



DEPARTMENT OF  
HIGHER EDUCATION &  
WORKFORCE DEVELOPMENT

## New Program Report

**Date Submitted:**

09/08/2023

**Institution**

Missouri University of Science & Technology

**Site Information**

**Implementation Date:**

1/1/2024 12:00:00 AM

**Added Site(s):**

**Selected Site(s):**

Missouri University of Science & Technology, 206 Parker Hall, Rolla, MO, 65409-0470

**CIP Information**

**CIP Code:**

140501

**CIP Description:**

A program that prepares individuals to apply mathematical and scientific principles to the design, development and operational evaluation of biomedical and health systems and products such as integrated biomedical systems, instrumentation, medical information systems, artificial organs and prostheses, and health management and care delivery systems.

**CIP Program Title:**

Bioengineering and Biomedical Engineering

**Institution Program Title:**

Biomedical Engineering

**Degree Level/Type**

**Degree Level:**

Bachelor's Degree

**Degree Type:**

Bachelor of Science

**Options Added:**

Collaborative Program:

N

**Mode of Delivery**

Current Mode of Delivery

Classroom

Student Preparation



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Special Admissions Procedure or Student Qualifications required:

The following preparation guidelines are recommended for students considering the BME program:

1. Strong background in mathematics: Students should have completed high school courses in algebra, geometry, trigonometry, and pre-calculus. AP or college-level calculus courses are highly recommended.
2. Science coursework: Prospective students should have a solid background in high school biology, chemistry, and physics. Advanced courses, such as AP or college-level courses in these subjects, are strongly encouraged.
3. Problem-solving and critical thinking skills: Students should develop their problem-solving and critical thinking abilities through participation in extracurricular activities, such as science clubs, engineering competitions, or research projects.
4. Communication skills: Biomedical engineers often work in interdisciplinary teams, so strong written and oral communication skills are essential. Students should practice these skills through writing assignments, presentations, and group projects.

Specific Population Characteristics to be served:

The BME program is designed for students who have a strong interest in engineering, medicine, and biology, and are motivated to pursue careers in this interdisciplinary field. The target population includes:

1. High school students with strong backgrounds in mathematics and science who are seeking a challenging and rewarding undergraduate engineering program with employment opportunities in the medical and health-related fields.
2. Transfer students from community colleges or other institutions who have completed the necessary foundational coursework and meet the program's GPA requirements.

### Faculty Characteristics

Special Requirements for Assignment of Teaching for this Degree/Certificate:

Faculty must have a Masters or PhD.

Estimate Percentage of Credit Hours that will be assigned to full time faculty:

Full time faculty will teach 70% of credit hours.

Expectations for professional activities, special student contact, teaching/learning innovation:

n/a

### Student Enrollment Projections Year One-Five

<b>Year 1</b>	<b>Full Time: 19</b>	<b>Part Time: 0</b>	
<b>Year 2</b>	<b>Full Time: 42</b>	<b>Part Time: 0</b>	
<b>Year 3</b>	<b>Full Time: 70</b>	<b>Part Time: 0</b>	<b>Number of Graduates:</b> 0
<b>Year 4</b>	<b>Full Time: 96</b>	<b>Part Time: 0</b>	
<b>Year 5</b>	<b>Full Time: 124</b>	<b>Part Time: 0</b>	<b>Number of Graduates:</b> 17

**Percentage Statement:**

n/a

Program Accreditation



## New Program Report

### Institutional Plans for Accreditation:

ABET: Accreditation Board for Engineering and Technology

We are committed to maintaining the highest standards of quality in our educational programs. To this end, the department will seek accreditation from ABET, a recognized accrediting body for engineering programs. ABET accreditation assures that the program meets established criteria for preparing students to excel in their chosen fields.

It is important to note that accreditation through the Engineering Accreditation Commission (EAC) of ABET cannot be sought until the first students have graduated from the program. The curriculum for the new BS degree in BME has been designed to achieve ABET accreditation. We will request an initial ABET accreditation review in year 4 when degrees are awarded and a full ABET accreditation review in year 6 for the new BME BS degree.

