonance; absorption, stimulated and spontaneous emission; methods of resonance, dressed atom formalism, masers and lasers, cavity quantum electrodynamics; structure of simple atoms, behavior in very strong fields; fundamental tests: time reversal, parity violations, Bell's inequalities; experimental methods.
D. Pritchard

8.422 Atomic and Optical Physics II

Prereq.: 8.05
Acad Year 1996-97: G (Spring)
Acad Year 1997-98: **Not offered**
3-0-9 H-LEVEL Grad Credit

The second of a two-semester subject sequence that provides the foundations for contemporary research in selected areas of atomic and optical physics. Non-classical states of light: squeezed states; multi-photon processes, Raman scattering; coherence: level crossings, quantum beats, double resonance, superradiance; trapping and cooling: light forces, laser cooling, atom optics, spectroscopy of trapped atoms and ions; atomic interactions: classical collisions, quantum scattering theory, ultracold collisions; experimental methods.
W. Ketterle

8.481, 8.482 Selected Topics in Physics of Atoms and Radiation

Prereq.: 8.321
G (Fall, Spring)
3-0-9 H-LEVEL Grad Credit

Presentation of topics of current interest, with content varying from year to year. Subject not routinely offered; given when sufficient interest is indicated.
Information: G. F. Koster.

8.510J Application of Group Theory to the Physics of Solids

(Same subject as 6.734J)
Prereq.: 8.231 or 6.732
Acad Year 1996-97: G (Spring)
Acad Year 1997-98: **Not offered**
3-0-9 H-LEVEL Grad Credit

See description under subject 6.734J.
M. S. Dresselhaus

8.511 Theory of Solids I

Prereq.: 8.231
G (Fall)
3-0-9 H-LEVEL Grad Credit

First term of a theoretical treatment of the physics of solids. Concept of elementary excitations. Symmetry: translational, rotational, and time-reversal invariances: theory of representations. Energy bands: APW, OPW, pseudopotential and LCAO schemes. Survey of electronic structure of metals, semimetals, semiconductors, and insulators. Excitons. Critical points. Response functions. Interactions in the electron gas.
P. Lee

8.512 Theory of Solids II

Prereq.: 8.511
G (Spring)
3-0-9 H-LEVEL Grad Credit

Second term of a theoretical treatment of the physics of solids. Interacting electron gas: many-body formulation, Feynman diagrams, random phase approximation and beyond. General theory of linear response: dielectric function; sum rules; plasmons; optical properties; applications to semiconductors, metals, and insulators. Transport properties: non-interacting electron gas with impurities, diffusons. Quantum Hall effect: integral and fractional. Electron-phonon interaction: general theory, applications to metals, semiconductors and insulators, polarons, field-theory description. Superconductivity: experimental observations, phenomenological theories, B.C.S. theory.
P. Lee

8.513 Many-body Techniques in Condensed Matter Physics

Prereq.: 8.511, 8.512
G (Fall)
3-0-9 H-LEVEL Grad Credit

Topics vary depending on lecturer. In 1996–97, introduces the use of functional integrals in condensed matter physics. Topics include quantum systems coupled to heat baths, the Hubbard-Stratonovitch formalism illustrated by the superconductivity order parameter, density of states of disordered systems and the quantum Hall effect, and the scaling theory of localization and transport in mesoscopic systems.
X.-G. Wen

8.515J Biological Physics

(Same subject as HST.450J)
Prereq.: 8.044 desirable but not necessary
G (Fall)
4-0-8 H-LEVEL Grad Credit

Designed to provide seniors and first-year graduate students with a quantitative, analytical understanding of selected biological phenomena. Topics include: Experimental and theoretical basis for the phase boundaries and equation of state of concentrated protein solutions, with application to diseases such as sickle cell anemia and cataract. Protein-ligand binding and linkage and the theory of allosteric regulation of protein function, with application to proteins as stores as transporters in respiration, enzymes in metabolic pathways, membrane receptors, regulators of gene expression, and self-assembling scaffolds. The physics of locomotion and chemoreception in bacteria and the biophysics of vision including the theory of transparency of the eye, molecular basis of photo reception and the detection of light as a signal to noise discrimination.
G. Benedek, F. Villars

8.532J Modern Topics in Solid State Physics

(Same subject as 6.735J)
Prereq.: 6.732 or 8.231
Acad Year 1996-97: **Not offered**
Acad Year 1997-98: G (Fall)
3-0-9 H-LEVEL Grad Credit

Quantum wells, superlattices, 2-D electron systems, quantized Hall effect, intercalation, semiconductor-metal transition, one-electron systems, organic conductors, magnetic semiconductors, localization phenomena, Bohm-Aharanov effect, Fullerenes.
M. S. Dresselhaus

8.562 Correlations and Critical Behavior in Condensed Matter

Prereq.: 8.511, 8.333
Acad Year 1996-97: **Not offered**
Acad Year 1997-98: G (Fall)
3-0-9 H-LEVEL Grad Credit

Views condensed-matter physics through space- and time-dependent correlation functions measured by scattering spectroscopy. Treats in detail experimental techniques of x-ray, light, electron, and neutron scattering. Theoretical development is strongly phenomenological to elucidate physical behavior with minimal mathematical complexity. Uses conservation laws, broken symmetry, and the fluctuation-dissipation theorem to illustrate the interconnection between apparently diverse systems, with special attention to behavior near phase transitions.
S. Mochrie

8.575J Statistical Thermodynamics of Complex Liquids

(Same subject as 22.52J, 10.44J)
Prereq.: 8.08, 10.213, or equivalent
Acad Year 1996-97: **Not offered**
Acad Year 1997-98: G (Spring)
3-0-9 H-LEVEL Grad Credit

See description under subject 22.52J.
S. H. Chen, D. Blankschtein

8.581, 8.582 Selected Topics in Physics of Solids

Prereq.: Permission of instructor
G (Fall, Spring)
3-0-9
Can be repeated for credit

Presentation of topics of current interest, with contents varying from year to year. Subject not routinely offered; given when sufficient interest is indicated.
Information: T. J. Greytak.

8.613J Introduction to Plasma Physics I

(Same subject as 6.651J, 22.611J)
Prereq.: 6.014 or 8.07; 18.04 or *18.075*
G (Fall)
3-0-9 H-LEVEL Grad Credit

Introduces plasma phenomena relevant to energy generation by controlled thermonuclear fusion and to astrophysics. Coulomb collisions and transport processes. Motion of charged particles in magnetic fields; plasma confinement schemes. MHD models; simple equilibrium and stability analysis. Two-fluid hydrodynamic plasma models; wave propagation in a magnetic field. Introduces kinetic theory; Vlasov plasma model; electron plasma waves and Landau damping; ion-acoustic waves; streaming instabilities.
A. Bers, B. Coppi

8.614J Introduction to Plasma Physics II

(Same subject as 6.652J, 22.612J)
Prereq.: 6.651J or 8.613J or 22.611J
G (Spring)
3-0-9 H-LEVEL Grad Credit

Linear waves and instabilities in magnetized plasma; solutions of Vlasov-Maxwell equations in homogeneous and inhomogeneous plasmas; conservation principles for energy and momentum; quasi-linear theory and nonlinear stabilization; solitons and coherent nonlinear phenomena; collisions and discrete particle effects; fluctuations in a stable plasma; Fokker-Planck equation and transport phenomena.
P. Catto

8.624 Plasma Waves

Prereq.: 8.613J
Acad Year 1996-97: **Not offered**
Acad Year 1997-98: G (Spring)
3-0-9 H-LEVEL Grad Credit

Comprehensive theory of electromagnetic waves in a magnetized plasma. Wave propagation in cold and hot plasmas. Energy flow. Absorption by Landau and cyclotron damping and by transit time magnetic pumping (TTMP). Wave propagation in inhomogeneous plasma: accessibility, WKB theory, mode conversion, connection formulae, Budden tunneling. Applications to RF plasma heating, wave propagation in the ionosphere and laser-plasma interactions. Wave propagation in toroidal plasmas, and applications to ion cyclotron (ICRF), electron cyclotron (ECRH), and lower hybrid (LHH) wave heating. Quasi-linear theory and applications to RF current drive in tokamaks. Extensive discussion of relevant experimental observations.
M. Porkolab, P. Bonoli

8.641 Physics of High-Energy Plasmas I

Prereq.: 8.613J
Acad Year 1996-97: **Not offered**
Acad Year 1997-98: G (Fall)
3-0-9 H-LEVEL Grad Credit

8.642 Physics of High-Energy Plasmas II

Prereq.: 8.613J
Acad Year 1996-97: **Not offered**
Acad Year 1997-98: G (Fall)
3-0-9 H-LEVEL Grad Credit

Basic concepts of plasmas, with temperatures of thermonuclear interest, relevant to fusion research and astrophysics. Microscopic transport processes due to inter-particle collisions and collective modes (e.g., microinstabilities). Relevant macroscopic transport coefficients (electrical resistivity, thermal conductivities, particle "diffusion"). Runaway and slide-away regimes. Magnetic reconnection processes and their relevance to experimental observations. Radiation emission from inhomogeneous plasmas. Conditions for thermonuclear burning and ignition (D-T and "advanced" fusion reactions, plasmas with polarized nuclei). Role of "impurity" nuclei. "Finite-β" (pressure) regimes and ballooning modes. Convective modes in configuration and velocity space. Trapped particle regimes. Nonlinear and explosive instabilities. Interaction of positive and negative energy modes. Each subject can be taken independently.
B. Coppi

8.681, 8.682 Selected Topics in Fluid and Plasma Physics

Prereq.: 8.613J
G (Fall, Spring)
3-0-9 H-LEVEL Grad Credit
Can be repeated for credit

Presentation of topics of current interest, with content varying from year to year. Subject not routinely offered; given when interest is indicated.
Information: M. Porkolab.

Nuclear and Particle Physics

8.701 Introduction to Nuclear and Particle Physics

Prereq.: 8.323
G (Fall)
3-0-9 H-LEVEL Grad Credit

The phenomenology and experimental foundations of particle and nuclear physics; the fundamental forces and particles, composites. Interactions of particles with matter, detectors. SU(2), SU(3), models of mesons and baryons. QED, weak interactions, parity violation, lepton-nucleon scattering, structure functions. QCD, gluon field and color. W and Z fields, electroweak unification, the CKM matrix. Nucleon-nucleon interactions, properties of nuclei, single and collective particle models. Electron and hadron interactions with nuclei. Relativistic heavy ion collisions, transition to quark-gluon plasma.
L. Osborne

8.711 Nuclear Physics

Prereq.: 8.321, 8.701
G (Spring)
4-0-8 H-LEVEL Grad Credit

Experimental foundations and theory of the structure of nucleons and nuclei. Nucleon excited states, form factors. Nucleon-nucleon interaction, few body systems, mesonic current and quark effects. Electromagnetic and hadron scattering from nucleons and nuclei with emphasis on spin degrees of freedom. Many-body physics, nuclear saturation, shell and collective models, correlations, electromagnetic transitions, giant resonances, sum rules, weak interactions. Inclusive and exclusive processes at intermediate and high energies, quark degrees of freedom. Relativistic heavy ion physics, high-temperature QCD, phase transition, quark-gluon plasma. Nuclear astrophysics.
E. Lomon

8.712 Advanced Topics in Nuclear Physics

Prereq.: 8.711 or permission of instructor
G (Spring)
4-0-8 H-LEVEL Grad Credit
Can be repeated for credit

Medium-energy physics (Spring 1996): Nuclear and nucleon structure and dynamics studied with medium- and high-energy probes (neutrinos, photons, electrons, nucleons, pions, and kaons). Studies of the weak and strong interactions.
Information: T. W. Donnelly.

8.731 Nuclear Physics Seminar

Prereq.: 8.322, 8.712
G (Spring)
2-0-4 [P/D/F] H-LEVEL Grad Credit
Can be repeated for credit

Advanced seminar on current topics. Short presentations by both experimentalists and theorists. Emphasis varies yearly. Typical topics: ultrarelativistic heavy-ion collisions; quark models of nucleons, nuclei, and nucleon-nucleon interaction; new observables in electron scattering, using polarized beams, polarized targets, and coincidence measurements; recent experiments on relativistic nucleon-nucleon scattering; developments in many-body theory, including functional integral and stochastic methods. Offered if sufficient interest is indicated.
A. M. Bernstein

8.781, 8.782 Selected Topics in Nuclear Theory

Prereq.: 8.323
G (Fall, Spring)
3-0-9 H-LEVEL Grad Credit

Presents topics of current interest in nuclear structure and reaction theory, with content varying from year to year. Subject not routinely offered; given when sufficient interest is indicated.
Information: J. W. Negele.

8.811 Particle Physics II

Prereq.: 8.701
G (Spring)
3-0-9 H-LEVEL Grad Credit

Survey of current research in High Energy Physics. Topics include electron-positron and proton-antiproton collisions; electroweak phenomena, heavy flavor physics, and high-precision tests of the Standard Model. Other topics include searches for new phenomena (compositeness, supersymmetry, GUTs). Discussion of our new experimental results (e.g. the Top Quark) and also expectations from future accelerators (B factory, LHC).
M. Chen

8.871, 8.872 Selected Topics in Theoretical Particle Physics

Prereq.: 8.323
G (Fall, Spring)
3-0-9 H-LEVEL Grad Credit
Can be repeated for credit

Presents topics of current interest in theoretical particle physics, with content varying from year to year. Subject not routinely offered; given when sufficient interest is indicated.
Information: J. W. Negele.

