

# ENGINEERING (ENGR)

## ENGR 1. Want to Be an Engineer?. 1 Unit.

This course is designed for you if you are a new student who has a hypothesis that you want to be a scientist, mathematician, or engineer but don't yet know what you want to major in. As a scientist, you know that you need data to test your hypothesis. As a design thinker, you know that there is no way forward except to be exposed to different things and weigh the results. As a potential engineer, you know that you need lots of information to make a decision. Each week a panel of faculty from STEM majors in the School of Engineering, the School of Humanities & Sciences, and Stanford Earth will present with the goal of helping you discover if their field is right for you.

## ENGR 10. Introduction to Engineering Analysis. 4 Units.

Integrated approach to the fundamental scientific principles that are the cornerstones of engineering analysis: conservation of mass, atomic species, charge, momentum, angular momentum, energy, production of entropy expressed in the form of balance equations on carefully defined systems, and incorporating simple physical models. Emphasis is on setting up analysis problems arising in engineering. Topics: simple analytical solutions, numerical solutions of linear algebraic equations, and laboratory experiences. Provides the foundation and tools for subsequent engineering courses. Prerequisite: AP Physics and AP Calculus or equivalent.

## ENGR 100. Teaching Public Speaking. 3 Units.

The theory and practice of teaching public speaking and presentation development. Lectures/discussions on developing an instructional plan, using audiovisual equipment for instruction, devising tutoring techniques, and teaching delivery, organization, audience analysis, visual aids, and unique speaking situations. Weekly practice speaking. Students serve as apprentice speech tutors. Those completing course may become paid speech instructors in the Technical Communications Program. Prerequisite: consent of instructor.

## ENGR 102W. Technical and Professional Communication. 3 Units.

Effective communication skills will help you advance quickly. Learn the best technical and professional techniques in writing and speaking. Group workshops and individual conferences with instructors. Designed for undergraduates going into industry. Allowed to fulfill WIM for Atmosphere/Energy and Environmental Systems Engineering majors only. Same as: CEE 102W

## ENGR 103. Public Speaking. 3 Units.

Priority to Engineering students. Introduction to speaking activities, from impromptu talks to carefully rehearsed formal professional presentations. How to organize and write speeches, analyze audiences, create and use visual aids, combat nervousness, and deliver informative and persuasive speeches effectively. Weekly class practice, rehearsals in one-on-one tutorials, videotaped feedback. Limited enrollment. Same as: ENGR 203

## ENGR 105. Feedback Control Design. 3 Units.

Design of linear feedback control systems for command-following error, stability, and dynamic response specifications. Root-locus and frequency response design techniques. Examples from a variety of fields. Some use of computer aided design with MATLAB. Prerequisites: Dynamics systems (EE 102B or ME 161), and ordinary differential equations (CME 102 or Math 53). This course will include synchronous teaching sessions, but will be recorded to allow asynchronous participation.

## ENGR 108. Introduction to Matrix Methods. 3-5 Units.

Formerly EE 103/CME 103. Introduction to applied linear algebra with emphasis on applications. Vectors, norm, and angle; linear independence and orthonormal sets; applications to document analysis. Clustering and the k-means algorithm. Matrices, left and right inverses, QR factorization. Least-squares and model fitting, regularization and cross-validation. Constrained and nonlinear least-squares. Applications include time-series prediction, tomography, optimal control, and portfolio optimization. Undergraduate students should enroll for 5 units, and graduate students should enroll for 3 units. Prerequisites: MATH 51 or CME 100, and basic knowledge of computing (CS 106A is more than enough, and can be taken concurrently). ENGR 108 and Math 104 cover complementary topics in applied linear algebra. The focus of ENGR 108 is on a few linear algebra concepts, and many applications; the focus of Math 104 is on algorithms and concepts.

## ENGR 110. Perspectives in Assistive Technology (ENGR 110). 1-2 Unit.

Online seminar and student project course that explores the personal, medical, social, ethical, and technical challenges surrounding the design, development, and use of technologies that improve the lives of people with disabilities and older adults. Guest lecturers include engineers, clinicians, researchers, and individuals with disabilities. Students from any discipline are welcome to enroll. Two credit units for students who pursue an individual assistive technology project (letter grade or S/NC) with a community partner. One credit unit for seminar attendance only (S/NC). See course website <http://enr110.stanford.edu> for more information. Designated a Cardinal Course by the Haas Center for Public Service.

Same as: ENGR 210

## ENGR 113A. Solar Decathlon 2015. 3 Units.

Open to all majors. Seminar / Lab format course facilitates the student-led administration, conception, development, and execution of the Solar Decathlon 2015 competition entry sponsored by the US Department of Energy. (<http://www.solardecathlon.gov/>) Students shall learn best practices in creating design teams to address multi-disciplinary design problems. Students shall work both as individuals and in teams across multiple Stanford SD2015 phases of project management, research, fundraising, design, engineering, contracting, construction administration, and competitive testing in Irvine CA.

Same as: ENGR 213A

## ENGR 113B. Solar Decathlon 2015. 3 Units.

Open to all majors. Seminar / Lab format course facilitates the student-led administration, conception, development, and execution of the Solar Decathlon 2015 competition entry sponsored by the US Department of Energy. (<http://www.solardecathlon.gov/>) Students shall learn best practices in creating design teams to address multi-disciplinary design problems. Students shall work both as individuals and in teams across multiple Stanford SD2015 phases of project management, research, fundraising, design, engineering, contracting, construction administration, and competitive testing in Irvine CA.

Same as: ENGR 213B

## ENGR 113C. Solar Decathlon 2015. 3 Units.

Open to all majors. Seminar / Lab format course facilitates the student-led administration, conception, development, and execution of the Solar Decathlon 2015 competition entry sponsored by the US Department of Energy. (<http://www.solardecathlon.gov/>) Students shall learn best practices in creating design teams to address multi-disciplinary design problems. Students shall work both as individuals and in teams across multiple Stanford SD2015 phases of project management, research, fundraising, design, engineering, contracting, construction administration, and competitive testing in Irvine CA.

