

MATERIALS SCIENCE AND ENGINEERING (COURSE 3)

3.001 Introduction to Materials Science and Engineering (New)

Prereq: None
U (Fall, Spring)
2-0-0 units

Provides a broad introduction to topics in materials science and the curricula in the Department of Materials Science and Engineering's core subjects. Emphasizes conceptual and visual examples of materials phenomena and engineering. Preference to sophomores in fall and freshmen in spring.

W. C. Carter, K. Keane

3.003 Principles of Engineering Practice

Subject meets with 3.004
Prereq: Physics I (GIR), Calculus I (GIR)
U (Spring)
1-2-6 units

Introduces students to the interdisciplinary nature of 21st-century engineering projects with three threads of learning: a technical toolkit, a social science toolkit, and a methodology for problem-based learning. Students encounter the social, political, economic, and technological challenges of engineering practice by participating in actual engineering projects involving public transportation and information infrastructure with faculty and industry. Student teams create prototypes and mixed media reports with exercises in project planning, analysis, design, optimization, demonstration, reporting and team building. Preference to freshmen.

L. Kimerling

3.004 Principles of Engineering Practice

Subject meets with 3.003
Prereq: Physics I (GIR), Calculus I (GIR)
U (Spring)
3-3-6 units

Introduces students to the interdisciplinary nature of 21st-century engineering projects with three threads of learning: a technical toolkit, a social science toolkit, and a methodology for problem-based learning. Students encounter the social, political, economic and technological challenges of engineering practice via case studies and participation in engineering projects. Includes a six-stage term project in which student teams develop solutions through exercises in project planning, analysis, design, optimization, demonstration, reporting, and team building.

L. Kimerling

3.005 Passion Projects: Living in a Material World

Prereq: None
U (Spring)
1-2-6 units

Project-based seminar in which students formulate and answer questions about a material or object that interests and inspires them. Uses cutting-edge equipment to characterize the materials' structure in order to understand its role and functionality. Analyzes the lifecycle of the material to better understand the full use case. Culminates in the creation of a website, video, and final presentation in which students share the results of their research. Preference to freshmen; limited to 15.

K. Van Vliet

3.012 Fundamentals of Materials Science and Engineering

Prereq: None. Coreq: 18.03, 18.032, or 3.016
U (Fall)
5-0-10 units. REST

Describes the fundamentals of structure and energetics that underpin materials science. Presents thermodynamic concepts and the laws governing equilibrium properties, and the connections between thermodynamic concepts and materials phenomena, such as phase transformations, multiphase equilibria, and chemical reactions. Introduces computerized thermodynamics. Structure of noncrystalline, crystalline, and liquid-crystalline states. Symmetry and tensor properties of materials. Point, line, and surface imperfections in materials. Diffraction and structure determination.

C. Ross, R. Jaramillo

3.014 Materials Laboratory

Prereq: None
U (Fall)
1-4-7 units. Institute LAB

Experimental exploration of the connections between structure, properties, processing, and performance of materials. Hands-on experience with materials characterization techniques and instrumentation. Covers methodology of technical communication (written and oral) with a view to integrate experimental design, execution, and analysis. Concurrent enrollment in 3.012 and 3.014 strongly recommended.

L. Kimerling, D. Sadoway

3.016 Computational Methods for Materials Scientists and Engineers

Prereq: Calculus II (GIR)

U (Fall)

3-1-8 units

Computational and analytical techniques necessary for materials science and engineering topics, such as material structure, symmetry, and thermodynamics, materials response to applied fields, mechanics and physics of solids and soft materials. Presents mathematical concepts and materials-related problem solving skills alongside symbolic programming techniques. Symbolic algebraic computational methods, programming, and visualization techniques; topics include linear algebra, quadratic forms, tensor operations, symmetry operations, calculus of several variables, eigensystems, systems of ordinary and partial differential equations, beam theory, resonance phenomena, special functions, numerical solutions, statistical analysis, Fourier analysis, and random walks.

W. C. Carter

3.017 Modelling, Problem Solving, Computing, and Visualization

Prereq: 3.016, 6.0001, 16.66, or 12.010; 3.014, 3.022, or 3.024; or permission of instructor

U (Spring)

2-2-8 units

Covers development and design of models for materials processes and structure-property relations. Emphasizes techniques for solving equations from models or simulating their behavior. Assesses methods for visualizing solutions and aesthetics of the graphical presentation of results. Topics include symmetry and structure, classical and statistical thermodynamics, solid state physics, mechanics, phase transformations and kinetics, statistics and presentation of data.

W. C. Carter

3.021 Introduction to Modeling and Simulation

Engineering School-Wide Elective Subject.

Offered under: 1.021, 3.021, 10.333, 22.00

Prereq: 18.03, 3.016, or permission of instructor

U (Spring)

4-0-8 units. REST

Basic concepts of computer modeling and simulation in science and engineering. Uses techniques and software for simulation, data analysis and visualization. Continuum, mesoscale, atomistic and quantum methods used to study fundamental and applied problems in physics, chemistry, materials science, mechanics, engineering, and biology. Examples drawn from the disciplines above are used to understand or characterize complex structures and materials, and complement experimental observations.

M. Buehler, R. Gomez-Bombarelli

3.022 Microstructural Evolution in Materials

Prereq: 3.012

U (Spring)

3-3-6 units

Covers microstructures, defects, and structural evolution in all classes of materials. Topics include solution kinetics, interface stability, dislocations and point defects, diffusion, surface energetics, grains and grain boundaries, grain growth, nucleation and precipitation, and electrochemical reactions. Lectures illustrate a range of examples and applications based on metals, ceramics, electronic materials, polymers, and biomedical materials. Explores the evolution of microstructure through experiments involving optical and electron microscopy, calorimetry, electrochemical characterization, surface roughness measurements, and other characterization methods. Investigates structural transitions and structure-property relationships through practical materials examples.

Y. Chiang, G. Beach, J. Hu

3.024 Electronic, Optical and Magnetic Properties of Materials

Prereq: 3.012

U (Spring)

3-3-6 units

Uses fundamental principles of quantum mechanics, solid state physics, electricity and magnetism to describe how the electronic, optical and magnetic properties of materials originate. Illustrates how these properties can be designed for particular applications, such as diodes, solar cells, optical fibers, and magnetic data storage. Involves experimentation using spectroscopy, resistivity, impedance and magnetometry measurements, behavior of light in waveguides, and other characterization methods. Uses practical examples to investigate structure-property relationships.

P. Anikeeva, G. Beach, Y. Chiang

3.032 Mechanical Behavior of Materials

Prereq: Physics I (GIR); 3.016 or 18.03

U (Fall)

3-1-8 units

Basic concepts of solid mechanics and mechanical behavior of materials: elasticity, stress-strain relationships, stress transformation, viscoelasticity, plasticity and fracture. Continuum behavior as well as atomistic explanations of the observed behavior are described. Examples from engineering as well as biomechanics. Lab experiments and demonstrations give hands-on experience of the physical concepts. Offers a combination of online and in-person instruction.

L. Gibson

3.034 Organic and Biomaterials Chemistry

Subject meets with 3.034A

Prereq: 3.012

U (Fall)

4-2-6 units

Focuses on the chemistry and chemical structure-property relationships of soft synthetic and biologically derived materials, and aims to develop a fundamental understanding of the molecular nature of materials. Topics include methods for preparing synthetic polymers by step- and chain-growth polymerizations; polymerization reaction kinetics; chemistry of proteins and nucleic acids; DNA nanotechnology; synthetic polypeptides and artificial amino acids; application of biologically derived materials into biomedical and sensing applications; electroactive organic materials; and polymer processing and mechanical properties. Includes firsthand application of lecture topics through design-oriented experiments.

