Vanderbilt University

**School of Engineering**

**Biomedical Engineering**

**Undergraduate Curriculum Guide**



**October 2022**

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elcome to the study of biomedical engineering at Vanderbilt University. The mission of our department encompasses that of the Vanderbilt School of Engineering, which is to provide a high-quality education in selected areas of engineering, balanced with broad learning oppor­tunities from other fields, and integrated to provide intellectual richness and flexibility. It is the mission of the Vanderbilt Department of Biomedical Engineering to

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* Enlighten our students with the engineering, mathematics and basic sciences that advance health care and biotechnology;
* Develop the reasoning faculties of our students, enlarge their mindsets and instill in them precepts of accuracy, ethics and enterprise; and
* Form the engineers, physicians, scientists and industrialists upon whose leadership continued progress in scientific understanding, health and industry depend.

The objectives of the Vanderbilt undergraduate program in biomedical engineering are

* To provide an educational program focused at the interface of engineering and biology that enables graduates to solve technological problems and contribute to human health through the practice of biomedical engineering or related fields.
* To provide an educational program with sufficient breadth to instill in its graduates the knowledge of their professional and ethical responsibilities, knowledge in liberal arts, and skills in effective communication that they will carry into their post-baccalaureate endeavors.
* To prepare students for programs of advanced study in engineering, the sciences or medicine, or placement in the health-care, biomedical device, and biotechnology industries or as practitioners in related fields.

To achieve these objectives, the BME faculty has designed the curriculum described in this guide. If you follow this curriculum, the objectives above will be met for you specifically and you will be prepared for the next stage of your life as a biomedical engineer. In particular, this curriculum is designed to provide you with the following outcomes:

* An ability to apply knowledge of mathematics, science, and engineering at the interface of engineering and biology.
* An ability to design and conduct experiments, including experiments on living systems.
* An ability to analyze and interpret data, including data from measurements on living systems.
* An ability to design a system, component, or process to meet desired needs, including systems involving the interaction of living and non-living states, within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.
* An ability to function on multi-disciplinary teams.
* An ability to identify, formulate, and solve engineering problems, including problems at the interface of engineering and biology.
* An understanding of professional and ethical responsibility.
* An ability to communicate effectively, in writing and speech
* The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context.
* A recognition of the need for and an ability to engage in life-long learning.
* A knowledge of contemporary issues.
* An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice and be prepared for further education in engineering, medicine, or biomedical science.

As is the case for most things worth learning, biomedical engineering as a field is too broad to cover in its entirety in an undergraduate curriculum. Vanderbilt BME spans a wide range of particular interests from devices that allow us to see inside the body without entering to systems of equations that provide insight on how the circulatory system responds to changes in cardiac function; from the observation and determination of how microscopic cells and groups of cells control macroscopic events to the management of information flow in a medical center. While you may focus on a particular part of BME, a working knowledge of other material is essential. Consequently, our curriculum will provide you the broad fundamentals of biomedical engineering and then allow you the flexibility to concentrate on your particular area of interest in your junior and senior years. Rather than being forced to choose from fixed specialty tracks, the curriculum gives you the opportunity to build on required core knowledge and explore and define your own area(s) of specialization for higher level study.

This guide, along with more information about our faculty and programs, can be found at our web site, [engineering.vanderbilt.edu/bme](http://engineering.vanderbilt.edu/bme). The roster of faculty, basic curriculum and descriptions of all classes are found in the Undergraduate Catalog, also known as The Bulletin, published annually by the University in hard copy and online at <http://www.vanderbilt.edu/catalogs/undergrad/>.

**Please note that our curriculum is not static. Consult with your academic adviser regarding changes to the curriculum and how they apply to you. For any other questions, please reach out to the Director of Undergraduate Affairs for biomedical engineering and/or their student assistant.**

**General Guidelines**

1. **Student Responsibility.** The student, not his or her adviser, is responsible for seeing that he or she has fulfilled all the requirements for graduation. The adviser's role is as a co-conspirator in the success of the student.

2. The **Undergraduate Catalog** (also known as “The Bulletin of Vanderbilt University”) contains all official information related to degree requirements. It is available in hard copy and online at <http://www.vanderbilt.edu/catalogs/undergrad/index.html>. In case of any conflict between the Catalog and this guide, the Undergraduate Catalog shall prevail.

3. **Credit Hours.** BME majors need credit hours as allocated in the table below to graduate.

|  |  |
| --- | --- |
|  | **Credit Hours** |
| Mathematics | 15 |
| Basic Sciences | 20 |
| Engineering Fundamentals | 6 |
| Electrical engineering | 3 |
| BME core | 38 |
| BME electives | 12 |
| Technical (science, engineering, math) electives | 9 |
| Liberal Arts Core | 18 |
| Open electives | 6 |
|  |  |
| Total hours | 127 |

4. **Core Curriculum.** The required courses that comprise the core curriculum are shown as explicitly listed courses in the detailed curricula on Page 14 and, for premed and double majors (BME/ChBE and BME/EE), on Pages 18 and 19, respectively. While there is some flexibility, the course sequence is laid out to ensure that students will have the necessary prerequisites for each course and will not encounter scheduling conflicts for required courses. Should you, by choice or by necessity, find yourself using a different sequence for completing these courses, pay careful attention to prerequisites, corequisites, and feasibility of scheduling.

