

MATERIALS ENGINEERING

<https://mate.calpoly.edu>

Materials engineering is an interdisciplinary field in which engineers design and optimize materials to achieve specific performance goals. By understanding how a material's structure determines its properties, materials engineers tailor metals, ceramics, polymers, semiconductors and composites to meet the demands of modern applications. Materials engineers contribute their expertise in virtually all areas of technology: from the nano-sized materials found in biomedical and microelectronic applications to the large-scale composites found in aerospace applications.

Because engineered products are often limited by materials issues (such as performance and manufacturability), materials engineers play a vital role on engineering design teams, working closely with other engineers. As part of these teams, they apply their knowledge of science, engineering, and state-of-the-art analytical instruments.

The majority of our graduates find employment in the biomedical, electronic/semiconductors, aerospace, automotive, and petroleum industries. Some work as consultants for large or small organizations. Others become executives. A significant number of materials engineers are involved in research and development. Some of our graduates are entrepreneurs who have started their own companies. Others are attorneys or physicians. Because of our broad-based, student focused curriculum, our graduates are able to excel in professions of their choosing.

Vision

To collaboratively address the grand challenges of our time, especially sustainability and transformative learning through our innovative materials engineering program.

Mission

To be a vibrant, creative, safe, and effectual learning community that cultivates the unique capabilities of each member of our materials engineering community to thrive in a complex, interconnected, technological, and ever-changing world.

Undergraduate Programs

- Materials Engineering (BS) (<https://catalog.calpoly.edu/engineering/materials/materials-engineering-bs/>)

MATE Courses

MATE 1110 Introduction to Materials Engineering (1 unit)

Term Typically Offered: F

Prerequisite: Materials Engineering major.

Principles, capabilities, career opportunities, and literacy of materials engineering. Finding, reading, and using American Society for Testing and Materials (ASTM) standards. Group projects to produce solutions for specific materials needs. Demonstrate breadth of materials engineering and highlight types of projects materials engineers can work on. 1 activity. Formerly MATE 110.

MATE 1210 Principles of Materials Engineering for Majors (3 units)

Term Typically Offered: SP

Prerequisite: CHEM 124 or CHEM 1120; and Manufacturing Engineering major or Material Engineering major. Recommended: Concurrent enrollment in MATE 1215.

Metals, polymers, ceramics, semiconductors, composites, and natural materials used to solve modern engineering problems. Relationship between material structure, property, processing, and performance. Materials selection. Course may be offered in classroom-based or online format. 3 lectures.

MATE 1215 Materials Laboratory I (1 unit)

Term Typically Offered: F, SP, SU

Corequisite: One of the following: MATE 210, MATE 1210, or MATE 1220.

Focus on processing-structure-properties relationships of materials, including crystal structures, electronic properties of materials, materials selection, phase diagrams, corrosion, mechanical properties of polymers, cold work and annealing of alloys, and heat treatments of steels. 1 laboratory. Formerly MATE 215.

MATE 1220 Principles of Materials Engineering for Non-Majors (2 units)

Term Typically Offered: F, SP, SU

Prerequisite: One of the following: CHEM 111, CHEM 124, CHEM 127, or CHEM 1120. Recommended: Concurrent enrollment in MATE 1215.

Structure of matter. Physical and mechanical properties of materials, including metals, polymers, ceramics, composites, and semiconductors. Phase diagrams, heat treatments, and materials selection. Not open to Manufacturing Engineering and Materials Engineering majors. Course may be offered in classroom-based or online format. 2 lectures. Formerly MATE 210.

MATE 2190 Materials Science of Sports, Food, and Functional Clothing (3 units)

Term Typically Offered: F, SP

Prerequisite: CHEM 124 or CHEM 1120.

Issues in material science as related to sports, food, and functional clothing. Materials, cutting-edge technologies, and innovative design strategies. Properties, processing, microstructures, performance, sustainability, and comfort. Industry case studies. Course may be offered in classroom-based or online format. 3 lectures.

