APPROVAL FORM FOR

DEGREE PROGRAMS

MISSISSIPPI STATE UNIVERSITY

NOTE: This form is a cover sheet that must accompany the degree program change proposal. The actual proposal should be prepared in accordance with format requirements provided in the *Guide and Format for Curriculum Proposals* published by the UCCC. Both cover sheet and proposal should be submitted, along with all required copies, to UCCC, Garner, Room 279, (Mail Stop 9702).

College or School: Bagley College of Engineering **Department:** Ag & Biological Engineering

Contact Person: Steve Elder **Mail Stop:** 9632 **E-mail:** selder@abe.msstate.edu

Nature of Change: Degree modification **Date Initiated:** 2/6/2023 **Effective Date:** Fall '23

New or Current Degree Program Name: Biomedical Engineering

Summary of Proposed Changes:

In the new curriculum, the introductory courses have been modified and expanded to two credit hours; some previously required courses have been replaced by electives, which provides the opportunity to emphasize in an area of interest. The increased flexibility will also facilitate course scheduling.

Approved by:	Date:
Department Head	2/7/23
Chair, College or School Curriculum Committee	3/9/23
Kari Babski-Reeves for Jason Ketih Digitally signed by Kari Babski-Reeves for Jason Ketih Date: 2023.03.10 16:51:19 -06'00' Dean, College or School	3/10/2023
Chair, University Committee on Courses & Curricula	
Chair, Graduate Council (if applicable)	
Chair, Deans Council	

IHL Action Required

SACS Letter Sent

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Approved by: Date:

J. Alex Thomasson Digitally signed by J. Alex Thomasson Date: 2023.02.07 11:48:12 -06'00' 2/7/23
Department Head

Chair, College or School Curriculum Committee

Dean, College or School

Chair, University Committee on Courses & Curricula

Chair, Graduate Council (if applicable)

Chair, Deans Council

Dana Porzyfal - Acad Grad 3/8/23

IHL Action Required

SACS Letter Sent

1. **CATALOG DESCRIPTION**
   See Outline Chart below.

2. **DEGREE MODIFICATION OUTLINE CHART**

CURRENT Degree Description		PROPOSED Degree Description	
Degree: Bachelor of Science Major: Biomedical Engineering Concentration:		Degree: Bachelor of Science Major: Biomedical Engineering Concentration:	
Biomedical Engineering is a growing interdisciplinary field of engineering that integrates engineering and life sciences to solve problems associated with the human body and human health. The curriculum is built on a core of fundamental math/physics/engineering courses which is similar across all engineering disciplines. It is distinguished by a wide range of life science courses and specialized biomedical engineering courses such as computational modeling, biomechanics, biomaterials, and bioinstrumentation. The curriculum also includes a two-semester capstone design course. It is designed to comply with current requirements for ABET accreditation. Apart from preparing students to work in biomedical industry, the B.S. in Biomedical Engineering is an excellent foundation for graduate study in many fields, including further study of biomedical engineering. It is also good preparation for entry into professional schools, including medical school, dental school, veterinary school, and law school.		Biomedical Engineering is a growing interdisciplinary field of engineering that integrates engineering and life sciences to solve problems associated with the human body and human health. The curriculum is built on a core of fundamental math/physics/engineering courses which is similar across all engineering disciplines. It is distinguished by a wide range of life science courses and specialized biomedical engineering courses such as computational modeling, biomechanics, biomaterials, and bioinstrumentation. The curriculum also includes a two-semester capstone design course. It is designed to comply with current requirements for ABET accreditation. Apart from preparing students to work in biomedical industry, the B.S. in Biomedical Engineering is an excellent foundation for graduate study in many fields, including further study of biomedical engineering. It is also good preparation for entry into professional schools, including medical school, dental school, veterinary school, and law school.	
CURRENT CURRICULUM OUTLINE	Required Hours	**PROPOSED CURRICULUM OUTLINE**	Required Hours
<u>English Composition</u> EN 1103 English Comp I OR EN 1163 Accelerated Comp I EN 1113 English Comp II OR EN 1173 Accelerated Comp II	6	<u>English Composition</u> EN 1103 English Comp I OR EN 1163 Accelerated Comp I EN 1113 English Comp II OR EN 1173 Accelerated Comp II	6
<u>Mathematics</u> See Major Core	6-9	<u>Mathematics</u> See Major Core	6-9
<u>Natural Sciences</u> See Major Core	6-8	<u>Natural Sciences</u> See Major Core	6-8