5. **Basic Sciences.** The core curriculum includes a basic science requirement (20 hours) consisting of Chemistry 1601-1602, 1601L-1602L, Physics 1601-1602, 1601L-1602L, and Biological Sciences 1510/1510L.

6. **Electives.** 27 hours of electives are required. Of these, at least 12 hours must be BME electives with no more than a total of 6 credit hours from BME 3860-3861. The remaining 15 hours may be selected from either Open (6 hours) or Technical electives (9 hours) listed on page 15. Both semesters of organic chemistry count as Technical electives. Courses taken to fulfill the program elective requirement may not be taken pass/fail.

7. **Liberal Arts Core.** Students must take 18 credit hours of liberal arts electives to satisfy the Liberal Arts Core (LAC) requirement.

1. At least 3 hours selected from courses classified in the AXLE Curriculum Course Distribution of the College of Arts and Science as Humanities and Creative Arts (HCA) with the exception of CMST 1500, 2100, 2110, and 2120, and
2. At least 3 hours selected from courses classified in the AXLE Curriculum Course Distribution of the College of Arts and Science as Social and Behavioral Sciences (SBS)
3. Remaining hours are to be selected from:
	1. Courses classified in the AXLE Curriculum Course Distribution of the College of Arts and Science as Humanities and Creative Arts (HCA), International Cultures (INT), History and Culture of the United States (US), Social and Behavioral Sciences (SBS), and Perspectives (P)
	2. CS 1151 and ENGM 2440
	3. Arabic 1101, Chinese 1011, 1012, 1101, English 1100, French 1101, German 1101, Greek 1101, Hebrew 1101, Italian 1101, Japanese 1011, 1012, 1101, Latin 1101, Portuguese 1101, Russian 1101, and Spanish 1100, 1101
	4. Peabody College courses in Psychology and Human Development numbered 1205, 1207, 1250, 2200, 2250, 2300, 2400, 2500, 2550, 2600, and 3150, and in Human and Organizational Development numbered 1250, 1300, 2100, 2260, 2400, 2500, 2700, and 3232
	5. All MUSC, MUSE, MUSO, COMP, MREP, MUTH, and performance courses in the Blair School of Music, **except** MUSO 1001

8. **Open Electives**. These credit hours allow students to explore an area of interest that may or may not be related to BME. All BME students should take **BME 1015**, which can be counted as 1 credit hour for Open or Technical electives. **Freshmen engineering seminars** carry 1 hour of Open elective credit and are recommended. Courses excluded from the liberal arts core listings may be counted as Open electives. All officer education courses designated as eligible for credit (see the Undergraduate Catalog, Special Programs for Undergraduates) may be taken as Open electives. In addition, officer education courses in history and political science carry AXLE designations and may be taken as part of the Liberal Arts Core. AFROTC students may count 6 hours of military courses as Open electives.

9. **Study Abroad.** Students interested in study abroad during the academic year (rather than a summer program) should begin planning early to deal with the challenges presented by sequences of courses that are not offered every semester. For more information, go to the School of Engineering Study Abroad website (<http://engineering.vanderbilt.edu/academics/Undergraduate/StudyAbroad/>), the Global Education Office website (<http://www.vanderbilt.edu/geo/>), or contact Associate Dean Cynthia Paschal (cynthia.paschal@vanderbilt.edu). To better plan your Study Abroad experience, contact your adviser and setup a meeting.

10. **AP, IB, and Transfer Credits.** Advanced Placement, International Baccalaureate, and transfer credits can be applied toward certain requirements for your BME degree if the specific credits are determined to be acceptable in the transfer credit process embedded in YES. Potential study abroad credits can also be seen in YES.

11. **Graduate School Preparation / Professional Preparation.** The BME curriculum should prepare you for graduate school or professional practice. Consult with your adviser to plan your electives to suit your career goals. Explore the **Specializations tab** on the BME website to see a list of select courses that will advance your knowledge in specific BME-associated fields of study. Students planning to take the Graduate Record Examination (GRE) in anticipation of applying to graduate school are encouraged to strengthen verbal skills by taking courses with significant non-technical reading, by reading for pleasure and by studying vocabulary frequently.