MATE 2200 Special Problems for Undergraduates (1-3 units)

Term Typically Offered: F, SP, SU

Prerequisite: Consent of department chair and consent of instructor.

Individual investigation, research, studies, or surveys of selected problems. Repeatable up to 6 units. Formerly MATE 200.

MATE 2225 Materials Microscopy Laboratory (1 unit)

Term Typically Offered: F

Prerequisite: MATE 215 or MATE 1215.

Structure-properties relationships of materials. Introduction to materials characterization techniques including sample prep, metallography, optical microscopy, and scanning electron microscopes (SEM). Emphasis on materials engineering professional practices and written communication. 1 laboratory. Formerly MATE 225.

MATE 2235 Materials Spectroscopy Laboratory (1 unit)

Term Typically Offered: SP

Prerequisite: MATE 215 or MATE 1215.

Hands-on experience on spectroscopic materials characterization techniques, spectroscopic properties of materials, literature search and data presentation. Principles of X-ray Fluorescence Spectroscopy (XRF), X-ray Diffractometer (XRD), Differential Scanning Calorimeter (DSC), and Fourier-Transform Infrared Spectroscopy (FTIR). 1 laboratory. Formerly MATE 235.

MATE 2245 Engineering Analysis and Technical Communication (1 unit)

Term Typically Offered: F

Prerequisite: One of the following: MATE 210, MATE 1210, or MATE 1220; and MATE 215 or 1215.

Quantitative and qualitative analysis methods and tools for materials engineering data. Statistics for experiments, data mining, data visualization, regression analysis, numerical integration, Weibull analysis, image analysis, and introduction to machine learning. Technical communication of results. 1 activity. Formerly MATE 245.

MATE 2270 Special Topics (1-4 units)

Term Typically Offered: F, SP, SU

Prerequisite: Consent of instructor.

Directed group study of special topics. The Class Schedule will list topic selected. Repeatable to 8 units. 1 to 4 lectures. Formerly MATE 270.

MATE 2280 Materials Thermodynamics and Kinetics (4 units)

Term Typically Offered: F

Prerequisite: One of the following: MATE 210, MATE 1210, or MATE 1220; MATH 143 or MATH 1262; and PHYS 141 or PHYS 1141.

Thermodynamics and kinetics of materials processing and manufacturing. Phase diagrams. Phase transformations. Applications include polymer degradation, steel carburization, and semiconductor defect engineering. 3 lectures, 1 laboratory. Formerly MATE 280.

MATE 3232 Materials Ethics, Diversity, and Society (3 units)

Term Typically Offered: SP

2026-28 or later: Upper-Div GE Area 4

2020-26 catalogs: Upper-Div GE Area D

Prerequisite: Junior standing; completion of GE Area 1 with grades of C- or better (GE Area A for the 2022-26 catalog); completion of GE Area 2 with a grade of C- or better (GE Area B4 for the 2022-26 catalog); completion of one lower-division course in GE Area 4 (GE Areas D1 or D2 for the 2022-26 catalog).

Engineering code of ethics, western and eastern ethical theories. Relationship between personal identities, engineering culture, and engineering identity. Social impact of materials sourcing, manufacturing, usage, and disposal through historical, cultural, and economic perspectives. Case study and ethnography analysis. 3 lectures. Fulfills GE Upper-Division 4 (GE Area Upper-Division D for students on the 2022-26 catalog).

MATE 3310 Polymeric Material Systems (4 units)

Term Typically Offered: SP

Prerequisite: One of the following: CHEM 125, CHEM 312, CHEM 1122, or CHEM 2240; and one of the following: MATE 210, MATE 1210, or MATE 1220.

Design and synthesis of non-crystalline material systems. Synthesis, processing techniques, properties, and fabrication methods of organic and inorganic polymeric materials. 3 lectures, 1 laboratory. Formerly MATE 310.

MATE 3340 Electronic Materials Systems (4 units)

Term Typically Offered: F

Prerequisite: One of the following: EE 201, EE 211, EE 2201, or EE 2211; and one of the following: MATE 210, MATE 1210, or MATE 1220.

