UC San Diego

JACOBS SCHOOL OF ENGINEERING

Shu Chien-Gene Lay Department of Bioengineering

Bioengineering: Biotechnology (BE27)
Triton Day 2023 Information Packet

Packet Contents

The UCSD Department of Bioengineering

Mission Statement

To provide our students with an excellent education that enables successful, innovative, and lifelong careers in bioengineering industries and professions.

Student Learning Outcomes

Upon completion of the Bioengineering Program, graduates in Bioengineering; Bioengineering: Biotechnology; Bioengineering: BioSystems; and Bioengineering: Bioinformatics are expected to have the desired knowledge, skills, attitudes, and behaviors as indicated below.

- An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.
- An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.
- An ability to communicate effectively with a range of audiences.
- An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.
- An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment , establish goals, plan tasks, and meet objectives.
- An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.
- An ability to acquire and apply new knowledge as needed, using appropriate learning strategies.
- An ability to develop innovative thinking to solve bioengineering problems with creativity and entrepreneurship.

Academic Integrity and Research Ethics

The overall mission of the Dept. of Bioengineering is to provide students with an education that enables successful, innovative, and lifelong careers in bioengineering industries and professions, including a recognition of professional and social responsibilities, and sensitivity to ethical and health-related issues.

The UCSD Policy on Academic Integrity states the general rules for student integrity. It establishes the standards that apply to academic course work undertaken by all undergraduate and graduate students of this University. The policy is based on the fundamental tenet that the principle of honesty must be upheld if the integrity of scholarship is to be maintained by an academic community.

BIOENGINEERING: BIOTECHNOLOGY MAJOR ~ "NEW"

(*EFFECTIVE FALL 2015)*

Accredited by the Engineering Accreditation Commission of the Accreditation Board for Engineering & Technology [EAC/ABET]

(ALL COURSES REQUIRED FOR THE MAJOR MUST BE TAKEN FOR LETTER GRADES.)

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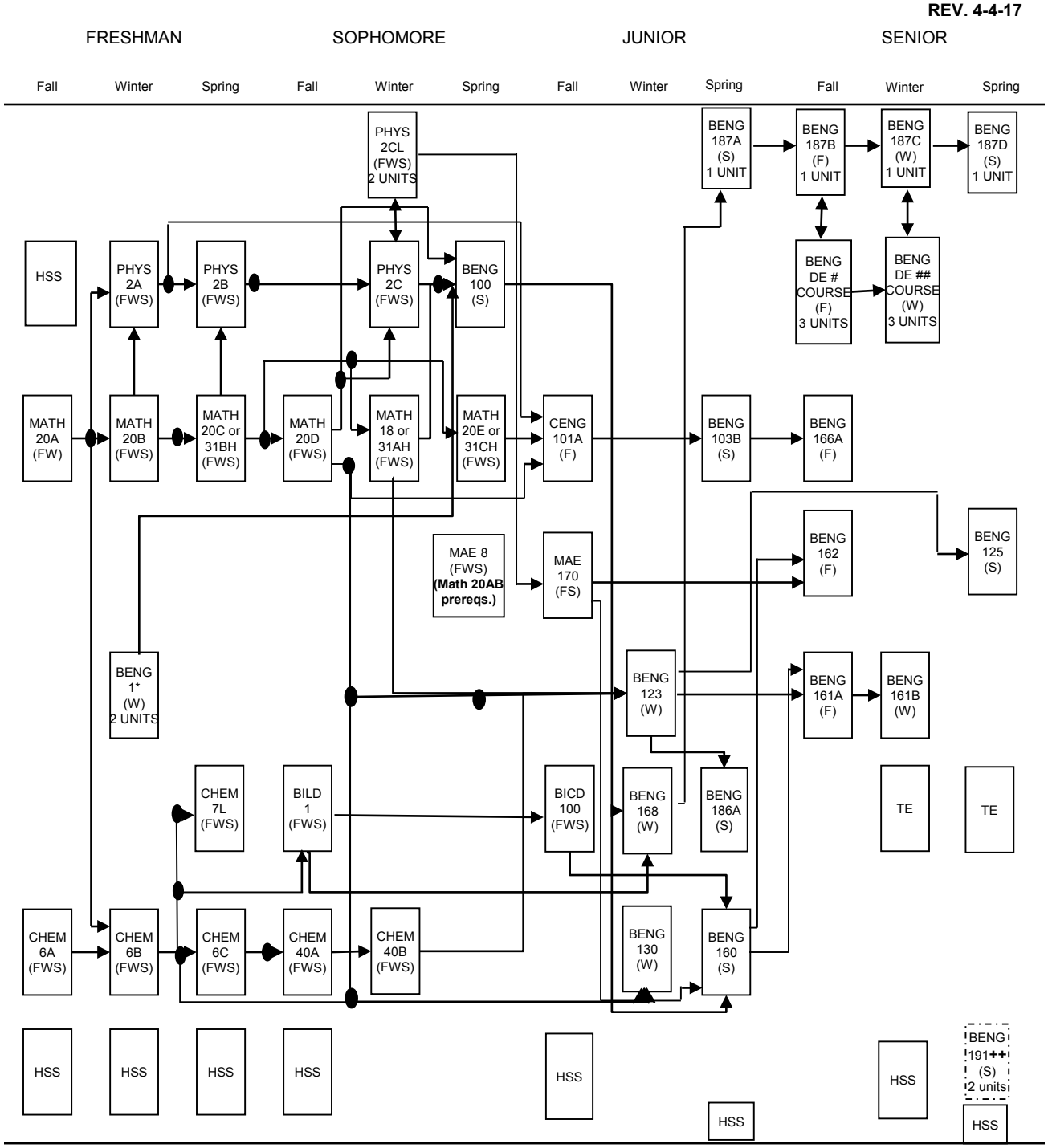