12. **Medical School Preparation.**  If you are considering medical school, note the following:

1. Premeds take organic chemistry with lab (Chem 2221-2222/2221L-2222L) as eight of their Technical Elective hours.
2. Premeds planning to take the medical college admission test (MCAT) need to take biochemistry (BSCI 2520) as 3 of their Technical Elective hours.
3. We recommend that premeds consider deferring Physiological Transport (BME 3000) until their senior year if taking biochemistry (BSCI 2520) in their junior year.
4. We strongly recommend that premeds not pursue a double major.
5. Premeds should take English courses as two of their six LAC courses. Writing (“W”) courses are encouraged. On some medical school applications, it may be possible to count BME 4900W as one of the “English” courses.
6. Premeds should also include courses in Psychology and Sociology as two of their six LAC courses.
7. Premeds should plan to take one year (8 credit hours) of Biology. BSCI 1510/1510L is required for the BME major, leaving students to select four more credit hours of Biology among their electives. Some medical schools require a year of Biology and lab, in which case BSCI 1511/1511L can be used to satisfy this requirement. These courses can be taken as Technical or Open electives.
8. The Health Professions Advising Office (HPAO) offers additional guidance and support to students preparing for medical school and should be contacted early in the degree program.
9. While AP credits are generally accepted toward the undergraduate degree, many medical schools do not accept AP credits when evaluating applicants’ credentials. So, while for example you may have four hours of AP credit for Chem 1601/1601L, you may need to take four additional credit hours of Vanderbilt chemistry in order to be considered for a particular medical school. Check said medical school’s website to be sure this is required.
10. Our curriculum will prepare students to apply to nearly all medical schools. However, students should be aware that some medical schools have additional requirements. Check with the HPAO (<http://as.vanderbilt.edu/hpao/>) regarding any unique requirements.

13. **Honors.** With approval of the Honors Program Director, Dr. Amanda Lowery, juniors and seniors in biomedical engineering who have achieved a **minimum GPA of 3.5** may be accepted into the undergraduate honors program. Honors students take at least six credit hours of 5000-level (for graduate credit) or higher BME courses, which can be counted toward the undergraduate degree requirements as BME electives or which can be taken for graduate school credit. Honors students must make a GPA of 3.0 in these classes and maintain an overall 3.5 GPA to be designated with honors upon graduation. The diploma designation is Honors in Biomedical Engineering. Students in the honors program must also complete a two semester-long research project and present a research report; this is accomplished through the [BME 3860 and 3861](https://forms.vanderbilt.edu/view.php?id=1030114) Undergraduate Research elective courses. The report is due in manuscript form to the Honors Program Director the same day as it is due to the research course director and project preceptor.

To apply, fill out the [Honors Program Application Form](https://forms.vanderbilt.edu/view.php?id=712752) detailing how you plan to meet the requirements for the honors program, complete your [Four Year Curriculum Spreadsheet](file:///C%3A%5CUsers%5Cjusti%5CDownloads%5CBME%20Curriculum%2C%20Class%20of%2022%27%2B.xlsx), and meet with your academic advisor to obtain their approval before the start of your senior year. Once these steps have been completed, your advisor will fill out an online approval form which will be sent to the Honors Program Director (amanda.r.lowery@vanderbilt.edu) for approval.

14. **Internships.** The experience of working as an intern in a biomedical engineering firm or research laboratory can be an invaluable component of your education and preparation for future employment. Such an experience strengthens the understanding of concepts learned in the classroom, teaches valuable workplace skills, and provides insight into future career options. Summer internships are strongly encouraged, especially for rising juniors and seniors. Please meet with your academic adviser and the Center for Student Professional Development for guidance **no later than January** of the year in which you wish to participate in an internship.

15. **Double majors.** At present, there are two formal double majors within the School of Engineering, one with chemical engineering/BME and another with electrical engineering/BME. The term ‘double major’ in this context identifies a pre-defined program that has been agreed to by both departments in such a way to meet the expectations of both majors in a reasonable number of total credit hours.

Students interested in the BME/ChBE double major should consult with Dr. Adam Anderson (adam.anderson@vanderbilt.edu) regarding requirements and details of scheduling—a sample curriculum is given on page 18 of this guide. The double major with electrical engineering is detailed on page 19; students considering the BME/EE double major are urged to consult with the BME/EE double major adviser, Prof. Benoit Dawant (benoit.dawant@vanderbilt.edu). Students **must declare** their intention to double major by completing the appropriate form available in the School of Engineering Office of Academic Services.

16. **Second Majors**. Occasionally students choose to obtain two majors outside those offered through the double major programs. Students pursuing two majors should note that there are no pre-approved exceptions between the two departments, and thus, in such cases, **students must meet all of the individual requirements of both majors**, which generally requires advanced placement credits, summer study, higher semester course loads, and/or extra semester(s). Students choosing this track must manage their requirements and will typically be assigned two academic advisers, one for each program. For any further questions or advice on planning, students are encouraged to consult both majors’ advisers and/or the Assistant to the Director of Undergraduate Studies for Biomedical Engineering ([see website](https://engineering.vanderbilt.edu/bme/UndergraduateProgram/)). In cases where two majors are unattainable but the areas of study are still of interest, students are encouraged to pursue a Minor in one of the subject areas. For further information and sample curricula, see page 20.

17. **Minors.** There are seven official minors in the School of Engineering: Computer Science, Energy and Environmental Systems, Engineering Management, Environmental Engineering, Materials Science, Nanoscience and Nanotechnology, and Scientific Computing. Students wishing to pursue these minors can spend their allotted hours of Technical and Open electives towards these minors. Please see the Undergraduate Catalog for sequences. **Other minors outside the School of Engineering are possible** and students are encouraged to consult the Undergraduate Catalog and faculty in the program of interest for minor requirements. Students must declare their intention to add a minor by completing the appropriate form available in the School of Engineering Office of Academic Services.