Same as: ENGR 213C

**ENGR 113D. SOLAR DECATHLON 2015. 3 Units.**

Open to all majors. Seminar / Lab format course facilitates the student-led administration, conception, development, and execution of the Solar Decathlon 2015 competition entry sponsored by the US Department of Energy. (<http://www.solardecathlon.gov/>) Students shall learn best practices in creating design teams to address multi-disciplinary design problems. Students shall work both as individuals and in teams across multiple Stanford SD2015 phases of project management, research, fundraising, design, engineering, contracting, construction administration, and competitive testing in Irvine CA.

Same as: ENGR 213D

**ENGR 115. Design the Tech Challenge. 2 Units.**

Students work with Tech Museum of San Jose staff to design the Tech Challenge, a yearly engineering competition for 6-12th grade students. Brainstorming, field trips to the museum, prototyping, coaching, and presentations to the Tech Challenge advisory board. See at <http://techchallenge.thetech.org>. May be repeated for credit.

Same as: ENGR 215

**ENGR 117. Expanding Engineering Limits: Culture, Diversity, and Equity. 3 Units.**

This course investigates how culture and diversity shape who becomes an engineer, what problems get solved, and the quality of designs, technology, and products. As a course community, we consider how cultural beliefs about race, ethnicity, gender, sexuality, abilities, socioeconomic status, and other intersectional aspects of identity interact with beliefs about engineering, influence diversity in the field, and affect equity in engineering education and practice. We also explore how engineering cultures and environments respond to and change with individual and institutional agency. The course involves weekly presentations by scholars and engineers, readings, short writing assignments, small-group discussion, and hands-on, student-driven projects. Students can enroll in the course for 1 unit (lectures only), or 3 units (lectures+discussion+project). For 1 unit, students should sign up for Section 1 and Credit/No Credit grading, and for 3 units students should sign up for Section 2 and either the C/NC or Grade option.

Same as: CSRE 117, CSRE 217, ENGR 217, FEMGEN 117, FEMGEN 217

**ENGR 119. Community Engagement Preparation Seminar. 1 Unit.**

This seminar is designed for engineering students who have already committed to an experiential learning program working directly with a community partner on a project of mutual benefit. This seminar is targeted at students participating in the Summer Service Learning Program offered through Stanford's Global Engineering Program.

Same as: ENGR 219

**ENGR 120. Fundamentals of Petroleum Engineering. 3 Units.**

Lectures, problems, field trip. Engineering topics in petroleum recovery; origin, discovery, and development of oil and gas. Chemical, physical, and thermodynamic properties of oil and natural gas. Material balance equations and reserve estimates using volumetric calculations. Gas laws. Single phase and multiphase flow through porous media.

Same as: ENERGY 120

**ENGR 14. Intro to Solid Mechanics. 3 Units.**

Introduction to engineering analysis using the principles of engineering solid mechanics. Builds on the math and physical reasoning concepts in Physics 41 to develop skills in evaluation of engineered systems across a variety of fields. Foundational ideas for more advanced solid mechanics courses such as ME80 or CEE101A. Interactive lecture sessions focused on mathematical application of key concepts, with weekly complementary lab session on testing and designing systems that embody these concepts. Limited enrollment, subject to instructor approval. Pre-requisite: Physics 41. When signing up for this course make sure to sign up both for the lecture and for a Discussion Section.

**ENGR 140A. Leadership of Technology Ventures. 3-4 Units.**

First of three-part sequence for students selected to the Mayfield Fellows Program. Management and leadership within high technology startups, focusing on entrepreneurial skills related to product and market strategy, venture financing and cash flow management, team recruiting and organizational development, and the challenges of managing growth and handling adversity in emerging ventures. Other engineering faculty, founders, and venture capitalists participate as appropriate. Recommended: accounting or finance course (MS&E 140, ECON 90, or ENGR 60).

**ENGR 140B. Leadership of Technology Ventures. 1-2 Unit.**

Open to Mayfield Fellows only; taken during the summer internship at a technology startup. Students exchange experiences and continue the formal learning process. Activities journal. Credit given following quarter.

**ENGR 140C. Leadership of Technology Ventures. 2-3 Units.**

Open to Mayfield Fellows only. Capstone to the 140 sequence. Students, faculty, employers, and venture capitalists share recent internship experiences and analytical frameworks. Students develop living case studies and integrative project reports.

**ENGR 145. Technology Entrepreneurship. 4 Units.**

How does the entrepreneurship process enable the creation and growth of high-impact enterprises? Why does entrepreneurial leadership matter even in a large organization or a non-profit venture? What are the differences between just an idea and true opportunity? How do entrepreneurs form teams and gather the resources necessary to create a successful startup? Mentor-guided projects focus on analyzing students' ideas, case studies allow for examining the nuances of innovation, research examines the entrepreneurial process, and expert guests allow for networking with Silicon Valley's world-class entrepreneurs and venture capitalists. For undergraduates of all majors with interest in startups the leverage breakthrough information, energy, medical and consumer technologies. No prerequisites. Limited enrollment.

Same as: ENGR 145S

**ENGR 145S. Technology Entrepreneurship. 4 Units.**

How does the entrepreneurship process enable the creation and growth of high-impact enterprises? Why does entrepreneurial leadership matter even in a large organization or a non-profit venture? What are the differences between just an idea and true opportunity? How do entrepreneurs form teams and gather the resources necessary to create a successful startup? Mentor-guided projects focus on analyzing students' ideas, case studies allow for examining the nuances of innovation, research examines the entrepreneurial process, and expert guests allow for networking with Silicon Valley's world-class entrepreneurs and venture capitalists. For undergraduates of all majors with interest in startups the leverage breakthrough information, energy, medical and consumer technologies. No prerequisites. Limited enrollment.

Same as: ENGR 145

**ENGR 148. Principled Entrepreneurial Decisions. 3 Units.**

Examines how leaders tackle significant events that occur in high-growth entrepreneurial companies. Students prepare their minds for the difficult entrepreneurial situations that they will encounter in their lives in whatever their chosen career. Cases and guest speakers discuss not only the business rationale for the decisions taken but also how their principles affected those decisions. The teaching team brings its wealth of experience in both entrepreneurship and VC investing to the class. Previous entrepreneurship coursework or experience preferred. Limited enrollment. Admission by application: <http://web.stanford.edu/class/engr248/apply>.