R. Macfarlane

3.034A Organic and Biomaterials Chemistry (New)

Subject meets with 3.034

Prereq: Chemistry (GIR)

U (Fall)

4-0-8 units

Focuses on the chemistry and chemical structure-property relationships of soft synthetic and biologically derived materials. Topics include methods for preparing synthetic polymers by step and chain growth polymerizations; polymerization reaction kinetics; chemistry of proteins, nucleic acids, polysaccharides and lipids; enzymatic reactions; electroactive organic materials; polymer mechanical properties and processing techniques; applications of biological and biomaterials; self-assembly of polymer, nanoparticle, and biological materials; instrumental techniques for characterizing soft materials. 3.034A students also complete additional written assignments in place of the 3.034 laboratory component.

R. Macfarlane

3.035 Problems in Materials Science and Engineering

Prereq: Permission of instructor

U (Fall, Spring, Summer)

Units arranged [P/D/F]

Can be repeated for credit.

For undergraduates desiring to carry on projects of their own choosing, which may be experimental, theoretical, or of a design nature. Also for undergraduate studies arranged by students or staff, which may consist of seminars, assigned reading, or laboratory projects. See UROP Coordinator for registration procedures.

Staff

3.036 Problems in Materials Science and Engineering

Prereq: Permission of instructor

U (Fall, Spring, Summer)

Units arranged [P/D/F]

Can be repeated for credit.

For undergraduates desiring to carry on projects of their own choosing, which may be experimental, theoretical, or of a design nature. Also for undergraduate studies arranged by students or staff, which may consist of seminars, assigned reading, or laboratory projects. See UROP Coordinator for registration procedures.

Staff

3.037 Problems in Materials Science and Engineering

Prereq: Permission of instructor

U (Fall, IAP, Spring, Summer)

Units arranged [P/D/F]

Can be repeated for credit.

For undergraduates desiring to carry on projects of their own choosing, which may be experimental, theoretical, or of a design nature. Also for undergraduate studies arranged by students or staff, which may consist of seminars, assigned reading, or laboratory projects. See UROP Coordinator for registration procedures.

Staff

3.038 Problems in Materials Science and Engineering

Prereq: Permission of instructor

U (Fall, Spring, Summer)

Units arranged

Can be repeated for credit.

For undergraduates desiring to carry on projects of their own choosing, which may be experimental, theoretical, or of a design nature. Also for undergraduate studies arranged by students or staff, which may consist of seminars, assigned reading, or laboratory projects. See UROP Coordinator for registration procedures.

Staff

3.039 Problems in Materials Science and Engineering

Prereq: Permission of instructor

U (Fall, Spring, Summer)

Units arranged

Can be repeated for credit.

For undergraduates desiring to carry on projects of their own choosing, which may be experimental, theoretical, or of a design nature. Also for undergraduate studies arranged by students or staff, which may consist of seminars, assigned reading, or laboratory projects. See UROP Coordinator for registration procedures.

Staff

3.038, 3.039, 3.04 Problems in Materials Science and Engineering

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

For undergraduates desiring to carry on projects of their own choosing, which may be experimental, theoretical, or of a design nature. Also for undergraduate studies arranged by students or staff, which may consist of seminars, assigned reading, or laboratory projects. See UROP Coordinator for registration procedures.

Staff

3.042 Materials Project Laboratory

Prereq: 3.014, 3.032, or 3.044
 U (Fall, Spring)
 1-6-5 units

Student project teams design and fabricate a working prototype using materials processing technologies (e.g. solid works 3-D design software, computer numerical controlled mill, injection molding, thermoforming, investment casting, powder processing, three-dimensional printing, physical vapor deposition) appropriate for the materials and device of interest. Goals include using MSE fundamentals in a practical application; understanding trade-offs between design, processing, and performance and cost; and fabrication of a deliverable prototype. Emphasis on teamwork, project management, communications and computer skills, with extensive hands-on work using student and MIT laboratory shops. Teams document their progress and final results by means of written and oral communication. Limited to 25.

M. Tarkanian

3.044 Materials Processing

Prereq: 3.012, 3.022
 U (Spring)
 4-0-8 units

Introduction to materials processing science, with emphasis on heat transfer, chemical diffusion, and fluid flow. Uses an engineering approach to analyze industrial-scale processes, with the goal of identifying and understanding physical limitations on scale and speed. Covers materials of all classes, including metals, polymers, electronic materials, and ceramics. Considers specific processes, such as melt-processing of metals and polymers, deposition technologies (liquid, vapor, and vacuum), colloid and slurry processing, viscous shape forming, and powder consolidation.

E. Olivetti

3.046 Thermodynamics of Materials

Prereq: 3.012 or permission of instructor
 U (Spring)
 4-0-8 units. REST

Explores equilibrium thermodynamics through its application to topics in materials science and engineering. Begins with a fast-paced review of introductory classical and statistical thermodynamics. Students select additional topics to cover; examples include batteries and fuel cells, solar photovoltaics, magnetic information storage, extractive metallurgy, corrosion, thin solid films, and computerized thermodynamics.

R. Jaramillo

3.048 Advanced Materials Processing

Prereq: 3.022, 3.044
 U (Spring)
 3-0-9 units

Fundamentals of materials processing. Building engineering structures from the atomic- and nano-scales to macroscopic levels. Case studies illustrating application of processing science to creation of modern metallic, ceramic, polymeric and biomaterials devices and components.

Staff

3.052 Nanomechanics of Materials and Biomaterials

Prereq: 3.032 or permission of instructor
 U (Spring)
 3-0-9 units

Latest scientific developments and discoveries in the field of nanomechanics, i.e. the deformation of extremely tiny (10-9 meters) areas of synthetic and biological materials. Lectures include a description of normal and lateral forces at the atomic scale, atomistic aspects of adhesion, nanoindentation, molecular details of fracture, chemical force microscopy, elasticity of individual macromolecular chains, intermolecular interactions in polymers, dynamic force spectroscopy, biomolecular bond strength measurements, and molecular motors.

C. Ortiz

3.053]] Molecular, Cellular, and Tissue Biomechanics

Same subject as 2.797]], 6.024]], 20.310]]
 Prereq: 2.370 or 2.772]]; 18.03 or 3.016; Biology (GIR)
 U (Fall)
 4-0-8 units

See description under subject 20.310]].

M. Bathe, K. Van Vliet, M. Jonas

3.054 Cellular Solids: Structure, Properties, Applications

Subject meets with 3.36

Prereq: 3.032

U (Fall)

2-0-10 units

Discusses processing and structure of cellular solids as they are created from polymers, metals, ceramics, glasses, and composites; derivation of models for the mechanical properties of honeycombs and foams; and how unique properties of honeycombs and foams are exploited in applications such as lightweight structural panels, energy absorption devices, and thermal insulation. Covers applications of cellular solids in medicine, such as increased fracture risk due to trabecular bone loss in patients with osteoporosis, the development of metal foam coatings for orthopedic implants, and designing porous scaffolds for tissue engineering that mimic the extracellular matrix. Includes modelling of cellular materials applied to natural materials and biomimicking. Offers a combination of online and in-person instruction. Students taking graduate version complete additional assignments.

L. Gibson

3.055]] Biomaterials Science and Engineering

Same subject as 20.363]]

Subject meets with 3.963]], 20.463]]

Prereq: 3.034, 20.110]], or permission of instructor

U (Fall)

3-0-9 units

See description under subject 20.363]].