8.881, 8.882 Selected Topics in Experimental Particle Physics

Prereq.: 8.811
G (Fall, Spring)
3-0-9 H-LEVEL Grad Credit
Can be repeated for credit

Presents topics of current interest in experimental particle physics, with content varying from year to year. Subject not routinely offered; given when sufficient interest is indicated.
Information: W. Busza.

8.896J Supersymmetric Quantum Field Theories

(Same subject as 18.396J)
Prereq.: 8.323
Acad Year 1996-97: **Not offered**
Acad Year 1997-98: G (Fall)
3-0-9 H-LEVEL Grad Credit
Can be repeated for credit

See description under subject 18.396J.
D. Z. Freedman

Space Physics and Astrophysics

8.901 Astrophysics I

Prereq.: 8.05, 8.06, 8.07
G (Fall)
3-0-9 H-LEVEL Grad Credit

Size and time scales. Historical astronomy. Astronomical instrumentation. Stars: spectra and classification. Stellar structure equations and survey of stellar evolution. Stellar oscillations. Degenerate and collapsed stars; radio pulsars. Interacting binary systems; accretion disks, x-ray sources. Gravitational lenses; dark matter. Interstellar medium: HII regions, supernova remnants, molecular clouds, dust; radiative transfer; Jeans' mass; star formation. High-energy astrophysics: Compton scattering, bremsstrahlung, synchrotron radiation, cosmic rays. Galactic stellar distributions and populations; Oort constants; Oort limit; globular clusters.
S. Rappaport

8.902 Astrophysics II

Prereq.: 8.911
Acad Year 1996-97: **Not offered**
Acad Year 1997-98: G (Spring)
3-0-9 H-LEVEL Grad Credit

Galactic dynamics: potential theory, orbits, collisionless Boltzmann equation, etc. Galaxy interactions. Groups and clusters; dark matter. Intergalactic medium; x-ray clusters. Active galactic nuclei: unified models, black hole accretion, radio and optical jets, etc.
Homogeneity and isotropy, redshift, galaxy distance ladder. Newtonian cosmology. Roberston-Walker models and cosmography. Early universe, primordial nucleosynthesis, recombination. Cosmic microwave background radiation. Large-scale structure, galaxy formation.
E. Bertschinger

8.913 Plasma Astrophysics I

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

8.914 Plasma Astrophysics II

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

For students interested in space physics, astrophysics, and plasma physics in general. Magnetospheres of rotating magnetized planets, ordinary stars, neutron stars, and black holes. Pulsar models: processes for slowing down, particle acceleration, and radiation emission; accreting plasmas and x-ray stars; stellar winds; heliosphere and solar wind: relevant magnetic field configuration, measured particle distribution in velocity space and induced collective modes; stability of the current sheet and collisionless processes for magnetic reconnection; theory of collisionless shocks; solitons; Ferroaro-Rosenbluth sheet; solar flare models; heating processes of the solar corona; earth's magnetosphere (auroral phenomena and their interpretation, bow-shock, magnetotail, trapped particle effects); relationship between gravitational (galactic) plasmas and electromagnetic plasmas. 8.913 deals with heliospheric, 8.914 with extra-heliospheric plasmas.
B. Coppi

8.921 Stellar Structure and Evolution

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

Observable stellar characteristics; overview of observational information. Principles underlying calculations of stellar structure. Physical processes in stellar interiors; properties of matter and radiation; radiative, conductive, and convective heat transport; nuclear energy generation; nucleosynthesis; neutrino emission. Protostars; the main sequence, and the solar neutrino flux; advanced evolutionary stages; variable stars; planetary nebulae, supernovae, white dwarfs, and neutron stars; close binary systems; abundance of chemical elements.
P. C. Joss

8.942 Cosmology

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

Thermal backgrounds in space. Cosmological principle and its consequences: Newtonian cosmology and types of "universes"; survey of relativistic cosmology; horizons. Overview of evolution in cosmology; radiation and element synthesis; physical models of the "early stages." Formation of large-scale structure to variability of physical laws. First and last states. Some knowledge of relativity expected. 8.962 recommended though not required.
E. W. Bertschinger

8.952 Particle Physics of the Early Universe

Prereq.: 8.323, *8.324*
Acad Year 1996-97: G (Spring)
Acad Year 1997-98: **Not offered**
3-0-9 H-LEVEL Grad Credit

Thermal equilibrium states in quantum field theories. Phase transitions and the fate of the false vacuum. Homotopy theory and topological defects: monopoles, strings, and domain walls. The standard cosmological model. The inflationary universe. Quantum field theory in de Sitter space. Quantum origin of density fluctuations in inflationary models.
U. Wiese

8.962 General Relativity

Prereq.: 18.03, 18.06, 8.06, 8.312 or equivalents
Acad Year 1996-97: **Not offered**
Acad Year 1997-98: G (Spring)
3-0-9 H-LEVEL Grad Credit

The basic principles of Einstein's general theory of relativity. Differential geometry. Experimental tests of general relativity. Black holes. Cosmology.
E. Farhi

8.971, 8.972 Astrophysics Seminar

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

Advanced seminar on current topics, with a different focus each semester. Typical topics: gravitational lenses, active galactic nuclei, neutron stars and pulsars, galaxy formation, supernovae and supernova remnants, brown dwarfs, and extrasolar planetary systems. The presenter at each session is selected by drawing names from a hat containing those of all attendees. Offered if sufficient interest is indicated.
Information: E. W. Bertschinger.

8.981, 8.982 Selected Topics in Astrophysics

Prereq.: Permission of instructor
G (Fall, Spring)
3-0-9 [P/D/F] H-LEVEL Grad Credit
Can be repeated for credit

Topics of current interest, varying from year to year. Subject not routinely offered; given when sufficient interest is indicated.
Information: P. Schechter.

8.ThG Graduate Physics Thesis

Prereq.: —
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.
Information: G. F. Koster.

Course 9

Brain and Cognitive Sciences

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

9.UR Undergraduate Research

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

9.URG Undergraduate Research

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

Individual participation in an ongoing research project.
Consult A. Hein.

9.00 Introduction to Psychology
(Revised Content)

Prereq.: —
U (Fall)
4-0-8 HASS-D, Category 4

A first course in psychology: how we think, see, feel, learn, talk, act, grow, fear, love, hate, lust, and find meaning. The great controversies: nature and nurture, free will, consciousness, human differences, self and society. Largely laboratory and field studies of behavior, with relevant ideas from evolutionary biology, genetics, brain science, philosophy, economics, sociology, and the arts. Enrollment may be limited.
S. Pinker

9.01 Neuroscience and Behavior

Prereq.: 9.62 or 9.00
U (Fall)
3-0-9 REST

Relation of structure and function at various levels of neuronal integration. Topics include: functional neuroanatomy and neurophysiology, sensory and motor systems, centrally programmed behavior, sensory systems, sleep and dreaming, motivation and reward, emotional displays of various types, "higher functions" and the neocortex, and neural processes in learning and memory.
G. E. Schneider

9.011J Principles of Neuroscience

(Same subject as 7.65J)
Prereq.: Permission of instructor
G (Fall)
6-0-9 H-LEVEL Grad Credit

Survey of principles underlying the structure and function of the nervous system, integrating molecular, cellular, systems, and computational approaches. Topics: development, cell biology of neurons, neurotransmitters and synaptic transmission, sensory systems of the brain, the neuroendocrine system, the motor system, higher cortical functions, behavioral and cellular analyses of learning and memory.
M. Sur, A. Graybiel, E. Bizzi, S. Corkin, P. Schiller, R. J. Wurtman, W. Quinn, M. Wilson, E. Miller, E. Adelson, H. Steller

9.02 Brain and Behavior Laboratory
(New)

Prereq.: 9.01
U (Spring)
1-5-6 Institute LAB

Consists of a series of "hands-on" laboratories designed to give students experience with common techniques for conducting neuroscience research. Included are sessions on anatomical, ablation, neurophysiological, and computer modeling techniques, and ways these techniques are used to study brain function. Each session consists of a brief quiz on assigned readings that provide background to the lab, a lecture that expands on the readings, and that week's laboratory. Weekly lab reports required.
E. Miller

9.021 Dynamic Neural Processing in the Vertebrate Forebrain

Prereq.: 9.011J
Acad Year 1996-97: G (Fall)
Acad Year 1997-98: **Not offered**
3-0-9 H-LEVEL Grad Credit

There is increasing evidence that neural processing is dynamic and subject to plastic changes over time. Subject considers topics related to neuroplasticity in the forebrain. Brain systems discussed include the cortex and thalamus, the basal ganglia, and elements of the limbic system. Short- and long-term changes in neuronal processing are considered. Alternate years.
A. M. Graybiel

9.029 Cellular Physiology

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

Focuses on combined biochemical, molecular, and biophysical approaches to investigate the physiology of excitable membranes. Emphasis is on structure, function, and regulation of membrane ion channels. Alternate years.
Staff

9.03 Neural Basis of Learning and Memory

(Subject meets with 9.031)
Prereq.: 9.01
Acad Year 1996-97: **Not offered**
Acad Year 1997-98: U (Fall)
3-0-9

9.031 Neural Basis of Learning and Memory

(Subject meets with 9.03)
Prereq.: —
Acad Year 1996-97: **Not offered**
Acad Year 1997-98: G (Fall)
3-0-9 H-LEVEL Grad Credit

Topics in mammalian learning and memory including cellular mechanisms. Neural plasticity, electrophysiology, behavior, and computational approaches considered. Emphasis on animal models of hippocampal mechanisms and function. Lectures and discussion of papers. An additional project is required for graduate credit.
M. Wilson, P. Dayan

9.036 The Visual System

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

Reviews the current neurophysiological and neuroanatomical research literature on the mammalian visual system. Alternate years.
P. H. Schiller

9.04 Neural Basis of Vision and Audition

Prereq.: 9.01 or permission of instructor
Acad Year 1996-97: U (Fall)
Acad Year 1997-98: **Not offered**
3-0-9

Examines the neural bases of visual and auditory processing for perception and sensorimotor control. Focuses on physiological and anatomical studies of the mammalian nervous system as well as behavioral studies of animals and humans. Studies visual pattern, color and depth perception, auditory responses and speech coding, and spatial localization. Offered alternate years.
P. H. Schiller, J. Mazer

9.05 Neural Basis of Movement

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

Surveys general principles and specific examples of motor control in biological systems. Emphasizes the neural mechanisms underlying different aspects of movement. Covers sensory reception, reflex arcs, spinal cord organization, pattern generators, muscle function, locomotion, and eye movement. Functions of central motor structures including cerebellum, basal ganglia, thalamus, and cerebral cortex considered. Motor learning and computational approaches to motor control are discussed.
A. Graybiel, M. Sur, E. Bizzi, P. Schiller

9.06 Conflicting Images of Humanity and Nature

Prereq.: —
U (Fall)
3-0-9 HASS

More than five billion and growing, we humans are straining the earth's natural resources to an unprecedented extent. How do our views of the world and its contents, including ourselves, relate to our treatment of the environment, including each other? We consider this question in historical perspective and in the light of recent developments in the natural and social sciences.
S. L. Chorover

9.09J Cellular Neurobiology

(Same subject as 7.29J)
Prereq.: 7.05
U (Spring)
4-0-8

See description under subject 7.29J.
W. G. Quinn, H. Steller

9.10 Cognitive Neuroscience

(Subject meets with 9.100)
Prereq.: 9.01
Acad Year 1996-97: U (Spring)
Acad Year 1997-98: **Not offered**
3-0-6

9.100 Cognitive Neuroscience

(Subject meets with 9.10)
Prereq.: 9.011J
Acad Year 1996-97: G (Spring)
Acad Year 1997-98: **Not offered**
3-0-6 H-LEVEL Grad Credit

Explores the relations between neural systems and cognition, emphasizing vision, language, motor control, memory, and emotion. Introduces basic neuroanatomy, imaging techniques, behavioral measures of cognition, and computational models. Discusses methods by which inferences about the brain bases of cognition are made. Considers evidence from patients with neurological diseases and from normal human subjects. Demonstrations of methods and case presentations. An additional project is required for graduate credit.
S. Corkin

9.110J Neurology, Neuropsychology, and Neurobiology of Aging

(New)

(Same subject as 7.92J)
Prereq.: Permission of instructor
G (Spring)
3-0-9 H-LEVEL Grad Credit

Lectures and discussion explore the clinical, behavioral, and molecular aspects of brain aging processes in humans. Topics include: loss of sensory and motor function and loss of memory and other cognitive abilitites in normal aging; neurodegenerative conditions, such as Parkinson's, Alzheimer's, and Huntington's diseases, and Down's syndrome. Based on lectures, readings taken from the primary literature, and discussions. Students are expected to present topics based on their readings. One written mid-term test and one final paper.
S. Corkin, V. Ingram

9.14 Development and Structure of the Mammalian Brain

Prereq.: 9.01
Acad Year 1996-97: U (Spring)
Acad Year 1997-98: **Not offered**
3-0-9

Early determination of brain subdivisions and cell fates. Cell proliferation and migration. Growth cone dynamics and molecular determinants. Axon elongation, formation of major tracts. Map formation and plasticity. Axon collateral formation and regression; end-arbor elaboration and synaptogenesis; shaping by activity; cell death and trophic factors. Regeneration and sprouting. Tissue culture and gene knockout models.
G. E. Schneider

9.15 Biochemistry and Pharmacology of Synaptic Transmission

(Subject meets with 9.150)
Prereq.: 9.01, 7.05, or permission of instructor
Acad Year 1996-97: **Not offered**
Acad Year 1997-98: U (Fall)
3-0-9