18. **Accelerated Graduate Program in Engineering.** Students with a significant number of class credits (**20 to 30 hours**), earned either through Advanced Placement tests or in college courses taken during high school, may be eligible for the Accelerated Graduate Program in Engineering. Through this program, a student is able to earn both a bachelor’s degree and a master of science in about the same time required for the bachelor’s degree. To be eligible for the program, a student must complete **86 hours** (senior standing) by the end of the sophomore year with a **minimum GPA of 3.5**.

To enroll, students must meet with and be approved by their current academic adviser, the Director of Graduate Studies in their department (craig.duvall@vanderbilt.edu for BME), the Senior Associate Dean of Engineering (cynthia.paschal@vanderbilt.edu), and the Senior Associate Dean of Graduate Education (duco.jansen@vanderbilt.edu) **in the specified order**. Upon admission to this program, a second “career” will be set up for the student which will allow the student to start taking graduate courses (course numbers > 5000) during the junior and senior years. These courses will be credited toward the Master of Science. Note that no double counting of courses is allowed (i.e., the student must meet the degree requirements for each degree independent of the other degree). The student receives the bachelor’s degree at the end of the fourth year and typically spends the summer finishing a master’s thesis to complete the Master of Science. Further information can be obtained from the director of graduate studies of the student’s major department.

**Disclaimer: This Sample Curriculum is only an example of a 4-year schedule. All BME core classes (except senior design courses) are offered during both Fall and Spring semesters, and there is flexibility as to the order in which courses are taken. However, students are responsible for checking and meeting course pre- and co-requisites prior to enrollment. For example, BME 2301 and BME 2302 can be taken in either order, and Systems Physiology does not have to be the first BME core course taken. Also, it may be beneficial to start the Quantitative Methods and Instrumentation series earlier, if possible, to enable further flexibility. BME 3000/Transport does not serve as a prerequisite or corequisite, making it a good candidate to take later if necessary. Courses may be interchanged to promote flexibility, provided fulfillment of all listed prerequisites (see table of co- and pre-requisites after the sections on electives). Consult with your academic advisor or contact the DUS or DUS assistant for any specific questions about your course enrollment or scheduling plans.**

**Biomedical Engineering Sample Curriculum**

|  |  |  |  |
| --- | --- | --- | --- |
| **First Year - Fall** | **Cr Hrs** | **First Year - Spring** | **Cr Hrs** |
| Chem 1601/1601LES 1401-1403\* Math 1300LAC Elective | General Chem + LabIntro to EngineeringCalculusVanderbilt Visions | 43430 | Chem 1602/1602L CS 1103/1101\*\*Math 1301 Physics 1601/1601L BME 1015  | General Chem + LabProgrammingCalculusGeneral Physics + LabInnovations & Careers | 43441 |
| **Total Hours**  | **14** | **Total Hours**  | **16** |
|  |  |  |  |
| **Second Year – Fall** |  | **Second Year - Spring** |  |
| BME 2301\*\*\*BSCI 1510/1510L\*\*\*\*\*\* Math 2300 Physics 1602/1602LLAC Elective  | Systems Physiology 1Intro Bio + LabMultivariable Calc.General Phys. + Lab | 34343 | BME 2302BME 2100Math 2400\*\*\*\* EECE 2112BME 2900WBME 2400 | Systems Physiology 2 BiomechanicsDiff Eqns/Linear AlgCircuitsEngineering Lab 1Quantitative Methods 1 | 33431 3  |
| **Total Hours**  | **17** | **Total Hours**  | **17** |
|  |  |  |  |
| **Third Year - Fall** |  | **Third Year - Spring** |  |
| BME 3000BME 3301BME 3400BME 3900W LAC ElectiveTech Elective\*\*\*\*\*  | Physiological Transp.Instrumentation 1Quantitative Methods 2Engineering Lab 2 | 343133 | BME 3302BME 3500 BME Elective\*\*\*\*\* BME ElectiveLAC Elective | Instrumentation 2Biomaterials | 43333 |
| **Total Hours**  | **17** | **Total Hours**  | **16** |
|  |  |  |  |
| **Fourth Year - Fall** |  | **Fourth Year - Spring** |  |
| BME 4901W BME 4950BME 4959 BME Elective Tech Elective LAC Elective Open Elective  | Engineering Lab 3BME DesignDesign Seminar | 1213332  | BME 4951 BME Elective Tech Elective Tech ElectiveLAC Elective  | BME Design | 33333 |
| **Total Hours**  | **15** | **Total Hours**  | **15** |

Hours required to graduate = 127

**Notes:**

**\***For transfer students, ES 1401-1403 can be replaced with any course(s) in the School of Engineering **except:**

1) CS 1151 and ENGM 2440, 2) ES 2700, 2900, 3884, 3) ENGM 3350, and 4) courses that is(are) restricted to open elective credit toward a degree in the school, such as BME 1015, 2201, 2860, CS 1000, ENGM 4800, ES 1001. The substituting course(s) cannot simultaneously be counted toward other requirements in the primary degree nor can it(they) be taken pass/fail.  Accepted substitutions include UG research courses and ES 2100W Technical Communications.