Same as: ENGR 248

**ENGR 15. Dynamics. 3 Units.**

The application of Newton's Laws to solve 2-D and 3-D static and dynamic problems, particle and rigid body dynamics, freebody diagrams, and equations of motion, with application to mechanical, biomechanical, and aerospace systems. Computer numerical solution and dynamic response. Prerequisites: Calculus (differentiation and integration) such as Math 19, 20; and ENGR 14 (statics and strength) or a mechanics course in physics such as PHYSICS 41.

**ENGR 150. Data Challenge Lab. 3-5 Units.**

In this lab, students develop the practical skills of data science by solving a series of increasingly difficult, real problems. Skills developed include: data manipulation, data visualization, exploratory data analysis, and basic modeling. The data challenges each student undertakes are based upon their current skills. Students receive one-on-one coaching and see how expert practitioners solve the same challenges. Limited enrollment; application required. See <http://datalab.stanford.edu> for more information.

Same as: COMM 173E

**ENGR 154. Vector Calculus for Engineers. 5 Units.**

Computation and visualization using MATLAB. Differential vector calculus: vector-valued functions, analytic geometry in space, functions of several variables, partial derivatives, gradient, linearization, unconstrained maxima and minima, Lagrange multipliers and applications to trajectory simulation, least squares, and numerical optimization. Introduction to linear algebra: matrix operations, systems of algebraic equations with applications to coordinate transformations and equilibrium problems. Integral vector calculus: multiple integrals in Cartesian, cylindrical, and spherical coordinates, line integrals, scalar potential, surface integrals, Green's, divergence, and Stokes' theorems. Numerous examples and applications drawn from classical mechanics, fluid dynamics and electromagnetism. Prerequisites: knowledge of single-variable calculus equivalent to the content of Math 19-21 (e.g., 5 on Calc BC, 4 on Calc BC with Math 21, 5 on Calc AB with Math 21). Placement diagnostic (recommendation non-binding) at: <https://exploreddegrees.stanford.edu/undergraduatedegreesandprograms/#aptex>.

Same as: CME 100

**ENGR 155A. Ordinary Differential Equations for Engineers. 5 Units.**

Analytical and numerical methods for solving ordinary differential equations arising in engineering applications are presented. For analytical methods students learn to solve linear and non-linear first order ODEs; linear second order ODEs; and Laplace transforms. Numerical methods using MATLAB programming tool kit are also introduced to solve various types of ODEs including: first and second order ODEs, higher order ODEs, systems of ODEs, initial and boundary value problems, finite differences, and multi-step methods. This also includes accuracy and linear stability analyses of various numerical algorithms which are essential tools for the modern engineer. This class is foundational for professional careers in engineering and as a preparation for more advanced classes at the undergraduate and graduate levels. Prerequisites: knowledge of single-variable calculus equivalent to the content of Math 19-21 (e.g., 5 on Calc BC, 4 on Calc BC with Math 21, 5 on Calc AB with Math 21). Placement diagnostic (recommendation non-binding) at: <https://exploreddegrees.stanford.edu/undergraduatedegreesandprograms/#aptex>.

Same as: CME 102

**ENGR 155B. Linear Algebra and Partial Differential Equations for Engineers. 5 Units.**

Linear algebra: systems of algebraic equations, Gaussian elimination, undetermined and overdetermined systems, coupled systems of ordinary differential equations, LU factorization, eigensystem analysis, normal modes. Linear independence, vector spaces, subspaces and basis. Numerical analysis applied to structural equilibrium problems, electrical networks, and dynamic systems. Fourier series with applications, partial differential equations arising in science and engineering, analytical solutions of partial differential equations. Applications in heat and mass transport, mechanical vibration and acoustic waves, transmission lines, and fluid mechanics. Numerical methods for solution of partial differential equations: iterative techniques, stability and convergence, time advancement, implicit methods, von Neumann stability analysis. Examples and applications drawn from a variety of engineering fields. Prerequisite: CME102/ENGR155A.

Same as: CME 104

**ENGR 155C. Introduction to Probability and Statistics for Engineers. 4 Units.**

Probability: random variables, independence, and conditional probability; discrete and continuous distributions, moments, distributions of several random variables. Numerical simulation using Monte Carlo techniques. Topics in mathematical statistics: random sampling, point estimation, confidence intervals, hypothesis testing, non-parametric tests, regression and correlation analyses. Numerous applications in engineering, manufacturing, reliability and quality assurance, medicine, biology, and other fields. Prerequisite: CME100/ENGR154 or Math 51 or 52.

Same as: CME 106

**ENGR 159Q. Japanese Companies and Japanese Society. 3 Units.**

Preference to sophomores. The structure of a Japanese company from the point of view of Japanese society. Visiting researchers from Japanese companies give presentations on their research enterprise. The Japanese research ethic. The home campus equivalent of a Kyoto SCTI course.

Same as: MATSCI 159Q

**ENGR 177A. Engineering and Sustainable Development: Toolkit. 1-3 Unit.**

The first of a two-quarter, project-based course sequence that address cultural, sociopolitical, organizational, technical, and ethical issues at the heart of implementing sustainable engineering projects in a developing world. Students work in interdisciplinary project teams to tackle real-world design challenges in partnership with social entrepreneurs, local communities, and/or NGOs. While students must have the skills and aptitude necessary to make meaningful contributions to technical product designs, the course is open to all backgrounds and majors. The first quarter focuses on cultural awareness, ethical implications, user requirements, conceptual design, feasibility analysis, and implementation planning. Admission is by application. Students should plan to enroll in CEE 177S/277S (ENGR 177B/277B) Engineering & Sustainable Development: Implementation following successful completion of this course. Designated a Cardinal Course by the Haas Center for Public Service. To satisfy a Ways requirement, students must register for an undergraduate course number (CEE 177S or ENGR 177A) and this course must be taken for at least 3 units. In AY 2020-21, a letter grade or 'CR' grade satisfies the Ways requirement.