9.150 Biochemistry and Pharmacology of Synaptic Transmission

(Subject meets with 9.15)
Prereq.: 9.011J or permission of instructor
Acad Year 1996-97: **Not offered**
Acad Year 1997-98: G (Fall)
3-0-9 H-LEVEL Grad Credit

Considers the process of neurotransmission, especially chemicals used in the brain and elsewhere to carry signals from nerve terminals to the structures they innervate. Focuses on monoamine transmitters (acetylcholine; serotonin; dopamine and norepinephrine); also examines amino acid and peptide transmitters and neuromodulators like adenosine. Macromolecules that mediate neurotransmitter synthesis, release, inactivation, and receptor-mediated actions are discussed, as well as factors that regulate their activity and the second-messenger systems they control. An additional project is required for graduate credit.
R. J. Wurtman

9.20 Animal Behavior

Prereq.: —
U (Fall)
3-0-9 HASS

Reviews selected issues including learning, cognition, perception, foraging and feeding, migration and navigation, defense, and social activities including conflict, collaboration, courtship and reproduction, and communication. The interacting contributions of environment and heredity are examined and the approaches of psychology, ethology, and ecology to this area of study are treated. The relation of human behavior patterns to those of nonhuman animals is explored.
A. Hein

9.201 Advanced Animal Behavior

Prereq.: 9.20 or equivalent
Acad Year 1996-97: G (Spring)
Acad Year 1997-98: **Not offered**
3-0-6 H-LEVEL Grad Credit

Survey and special topics designed for graduate students in the brain and cognitive sciences. Emphasizes ethological studies of natural behavior and its analysis in laboratory work, with contributions from field studies, sociobiology, and comparative psychology. Stresses mammalian behavior but also includes studies of other vertebrates and of invertebrates. Discussions include human ethology, applications to neuropsychology and behavioral pharmacology, and welfare of captive animals. Alternate years.
G. E. Schneider

9.301J Neural Plasticity in Learning and Development

(Same subject as 7.98J)
Prereq.: Permission of instructor
G (Spring)
3-0-9 H-LEVEL Grad Credit

See description under subject 7.98J.
S. Tonegawa, W. Quinn, M. Wilson, H. Steller

9.322J Genetic Neurobiology

(Same subject as 7.67J)
Prereq.: —
Acad Year 1996-97: **Not offered**
Acad Year 1997-98: G (Fall)
3-0-6 H-LEVEL Grad Credit

Deals with the specific functions of neurons, the interactions of neurons in development, and the organization of neuronal ensembles to produce behavior, by functional analysis of mutations and molecular analysis of their genes. Concentrates on work with nematodes and fruit flies. Alternate years.
W. G. Quinn, H. Steller

9.33 Methods in Neural Modeling
(New)

(Subject meets with 9.331)
Prereq.: 9.01, 9.03/9.031, 9.369, or permission of instructor
Acad Year 1996-97: U (Fall)
Acad Year 1997-98: **Not offered**
3-0-9

9.331 Methods in Neural Modeling
(New)

(Subject meets with 9.33)
Prereq.: 9.01, 9.03/9.031 or 9.369 or permission of instructor
Acad Year 1996-97: G (Fall)
Acad Year 1997-98: **Not offered**
3-0-9

Reading, presentation, discussion and implementation of biophysical and systems models of invertebrate and vertebrate neural computation. Computer simulation and/or mathematical analysis forms an essential component. Written presentation of a final project is required for graduate credit.
M. Wilson, P. Dayan

9.34J Cognitive Architectures

(Same subject as MAS.234J, MAS.654)
Prereq.: 9.62 or 9.00
U (Fall)
3-0-6

The acquisition and communication of knowledge demands a coherent cognitive framework within which we can reason about events and states in the world. What frameworks are plausible, and how do these choices affect our deductive and creative processes? Material includes analog representations, Bayesean nets, grammars, default logics, belief theory, and discourse analysis.
W. A. Richards

9.35 Perceptual Information Processing

Prereq.: 9.62 or 9.00
U (Spring)
3-0-9

The senses are our gateways to the world. Everything we know about what is going on out there comes to us through vision, hearing, touch, taste, smell. How do the senses work? How do physical stimuli get transduced into signals in the nervous system? How can the brain use those signals to determine the flavor of a banana, the sound of a flute, or the shape of a cow? All senses discussed. Vision is covered most extensively. Includes perception of color, motion, form and depth, and development.
E. H. Adelson, B. Anderson

9.358J Image Representations for Vision

(Same subject as MAS.626J)
Prereq.: MAS.510 or permission of instructor
G (Fall)
2-0-7 H-LEVEL Grad Credit

See description under subject MAS.626J.
E. H. Adelson, A. Pentland, A. Bobick

9.359J Special Topics in Vision Science

(Same subject as MAS.627J)
Prereq.: Permission of instructor
G (Spring)
2-0-7 H-LEVEL Grad Credit
Can be repeated for credit

An advanced seminar on issues of current interest in computational and biological vision. Topics vary from year to year. Participants discuss the current literature as well as their own ongoing research.
E. H. Adelson

9.363 Research in Natural Computation

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

Closely supervised research on a problem of inferring a property of the world, given only limited sensory data. Problems may be chosen from the fields of vision, audition, or force sensing (touch). The use of constraint in the inference process is stressed, as well as the exclusion of false inferences.
W. A. Richards

9.369 Computational Neuroscience
(New)

Prereq.: —
G (Spring)
3-0-9

On the construction and use of computational models in neuroscience. Focuses on systems-level models of activity dependent development and animal learning and involves computational and mathematical investigations. A modeling project or paper is required for credit.
P. Dayan

9.371 Advanced Seminar on Inference and Learning

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

Reading and discussion of selected current topics in inference and learning, with focus on probabilistic approaches. Examples of topics include exact and approximate inference in Bayesian belief networks, chain graphs, Markov chain Monte Carlo, information geometry, Bayesian decision theory, reinforcement learning and adaptive control.
M. Jordan

9.373 Somatosensory and Motor Systems

Prereq.: 9.011J
Acad Year 1996-97: **Not offered**
Acad Year 1997-98: G (Spring)
3-0-6 H-LEVEL Grad Credit

General principles of motor control in biological systems. Structure and function of sensory receptors. Muscle structure and reflex arcs. Spinal cord: descending and ascending pathways. Locomotion. Oculomotor control. Cerebellar structure and function. Motor thalamus. Basal ganglia. Somatosensory cortex: maps and neuronal properties. Motor psychophysics and computational approaches to motor control. Alternate years.
E. Bizzi, M. Sur, A. Graybiel

9.382 Seminar on Information Processing

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

Theory and the application of learning, including machine vision and biological vision. Centers around ongoing work by participants and presentations by them.
T. A. Poggio, M. Jordan

9.39 Computational Laboratory in Cognitive Science

(Subject meets with 9.390)
Prereq.: 9.62, 6.001, and 18.06
Acad Year 1996-97: U (Spring)
Acad Year 1997-98: **Not offered**
0-6-6

9.390 Computational Laboratory in Cognitive Science

(Subject meets with 9.39)
Prereq.: Permission of instructor
Acad Year 1996-97: G (Spring)
Acad Year 1997-98: **Not offered**
0-6-6 H-LEVEL Grad Credit

An introduction to computational modeling in cognitive science. Case studies in perception, memory, reasoning, language processing, and action are used to introduce widely used computational techniques and to evaluate particular models. Makes extensive use of computer simulation, and previous experience with computers is required. An additional project is required for graduate credit. Alternate years.
M. I. Jordan

9.401 Survey of Cognitive Science

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

Survey of theories, methods, and findings in cognitive psychology and perception. Includes perception and psychophysics, pattern recognition, imagery and mental codes, memory and attention, and language comprehension and production. Ordinarily restricted to Course IX graduate students; permission of instructor required for others.
M. C. Potter, M. I. Jordan, K. Wexler, E. Adelson, E. Gibson, R. Held, B. Anderson, M. Wilson, E. Miller, P. Dayan, S. Pinker

9.50 Research in Brain and Cognitive Sciences

Prereq.: 9.00 or 9.62; and one other subject in Course IX
U (Fall, Spring, Summer)
2-8-2 Institute LAB
Can be repeated for credit

Laboratory research in brain and cognitive science, using physiological, anatomical, pharmacological, developmental, behavioral, and computational methods. Each student carries out an experimental study under the direction of a member of the faculty. Project must be approved in advance by faculty supervisor and either A. Hein or P. H. Schiller. Written presentation of results is required.
Consult A. Hein or P. H. Schiller.

9.520 Learning, Approximation, and Networks

Prereq.: 9.01, 9.35, 18.02
G (Spring)
3-0-9 H-LEVEL Grad Credit

Study of the problem of learning from examples, from the perspective of statistics and of the theory of multivariate function approximation from sparse data. Examines applications in the field of computer vision, computer graphics, time-series analysis and prediction, and adaptive control. Also considers implications for how the brain may work, in particular for the neurobiology of object recognition.
T. Poggio, F. Girosi

9.59J Psycholinguistics

(Same subject as 24.905J)
Prereq.: 9.62 or 24.900J
U (Fall)
3-0-9 HASS

Central topics in first language acquisition and real-time language comprehension. How does a child acquire language despite impoverished output? What makes language easy or hard to understand? Experimental methodology and explicit models are discussed. An emphasis on the relation of linguistic principles to the problems of language acquisition and real-time processing. Discussion of computational modeling.
E. Gibson, K. Wexler

9.591 Language Processing

Prereq.: 9.59J, 9.401, or permission of instructor
G (Spring)
3-0-6 H-LEVEL Grad Credit

Seminar in real-time language comprehension. Formal models of sentence processing from the linguistic, psychology, and artificial intelligence literature. Ambiguity resolution. Linguistic complexity. The use of lexical, syntactic, semantic, pragmatic, and contextual information in language comprehension. The psychological reality of linguistic representations.
E. Gibson

9.601J Language Acquisition I

(Same subject as 24.949J)
Prereq.: Permission of instructor
Acad Year 1996-97: G (Fall)
Acad Year 1997-98: **Not offered**
3-0-6 H-LEVEL Grad Credit

Lectures, reading, and discussion of current theory and data concerning the psychology and biology of language acquisition. Emphasizes learning of syntax and morphology, and especially research relating grammatical theory and learnability theory to empirical studies of children.
K. Wexler

9.602J Language Acquisition II

(Same subject as 24.950J)
Prereq.: Permission of instructor
Acad Year 1996-97: **Not offered**
Acad Year 1997-98: G (Spring)
3-0-6 H-LEVEL Grad Credit

Continues discussion of topics described under 9.601J.
K. Wexler

9.611J Natural Language and the Computer Representation of Knowledge

(Same subject as 6.863J)
Prereq.: 6.034
G (Spring)
3-3-6 H-LEVEL Grad Credit

See description under subject 6.863J.
R. C. Berwick

9.62 Introduction to Cognitive Science

Prereq.: —
U (Fall)
3-0-9 HASS

Surveys major issues that occupy contemporary cognitive science. Topics include visual perception, memory, thinking and reasoning, language and communication.
M. C. Potter, E. Gibson

9.63 Laboratory in Cognitive Science

(Subject meets with 9.631)
Prereq.: 9.62
U (Spring)
3-6-3 Institute LAB

9.631 Laboratory in Cognitive Science

(Subject meets with 9.63)
Prereq.: Permission of instructor
G (Spring)
3-6-3 H-LEVEL Grad Credit

Introduces the principles of experimental design and interpretation in cognitive psychology, including an overview of inferential statistics and analyses of common sources of artifact. Demonstration of experiments in a number of areas of cognitive science. Students design, execute, and write up an experiment of their own. Graduate students required to do additional reading and more technically demanding assignments.
B. Anderson

9.641 Introduction to Neural Networks

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

Study of representation, processing, and adaptation in highly interconnected networks of simple analog processing units. Explores basic algorithms, including backpropagation, Boltzmann machines, mixtures of experts, recurrent algorithms, hidden Markov models, and junction tree propagation. Emphasizes the ties to dynamical systems and statistics. Applications to models of memory, perception, reasoning, and motor control.
M. I. Jordan

9.65 Cognitive Processes

Prereq.: —
Acad Year 1996-97: **Not offered**
Acad Year 1997-98: U (Spring)
3-0-9 HASS

An introduction to human information processing and learning; topics include the nature of mental representation and processing; the architecture of memory; pattern recognition; imagery and mental codes; concepts and prototypes; reasoning and problem solving.
Staff

9.651 Cognitive Processes

Prereq.: 9.62, 9.65, or equivalent
Acad Year 1996-97: G (Fall)
Acad Year 1997-98: **Not offered**
3-0-9 H-LEVEL Grad Credit

Surveys major issues and basic findings in human cognitive processing. Topics include pattern recognition, word perception, the architecture of memory, mental codes, learning, and attention, in addition to special topics of current interest. Alternate years.
M. C. Potter

9.671J Problems of Mental Representation

(Same subject as 24.518J)
Prereq.: Two Philosophy subjects and permission of instructor
G (Spring)
3-0-9 H-LEVEL Grad Credit
Can be repeated for credit

See description under subject 24.518J.
R. Stalnaker

9.68 Affect: Biological, Psychological, and Social Aspects of "Feelings"

Prereq.: 9.00
U (Spring)
3-0-9 HASS

Affect is to cognition and behavior as feeling is to thinking and acting or as values are to beliefs and practices. Subject considers these relations, both at the psychological level of organization and in terms of their neurobiological and sociocultural counterparts.
S. L. Chorover

9.70 Social Psychology

Prereq.: —
U (Spring)
3-0-9 HASS

Examines interpersonal and group dynamics, considers how the thoughts, feelings, and actions of individuals are influenced by (and influence) the beliefs, values, and practices of large and small groups. Learning occurs mainly through class discussions and participation in study groups. Regular homework assignments, occasional lectures, and demonstrations.
S. L. Chorover

9.75J Psychology of Gender

(Same subject as SP.460J)
Prereq.: —
Acad Year 1996-97: **Not offered**
Acad Year 1997-98: U (Spring)
3-0-9 HASS

Examines evidence (and lack thereof) regarding when and how an individual's thoughts, feelings, and actions are affected by gender. Topics include: gender development; gender differences in cognition and emotion; gender stereotypes; how gender is related to physical and mental health, sexuality, close relationships, and work.
M. Parlee

9.85 Developmental Psychology

Prereq.: 9.00 or 9.62
U (Spring)
3-0-9 HASS

An introduction to the literature on human development. Some attention to social and emotional development; major focus on cognitive development. Empirical research on such theoretical issues as the nativist/empiricist debate and the nature of qualitative changes during development reviewed. Some applications of research to educational issues also discussed.
L. Spelke

9.88 Origins of Behavior

Prereq.: 9.00 or 9.62
U (Spring)
3-0-9 HASS

Examines our evolving understanding of the prenatal, infant, and early post-infant periods. Addresses the interaction of innate and environmental factors in the development of intelligence, learning ability, perception, motor activities including vocalization, and social interactions in humans. Considers their relation to similar capacities in other animals, emphasizing the primates.
A. Hein

9.891 Cognitive Development

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

Surveys recent research in cognitive development. Topics include constraints on induction, knowledge representation and reorganization, cognition in infancy, semantic development, and conceptual change. Alternate years.
L. Spelke

9.91 Topics in Cognitive Sciences

Prereq.: 9.00 or 9.62 and any other two subjects in Brain and Cognitive Sciences
U (Fall, IAP, Spring, Summer)
Units arranged
Can be repeated for credit

Individual study of a special topic under the direction of a member of the faculty.
Consult A. Hein.