**\*\***Students with an interest in advanced computer science should consider taking CS 1101 rather than CS 1103. However, these students will be responsible for learning the MATLAB skills (taught in CS 1103) needed in later BME courses.

**\*\*\***BME 2301 does not have to be the first BME class taken in fall of sophomore year. Other examples on how to launch into initial BME courses are to enroll in BME 2100 or BME 2400 (provided completion of the MATH 2300 prerequisite). The first requirement for BME 2301 is that it is a co-requisite for junior BME lab (BME 3900W).

**\*\*\*\***Math 2400 is the required course, though a combination of BOTH Math 2420 and either Math 2410 or 2600 may be substituted, with the extra math hours counting as Technical electives.

**\*\*\*\*\***BME students take at least 12 credit hours of BME program electives and 9 credit hours of Technical (science, engineering, or math) electives. See following sections on electives.

**\*\*\*\*\*\***AP Biology credit (BSCI 1100/1100L) will NOT fulfill this requirement. BSCI 1510/1510L is a required course.

**Program Electives**

**BME Electives**

A total of 12 BME elective hours must be taken. BME Electives are elective courses taught within the BME department and carrying a “BME” course code at the 2000-level and higher (e.g., BME 4100).

* Up to 6 credit hours of Undergraduate Research, BME 3860/3861, generally taken junior spring semester or senior year, may count as a BME elective.
* BME students may count **only one of the following** VUSE courses as BME electives: ChBE 4810, 4500, 4870; EECE 3214, 4353, 4354; ENVE 4610; and ME 2220. This option does not apply to BME/EE double majors.
* BME freshman seminars, BME 2201 Biomedical Ethics, and BME 3890: Pathology and Pathophysiology (Counts as Technical/Open Elective) cannot count as BME electives.
* BME graduate courses, with the exception of BME 8991-8994, may be taken as electives provided the student has a 3.5 GPA and appropriate permissions.

**TECHNICAL Electives**

A total of 9 hours of Technical (Science, Engineering, or Math) electives must be taken. Technical electives include the following:

* Courses in the School of Engineering **except** BME 2201, 2860, CHBE 3300, CE 2200, CS 1000, 1151, ENGM 2160, 2440, 3100, 3350, ME 2171, and listings in Engineering Science.
* Up to 3 hours of independent study courses in the School of Engineering may be taken as technical electives.
* Courses numbered 2000 or higher in the mathematics and natural sciences (MNS) AXLE category in the College of Arts and Science **except** MATH 2600, 2610, 2810, and 3000.
* Biological Sciences BSCI 1511/1511L and Nursing NURS 1500, 1600.

**CORE PREREQUISITES**

|  |
| --- |
|  |
| **Course Number; Title** | **Preferred Semester** | **Prerequisites** | **Corequisites** |
|  |
| BSCI 1510/L; Intro Bio with Lab | Sophomore Fall | CHEM 1601 | CHEM 1601 |
| BME 2301; Sys Physiology I | Sophomore Fall, Spring | CS 1101/1103 | BSCI 1510, PHYS 1602 |
| BME 2302; Sys Physiology II | Sophomore Fall, Spring | CS 1101/1103, PHYS 1601 | BSCI 1510, PHYS 1602 |
| BME 2100; Biomechanics | Sophomore Spring | PHYS 1601, MATH 1301, CS 1101/1103 |  |
| BME 2400; Quant. Mthds. I: Stat. Analysis | Sophomore Spring | MATH 2300 | CS 1101/1103 |
| BME 2900W; BME Laboratory | Sophomore Spring | CS 1101/1103 | BME 2301 |
| EECE 2112; Circuits I | Sophomore Spring |  | PHYS 1602, MATH 2300 |
| MATH 2300; Multivariable Calculus | Sophomore Fall | MATH 1301 or MATH 2200 |  |
| Math 2400; Diff. Eqtns. with Linear Algebra | Sophomore Spring | MATH 2300 | MATH 2300 |
| PHYS 1602/L; General Physics II with Lab | Sophomore Fall |  |  |
| BME 3000; Phys. Transport Phenomena | Junior Fall | BME 2100, MATH 2400/2420 |  |
| BME 3301; Biomed. Instr. I | Junior Fall, Spring | EECE 2112 | BME 3400 |
| BME 3302; Biomed Instr. I, II | Junior Fall, Spring | BME 3301 |  |
| BME 3400; Quant. Mthds. II: Sgnls. & Mdlng. | Junior Fall | CS 1101/1103, MATH 2400 | BME 2400 |
| BME 3500; Biomedical Materials | Junior Fall | CHEM 1602, PHYS 1601 |  |
| BME 3900W; BME Laboratory | Junior Fall | BME 2900W | BME 2302, 2100 |
| BME 4901W; BME Laboratory III | Senior Fall | BME 2400, BME 3900W |  |
| BME 4950, 4951; Dsgn. of Biomed Eng. Sys I, II | Senior Fall, Spring |  | BME 3302 |
| BME 4959; Snr Eng. Design Seminar | Senior Fall | Senior Standing\* | BME 4950 |

\*Senior standing may also be awarded to students pursuing accelerated degrees, if eligible. See page 13 for more information.