Same as: CEE 177X, CEE 277X, ENGR 277A

**ENGR 177B. Engineering and Sustainable Development. 1-3 Unit.**

The second of a two-quarter, project-based course sequence that address cultural, political, organizational, technical and business issues at the heart of implementing sustainable engineering projects in the developing world. Students work in interdisciplinary project teams to tackle real-world design challenges in partnership with social entrepreneurs and/or NGOs. This quarter focuses on implementation, evaluation, and deployment of the designs developed in the winter quarter. Designated a Cardinal Course by the Haas Center for Public Service.

Same as: CEE 177S, CEE 277S, ENGR 277B

**ENGR 192. Engineering Public Service Project. 1-2 Unit.**

Volunteer work on a public service project with a technical engineering component. Project requires a faculty sponsor and a community partner such as a nonprofit organization, school, or individual. Required report. See <http://soe.stanford.edu/publicservice>. May be repeated for credit. Prerequisite: consent of instructor.

**ENGR 193. Discover Engineering: How to Aim High, Embrace Uncertainty, and Achieve Impact. 1 Unit.**

This weekly seminar will provide students of all engineering majors with practical leadership skills training (e.g. how to network, advocate for yourself, assert influence) in order to make innovative and meaningful contributions in their fields. Career exploration and mentorship opportunities will be delivered through an inspiring line up of guest speakers and interactive activities, demonstrations and tours. May be repeat for credit.

**ENGR 199. Special Studies in Engineering. 1-15 Unit.**

Special studies, lab work, or reading under the direction of a faculty member. Often research experience opportunities exist in ongoing research projects. Students make arrangements with individual faculty and enroll in the section number corresponding to the particular faculty member. May be repeated for credit. Prerequisite: consent of instructor.

**ENGR 199A. Additional Calculus for Engineers. 1 Unit.**

Additional problem solving practice for the calculus courses. Sections are designed to allow students to acquire a deeper understanding of calculus and its applications, work collaboratively, and develop a mastery of the material. Limited enrollment, permission of instructor required. Concurrent enrollment in MATH 19, 20, 52, or 53 required.

**ENGR 199W. Writing of Original Research for Engineers. 1-3 Unit.**

Technical writing in science and engineering. Students produce a substantial document describing their research, methods, and results. Prerequisite: completion of freshman writing requirements; prior or concurrent in 2 units of research in the major department; and consent of instructor. WIM for select School of Engineering majors with permission from advisor.

**ENGR 20. Introduction to Chemical Engineering. 4 Units.**

Overview of chemical engineering through discussion and engineering analysis of physical and chemical processes. Topics: overall staged separations, material and energy balances, concepts of rate processes, energy and mass transport, and kinetics of chemical reactions. Applications of these concepts to areas of current technological importance: biotechnology, energy, production of chemicals, materials processing, and purification. Prerequisite: CHEM 31. Same as: CHEMENG 20

**ENGR 202C. Technical Communication for CEE SDC Students. 3 Units.**

Students learn how to write and present technical information clearly, with a focus on how to draft and revise reader-centered professional documents. The course includes elements of effective oral communication and presentation. This offering for CEE SDC students only.

**ENGR 202S. Directed Writing Projects. 1 Unit.**

Individualized writing instruction for students working on writing projects such as dissertations, proposals, grant applications, theses, journal articles, conference papers, and teaching and research statements. Weekly one-on-one conferences with writing instructors from the Technical Communication Program. Students receive close attention to and detailed feedback on their writing. TCP Director assigns each student to an instructor. No prerequisite. Grading: Satisfactory/No Credit. This course may be repeated for credit.

**ENGR 202W. Technical Communication. 3 Units.**

This course focuses on how to write clear, concise, and organized technical writing. Through interactive presentations, group workshops, and individual conferences, students learn best practices for communicating to academic and professional audiences for a range of purposes.

**ENGR 203. Public Speaking. 3 Units.**

Priority to Engineering students. Introduction to speaking activities, from impromptu talks to carefully rehearsed formal professional presentations. How to organize and write speeches, analyze audiences, create and use visual aids, combat nervousness, and deliver informative and persuasive speeches effectively. Weekly class practice, rehearsals in one-on-one tutorials, videotaped feedback. Limited enrollment. Same as: ENGR 103

**ENGR 205. Introduction to Control Design Techniques. 3 Units.**

Review of root-locus and frequency response techniques for control system analysis and synthesis. State-space techniques for modeling, full-state feedback regulator design, pole placement, and observer design. Combined observer and regulator design. Lab experiments on computers connected to mechanical systems. Prerequisites: 105, MATH 103, 113. Recommended: Matlab.

**ENGR 207A. Linear Control Systems I. 3 Units.**

Introduction to control of discrete-time linear systems. State-space models. Controllability and observability. The linear quadratic regulator. Prerequisite: 105 or 205.

**ENGR 207B. Linear Control Systems II. 3 Units.**

Probabilistic methods for control and estimation. Statistical inference for discrete and continuous random variables. Linear estimation with Gaussian noise. The Kalman filter. Prerequisite: EE 263.

**ENGR 209A. Analysis and Control of Nonlinear Systems. 3 Units.**

Introduction to nonlinear phenomena: multiple equilibria, limit cycles, bifurcations, complex dynamical behavior. Planar dynamical systems, analysis using phase plane techniques. Describing functions. Lyapunov stability theory. SISO feedback linearization, sliding mode control. Design examples. Prerequisite: 205.

**ENGR 21. Engineering of Systems. 3 Units.**

A high-level look at techniques for analyzing and designing complex, multidisciplinary engineering systems, such as aircraft, spacecraft, automobiles, power plants, cellphones, robots, biomedical devices, and many others. The need for multi-level design, modeling and simulation approaches, computation-based design, and hardware and software-in-the-loop simulations will be demonstrated through a variety of examples and case studies. Several aspects of system engineering will be applied to the design of large-scale interacting systems and contrasted with subsystems such as hydraulic systems, electrical systems, and brake systems. The use of design-thinking, story-boarding, mockups, sensitivity analysis, simulation, team-based design, and the development of presentation skills will be fostered through several realistic examples in several fields of engineering.