D. Irvine, K. Ribbeck

3.063 Polymer Physics

Subject meets with 3.942

Prereq: 3.012

U (Fall)

4-0-8 units

The mechanical, optical, electrical, and transport properties of polymers and other types of "soft matter" are presented with respect to the underlying physics and physical chemistry of polymers and colloids in solution, and solid states. Topics include how enthalpy and entropy determine conformation, molecular dimensions and packing of polymer chains and colloids and supramolecular materials. Examination of the structure of glassy, crystalline, and rubbery elastic states of polymers; thermodynamics of solutions, blends, crystallization; liquid crystallinity, microphase separation, and self-assembled organic-inorganic nanocomposites. Case studies of relationships between structure and function in technologically important polymeric systems. Students taking graduate version complete additional assignments.

A. Alexander-Katz, G. Rutledge

3.064 Polymer Engineering

Prereq: 3.032, 3.044

Acad Year 2017-2018: Not offered

Acad Year 2018-2019: U (Fall)

3-0-9 units

Overview of polymer material science and engineering. Treatment of physical and chemical properties, mechanical characterization, processing, and their control through inspired polymer material design.

N. Holten-Andersen

3.07 Introduction to Ceramics

Prereq: 3.012

U (Fall)

3-0-9 units

Discusses structure-property relationships in ceramic materials. Includes hierarchy of structures from the atomic to microstructural levels. Defects and transport, solid-state electrochemical processes, phase equilibria, fracture and phase transformations are discussed in the context of controlling properties for various applications of ceramics. Numerous examples from current technology.

Y. Chiang

3.071 Amorphous Materials

Prereq: 3.024

U (Fall)

3-0-9 units

Discusses the fundamental material science behind amorphous solids (non-crystalline materials). Covers formation of amorphous solids; amorphous structures and their electrical and optical properties; and characterization methods and technical applications.

J. Hu

3.072 Symmetry, Structure and Tensor Properties of Materials

Subject meets with 3.60

Prereq: 3.016 or 18.03

U (Fall)

4-0-8 units

Studies the underlying structures of materials and deepens understanding of the relationship between the properties of materials and their structures. Topics include lattices, point groups, and space groups in both two and three dimensions; the use of symmetry in the tensor representation of crystal properties; and the relationship between crystalline structure and properties, including transport properties, piezoelectricity, and elasticity. Students taking graduate version complete additional assignments.

E. Fitzgerald

3.074 Imaging of Materials

Subject meets with 3.34

Prereq: 3.024

U (Spring)

3-0-9 units

Principles and applications of imaging techniques for materials characterization including transmission and scanning electron microscopy and scanning probe microscopy. Topics include electron diffraction; image formation in transmission and scanning electron microscopy; diffraction and phase contrast; imaging of crystals and crystal imperfections; review of the most recent advances in electron microscopy for bio- and nanosciences; analysis of chemical composition and electronic structure at the atomic scale. Lectures, real-case studies and computer simulations.

S. Gradečak

3.080 Strategic Materials Selection

Prereq: 3.012, 3.014, or permission of instructor

U (Spring)

3-0-9 units

Provides a survey of methods for evaluating choice of material and explores the implications of that choice. Topics include manufacturing economics and utility analysis. Students carry out a group project selecting materials technology options based on economic characteristics.

R. Kirchain

3.081 Industrial Ecology of Materials

Subject meets with 3.560

Prereq: 3.012, 3.014, or permission of instructor

Acad Year 2017-2018: Not offered

Acad Year 2018-2019: U (Fall)

3-0-9 units

Covers quantitative techniques to address principles of substitution, dematerialization, and waste mining implementation in materials systems. Includes life-cycle and materials flow analysis of the impacts of materials extraction; processing; use; and recycling for materials, products, and services. Student teams undertake a case study regarding materials and technology selection using the latest methods of analysis and computer-based models of materials process. Students taking graduate version complete additional assignments.

E. Olivetti

3.085[] Venture Engineering

Same subject as 2.912[], 15.373[]

Prereq: None

U (Spring)

3-0-9 units

See description under subject 15.373[].

S. Stern, E. Fitzgerald

3.086 Innovation and Commercialization of Materials Technology

Subject meets with 3.207

Prereq: None

U (Spring)

4-0-8 units

Introduces the fundamental process of innovating and its role in promoting growth and prosperity. Exposes students to innovation through team projects as a structured process, while developing skills to handle multiple uncertainties simultaneously. Provides training to address these uncertainties through research methods in the contexts of materials technology development, market applications, industry structure, intellectual property, and other factors. Case studies place the project in a context of historical innovations with worldwide impact. Combination of projects and real-world cases help students identify how they can impact the world through innovation.

E. Fitzgerald

3.091 Introduction to Solid-State Chemistry

Subject meets with ES.3091

Prereq: None

U (Fall, Spring)

5-0-7 units. CHEMISTRY

Credit cannot also be received for 5.111, 5.112, CC.5111, ES.5111, ES.5112

Basic principles of chemistry and their application to engineering systems. The relationship between electronic structure, chemical bonding, and atomic order. Characterization of atomic arrangements in crystalline and amorphous solids: metals, ceramics, semiconductors, and polymers. Topical coverage of organic chemistry, solution chemistry, acid-base equilibria, electrochemistry, biochemistry, chemical kinetics, diffusion, and phase diagrams. Examples from industrial practice (including the environmental impact of chemical processes), from energy generation and storage (e.g., batteries and fuel cells), and from emerging technologies (e.g., photonic and biomedical devices).

Fall: J. Grossman

Spring: N. Holten-Andersen, R. Macfarlane

3.094 Materials in Human Experience

Prereq: None

U (Spring)

2-3-4 units. HASS-S

Examines the ways in which people in ancient and contemporary societies have selected, evaluated, and used materials of nature, transforming them to objects of material culture. Some examples: glass in ancient Egypt and Rome; sounds and colors of powerful metals in Mesoamerica; cloth and fiber technologies in the Inca empire. Explores ideological and aesthetic criteria often influential in materials development. Laboratory/workshop sessions provide hands-on experience with materials discussed in class. Subject complements 3.091. Enrollment may be limited.

*H. N. Lechtman, D. Hosler***3.095 Introduction to Metalsmithing (New)**

Prereq: None

U (Spring)

2-3-4 units. HASS-A

Centers around art history, design principles, sculptural concepts, and metallurgical processes. Covers metalsmithing techniques of enameling, casting, and hollowware. Students create artworks that interpret lecture material and utilize metalsmithing techniques and metal as means of expression. Also covers topics of art patronage, colonial influence upon arts production, and gender and class issues in making. Lectures and lab sessions supplemented by a visiting artist lecture and art museum field trip. Limited to 12.

*T. Fadenrecht***3.14 Physical Metallurgy**

Subject meets with 3.40[]], 22.71[]]

Prereq: 3.022, 3.032

U (Fall)

3-0-9 units

Focuses on the links between the processing, structure, and properties of metals and alloys. First, the physical bases for strength, stiffness, and ductility are discussed with reference to crystallography, defects, and microstructure. Second, phase transformations and microstructural evolution are studied in the context of alloy thermodynamics and kinetics. Together, these components comprise the modern paradigm for designing metallic microstructures for optimized properties. Concludes with a focus on processing/microstructure/property relationships in structural engineering alloys, particularly steels and aluminum alloys. Students taking the graduate version explore the subject in greater depth.

*C. Tasan***3.15 Electrical, Optical, and Magnetic Materials and Devices**

Prereq: 3.024

Acad Year 2017-2018: Not offered

Acad Year 2018-2019: U (Spring)

3-0-9 units

Explores the relationships between the performance of electrical, optical, and magnetic devices and the microstructural and defect characteristics of the materials from which they are constructed. Features a device-motivated approach that places strong emphasis on the design of functional materials for emerging technologies. Applications center around diodes, transistors, memristors, batteries, photodetectors, solar cells (photovoltaics) and solar-to-fuel converters, displays, light emitting diodes, lasers, optical fibers and optical communications, photonic devices, magnetic data storage and spintronics.