Design of materials in electronic applications. Classical and quantum electron theory of solids. Electrical, magnetic, and optical properties of materials. Cleanroom processing. Analysis of electronic device and circuit performance. 3 lectures, 1 laboratory. Formerly MATE 340.

MATE 3359 Living in a Material World (3 units)

Term Typically Offered: F, SP, SU

2026-28 or later: Upper-Div GE Area 2/5

2020-26 catalogs: Upper-Div GE Area B

Sustainability Related

Prerequisite: Junior standing; completion of GE Area 1 with grades of C- or better (GE Area A for the 2020-26 catalogs); completion of GE Area 2 with a grade of C- or better (GE Area B4 for the 2020-26 catalogs); and CHEM 124 or CHEM 1120.

Evolution of materials, including ceramics, metals, polymers, composites, and semiconductors in the context of history. Traces the link between historical and technological developments enabled by materials from the Stone Age to the Electronic Age. Course may be offered in classroom-based or online format. 3 lectures. Fulfills GE Areas Upper-Division 2 or Upper-Division 5 (GE Area Upper-Division B for students on the 2020-26 catalogs). Formerly MATE 359.

MATE 3360 Metallurgical Materials Systems (4 units)

Term Typically Offered: SP

Prerequisite: One of the following: MATE 210, MATE 1210, or MATE 1220; and MATE 225 or MATE 2225.

Theories, concepts, and the applications of metallic and metallurgical materials systems. Connection to phase diagrams, microstructural development, phase transformations, physical and mechanical properties, precipitation hardening, cold work, and heat treatment. 3 lectures, 1 laboratory. Formerly MATE 360.

MATE 3401 Advanced Materials Characterization (1 unit)

Term Typically Offered: SP

Prerequisite: One of the following: MATE 210, MATE 1210, or MATE 1220. Recommended: MATE 215 or MATE 1215.

Hands-on experience with materials characterization instruments such as light microscopy, scanning electron microscopy, X-ray diffraction, and various spectroscopies. Team projects develop expertise with problem solving, materials characterization, and analysis. 1 laboratory. Formerly MATE 401.

MATE 3403 Computational Materials Engineering (2 units)

Term Typically Offered: SP

Prerequisite: One of the following: MATE 210, MATE 1210, or MATE 1220; and MATE 280 or MATE 2280.

Project-based theory and practice of multiscale computational methods, such as density functional theory (DFT), calculation of phase diagrams (CALPHAD), and finite element analysis (FEA), applied to engineering materials. 1 lecture, 1 activity. Formerly MATE 403.

MATE 3480 Composite Material Systems (4 units)

Term Typically Offered: F

Prerequisite: Junior standing; and one of the following: MATE 210, MATE 1210, or 1220.

Properties, design, manufacture, and applications of composite material systems, concentrating on polymer-matrix and ceramic-fiber composites. Mechanical testing of fiber-reinforced composite materials, fiber volume characterization, and laminate analysis software. 3 lectures, 1 laboratory. Formerly MATE 480.

MATE 4300 Materials Selection for the Life Cycle (3 units)

Term Typically Offered: F

GWR

Prerequisite: Junior standing; and one of the following: MATE 210, MATE 1210, or MATE 1220. Recommended: MATE 215 or MATE 1215.

Materials selection for sustainable product design. Use of software and techniques to solve design problems. Focus on Triple Bottom Line design, including functionality, economics, and sustainability. 3 lectures. Fulfills GWR. Formerly MATE 300.

MATE 4390 Fibrous Materials (3 units)

Term Typically Offered: F, SP

Prerequisite: Junior standing; and one of the following: MATE 210, MATE 1210, or MATE 1220. Recommended: MATE 310 or MATE 3310.

Processing, microstructure, properties, and applications of engineering fibers, including polymers, metals, ceramics, and glass. Tailoring fiber properties depending on their applications. Engineering design case study on the fibers for reduced environmental impact. 3 lectures. Formerly MATE 390.

MATE 4400 Special Problems for Advanced Undergraduates (1-4 units)

Term Typically Offered: F, SP, SU

Prerequisite: Consent of department chair and consent of instructor.