### Process and Timeline for Achieving Accreditation:

- **Self-Study Report:** The department will prepare a comprehensive self-study report, providing detailed information about the program, its objectives, outcomes, curriculum, resources, faculty, and assessment processes. This report will be submitted to ABET approximately one year before the scheduled accreditation visit.
- **On-site Evaluation:** ABET will conduct an on-site evaluation, during which a team of program evaluators (PEVs) will visit the campus to assess the program's compliance with ABET criteria. The evaluation typically occurs in the fall semester, with the specific dates agreed upon by the department and ABET.
- **Evaluation Report and Institutional Response:** Following the on-site visit, the department will receive a draft evaluation report from ABET. The department will have the opportunity to respond to any findings or concerns raised in the report, providing additional information or clarification as needed.
- **Final Accreditation Decision:** The ABET Engineering Accreditation Commission (EAC) will review the self-study report, evaluation report, and institutional response before making a final accreditation decision. This decision is usually communicated to the department within a few months after the EAC's review.
- **Continuous Improvement:** Upon receiving accreditation, the department will continue to monitor and improve the program, ensuring that it remains aligned with ABET criteria and the needs of its constituencies. ABET accreditation is typically valid for a period of six years, after which the department will need to undergo the reaccreditation process.

By pursuing and maintaining ABET accreditation, the Chemical and Biochemical Engineering Department demonstrates its commitment to providing a high-quality educational experience for its students and preparing them for success in their careers.

### Program Structure

**Total Credits:**

128

**Residency Requirements:**

n/a

**General Education Total Credits:**

42



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**Major Requirements Total Credits:**

104

**Course(s) Added**

COURSE NUMBER	CREDITS	COURSE TITLE
ChemEng 4201	3	Bioseparations Lab
ChemEng 2100	4	Mass & Energy Balances
ChemEng 3150	3	Reactor Design
BME 4xxx	3	BioMed Eng Design I
Stat 3425	3	Intro to Biostatistics
Chem 2210/19	4	Organic Chemistry I/Lab
Math 1214	4	Calculus I
ChemEng 5xxx	3	Vaccine Manufacturing
Math 3304	3	Differential Equations
BioSci 3333/59	4	Anatomy and Physiology I/Lab
Chem 1100	1	Lab Safety
CompSci 1500	3	Intro to Computing
FE 1100	1	Intro to Engineering
ChemEng 4241	3	Safety
Chem 1310	4	General Chem I
Chem 1319	1	General Chem I Lab
Phys 2135	4	Physics II
Math 1215	4	Calculus II
BioSci 2213/19	4	Cell Biology/Lab
ChemEng 3120	3	Thermodynamics II
Track Elective	6	Choose elective courses
MS&E 5210	3	Tissue Engineering
Math 2222	4	Calculus III
ChemEng 5250	3	Bioseparations
ChemEng 4220	3	Bioreactor Lab
ChemEng 4210	3	Bioreactors
ChemEng 2110	3	Thermodynamics I
Phys 1135	4	Physics I
BME 3xxx	4	Intro to Transport for Biologicals
Chem 1320	3	General Chem II
BME 4xxx	3	BioMed Eng Design II
ChemEng 3210	3	Intro to Biomedical Engineering

**Free Elective Credits:**

0





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### **Internship or other Capstone Experience:**

All the seniors are required to take Capstone Design I & II, and to meet S&T requirements for experiential learning activities.

### **Assurances**

I certify that the program is clearly within the institution's CBHE-approved mission. The proposed new program must be consistent with the institutional mission, as well as the principal planning priorities of the public institution, as set forth in the public institution's approved plan or plan update.

I certify that the program will be offered within the proposing institution's main campus or CBHE-approved off-site location.

I certify that the program will not unnecessarily duplicate an existing program of another Missouri institution in accordance with 6 CSR 10-4.010, subsection (9)(C) Submission of Academic Information, Data and New Programs.

I certify that the program will build upon existing programs and faculty expertise.

I certify that the program can be launched with minimal expense and falls within the institution's current operating budget.