*J. L.M. Rupp***3.152 Magnetic Materials**

Subject meets with 3.45

Prereq: 3.024

U (Spring)

3-0-9 units

Topics include origin of magnetism in materials, magnetic domains and domain walls, magnetostatics, magnetic anisotropy, antiferro- and ferrimagnetism, magnetism in thin films and nanoparticles, magnetotransport phenomena, and magnetic characterization. Discusses a range of applications, including magnetic recording, spin-valves, and tunnel-junction sensors. Assignments include problem sets and a term paper on a magnetic device or technology. Students taking graduate version complete additional assignments.

*C. Ross***3.153 Nanoscale Materials**

Prereq: 3.024

Acad Year 2017-2018: Not offered

Acad Year 2018-2019: U (Spring)

4-0-8 units

Builds on concepts from quantum mechanics and electromagnetics to develop an understanding of the properties of materials on the nanoscale. Illustrates the promise and challenges facing the field through case studies and the survey of fabrication methods.

Staff

3.154[] Materials Performance in Extreme Environments

Same subject as 22.054[]
 Prereq: 3.032, 3.044
 Acad Year 2017-2018: U (Spring)
 Acad Year 2018-2019: Not offered
 3-2-7 units

Studies the behavior of materials in extreme environments typical of those in which advanced energy systems (including fossil, nuclear, solar, fuel cells, and battery) operate. Takes both a science and engineering approach to understanding how current materials interact with their environment under extreme conditions. Explores the role of modeling and simulation in understanding material behavior and the design of new materials. Focuses on energy and transportation related systems.

R. Ballinger

3.155[] Micro/Nano Processing Technology

Same subject as 6.152[]
 Prereq: Calculus II (GIR), Chemistry (GIR), Physics II (GIR), or permission of instructor
 U (Fall)
 3-4-5 units

See description under subject 6.152[]].

L. F. Velasquez-Garcia, J. Michel

3.156 Photonic Materials and Devices

Subject meets with 3.46
 Prereq: 3.016 or 18.03; 3.024
 U (Fall)
 3-0-9 units

Optical materials design for semiconductors, dielectrics, organic and nanostructured materials. Ray optics, electromagnetic optics and guided wave optics. Physics of light-matter interactions. Device design principles: LEDs, lasers, photodetectors, solar cells, modulators, fiber and waveguide interconnects, optical filters, and photonic crystals. Device processing: crystal growth, substrate engineering, thin film deposition, etching and process integration for dielectric, silicon and compound semiconductor materials. Micro- and nanophotonic systems. Organic, nanostructured and biological optoelectronics. Assignments include three design projects that emphasize materials, devices and systems applications. Students taking graduate version complete additional assignments.

P. Anikeeva

3.171 Structural Materials

Prereq: 3.012, 3.014
 U (Fall, Spring; partial term)
 2-0-10 units
 Can be repeated for credit. Credit cannot also be received for 2.821[], 3.371[]

Combines online and in-person lectures to discuss structural materials selection, design and processing using examples from deformation processes, casting, welding and joining, non-destructive evaluation, failure and structural life assessment, and codes and standards. Emphasizes the underlying science of a given process rather than a detailed description of the technique or equipment. Presented in modules to be selected by student. Students taking graduate version must submit additional work. Meets with 3.171 when offered concurrently.

T. Eagar

3.18 Materials Science and Engineering of Clean Energy

Subject meets with 3.70
 Prereq: 3.022, 3.024
 U (Spring)
 3-0-9 units

Develops the materials principles, limitations, and challenges of clean energy technologies, including solar, energy storage, thermoelectrics, fuel cells, and novel fuels. Draws correlations between the limitations and challenges related to key figures of merit and the basic underlying thermodynamic, structural, transport, and physical principles, as well as to the means for fabricating devices exhibiting optimum operating efficiencies and extended life at reasonable cost. Students taking graduate version complete additional assignments.

H. Tuller, K. Van Vliet

3.19 Sustainable Chemical Metallurgy

Subject meets with 3.50
 Prereq: 3.022
 U (Spring)
 3-0-9 units

Covers principles of metal extraction processes. Provides a direct application of the fundamentals of thermodynamics and kinetics to the industrial production of metals from their ores, e.g., iron, aluminum, or reactive metals and silicon. Discusses the corresponding economics and global challenges. Addresses advanced techniques for sustainable metal extraction, particularly with respect to greenhouse gas emissions. Students taking graduate version complete additional assignments.

A. Allanore

3.20 Materials at Equilibrium

Prereq: 3.012, 3.014, 3.022, 3.024, 3.034, 3.042; or permission of instructor

G (Fall)

5-0-10 units

Laws of thermodynamics: general formulation and applications to mechanical, electromagnetic and electrochemical systems, solutions, and phase diagrams. Computation of phase diagrams. Statistical thermodynamics and relation between microscopic and macroscopic properties, including ensembles, gases, crystal lattices, phase transitions. Applications to phase stability and properties of mixtures. Representations of chemical equilibria. Interfaces.

A. Allanore

3.207 Innovation and Commercialization

Subject meets with 3.086

Prereq: None

G (Spring)

4-0-8 units

Explores in depth projects on a particular materials-based technology. Investigates the science and technology of materials advances and their strategic value, explore potential applications for fundamental advances, and determine intellectual property related to the materials technology and applications. Students map progress with presentations, and are expected to create an end-of-term document enveloping technology, intellectual property, applications, and potential commercialization. Lectures cover aspects of technology, innovation, entrepreneurship, intellectual property, and commercialization of fundamental technologies.

E. Fitzgerald

3.21 Kinetic Processes in Materials

Prereq: 3.012, 3.022, 3.044, or permission of instructor

G (Spring)

5-0-10 units

Unified treatment of phenomenological and atomistic kinetic processes in materials. Provides the foundation for the advanced understanding of processing, microstructural evolution, and behavior for a broad spectrum of materials. Topics include irreversible thermodynamics; rate and transition state theory, diffusion; nucleation and phase transitions; continuous phase transitions; grain growth and coarsening; capillarity driven morphological evolution; and interface stability during phase transitions.

C. Thompson

3.22 Mechanical Behavior of Materials

Prereq: 3.032 or permission of instructor

G (Spring)

4-0-8 units

Explores how the macroscale mechanical behavior of materials originates from fundamental, microscale mechanisms of elastic and inelastic deformation. Topics include: elasticity, viscoelasticity, plasticity, creep, fracture, and fatigue. Case studies and examples are drawn from a variety of material classes: metals, ceramics, polymers, thin films, composites, and cellular materials.

C. Tasan

3.23 Electrical, Optical, and Magnetic Properties of Materials

Prereq: 8.03, 18.03

G (Fall)

4-0-8 units

Origin of electrical, magnetic and optical properties of materials. Focus on the acquisition of quantum mechanical tools. Analysis of the properties of materials. Presentation of the postulates of quantum mechanics. Examination of the hydrogen atom, simple molecules and bonds, and the behavior of electrons in solids and energy bands. Introduction of the variation principle as a method for the calculation of wavefunctions. Investigation of how and why materials respond to different electrical, magnetic and electromagnetic fields and probes. Study of the conductivity, dielectric function, and magnetic permeability in metals, semiconductors, and insulators. Survey of common devices such as transistors, magnetic storage media, optical fibers.

G. Beach

3.30]] Properties of Solid Surfaces

Same subject as 22.75]]

Prereq: 3.20, 3.21, or permission of instructor

G (Spring)

3-0-9 units

See description under subject 22.75]].