9.911–9.916 Special Topics in Brain and Cognitive Sciences

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

Opportunity for graduate study of advanced subjects in Brain and Cognitive Sciences not included in other subject listings. 9.911 is taught P/D/F.
Consult M. C. Potter or G. E. Schneider.

9.919 Teaching Brain and Cognitive Sciences

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

For teaching assistants in Brain and Cognitive Sciences, in cases where teaching assignment is approved for academic credit by the department.
M. C. Potter, G. E. Schneider

9.921 Research in Brain and Cognitive Sciences

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

Guided research under the sponsorship of individual members of the faculty. Ordinarily restricted to candidates for the doctoral degree in Course IX.
Consult M. C. Potter or G. H. Schneider.

9.93–9.99 Independent Activities

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

For undergraduates taking Course 9 IAP subjects for credit. See IAP Guide for details.
Consult A. Hein.

9.931 Research Reports

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

Course IX graduate students submit written reports of their research efforts according to stated deadlines. Registration is mandatory in fall term of third year and in term when thesis proposal is to be submitted.
Consult M. C. Potter or G. E. Schneider.

9.ThG Graduate Thesis

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

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

Psychology

The undergraduate program in Psychology is described in Chapter 7. For additional related subjects in Psychology, see also:

Architecture: 4.265

Brain and Cognitive Sciences: 9.00, 9.01, 9.06, 9.09J, 9.10, 9.20, 9.201, 9.35, 9.39, 9.59J, 9.601J, 9.62, 9.63, 9.641, 9.65, 9.68, 9.70, 9.75J, 9.85, 9.88

Management: 15.301, 15.310, 15.312, 15.313, 15.341, 15.361, 15.665, 15.824, 15.832

Humanities: 21H.966J

Science, Technology, and Society: STS.060J, STS.518J

Course 10

Chemical Engineering

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

10.UR Undergraduate Research

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

10.URG Undergraduate Research

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

Opportunity for participation in a research group, or for special investigation in a particular field. Topic and hours to fit individual requirements.
C. M. Mohr

10.ThU Undergraduate Thesis

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

Program of undergraduate research, leading to writing an S.B. thesis; topic arranged between student and MIT faculty member.
C. M. Mohr

10.001 Introduction to Computer Methods

Prereq.: —
U (Fall, IAP)
2-0-4

Introduction to computers in chemical engineering and to the Athena computer environment. Exposure to methods for text and picture creation and manipulation, symbolic computing, numerical programming in C, and elementary methods for numerical analysis.
G. C. Rutledge

10.02J Biotechnology and Engineering

(Same subject as 5.22J, TOX.105J)
Prereq.: —
U (Spring)
4-0-5

See description under subject 5.22J.
J. M. Essigmann, R. S. Langer

10.100 Interdisciplinary Research in Biomedical Engineering
(New)

Prereq.: 5.07 or 7.05, 7.06 or 7.08, 18.03, 2.003 or 3.185 or 6.001 or 10.301 or 16.030/16.040
U (Fall, Spring)
1-2-3
Can be repeated for credit

Individual research work in biomedical engineering not covered by other subjects. Project must integrate biology and engineering or medicine and engineering. Approval of the CBE Curriculum committee required. Students must enroll for at least 12 units in the term the work is done in order to receive credit as a restricted elective in the BME Minor. Consult the departmental BME Minor advisor early in the term. Can be used to fulfill Phase II.
L. G. Cima

10.11 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 562.
F. Peña-Mora

10.200 Sophomore Advising Seminar

Prereq.: —
U (Fall)
2-0-4 [P/D/F]

Special topics in chemical engineering designed to help acquaint and orient new students to the field. All sophomores beginning in chemical engineering are encouraged to take this seminar.
C. L. Cooney

10.21 Structures and Properties of Matter

Prereq.: 5.11, 5.60, 10.001
U (Fall)
3-0-6

Atomic and molecular interactions and their importance in determining physical and chemical properties of matter. Dielectric properties of materials. Description of physical and specific chemical intermolecular forces, including hydrogen bonds. Bulk and interfacial properties of pure and mixed gases and liquids. Techniques for characterizing molecular structure and for predicting properties of matter.
C. K. Colton

10.213 Chemical Engineering Thermodynamics

Prereq.: 5.60, 10.001
U (Fall, Spring)
4-0-8

Thermodynamics of multicomponent, multiphase systems. Applications of first, second, and third laws of thermodynamics to open and closed systems. Properties of mixtures, including colligative properties, chemical reaction equilibrium, and phase equilibrium; non-ideal solutions; power cycles; refrigeration; separation systems.
D. Blankschtein, K. K. Gleason, T. A. Hatton, P. E. Laibinis, H. H. Sawin

10.25 Industrial Chemistry and Chemical Process Pathways

Prereq.: 5.11, 10.213, 10.37
G (Fall)
3-0-6 H-LEVEL Grad Credit

Chemical and engineering principles involved in creation and operation of viable industrial processes. Topics: analysis of process chemistry by p-pathways (i.e., radical, ionic, and pericyclic reactions of organic syntheses) and d-pathways (i.e., catalysis by transition-metal complexes). Use of reaction mechanisms for inference of co-product formation, kinetics, and equilibria: process synthesis logic related to reaction selectivity, recycle, separations. Illustrations drawn from current and contemplated commercial practice.
P. S. Virk

10.26 Chemical Engineering Projects Laboratory
(Revised Units)

Prereq.: 10.302
U (Fall, Spring)
1-8-3

Laboratory projects in applied chemical research and unit operations. Students work in groups on one project for the term. Projects are often suggested by local industry. Training in research planning, execution of experimental work, oral presentations, and report writing.
C. K. Colton, J.-F. Hamel, P. E. Laibinis, R. S. Langer, H. H. Sawin, G. N. Stephanopoulos

10.27 Chemical Engineering Processes Laboratory

Prereq.: *10.32, 10.37*
U (Fall)
0-8-4

Introduces practical chemical engineering unit operations through hands-on experience with pilot-scale equipment and processes. Intended to provide instruction in experimentation and data analysis. Introduces theory of selected unit operations. Emphasis on developing oral and written communication skills.
J.-F. Hamel, J. B. Howard

10.301 Fluid Mechanics

Prereq.: 18.03, 10.001
U (Spring)
3-0-9 REST

Introduces the mechanical principles governing fluid flow. Stress in a fluid. Conservation of mass and momentum, using differential and integral balances. Elementary constitutive equations. Hydrostatics. Exact solutions of the Navier-Stokes equations. Approximate solutions using control volume analysis. Mechanical energy balances and Bernoulli's equation. Dimensional analysis and dynamic similarity. Introduces boundary-layer theory and turbulence.
W. M. Deen, P. S. Virk

10.302 Transport Processes

Prereq.: 5.60, 10.301
U (Fall)
4-0-8

Principles of heat and mass transfer. Steady and transient conduction and diffusion. Convective transport of heat and mass in both laminar and turbulent flows. Natural convection. Condensation and boiling. Application to design of heat exchangers. Radiative heat transfer.
L. G. Cima, K. A. Smith, Gr. Stephanopoulos

10.31 Separations and the Environment

Prereq.: Permission of instructor
Acad Year 1996-97: **Not offered**
Acad Year 1997-98: G (Fall)
3-0-6

Separations technology as applied to environmental remediation and pollution control. Sources of pollution and contaminated environments: industrial effluents and emissions, domestic sources, run-offs, in the atmosphere, surface water, ground water, and soils. Chemical and physical properties of pollutants, partitioning and distribution in the environment. Separations involving dilute aqueous streams, gas mixtures, recoverable organic products. *In situ* remediation of contaminated waste sites.
T. A. Hatton

10.32 Separation Processes

Prereq.: 10.213, 10.302
U (Spring)
3-0-9

General principles of separation by equilibrium and rate processes. Staged cascades. Applications to distillation, absorption, adsorption, and membrane processes. Phase equilibria and role of diffusion.
C. M. Mohr

10.33 Analytical Treatment of Chemical Engineering Transport Processes

Prereq.: 10.301, 18.03
G (Fall)
3-0-6 H-LEVEL Grad Credit

Mathematical techniques underlying transport problems basic to most chemical engineering processes. Quaternions, vectors, polyadics, Cartesian tensors, general tensors, curvilinear coordinate systems. Representations of rotation and orientation. Anisotropic material tensor properties. Applications to the derivation of transport equations in physical space, at interfaces, along lines, and in multidimensional phase spaces.
H. Brenner

10.331 Nonlinear Analysis in Chemical Engineering

Prereq.: 10.50
G (Spring)
3-0-6

Emphasizes both classical and modern methods for analyzing nonlinear ordinary and partial differential equations arising in reaction engineering and transport phenomena. Topics: elementary stability theory and bifurcation analysis of steady states; introduction to time-periodic phenomena and transitions to chaos; numerical methods for tracking multiple-steady and time-periodic states.
R. A. Brown

10.332 Linear Operator Theory in Chemical Engineering Science

Prereq.: 18.03, 18.06, or equivalent
G (Fall)
3-0-6

Introduction to linear operator theory. Set theory, metric and linear spaces. Inner product and Hilbert spaces, orthogonality, adjoint and self-adjoint operators, spectral representation theory, Green's functions, and Sturm-Liouville operators. Applications to problems in partial differential equations and control theory.
T. A. Hatton, R. A. Brown

10.34 Numerical Methods Applied to Chemical Engineering

Prereq.: 10.33
G (Spring)
3-0-6 H-LEVEL Grad Credit

Numerical methods for solving problems arising in heat and mass transfer, fluid mechanics, and chemical reaction engineering. Topics: numerical linear algebra, solution of nonlinear algebraic equations and ordinary differential equations, and finite-difference and finite-element methods for elliptic and parabolic partial differential equations. All methods presented in context of problems arising in transport phenomena. Lectures and assignments assume knowledge of FORTRAN.
R. A. Brown

10.341 Finite Element Methods for Problems in Transport Phenomena

Prereq.: 10.34
G (Fall)
3-0-6 H-LEVEL Grad Credit

Advanced methods for solving problems in fluid mechanics and heat and mass transfer. Emphasis on efficient techniques for handling highly irregular boundaries, nonlinearities, complicated boundary conditions, and singularities. Variational, Galerkin, and collocation schemes discussed.
R. A. Brown

10.37 Chemical Kinetics and Reactor Design

Prereq.: 5.60, 10.301
U (Spring)
3-0-6

Introduces design of commercial chemical reactors, emphasizing synthesis of chemical kinetics, transport phenomena. Topics: kinetics and equilibrium — elementary steps, transition-state theory, multistep reactions. Ideal reactors — batch, plug flow, well-stirred; residence-time distributions. Transport in reactors — heat and mass transfer, diffusion to and within catalyst particles. Reactor design; reactor size; modeling of performance.
C. L. Cooney, J. Y. Ying

10.390 Process Design

Prereq.: 5.11, 10.213, 10.301
U (Fall)
3-0-9

Presentation and discussion of process design case studies, selected from a variety of areas in which chemical engineers work. Emphasis on the applications of engineering science to the solution of real problems, including conceptual design and analysis leading to optimal solutions. Discussion of the trade-offs inherent in design, including economics, environmental impact, and contextual issues. Review of required engineering science and presentation of the basics of process economics.
C. M. Mohr

10.40 Chemical Engineering Thermodynamics

Prereq.: 5.60 or equivalent
G (Fall, Spring)
3-0-6 H-LEVEL Grad Credit

Basic postulates of classical thermodynamics. Application to transient open and closed systems. Criteria of stability and equilibria. Thermodynamic properties of pure materials and mixtures. Phase and chemical equilibria of multicomponent systems. Applications emphasized through extensive problem work relating to practical cases.
D. Blankschtein, J. W. Tester

