

**COMBINED BACHELOR OF SCIENCE IN BIOLOGICAL
SCIENCES/MASTER OF SCIENCE IN BIOENGINEERING** (Revised 9/25/2015)

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Biological Sciences undergraduates at Clemson University may begin a Master of Science (MS) degree in Bioengineering while completing their Bachelor of Science (BS) degree by using a limited number of courses to satisfy both degrees. The following specific requirements apply:

1. To be eligible for this plan (to file GS6BS/MS form), students must have completed their bachelor's curriculum through their junior year (minimum 90 credits) and have a minimum overall grade point ratio of 3.4. **Note:** The GRE requirement for admissions is eliminated for students with approved GS6BS/MS forms: [Combined Bachelor's/Masters Plan](#)
2. Students should select the PHYS 1220, 1240 and PHYS 2210, 2230 options to fulfill the physics requirement for their BS degree.
3. Students will be required to take the following courses (a-d) as undergraduates:
 - a. Calculus of Several Variables (MATH 2060, 4 credits) **and** Intro to Ordinary Differential Equations (MATH 2080, 4 credits)
 - b. Statics (CE 2010, 3 credits)
 - c. Introduction to Materials Science (MSE 2100, 3 credits) **or** Introductory Circuit (ECE 2070/2080, 4 credits)
 - d. An additional junior-level engineering course: e.g., Biomechanics (BIOE 3200), Biofluid Mechanics (BIOE 3210) Bioinstrumentation (BIOE 3700), Thermodynamics of Materials (MSE 3260), Transport Phenomena (MSE 3270), Mechanical Behavior of Materials (MSE 4220)
4. Up to 6 credit hours of 6000 level elective courses from BIOE, BIOL or BCHM may be used to satisfy both the BS and MS requirements. However, the core requirement courses for the BIOL BS degree (e.g., BIOL 4610/6610, Cell Biology) cannot be counted twice for both degrees. Biotechnology for Bioengineers (BIOE 6400) is recommended. For other courses, see advisor.
5. Students will most often enroll into the non-thesis MS program. Students may take the MS thesis option if they are able to arrange for a faculty member in either Biological Sciences or Bioengineering to be their thesis advisor for a defined research project. Those who intend to follow the thesis option may start their research as BIOL 4910 during their junior year and continue under this during their senior year. Beginning in the summer after their senior year students will enroll in BIOE 8910 (6 credits total required) for thesis option or BIOE 8920 (6 credits total required) for a non-thesis option. The intended outcome for the thesis student is publishable experimental research. The intended outcome for the non-thesis student is a paper based on library or limited laboratory work or both. Both types of students will undergo an oral exam in which they defend their project work and are tested on relevant general knowledge of biology and bioengineering.
6. As part of the graduate program students will be required to take Seminar in Bioengineering Research (BIOE 8000, 1 credit each semester – only 1 credit counted towards degree requirements), Research Principles (BIOE 6150, 1 credit), Biomaterials (BIOE 8010, 3 credits); Biomedical Basis for Engineered Replacement (BIOE 8460, 3 credits), and one of the following three courses: Structural Biomechanics (BIOE 8200, 3 credits), Transport Processes in Bioengineering (BIOE 8470, 4 credits), or Bioinstrumentation (BIOE 8700, 3 credits). During the summer following their senior year students will enroll in Statistical Methods I (STAT 8010/8011, 4 credits). These courses with an additional elective (6000- or 8000-level BIOE or BIOL, 2-3credit) course will fully satisfy the total of 30 credits required for the thesis option. Non-thesis students will need to take additional 5-6 credit hours as necessary to meet the 33 credits required; course selection to satisfy these additional credit hours should be made in consultation with the student's research advisor.
7. Students in a combined degree program are conditionally accepted to the graduate program until completion of the BS degree requirements. Students enrolled in the MS degree program should anticipate covering the full amount of tuition, fees, and living expenses for their MS degree. Under special circumstances, research assistantship support for MS thesis projects may be available from individual faculty members or teaching assistantship support from the Department of Biological Sciences.