***BENG 1 must be taken.**

DE COURSES (FALL): BENG 119A, 126A,127A, 128A, 129A, 139A, 147A, 148A, 149A, 169A or 179A

DE COURSES (WTR.): BENG 119B, 126B, 127B, 128B, 129B, 139B, 147B, 148B, 149B, 169B or 179B

++BENG 191 may be taken once and is recommended for Juniors and Seniors, but not required.

Electives: BENG 196 (FWS), BENG 199 (FWS)

Biotechnology Major Requirements

(Note: All descriptions and prerequisites are from the 2022-23 Course Catalog.)

Freshman Year Courses

Fall Quarter

MATH 20A. Calculus for Science and Engineering (4) Foundations of differential and integral calculus of one variable. Functions, graphs, continuity, limits, derivative, tangent line. Applications with algebraic, exponential, logarithmic, and trigonometric functions. Introduction to the integral. (Two credits given if taken after MATH 1A/10A and no credit given if taken after MATH 1B/10B or MATH 1C/10C. Formerly numbered MATH 2A.) ***Prerequisites*:** Math Placement Exam qualifying score, or AP Calculus AB score of 3 (or equivalent AB subscore on BC exam), or SAT II MATH 2C score of 650 or higher, or MATH 4C or MATH 10A.

CHEM 6A. General Chemistry I (4) First quarter of a three-quarter sequence intended for science and engineering majors. Topics include atomic theory, bonding, molecular geometry, stoichiometry, types of reactions, and thermochemistry. May not be taken for credit after CHEM 6AH. Recommended: proficiency in high school chemistry and/or physics. ***Corequisite:*** MATH 10A or 20A or prior enrollment.

PHYS 2A. Physics—Mechanics (4) A calculus-based science-engineering general physics course covering vectors, motion in one and two dimensions, Newton's first and second laws, work and energy, conservation of energy, linear momentum, collisions, rotational kinematics, rotational dynamics, equilibrium of rigid bodies, oscillations, gravitation. Students continuing to PHYS 2B/4B will also need MATH 20B. ***Prerequisites**:* MATH 10A-B or 20A or 20B or 20C or 31BH. Recommended preparation: prior or concurrent enrollment in MATH 20B.

Winter Quarter

MATH 20B. Calculus for Science and Engineering (4) Integral calculus of one variable and its applications, with exponential, logarithmic, hyperbolic, and trigonometric functions. Methods of integration. Infinite series. Polar coordinates in the plane and complex exponentials. (Two units of credits given if taken after MATH 1B/10B or MATH 1C/10C.) ***Prerequisites:*** AP Calculus AB score of 4 or 5, or AP Calculus BC score of 3, or MATH 20A with a grade of C– or better, or MATH 10B with a grade of C– or better, or MATH 10C with a grade of C– or better.

BENG 1. Introduction to Bioengineering (2) An introduction to bioengineering that includes lectures and hands-on laboratory for design projects. The principles of problem definition, engineering inventiveness, team design, prototyping, and testing, as well as information access, engineering standards, communication, ethics, and social responsibility will be emphasized. P/NP grades only. ***Prerequisites**:* none. (W)

CHEM 6B. General Chemistry II (4) Second quarter of a three-quarter sequence intended for science and engineering majors. Topics include gases, liquids, and solids, thermochemistry and thermodynamics, physical and chemical equilibria, solubility. May not be taken for credit after CHEM 6BH. *Prerequisites:* CHEM 6A or 6AH and MATH 10A or 20A. Recommended: concurrent or prior enrollment in MATH 10B or 20B.

Spring Quarter

MATH 20C. Calculus and Analytic Geometry for Science and Engineering (4) Vector geometry, vector functions and their derivatives. Partial differentiation. Maxima and minima. Double integration. (Two units of credit given if taken after MATH 10C. Credit not offered for both MATH 20C and 31BH. Formerly numbered MATH 21C.) ***Prerequisites:*** AP Calculus BC score of 4 or 5, or MATH 20B with a grade of C– or better.

PHYS 2B. Physics—Electricity and Magnetism (4) Continuation of PHYS 2A covering charge and matter, the electric field, Gauss's law, electric potential, capacitors and dielectrics, current and resistance, electromotive force and circuits, the magnetic field, Ampere's law, Faraday's law, inductance, electromagnetic oscillations, alternating currents and Maxwell's equations. Students continuing to PHYS 2C will also need MATH 20C or 31BH. ***Prerequisites**:* PHYS 2A or 4A and MATH 20B or 20C or 31BH. Recommended preparation: prior or concurrent enrollment in MATH 20C or 31BH.