I certify that the institution has conducted research on the feasibility of the proposal and it is likely the program will be successful. Institutions' decision to implement a program shall be based upon demand and/or need for the program in terms of meeting present and future needs of the locale, state, and nation based upon societal needs, and/or student needs.

### Contact Information

First and Last Name: Zandra  
Kent

Email: [zlkhd4@umsystem.edu](mailto:zlkhd4@umsystem.edu)

Phone: 573-882-6756

# New Degree Proposal

## FULL PROPOSAL

### Basic Program Information

Sponsoring University: Missouri University of Science and Technology

College or School: College of Engineering and Computing

Department: Chemical and Biochemical Engineering\*  
*\*Upon full proposal approval, we'll pursue renaming the department to Chemical and Biomedical Engineering.*

Proposed Program Title: Biomedical Engineering

Degree Level/Type: BS

Emphasis Areas: Biomanufacturing  
Biomaterials

Program Modality: Full in-person

If online component: None

Program CIP Code<sup>1</sup>: 14.0501

Implementation: January/2024

Expected Date of First Graduation: May/2027

Proposal Author(s): Hu Yang

Name, phone, and email of person primarily responsible for the proposal:

Hu Yang, Chair of Chemical and Biochemical Engineering  
Phone: (573) 341-4854; Email: huyang@mst.edu

Individual(s) Responsible for Success of the Program:

Hu Yang, Chair of Chemical and Biochemical Engineering  
Phone: (573) 341-4854; Email: huyang@mst.edu

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<sup>1</sup> A selection of CIP codes can be viewed on the National Center for Education Statistics website:  
<https://nces.ed.gov/ipeds/cipcode/browse.aspx?y=55>

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# Executive Summary

The proposed biomedical engineering (BME) Bachelor of Science (BS) program at Missouri S&T will provide a transformative education for engineering students interested in health and life-sciences fields, including biomanufacturing, biomaterials, and medical sciences and engineering. This new degree program will require 125 or 128 credit hours depending on the track. Through this education, we will train the next generation workforce in these areas. The creation of the BME degree fills a crucial gap in our existing engineering portfolio and aligns with campus, college, and departmental goals of providing educational opportunities involving medical and biological engineering and science. The program will differentiate itself from other BME programs in the UM system through its focus on biomanufacturing and biomaterials, and its integration with other engineering disciplines at Missouri S&T. This undergraduate program will also prepare students to pursue advanced degrees in engineering, science, and medicine.

The demand for BME professionals in the state of Missouri is projected to have an 18% growth in the next 10 years, 1.87 times greater than the national average, according to a Lightcast™ report. A 2021 ASEE report shows that BME is the 2nd most popular engineering degree awarded to female students. Introducing a BME degree program at S&T is an important step in our efforts to increase female enrollment and improve the overall diversity of our student population. Employers have expressed interest in such a program at Missouri S&T, which will provide a skilled workforce to meet increasing demand in the biomedical industry (see letters of support).

The program will leverage existing interdisciplinary resources to minimize program start-up costs. Revenue is expected to be primarily generated from tuition and fees for new students, but the expansion of the S&T educational portfolio into BME is expected to provide new opportunities for federal support, particularly from the National Institutes of Health and related agencies. A comprehensive marketing strategy will be implemented to recruit students from Missouri and the greater region, targeting those interested in life science and engineering fields. This strategy will enhance Missouri S&T's brand recognition and promote STEM careers.

The program's evaluation and assessment will be conducted annually by a steering committee comprised of faculty members from participating departments and an external advisory panel. The committee will generate a program evaluation report that covers undergraduate enrollment numbers, student credit hours taught, recruiting and retention efforts, and ABET data collection activities. This information will be used to allocate future resources for the departments and colleges involved, ensuring the program's ongoing economic health.

In conclusion, the proposed BME BS program at Missouri S&T addresses the growing demand for skilled professionals in this field, aligns with the strategic goals of the campus, and offers a strong case for its establishment as an essential component of the university's academic offerings.