**ENGR 210. Perspectives in Assistive Technology (ENGR 110). 1-2 Unit.**

Online seminar and student project course that explores the personal, medical, social, ethical, and technical challenges surrounding the design, development, and use of technologies that improve the lives of people with disabilities and older adults. Guest lecturers include engineers, clinicians, researchers, and individuals with disabilities. Students from any discipline are welcome to enroll. Two credit units for students who pursue an individual assistive technology project (letter grade or S/NC) with a community partner. One credit unit for seminar attendance only (S/NC). See course website <http://engr110.stanford.edu> for more information. Designated a Cardinal Course by the Haas Center for Public Service. Same as: ENGR 110

**ENGR 213. Solar Decathlon. 1-4 Unit.**

Open to all engineering majors. Project studio for all work related to the Solar Decathlon 2013 competition. Each student will develop a personal work plan for the quarter with his or her advisor and perform multidisciplinary collaboration on designing systems for the home or pre-construction planning. Work may continue through the summer as a paid internship, as well as through the next academic year. For more information about the team and the competition, please visit [solardecathlon.stanford.edu](http://solardecathlon.stanford.edu).

**ENGR 213A. Solar Decathlon 2015. 3 Units.**

Open to all majors. Seminar / Lab format course facilitates the student-led administration, conception, development, and execution of the Solar Decathlon 2015 competition entry sponsored by the US Department of Energy. (<http://www.solardecathlon.gov/>) Students shall learn best practices in creating design teams to address multi-disciplinary design problems. Students shall work both as individuals and in teams across multiple Stanford SD2015 phases of project management, research, fundraising, design, engineering, contracting, construction administration, and competitive testing in Irvine CA.

Same as: ENGR 113A

**ENGR 213B. Solar Decathlon 2015. 3 Units.**

Open to all majors. Seminar / Lab format course facilitates the student-led administration, conception, development, and execution of the Solar Decathlon 2015 competition entry sponsored by the US Department of Energy. (<http://www.solardecathlon.gov/>) Students shall learn best practices in creating design teams to address multi-disciplinary design problems. Students shall work both as individuals and in teams across multiple Stanford SD2015 phases of project management, research, fundraising, design, engineering, contracting, construction administration, and competitive testing in Irvine CA.

Same as: ENGR 113B

**ENGR 213C. Solar Decathlon 2015. 3 Units.**

Open to all majors. Seminar / Lab format course facilitates the student-led administration, conception, development, and execution of the Solar Decathlon 2015 competition entry sponsored by the US Department of Energy. (<http://www.solardecathlon.gov/>) Students shall learn best practices in creating design teams to address multi-disciplinary design problems. Students shall work both as individuals and in teams across multiple Stanford SD2015 phases of project management, research, fundraising, design, engineering, contracting, construction administration, and competitive testing in Irvine CA.

Same as: ENGR 113C

**ENGR 213D. SOLAR DECATHLON 2015. 3 Units.**

Open to all majors. Seminar / Lab format course facilitates the student-led administration, conception, development, and execution of the Solar Decathlon 2015 competition entry sponsored by the US Department of Energy. (<http://www.solardecathlon.gov/>) Students shall learn best practices in creating design teams to address multi-disciplinary design problems. Students shall work both as individuals and in teams across multiple Stanford SD2015 phases of project management, research, fundraising, design, engineering, contracting, construction administration, and competitive testing in Irvine CA.

Same as: ENGR 113D

**ENGR 215. Design the Tech Challenge. 2 Units.**

Students work with Tech Museum of San Jose staff to design the Tech Challenge, a yearly engineering competition for 6-12th grade students. Brainstorming, field trips to the museum, prototyping, coaching, and presentations to the Tech Challenge advisory board. See at <http://techchallenge.thetech.org>. May be repeated for credit.

Same as: ENGR 115

**ENGR 217. Expanding Engineering Limits: Culture, Diversity, and Equity. 3 Units.**

This course investigates how culture and diversity shape who becomes an engineer, what problems get solved, and the quality of designs, technology, and products. As a course community, we consider how cultural beliefs about race, ethnicity, gender, sexuality, abilities, socioeconomic status, and other intersectional aspects of identity interact with beliefs about engineering, influence diversity in the field, and affect equity in engineering education and practice. We also explore how engineering cultures and environments respond to and change with individual and institutional agency. The course involves weekly presentations by scholars and engineers, readings, short writing assignments, small-group discussion, and hands-on, student-driven projects. Students can enroll in the course for 1 unit (lectures only), or 3 units (lectures+discussion+project). For 1 unit, students should sign up for Section 1 and Credit/No Credit grading, and for 3 units students should sign up for Section 2 and either the C/NC or Grade option.

Same as: CSRE 117, CSRE 217, ENGR 117, FEMGEN 117, FEMGEN 217

**ENGR 219. Community Engagement Preparation Seminar. 1 Unit.**

This seminar is designed for engineering students who have already committed to an experiential learning program working directly with a community partner on a project of mutual benefit. This seminar is targeted at students participating in the Summer Service Learning Program offered through Stanford's Global Engineering Program.

Same as: ENGR 119

**ENGR 231. Transformative Design. 3 Units.**

Too many alums are doing what they've always been told they're good at, and are living with regret and a sense that they're just resigned to doing this thing for the rest of their lives. Capabilities displaced their values as the primary decision driver in their lives. Our ultimate goal is to restore a sense of agency and passion into the lives of current Stanford students by creating the space to explore and experiment with the greatest design project possible: YOUR LIFE. We will turn d.school tools and mindsets onto the topic of our lives -- not in theory, but in reality -- and will prototype changes to make your life and career more fulfilling and rewarding. We will actively empathize and experiment in your life and work, so if you don't want to do that kind of self-examination, this class will not be a good fit for you.

**ENGR 240. Introduction to Micro and Nano Electromechanical Systems. 3 Units.**

Miniaturization technologies now have important roles in materials, mechanical, and biomedical engineering practice, in addition to being the foundation for information technology. This course will target an audience of first-year engineering graduate students and motivated senior-level undergraduates, with the goal of providing an introduction to M/NEMS fabrication techniques, selected device applications, and the design tradeoffs in developing systems. The course has no specific prerequisites, other than graduate or senior standing in engineering; otherwise, students will require permission of the instructors.

