UC San Diego

JACOBS SCHOOL OF ENGINEERING

Shu Chien-Gene Lay Department of Bioengineering

Bioengineering (BE25)

Transfer 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.

Transfer Students in the Bioengineering (BENG) Major

1. **BENG Major Flowchart**

Please review the flowchart of required courses to determine your progress in completing courses for your BENG major. Just cross off the UCSD equivalent courses you've already completed at community college, and the flowchart will provide you with an accurate snapshot of your status.

2. **HSS Boxes on Flowchart**

The boxes along the bottom of the flowchart marked "HSS" refer to your college general education (GE) course requirements. Boxes are included to allow for completion of 10 GE courses (40 units); however, depending upon which of the six colleges you are in, you may have to complete more than 10 courses. *(Please contact your college advisor to obtain more detailed information.)*

3. **Following the Flowchart**

Hopefully you'll have completed many of the required lower-division courses at your community college. Since upper division BENG courses are offered only one time a year, it is important to follow your plan to avoid further graduation delay.

4. **Flowchart: Freshman Year**

Note that BENG 1, *Intro to BENG Seminar (2 units)* could not have been completed at your community college. Please take this course in Winter 2024.

5. **Flowchart: Sophomore Year Winter Quarter**

Note that BENG 140A, *Bioengineering Physiology* and MAE 40, *Linear Circuits* are courses which you could not have taken at community college. Please take these courses in Winter 2024. Also enroll in MAE 8, *MatLab*, in Winter 2024 if you have not completed this course.

6. **Flowchart: Sophomore Year Spring Quarter**

Note that BENG 100, *Intro to BENG Design;* BENG 140B*, Bioengineering Physiology* and MAE 3, *Intro to Engineering Graphics & Design* are 3 courses which could not have been taken at community college. Please take these courses in Spring 2024. Please note that MATH 20E could not have been taken at community college and must be either tested out of or taken at UCSD.

7. **Contacting an Advisor About Your Courses**

Incoming students will be able to ask departmental questions using the Virtual Advising Center beginning in mid-June 2023. The Virtual Advising Center is available under the Advising tab on TritonLink. In the meantime, you may contact our student affairs staff via email at be-uginfo@bioeng.ucsd.edu. Bioengineering Student Affairs is located on the Warren campus in Powell-Focht Bioengineering Hall, room 141 (on the 1st floor right next to the elevators). Our building is just a little west of the 2-story Bear sculpture.