Humanities Any Gen Ed course	6	Humanities Any Gen Ed course	6
Fine Arts Any Gen Ed course	3	Fine Arts Any Gen Ed course	3
Social/Behavioral Sciences Any Gen Ed course	6	Social/Behavioral Sciences Any Gen Ed course	6
Major Core Math and Basic Science MA 1713 Calculus I MA 1723 Calculus II MA 2733 Calculus III MA 2743 Calculus IV MA 3253 Differential Equations I CH 1213 Chemistry I CH 1211 Investigations in Chemistry I CH 1223 Chemistry II CH 1221 Investigations in Chemistry II *CH 2503 Elementary Organic Chemistry OR* *CH 4513 Organic Chemistry I* *CH 2501 Elementary Organic Chem Lab OR* *CH 4511 Organic Chemistry I Lab* PH 2213 Physics I PH 2223 Physics II BIO 1134 Biology I *BIO 3304 General Microbiology* *BCH 4013 Principles of Biochemistry OR General Biochemistry*	 *44*	Major Core Math and Basic Science MA 1713 Calculus I MA 1723 Calculus II MA 2733 Calculus III MA 2743 Calculus IV MA 3253 Differential Equations I CH 1213 Chemistry I CH 1211 Investigations in Chemistry I CH 1223 Chemistry II CH 1221 Investigations in Chemistry II PH 2213 Physics I PH 2223 Physics II BIO 1134 Biology I	 **33**
Engineering Topics *ABE 1911 Intro to Engineering in Life Sciences* *ABE 1921 Intro to Engineering Design* ABE 4803 Biosystems Simulation ABE 3413 Bioinstrumentation I ABE 3303 Transport in Biological Environment	*42*	Engineering Topics **ABE 1912 Computer-Based Problem Solving in Biological Engineering** **ABE 1922 Intro to Engineering Design and Manufacturing** ABE 4803 Biosystems Simulation ABE 3413 Bioinstrumentation I ABE 3303 Transport in Biological Environment	**43**

ABE 4323 Physiological Systems in Biomedical Engineering ABE 4423 Bioinstrumentation II ABE 3813 Biophysical Properties of Materials ABE 4813 Principles of Engineering Design ABE 4833 Practices of Engineering Design *ABE 4911 Engineering Seminar* *MA 3123 Introduction to Statistical Inference* EM 2413 Engineering Mechanics I EM 2433 Engineering Mechanics II EM 3213 Mechanics of Materials EM 3313 Fluid Mechanics		ABE 4323 Physiological Systems in Biomedical Engineering ABE 4423 Bioinstrumentation II ABE 3813 Biophysical Properties of Materials ABE 4813 Principles of Engineering Design ABE 4833 Practices of Engineering Design **MA 3123 Introduction to Statistical Inference OR** **IE 4613 Engineering Statistics I** EM 2413 Engineering Mechanics I EM 2433 Engineering Mechanics II EM 3213 Mechanics of Materials EM 3313 Fluid Mechanics	
<u>Oral Communication Requirement</u> Fulfilled in GE 3513 and other ABE courses		<u>Oral Communication Requirement</u> Fulfilled in GE 3513 and other ABE courses	
<u>Writing Requirement</u> GE 3513 Technical Writing	3	<u>Writing Requirement</u> GE 3513 Technical Writing	3
<u>Computer Literacy</u> Fulfilled in Engineering Topics courses		<u>Computer Literacy</u> Fulfilled in Engineering Topics courses	
<u>Restricted Electives</u> Biological Science Elective * *Engineering Elective (at least 6 hours must be ABE electives)*** Engineering Elective OR Math/Physics Elective*** *Bio Sci Electives: BIO 2103 Cell Biology, BIO 3004 Human Anatomy, BIO 3014 Human Physiology, BIO 3103 Genetics I, BIO 3504 Comparative Anatomy, BIO 3524 Biology of Vertebrates, BIO 4113 Evolution, *BIO 4114 Cellular Physiology*, BIO 4133 Human Genetics, BIO 4143 Population Genetics, BIO 4405 Pathogenic Microbiology, BIO	3 12 3	<u>Restricted Electives</u> Biological Science Elective* **Engineering/Technical Elective**** **Engineering Elective** Engineering OR Math/Physics Elective*** **ABE Elective***** *Bio Sci Electives: BIO 2103 Cell Biology, BIO 3004 Human Anatomy, BIO 3014 Human Physiology, BIO 3103 Genetics I, **BIO 3443 Biology of Cancer,** BIO 3504 Comparative Anatomy, BIO 3524 Biology of Vertebrates, BIO 4113 Evolution, BIO 4133 Human Genetics, BIO 4143 Population Genetics, BIO 4405 Pathogenic Microbiology, BIO 4413	3 **10** **6** 3 **6**