Students interested in this combined BS/MS degree program should consult with Ms. Londa Means as early as possible in their undergraduate curriculum. Application should be made by the end of their junior year (minimum 90 credits), but can be made at any time so long as the requirements for the program are met. The GS6BS/MS form is submitted to the Graduate School.

BIOE COURSES – BIOMATERIALS TRACK

BIOE 3200 Biomechanics 3 (3) Study of relation between biological and mechanical functions of musculoskeletal tissues such as bone, ligaments, muscles, cartilage, etc.; mechanics of human joints; analysis of implants and implant failure. Preq: CE 2010 and MATH 2080. Fall & Spring.

BIOE 6120 Orthopaedic Engineering and Pathology 3 (3) Interdisciplinary study of clinical orthopaedic cases (bone growth, bone remodeling, osteoarthritis, implant fixation and joint replacements); biomechanical, biomaterials, tribology and clinical diagnosis of failed implants (total joint replacements, fracture fixation and spinal instrumentation); basic concepts of orthopaedic pathology for engineers. Preq: BIOE 3020 and BIOE 3200; Preq or concurrent enrollment: BIOL 3150. Fall.

BIOE 6230 Cardiovascular Engineering and Pathology 3 (3) Medical and bioengineering aspects of artificial cardiovascular and vascular devices; physiology and pathological aspects of patients with need for such devices; diagnostic techniques and surgical management of diseases and pathology; design aspects of current devices and selection; state of the art in experiments and human clinical trials. Preq: BIOE 3020 and BIOE BIOL 3150; and either BIOE 3200 or BIOE 3210. Spring.

BIOE 6400 Biopharmaceutical Engineering 3 (3) This course examines the design principles necessary to use bacteria, fungi, and mammalian cells in bioengineering applications, including molecular techniques, fermentation, process scale-up, purification processes, and FDA regulations. The production of biopharmaceuticals derived from recombinant systems, including uses in medical systems, is emphasized. Preq: BCHM 3050. Fall.

BIOE 6820 Biomaterial Implantology 3 (2) Provides training in the planning and conduct of experimental surgery, including laws and regulations; institutional requirements; selection of animal models; ethical considerations of animal research; preparation of animals for surgery; general and special surgical techniques; aseptic surgical techniques; and basic and applied instrumentation. Preq: Junior standing in Bioengineering. Coreq: BIOE 4821. Summer.

CE 2010 Statics 3 (3) Forces and force systems and their external effect on bodies, principally the condition of equilibrium. The techniques of vector mathematics are employed, and the rigor of physical analysis is emphasized. Includes Honors sections. Preq: PHYS 1220 with a C or better. Preq or concurrent enrollment: ENGR 1070 and MATH 2060. Fall & Spring.

MSE 2100 Introduction to Materials Science 3 (3) Introductory course in materials science designed primarily for engineering students. Studies the relation between the electrical, mechanical, and thermal properties of products and the structure and composition of these products. All levels of structure are considered from gross structures easily visible to the eye through electronic structure of atoms. Preq: CH 1010 with a C or better. Preq or concurrent enrollment: MATH 1080. Fall & Spring.

BIOE COURSES – BIOINSTRUMENTATION TRACK

BIOE 3700 Bioinstrumentation and Bioimaging 3 (2) Introduction of fundamental topics in bioinstrumentation and bioimaging focused on the acquisition and monitoring of vital signals. Basic principles for the selection and appropriate use of instruments for solving bioengineering and medical problems such as microscopy, magnetic resonance imaging, and ultrasounds, among others, are addressed. Preq: MATH 2080; and ECE 2020 or ECE 2070. Coreq: BIOE 3701. Fall & Spring.