**ENGR 241. Advanced Micro and Nano Fabrication Laboratory. 3 Units.**

This project course focuses on developing processes for ExFab, a shared facility that supports flexible lithography, heterogeneous integration, and rapid micro prototyping. Team projects are approved by the instructor and are mentored by an ExFab staff member. Students will plan and execute experiments and document them in a final presentation and report, to be made available on the lab's Wiki for the benefit of the Stanford research community. This year's offering of ENGR241 will span two quarters: students interested in taking this course must sign up for both fall and winter courses, and will be researching a single project over that time. Students must consult with Prof. Fan or the SNF staff before signing up. For Autumn 18-19, the course will meet from 4:00pm-5:50pm in Allen 101X (note the start time).

**ENGR 243. LAW, TECHNOLOGY, AND LIBERTY. 2 Units.**

New technologies from gene editing to networked computing have already transformed our economic and social structures and are increasingly changing what it means to be human. What role has law played in regulating and shaping these technologies? And what role can and should it play in the future? This seminar will consider these and related questions, focusing on new forms of networked production, the new landscape of security and scarcity, and the meaning of human nature and ecology in an era of rapid technological change. Readings will be drawn from a range of disciplines, including science and engineering, political economy, and law. The course will feature several guest speakers. There are no formal prerequisites in either engineering or law, but students should be committed to pursuing novel questions in an interdisciplinary context. The enrollment goal is to balance the class composition between law and non-law students. Elements used in grading: Attendance, Class Participation, Written Assignments. **CONSENT APPLICATION:** To apply for this course, students must complete and submit a Consent Application Form available on the SLS website (Click Courses at the bottom of the homepage and then click Consent of Instructor Forms). See Consent Application Form for instructions and submission deadline. This course is cross-listed with the School of Engineering (TBA). May be repeat for credit.

Same as: BIOE 242

**ENGR 245. The Lean LaunchPad: Getting Your Lean Startup Off the Ground. 3-4 Units.**

Learn how to turn a technical idea from a lab, research, or vision into a successful business using the Lean Launchpad process (business model canvas, customer development, running experiments, and agile engineering.) Hands-on experiential class. 15+ hours per week talking to customers, regulators and partners outside the classroom, plus time building minimal viable products. This class is the basis of the National Science Foundation I-Corps  $\zeta$  with a focus on understanding all the components to build for deep technology and life science applications. Team applications required in March. Proposals may be software, hardware, or service of any kind. See course website <http://leanlaunchpad.stanford.edu/>. Prerequisite: interest in and passion for exploring whether your technology idea can become a real company. Limited enrollment.

**ENGR 248. Principled Entrepreneurial Decisions. 3 Units.**

Examines how leaders tackle significant events that occur in high-growth entrepreneurial companies. Students prepare their minds for the difficult entrepreneurial situations that they will encounter in their lives in whatever their chosen career. Cases and guest speakers discuss not only the business rationale for the decisions taken but also how their principles affected those decisions. The teaching team brings its wealth of experience in both entrepreneurship and VC investing to the class. Previous entrepreneurship coursework or experience preferred. Limited enrollment. Admission by application: <http://web.stanford.edu/class/engr248/apply>.

Same as: ENGR 148

**ENGR 250. Data Challenge Lab. 1-6 Unit.**

In this lab, students develop the practical skills of data science by solving a series of increasingly difficult, real problems. Skills developed include: data manipulation, exploratory data analysis, data visualization, and predictive modeling. The data challenges each student undertakes are based upon their current skills. Students receive one-on-one coaching and see how expert practitioners solve the same challenges. Prerequisite: ENGR150. Limited enrollment; application required. May be repeated for credit. See <http://datalab.stanford.edu> for more information.

**ENGR 277A. Engineering and Sustainable Development: Toolkit. 1-3 Unit.**

The first of a two-quarter, project-based course sequence that address cultural, sociopolitical, organizational, technical, and ethical issues at the heart of implementing sustainable engineering projects in a developing world. Students work in interdisciplinary project teams to tackle real-world design challenges in partnership with social entrepreneurs, local communities, and/or NGOs. While students must have the skills and aptitude necessary to make meaningful contributions to technical product designs, the course is open to all backgrounds and majors. The first quarter focuses on cultural awareness, ethical implications, user requirements, conceptual design, feasibility analysis, and implementation planning. Admission is by application. Students should plan to enroll in CEE 177S/277S (ENGR 177B/277B) Engineering & Sustainable Development: Implementation following successful completion of this course. Designated a Cardinal Course by the Haas Center for Public Service. To satisfy a Ways requirement, students must register for an undergraduate course number (CEE 177S or ENGR 177A) and this course must be taken for at least 3 units. In AY 2020-21, a letter grade or 'CR' grade satisfies the Ways requirement.

Same as: CEE 177X, CEE 277X, ENGR 177A

**ENGR 277B. Engineering and Sustainable Development. 1-3 Unit.**

The second of a two-quarter, project-based course sequence that address cultural, political, organizational, technical and business issues at the heart of implementing sustainable engineering projects in the developing world. Students work in interdisciplinary project teams to tackle real-world design challenges in partnership with social entrepreneurs and/or NGOs. This quarter focuses on implementation, evaluation, and deployment of the designs developed in the winter quarter. Designated a Cardinal Course by the Haas Center for Public Service.

Same as: CEE 177S, CEE 277S, ENGR 177B

**ENGR 280. From Play to Innovation. 2-4 Units.**

Focus is on enhancing the innovation process with playfulness. The class will be project-based and team-centered. We will investigate the human "state of play" to reach an understanding of its principal attributes and how important it is to creative thinking. We will explore play behavior, its development, and its biological basis. We will then apply those principles through design thinking to promote innovation in the corporate world. Students will work with real-world partners on design projects with widespread application. This course requires an application. You can find the application here: [dschool.stanford.edu/classes](http://dschool.stanford.edu/classes).

**ENGR 281. d.media - Designing Media that Matters. 2-3 Units.**

The combination of always-on smartphones, instant access to information and global social sharing is changing behavior and shifting cultural norms. How can we design digital experiences that make this change positive? Join the d.media team and find out! This course is project-based and hands-on. Three projects will explore visual design, interaction design and behavioral design all in the context of today's technology landscape and in service of a socially positive user experience. See <http://dmedia.stanford.edu>, Admission by application. See [dschool.stanford.edu/classes](http://dschool.stanford.edu/classes) for more information.