# 1. Introduction

The proposed biomedical engineering (BME) BS program at Missouri S&T will address the growing demand for skilled professionals in the fields of biomanufacturing, biomaterials, healthcare, and related industries and professions. This interdisciplinary program will equip students with the knowledge and skills required to excel in various career paths, including biotechnology, medical device development, pharmaceuticals, and healthcare management. The program is being proposed at this time due to the growing interest in the life sciences and engineering fields among prospective students at Missouri S&T, as evidenced by the current popularity of related minors and emphasis areas and by national trends in engineering education.

## Academic Components and Career Paths

The BME BS program integrates a strong foundation in engineering principles with a focus on biomanufacturing, biomolecular processes, and materials science. Students will benefit from existing courses in areas such as chemical engineering, electrical engineering, and materials science and engineering while also taking new courses designed specifically for this program. Graduates of the program will be well-prepared for a variety of career paths, including:

- Biomedical device design and development, including working with medical devices, prosthetics, and implants;
- Biotechnology and pharmaceutical research and manufacturing, focusing on drug and biologics discovery, production, development, and translation;
- Tissue engineering and regenerative medicine, working on cutting-edge solutions for organ repair and replacement;
- Healthcare management and consulting, applying engineering principles to improve healthcare systems and patient outcomes;
- Advanced degrees (PhD, MD, DDS, etc.) in the medical sciences and engineering.

## Evolution of the Program Concept

The concept for the BME BS program at Missouri S&T has evolved over time, with the initial establishment of a Biochemical Engineering emphasis area within the Chemical Engineering degree more than 30 years ago, supported by the creation of the Department of Biological Sciences in 1983. For the past two decades, the Missouri S&T Department of Materials Science and Engineering has hosted an interdisciplinary minor program in BME, a program that has been completed by 67 students over the past five years. The Center for Biomedical Research (CBR) on our campus includes 49 faculty from across campus, who presently form the foundation for biomedical research and education at Missouri S&T.

BME is one of the fastest-growing engineering disciplines in the country and is one of the only ABET-accredited 4-year engineering degree program missing from S&T's

educational portfolio. Given trends in student interests, national needs, and local demand, this is the ideal time to begin a BME undergraduate degree program at S&T.

### **Integration of Existing Courses**

The proposed program will leverage existing engineering (105 credit hours of required and track electives) and life science courses (38 credit hours of required and track electives) in related areas to provide students with a comprehensive educational experience. These existing courses will be integrated into the program's curriculum (comprising 85% of engineering courses and 100% of life sciences courses in the curriculum) alongside three new courses (10 credit hours) designed explicitly for the BME BS program. This approach ensures that students receive a well-rounded biomedical engineering education while minimizing the need for additional resources to create the new program.

### **Program Coordinator**

The individual responsible for the success of the proposed BME BS program is Dr. Hu Yang, Chair of the Doshi Department of Chemical and Biochemical Engineering (ChBE). He can be reached at [huyang@mst.edu](mailto:huyang@mst.edu) or (573) 341-4854. Dr. Yang will oversee the development and implementation of the program, ensuring its alignment with the university's strategic goals and the needs of students and employers. Dr. Christi Luks, Associate Chair for Academic Affairs in the ChBE Department, will serve as program coordinator. She can be reached at [luksc@mst.edu](mailto:luksc@mst.edu) or (573) 341-7641. As the program coordinator, she will be responsible for curriculum development and monitoring and evaluating the program's overall performance to ensure continuous improvement for ABET accreditation. The program will be evaluated annually to determine if additional staffing is necessary to support its growth and success.

## **2. University Mission & Program Analysis**

### **2.A. Alignment with University Mission & Goals**

**Alignment with campus goals.** The proposed BME BS program at Missouri S&T is in perfect alignment with the university's mission and goals, as well as with specific departmental and college priorities. Missouri S&T's mission is to integrate education, research, and application to create and convey knowledge that serves our state and helps solve the world's great technological challenges. This mission resonates with the key concept of the proposed program, which aims to develop a next-generation workforce that can tackle important societal problems associated with healthcare and medicine.