BIOE 6310 Medical Imaging 3 (2) Introduction to the history, physics, and basis of medical imaging devices; including X-ray, Computed Tomography, Magnetic Resonance Imaging, and Ultrasound. Students will understand imaging from both an engineering and clinical prospective. Students will have the opportunity to work with real medical-images, to understand the trade-offs between modalities. Preq: MATH 2080; and one of ECE 2020 or ECE 2070. Preq or concurrent enrollment: BIOE 3700. Coreq: BIOE 6311. Fall.

BIOE 6400 Biopharmaceutical Engineering 3 (3) This course examines the design principles necessary to use bacteria, fungi, and mammalian cells in bioengineering applications, including molecular techniques, fermentation, process scale-up, purification processes, and FDA regulations. The production of biopharmaceuticals derived from recombinant systems, including uses in medical systems, is emphasized. Preq: BCHM 3050. Fall.

BIOE 6710 Biophotonics 3 (3) Biophotonics is an interdisciplinary subject of applying photonics to study biological samples from individual cells to the entire body. Introduces fundamental and frontier topics in optical imaging aspects of biophotonics for senior-level undergraduates and graduate students to gain the ability to solve bioimaging-related biomedical problems. Preq: MATH 2080; and PHYS 2210; and either ECE 2070 or ECE 3200. Spring.

BIOE 6820 Biomaterial Implantology 3 (2) Provides training in the planning and conduct of experimental surgery, including laws and regulations; institutional requirements; selection of animal models; ethical considerations of animal research; preparation of animals for surgery; general and special surgical techniques; aseptic surgical techniques; and basic and applied instrumentation. Preq: Junior standing in Bioengineering. Coreq: BIOE 6821. Summer.

CE 2010 Statics 3 (3) Forces and force systems and their external effect on bodies, principally the condition of equilibrium. The techniques of vector mathematics are employed, and the rigor of physical analysis is emphasized. Includes Honors sections. Preq: PHYS 1220 with a C or better. Preq or concurrent enrollment: ENGR 1070 and MATH 2060. Fall & Spring.

ECE 2070 Basic Electrical Engineering 2 (2) A first course in electrical engineering to provide non-Electrical Engineering majors with a knowledge of DC and AC circuit theory, AC power distribution, and numerous electrical devices, apparatus, and digital systems. Credit may not be received for both ECE 2070 and ECE 3080. Preq: MATH 2060 and PHYS 2210. Fall & Spring.

ECE 2080 Electrical Engineering Laboratory II (2) Laboratory to accompany ECE 2070. Basic electrical circuits and instrumentation. Preq or enrollment: ECE 2070. Fall & Spring.

B. S. BIOLOGICAL SCIENCES / M.S. BIOENGINEERING ROADMAP 2017-2018

FRESHMAN YEAR

<u>First Semester</u>	<u>Second Semester</u>
BIOL 1010 Frontiers in Biol. I1(1,0)	BIOL 1110 Prin. of Biol. II ¹5(4,3)
BIOL 1100 Prin. of Biol. I ¹5(4,3)	CH 1020 General Chemistry4(3,3)
CH 1010 General Chemistry4(3,3)	ENGL 1030 Composition and Rhetoric3(3,1)
MATH 1060 Calculus of One Var. I4(4,0)	MATH 1080 Calculus of One Var. II.....4
Oral Communication Requirement ² 3	16
17	

SOPHOMORE YEAR

CH 2230 Organic Chemistry and3(3,0)	BCHM 3050 Essential Elements of Bioch ⁷3(3,0)
CH 2270 Organic Chemistry Lab ^{3,4}1(0,3)	BIOL 3350 Evolutionary Biology3(3,0)
GEN 3000 Fundamental Genetics ⁵3(3,0)	MATH 2080 Intro. Ordin. Differ. Equ4(4,0)
MATH 2060 Calculus of Several Var4(4,0)	Social Science Requirement ⁸3
Organismal Diversity Requirement ⁶4	Major Requirement ⁹3
15	16