10.42 Advanced Thermodynamics

Prereq.: 10.40
G (Spring)
3-0-6 H-LEVEL Grad Credit

Equilibrium and stability concepts examined in depth for multicomponent, multiphase systems. Equations of state for pure components and mixtures, solution models for mixtures of electrolytes and non-electrolytes. Surface thermodynamics, statistical thermodynamics and Monte Carlo and Molecular Dynamics applications comprise other topics.
J. W. Tester, D. Blankschtein

10.420 Molecular Aspects of Chemical Engineering

(Subject meets with 10.520)
Prereq.: 5.13, 10.213, or equivalent
U (Fall)
3-0-6

Meets with graduate subject 10.520, but assignments differ. See description under subject 10.520.
P. E. Laibinis, P. T. Hammond

10.421 Heterogeneous Catalysis and Catalytic Processes

(Subject meets with 10.521)
Prereq.: 5.13, 10.37 or equivalents
U (Fall)
3-0-6

Meets with graduate subject 10.521, but assignments differ. See description under subject 10.521.
J. Y. Ying

10.43 Introduction to Interfacial Phenomena

Prereq.: 10.213 or an equivalent introductory subject in thermodynamics or physical chemistry
Acad Year 1996-97: G (Fall)
Acad Year 1997-98: **Not offered**
3-0-6

Introduces fundamental and applied aspects of interfacial phenomena. Theory of capillarity. Experimental determination of interfacial tension. Thermodynamics of interfaces. The Gibbs adsorption equation. Surface tension of pure liquids and solutions. Surface films. Wetting and contact angles. Effect of curvature on the equilibrium state of pure systems and mixtures. Fundamentals of adsorption, micellization, solubilization, and emulsification.
D. Blankschtein

10.44J Statistical Thermodynamics of Complex Liquids

(Same subject as 22.52J, 8.575J)
Prereq.: 8.08, 10.213, or equivalent
Acad Year 1996-97: **Not offered**
Acad Year 1997-98: G (Spring)
3-0-9 H-LEVEL Grad Credit

See description under subject 22.52J.
D. Blankschtein, S. H. Chen

10.441J Molecular and Engineering Aspects of Biotechnology

(Same subject as 7.37J)
Prereq.: 7.03 or 7.05, 5.60
Acad Year 1996-97: **Not offered**
Acad Year 1997-98: U (Spring)
4-0-8

See description under subject 7.37J.
D. I. C. Wang, H. Lodish

10.442 Biochemical Engineering
(New)

(Subject meets with 10.542)
Prereq.: Permission of instructor
Acad Year 1996-97: **Not offered**
Acad Year 1997-98: U (Spring)
4-0-8

Meets with graduate subject 10.542, but assignments differ. See description for 10.542.
C. L. Cooney, D. I. C. Wang

10.445 Separation Processes for Biochemical Products
(New)

(Subject meets with 10.545)
Prereq.: Permission of instructor
Acad Year 1996-97: U (Spring)
Acad Year 1997-98: **Not offered**
3-0-6

Meets with graduate subject 10.545, but assignments differ. See description for 10.545.
C. L. Cooney

10.450 Process Dynamics, Operations, and Control

(Subject meets with 10.550)
Prereq.: 10.32, 10.37, 18.03
U (Spring)
3-0-6

Meets with graduate subject 10.550, but assignments differ. See description under subject 10.550.
Geo. Stephanopoulos

10.467 Polymer Science Laboratory

Prereq.: 5.12 or equivalent
U (Fall, Spring)
2-7-3 Institute LAB

Experiments broadly aimed at acquainting students with the range of properties of polymers, methods of synthesis, and physical chemistry. Examples: solution polymerization of acrylamide, bead polymerization of divinylbenzene, interfacial polymerization of nylon 6,10, derivitization of formed polymers (amylose to amylose triacetate). Evaluation of elastic networks by tensile and swelling experiments; of linear polymers by gel permeation chromatography and light scattering. Relation of observed properties to specific conditions of synthesis, or choice of route of synthesis.
P. T. Hammond, E. W. Merrill, G. C. Rutledge

10.470J Environment and Technology

(Subject meets with 1.10J, 10.570J, TPP.52J)
Prereq.: —
U (Fall)
3-0-6

Meets with subjects 1.10J, 10.570J, and TPP.52J; but assignments differ. See description under subject 1.10J.
P. Gschwend, J. Ehrenfeld, A. Sarofim

10.471 Introduction to Air Pollution

Prereq.: Permission of instructor
Acad Year 1996-97: **Not offered**
Acad Year 1997-98: U (Spring)
3-0-6

History of air pollution. Criteria for anticipating environmental problems, indoor air, risk assessment, plume dispersion, stationary combustion sources, acid rain, NOx and SOx emissions and their control. Smog formation models. CO, HC, and NOx emissions from internal combustion engines. Particulate emissions from internal combustion engines. Particulate emissions and controls. Assessment of global warming and strategies for control. Stratospheric ozone and air toxics. Limits to growth: resource consumption and population momentum.
A. F. Sarofim

10.480J Microelectronics Processing Technology

(Same subject as 6.152J, 3.155J)
Prereq.: Permission of instructor
U (Fall, Spring)
3-4-5

See description under subject 6.152J.
K. K. Gleason, H. H. Sawin, M. A. Schmidt, C. G. Sodini, C. V. Thompson, L. C. Kimerling

10.490 Integrated Chemical Engineering I

Prereq.: 10.32, 10.37
U (Fall)
4-0-8

Presents and solves chemical engineering problems in an industrial context. Emphasis is placed on the integration of fundamental concepts with approaches of process design. Problems are emphasized that demand synthesis, economic analysis, and process design.
Geo. Stephanopoulos, G. J. McRae, C. M. Mohr, P. I. Barton

10.491 Integrated Chemical Engineering II

Prereq.: 10.490
U (IAP, Spring)
4-0-8

Three modules present and solve chemical engineering problems in an industrial context. Emphasis placed on integration of fundamentals with material property estimation, process control, product development, and computer simulation. Integration of societal issues, such as engineering ethics, environmental and safety considerations, and impact of technology on society are addressed in the context of case studies. One module may be taken during IAP.
P. I. Barton, R. S. Langer, D. A. Lauffenburger, G. C. Rutledge, A. F. Sarofim, H. H. Sawin, Gr. Stephanopoulos

10.50 Analysis of Heat and Mass Transfer

Prereq.: 10.302
G (Fall, Spring)
3-0-6 H-LEVEL Grad Credit

Analyzes diffusive and convective transport of heat and mass. Analytical solutions to steady-state and transient diffusion or conduction problems. Forced and free convection of heat and mass in laminar flow. Simultaneous heat and mass transfer with chemical reaction or phase change.
R. C. Armstrong, W. M. Deen, H. Brenner, T. A. Hatton

10.52 Mechanics of Fluids

Prereq.: 10.50
G (Spring)
3-0-6 H-LEVEL Grad Credit

Advanced course in fluid and continuum mechanics. Content may vary, drawing from such topics as low Reynolds number hydrodynamics, Brownian motion, suspension mechanics, flow in porous media, multiphase/particulate flow, ideal fluid theory, laminar boundary-layer theory, stability theory, and turbulence.
K. A. Smith

10.520 Molecular Aspects of Chemical Engineering

(Subject meets with 10.420)
Prereq.: 5.13, 10.213, or equivalent
G (Fall)
3-0-6 H-LEVEL Grad Credit

Molecular-level engineering and analysis of chemical processes. Use of chemical bonding, reactivity, and other key concepts in the design and tailoring of organic systems. Application and development of structure-property relationships to examples of adhesion, wetting, solvation, and adsorption. Descriptions of the chemical forces, recognition events, and structural ordering factors that govern supramolecular phenomena such as crystallization and phase equilibria.
P. E. Laibinis, P. T. Hammond

10.521 Heterogeneous Catalysis and Catalytic Processes

(Subject meets with 10.421)
Prereq.: 5.13, 10.37, or equivalents
G (Fall)
3-0-6 H-LEVEL Grad Credit

An introduction to applied catalysis, focusing on principles of importance in the development and improvement of catalysts and their practical use in industry. Topics include adsorption phenomena, catalyst preparation, and surface characterization techniques. Application of catalyst functionality concepts for control of reaction selectivity and kinetic models. Commonality of mechanisms for significant groups of catalyzed reactions such as hydrogenation, partial oxidation, and hydrocarbon reactions catalyzed by solid acids and zeolites. Control of pollutant emissions by catalysis. Meets with undergraduate subject 10.421, but assignments differ.
J. Y. Ying

10.531 Macromolecular Hydrodynamics

Prereq.: 10.301
Acad Year 1996-97: G (Fall)
Acad Year 1997-98: **Not offered**
3-0-6 H-LEVEL Grad Credit

Observed phenomena in polymeric flow systems. Techniques of viscometry and viscoelastic measurements for polymeric fluids. Rheological models. Continuum theories. Molecular theories of polymeric fluids. Analytical solutions to flow problems; non-Newtonian viscosity, linear viscoelasticity, normal stresses, recoil, stress relaxation.
R. C. Armstrong

10.534 Macrotransport Processes

Prereq.: 10.50
G (Fall)
3-0-6 H-LEVEL Grad Credit

Generalized Taylor dispersion theory applied to chromatographic separation processes, flow and transport in porous media, transport properties of macromolecular solutions, and generic analyses of heterogeneous systems, including adsorption phenomena, thermal transport processes, and chemically reactive continua.
H. Brenner

10.535 Interfacial Transport Processes and Rheology

Prereq.: 10.50 or equivalent
G (Fall)
3-0-6 H-LEVEL Grad Credit

Introduction to the theory and applications of liquid-liquid interfacial transport phenomena. General tensor analysis; interfacial statics; kinematics, and transport across and within curved, deforming interfaces; two-dimensional momentum transport processes, Newtonian and non-Newtonian interfacial stress constitutive relations, applications to surface rheology; surfactant transport and adsorption at interfaces, surface diffusion, Marangoni phenomena, interphase mass transfer; asymptotic theory of diffuse interfaces; line tension phenomena.
H. Brenner

10.540 Cell Bioengineering

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

Analysis of mammalian cell function from a quantitative, engineering perspective, focusing on receptor-mediated behavior and underlying receptor/ligand interactions. Topics include receptor/ligand binding; receptor/ligand trafficking; physical aspects of receptor ligand interactions (probability, diffusion, multivalency); signal transduction; cell proliferation; cell adhesion; cell migration.
D. A. Lauffenburger

10.542 Biochemical Engineering

(10.541)
(Subject meets with 10.442)
Prereq.: Permission of instructor
Acad Year 1996-97: **Not offered**
Acad Year 1997-98: G (Spring)
4-0-8 H-LEVEL Grad Credit

Interaction of chemical engineering, biochemistry, and microbiology. Mathematical representations of microbial systems. Kinetics of growth, death, and metabolism. Continuous fermentation, agitation, mass transfer, and scale-up in fermentation systems, enzyme technology.
C. L. Cooney, D. I. C. Wang

10.543J The Protein Folding Problem
(New)

(Same subject as 7.88J, 5.48J)
Prereq.: 5.07 or 7.05 or equivalent
G (Spring)
3-0-9 H-LEVEL Grad Credit

See description under subject 7.88J.
J. A. King

10.545 Separation Processes for Biochemical Products

(Subject meets with 10.445)
Prereq.: —
Acad Year 1996-97: G (Spring)
Acad Year 1997-98: **Not offered**
3-0-6 H-LEVEL Grad Credit

Introduction to fundamental principles of separation operations for the recovery of products from biological processes, membrane filtration, chromatography, centrifugation, cell disruption, extraction, and process design.
C. L. Cooney

10.546J Principles and Methodologies of Metabolic Engineering

(Same subject as 7.546J)
Prereq.: 7.05 or permission of instructor
G (Spring)
3-0-6

Application of chemical reaction engineering principles and genetic engineering techniques to the analysis and modification of metabolic pathways of microorganisms and mammalian cells. The goal is to optimize flux distributions of carbon and energy at critical junctions of the metabolic network in order to enhance product synthesis. Topics include: determination of flux distributions in primary metabolism by stoichiometric and labelling techniques; kinetics and thermodynamics of metabolic networks; metabolic control theory; genetic engineering techniques for the overexpression, deregulation, or inhibition of targeted enzymes; biochemistry and enzymology of metabolic networks.
Gr. Stephanopoulos, A. J. Sinskey

10.547J Health Technology

(Same subject as 15.136J, HST.920J)
Prereq.: Permission of instructor
Acad Year 1996-97: **Not offered**
Acad Year 1997-98: G (Spring)
3-0-6 H-LEVEL Grad Credit

See description under subject 15.136J.
S. N. Finkelstein, C. L. Cooney

10.548J Transport Phenomena and Tumor Pathophysiology

(Same subject as HST.525J)
Prereq.: 18.03; 2.20 or 10.301 or equivalent
G (Spring)
2-0-4 H-LEVEL Grad Credit

See description under subject HST.525J.
R. K. Jain

10.549 Tissue Engineering

Prereq.: 10.302 or equivalent, 7.012/7.013/7.014
Acad Year 1996-97: **Not offered**
Acad Year 1997-98: G (Spring)
3-0-6