Individual investigation, research, studies, or surveys of selected problems. Repeatable up to 8 units. Formerly MATE 400.

MATE 4402 Materials Characterization Theory (3 units)

Term Typically Offered: F, SP

Prerequisite: One of the following: MATE 210, MATE 1210, or MATE 1220.

Theory behind microscopy, diffraction, and spectroscopy techniques. Measurement of atomic structure, microstructure, and electronic structure. Compositional analysis and phase detection. Data interpretation and technique artifacts. 3 lectures. Formerly MATE 402.

MATE 4410 Nanoscale Materials (3 units)

Term Typically Offered: F, SP

Prerequisite: CHEM 125 or CHEM 1122; PHYS 143 or PHYS 1143; and one of the following: MATE 210, MATE 1210, or MATE 1220.

Distinctive structure, properties, processing, and performance of nanoscale materials. Introduction to quantum mechanics and applications to nanomaterials. Examples and applications of zero-, one-, and two-dimensional nanomaterials. 3 lectures. Formerly MATE 410.

MATE 4420 Biotechnology for Sustainable Materials (4 units)

Term Typically Offered: F, SP

Prerequisite: One of the following: CHEM 444, CHEM 544, CHEM 4480, CHEM 5580, MATE 310, or MATE 3310.

Sustainable material technologies for biotechnology research. Biopolymers, enzymes, synthetic biology, biochemical, and process engineering. Reading and interpreting contemporary scientific literature. Course may be offered in classroom-based or online format. 4 lectures. Formerly MATE 420.

MATE 4422 Ceramic and Glass Materials Systems (3 units)

Term Typically Offered: F

Prerequisite: One of the following: MATE 210, MATE 1210, or MATE 1220.

Structure, development, processing, applications, and control of properties in ceramic and glass materials. Emphasis on application on processing to achieve desired structure and properties. Mechanical, thermal, optical, magnetic, and electrical properties. 3 lectures. Formerly MATE 422.

MATE 4425 Corrosion Engineering (3 units)

Term Typically Offered: F, SP

Prerequisite: One of the following: MATE 210, MATE 1210, or MATE 1220; MATE 215 or MATE 1215; and MATE 280 or MATE 2280.

Types of corrosion, effects of environmental variables on corrosion, and corrosion prevention design. 3 lectures. Formerly MATE 425.

MATE 4434 Micro/Nano Fabrication (2 units)

Term Typically Offered: SP

Prerequisite: One of the following: BMED 420, BMED 2420, MATE 210, MATE 1210, MATE 1220, EE 306, or EE 3306.

Fabrication science and technology for creating micro and nano scale devices. Unit operations including oxidation, diffusion, ion implantation, etching, chemical and physical vapor deposition, and photolithography. Analyze process physics to design proper steps for electronic/photonics device fabrication. 2 lectures. Crosslisted as BMED/MATE/ME 4434. Formerly BMED 434/EE 423/MATE 430.

MATE 4435 Micro/Nano Fabrication Laboratory (1 unit)

Term Typically Offered: SP

Corequisite: BMED 434/EE 423/MATE 430 or BMED/MATE/ME 4434.

Application of basic operations involved in microfabrication: cleanroom protocol, oxidation, diffusion, photolithography, etching, and sputtering. Student teams explore process development through fabrication and testing of microscale silicon devices. 1 laboratory. Crosslisted as BMED/MATE/ME 4435. Formerly BMED 435/EE 473/MATE 435.

MATE 4440 Welding Metallurgy and Joining of Advanced Materials (4 units)

Term Typically Offered: F, SP

Prerequisite: One of the following: IME 142, IME 1142, MATE 210, MATE 1210, or MATE 1220; and MATE 360 or MATE 3360.

Materials manufacturing methods that join materials together. Welding, soldering, crimping, riveting, and adhesives. Material compatibility, process flow, and tradeoffs. Structure property processing relationship. Preparation for the American Welding Society (AWS) Certified Welding Inspectors (CWI) welding certification. 3 lectures, 1 laboratory. Formerly MATE 440.