4413 Immunology, BIO 4433 Principles of Virology, BIO 4503 Vertebrate Histology, BIO 4504 Comparative Vertebrate Embryology, BIO 4514 Animal Physiology, ADS 4613 Physiology of Reproduction, BCH 4113 Essentials of Molecular Genetics, CVM 2443 Essentials of Biotechnology		Immunology, BIO 4433 Principles of Virology, BIO 4503 Vertebrate Histology, BIO 4504 Comparative Vertebrate Embryology, BIO 4514 Animal Physiology, ADS 4613 Physiology of Reproduction, **BCH 2023 Molecular Mechanisms of Human Diseases**, BCH 4113 Essentials of Molecular Genetics, **BCH 4443 Introduction to Human Health**, CVM 2443 Essentials of Biotechnology, **CVM 4193 Medical Pharmacology**	
***Engineering Electives: ABE 4523 Biomedical Materials, ABE 4613 Biomechanics, ABE 4723 Tissue Engineering and Regeneration, ABE 4624 Experimental Methods in Materials Research, ABE 4513 Dynamics of Aging, ABE 4533 Rehabilitation Engineering,* EM 4123 An Introduction to the Finite Element Method, EM 4133 Mechanics of Composite Materials, EM 4213 Advanced Mechanics of Materials, ME 3113 Engineering Analysis, *ME 3533 Thermodynamics,* ME 4123 Failure of Engineering Materials, ME 4743 Labview, ME 4833 Intermediate Fluid Mechanics, EG 1143 Graphic Communication, CSE 4613 Bio-computing, CSE 4623 Computational Biology, IE 3913 Engineering Economy, IE 4113 Human Factors Engineering*, IE 4173 Occupational Safety Engineering,* IE 4553 Engineering Law and Ethics, IE 4733 Linear Programming, IE 4743 Engineering Design Optimization*,* ECE 3714 Digital Devices and Logic Design , ECE 3443 Signals and Systems		****Engineering/Technical Electives: ABE 4911 Engineering Seminar, ASE 3213 Mechanics of Deformable Structures, BIO 3304 General Microbiology, BCH 4013 Principles of Biochemistry**, **CH 2503 Elementary Organic Chemistry, CH 2501 Elementary Organic Chemistry – Lab, CH 4331 Practical Mass Spectrometry, CH 4341 Practical Materials Characterization, CH 4461 Practical Optical Spectroscopy, CH 4513 Organic Chemistry I, CH 4511 Organic Chemistry Lab I**, **CH 4523 Organic Chemistry II, CH 4521 Organic Chemistry Lab II**, **CHE 3413 Engineering Materials, CHE 4143 Advanced Poly/Composite Materials, CSE 1233 Computer Programming – C, CSE 1273 Computer Programming – Java,** CSE 4613 Bio-Computing, CSE 4623 Computational Biology, **CSE 4683 Machine Learning and Soft Comp**, **ECE 3213 Solid State Electronics, ECE 3413 Introduction to Electronic Circuits, ECE 3283 Electronics, ECE 3423 Circuits I, ECE 3421 Circuits I Lab, ECE 3424**	