Analysis of fundamental processes in tissue engineering for human therapeutic applications. Overview of major approaches in tissue engineering (cell encapsulation, cell transplantation, matrix-guided regeneration, extracorporeal reactors) and focus on specific tissues representative of applications in regenerating metabolic tissues (e.g., liver, pancreas) and connective tissues (e.g., bone, cartilage). Cellular nutrient metabolism, cell regulation by macromolecules, and transport limitations in device design. Guided organization of multicellular structures. Regulatory issues and current clinical prospects.
L. G. Cima, W. M. Deen

10.55 Colloid and Surfactant Science

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

Introduction to theory and applications of colloidal dispersions and surfactant science. Monolayer adsorption at interfaces, electrical double layers, dispersion forces, electrokinetic phenomena, and stabilization of dispersions. Chemistry, structure, and classification of surfactants, critical micelle concentrations, micellar solubilization, and catalysis. Detergency and wetting phenomena. Emulsion technology and applications.
T. A. Hatton

10.550 Process Dynamics, Operations, and Control

(Subject meets with 10.450)
Prereq.: 10.32, 10.37, 18.03
G (Spring)
3-0-6 H-LEVEL Grad Credit

Introduction to modeling and analysis of dynamic processes and the engineering tasks of process operations and control. Subject covers the following topics: incentives for process monitoring, analysis, and control; modeling the static and dynamic behavior of processes; control strategies; design of feedback, feedforward, and other control structures; model-predictive, inferential, and adaptive control systems; digital computer control process identification; fault diagnosis and supervisory control; computer-integrated manufacturing and industrial practice of process control. Meets with undergraduate subject 10.450, but assignments differ.
Geo. Stephanopoulos

10.551 Systems Engineering

Prereq.: 10.213, 10.302, 10.37
G (Spring)
3-0-6 H-LEVEL Grad Credit

Introduction to the elements of systems engineering. Special attention devoted to those tools that help students structure and solve complex problems. Illustrative examples drawn from a broad variety of chemical engineering topics, including product development and design, process development and design, experimental and theoretical analysis of physicochemical process, analysis of process operations, etc.
G. J. McRae, Geo. Stephanopoulos, P. I. Barton

10.560 Structure and Properties of Polymers

Prereq.: 10.213 or permission of instructor
G (Spring)
3-0-6 H-LEVEL Grad Credit

Review of polymer molecular structure and bulk morphology; survey of molecular and morphological influence on bulk physical properties including non-Newtonian flow, macromolecular diffusion, gas transport in polymers, electrical and optical properties, solid-state deformation, and toughness. Case studies for product design.
R. E. Cohen

10.561 Molecular and Phenomenological Interpretation of Polymer Viscoelasticity

Prereq.: —
Acad Year 1996-97: **Not offered**
Acad Year 1997-98: G (Fall)
2-0-7 H-LEVEL Grad Credit

Theory and phenomenology of linear viscoelastic behavior of polymers. Material functions and their interconversion, model representation, time-temperature equivalence. Reviews molecular theories. Introduces nonlinear viscoelasticity.
R. E. Cohen

10.568 Physical Chemistry of Polymers

Prereq.: 5.60 or 10.213 or 10.40
G (Fall)
3-0-6 H-LEVEL Grad Credit

Chain macromolecules as random coils (unperturbed, expanded) and as other shapes. Statistical thermodynamics of interpenetrating random coiling polymers in solution with application to phase separations, swelling of networks, depression of melting point. The isolated chain molecule in dilute solutions analyzed for mass or size by static methods (osmometry, light scattering, neutron scattering) and by dynamic methods (intrinsic viscosity, size exclusion chromatography, sedimentation).
R. E. Cohen

10.569 Synthesis of Polymers

Prereq.: 5.12
G (Spring)
3-0-6 H-LEVEL Grad Credit

Studies synthesis of polymeric materials, emphasizing interrelationships of chemical pathway, process conditions, and "microarchitecture" of molecules produced. Chemical pathway: anionic, radical, condensation, ring-opening. Process conditions: bulk, solution, emulsion, suspension, gas phase, batch vs continuous fluidized bed. "Microarchitecture": tacticity, molecular-weight distribution, sequence distributions in copolymers, "errors" in chains such as branches, head-to-head addition, peroxide incorporation.
E. W. Merrill, P. T. Hammond

10.570J Chemicals in the Environment: Sources and Control

(Subject meets with 1.10J, 10.470J, TPP.52J)
Prereq.: Permission of instructor
G (Fall)
3-0-6 H-LEVEL Grad Credit

Meets with subjects 1.10J, 10.470J, and TPP.52J. Graduate credit based on two term projects. See description under subject 1.10J.
A. F. Sarofim, J. R. Ehrenfeld, P. Gschwend

10.571J Air Pollution Control

(Same subject as 2.29J)
Prereq.: Permission of instructor
G (Spring)
3-0-9 H-LEVEL Grad Credit

Common gaseous and particulate air pollutants and their environmental effects. Modeling of atmospheric chemical and physical processes that disperse, transport, transform, and remove air pollutants on local, regional, and global scales. Formation of air pollutants in combustion processes. Control technology and costs. Regulation of air quality and emissions.
G. J. McRae

10.572 Principles of Combustion

Prereq.: 5.62, 10.302, or equivalent
G (Spring)
3-0-6 H-LEVEL Grad Credit

Basic concepts and applications of combustion. Gas-phase reaction mechanisms and thermochemical kinetics: reaction property estimation; treatment of pressure and temperature dependence; elementary and global reaction modeling of multiple reaction systems. Theory of ignition, flame propagation, explosion, and detonation. Characteristics of premixed, diffusion, laminar, and turbulent flames. Combustion of liquids and solids; pyrolysis and volatilization; gas reactions with solid carbon. Formation mechanisms of pollutants and valuable materials in flames.
J. B. Howard

10.580 Solid-State Surface Science

Prereq.: 10.213
Acad Year 1996-97: **Not offered**
Acad Year 1997-98: G (Spring)
3-0-6 H-LEVEL Grad Credit

Structural, chemical, and electronic properties of solids and solid surfaces. Analytical tools used to characterize surfaces including Auger and photoelectron spectroscopies and electron diffraction techniques. Surface thermodynamics and kinetics including adsorption-desorption, catalytic properties, and sputtering processes. Applications to microelectronics, optical materials, and catalysis.
K. K. Gleason, H. H. Sawin

10.581J Materials Processing

(Same subject as 3.52J)
Prereq.: 3.01, 3.185, or equivalents
G (Spring)
3-0-6 H-LEVEL Grad Credit

See description under subject 3.52J.
A. Mortensen, K. F. Jensen, M. C. Flemings

10.582J Plasma Processing in Integrated Circuit Fabrication

(Same subject as 6.776J)
Prereq.: Permission of instructor
Acad Year 1996-97: G (Spring)
Acad Year 1997-98: **Not offered**
3-0-9 H-LEVEL Grad Credit

See description under subject 6.776J.
H. H. Sawin, L. R. Reif

10.610 Applied Quantum Mechanics

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

Application of quantum mechanics to chemical systems and materials. Quantum mechanical methods of predicting chemical structure, spectroscopic properties, chemical reactivity, and properties of materials. Hartree-Fock theory, density functional theory, modern computational techniques, methods of approximating correlation energy.
Staff

10.631 Structural Theories of Polymer Fluid Mechanics

Prereq.: 10.301
Acad Year 1996-97: **Not offered**
Acad Year 1997-98: G (Fall)
3-0-6 H-LEVEL Grad Credit

Structural and molecular models for polymeric liquids. Nonequilibrium properties are emphasized. Elementary kinetic theory of polymer solutions. General phase space kinetic for polymer melts and solutions. Network theories. Interrelations between structure and rheological properties.
R. C. Armstrong

10.633 Physicochemical Hydrodynamics

Prereq.: 10.50, 2.25
Acad Year 1996-97: **Not offered**
Acad Year 1997-98: G (Fall)
3-0-9 H-LEVEL Grad Credit

Fundamentals of physical-chemical interactions with fluid flow including aspects of biomolecular hydrodynamics. Transport of mass, heat, and charge in laminar flow. Particle-liquid flows with and without charge effects. Macromolecules as hydrodynamic particles with application to separation processes. Surface tension, phase change, and chemical reactions in flows. Rheology and concentrated suspensions.
H. Brenner, R. F. Probstein

10.65 Chemical Reactor Engineering

Prereq.: 10.37
G (Fall)
3-0-6 H-LEVEL Grad Credit

Applies chemical kinetics to development and improvement of industrial processes. Nonideal reactor analysis, including residence-time distributions, concepts of mixedness, and segregation, dispersion, and CSTR models. Mass and energy transfer limitations in heterogeneous noncatalytic and catalytic reaction systems. Reactor stability and sensitivity to operating parameters. Choice and design of reactors for heterogeneous reactions.
K. K. Gleason, K. F. Jensen

10.652 Principles and Applications of Chemical Kinetics

Prereq.: 10.65 or 10.37, 5.62
G (Spring)
3-0-6 H-LEVEL Grad Credit

Estimation of thermodynamic and kinetic properties based on molecular dynamics. Methods including collisional theory and transition state theory will be developed for the estimation of unimolecular, bimolecular, termolecular, and complex reaction systems. Pressure effects and fall-off treatment using Lindemann-Hinshelwood, Kassel, RRK, and RRKM treatments. Chemical activation and ion-molecule reactions. Content may vary drawing on applications in combustion, plasma chemistry, and heterogeneous reactions.
J. B. Howard, H. H. Sawin

10.668J Statistical Mechanics of Polymers

(Same subject as 3.941J)
Prereq.: 10.568 or permission of instructor
G (Spring)
3-0-9 H-LEVEL Grad Credit

Concepts of statistical mechanics and thermodynamics applied to macromolecules: polymer conformations in melts, solutions, and gels; Rotational Isomeric State theory, Markov processes and molecular simulation methods applied to polymers; incompatibility and segregation in incompressible and compressible systems; molecular theory of viscoelasticity; relation to scattering and experimental measurements.
G. Rutledge, A. Mayes

10.74J Radiative Transfer

(Same subject as 2.58J)
Prereq.: 10.302 or 2.51
Acad Year 1996-97: **Not offered**
Acad Year 1997-98: G (Spring)
2-0-4 H-LEVEL Grad Credit

See description under subject 2.58J.
A. F. Sarofim, L. R. Glicksman

10.792J Proseminar in Manufacturing

(Same subject as 15.792J, 2.890J, 3.80J, 16.985J)
Prereq.: —
G (Fall, Spring)
Units arranged [P/D/F]
Can be repeated for credit

See description under subject 15.792J.
D. B. Rosenfield, J. S. Carroll

10.801 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

10.805J Technology, Law, and the Working Environment

(Same subject as 15.656J, TPP.35J)
Prereq.: —
Acad Year 1996-97: **Not offered**
Acad Year 1997-98: G (Fall)
3-0-6 H-LEVEL Grad Credit

Addresses relationship between technology-related problems and the law applicable to work environment. National Labor Relations Act, Occupational Safety and Health Act. Toxic Substances Control Act, state worker's compensation, and suits by workers in the courts discussed. Problems related to occupational health and safety, collective bargaining as a mechanism for altering technology in the workplace, job alienation, productivity, and the organization of work addressed. Prior courses or experience in the environmental, public health, or law-related areas.
N. A. Ashford, C. C. Caldart

10.806 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

10.816 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 999.
G. Apostolakis, A. W. Drake, A. R. Odoni

School of Chemical Engineering Practice

10.80 (10.82) School of Chemical Engineering Practice — Technical Accomplishment — West Point Station

Prereq.: Permission of instructor, *10.81 (10.83)*
G (Fall, Spring, Summer)
0-6-0 H-LEVEL Grad Credit

Conducted at the Merck & Company Inc. facility in West Point, Pennsylvania. Group problem assignments include process development design, simulation and control, technical service, and new-product development. Grading based on technical accomplishment. Credit granted in lieu of master's thesis; see departmental description on School of Chemical Engineering Practice in Chapter 7 for details. Enrollment limited and subject to plant availability.
T. A. Hatton

10.81 (10.83) School of Chemical Engineering Practice — Communication Skills and Human Relations — West Point Station

Prereq.: Permission of instructor, *10.80 (10.82)*
G (Fall, Spring, Summer)
0-6-0 H-LEVEL Grad Credit

Conducted at the Merck & Company Inc. facility in West Point, Pennsylvania. Group problem assignments include process development, design, simulation and control, technical service, and new-product development. Grading based on communication skills and human relations in group assignments. Credit granted in lieu of master's thesis; see departmental description on School of Chemical Engineering Practice in Chapter 7 for details. Enrollment limited and subject to plant availability.
T. A. Hatton

10.84 (10.86) School of Chemical Engineering Practice — Technical Accomplishment — Midland Station

Prereq.: Permission of instructor, *10.85 (10.87)*
G (Fall, Spring, Summer)
0-6-0 H-LEVEL Grad Credit

Conducted at the research laboratories and manufacturing facilities of the Dow Chemical Company in Midland, Michigan. Group problem assignments include process development, design, simulation and control, technical service, and new-product development. Grading based on technical accomplishment. Credit granted in lieu of master's thesis; see departmental description on School of Chemical Engineering Practice in Chapter 7 for details. Enrollment limited and subject to plant availability.
T. A. Hatton

10.85 (10.87) School of Chemical Engineering Practice — Communication Skills and Human Relations — Midland Station

Prereq.: Permission of instructor, *10.84 (10.86)*
G (Fall, Spring, Summer)
0-6-0 H-LEVEL Grad Credit

Conducted at the research laboratories and manufacturing facilities of the Dow Chemical Company in Midland, Michigan. Group problem assignments include process development design, simulation and control, technical service, and new-product development. Credit granted in lieu of master's thesis; see departmental description on School of Chemical Engineering Practice in Chapter 7 for details. Enrollment limited and subject to plant availability.
T. A. Hatton