MATE 4450 Fracture and Failure Analysis (4 units)

Term Typically Offered: F, SP

Prerequisite: MATE 360 or MATE 3360.

Modes of mechanical failure in metal alloys, polymers, ceramics, and composites. Relationship between mechanical properties, environmental conditions, and microstructure. Fracture surface analysis, failure analysis, and mechanical testing. 3 lectures, 1 laboratory. Formerly MATE 450.

MATE 4456 Materials, Design, and Sustainability of Energy Generation and Storage (3 units)

Term Typically Offered: F, SP

Prerequisite: One of the following: MATE 210, MATE 1210, or MATE 1220.

Properties, processing, and performance of materials used in solar cells and batteries. Stand-alone and grid connected solar cell and battery system design. Sustainability and regulation concerns. 3 lectures. Formerly MATE 456.

MATE 4461 Senior Project I (1 unit)

Term Typically Offered: F

Prerequisite: Senior standing; and Materials Engineering major.

Foundations of senior project design. Completion of senior project selection, project report structure, safety, design of experiments, project management, professionalism, and intellectual property. Review of purchasing and experimental set up. 1 activity. Formerly MATE 482.

MATE 4462 Senior Project II (2 units)

Term Typically Offered: SP

Prerequisite: MATE 482 or MATE 4461.

Continuation of senior project. Completion of a senior project experimental component under the guidance of a faculty supervisor. Research methodology, experimental design, experimental work, and data analysis. 2 laboratories. Formerly MATE 483.

MATE 4470 Special Advanced Topics (1-4 units)

Term Typically Offered: F, SP, SU

Prerequisite: Consent of instructor.

Directed group study of special topics for advanced students. The Class Schedule will list topic selected. Repeatable up to 8 units. 1 to 4 lectures. Formerly MATE 470.

MATE 4471 Special Advanced Laboratory (1-4 units)

Term Typically Offered: F, SP, SU

Prerequisite: Consent of instructor.

Directed group laboratory study of special topics for advanced students. The Class Schedule will list topic selected. Repeatable up to 8 units. 1 to 4 laboratories. Formerly MATE 471.

MATE 4481 Materials and the Environment (3 units)

Term Typically Offered: F, SP

Prerequisite: One of the following: MATE 210, MATE 1210, or MATE 1220; and PHYS 143 or PHYS 1143.

Materials impacts on air, water, land, and human health. Introduction to climate change. Life cycle assessment for quantifying environmental impact. Green materials. Overview of renewable energy technologies. Non-technical aspects of environmental technologies. Field trip required. 3 lectures. Formerly MATE 485.

MATE 4486 Surface Chemistry of Materials (3 units)

Term Typically Offered: SP

Prerequisite: One of the following: CHEM 351, CHEM 353, CHEM 3390, CHEM 3392, MATE 280, MATE 380, MATE 2280, or ME 302.

Surface energy. Capillarity, solid and liquid interface, and adsorption. Surface areas of solids. Contact angles and wetting. Friction, lubrication, and adhesion. Surface properties of materials. Applications. 3 lectures. Crosslisted as CHEM/MATE 4486. Formerly CHEM/MATE 446.

MATE 4490 Solidification and Densification (4 units)

Term Typically Offered: F, SP

Prerequisite: MATE 280 or MATE 2280.

Casting, sintering, additive manufacturing techniques. Relationship between material composition, microstructure, and defects during solidification and densification processes. Solid-liquid interface of cast metals. Rapid prototyping. 4 lectures. Formerly MATE 490.

MATE 4495 Cooperative Education Experience (12 units)

Term Typically Offered: F, SP, SU

CR/NC

Prerequisite: Consent of instructor.

Work experience in business, industry, government, and other areas of student career interest. Positions are paid, usually require relocation, and registration in course for one or two consecutive semesters. A formal report and evaluation by work supervisor required. Credit/No Credit grading only. No major credit allowed. Repeatable up to 24 units. Formerly MATE 495.