The proposed BME program aligns with a bold new vision for Missouri S&T that coalesces and greatly expands our bioengineering and bioscience research and education initiatives. We call this our "Bio-X" vision, where the X represents the many research directions we intend to coalesce and grow. A major focus of Bio-X is to

position Missouri S&T as a partner in education and research in areas that will complement ongoing medical education and research efforts in the UM system, such as the NextGen precision medicine initiative at MU. Another goal is for more of our students to feed into the existing medical, dental, and pharmacological schools at MU and UMKC. The creation of a BME BS degree is an essential component of the Bio-X vision.

**Alignment with college goals.** The mission of the College of Engineering and Computing (CEC) is to (i) Provide our students with a transformative education that prepares and inspires them to shape the future, and to (ii) Lead the way in improving our world and in solving grand societal challenges through research and innovation. The overall goal and objectives of the BME program align well with and provide strong support to the CEC mission.

The CEC at Missouri S&T provides over 4000 undergraduate students with a wide variety of engineering degree offerings. The addition of the BME degree will fill a significant hole in our educational portfolio. The BME degree will allow us to enhance the education of our existing students, connect to new students who seek these opportunities, and to develop a workforce in this important and growing area. This new program will equip graduates with the skills and knowledge necessary to excel in a wide range of biomedical engineering career paths and contribute to technological advancements in the field.

The proposed BME degree program is built on a strong foundation of education in mathematics, sciences, and interdisciplinary engineering. Within CEC, the BME undergraduate program will be supported by faculty and coursework in Chemical and Biochemical Engineering, Materials Science and Engineering, Electrical Engineering, Mechanical Engineering, and Computer Science, and this will be supplemented by faculty in the Departments of Biological Sciences and Chemistry in the College of Arts, Sciences, and Education.

**Alignment with departmental goals.** The Doshi Department of Chemical and Biochemical Engineering has long had the goal of growing the Biochemical Engineering emphasis area into an independent degree program. As our department strives to achieve nationally-recognized excellence in research and education, a series of strategic alignments have been identified to bolster our efforts. First and foremost, fostering closer relationships with the pharmaceutical industry will enable collaborative research endeavors, knowledge exchange, and potential funding sources. Concurrently, we will actively pursue opportunities from the National Institutes of Health (NIH) and various foundations to support undergraduate education through grants, scholarships, and internships. In our quest to promote diversity, our efforts will include recruiting female and underrepresented students who want to pursue careers in healthcare-related engineering disciplines. The creation of the BME BS program supports and aligns perfectly with the department's goals, contributing to the fulfillment of broader institutional objectives and priorities.

## **2.B. Duplication & Collaboration within Campus, Across System**

Within the Missouri S&T engineering portfolio, we currently offer a minor in BME and an emphasis area in biochemical engineering. However, we lack an independent undergraduate engineering degree in any bio-related area. Across the UM system, UM-Columbia and UMKC both offer BS degree programs in BME. The BME undergraduate degree program at UM-Columbia offers four tracks: biomaterials, biomechanics, biomedical imaging and instrumentation, and bioinformatics. The BME BS program at UMKC does not offer tracks, but students have opportunities to study biomaterials, biomechanics, and bio-electromagnetics.

Although there are similar elements among the UMKC, UM-Columbia and our proposed degree, we believe our strength in the biomanufacturing area (one of our two tracks) provides some level of distinction among the three degrees. The biomaterials tracks do have overlap but are natural areas of emphasis for Missouri S&T because we already have BS, MS, and PhD degrees in materials science and engineering areas, as well as a minor in BME housed in materials science and engineering. The other campuses in the UM system have no existing degrees in materials science/engineering.

With the goal of increasing the number of medical professionals in our state, we have been working with the UM system to develop pathways for our top engineering students to attend the medical schools at UM and UMKC. These initiatives are designed not only to facilitate a seamless transition for our students but also to foster interdisciplinary learning and collaboration across different campuses. Our new BME program is a key part of these efforts. Through this program, we will better equip our students with skills that are increasingly valued in the medical, dental, and pharmacy fields. One of our aims with this degree is to cultivate a pool of exceptional candidates for these advanced professional degrees.