CHEM 6C. General Chemistry III (4) Third quarter of a three-quarter sequence intended for science and engineering majors. Topics include kinetics, acid-base equilibria, electrochemistry, coordination chemistry, and an

introduction to nuclear chemistry. May not be taken for credit after CHEM 6CH. ***Prerequisites:*** CHEM 6B or 6BH. Recommended: completion of MATH 10B or 20B.

CHEM 7L. General Chemistry Laboratory (4) Condenses a year of introductory training in analytical, inorganic, physical, and synthetic techniques into one intensive quarter. A materials fee is required. A mandatory safety exam must be passed. Students may not receive credit for both CHEM 7L and CHEM 7LM. ***Prerequisites:*** CHEM 6B or CHEM 6BH.

Sophomore Year Courses

Fall Quarter

MATH 20D. Introduction to Differential Equations (4) Ordinary differential equations: exact, separable, and linear; constant coefficients, undetermined coefficients, variations of parameters. Systems. Series solutions. Laplace transforms. Techniques for engineering sciences. Computing symbolic and graphical solutions using Matlab. (Formerly numbered MATH 21D.) May be taken as repeat credit for MATH 21D. ***Prerequisites****:* MATH 20C (or MATH 21C) or MATH 31BH with a grade of C– or better.

BILD 1. The Cell (4) An introduction to cellular structure and function, to biological molecules, bioenergetics, to the genetics of both prokaryotic and eukaryotic organisms, and to the elements of molecular biology. Recommended preparation: prior completion of high school- or college-level chemistry course.

CHEM 40A. Organic Chemistry I (4) Renumbered from CHEM 140A. Introduction to organic chemistry with applications to biochemistry. Bonding theory, isomerism, stereochemistry, chemical and physical properties. Introduction to substitution, addition, and elimination reactions. Students may only receive credit for one of the following: CHEM 40A, 40AH, 140A, or 140AH. ***Prerequisites****:* CHEM 6B or CHEM 6BH.

Winter Quarter

PHYS 2C. Physics—Fluids, Waves, Thermodynamics, and Optics (4) Continuation of PHYS 2B covering fluid mechanics, waves in elastic media, sound waves, temperature, heat and the first law of thermodynamics, kinetic theory of gases, entropy and the second law of thermodynamics, Maxwell's equations, electromagnetic waves, geometric optics, interference and diffraction. Students continuing to PHYS 2D will need MATH 20D. ***Prerequisites:*** PHYS 2A or 4A, and MATH 20C or 31BH. Recommended preparation: prior or concurrent enrollment in MATH 20D. Prior completion of PHYS 2B is strongly recommended.

PHYS 2CL. Physics Laboratory—Electricity and Magnetism (2) Experiments on L-R-C circuits; oscillations, resonance and damping, measurement of magnetic fields. One hour lecture and three hours laboratory. Program or materials fee may apply. ***Prerequisites****:* PHYS 2A or 4A, and 2B or 4C. Recommended preparation: prior or concurrent enrollment in PHYS 2C or 4D.

MATH 18. Linear Algebra (4) Matrix algebra, Gaussian elimination, determinants. Linear and affine subspaces, bases of Euclidean spaces. Eigenvalues and eigenvectors, quadratic forms, orthogonal matrices, diagonalization of symmetric matrices. Applications. Computing symbolic and graphical solutions using Matlab. Students may not receive credit for both MATH 18 and 31AH. ***Prerequisites:*** Math Placement Exam qualifying score, or AP Calculus AB score of 3 (or equivalent AB subscore on BC exam), or SAT II Math Level 2 score of 650 or higher, or MATH 4C, or MATH 10A, or MATH 20A. Students who have not completed listed prerequisites may enroll with consent of instructor.

CHEM 40B. Organic Chemistry II (4) Renumbered from CHEM 140B. Continuation of CHEM 40A, Organic Chemistry I. Methods of analysis, chemistry of hydrocarbons, chemistry of the carbonyl group. Introduction to the reactions of biologically important molecules. Students may only receive credit for one of the following: CHEM 40B, 40BH, 140B, or 140BH. ***Prerequisites****:* CHEM 40A or 140A (a grade of C or higher in CHEM 140A or 40A is strongly recommended).

Spring Quarter

BENG 100. Introduction to Bioengineering Design (4) General introduction to probability and statistical analysis, applied to bioengineering design. Topics include preliminary data analysis, probabilistic models, experiment design, model fitting, goodness-of-fit analysis, and statistical inference/estimation. Written and software problems are

provided for modeling and visualization. ***Prerequisites:*** BENG 1, MATH 18 or MATH 31AH or MATH 20F, MATH 20C or MATH 31BH, and MATH 20D, and PHYS 2A-B-C, or consent of department. (S)

MAE 8. Matlab Programming for Engineering Analysis (4) Computer programming in Matlab with elementary numerical analysis of engineering problems. Arithmetic and logical operations, arrays, graphical presentation of computations, symbolic mathematics, solutions of equations, and introduction to data structures. ***Prerequisites****:* MATH 20A and 20B or consent of instructor.

MATH 20E. Vector Calculus (4) Change of variable in multiple integrals, Jacobian, Line integrals, Green's theorem. Vector fields, gradient fields, divergence, curl. Spherical/cylindrical coordinates. Taylor series in several variables. Surface integrals, Stoke's theorem. Gauss' theorem. Conservative fields. ***Prerequisites****:* MATH 18 or MATH 20F or MATH 31AH and MATH 20C (or MATH 21C) or MATH 31BH with a grade of C– or better.