***Math/Physics Electives: MA 3113 Introduction to Linear Algebra, MA 3353 Differential Equations II, MA 4143 Graph		**Intermediate Electronic Circuits,** ECE 3443 Signals and Systems, ECE 3714 Digital Devices, **ECE 4273 Microelectronics Device Design, ECE 4293 Nano-electronics, IE 3121 Industrial Ergonomics Laboratory, EM 3413 Vibrations**, EM 4123 Introduction to Finite Elements, EM 4133 Composite Materials, **EM 4143 Engineering Design Optimization**, EM 4213 Advanced Mechanics of Materials, **IE 3123 Industrial Ergonomics**, IE 3913 Engineering Economy, IE 4113 Human Factors Engineering, IE 4553 Engineering Law & Ethics, **IE 4623 Engineering Statistics II, IE 4683 Machine Learning with IE Applications,** IE 4733 Linear Programming, IE 4743 Engineering Design Optimization, **IE 4753 Systems Engineering & Analysis,** EG 1143 Graphic Communication**,** ME 3113 Engineering Analysis, ME 3163 Introduction to Design with Finite Element Analysis, **ME 3403 Materials for Mechanical Engineering Design, ME 3423 Mechanics of Machinery, ME 3513 Thermodynamics I, ME 3613 System Dynamics, ME 4113 Material Selection in Design,** ME 4123 Failure of Engineering Materials, **ME 4233 Fundamentals of Finite Element Analysis, ME 4643 Introduction to Vibration/Controls,** ME 4723 Labview, ME 4833 Intermediate Fluid Mechanics, **SBP 3133 Mechanics of Biomaterials** ***Math/Physics Electives: MA 3113 Introduction to Linear Algebra, MA 3353 Differential Equations II, MA 4143 Graph	

Theory, MA 4373 Introduction to Partial Differential Equations, PH 2233 Physics III, PH 3613 Modern Physics, PH 4113 Elec Circuit Scien		Theory, MA 4373 Introduction to Partial Differential Equations, PH 2233 Physics III, PH 3613 Modern Physics, PH 4113 Elec Circuit Scien ******ABE Elective: ABE 3773 Current Topics in Biomedical Engineering, ABE 4443 Spectroscopic Sensing in Biosystems, ABE 4463 Introduction to Imaging in Biological Systems, ABE 4523 Biomedical Materials, ABE 4613 Biomechanics, ABE 4723 Tissue Engineering**	
Total Hours	128	Total Hours	128

3. JUSTIFICATION AND STUDENT LEARNING OUTCOMES

The current BME curriculum is highly prescriptive and offers students little opportunity to specialize in a particular area. It serves the pre-medical students well, but it does not have the flexibility that would allow students interested in an industry position or graduate school a chance to tailor the curriculum to their needs. The proposed modification still accommodates the pre-medical emphasis while offering all students a much wider range of courses from which to choose. For example, students interested in developing new medical technology will be able to choose engineering courses in place of some currently required natural science courses (e.g. Elementary Organic Chemistry and Biochemistry). Furthermore, during 2021 and 2022 meetings of the ABE Advisory Board, members reported that recent graduates may have been less competitive than they could have been for industry positions had they been able to demonstrate deeper knowledge in at least one area of specialization. They suggested that we consider a curriculum modification that facilitates students emphasizing in a particular area of interest. Finally, we have noticed that the current rigid curriculum frequently creates course scheduling difficulties. Therefore, we propose a modified base curriculum with fewer "hard-wired" courses and more electives.