JUNIOR YEAR

BIOL 4610 Cell Biology3(3,0)	BIOE 3200 Biomechanics ¹⁰ or3(3,0)
BIOL 4620 Cell Biology Laboratory.....2(1,2)	BIOE 3700 Bioinstr and Bioimaging ¹¹3(2,3)
CE 2010 Statics3(3,0)	ENGL 3150 Scientific Writing and Comm. ¹²3(3,0)
MSE 2100 Intro. Material Science ¹⁰ or3(3,0)	PHYS 2210 Physics with Calculus II and3(3,0)
ECE 2070 Basic Elect Engineer ¹¹ and2(2,0)	PHYS 2230 Physics Laboratory II1(0,3)
ECE 2080 Elect Engineering Lab I.....1(0,2)	Arts and Humanities (Literature) Req. ²3
PHYS 1220 Physics with Calculus I and3(3,0)	Functional Biol. Requirement ¹³3
PHYS 1240 Physics Laboratory I.....1(0,3)	16
15	

SENIOR YEAR

BIOE 6400 Biopharmaceutical Engineer3(3,0)	Arts and Humanities (Non-Lit) Req. ⁸3
BIOL 3150 Functional Human Anatomy4(3,3)	BIOE, BIOL OR BCHM 6xxx.....3
BIOL 4930 Senior Seminar or	Ecology Requirement ¹⁴3
MICR 4930 Senior Seminar.....2(2,0)	Major Requirement ^{9,15}3
Major Requirement ⁹3	12
Social Science Requirement ⁸3	
15	

Total Semester Hours = 122

¹ BIOL 1100 and 1110 are strongly recommended; however, BIOL 1030/1050 may substitute for BIOL 1100 and BIOL 1040/1060 may substitute for BIOL 1110. The remaining 1-2 credit hours required must be satisfied by completing 1-2 extra credits.

² See General Education Requirements.

³ Most professional health sciences schools require the second semester of organic chemistry with laboratory, CH 2240/2280.

⁴ CH 2010 and CH 2020 may substitute.

⁵ GEN 3020 may substitute.

⁶ At least one lecture and associated laboratory selected from BIOL 3010/3011, 3020/3060, 3030/3070, 3040/3080, 3200/3201, 4060/4070, 4250/4260

⁷ BCHM 3010 may substitute.

⁸ See General Education Requirements. Six of these credit hours must also satisfy the Cross-Cultural Awareness and the Science and Technology in Society Requirements. The Medical Colleges Admissions Test (MCAT) includes questions on psychology and sociology.

⁹ Credit hours must come from BIOL or MICR courses at the 3000-level or above, three classes of which must be laboratory. Two semesters of BIOL 4910 are recommended for BIOE MS thesis option.

¹⁰ Biomaterials track

¹¹ Bioinstrumentation track

¹² ENGL 3140 may substitute.

¹³ At least one course selected from selected from BIOL 4010, 4080, 4200, 4400, 4590, 4750, 4800, 4830, 4840, or MICR 4140.

¹⁴ At least one course selected from BIOL 4100, 4410, 4420, 4430, 4460, 4700, MICR 4010, or 4030.

¹⁵ Students may take additional graduate courses during this semester. See advisor.