Junior Year Courses

Fall Quarter

CENG 101A. Introductory Fluid Mechanics (4) Kinematics and equation of motion; hydrostatics; Bernoulli's equation; viscous flows; turbulence, pipe flow; boundary layers and drag in external flows; applications to chemical, structural, and bioengineering. Students may not receive credit for both MAE 101A and CENG 101A. ***Prerequisites:*** admission to the major and grades of C– or better in PHYS 2A, MATH 20D, and 20E, or consent of instructor.

MAE 170. Experimental Techniques (4) Principles and practice of measurement and control and the design and conduct of experiments. Technical report writing. Lectures relate to dimensional analysis, error analysis, signal-to-noise problems, filtering, data acquisition and data reduction, as well as background of experiments and statistical analysis. Experiments relate to the use of electronic devices and sensors. ***Prerequisites****:* PHYS 2C or PHYS 4B and PHYS 2CL or MAE 140. Enrollment restricted to MC 25, MC 27, MC 29, CE 25, BE 25, BE 27.

BICD 100. Genetics (4) An introduction to the principles of heredity emphasizing diploid organisms. Topics include Mendelian inheritance and deviations from classical Mendelian ratios, pedigree analysis, gene interactions, gene mutation, linkage and gene mapping, reverse genetics, population genetics, and quantitative genetics. ***Prerequisites:*** BILD 1 and BILD 3 (note: BILD 3 **is** a required prerequisite, but not a major requirement).

Winter Quarter

BENG 123. Dynamic Simulation in Bioengineering (4) Dynamic simulation of biochemical reaction networks, including reconstruction of networks, mathematical description of kinetics of biochemical reactions, dynamic simulation of systems of biochemical reactions, and use of simulators for data interpretation and prediction in biology. Emphasis on a design project. ***Prerequisites:*** MATH 18 or MATH 31AH, MATH 20D, BENG 120, or CHEM 40B; majors only or consent of department. (W)

BENG 168. Biomolecular Engineering (4) Basic molecular biology and recombinant DNA technologies. Structure and function of biomolecules that decode genomes and perform energy conversion, enzymatic catalysis, and active transport. Metabolism of macromolecules. Molecular diagnostics. Design, engineering, and manufacture of proteins, genomes, cells, and biomolecular therapies. ***Prerequisites:*** BILD 1 and BENG 100, or consent of department. (W)

BENG 130. Biotechnology Thermodynamics and Kinetics (4) An introduction to physical principles that govern biological matter and processes, with engineering examples. Thermodynamic principles, structural basis of life, molecular reactions and kinetics, and models to illustrate biological phenomena. ***Prerequisites:*** CHEM 6B, MATH 20A, 20B, 20D, PHYS 2A, 2B, 2C; majors only or consent of department. (W)

Spring Quarter

BENG 187A. Bioengineering Design Project: Planning (1) General engineering design topics including project planning and design objectives, background research, engineering needs assessment, technical design specifications, engineering standards, and design requirements and constraints. Introduction to biomedical and biotechnology design projects. Career and professional advising. Majors must enroll in the course for a letter grade in order to count the sequence toward the major. No exceptions will be approved. ***Prerequisites:*** BENG 112A or BENG 152 or BENG 168; bioengineering, bioengineering: biotechnology, or bioengineering: biosystems majors only or consent of

department. (S)

BENG 103B. Bioengineering Mass Transfer (4) Mass transfer in solids, liquids, and gases with application to biological systems. Free and facilitated diffusion. Convective mass transfer. Diffusion-reaction phenomena. Active transport. Biological mass transfer coefficients. Steady and unsteady state. Flux-force relationships. (Credit not allowed for both CENG 101C and BENG 103B.) ***Prerequisites:*** CENG 101A or MAE 101A or BENG 112A, or consent of department. (S)

BENG 160. Chemical and Molecular Bioengineering Techniques (4) Introductory laboratory course in current principles and techniques of chemistry and molecular biology applicable to bioengineering. Quantitation of proteins and nucleic acids by spectrophotometric, immunological, and enzymatic methods. Separations and purification by centrifugation, chromatographic, and electrophoretic methods. Course materials fees may apply. ***Prerequisites:*** BICD 100, BENG 100, MAE 170; majors only or consent of department. (S)

BENG 186A. Principles of Biomaterials Design (4) Fundamentals of materials science as applied to bioengineering design. Natural and synthetic polymeric materials. Materials characterization and design. Wound repair, blood clotting, foreign body response, transplantation biology, biocompatibility of materials, tissue engineering. Artificial organs and medical devices. Government regulations. Patenting. Economic impact. Ethical issues. A term project and oral presentation are required. ***Prerequisites:*** BENG 112B or BENG 123, or consent of department. (S)