**Note:** The curriculum for all first-year engineering disciplines is the same, and thus those courses are not listed here but can be found online in the Undergraduate Catalog.

**BME Premed Sample Curriculum**

|  |  |  |  |
| --- | --- | --- | --- |
| **First Year - Fall** | **Cr Hrs** | **First Year - Spring** | **Cr Hrs** |
| Chem 1601/1601LES 1401-1403 Math 1300LAC ElectivePSY 1200 | General Chem + LabIntro to EngineeringCalculusGeneral PsychologyVanderbilt Visions | 434330 | Chem 1602/1602L CS 1103/1101 Math 1301 Physics 1601/1601L BME 1015  | General Chem + LabProgrammingCalculusGeneral Physics + LabInnovations & Careers | 43441 |
| **Total Hours**  | **17** | **Total Hours**  | **16** |
|  |  |  |  |
| **Second Year – Fall** |  | **Second Year - Spring** |  |
| BME 2301BSCI 1510/1510L Math 2300 Physics 1602/1602LChem 2221/2221L  | Systems Physiology 1Intro Bio + LabMultivariable Calc.General Phys. + LabOrganic Chem + Lab | 34344 | BME 2302Math 2400 BSCI 1511/1511LBME 2900WChem 2222/2222L | Systems Physiology 2 Diff Eqns/Linear AlgIntro Bio + LabEngineering Lab 1Organic Chem + Lab | 3441 4  |
| **Total Hours**  | **18** | **Total Hours**  | **16** |
|  |  |  |  |
| **Third Year - Fall** |  | **Third Year - Spring** |  |
| BME 2100EECE 2112BME 2400BME 3900W SOC 1010 BME Elective  | BiomechanicsCircuits 1Quantitative Methods 1Engineering Lab 2Sociology | 333133 | BME 3301BME 3500 BME 3400 BME ElectiveBSCI 2520 | Instrumentation 1BiomaterialsQuantitative Methods 2Biochemistry | 43333 |
| **Total Hours**  | **16** | **Total Hours**  | **16** |
|  |  |  |  |
| **Fourth Year - Fall** |  | **Fourth Year - Spring** |  |
| BME 4901W BME 4950BME 4959 BME 3000 BME 3302BME Elective LAC Elective  | Engineering Lab 3BME DesignDesign SeminarPhysiological Transp.Instrumentation 2 | 1213433  | BME 4951 LAC Elective BME Elective LAC Elective  | BME Design | 3333 |
| **Total Hours**  | **17** | **Total Hours**  | **12** |

Hours required to graduate = 128

**Notes**

Students with advanced placement in math may wish to omit a math class in the third semester.

**BME/ChBE Double Major Sample Curriculum**

|  |  |  |  |
| --- | --- | --- | --- |
| **First Year - Fall** | **Cr Hrs** | **First Year - Spring** | **Cr Hrs** |
| Chem 1601/1601LES 1401-1403 Math 1300LAC Elective | General Chem. + LabIntro to EngineeringCalculusVanderbilt Visions | 43430 | Chem 1602/1602L CS 1103/1101 Math 1301 Physics 1601/1601L  | General Chem. + LabProgrammingCalculusGeneral Physics + Lab | 4344 |
| **Total Hours**  | **14** | **Total Hours**  | **15** |
|  |  |  |  |
| **Second Year – Fall** |  | **Second Year - Spring** |  |
| CHBE 2100BSCI 1510/1510L Math 2300 Physics 1602/1602LChem 2221/2221L  | Chem. Proc. PrinciplesIntro Bio + LabMultivariable Calc.General Phys. + LabOrganic Chem. + Lab | 34344 | BME 2301CHBE 2200Math 2400 EECE 2112BME 2900WChem 2222/2222L | Systems Physiology 1 ThermodynamicsDiff Eqns/Linear AlgCircuitsEngineering Lab 1Organic Chem. + Lab | 33431 4  |
| **Total Hours**  | **18** | **Total Hours**  | **18** |
|  |  |  |  |
| **Third Year - Fall** |  | **Third Year - Spring** |  |
| BME 2302BME 2100BME 2400CHBE 3300 CHBE 3200 LAC Elective  | Systems Physiology 2BiomechanicsQuantitative Methods 1Fluid Mech. & Ht. TrnsPhase Equil. & Sep. | 333333 | BME 3301BME 3400 BME 3500 BME 3900WCHBE 3250CHBE 3350 | Instrumentation 1Quantitative Methods 2BiomaterialsEngineering Lab 2Chem Reaction Eng.Mass Trns. & Sep. | 433133 |
| **Total Hours**  | **18** | **Total Hours**  | **17** |
|  |  |  |  |
| **Fourth Year - Fall** |  | **Fourth Year – Spring** |  |
| BME 4959 BME 3302CHBE 4900WCHBE 4950W CHBE 4959 LAC Elective  | Design SeminarInstrumentation 2Chem. Lab 2Chem Eng. & DesignSafety in ChE Design | 14341 3 |  ChBE 4951WBME/CHBE Elective1 LAC ElectiveLAC ElectiveLAC Elective  | ChE Design | 33333 |
| **Total Hours**  | **16** | **Total Hours**  | **15** |

Hours required to graduate = 131

\*All double majors should have Dr. Paul Laibinis (ChE) or Dr. Craig Duvall (BME) assigned as their academic advisor

\*For double majors, students must pursue a senior design project that incorporates key concepts from both fields of study.