8. **Fall Quarter Orientation**

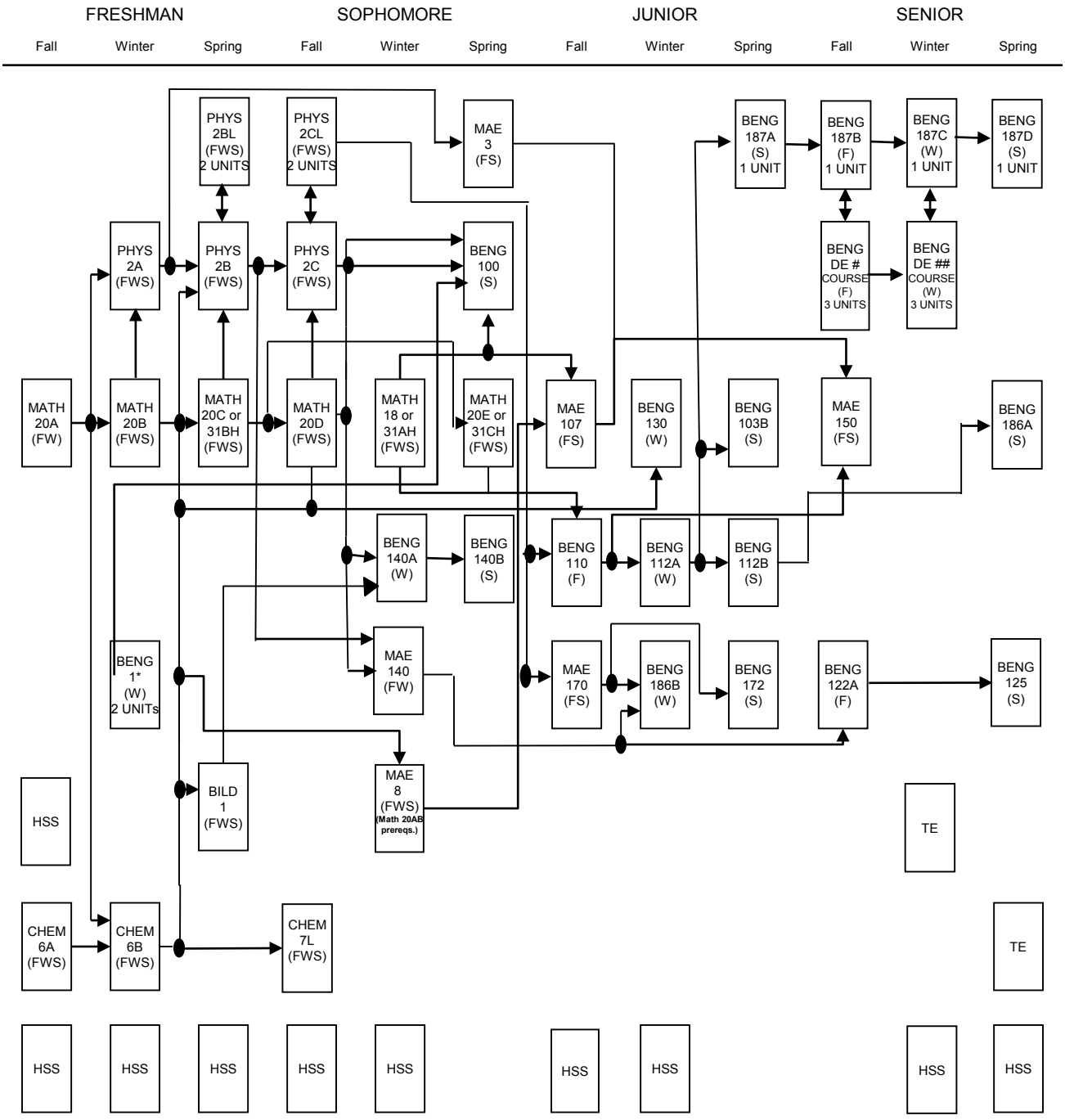
In Fall 2023, our "New Student Orientation" session will be held during welcome week. (You'll receive more information about Orientation at a later date.) We will have group Q&A sessions during this time.

BIOENGINEERING (BENG) ~ "NEW" COURSE FLOWCHART

(*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.) ~REV. 4/4/17



 # 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 <u>once</u> and is <u>recommended for Juniors and Seniors</u>, but <u>not</u> required.

<u>Electives</u>: BENG 191 ++ 2 units; BENG 199 (FWS)

Additional Courses for Medical School

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

1. BILD 2
2. BILD 3
3. CHEM 6C
4. CHEM 41A
5. CHEM 41B
6. CHEM 41C
7. CHEM 43A
8. One of the following: BIBC 100, BIBC 102, CHEM 114A, or CHEM 114B
9. One year of English composition or writing (general education courses dependent on written material for grading should suffice)
10. One course in psychology and sociology (PSYC 1 and SOCI 70) helpful for the MCAT but not a prerequisite
11. Recommended additional coursework
    a. Genetics (BICD 100)
    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?**

No. The only way for an incoming transfer student to enter a capped major is to be directly admitted from a community college or other university.

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. **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.

4. **Can I graduate in two years with a major in the Bioengineering Department?**

Not usually for transfers. Our department's major flowcharts are designed to be completed in four years for students *who enter as freshmen*. Additionally, depending upon which of the 6 UCSD colleges you are in, you will possibly need to plan on taking summer school courses in order to satisfy all *"Major"* and *"College"* (General Education breadth) requirements. Engineering students are expected to take a minimum of 16 units (4 classes) most quarters, and either take an increased course load for a few quarters or enroll in some summer session courses at various times during their academic career. While the 6 colleges and the departments are committed to encouraging and assisting students to finish as quickly as possible, it typically takes transfer students 3 years to graduate.