Senior Year Courses

Fall Quarter

BENG 187B. Bioengineering Design Project: Development (1) Development of an original bioengineering design for solution of a problem in biology or medicine. Analysis of economic issues, manufacturing and quality assurance, ethics, safety, design constraints, government regulations, and patent requirements. Oral presentation and formal engineering reports. Career and professional advising. Majors must enroll in the course for a letter grade in order to count the sequence toward the major. No exceptions will be approved. ***Prerequisites:*** BENG 187A; concurrent enrollment in one of BENG 119A, BENG 126A, BENG 127A, BENG 128A, BENG 129A, BENG 139A, BENG 147A, BENG 148A, BENG 149A, BENG 169A, or BENG 179A; bioengineering, bioengineering: biotechnology, or bioengineering: biosystems majors only or consent of instructor. (F)

BENG 166A. Cell and Tissue Engineering (4) Engineering analysis of physico-chemical rate processes that affect, limit, and govern the function of cells and tissues. Cell migration, mitosis, apoptosis, and differentiation. Dynamic and structural interactions between mesenchyme and parenchyme. The role of the tissue microenvironment including cell-cell interactions, extracellular matrix, and growth factor communication. The design of functional tissue substitutes including cell and material sourcing, scale-up and manufacturability, efficacy and safety, regulatory, and ethical topics. Clinical applications. ***Prerequisites:*** BENG 103B or BENG 112B; senior standing or consent of department. (F)

BENG 162. Biotechnology Laboratory (4) Laboratory practices and design principles for biotechnology. Culture of microorganisms and mammalian cells, recombinant DNA bioreactor design and operation. Design and implementation of biosensors. A team design-based term project and oral presentation required. Course materials fees may apply. ***Prerequisites:*** MAE 170 and BENG 160; majors only or consent of department. (F)

BENG 161A. Bioreactor Engineering (4) Engineering, biochemical, and physiological considerations in the design of bioreactor processes: enzyme kinetics, mass transfer limitations, microbial growth, and product formation kinetics. Fermentation reactor selection, design, scale-up, control. Quantitative bioengineering analysis and design of biochemical processes and experiments on biomolecules. ***Prerequisites:*** BENG 123 and BENG 160 or consent of department. (F)

Winter Quarter

BENG 187C. Bioengineering Design Project: Implementation (1) Approaches to implementation of senior design project, including final report. Teams will report on construction of prototypes, conduct of testing, collection of data, and assessment of reliability and failure. Majors must enroll in the course for a letter grade in order to count the sequence toward the major. No exceptions will be approved. ***Prerequisites:*** BENG 187B; concurrent enrollment in one of the following lab sections: BENG 119B, BENG 126B, BENG 127B, BENG 128B, BENG 129B, BENG

139B, BENG 147B, BENG 148B, BENG 149B, BENG 169B, or BENG 179B; bioengineering, bioengineering: biotechnology, or bioengineering: biosystems majors only or consent of instructor. (W)

BENG 161B. Biochemical Engineering (4) Commercial production of biochemical commodity products. Application of genetic control systems and mutant populations. Recombinant DNA and eukaryotic proteins in *E. coli* and other host organisms. Product recovery operations, including the design of bioseparation processes of filtration, adsorption, chromatography, and crystallization. Bioprocess economics. Human recombinant erythropoietin as an example, from genomic cloning to CHO cell expression, to bioreactor manufacturing and purification of medical products for clinical application. ***Prerequisites:*** BENG 161A or consent of department. (W)

Spring Quarter

BENG 187D. Bioengineering Design Project: Presentation (1) Oral presentations of design projects, including design, development, and implementation strategies and results of prototype testing. Majors must enroll in the course for a letter grade in order to count the sequence toward the major. No exceptions will be approved. ***Prerequisites:*** BENG 187C; bioengineering, bioengineering: biotechnology, or bioengineering: biosystems majors only or consent of instructor. (S)

BENG 125. Modeling and Computation in Bioengineering (4) Computational modeling of molecular bioengineering phenomena: excitable cells, regulatory networks, and transport. Application of ordinary, stochastic, and partial differential equations. Introduction to data analysis techniques: power spectra, wavelets, and nonlinear time series analysis. ***Prerequisites:*** BENG 122A or BENG 123 or consent of department. (S)

BENG 191/291. Senior Seminar I: Professional Issues in Bioengineering (2)** (Conjoined with BENG 291.) Instills skills for personal and organizational development during lifelong learning. Student prepares portfolio of personal attributes and experiences, prepares for career interviews plus oral report of interviewing organizational CEO. Graduate students will prepare a NIH small business research grant. ***Prerequisites: consent of instructor. (F)

Two ("A" & "B") Design Elective Courses (6 units total) - Seniors work in teams on a project to design a solution to a multidisciplinary bioengineering problem suggested by professionals in bioengineering industry, academia, or medicine. Taken Fall and Winter quarter of Senior year.

****Two 4-unit Technical Elective courses**
Required for all students

**Recommended but not required; may be taken once.*
***See departmental Student Affairs Office for additional information.*

Additional Courses for Medical School

Biotechnology students planning to apply to med school take the following courses in addition major requirements:

1. BILD 2
2. BILD 3
3. PHYS 2BL
4. CHEM 41C
5. CHEM 43A
6. One of the following: BIBC 100, BIBC 102, CHEM 114A, or CHEM 114B
7. One year of English composition or writing (general education courses dependent on written material for grading should suffice)
8. One course in psychology and sociology (PSYC 1 and SOCI 70) helpful for the MCAT but not a prerequisite
9. Recommended additional coursework
    a. Human Physiology (BIPN 100 and/or BIPN 102)
    b. Cell biology (BICD 110)
    c. Molecular Biology (BIMM 100)
    d. Microbiology (BIMM 120)

Most medical schools accept some AP and IB credit for prerequisites. Some medical schools do NOT accept AP/IB credit for prerequisites, and additional upper division coursework may be required. Please consult with a pre-med advisor if you have concerns.