B. Yildiz

3.31]] Radiation Damage and Effects in Nuclear Materials

Same subject as 22.74]]

Prereq: 22.14, 3.21, or permission of instructors

G (Fall)

3-0-9 units

See description under subject 22.74]].

M. Short, B. Yildiz

3.320 Atomistic Computer Modeling of Materials

Prereq: 3.022, 3.20, 3.23 or permission of instructor

Acad Year 2017-2018: Not offered

Acad Year 2018-2019: G (Spring)

3-0-9 units

Theory and application of atomistic computer simulations to model, understand, and predict the properties of real materials. Energy models: from classical potentials to first-principles approaches. Density-functional theory and the total-energy pseudopotential method. Errors and accuracy of quantitative predictions. Thermodynamic ensembles: Monte Carlo sampling and molecular dynamics simulations. Free energies and phase transitions. Fluctuations and transport properties. Coarse-graining approaches and mesoscale models.

Staff

3.33[J] Defects in Materials

Same subject as 22.73[J]

Prereq: 3.21, 3.22

Acad Year 2017-2018: Not offered

Acad Year 2018-2019: G (Fall)

3-0-9 units

Examines point, line, and planar defects in structural and functional materials. Relates their properties to transport, radiation response, phase transformations, semiconductor device performance and quantum information processing. Focuses on atomic and electronic structures of defects in crystals, with special attention to optical properties, dislocation dynamics, fracture, and charged defects population and diffusion. Examples also drawn from other systems, e.g., disclinations in liquid crystals, domain walls in ferromagnets, shear bands in metallic glass, etc.

J. Li

3.34 Imaging of Materials

Subject meets with 3.074

Prereq: 3.23 or permission of instructor

G (Spring)

3-0-9 units

Principles and applications of imaging techniques for materials characterization including transmission and scanning electron microscopy and scanning probe microscopy. Topics include electron diffraction; image formation in transmission and scanning electron microscopy; diffraction and phase contrast; imaging of crystals and crystal imperfections; review of the most recent advances in electron microscopy for bio- and nanosciences; analysis of chemical composition and electronic structure at the atomic scale. Lectures, real-case studies and computer simulations. Graduate students complete additional assignments.

S. Gradečak

3.35 Fracture and Fatigue

Prereq: 3.22 or permission of instructor

Acad Year 2017-2018: Not offered

Acad Year 2018-2019: G (Spring)

3-0-9 units

Advanced study of material failure in response to mechanical stresses. Damage mechanisms include microstructural changes, crack initiation, and crack propagation under monotonic and cyclic loads. Covers a wide range of materials: metals, ceramics, polymers, thin films, biological materials, composites. Describes toughening mechanisms and the effect of material microstructures. Includes stress-life, strain-life, and damage-tolerant approaches. Emphasizes fracture mechanics concepts and latest applications for structural materials, biomaterials, microelectronic components as well as nanostructured materials. Limited to 10.

M. Dao

3.36 Cellular Solids: Structure, Properties, Applications

Subject meets with 3.054

Prereq: 3.032 or permission of instructor

G (Fall)

3-0-9 units

Discusses processing and structure of cellular solids as they are created from polymers, metals, ceramics, glasses, and composites; derivation of models for the mechanical properties of honeycombs and foams; and how unique properties of honeycombs and foams are exploited in applications such as lightweight structural panels, energy absorption devices, and thermal insulation. Covers applications of cellular solids in medicine, such as increased fracture risk due to trabecular bone loss in patients with osteoporosis, the development of metal foam coatings for orthopedic implants, and designing porous scaffolds for tissue engineering that mimic the extracellular matrix. Includes modelling of cellular materials applied to natural materials and biomimicking. Students taking graduate version complete additional assignments.

L. Gibson

3.371[J] Structural Materials

Same subject as 2.821[J]

Prereq: Permission of instructor

G (Fall, Spring, Summer; partial term)

2-0-10 units

Can be repeated for credit. Credit cannot also be received for 3.171

Combines online and in-person lectures to discuss structural materials selection, design and processing using examples from deformation processes, casting, welding and joining, non-destructive evaluation, failure and structural life assessment, and codes and standards. Emphasizes the underlying science of a given process rather than a detailed description of the technique or equipment. Presented in modules to be selected by student. Students taking graduate version must submit additional work. Meets with 3.171 when offered concurrently.

T. Eagar, A. Slocum

3.38 Ceramics: Processing, Properties and Functional Devices (New)

Prereq: None

G (Spring)

3-0-9 units

Explores modern ceramic processing - ranging from large-scale synthesis, 3D manufacturing and printing to nanoscale-thin film structures integrated for microelectronics useful for material, chemical, electronic or mechanical engineers. Examples of devices studied include opto-electronic materials, sensors, memories, batteries, solar-to-fuel convertors, and solid oxide fuel cells. Provides the skills and guidance to design ceramic and glassy materials for large-scale components as energy storage or convertors or for nano-scale electronic applications in information storage devices.

J. L. M. Rupp

3.40[J] Modern Physical Metallurgy

Same subject as 22.71[J]

Subject meets with 3.14

Prereq: 3.022, 3.032

G (Fall)

3-0-9 units

Examines how the presence of 1-, 2- and 3-D defects and second phases control the mechanical, electromagnetic and chemical behavior of metals and alloys. Considers point, line and interfacial defects in the context of structural transformations including annealing, spinodal decomposition, nucleation, growth, and particle coarsening. Concentrates on structure-function relationships, and in particular how grain size, interstitial and substitutional solid solutions, and second-phase particles impact mechanical and other properties. Industrially relevant case studies illustrate lecture concepts. Students taking the graduate version explore the subject in greater depth.

C. Tasan

3.41 Colloids, Surfaces, Absorption, Capillarity, and Wetting Phenomena

Prereq: 3.20, 3.21

G (Spring)

3-0-9 units

Integrates elements of physics and chemistry toward the study of material surfaces. Begins with classical colloid phenomena and the interaction between surfaces in different media. Discusses the mechanisms of surface charge generation as well as how dispersion forces are created and controlled. Continues with exploration of chemical absorption processes and surface design of inorganic and organic materials. Includes examples in which such surface design can be used to control critical properties of materials in applications. Addresses lastly how liquids interact with solids as viewed by capillarity and wetting phenomena. Studies how materials are used in processes and applications that are intended to control liquids, and how the surface chemistry and structure of those materials makes such applications possible.

M. Cima

3.42 Electronic Materials Design

Prereq: 3.23

G (Fall)

3-0-9 units

Extensive and intensive examination of structure-processing-property correlations for a wide range of materials including metals, semiconductors, dielectrics, and optical materials. Topics covered include defect equilibria; junction characteristics; photodiodes, light sources and displays; bipolar and field effect transistors; chemical, thermal and mechanical transducers; data storage. Emphasis on materials design in relation to device performance.

H. L. Tuller

3.43[J] Integrated Microelectronic Devices

Same subject as 6.720[J]

Prereq: 6.012 or 3.42

G (Fall)

4-0-8 units

See description under subject 6.720[J].

J. A. del Alamo, H. L. Tuller

3.44 Materials Processing for Micro- and Nano-Systems

Prereq: 3.20, 3.21

G (Fall)

3-0-9 units

Processing of bulk, thin film, and nanoscale materials for applications in electronic, magnetic, electromechanical, and photonic devices and microsystems. Topics include growth of bulk, thin-film, nanoscale single crystals via vapor and liquid phase processes; formation, patterning and processing of thin films, with an emphasis on relationships among processing, structure, and properties; and processing of systems of nanoscale materials. Examples from materials processing for applications in high-performance integrated electronic circuits, micro-/nano-electromechanical devices and systems and integrated sensors.