Our BME program has the potential to be mutually beneficial for S&T, MU, and UMKC, as we plan to increase the pool of prospective students interested in professional degrees available on the other campuses. This pool of students would bring a unique blend of expertise and perspectives that would have value for MU and UMKC's established medical, dental, and pharmacy schools. We also believe that these career pathways can benefit by having more students with engineering backgrounds who can apply their expertise in healthcare contexts.

The initiation of the BME program has been discussed with college leaders at MU and UMKC. Potential collaborative opportunities have also been explored among several faculty members on the different campuses. In addition to these individual engagements, we have fostered broader institutional collaborations in the UM system in this area. The most recent instance includes our partnership with the University of Missouri–St. Louis (UMSL) on the National Science Foundation proposal titled “NSF Engines: Type-2: Reshoring API Manufacture through Innovation.” In this joint venture, Missouri S&T has been chiefly focused on advancing innovation and workforce development in downstream pharmaceutical processes and continuous manufacturing.



The BME degree and growth in related research areas are pivotal in encouraging the reshoring of pharmaceutical manufacturing.

No existing programs at Missouri S&T will be combined, placed on inactive status, or deleted as a result of implementing this program.

## **3. Business-Related Criteria & Justification**

### **3.A. Market Analysis**

#### *3.A.1. Rationale & Workforce Demand for the Program*

Global Market Insight reported that the US biotechnology market was valued at approximately \$417B in 2018 and was projected to grow to over \$950B by 2027, exhibiting a compound annual growth rate (CAGR) of more than 9.4%. We conducted a comprehensive labor market analysis using Lightcast™. This analysis used the occupation code 17-2031 Bioengineers and Biomedical Engineers and set the time frame of 2022-2032.

The report highlights the need to develop a biomedical engineering workforce at all education levels across the nation, the state of Missouri, and the St. Louis metropolitan area. For instance, Occupation Analysis Reports indicate that 18,963 bioengineer and biomedical engineer job openings were posted nationwide in 2022, with a projected growth of 15% over the next decade. The Lightcast™ report shows there were 109 job postings for biomedical engineers in 2022 and the median wage was \$78,428 in the state. Although the job posting demand in the state is currently lower than the national average, the projected growth is 18% between 2022 and 2032, which is approximately 1.87 times greater than the national average.

It is important to recognize that while the most recent number of Missouri completions (144 in 2021) surpasses the number of Missouri job postings (109), we believe that this does not imply an oversaturation of the market or a lack of job opportunities for BME graduates. A large fraction of BME graduates choose to further their education by enrolling in graduate studies or pursuing professional degrees in health fields, rather than entering the workforce directly. This decision can be motivated by a desire for deeper specialization, a drive for research and innovation, or ambitions to occupy high-level positions in academia or industry in the future. Hence, these graduates represent a significant investment in the future of the field and for healthcare fields in Missouri. We conducted an anonymous survey among students currently enrolled at Missouri S&T. According to the survey, students pursuing a BS in chemical engineering with a biochemical engineering emphasis (BioChE) show a very high interest in getting an advanced degree. Twelve out of 13 respondents expressed interest in a biomedical engineering or bioengineering PhD.

BME is also a broad, versatile, and in-demand field, meaning many graduates will be competitive for job opportunities nationally and may see those opportunities based on their particular sectors of interest. Moreover, BME graduates are equipped with a diverse set of skills that are applicable in various related fields, which may not be fully captured in the market analysis. Some graduates might opt for jobs that are not strictly defined as BME but still make use of their skillset. This could include roles in related engineering fields, medical technology, healthcare consulting, and more.

Given the projected growth numbers for job openings in this area in Missouri and elsewhere, it appears that there is still substantial market demand for biomedical engineers.

This program will meet Missouri's academic and economic needs by producing graduates who can contribute to the growing biotechnology sector. Employers, community partners and stakeholders have provided strong support for the establishment of this new program, as evidenced by their letters of support (**Appendix 1**). Quotes from their letters are provided below.