**ENGR 295. Learning & Teaching of Science. 3 Units.**

This course will provide students with a basic knowledge of the relevant research in cognitive psychology and science education and the ability to apply that knowledge to enhance their ability to learn and teach science, particularly at the undergraduate level. Course will involve readings, discussion, and application of the ideas through creation of learning activities. It is suitable for advanced undergraduates and graduate students with some science background.

Same as: EDUC 280, MED 270, PHYSICS 295, VPTL 280

**ENGR 298. Seminar in Fluid Mechanics. 1 Unit.**

Interdepartmental. Problems in all branches of fluid mechanics, with talks by visitors, faculty, and students. Graduate students may register for 1 unit, without letter grade; a letter grade is given for talks. May be repeated for credit.

**ENGR 299. Special Studies in Engineering. 1-15 Unit.**

Special studies, lab work, or reading under the direction of a faculty member. Often research experience opportunities exist in ongoing research projects. Students make arrangements with individual faculty and enroll in the corresponding section. Prerequisite: consent of instructor.

**ENGR 2A. SSEA Seminar: Developing Your Leadership Toolkit. 1 Unit.**

In this weekly seminar, SSEA students will learn practical leadership skills so they can successfully navigate academic and professional opportunities while at Stanford and achieve meaningful results. Mentorship and career exploration will also be delivered through an inspiring line up of guest speakers and interactive activities.

**ENGR 311A. Women's Perspectives. 1 Unit.**

Graduate seminar series, driven by student interests, with guest speakers from academia and industry. Previous themes have included Finding your North, Becoming Fearless, Daydreams to Reality, and Letters to My Younger Self. Discussion is encouraged as graduate students share experiences and learn with speakers and each other. Possible topics of discussion range from time management and career choices to diversity, health, and family. Several optional informal dinners are hosted after the seminar to continue conversation with the speakers. May be repeated for credit.

**ENGR 311B. Designing the Professional. 1 Unit.**

Wondering how to weave together what really fits you, is doable, and will be satisfying and meaningful? Have more questions than answers? Have too many ideas for your career, or not enough? This course applies the mindsets and innovation principles of design thinking to the "wicked problem" of designing your life and vocation. Students gain awareness and empathy, define areas of life and work on which they want to work, ideate about ways to move forward, try small prototypes, and test their assumptions. The course is highly interactive. It will conclude with creation of 3 versions of the next 5 years and prototype ideas to begin making those futures a reality. The course will include brief readings, writing, reflections, and in-class exercises. Expect to practice ideation and prototyping methodologies, decision making practices and to participate in interactive activities in pairs, trios, and small groups. Seminar open to all graduate students and Postdocs in all 7 schools.

**ENGR 311D. Portfolio to Professional: Supporting the Development of Digital Presence Through ePortfolios. 1 Unit.**

This course guides graduate students in creating a professional ePortfolio and establishing an online presence. The course includes seminar-style presentations and discussions, opportunities for feedback with career mentors, classmates, alumni, employers, and other community members using think-aloud protocols and peer review approaches. Curriculum modules focus on strategies for telling your story in the digital environment, platform considerations, evidence and architecture, visual design and user experience. Open to all graduate students and majors.

**ENGR 312. Science and Engineering Course Design. 2-3 Units.**

For students interested in an academic career and who anticipate designing science or engineering courses at the undergraduate or graduate level. Goal is to apply research on science and engineering learning to the design of effective course materials. Topics include syllabus design, course content and format decisions, assessment planning and grading, and strategies for teaching improvement. Same as: CTL 312

**ENGR 313. Topics in Engineering and Science Education. 1-2 Unit.**

This seminar series focuses on topics related to teaching science, technology, engineering, and math (STEM) courses based on education research. Each year focuses on a different topic related to STEM education. This course may be repeated for credit each year. This year we will explore problem-based learning in STEM courses, particularly focusing on design and evaluation of problem-based learning activities. The course will involve in-class discussions, small group activities, and guest lectures. Throughout the quarter, there will be several opportunities for directly practicing and applying STEM education strategies to specific teaching goals in your field.

**ENGR 341. Micro/Nano Systems Design and Fabrication. 3-5 Units.**

Laboratory course in micro and nano fabrication technology that combines lectures on theory and fundamentals with hands-on training in the Stanford Nanofabrication Facility. Prerequisite: ENGR 240 or equivalent.

**ENGR 342. MEMS Laboratory II. 3-4 Units.**

Emphasis is on tools and methodologies for designing and fabricating N/MEMS-based solutions. Student interdisciplinary teams collaborate to invent, develop, and integrate N/MEMS solutions. Design alternatives fabricated and tested with emphasis on manufacturability, assembly, test, and design. Limited enrollment. Prerequisite: ENGR 341.

**ENGR 350. Data Impact Lab. 1-6 Unit.**

In this lab, multi-disciplinary teams of students tackle high-impact, unsolved problems for social sector partners. Teams receive mentorship and coaching from Stanford faculty, domain experts, and data science experts from industry. Sample projects include innovations for: poverty alleviation in the developing world, local government services, education, and healthcare. Limited enrollment; application required. May be repeated for credit. See <http://datalab.stanford.edu> for more information.

**ENGR 391. Engineering Education and Online Learning. 3 Units.**

A project based introduction to web-based learning design. In this course we will explore the evidence and theory behind principles of learning design and game design thinking. In addition to gaining a broad understanding of the emerging field of the science and engineering of learning, students will experiment with a variety of educational technologies, pedagogical techniques, game design principles, and assessment methods. Over the course of the quarter, interdisciplinary teams will create a prototype or a functioning piece of educational technology.

Same as: EDUC 391

**ENGR 395. Summer Opportunities in Engineering Research & Leadership. 1 Unit.**

Summer First provides Fellows from a range of engineering disciplines the opportunity to gain exposure to the wealth of resources on campus, and explore the research environment(s) in their own doctoral programs. This experience effectively serves as a supplementary research rotation for these graduate students, enabling them to explore research options over an additional quarter. Fellows also engage in small literature discussion groups, professional development workshops, excursions, mentoring opportunities, and social activities as a mechanism for fostering a sense of belonging and community. Fellows are incoming first year PhD students nominated by their departments. Instructor permission required.