5. **How do I know which of my courses will transfer to UCSD from a California community college?**

Please use www.assist.org to view the transfer equivalencies between your community college and UC San Diego for your major. If a course you took is not listed as equivalent, you may petition the course for credit with the appropriate department. For example, if you wish to petition to have a Chemistry course you took at community college count for CHEM 40A (Organic Chemistry) you may submit a petition to the Chemistry department. Petitions will only be submitted to the Bioengineering department for courses you believe to be equivalent to Bioengineering courses. Community college courses are typically only eligible for lower division course credit (1-99) at UCSD.

6. **I transferred from another 4-year institution or non-California community college. How will I know which of my courses articulate?**

The UCs unfortunately do not have articulation agreements with each other, nor with any other 4 year university or out of state community college. You will need to wait until your transcript is processed by admissions over the summer to see which of your courses articulated. This information will be available to view under your Academic History on TritonLink in mid to late summer. If a course you took does not show an articulation, then you will need to directly petition the department that offers the course in the subject you are petitioning.

7. **What is needed for a petition?**

You should aim to provide as much information as possible, including:

- Name/title/author/edition of the textbook used for the course
- Syllabus for the course
- Any homework assignments/tests (optional, but recommended)
- Undergraduate Student Petition (available under the Forms tab on TritonLink) filled out describing why you believe the course is similar to what you believe to be our equivalent (similar subjects covered, textbook, homework, etc.,) and the course that you believe it to be equivalent to as well as where you took the course. A strong petition draws on the similarities between course descriptions (see the UCSD Course Catalog). Please bear in mind that the response rate will vary by department and may take up to a month.

I. 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

II. 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 (according to the "Junior" section of their major flowchart) 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. Transfer students are eligible to apply if they meet the junior standing requirement.

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

More information about Bioengineering graduate programs: Graduate Students | Shu Chien - Gene Lay Department of Bioengineering

III. 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/

Bioengineering 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.

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.

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.

PHYS 2BL. Physics Laboratory—Mechanics (2) Experiments include gravitational force, linear and rotational motion, conservation of energy and momentum, collisions, oscillations and springs, gyroscopes. Data reduction and error analysis are required for written laboratory reports. One hour lecture and three hours laboratory. ***Prerequisites:*** PHYS 2A or 4A. Recommended preparation: prior or concurrent enrollment in PHYS 2B or 4C.

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.

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.

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.

Winter Quarter

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.

BENG 140A. Bioengineering Physiology (4) Introductory mammalian physiology for bioengineering students, with emphasis on control mechanisms and engineering principles. Basic cell functions; biological control systems; muscle; neural; endocrine, and circulatory systems. Not intended for premedical bioengineering students. Credit not allowed for both BIPN 100 and BENG 140A. ***Prerequisites****:* CHEM 6A-B, PHYS 2A-B-C, BILD 1, or BENG 102; majors only or consent of department. (W)

MAE 40. Linear Circuits (4) Steady-state and dynamic behavior of linear, lumped-parameter electrical circuits. Kirchhoff's laws. RLC circuits. Node and mesh analysis. Operational amplifiers. Signal acquisition and conditioning. Electric motors. Design applications in engineering. ***Prerequisites****:* MATH 20D and MATH 31AH or MATH 18 or MATH 20F, and PHYS 2B.

MAE 08. 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.

Spring Quarter

MAE 03. Introduction to Engineering Graphics and Design (4) Introduction to design process through a hands-on design project performed in teams. Topics include problem identification, concept generation, project management, risk reduction. Engineering graphics and communication skills are introduced in the areas of: Computer-Aided Design (CAD), hand sketching, and technical communication. Program or materials fees may apply. ***Prerequisites:*** PHYS 2A or 4A. Enrollment restricted to BE 25, MC 25, MC 27, MC 29, and MC 30–34 majors only.

BENG 100. Statistical Reasoning for Bioengineering Applications (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)

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.