For more information, please visit: https://career.ucsd.edu/plan/explore/pre-health-med/medicine/prepare.html and consider meeting with a pre-med advisor. This information is meant to guide students in planning for a pre-med track, but may not fully encompass all requirements.

Frequently Asked Questions

1. **I was not directly admitted into the Bioengineering department. Is there a way that I can change into any of the "capped" majors later on?**

Possibly. Freshman students admitted in **FALL 2023** will be able to apply **"one time only"** to a "capped" major in **FALL 2024.** A certain number (*determined on an annual basis*) of "continuing" sophomore students who apply will be selected to enter the "capped" *Bioengineering*, *Bioengineering: Biotechnology*, *Bioengineering: Bioinformatics,* or the *Bioengineering: BioSystems* major. Interested continuing students must not be past sophomore standing, as time to graduation would be delayed. You are required to complete the following courses (depending on which major you wish to apply for) **prior** to applying in **FALL 2024**:
Bioengineering and *Bioengineering: Biotechnology*: BILD 1 (biology); CHEM 6AB; MAE 8 (MatLab); Math 20ABC; Physics 2AB.
Bioengineering: Bioinformatics: BILD 1; CHEM 6AB; CSE 11 (or CSE 8A and 8B); MATH 20ABC; PHYS 2AB.
Bioengineering: BioSystems: CHEM 6AB; MATH 20ABC; PHYS 2AB.

If you have met some of the courses by Advanced Placement ("AP") work, please be advised of the following: A minimum of 3 courses listed must have been completed at UC San Diego. If students can not meet this 3-course minimum due to prior credit, students may offer grades for **MATH 20D** (Differential Equations), **MATH 18** (Linear Algebra) or **MATH 20E** (Vector Calculus) until the 3 course minimum has been met.
Applications will be available **September 23, 2024**, and must be submitted by Friday of the second week of instruction- **Oct. 4, 2024**. Applications will be ranked according to the GPA obtained in the required courses and will be approved, starting with the student having the highest GPA in those courses, until the "open" slots are filled in each of the "capped" majors. Bioengineering Student Affairs staff will notify all applicants re: their status on **Wednesday ,Oct 9th, 2024**.

2. **What are the differences among the four majors within the Bioengineering Dept?**

Bioengineering (BENG)*:* This major prepares students for careers in the biomedical device industry and for further education in graduate school. Students completing the B.S. degree in Bioengineering have a broad preparation in traditional topics in engineering, allowing for a variety of career pathways. This program addresses the bioengineering topics of biomechanics, biotransport, bioinstrumentation, bioelectricity, biosystems, and biomaterials, and the complementary fields of systems and integrative physiology. Education in these areas allows application of bioengineering and other scientific principles to benefit human health by advancing methods for effective diagnosis and treatment of disease, e.g., through development of medical devices and technologies. The *BENG* major is accredited by the Engineering Accreditation Commission of the Accreditation Board for Engineering & Technology [EAC/ABET].

Bioengineering: Biotechnology (BTEC)*:* This major prepares students for careers in the biotechnology industry and for further education in graduate school. The curriculum has a strong engineering foundation with emphasis on biochemical process applications. This program addresses the bioengineering topics of biochemistry, metabolism, kinetics, biotransport, biosystems, bioreactors, bioseparations, tissue engineering, and the complementary fields of cellular physiology. Education in these areas allows application of bioengineering and physicochemical principles to cellular and molecular biology, with the applications that benefit human health. The *BTEC* major is accredited by [EAC/ABET].

Bioengineering: Bioinformatics (BINF)*:* Bioinformatics is the study of the flow of information (genetic, metabolic, and regulatory) in living systems to provide an understanding of the properties of

cells and organisms. This major has been developed by the Departments of Bioengineering, Chemistry and Biochemistry, Computer Science and Engineering, and Division of Biology. The bioinformatics major in bioengineering emphasizes systems engineering and model-based approaches to interpreting and integrating bioinformatics data. The bioinformatics major prepares students for careers in the pharmaceutical, biotechnology, and biomedical software industries, and for further studies in graduate school. The *BINF* major is not accredited by a Commission of [EAC/ABET].

Bioengineering: BioSystems (BSYS)*:* This major focuses on the interaction and integration of components in complex biological and engineering assemblages, and how the function and interactions of these components affect overall performance. The major draws on foundations of classical electrical and systems engineering, with biological applications at levels of the molecular and cellular to the physiological and whole organism, and provides an alternative to other bioengineering majors that emphasize mechanical, chemical, and computational approaches. The major prepares students for careers in the bioengineering industry, in research and development, and for further education in graduate, medical, and business schools. The *BSYS* major is accredited to a [EAC/ABET].

3. **I have received Advanced Placement credit from high school in one or more subjects. Does AP work exempt me from taking specific courses?**

Yes. Depending upon the score you receive on an AP exam, you may be exempt from taking one or more courses required for your major. Please refer to section I below and/or the online UCSD General Catalog.