C. V. Thompson

3.45 Magnetic Materials

Subject meets with 3.152

Prereq: 3.23

G (Spring)

3-0-9 units

Foundation topics include magnetostatics, origin of magnetism in materials, magnetic domains and domain walls, magnetic anisotropy, reversible and irreversible magnetization processes; hard and soft magnetic materials and magnetic recording. Special topics are selected from magnetism at nanoscale (thin films, surfaces, particles); amorphous and nanocrystalline magnetic materials; electronic transport in ferromagnets including magnetoresistive, spin-valve and spin-tunnel junction sensors.

C. Ross

3.46 Photonic Materials and Devices

Subject meets with 3.156

Prereq: 3.23

G (Fall)

3-0-9 units

Optical materials design for semiconductors, dielectrics and polymers. Ray optics, electromagnetic optics and guided wave optics. Physics of light-matter interactions. Device design principles: LEDs, lasers, photodetectors, modulators, fiber and waveguide interconnects, optical filters, and photonic crystals. Device processing: crystal growth, substrate engineering, thin film deposition, etching and process integration for dielectric, silicon and compound semiconductor materials. Microphotonic integrated circuits. Telecom/datacom systems. Assignments include three design projects that emphasize materials, devices and systems applications. Students taking graduate version complete additional assignments.

P. Anikeeva

3.50 Sustainable Chemical Metallurgy

Subject meets with 3.19

Prereq: 3.022 or permission of instructor

G (Spring)

3-0-9 units

Covers principles of metal extraction processes. Provides a direct application of the fundamentals of thermodynamics and kinetics to the industrial production of metals from their ores, e.g. iron, aluminum, or reactive metals and silicon. Discusses the corresponding economics and global challenges. Addresses advanced techniques for sustainable metal extraction, particularly with respect to greenhouse gas emissions. Students taking graduate version complete additional assignments.

A. Allanore

3.53 Electrochemical Processing of Materials

Prereq: 3.044

G (Spring; partial term)

3-0-6 units

Thermodynamic and transport properties of aqueous and nonaqueous electrolytes. The electrode/electrolyte interface. Kinetics of electrode processes. Electrochemical characterization: d.c. techniques (controlled potential, controlled current), a.c. techniques (voltametry and impedance spectroscopy). Applications: electrowinning, electrorefining, electroplating, and electrosynthesis, as well as electrochemical power sources (batteries and fuel cells).

*D. R. Sadoway***3.54[J] Corrosion: The Environmental Degradation of Materials**

Same subject as 22.72[J]

Prereq: 3.012

Acad Year 2017-2018: Not offered

Acad Year 2018-2019: G (Spring)

3-0-9 units

Applies thermodynamics and kinetics of electrode reactions to aqueous corrosion of metals and alloys. Application of advanced computational and modeling techniques to evaluation of materials selection and susceptibility of metal/alloy systems to environmental degradation in aqueous systems. Discusses materials degradation problems in marine environments, oil and gas production, and energy conversion and generation systems, including fossil and nuclear.

*R. G. Ballinger***3.560 Industrial Ecology of Materials**

Subject meets with 3.081

Prereq: 3.20 or permission of instructor

Acad Year 2017-2018: Not offered

Acad Year 2018-2019: G (Fall)

3-0-9 units

Covers quantitative techniques to address principles of substitution, dematerialization, and waste mining implementation in materials systems. Includes life-cycle and materials flow analysis of the impacts of materials extraction; processing; use; and recycling for materials, products, and services. Student teams undertake a case study regarding materials and technology selection using the latest methods of analysis and computer-based models of materials process. Students taking graduate version complete additional assignments.

*E. Olivetti***3.57 Materials Selection, Design, and Economics**

Prereq: Permission of instructor

G (Spring)

3-0-6 units

A survey of techniques for analyzing how the choice of materials, processes, and design determine properties, performance, and cost. Topics include production and cost functions, mathematical optimization, evaluation of single and multi-attribute utility, decision analysis, materials property charts, and performance indices. Students use analytical techniques to develop a plan for starting a new materials-related business.

*Staff***3.60 Symmetry, Structure, and Tensor Properties of Materials**

Subject meets with 3.072

Prereq: 3.016 or 18.03

G (Fall)

4-0-8 units

Studies the underlying structures of materials and deepens understanding of the relationship between the properties of materials and their structures. Topics include lattices, point groups, and space groups in both two and three dimensions; the use of symmetry in the tensor representation of crystal properties; and the relationship between crystalline structure and properties, including transport properties, piezoelectricity, and elasticity. Students taking graduate version complete additional assignments.

*E. Fitzgerald***3.65 Soft Matter Characterization**

Prereq: Permission of instructor

Acad Year 2017-2018: Not offered

Acad Year 2018-2019: G (Spring)

2-1-9 units

Focuses on the design and execution of advanced experiments to characterize soft materials, such as synthetic and natural polymers, biological composites, and supramolecular nanomaterials. Each week focuses on a new characterization technique explored through interactive lectures, demonstrations, and lab practicum sessions in which students gain experience in key experimental aspects of soft matter sample preparation and characterization. Among others, topics include chemical characterization, rheology and viscometry, microscopy, and spectroscopic analyses. Limited to 15.

J. Ortony

3.69 Teaching Fellows Seminar

Prereq: None

G (Fall)

2-0-1 units

Can be repeated for credit.

Provides instruction to help prepare students for teaching at an advanced level and for industry or academic career paths. Topics include preparing a syllabus, selecting a textbook, scheduling assignments and examinations, lecture preparation, "chalk and talk" vs. electronic presentations, academic honesty and discipline, preparation of examinations, grading practices, working with teaching assistants, working with colleagues, mentoring outside the classroom, pursuing academic positions, teaching through technical talks, and successful grant writing strategies.

C. Schuh

3.691 Teaching Materials Science and Engineering

Prereq: Permission of instructor

U (Fall, Spring)

0-1-0 units

Can be repeated for credit.

Provides classroom or laboratory teaching experience under the supervision of faculty member(s). Students assist faculty by preparing instructional materials, leading discussion groups, and monitoring students' progress. Limited to Course 3 undergraduates selected by Teaching Assignments Committee.

G. Beach

3.692 Teaching Materials Science and Engineering

Prereq: Permission of instructor

U (Fall, Spring)

Units arranged

Can be repeated for credit.

Provides classroom or laboratory teaching experience under the supervision of faculty member(s). Students assist faculty by preparing instructional materials, leading discussion groups, and monitoring students' progress. Credit arranged on a case-by-case basis and reviewed by the department. Limited to Course 3 undergraduates selected by Teaching Assignments Committee.

G. Beach

3.693-3.699 Teaching Materials Science and Engineering

Prereq: None

G (Fall)

Units arranged

Can be repeated for credit.

Laboratory, tutorial, or classroom teaching under the supervision of a faculty member. Students selected by interview. Enrollment limited by availability of suitable teaching assignments.

D. Sadoway

3.70 Materials Science and Engineering of Clean Energy

Subject meets with 3.18

Prereq: 3.20, 3.23, or permission of instructor

G (Spring)

3-0-9 units

Develops the materials principles, limitations and challenges in clean energy technologies, including solar, energy storage, thermoelectrics, fuel cells, and novel fuels. Draws correlations between the limitations and challenges related to key figures of merit and the basic underlying thermodynamic, structural, transport, and physical principles, as well as to the means for fabricating devices exhibiting optimum operating efficiencies and extended life at reasonable cost. Students taking graduate version complete additional assignments.

H. Tuller, K. Van Vliet

3.903[] Seminar in Polymers and Soft Matter

Same subject as 10.960[]

Prereq: None

G (Fall, Spring)

2-0-0 units

Can be repeated for credit.