**Notes**

1. ChBE/BME Elective: 3 hours selected from CHBE 4500, 4800, 4805, 4810, 4820. This major elective can also be satisfied by any BME course numbered 4000 or higher except BME 6110. Other BME courses below 4000 (for example, BME 3890 special topics courses) will be considered as exceptions that must be approved by your BME/ChE double major advisor (Craig Duvall and/or Paul Laibinis).

**BME/ECE Double Major Sample Curriculum**

|  |  |  |  |
| --- | --- | --- | --- |
| **First Year - Fall** | **Cr Hrs** | **First Year - Spring** | **Cr Hrs** |
| Chem 1601/1601LES 1401-1403 Math 1300LAC Elective | General Chem. + LabIntro to EngineeringCalculusVanderbilt Visions | 43430 | Chem 1602/1602L CS 1101 Math 1301 Physics 1601/1601L BME 1015 | General Chem. + LabProgrammingCalculusGeneral Physics + Lab | 43441 |
| **Total Hours**  | **14** | **Total Hours**  | **16** |
|  |  |  |  |
| **Second Year – Fall** |  | **Second Year - Spring** |  |
| BME 2301BSCI 1510/1510L Math 2300 Physics 1602/1602LEECE 2112/2112L  | Systems Physiology 1Intro Bio + LabMultivariable Calc.General Phys. + LabCircuits 1 + Lab | 34344 | BME 2302BME 2100Math 2400 EECE 2123/2123LEECE 2214 | Systems Physiology 2 BiomechanicsDiff Eqns/Linear AlgDigital Systems + LabAnalog Circuits and Systems | 33443  |
| **Total Hours**  | **18** | **Total Hours**  | **17** |
|  |  |  |  |
| **Third Year - Fall** |  | **Third Year - Spring** |  |
| CS 2201/2203BME 2900WBME 2400EECE 3235/3235L LAC ElectiveLAC Elective  | Program Design and Data StructuresEngineering Lab 1Quantitative Methods 1Electronics 1 | 313433 | BME 3302BME 3500 BME 3900WEECE ElectiveEECE ElectiveLAC Elective | Instrumentation 2BiomaterialsEngineering Lab 2 | 431333 |
| **Total Hours**  | **17** | **Total Hours**  | **17** |
|  |  |  |  |
| **Fourth Year - Fall** |  | **Fourth Year – Spring** |  |
| BME 4901W BME 4950\*BME 4959 BME 3000EECE ElectiveEECE ElectiveLAC Elective  | Engineering Lab 3BME DesignDesign SeminarPhysiological Trans. | 1213333  | BME 4951\* BME Elective EECE ElectiveEECE ElectiveLAC Elective  | BME Design | 33333 |
| **Total Hours**  | **16** | **Total Hours**  | **15** |

Hours required to graduate = 130

\*For double majors, students must pursue a senior design project that incorporates key concepts from both fields of study.

**Notes**

Within the 18 hours of EECE electives, students must complete **at least 9 hours** in one and at least **at least 6 hours** in another of the Areas of Concentration listed under Electrical and Computer Engineering in the Undergraduate Catalog. BME 3302 may be included toward satisfying the Area of Concentration requirement but cannot be counted as an Electrical and Computer Engineering elective. Also, at least one of the elective courses must be an approved Design Domain Expertise (“DE”) course.

**BME/CS Second Major Sample Curriculum Assuming AP Credits Described Below**

|  |  |  |  |
| --- | --- | --- | --- |
| **First Year - Fall** | **Cr Hrs** | **First Year - Spring** | **Cr Hrs** |
| MATH 2300LAC ElectiveES 1401-3CS 1101\*\*CS 1151 | Multivariable CalculusIntro to EngineeringInto to Java/PythonComputers and Ethics | 33333 | MATH 2410/2600 LAC ElectiveEECE 2112CS 2201CS 2212BME 1015 (opt.) | Linear AlgebraCircuits 1Data StructuresDiscrete Structures | 333331 |
| **Total Hours**  | **15** | **Total Hours**  | **16** |
|  |  |  |  |
| **Second Year – Fall** |  | **Second Year - Spring** |  |
| BME 2301EECE 2123/L LAC ElectiveMATH 2400 CS 3251  | Systems Physiology 1Digital SystemsDif. Eqtns. w/ Lin. Alg.Intrmed. Software Dsg. | 34343 | BME 2302BME 2100CS 3250LAC ElectiveBME ElectiveBME 2400 | Systems Physiology 2 BiomechanicsAlgorithmsQuantitative Methods 1 | 333333 |
| **Total Hours**  | **17** | **Total Hours**  | **18** |
|  |  |  |  |
| **Third Year - Fall** |  | **Third Year - Spring** |  |
| CS 3270BME 2900WCS 3281BME ElectiveBME 3301BME 3400 | Programming Lang.’sEngineering Lab 1Prin. Of Op. Sys.’sInstrumentation 1Quantitative Methods 2 | 313343 | BME 3302BME 3500 BME 3900WCS 3250CS DepthBME 3000 | Instrumentation 2BiomaterialsEngineering Lab 2AlgorithmsPhysiological Transport | 431333 |
| **Total Hours**  | **17** | **Total Hours**  | **17** |
|  |  |  |  |
| **Fourth Year - Fall** |  | **Fourth Year – Spring** |  |
| BME 4901W BME 4950BME 4959 CS DepthCS DepthBME Elective | Engineering Lab 3BME DesignDesign Seminar | 121333  | BME 4951 BME Elective CS DepthCS Project  | BME Design | 3333 |
| **Total Hours**  | **13** | **Total Hours**  | **12** |