Students will benefit from the curriculum modification by having a curriculum that better prepares them for (a) careers in the broad area of medical device design and manufacturing (b) graduate study in biomedical engineering or related engineering discipline. Through a deliberate and judicious selection of electives, a student will be able to create a curriculum with emphasis in a particular area of interest, for example Biosensors or Biomaterials, in addition to Pre-Medical. Concentrations within BME programs are quite common, almost the rule rather than the exception. For example, students in the University of Alabama at Birmingham's BME program can concentrate in Biomechanics, Biomaterials, or Tissue Engineering, and students in Duke's BME program (ranked 7th nationally) may learn specific knowledge in Biomedical Imaging and Instrumentation, Biomolecular and

Tissue Engineering, Biomechanics, and Electrobiology. The proposed new base curriculum supports the creation of concentrations, which we intend to add in the future.

While the proposed curriculum modification offers students much wider choice than they have currently, the learning outcomes have not changed and are aligned with the student outcomes of ABET-accredited engineering programs as listed below.

Upon graduation, Biomedical Engineering students will be able to demonstrate:

1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.
2. 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.
3. an ability to communicate effectively with a range of audiences.
4. 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.
5. 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.
6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.
7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

Responses to additional questions are below.

- Will this program change meet local, state, regional, and national educational and cultural needs?

  Yes. Improving our nation's health and lowering healthcare costs are national priorities. Biomedical engineers develop devices and procedures that solve medical and health-related problems by combining their knowledge of biology and medicine with engineering principles and practices. They develop and evaluate systems and products such as artificial organs, prostheses (artificial devices that replace missing body parts), instrumentation, medical information systems, and health management and care delivery systems. According the Bureau of Labor Statistics the job outlook for biomedical engineers is a faster-than-average 10% over the next decade. The aging of the population and a growing focus on health issues will drive demand for better medical devices and equipment designed by biomedical engineers.

- Will this program change result in duplication in the System?

  No. MSU began offering a formal concentration in Biomedical Engineering in 2008, which evolved into its own ABET-accredited bachelor of science program in 2017. The proposed change does not affect its delineation from other engineering disciplines.

- Will this program change/advance student diversity within the discipline?

  Yes, especially in terms of gender diversity. It is expected to have a positive impact on enrollment, and BME attracts a much higher percentage of women than most other engineering disciplines; women currently make up 57% of students enrolled in the MSU BME B.S. program (170 out of 298).

- Will this program change result in an increase in the potential placement of graduates in MS, the Southeast, and the U.S.?

  Yes. Because most students' curricula will include more engineering electives, we expect that graduates will generally be more competitive for jobs in the biomedical industry.

- Will this program change result in an increase in the potential salaries of graduates in MS, the Southeast, and the U.S.?

  Yes. We expect the new curriculum will qualify our graduates for additional jobs, and the 2021 median pay for biomedical engineers was $97,410 per year.

4. SUPPORT
   See attached letter.

5. PROPOSED 4-LETTER ABBREVIATION
   BME

6. EFFECTIVE DATE
   August 15, 2023

MISSISSIPPI STATE UNIVERSITY

Department of Agricultural and Biological Engineering
P. O. Box 9632, Mississippi State, MS 39762
Phone: 662.325.3282; Website: abe.msstate.edu

December 19, 2022

Dr. Andy Perkins, Chair
University Committee on Courses and Curricula

Dear Dr. Perkins,

We propose to modify the BME Bachelor of Science program to increase our students' elective choices and to facilitate the creation of new emphases in areas such as biomaterials and biosensors. The new curriculum will also accommodate the existing pre-medical emphasis with minor modification.

This modification was partly motivated by feedback from our departmental advisory board.

Sincerely,

Steven Elder, Ph.D.
Professor and Biomedical Engineering Curriculum Coordinator

Concurrence:

Daniel Chesser

Jessica Drewry

John Lowe

Yuzhen Lu

Vitor Martins

Prem Parajuli

Joel Paz

Lauren Priddy

LaShan Simpson

Amirtahà Taebi

Mary Love Tagert

J. Alex Thomasson

Filip To

David Vandenheever

Nuwan Wijewardane

Fei Yu

Xin Zhang