See description under subject 10.960[].

A. Alexander-Katz, R. E. Cohen, D. Irvine

3.91 Mechanical Behavior of Polymers

Prereq: Permission of instructor

Acad Year 2017-2018: Not offered

Acad Year 2018-2019: G (Spring)

3-0-9 units

Influence of processing and structure on mechanical properties of synthetic and natural polymers: Hookean and entropic elastic deformation, linear viscoelasticity, composite materials and laminates, yield and fracture. Introductory subjects in solid mechanics and polymers recommended, e.g. 3.032, 3.034.

Staff

3.930 Internship Program

Prereq: None

U (Summer)

0-6-0 units

Provides academic credit for first approved materials science and engineering internship. For reporting requirements, consult the faculty internship program coordinator. Limited to Course 3 internship track majors.

*T. Eagar***3.931 Internship Program**

Prereq: 3.930

U (Summer)

0-6-0 units

Provides academic credit for second approved materials science and engineering internship in the year following completion of 3.930. For reporting requirements consult the faculty internship program coordinator. Limited to Course 3 internship track majors.

*T. Eagar***3.932 Industrial Practice**

Prereq: Permission of instructor

G (Fall, IAP, Spring, Summer)

Units arranged

Can be repeated for credit.

Provides academic credit to graduate students for approved work assignments at companies/national laboratories. Restricted to DMSE SM or PhD/ScD students.

*D. Sadoway***3.94 Morphology of Polymers**

Prereq: 3.063

Acad Year 2017-2018: Not offered

Acad Year 2018-2019: G (Fall)

3-0-6 units

Structure of noncrystalline, crystalline, and liquid crystalline polymers, including polymers blends, and block copolymers. Texture development from processing operations, mechanical deformation, and applied electric and magnetic fields. Hybrid organic-inorganic nano and microcomposites. Phase transformations, including classical nucleation theory and spinodal decomposition. Use of morphological characterization methods such as wide- and small-angle x-ray scattering and scanning, transmission electron microscopy and atomic force microscopy are also covered.

*Staff***3.941[] Statistical Mechanics of Polymers**

Same subject as 10.668[]

Prereq: 10.568 or permission of instructor

Acad Year 2017-2018: Not offered

Acad Year 2018-2019: G (Fall)

3-0-9 units

See description under subject 10.668[].

*G. C. Rutledge, A. Alexander-Katz***3.942 Polymer Physics**

Subject meets with 3.063

Prereq: 3.032 or permission of instructor

G (Fall)

4-0-8 units

The mechanical, optical, electrical, and transport properties of polymers and other types of "soft matter" are presented with respect to the underlying physics and physical chemistry of polymers and colloids in solution, and solid states. Topics include how enthalpy and entropy determine conformation, molecular dimensions and packing of polymer chains and colloids and supramolecular materials. Examination of the structure of glassy, crystalline, and rubbery elastic states of polymers; thermodynamics of solutions, blends, crystallization; liquid crystallinity, microphase separation, and self-assembled organic-inorganic nanocomposites. Case studies of relationships between structure and function in technologically important polymeric systems. Students taking graduate version complete additional assignments.

*A. Alexander-Katz, G. Rutledge***3.963[] Biomaterials Science and Engineering**

Same subject as 20.463[]

Subject meets with 3.055[], 20.363[]

Prereq: 3.034, 20.110[], or permission of instructor

G (Fall)

3-0-9 units

See description under subject 20.463[].

*D. Irvine, K. Ribbeck***3.971[] Molecular, Cellular, and Tissue Biomechanics**

Same subject as 2.798[], 6.524[], 10.537[], 20.410[]

Prereq: Biology (GIR); 2.002, 2.006, 6.013, 10.301, or 10.302

Acad Year 2017-2018: Not offered

Acad Year 2018-2019: G (Fall)

3-0-9 units

See description under subject 20.410[].

R. D. Kamm, K. J. Van Vliet

3.98 Polymer Synthetic Chemistry

Prereq: One basic polymer chemistry subject

Acad Year 2017-2018: Not offered

Acad Year 2018-2019: G (Spring)

3-0-6 units

An examination of the fundamental reaction mechanisms and chemistry of polymerization reactions with an emphasis on the synthesis of new advanced polymers and their properties.

Staff

Archaeology and Archaeological Science

3.981 Communities of the Living and the Dead: the Archaeology of Ancient Egypt

Prereq: None

U (Spring)

3-0-9 units. HASS-S

Examines the development of complex societies in Egypt over a 3000-year period. Uses archaeological and historical sources to determine how and why prehistoric communities coalesced into a long-lived and powerful state. Studies the remains of ancient settlements, tombs, and temples, exploring their relationships to one another and to the geopolitical landscape of Egypt and the Mediterranean world. Considers the development of advanced technologies, rise of social hierarchy, expansion of empire, role of writing, and growth of a complex economy.

M. Price

3.982 The Ancient Andean World

Prereq: None

U (Fall)

3-0-6 units. HASS-S

Examines development of Andean civilization which culminated in the extraordinary empire established by the Inka. Archaeological, ethnographic, and ethnohistorical approaches. Particular attention to the unusual topography of the Andean area, its influence upon local ecology, and the characteristic social, political, and technological responses of Andean people to life in a topographically "vertical" world. Characteristic cultural styles of prehistoric Andean life.

H. N. Lechtman

3.983 Ancient Mesoamerican Civilization

Prereq: None

U (Spring)

3-0-6 units. HASS-S

Examines development of selected ancient Mesoamerican civilizations using archaeological and ethnohistorical evidence. Focuses on Olmec, Maya, Teotihuacan and Aztec, considering key technological, environmental, social organizational and ideological variables. Includes major group research project. Limited to 10.

D. Hosler

3.984 Materials in Ancient Societies: Ceramics

Prereq: Permission of instructor

G (Fall)

3-6-3 units

Seminars and labs provide in-depth study of the technologies ancient societies used to produce objects from ceramic materials, including clays and mortars. Seminars cover basic ceramic materials science and engineering and relate materials selection and processing to environment, exchange, political power, and cultural values.

H. N. Lechtman, J. Meanwell

3.985]] Archaeological Science

Same subject as 5.24]], 12.011]]

Prereq: Chemistry (GIR) or Physics I (GIR)

U (Spring)

3-1-5 units. HASS-S

Pressing issues in archaeology as an anthropological science. Stresses the natural science and engineering methods archaeologists use to address these issues. Reconstructing time, space, and human ecologies provides one focus; materials technologies that transform natural materials to material culture provide another. Topics include ¹⁴C dating, ice core and palynological analysis, GIS and other remote sensing techniques for site location, organic residue analysis, comparisons between Old World and New World bronze production, invention of rubber by Mesoamerican societies, analysis and conservation of Dead Sea Scrolls.

H. N. Lechtman

3.986 The Human Past: Introduction to Archaeology

Prereq: None

U (Fall)

3-0-9 units. HASS-S; CI-H

From an archaeological perspective, examines ancient human activities and the forces that shaped them. Draws on case studies from the Old and/or New World. Exposes students to various classes of archaeological data, such as stone, bone, and ceramics, that help reconstruct the past.

*M. Price***3.987 Human Evolution: Data from Palaeontology, Archaeology, and Materials Science**

Prereq: None

U (Spring)

3-6-3 units. HASS-S

Examines human physical and cultural evolution over the past five million years via lectures and labs that incorporate data from human palaeontology, archaeology, and materials science. Topics include the evolution of hominin morphology and adaptations; the nature and structure of bone and its importance in human evolution; and the fossil and archaeological evidence for human behavioral and cultural evolution, from earliest times through the Pleistocene. Laboratory sessions include study of stone technology, artifacts, and fossil specimens.