4. **Is it possible to do research as an undergraduate?**

Yes. As a student with lower-division standing, upon completion of 30 UCSD units with a 3.0 GPA, you may request to work with a faculty member and enroll in a BENG 99 (Independent Study for Undergraduates) course. Additionally, when you achieve upper-division standing and have completed a total of 90 units with a 2.5 GPA, you are encouraged to participate in research with a faculty member by enrolling in a BENG 199 course. Please refer to the Research Labs listing to see an up to date list of our faculty who you may have the option of doing research with.

5. **Can I graduate in four years with a major in the Bioengineering Department?**

Yes. Our department's major flowcharts are designed to be completed in four years.

6. **Is it possible to complete a minor or double major with a major in Bioengineering?**

Completion of a minor or a double major is not encouraged among the engineering departments. Engineering majors are very rigorous and require a large number of units to be completed. Often a student's graduation will be delayed if a minor or double major is planned. Students may not complete a minor or double major with another engineering department, per University policy.

7. **How many students are in the Bioengineering Dept?**

Approximately 535 undergraduate students across 4 majors.

8. **Does Bioengineering have a 5-Year BS/MS Program?**

Yes. Please reference section III below.

I. Advanced Placement Course Information

Exam and Units for University Credit	**UCSD Course Exemptions for Use in Satisfying Bioengineering Major Requirements**
Biology ~ 8 units	Score of 3 = BILD 10; may take BILD 1, 2, 3 for credit Score of 4 or 5 = exempts from BILD 1, 2, 3
Chemistry ~ 8 units	Score of 3 = exempts Chem. 4 Score of 4 = exempts Chem. 4 or 11; may take Chem. 6A, 6B, 6C for credit Score of 5 = exempt from Chem. 6A-B-C; may take Chem. 6AH, 6BH, 6CH for credit. **MUST TAKE CHEM 7L.**
Math: Calculus AB ~ 4 units	AB: Score of 3 on AB exam = exempts Math 10A AB: Score of 4 or 5 = exempts Math 20A
Math: Calculus BC ~ 8 units (8-unit max for both tests)	BC: Score of 3 on BC exam = exempts Math 20A BC: Score of 4 or 5 on BC exam = exempts Math 20A and 20B
Physics: Physics 1 or 2 Physics C: Mechanics ~ 4 units Physics C: Electricity and Magnetism ~ 4 units (8-unit max for all 3 tests)	1 or 2 exam = elective credit and exempt Phys. 10 C exam (Mech.) score of 3= exempt Phys. 1A C exam (Mech.) score of 4 or 5= exempt Phys 1A or 2A C exam (E&M) score of 3= exempt Phys. 1B C exam (E&M) score of 4 or 5= exempt Phys 1B or 2B

II. Technical Elective (TE) Course Policy

All Bioengineering majors must complete 8 units of technical elective credit to satisfy their major requirements. The number of units that must have "engineering" as the primary component depends on the major, as listed below.

MAJOR	Total # of TE Units Required	Minimum # of TE Units with Engineering Content Required
BENG	8	4 units
BTEC	8	6 units
BINF	8	8 units
BSYS	8	8 units

Courses that have "engineering" as its primary component, and are normally approved, include most 4-unit, upper-division (100 series) courses taken for a letter grade, not required for the major and taught in one of the departments of the Jacobs School of Engineering. ALL proposed technical electives must be approved by the Bioengineering Student Affairs office ***prior to*** enrollment in the course to verify technical elective credit.

Any portion of the TE requirement not fulfilled by "engineering" courses must be fulfilled by "science" courses. Courses that have "science" as its primary component and are normally approved are 4-unit, upper-division (100 series) courses taken for a letter grade, not required for the major and taught in the departments of Biological Sciences, Chemistry/Biochemistry, or Physics. Courses having a lab component are acceptable.

BENG 199, *Independent Study Research* courses may also be used toward satisfaction of the TE requirement. Students interested in doing research via BENG 199 courses must enroll with the same faculty member in two quarters of BENG 199. Doing so will satisfy both the TE course requirement and the required engineering component.

"Teams in Engineering Sciences" (TIES) courses may also be used to satisfy the TE requirement for all departmental majors. The ENG 100D and ENG 100L courses are considered as "engineering"-type TE courses. Students will receive 8 units of TE credit after passing 1 quarter of ENG 100D (4 units) taken concurrently with ENG 100L (2 units), and passing 1 additional quarter of ENG 100L (2 units each), thus satisfying the TE course requirements for the major.

BENG 196 may be used to fulfill 4 units of technical elective requirements for all majors. Please see the Student Affairs office for instructions on enrolling in this course. **BENG 197 or BENG 198** courses may not be used to satisfy TE requirements in any majors in the Department of Bioengineering.

Additional Technical Elective Information:
https://bioengineering.ucsd.edu/undergrad/programs/technical-electives

III. 5 Year Bachelors/Masters Degree

The Department of Bioengineering (BENG) offers a five-year process leading to Bachelor of Science and Master of Science degrees in Bioengineering. It is available to undergraduate students who are enrolled in any of the major programs offered by BENG. The purpose of the BS/MS is to allow interested students to obtain the MS degree within one year following completion of the BS degree. **The program is open only to UCSD undergraduates and is only for the MS degree, not the M.Eng degree.** Application to this program is a two-step process.