Hours required to graduate assuming AP credits described below = 125\*

\*\*CS 1101 counts towards both BME and CS majors, as well as a CS minor

**Notes**

Completing CS as a second major requires a large number of credit hours, and BME students interested

in depth of CS study are recommended to first consider pursuit of a CS minor. The sample curriculum

above is based on the assumption that a student pursuing a second major in CS would bring 30 hours of AP

credit, including 1 English (3 hours LAC), 1 History (3 hours LAC), 2 Biology (6 hours), 2 Chemistry (6

hours), 2 Physics (6 hours), and 2 Math (6 hours). A student would not have to have these exact AP

credits to pursue this second major, but a similar number of overall AP credits would be ideal. Math classes in the first and second years can be delayed and/or rearranged to accommodate any extra classes. The above Sample Curriculum is only intended as a starting point for each student’s unique situation.

**BME/CSET (Communication of Science, Engineering, and Technology) Second Major Sample Curriculum**

|  |  |  |  |
| --- | --- | --- | --- |
| **First Year - Fall** | **Cr Hrs** | **First Year - Spring** | **Cr Hrs** |
| CHEM 1601/LES 1401-3MATH 1300LAC Elective | General Chem + LabIntro to EngineeringCalculus | 4343 | CHEM 1602/LCS 1103/1101MATH 1301PHYS 1601/LBME 1015 | General Chem + LabProgrammingCalculusGeneral Physics + LabInnovations & Careers | 43441 |
| **Total Hours**  | **14** | **Total Hours**  | **16** |
|  |  |  |  |
| **Second Year – Fall** |  | **Second Year - Spring** |  |
| BME 2301BSCI 1510/LMATH 2300PHYS 1602/LLAC Elective | Systems Physiology 1Intro Bio + LabMultivariable Calc.General Physics + Lab | 34343 | BME 2302BME 2100MATH 2400EECE 2112BME 2900WBME 2400 | Systems Physiology 2 BiomechanicsDif. Eqtns. w/ Lin. Alg.CircuitsEngineering Lab 1Quantitative Methods 1 | 334313 |
| **Total Hours**  | **17** | **Total Hours**  | **17** |
|  |  |  |  |
| **Third Year – Fall** |  | **Third Year – Spring** |  |
| BME 3000BME 3301BME 3400BME 3900WCSET 2100Tech Elective | Physiological Transp.Instrumentation 1Quantitative Methods 2Engineering Lab 2Science Comm. | 343133 | BME 3302BME 3500 BME ElectiveBME ElectiveCMST 1501, 2100, 2110, 2120 | Instrumentation 2BiomaterialsPublic Speaking | 433333 |
| **Total Hours**  | **17** | **Total Hours**  | **16** |
|  |  |  |  |
| **Fourth Year - Fall** |  | **Fourth Year – Spring** |  |
| BME 4901W BME 4950BME 4959 Tech ElectiveBME ElectiveENGL 3215\*ECON 2350\*\* | Engineering Lab 3BME DesignDesign SeminarArt of BloggingHealth Care Policy | 1213333  | BME 4951 BME Elective Tech ElectiveOpen ElectiveOpen Elective | BME Design | 33333 |
| **Total Hours**  | **15** | **Total Hours**  | **15** |

\*or any course specified in the [UCG](https://www.vanderbilt.edu/catalogs/documents/UGAD.pdf) (pg. 93) as a CSET Non-science Writing Course

\*\*or any course specified in the [UCG](https://www.vanderbilt.edu/catalogs/documents/UGAD.pdf) (pg. 94) as a CSET Bridging Course AND a LAC SBS (social and behavioral sciences) course

Hours required to graduate = 127

**Notes**

It is possible to complete all CSET requirements without exceeding the number of credit hours required for the normal BME degree (126). The requirements for the second major in CSET can typically be accomplished by appropriate choice of courses to fulfill elective requirements. To pursue this path, students will typically need to declare the CSET second major before the Fall Semester of their junior year. For concerns and help with course selection for the CSET Non-Science Writing Course and/or Bridging Course, students are encouraged to contact the CSET Program Chair Dr. David Weintraub (david.weintraub@vanderbilt.edu).

**List of other Common Second Majors**

Blair, Music Performance

Data Science