General

10.90 Independent Research Problem

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

For special and graduate students who wish to carry out some minor investigation in a particular field. Subject and hours to fit individual requirements.
R. E. Cohen

10.910 Independent Research Problem

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

10.911 Independent Research Problem

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

For undergraduates who wish to do a special investigation or special topic in a particular field. Topic and hours arranged.
C. M. Mohr

10.920 Indepartmental Seminar in Nanostructured Materials

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

Research seminars on the synthesis, structural characterization, and application of nanostructured materials. Presentations by faculty and students from Departments of Chemical Engineering, Chemistry, Electrical Engineering and Computer Science, and Materials Science and Engineering engaging in studies of nanocrystallites, clusters, thin films, and quantum dots. Open to students interested in an interdisciplinary approach to ultrafine materials processing.
J. Y. Ying

10.94 Special Problems in Chemical Engineering

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

Problem of current interest, varying from year to year.
C. L. Cooney

10.940J Seminar on Pharmaceutical and Biotechnology Industry Management

(Same subject as 15.138J, 7.89J)
Prereq.: Permission of instructor
G (Fall)
3-0-6 H-LEVEL Grad Credit
Can be repeated for credit

See description under subject 15.138J.
T. J. Allen, C. L. Cooney, S. N. Finkelstein, A. Sinskey

10.95 Special Problems in Chemical Engineering

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

Directed research and study of special chemical engineering problems.
R. E. Cohen

10.960J Student Seminar in Polymer Science and Technology

(Same subject as 3.903J)
Prereq.: —
G (Fall, Spring)
2-0-0 [P/D/F]
Can be repeated for credit

A series of seminars covering a broad spectrum of topics in polymer science and engineering, featuring both on- and off-campus speakers.
R. E. Cohen, P. T. Hammond, E. W. Merrill, G. C. Rutledge, E. L. Thomas

10.961 Seminar in Advanced Air Pollution Research

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

Research seminars, presented by students engaged in thesis work in the field of air pollution. Particular emphasis given to atmospheric chemistry, mathematical modeling, and policy analysis.
G. J. McRae

10.962 Seminar in Molecular Cell Engineering

(New)

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

Weekly seminar with discussion of ongoing research and relevant literature by graduate students, postdoctoral fellows, and visiting scientists on issues at the interface of chemical engineering with molecular cell biology. Emphasis is on quantitative aspects of physicochemical mechanisms involved in receptor/ligand interactions, receptor signal transduction processes, receptor-mediated cell behavioral responses, and applications of these in biotechnology and medicine.
D. A. Lauffenburger

10.971 Seminar in Fluid Mechanics and Transport Phenomena

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

Seminar series on current research on Newtonian and non-Newtonian fluid mechanics and transport phenomena, and applications to materials processing. Seminars given by guest speakers and research students.
R. A. Brown, R. C. Armstrong

10.972 Biochemical Engineering Research Seminar

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

Seminar allows students to present their research programs to other students and staff. The research topics include fermentation and enzyme technology, mammalian and animal cell cultivation, and biological product separation.
D. I. C. Wang, C. L. Cooney

10.973 Bioengineering

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

Seminar covering topics related to current research in the application of chemical engineering principles to biomedical science and biotechnology.
C. K. Colton, W. M. Deen

10.974 Catalysis and Reaction Engineering

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

Seminar on research topics and recent developments in heterogeneous catalysis, reaction engineering, and related topics. Intended primarily for students engaged in research in these areas, but open to students with background and interest in related areas such as surface sciences and noncatalytic reactions.
M. Flytzani-Stephanopoulos

10.975 Seminar in Polymer Science and Engineering

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

Research seminars, presented by students engaged in thesis work in the field of polymers and by visiting lecturers from industry and academia.
R. E. Cohen, P. T. Hammond, E. W. Merrill, G. C. Rutledge

10.976 Process Design, Operations, and Control

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

Seminars on the state of the art in design, operations, and control of processing systems, with emphasis on computer-based tools. Discussions guided by the research interests of participating students. Topics include mathematical and numerical techniques, representational methodologies, and software development.
P. I. Barton

10.977 Process Systems Engineering

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

Seminars on the state of the art in process systems engineering including: process development and design; product design; process operations monitoring, analysis, and control; process simulation, planning, and scheduling; environmental considerations; computer-aided tools for analysis, design, optimization. Seminars presented by doctoral students and visiting scientists/engineers.
Geo. Stephanopoulos, G. J. McRae, P. I. Barton

10.978 Seminar in Applied Thermodynamics, Kinetics, and Transport

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

Review of current topics in phase equilibria, mass transport, and chemical kinetics. Subjects include oxidation and hydrolysis reactions, and solid-salt nucleation and solubility in supercritical water; dissolution, corrosion, electrochemistry, and equations of state in high-temperature, high-pressure aqueous systems; fundamental processes in the thermal spallation of rock.
J. W. Tester, J. B. Howard, K. A. Smith

10.979 Plasma Processing

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

Advanced topics in plasma processing used in the fabrication of microelectronics. Emphasis placed on topics of plasma kinetics, gas-solid interactions, sputtering, and reactor design. Discussions include current research in the literature.
H. H. Sawin

10.980 Macrotransport Processes

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

Seminar covering current research topics on theoretical aspects of transport processes, continuum mechanics, and statistical mechanics. Seminars given by graduate and postdoctoral students, participating faculty, and guest speakers.
H. Brenner

10.981 Seminar in Colloid and Interface Science

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

Review of current topics in colloid and interface science. Topics include statistical mechanics and thermodynamics of micellar solutions, self-assembling systems, and microemulsions; solubilization of simple ions, amino acids, and proteins in reversed micelles; enzymatic reactions in reversed micelles; phase equilibria in colloidal systems; interfacial phenomena in colloidal systems; biomedical aspects of colloidal systems.
D. Blankschtein, T. A. Hatton, P. E. Laibinis

10.982 Special Topics in Experimental Colloid and Surface Science
(Revised Content)

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

In-depth discussion of fundamental physical relationships underlying techniques commonly used in the study of colloids and surfaces with a focus on recent advances and experimental applications. Topics have included the application of steady-state and time-resolved fluorescence spectroscopies, infrared spectroscopy, and scanning probe microscopies.
T. A. Hatton, P. E. Laibinis

10.983 Reactive Processing of Materials

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

Advanced topics in synthesis of materials through processes involving transport phenomena and chemical reactions. Chemical vapor deposition, plasma processing, and chemical vapor infiltration, modeling and experimental approaches to kinetics of gas phase and surface reactions, transport phenomena in complex systems, materials synthesis, and materials characterization. Seminars by graduate students, postdoctoral associates, participating faculty, and visiting lecturers.
K. F. Jensen

10.984 Biomedical Applications of Chemical Engineering

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

Weekly seminar with lectures on current research by graduate students, postdoctoral fellows, and visiting scientists on topics related to biomedical applications of chemical engineering. Specific topics include polymeric controlled release technology, extracorporal reactor design, biomedical polymers, bioengineering aspects of pharmaceuticals, and biomaterials/tissue and cell interactions.
R. S. Langer, L. G. Cima

10.985 Seminar in Combustion Chemistry

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

Readings, presentations, and discussions of selected, currently active research topics in combustion chemistry. Examples include chemistry and structure of flames, thermochemical kinetics methods and calculations, mathematical modeling and computer analysis of reaction networks, experimental methods, interactions of chemistry with transport and fluid mechanics.
J. B. Howard

10.986 Gas-Solid Reactions

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

Review of current literature and research on gas-solid reactions, with particular emphasis on combustion, gasification, and gas absorption at high temperatures. Includes the mechanisms and kinetics of gas-solid reactions, the characterization of the structure and modeling of diffusion in porous solids, aerosol formation, and growth.
M. Flytzani-Stephanopoulos, A. F. Sarofim

10.987 Solid Thin Films and Interfaces

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

Current research topics and fundamental issues relating the structure and properties of solid thin films and interfaces to processing history. Emphasis on applying analytical techniques, such as solid-state NMR, to explore the thermodynamics and kinetics of growth, defect formation, and structural modification incurred during microelectronics fabrication.
K. K. Gleason

10.988 Synthesis and Surface Chemistry of Materials

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

Lectures, readings, and discussions of novel synthesis of advanced ceramic, catalytic, electronic, and optical materials by physical and chemical routes. Examines surface-structure-property relationships of ultrafine materials. Utilizes process variables and specialized surface characterization techniques to approach structure tailoring of materials. Open to undergraduate students and UROP students interested in these selected research topics.
J. Y. Ying

10.989 Special Topics in Biotechnology

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

Research seminars, presented by graduate students and visitors from industry and academia, covering a broad range of topics of current interest in biotechnology. Discussion focuses on generic questions with potential biotechnological applications and the quest for solutions through a coordinated interdisciplinary approach.
Gr. Stephanopoulos

10.990 Introduction to Chemical Engineering Research

Prereq.: —
G (Fall)
3-0-3 [P/D/F]
Can be repeated for credit

Introduction to research in chemical engineering by faculty of chemical engineering department. Focus is on recent developments and research projects available to new graduate students.
R. A. Brown

10.991 Seminar in Chemical Engineering

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

10.992 Seminar in Chemical Engineering

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

For students working on doctoral theses.
R. A. Brown

10.ThG Graduate Thesis

Prereq.: —
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., Chem.E., Ph.D., or Sc.D. thesis; to be arranged by the student and appropriate MIT faculty member.
R. E. Cohen

Course 11

Urban Studies and Planning

For degree requirements, see listing in Chapter VII under the School of Architecture and Planning.

Undergraduate Subjects

Introductory Subjects

11.001J Introduction to Urban Design and Development

(Same subject as 4.250J)
Prereq.: —
U (Fall)
3-0-9 HASS

Examines both the structure of the cities and ways that they can be changed. Includes historical forces that have produced cities, models of urban analysis, contemporary theory of urban design, and implementation strategies. A series of core lectures focuses on student work. Speakers present cases, involving current projects, which illustrate the scope and methods of urban design practice.
L. Vale

11.002 Introduction to Public Policy Analysis and Government Action

Prereq.: —
U (Spring)
3-1-8 HASS

Presents major analytic techniques of public policy analysis: deterministic and probabilistic models, cost-benefit analysis, decision analysis, linear programming. Class sessions organized in order of main tasks of policy analyst: identifying alternatives, implementation, evaluation. Compares alternative approaches to public policy analysis.
Consult Department Headquarters.

11.007J Controversies in Public Policy

(Same subject as 17.201J)
Prereq.: —
U (Spring)
3-0-9 HASS

Introduction to political aspects of public policy. Considers philosophical rationales for government action and the evolution of public policy in America; the policy-making process; basic strategies of public policy, including markets, government regulation, mass persuasion; and ways of analyzing the impacts of public policies — social indicators, cost/benefit analysis, evaluation of distributive equity, and unintended consequences.
L. E. Susskind

11.011 The Art and Science of Negotiation

Prereq.: —
U (Fall)
3-0-9 HASS

Drawing on lessons of game theory and decision analysis, this subject presents a strategic view of negotiation. The paradoxical nature of bargaining power, coalition behavior, and asymmetries of communication are closely examined. The value (and limits) of this discipline are examined and critiqued in a variety of real-world applications, including international conflict, environmental disputes, and plea-bargaining. All students participate in a series of simulations designed to sharpen their analytic and creative skills.
Consult Department Headquarters.

11.013J American Urban History I

(Same subject as 21H.231J)
Prereq.: —
U (Fall)
3-0-6 HASS

Seminar on the history of institutions and institutional change in urban America from roughly 1890 to the present. Among the institutions considered are political machines, police departments, schools, courts, hospitals, prisons, welfare departments, and universities. Focuses on readings and discussions.
R. M. Fogelson

11.014J American Urban History II

(Same subject as 21H.232J)
Prereq.: —
U (Spring)
3-0-6 HASS

Seminar on the history of selected features of the physical environment of urban America. Among the features considered are parks, cemeteries, tenements, suburbs, zoos, skyscrapers, department stores, supermarkets, and amusement parks. Focuses on readings and discussions.
R. M. Fogelson

11.015J Riots, Strikes, and Conspiracies in American History

(Same subject as 21H.104J)
Prereq.: —
U (Fall)
3-0-9 HASS-D, Category 5

See description under subject 21H.104J.
R. M. Fogelson

11.018 Solving the Infrastructure Crisis

Prereq.: —
U (Spring)
3-0-9 HASS

Examines the influence of infrastructure planning and development on cities and regions. Identifies the political, physical, and economic forces that influence the construction (and maintenance) of roads, bridges, water and sewer lines, etc. Considers different strategies for repairing crumbling infrastructure, including privatization.
P. Levy

11.020 Poverty, Public Policy, and Controversy
(Revised Content and Units)

Prereq.: —
U (Fall)
3-0-9 HASS-D, Category 4

Introductory subject to the study of poverty in the United States, viewed from an international perspective. Much social controversy in the 1990s has been concerned with how society should respond to poverty, and the related issues of welfare, out-of-wedlock births, homelessness, crime, and drugs. Subject investigates how particular societal findings are brought to controversies. Examines both knowledge about poverty and related behaviors from social science research and how this knowledge is incorporated into public discourse. Experience of other countries is introduced to make explicit the assumptions on which American approaches to poverty are based.
M. Rein

11.022J American Living Standards and Income Inequality

(Subject meets with 11.450, 14.65J)
Prereq.: 14.01 or equivalent
U (Spring)
3-0-9 HASS