2017/2018 B.S. BIOLOGICAL SCIENCES/M.S. BIOENGINEERING WORKSHEET

BIOL Core Requirement: (31 cr.)	SEM/Yr	Grade
BIOL 1010	1(1,0)	_____
BIOL 1100/1101	5(4,3) ¹	_____
BIOL 1110/1111	5(4,3) ¹	_____
BIOL 3350	3(3,0)	_____
BIOL 4610	3(3,0)	_____
BIOL 4620/4621	2(1,2)	_____
BIOL 4930 OR MICR 4930	2(2,0)	_____
<i>Organismal Diversity Requirement (4 cr.)</i>		
BIOL 3010/3011, 3020/3060, 3030/3070, 3040/3080, 3200/3201, 4060/4070, OR 4250/4260	_____	_____
<i>Ecology (3 cr.)</i>		
BIOL 4410, 4420, 4430, 4460, 4700, MICR 4010, OR 4030	_____	_____
<i>Functional Biology Requirement (3 cr.)</i>		
BIOL 4010, 4080, 4200, 4400, 4590, 4750, 4800, 4830, 4840, OR MICR 4140	_____	_____
Major Requirement: (21 cr.) ²		
Laboratory course req. BIOL 3151 (0)	_____	_____
Laboratory Course req.	_____	_____
Laboratory Course req.	_____	_____
BIOL 3150 (4)	_____	_____
MATH 2060 (4) ³	_____	_____
MATH 2080 (4) ³	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
Required Science Courses (34 cr.)		
BCHM 3050	3(3,0)	_____
CH 1010/1011	4(3,3)	_____
CH 1020/1021	4(3,3)	_____
CH 2230, 2270 OR CH 2010, CH 2020	3(3,0) & 1(0,3) ⁴	_____
GEN 3000	3(3,0)	_____
MATH 1060	4(4,0)	_____
MATH 1080	4(4,0)	_____
PHYS 1220, 1240	3(3,0) & 1(0,2)	_____
PHYS 2210, 2230	3(3,0) & 1(0,2)	_____
Required Non-Science Courses (21 cr.)		
ENGL 1030/1031	3(3,1)	_____
ENGL 3150 OR 3140	3(3,0)	_____
Arts & Humanities – Literature	3(3,0) ⁶	_____
Arts & Humanities – Non-Literature	3(3,0) ^{6,7}	_____
Oral Communication Requirement	3(3,0) ⁶	_____
Social Sciences	_____	_____
_____	3(3,0) ^{6,7}	_____
_____	3(3,0) ^{6,7}	_____

- ¹ BIOL 1100 and 1110 are strongly recommended. However, BIOL 1030/1050 may substitute for BIOL 1100 and BIOL 1040/1060 may substitute for BIOL 1110; the remaining 1-2 credits required must be satisfied by completing 1-2 extra credits.
- ² Twenty-one credit hours from 3000-level or higher BIOL or MICR courses or from CH 2240/2280, including at least three laboratory courses. Any combination of BIOL or MICR 3940, 4910, 4920, 4940, and 4950 may not exceed eight credits. Two semesters of BIOL 4910 are recommended for the Bioengineering M.S. Thesis Option.
- ³ Requires course substitution.
- ⁴ Most medical and dental schools require two semesters of organic chemistry with laboratory (CH 2230, 2270 and 2240, 2280).
- ⁵ CH 2240/2280 satisfies 4 credits of Major Requirement.
- ⁶ See General Education Requirements.
- ⁷ Six of these credit hours may also satisfy the Cross-Cultural Awareness (CCA) and Science and Technology in Society Requirements (STS).
- ⁸ Biomaterials track. See advisor if this course is not available.
- ⁹ Bioinstrumentation track
- ¹⁰ Used to satisfy both the BS and MS requirements (6 credits total).
- ¹¹ Requires prerequisite override from Civil Engineering

Other Courses	SEM/Yr	Grade
CU 1000 _____	_____	_____
CCA _____	_____	_____
STS _____	_____	_____

Electives (15 cr.)		
BIOE 3200 ⁸ (3) OR BIOE 3700 ⁹ (3)	_____	_____
BIOE 6400 ¹⁰ (3)	_____	_____
CE 2010 (3) ¹¹	_____	_____
MSE 2100 (3) ⁸ OR ECE 2070 (2) ⁹ and ECE 2080 (1)	_____	_____
BIOE, BIOL OR BCHM 6xxx ¹⁰ (3)	_____	_____
_____	_____	_____

Total Semester Hours = 122