Program Information

Twelve units of Bioengineering graduate level courses must be completed during the student's senior undergraduate year, ***in addition*** to the requirements for the bachelor's degree.

- These twelve units will count toward the requirements for the master's degree **only** and must be taken for a letter grade. The student *may* take up to six graduate level courses during their senior year; six is the maximum that can be transferred per OGS requirements.

The student will arrange a schedule of courses for the senior year that will fulfill the requirements for the BS degree while also serving the program planned for the MS degree. Students are expected to meet the requirements for the MS degree in one year (three consecutive academic quarters) from the date of the receipt of the BS degree.

- Students are encouraged to meet with the Undergraduate and Graduate Coordinators to plan the undergraduate and graduate courses to be taken during the senior year. *Enrollment in graduate level courses is done manually and requires authorization from the Graduate Coordinator.*

Admission Requirements

To be eligible, students must have completed the first two quarters of their junior year in residence at UCSD and have an upper-division GPA of 3.5 or better. However, it should be noted that meeting and even exceeding minimum requirements does not *guarantee* admission. **Students taking a fifth year of undergraduate study are not eligible.**

More information: Five-Year BS/MS Program | Shu Chien - Gene Lay Department of Bioengineering

IV. Research Labs

Biodynamics	Jeff Hasty
Bioinformatics and Systems Biology	Shankar Subramaniam
Biomaterials	Brian Aguado
Biomaterials and Regenerative Medicine	Karen Christman
Cardiac Mechanics	Andrew McCulloch
Cardiovascular Disease	Francisco Contijoch
Cardiovascular Imaging	Elliot McVeigh
Cartilage Tissue Engineering	Robert Sah
Composition of Biomolecules	Rob Knight
Computational Genomics and Stem Cell Biology	Sheng Zhong
Computational Genomics	Ludmil Alexandrov
Functional Cardiovascular Engineering	Pedro Cabrales
Genomics and Systems Biotechnology	Xiaohua Huang
Gene Regulation and Imaging	Bogdan Bintu
Health and Performance Indicators	Benjamin Smarr
Integrated Systems Neuroengineering	Gert Cauwenberghs
Microcirculation	Geert Schmid-Schoenbein
Multiscale Modeling of Pulmonary Arterial Hypertension	Daniela Valdez-Jasso
Nanoscale Bioengineering	Ester Kwon
Nanosensors and Devices for Biomedical Systems	Ratnesh Lal
Neural Engineering	Gabriel Silva
Optical Bioimaging and Spectroscopy	Lingyan Shi
Stem Cell Biology and Bioengineering Laboratory	Adam Engler
Systems Biology and Genetic Circuits	Bernhard Palsson
Systems Biology and Disease	Stephanie Fraley
Synthetic Biology and Stem Cell Engineering	Prashant Mali

See the full list of Bioengineering faculty here: Faculty | Shu Chien - Gene Lay Department of Bioengineering

Undergraduate Student Resources

Academic	Well-Being	Cultural/Community
Bioengineering Student Affairs Office https://bioengineering.ucsd.edu/undergrad/advising **IDEA Engineering Student Center** (Inclusion, Diversity, Excellence, Achievement) https://jacobsschool.ucsd.edu/idea/ **Academic Internship Program** (AIP) https://aip.ucsd.edu/ **Study Abroad Office** https://studyabroad.ucsd.edu/ **Career Center** https://career.ucsd.edu/ Pre-Med Advising: https://career.ucsd.edu/advising/pre-health-med/index.html **Office of Academic Support and Instructional Studies** (OASIS) https://oasis.ucsd.edu/ **Office of Financial Aid and Scholarships** (OFAS) https://fas.ucsd.edu/	**Office for Students with Disabilities** (OSD) https://osd.ucsd.edu/ **Counseling and Psychological Services** (CAPS) https://caps.ucsd.edu/ **CARE at the Sexual Assault Resource Center** (CARE at SARC) https://care.ucsd.edu/ **The Hub Basic Needs Center** https://basicneeds.ucsd.edu/ **Student Health Services** https://studenthealth.ucsd.edu/	**Asian, Pacific Islander, Middle Eastern, Desi American Programs and Services** (APIMEDA) https://apimeda.ucsd.edu/ **Veterans Resource Center** https://svrc.ucsd.edu/ **Intertribal Resource Center** https://itrc.ucsd.edu/ **LGBT Resource Center** https://lgbt.ucsd.edu/ **Cross Cultural Center** https://ccc.ucsd.edu/ **Women's Center** https://women.ucsd.edu/ **Undocumented Student Center** https://uss.ucsd.edu/ **Black Resource Center** https://brc.ucsd.edu/ **Raza Resource Centro** https://raza.ucsd.edu/

Bioengineering Student Organizations

- Biomedical Engineering Society - https://bmes.ucsd.edu/
- Engineering World Health - https://ewh.ucsd.edu/
- International Society for Pharmaceutical Engineering - http://ispeucsd.weebly.com/
- Gender Minorities in Bioengineering - https://gmbe.ucsd.edu/
- Undergraduate Bioinformatics Club - https://ubicucsd.github.io/