*M. Price***3.989 Materials in Ancient Societies: Ceramics Laboratory**

Prereq: Permission of instructor

G (Spring)

3-6-3 units

Laboratory analysis of archaeological artifacts of ceramics. Follows on 3.984.

*H. N. Lechtman, J. Meanwell***3.990 Seminar in Archaeological Method and Theory**

Prereq: 3.985[[]], 3.986, 21A.00

U (Fall, Spring)

3-0-6 units

Designed for undergraduate seniors majoring in Archaeology and Materials. Critical analysis of major intellectual and methodological developments in American archaeology, including evolutionary theory, the "New Archaeology," Marxism, formal and ideological approaches. Explores the use of science and engineering methods to reconstruct cultural patterns from archaeological data. Seminar format, with formal presentations by all students. Non-majors fulfilling all prerequisites may enroll by permission of instructors. Instruction and practice in oral and written communication provided.

*D. Hosler, H. Lechtman***3.993 Archaeology of the Middle East**

Prereq: None

U (Spring)

3-0-6 units. HASS-S

Focus on the rise of settled communities, cities, and empires and their technological achievements in various areas of the Middle East including Anatolia, the Levant, and Mesopotamia. Using archaeological and written sources, examines why such complex societies arose in this area. Considers the technological basis of these societies; the role of temples and religious hierarchies, of crafts and trade in luxury goods, of writing and bureaucracies, and of class stratification in the rise of early civilizations.

*Staff***3.997 Graduate Fieldwork in Materials Science and Engineering**

Prereq: Permission of instructor

G (Fall, Spring, Summer)

Units arranged

Can be repeated for credit.

Program of field research in materials science and engineering leading to the writing of an SM, PhD, or ScD thesis; to be arranged by the student and an appropriate MIT faculty member.

*H. Lechtman***3.998 Doctoral Thesis Update Meeting**

Prereq: None

G (Fall, Spring)

0-1-0 units

Thesis research update presentation to the thesis committee. Held the first or second academic term after successfully passing the Thesis Area Examination.

*Staff***3.EPE UPOP Engineering Practice Experience**

Engineering School-Wide Elective Subject.

Offered under: 1.EPE, 2.EPE, 3.EPE, 6.EPE, 10.EPE, 16.EPE, 22.EPE

Prereq: 2.EPW or permission of instructor

U (Fall, Spring)

0-0-1 units

See description under subject 2.EPE.

Staff

3.EPW UPOP Engineering Practice Workshop

Engineering School-Wide Elective Subject.

Offered under: 1.EPW, 2.EPW, 3.EPW, 6.EPW, 10.EPW, 16.EPW, 20.EPW, 22.EPW

Prereq: None

U (Fall, IAP)

1-0-0 units

See description under subject 2.EPW.Enrollment limited.

Staff

3.S01 Special Subject in Materials Science and Engineering

Prereq: Permission of instructor

Acad Year 2017-2018: Not offered

Acad Year 2018-2019: U (Fall)

Units arranged

Can be repeated for credit.

Lecture, seminar, or laboratory consisting of material not offered in regularly scheduled subjects. Can be repeated for credit only for completely different subject matter.

Staff

3.S02 Special Subject in Materials Science and Engineering

Prereq: Permission of instructor

U (Fall)

Units arranged

Can be repeated for credit.

Lecture, seminar, or laboratory consisting of material not offered in regularly scheduled subjects. Can be repeated for credit only for completely different subject matter.

A. Allanore, T. Carneiro

3.S03 Special Subject in Materials Science and Engineering

Prereq: Permission of instructor

U (Fall)

Units arranged

Can be repeated for credit.

Lecture, seminar, or laboratory consisting of material not offered in regularly scheduled subjects. Can be repeated for credit only for completely different subject matter.

C. Ortiz

3.S04 Special Subject in Materials Science and Engineering

Prereq: Permission of instructor

U (Fall, IAP, Spring, Summer)

Not offered regularly; consult department

Units arranged

Can be repeated for credit.

Lecture, seminar, or laboratory consisting of material not offered in regularly scheduled subjects. Can be repeated for credit only for completely different subject matter.

Staff

3.S05 Special Subject in Materials Science and Engineering

Prereq: Permission of instructor

U (Fall, IAP, Spring, Summer)

Not offered regularly; consult department

Units arranged

Lecture, seminar, or laboratory consisting of material not offered in regularly scheduled subjects. Can be repeated for credit only for completely different subject matter.

Staff

3.S06 Special Subject in Materials Science and Engineering

Prereq: Permission of instructor

U (Fall)

Units arranged [P/D/F]

Lecture, seminar, or laboratory consisting of material not offered in regularly scheduled subjects. Can be repeated for credit only for completely different subject matter.

A. Alexander-Katz

3.S07 Special Subject in Materials Science and Engineering

Prereq: Permission of instructor

U (Fall, IAP, Spring, Summer)

Not offered regularly; consult department

Units arranged [P/D/F]

Can be repeated for credit.

Lecture, seminar, or laboratory consisting of material not offered in regularly scheduled subjects. Can be repeated for credit only for completely different subject matter.

Staff

3.S08 Special Subject in Materials Science and Engineering

Prereq: Permission of instructor

U (Fall, IAP, Spring, Summer)

Not offered regularly; consult department

Units arranged [P/D/F]

Lecture, seminar, or laboratory consisting of material not offered in regularly scheduled subjects. Can be repeated for credit only for completely different subject matter.

*Staff***3.S09 Special Subject in Materials Science and Engineering**

Prereq: Permission of instructor

U (Fall, IAP, Spring, Summer)

Not offered regularly; consult department

Units arranged [P/D/F]

Lecture, seminar, or laboratory consisting of material not offered in regularly scheduled subjects. Can be repeated for credit only for completely different subject matter.

*Staff***3.S70-3.S75 Special Subject in Materials Science and Engineering**

Prereq: Permission of instructor

G (Fall, IAP, Spring, Summer)

Units arranged

Covers advanced topics in Materials Science and Engineering that are not included in the permanent curriculum.

*Staff***3.S76-3.S79 Special Subject in Materials Science and Engineering**

Prereq: Permission of instructor

G (Fall, IAP, Spring, Summer)

Units arranged [P/D/F]

Covers advanced topics in Materials Science and Engineering that are not included in the permanent curriculum.

*Staff***3.THG Graduate Thesis**

Prereq: Permission of instructor

G (Fall, IAP, Spring, Summer)

Units arranged

Can be repeated for credit.

Program of research leading to the writing of an SM, PhD, or ScD thesis; to be arranged by the student and an appropriate MIT faculty member.

*D. Sadoway***3.THU Undergraduate Thesis**

Prereq: None

U (Fall, IAP, Spring, Summer)

Units arranged

Can be repeated for credit.

Program of research leading to the writing of an SB thesis; to be arranged by the student and an appropriate MIT faculty member. Instruction and practice in oral and written communication.

*Information: DMSE Academic Office***3.UR Undergraduate Research**

Prereq: None

U (Fall, IAP, Spring, Summer)

Units arranged [P/D/F]

Can be repeated for credit.

Extended participation in work of a research group. Independent study of literature, direct involvement in group's research (commensurate with student skills), and project work under an individual faculty member. See UROP coordinator for registration procedures.

*Information: DMSE Academic Office***3.URG Undergraduate Research**

Prereq: None

U (Fall, IAP, Spring, Summer)

Units arranged

Can be repeated for credit.

Extended participation in work of a research group. Independent study of literature, direct involvement in group's research (commensurate with student skills), and project work under an individual faculty member. See UROP coordinator for registration procedures.

Information: DMSE Academic Office