BENG 140B. Bioengineering Physiology (4) Introductory mammalian physiology for bioengineering students, with emphasis on control mechanisms and engineering principles. Digestive, respiratory, renal, and reproductive systems; regulation of metabolism, and defense mechanisms. (Credit not allowed for both BIPN 102 and BENG 140B.) ***Prerequisites:*** BENG 140A; majors only or consent of instructor. (S)

Junior Year Courses

Fall Quarter

MAE 107. Computational Methods in Engineering (4) Introduction to scientific computing and algorithms; iterative methods, systems of linear equations with applications; nonlinear algebraic equations; function interpolation and differentiation and optimal procedures; data fitting and least-squares; numerical solution of ordinary differential equations. ***Prerequisites****:* MAE 8 or 9, and MATH 18 or 20F or 31AH.

BENG 110. Foundation of Biomechanics (4) Statics, dynamics, and solid mechanics of hard and soft musculoskeletal tissues. Forces, moments, static equilibrium, kinematics, kinetics applied to human mechanics, and movement. Stress, strain, and material properties of musculoskeletal tissues. Problem solving and design in biomechanics. ***Prerequisites****:* MATH 20D, MATH 20E or MATH 31CH, MATH 18 or MATH 31AH; PHYS 2C, or consent of department. (F)

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 40. Enrollment restricted to MC 25, MC 27, MC 29, CE 25, BE 25, BE 27.

Winter Quarter

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)

BENG 112A. Soft Tissue Biomechanics (4) Tensor analysis. Stress, strain, equilibrium, and constitutive law for soft biological tissues. Applications of solid mechanics to mammalian tissue physiology. Viscoelasticity. Finite elasticity. Problem solving and design in soft tissue biomechanics. ***Prerequisites****:* BENG 110 or consent of department. (W)

BENG 186B. Principles of Bioinstrumentation Design (4) Biophysical phenomena, transducers, and electronics as related to the design of biomedical instrumentation. Potentiometric and amperometric signals and amplifiers.

Biopotentials, membrane potentials, chemical sensors. Electrical safety. Mechanical transducers for displacement, force, and pressure. Temperature sensors. Flow sensors. Light-based instrumentation. ***Prerequisites:*** ECE 35 or MAE 140; ECE 45 or MAE 170; 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 112B. Fluid and Cell Biomechanics (4) Fluid hydrostatics and flow dynamics. Flow kinematics and conservation laws applied to the circulation. Viscous biofluids. Biopolymers, cell mechanics, and mechanobiology. Problem solving and design in biofluid and cell mechanics. ***Prerequisites:*** BENG 112A or consent of department. (S)

BENG 172. Bioengineering Laboratory (4) A laboratory course demonstrating basic concepts of biomechanics, bioengineering design, and experimental procedures involving animal tissue. Sources of error and experimental limitations. Computer data acquisition, modeling, statistical analysis. Experiments on artery, muscle and heart mechanics, action potentials, viscoelasticity, electrocardiography, hemorheology. Course materials fees may apply. ***Prerequisites:*** MAE 170; junior or senior standing in the major or consent of instructor. (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)

MAE 150. Computer-Aided Design (4) Computer-aided analysis and design. Design methodology, tolerance analysis, Monte Carlo analysis, kinematics and computer-aided design of linkages, numerical calculations of moments of inertia, design of cams and cam dynamics; finite element analysis, design using Pro-E, Mechanica Motion and Mechanical Structures. ***Prerequisites****:* MAE 30A or MAE 130A or SE 101A or BENG 110, MAE 107 or SE 121, MAE 3, and senior standing in engineering major, or consent of instructor.

BENG 122A. Biosystems and Control (4) Systems and control theory applied to bioengineering. Modeling, linearization, transfer functions, Laplace transforms, closed-loop systems, design and simulation of controllers. Dynamic behavior and controls of first and second order processes. PID controllers. Stability. Bode design. Features of biological controls systems. A simulation project using Matlab and an oral presentation are required. Credit not allowed for both ECE 101 and BENG 122A. ***Prerequisites:*** MAE 140 or BENG 134 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)

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 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)

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.*