**ENGR 40A. Introductory Electronics. 3 Units.**

Instruction will be completed in the first seven weeks of the quarter. Students not majoring in Electrical Engineering may choose to take only ENGR 40A; Electrical Engineering majors should take both ENGR 40A and ENGR 40B. Overview of electronic circuits and applications. Electrical quantities and their measurement, including operation of the oscilloscope. Basic models of electronic components including resistors, capacitors, inductors, and operational amplifiers. Lab. Lab assignments. Enrollment limited to 300.

**ENGR 40B. Introductory Electronics Part II. 2 Units.**

Instruction will be completed in the final three weeks of the quarter. Students should not enroll in ENGR 40B without having taken (or enrolling concurrently in) ENGR 40A. Project on digital hardware and software implementations of a robotic car. Lab. Lab assignments. Pre- or co-requisite: ENGR 40A. Enrollment limited to 300.

**ENGR 40M. An Intro to Making: What is EE. 5 Units.**

Is a hands-on class where students learn to make stuff. Through the process of building, you are introduced to the basic areas of EE. Students build a "useless box" and learn about circuits, feedback, and programming hardware, a light display for your desk and bike and learn about coding, transforms, and LEDs, a solar charger and an EKG machine and learn about power, noise, feedback, more circuits, and safety. And you get to keep the toys you build. Prerequisite: CS 106A.

**ENGR 42. Introduction to Electromagnetics and Its Applications. 5 Units.**

Electricity and magnetism and its essential role in modern electrical engineering devices and systems, such as sensors, displays, DVD players, and optical communication systems. The topics that will be covered include electrostatics, magnetostatics, Maxwell's equations, one-dimensional wave equation, electromagnetic waves, transmission lines, and one-dimensional resonators. Pre-requisites: none.

Same as: EE 42

**ENGR 50. Introduction to Materials Science, Nanotechnology Emphasis. 4 Units.**

The structure, bonding, and atomic arrangements in materials leading to their properties and applications. Topics include electronic and mechanical behavior, emphasizing nanotechnology, solid state devices, and advanced structural and composite materials.

**ENGR 50E. Introduction to Materials Science, Energy Emphasis. 4 Units.**

Materials structure, bonding and atomic arrangements leading to their properties and applications. Topics include electronic, thermal and mechanical behavior; emphasizing energy related materials and challenges.

**ENGR 50M. Introduction to Materials Science, Biomaterials Emphasis. 4 Units.**

Topics include: the relationship between atomic structure and macroscopic properties of man-made and natural materials; mechanical and thermodynamic behavior of surgical implants including alloys, ceramics, and polymers; and materials selection for biotechnology applications such as contact lenses, artificial joints, and cardiovascular stents. No prerequisite.

**ENGR 60. Engineering Economics and Sustainability. 3 Units.**

Engineering Economics is a subset of the field of economics that draws upon the logic of economics, but adds that analytical power of mathematics and statistics. The concepts developed in this course are broadly applicable to many professional and personal decisions, including making purchasing decisions, deciding between project alternatives, evaluating different processes, and balancing environmental and social costs against economic costs. The concepts taught in this course will be increasingly valuable as students climb the career ladder in private industry, a non-governmental organization, a public agency, or in founding their own startup. Eventually, the ability to make informed decisions that are based in fundamental analysis of alternatives is a part of every career. As such, this course is recommended for engineering and non-engineering students alike. This course is taught exclusively online in every quarter it is offered. (Prerequisites: MATH 19 or 20 or approved equivalent.).

Same as: CEE 146S

**ENGR 62. Introduction to Optimization. 3-4 Units.**

Formulation and computational analysis of linear, quadratic, and other convex optimization problems. Applications in machine learning, operations, marketing, finance, and economics. Prerequisite: CME 100 or MATH 51.

Same as: MS&E 111, MS&E 211

**ENGR 62X. Introduction to Optimization (Accelerated). 3-4 Units.**

Optimization theory and modeling. The role of prices, duality, optimality conditions, and algorithms in finding and recognizing solutions. Perspectives: problem formulation, analytical theory, computational methods, and recent applications in engineering, finance, and economics. Theories: finite dimensional derivatives, convexity, optimality, duality, and sensitivity. Methods: simplex and interior-point, gradient, Newton, and barrier. Prerequisite: CME 100 or MATH 51 or equivalent.

Same as: MS&E 111X, MS&E 211X

**ENGR 76. Information Science and Engineering. 4 Units.**

What is information? How can we measure and efficiently represent it? How can we reliably communicate and store it over media prone to noise and errors? How can we make sound decisions based on partial and noisy information? This course introduces the basic notions required to address these questions, as well as the principles and techniques underlying the design of modern information, communication, and decision-making systems with relations to and applications in machine-learning, through genomics, to neuroscience. Students will get a hands-on appreciation of the concepts via projects in small groups, where they will develop their own systems for streaming of multi-media data under human-centric performance criteria. Prerequisite: CS 106A.

**ENGR 80. Introduction to Bioengineering (Engineering Living Matter). 4 Units.**

Students completing BIOE.80 should have a working understanding for how to approach the systematic engineering of living systems to benefit all people and the planet. Our main goals are (1) to help students learn ways of thinking about engineering living matter and (2) to empower students to explore the broader ramifications of engineering life. Specific concepts and skills covered include but are not limited to: capacities of natural life on Earth; scope of the existing human-directed bioeconomy; deconstructing complicated problems; reaction & diffusion systems; microbial human anatomy; conceptualizing the engineering of biology; how atoms can be organized to make molecules; how to print DNA from scratch; programming genetic sensors, logic, & actuators; biology beyond molecules (photons, electrons, etc.); what constraints limit what life can do?; what will be the major health challenges in 2030?; how does what we want shape bioengineering?; who should choose and realize various competing bioengineering futures?.

Same as: BIOE 80

**ENGR 90. Environmental Science and Technology. 3 Units.**

Introduction to environmental quality and the technical background necessary for understanding environmental issues, controlling environmental degradation, and preserving air and water quality. Material balance concepts for tracking substances in the environmental and engineering systems.

Same as: CEE 70