Provides students with an integrated overview of the contemporary US economy, including trends in living standards and income inequality, productivity within the manufacturing and service sectors, savings and investment, the federal budget deficit, and the changing nature of the poverty population. Applies recent economic research and economic data sources to the study of current economic problems. Meets with graduate subject 11.450, but assignments differ.
F. S. Levy

11.023 Bridging Cultural and Racial Differences

Prereq.: —
Acad Year 1996-97: **Not offered**
Acad Year 1997-98: U (Fall)
4-0-5

Explores cultural and racial stereotypes to increase understanding and appreciation of differences. Emphasis on developing techniques for conflict resolution in a more diversified America in the next century. Attention to economic status, residential segregation, education, political participation, and crime through current readings, films/videos, and guest speakers.
C. G. Williams

11.024 Great Cities

Prereq.: —
U (Spring)
3-0-6

Seminar that explores the attributes of cities that are described by a variety of sources, including members of the class, as "great cities." Class concerns a variety of criteria that have been, or might be, used to ascribe greatness to cities, such as attractiveness, quality of life, and richness of opportunity, and exmaines the consistency and/or contradictory evidence in judgments about cities.
J. P. de Monchaux

11.026J Downtown
(New)

(Subject meets with 21H.234J, 11.339)
Prereq.: —
U (Spring)
2-0-7 HASS

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. Subjects considered include subways, skyscrapers, highways, urban renewal, and retail centers. Focus on readings, discussions, and individual research projects. Meets with graduate subject 11.339, but assignments differ.
R. M. Fogelson, B. J. Frieden

Specialized Subjects

11.102J Theories of Economic Development

(Same subject as 14.75J)
Prereq.: 14.01, 14.02
U (Fall)
3-0-9 HASS

See description under subject 14.75J.
A. Banerjee

11.104 Infrastructure in Developing Countries

(Subject meets with 11.469J, 1.254J)
Prereq.: —
U (Fall)
3-0-9

Meets with graduate subject 11.469J, but assignments differ. See description under subject 11.469J.
R. A. Gakenheimer

11.122 Environmental Policy and Regulation

Prereq.: —
U (Spring)
3-0-9 HASS

Evaluates the strengths and weaknesses of different ways in which the government can act to protect the environment: pollution standards, marketable rights, taxes, and citizen empowerment. Emphasis on economic analysis, but also compares other policy perspectives including law and politics.
Consult Department Headquarters.

11.123 Big Plans

Prereq.: —
U (Fall)
2-0-7 HASS

Explores social, technological, political, economic, and cultural implications of "Big Plans" — those that are vast in scale (whether financially, geographically, or across functional areas). Examples include the Boston Harbor Cleanup, Washington as a national capital, and housing plans in developing countries.
J. P. de Monchaux

11.124 Introduction to Teaching and Learning

Prereq.: —
U (Fall)
3-6-3 HASS

Emphasis on teaching and learning in urban settings. Concentrates on understanding the child as knowledge constructor and on different approaches to curriculum design and assessment. Students work through constructive learning projects, analyze videotapes of precollege students engaged in similar projects, and compare their own theories and problem-solving strategies with those of younger students. Participants analyze videotapes of master math/science teachers working in the classroom with students. Each student is paired with an experienced middle- or high-school teacher/mentor who attends the subject. Recommended for students considering careers in teaching.
J. Bamberger, S. Carey

11.125 Observation and Analysis of Classroom Settings

Prereq.: 11.124 or permission of instructor
U (Spring)
3-6-3 HASS

Five hours of observation in math and science classrooms grades 6–12. Includes interpretation development, observation skills, log-keeping, analysis and critiques of student observations. High school teachers consult on classroom management, discipline, learning styles, administration, diverse communities. Subject instructors, MIT Teaching Fellows, and high school teachers meet with students to critique logs and help design curriculum units for classroom testing. Satisfies 75 hours of supervised classroom observation required for Mass. teacher's certification.
J. Bamberger, S. Carey

11.165 Courts and American Society

Prereq.: —
Acad Year 1996-97: **Not offered**
Acad Year 1997-98: U (Spring)
3-0-9 HASS-D, Category 4

Analyzes the historical evolution of the courts in American society. Topics covered include the debate over judicial activism, the role of the courts as agents of social change, and the American proclivity for litigation to resolve both public and private disputes. Controversies examined include the abortion decisions, the school desegregation cases, and the evolution of the insanity defense.
Consult Department Headquarters.

Laboratories

11.188 Urban Planning and Social Science Laboratory

Prereq.: Permission of instructor
U (Spring)
3-6-3 Institute LAB

Introduces social science research methods and empirical analysis experience in a "workshop" setting involving urban planning problems. Explores various qualitative and quantitative methods — surveys, case studies, comparative research, statistical and spatial analysis. Emphasizes development of a research project related to a real-world planning problem, selection of appropriate methods, use of primary and secondary data, and computer-based modeling and spatial analysis. Includes experience in interviewing and conducting research work in the field.
J. Ferreira, Jr., Q. Shen

Tutorials, Fieldwork, and Internships

11.UR Undergraduate Research

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

11.URG Undergraduate Research

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

Undergraduate research opportunities in Urban Studies and Planning. For further information, consult the Departmental Coordinators.
J. Ferreira, Jr.

11.191, 11.192 Supervised Readings in Urban Studies

Prereq.: —
U (Fall, Spring)
3-0-6
Can be repeated for credit

Reading and discussion of special topics in urban studies. By arrangement with individual members of the staff.
J. P. de Monchaux

11.194, 11.195 Special Topics in Urban Studies and Planning

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

Small-group study of special topics under staff supervision. For undergraduates wishing to pursue further study or fieldwork in specialized areas of urban studies or city and regional planning not covered in regular subjects of instruction.
J. P. de Monchaux

11.196 Urban Fieldwork and Internships

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

Practical application of city and regional 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 under staff supervision.
J. P. de Monchaux

11.197, 11.198, 11.199 Special Studies in Urban Studies and Planning

Prereq.: —
U (IAP)
Units arranged
Can be repeated for credit

Planned subjects of instruction for use during IAP only. 11.197 is taught P/D/F.
J. P. de Monchaux

Graduate Subjects

Master's Core Subjects

11.200 Planning and Institutional Processes (Revised Units)

Prereq.: Permission of instructor
G (Fall)
3-0-9

Basic paradigms and theories of planning practice. Evaluates historical and current developments in planning, with special emphasis on the institutional setting of planning in American society. Lectures, case studies, and comparative analyses explore the changing roles of the planner and the key dilemmas in planning practice. Focuses on strategies of institutional intervention and implementation. Restricted to first-year M.C.P. students.
G. Hack, L. E. Susskind

11.205 Planning and Institutional Processes in Developing Countries (Revised Units)

Prereq.: —
G (Fall)
3-0-9

The planning process in developing countries. Interaction between planners and institutions at both national and local levels. Overview of theories of state, organizational arrangements, implementation mechanisms, and planning styles. Case studies of planning: decentralization, provision of low-cost housing, and new-town development. Analyzes various roles planners play in different institutional contexts. Professional ethics and values amidst conflicting demands. Restricted to first-year M.C.P. and SPURS students.
B. Sanyal

11.207 Introduction to Computers in Public Management I

(11.227)
Prereq.: 11.220
G (Fall)
1-1-1

11.208 Introduction to Computers in Public Management II

(11.228)
Prereq.: 11.227
G (IAP)
1-1-1

Basic understanding of microcomputer uses in planning and public management. Develop problem-solving skills using computer-based tools for "what-if" analyses. Emphasis on constructing, running, and interpreting various analytic models and spatial analyses using spreadsheets, database management, and mapping. Introductions to geographic information systems and structured programming.
J. Ferreira, Jr., Q. Shen

11.210 Political Economy for Planners I

Prereq.: Permission of instructor
G (Fall)
4-2-6

Introduces economic analysis for planners emphasizing problems which are encountered in professional education. Topics include basic elements of economic theory, multiple perspectives on the labor market, environmental issues, productivity growth and restructuring, income inequality, health care, and the new location theory. Restricted to first-year M.C.P. students.
F. Levy

11.220 Quantitative Reasoning and Statistical Methods for Planning I

Prereq.: Permission of instructor
G (Spring)
4-2-6

Develops logical, empirically based arguments using statistical techniques and analytic methods. Covers elementary statistics, probability, and other types of quantitative reasoning useful for description; estimation, comparison, and explanation. Emphasizes the use and limitations of analytical techniques in planning practice. Restricted to first-year M.C.P. students.
J. M. Schuster

Department-wide Subjects

Methods

11.221 Quantitative Reasoning and Statistical Methods for Planning II

Prereq.: 11.220
Acad Year 1996-97: G (Spring)
Acad Year 1997-98: **Not offered**
4-2-6

Using the analytical skills developed in 11.220, this subject extends the statistical techniques to address topics in modeling and forecasting. Emphasizes the use and limitation of modeling in planning practice. Covers techniques of multiple regression and time series analysis. Uses data sets from actual planning applications for examples and problem sets.
Q. Shen

11.223 Introduction to Modes of Argumentation and Writing for Professional Planning
(New)

Prereq.: —
G (Spring)
2-0-7

Introductory subject in preparation for writing the thesis or dissertation, required of first-year students who are not exempted on the basis of their performance in the department's writing assessment, and open to others as an elective. Reviews the essential principles of exposition in English, focusing on the research essay as the primary vehicle for developing policy positions and ideas. Students encouraged to focus on consideration of purpose and audience; exploring topics; planning and drafting; revising and editing; and constructing and analyzing arguments. Problems encountered particularly by multilingual students also addressed as needed.
J. Morrison

11.225 Modes of Argumentation and Writing for Advanced Students
(New)

Prereq.: —
G (Fall, Spring)
3-0-6

Advanced subject in the principles and practices of analyzing, devising, and framing arguments in the context of writing about public issues and policies, open to advanced M.C.P. and Ph.D. students. Argumentation approached from rhetorical, social, dialectical, and heuristic points of view. Students develop a research-based term paper, which for M.C.P. students can be part of their thesis, and for Ph.D. candidates either their first-year paper or a portion of their dissertation.
J. Morrison

11.232 The Uses of Social Science for Social Change
(Revised Units)

Prereq.: —
G (Spring)
2-0-7

Examines the ways that research has been used and can be used to promote and support change in policy and practice. The social sciences provide theory, ideas, and empirical evidence to justify new policy initiatives and revise old ones.
M. Rein

11.233 Introduction to Research Design and Methodology
(New)

Prereq.: —
G (Fall)
3-0-9

For graduate students planning independent research projects. Offers an overview of the most common types of research design and analytical strategies employed in the social sciences, including survey research, ethnography, and comparative historical methods. Particular attention to the strengths and limitations of qualitative and quantitative approaches, and to ensuring that research questions drive the methodology and not the other way around. The main class requirement is a research proposal. Students select a topic, review the relevant literature, and identify and justify the kinds of resources and methods appropriate to their respective studies.
A. Cintrón

11.234 Making Sense: Qualitative Methods in Environmental Design

Prereq.: —
G (Spring)
2-4-6

Surveys uses of qualitative methods in environmental design practice and research. Topics include: observing environments and physical traces, observing environmental behavior, asking questions, focused interviews, standardized questionnaires, use of written archival materials, use of visual materials including photographs and maps, case studies, and comparative methods. Emphasizes use of each of these skills to collect and make sense of qualitative data.
L. Vale

11.235 Analyzing Projects and Organizations
(Revised Units)

Prereq.: 11.205
G (Fall)
3-0-9 H-LEVEL Grad Credit

Seminar builds analytic skills for evaluating programs and projects, the organizations that carry them out, and their environment covers 1) using proxy indicators where data are poor and time is short; 2) preparing for, conducting, and interpreting interviews; 3) conducting cross-project and cross-organization comparisons; and 4) seeing the rationality in seemingly chaotic organizational and project environments. Desirable for students preparing for Master's or Ph.D. theses.
J. Tendler

11.237 Gender, Work, and Public Policy
(New)

(Subject meets with SP.470)
Prereq.: —
G (Spring)
3-0-9

Women workers rarely appear in labor market theory. When they do, they are represented as a separate category, determined by biological differences and their family responsibilities. Subject examines the status of working women under a variety of governmental policies and labor conditions. First part is a survey of key debates on sex and gender differences in employment and wages. Using the changing structure of the US labor force as an example, second part examines attempted policy responses to the increasing feminization of the labor force. Students apply theoretical issues to a policy topic of their choice (e.g., familiy leave, unionization, tax credit, or income support, etc.).
A. Cintrón

11.251 The Policy-Making Process

Prereq.: —
Acad Year 1996-97: G (Spring)
Acad Year 1997-98: **Not offered**
2-0-7

Focuses on the process by which public policy is made. Organized as a cooperative venture by students and intended to build on their interest in and knowledge of different policy arenas. The readings include case studies of policy making and attempts by authors to describe the process by which public policy is made. The intent is to help students develop their own perspective on this process.
M. Rein

11.254 Public Sector Economics for Planners

Prereq.: 11.210
Acad Year 1996-97: **Not offered**
Acad Year 1997-98: G (Fall)
3-0-9

Develops basic concepts of public finance theory, including public goods, externalities, tax incidence, and distributional equity, as they apply to decentralized government institutions in today's changing fiscal environment. Focus is on revenue generation, service provision, and intergovernmental fiscal relations. Options for improving state and local government performance through tax reform, increased cost recovery, and alternative service delivery arrangements, such as private sector involvement in traditional "public" sector functions, are considered.
P. Smoke

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