Bipin Doshi, Trustee Missouri S&T, Board Member KI Foundation, Past Chair Beacon Health System Board, South Bend, Indiana states *“This invitation (from the UM system) has come at the most appropriate time. A growing demand for Biochemists and Biochemical Engineers requires us to develop an industry appropriate curriculum to educate and train engineers who are equally proficient in chemical and biochemical fields.”* He further stresses that *“There is a need nationwide for these curriculums and MST is well positioned to leverage its various programs in a well-coordinated program within the Chemical and Biochemical Engineering Department.”*

Jason Shenefield, President and CEO, Phelps Health, passionately exclaims *“The proposed BME BS program at Missouri S&T will be instrumental in preparing graduates to meet this demand and contribute significantly to the future of healthcare.”* Furthermore, Phelps Health expresses interest in working with us to *“explore new opportunities for educational initiatives, internships, and research activities through this program”*. He adds that *“such a program will greatly benefit our healthcare system, the university, and the broader community by fostering the growth of biomedical engineering professionals and promoting innovative healthcare solutions.”*

Justin Sperry, Vice President – Transformational Technology and Chesterfield Site Head, Pfizer, states that *“...there is a significant need for highly skilled professionals with a strong foundation in the principles of biomedical engineering. The proposed BME BS program at Missouri S&T would help address this need by preparing students for successful careers in these rapidly evolving fields.”* He further adds that *“Missouri S&T's reputation for excellence in engineering education and research, combined with its strategic location in the heart of the Midwest, makes it an ideal institution to develop such a program. The university's proximity to major biomanufacturing and biomedical hubs will enable students to engage in cutting-edge research and gain valuable industry experience through internships and co-op opportunities. This, in turn, will help build a*

*strong talent pipeline to support continued growth and innovation in the biopharmaceutical and biomedical sectors.”*

Mart Berutti, Vice President Sales, Life Sciences of Emerson points out that *“The Life Sciences industry is changing rapidly as the promise of personalized healthcare grows under the development of new cell, gene, and tissue therapies.”* He states that *“Emerson’s challenge to deliver value for these new therapies will require engineering staff that includes traditional Chemical and Biological Engineering foundation with knowledge of therapy delivery methods, clinical data management, and other new skills. The addition of a Biomedical Engineering BS program would grow our corporate body of knowledge and prepare us well for future challenges.”*

Charles W. Lyon, Senior Vice President and Chief Commercial Officer, FutureFuel Chemical Company, points out that *“It would be excellent to also recruit engineers and scientists associated with a new program like this to support our strategy for the pharma industry”.* He sees *“opportunities for FutureFuel and the department to collaborate in joint research projects in areas such as process development and design (ie. flow reactor technology)”.* He stresses that the Biomedical Engineering program and his company can mutually support each other, exploring untapped potential for success.

Sarah Bock, Director Capital Engineering, Curium, indicates that *“Curium, a leading global manufacturer and distributor of radiopharmaceutical products, stands to benefit greatly from graduates of the BME program at Missouri S&T.”* She adds that *“The establishment of a BME program at Missouri S&T will address the increasing demand for biomedical engineers, many of whom desire to stay in the St. Louis area or Missouri after graduation. As the healthcare industry continues to grow, there will be a need for skilled professionals capable of developing and implementing innovative solutions to pressing medical challenges.”*

Ralph Grant, Director of Business Development-Associate, Clark, Richardson and Biskup Consulting Engineers, Inc., states that establishing this new program at Missouri S&T *“is an exciting and transformative step towards advancing healthcare technology and research in St. Louis Metropolitan area and in the state of Missouri”*, *“ultimately contributing to a healthier, more sustainable future for the people of Missouri and beyond”.*

Fred Kielhorn, CEO, DeNovix Inc. *“attests to the importance of a well-rounded education in biomedical engineering for those entering the field.”* He states *“The establishment of a BME BS program at Missouri S&T would not only help address the growing demand for qualified professionals in the industry but also strengthen the university’s reputation as a leading institution in the field of engineering.”*

Brian K. Donley, P.E., bd Solutions, LLC, says *“The proposed Biomedical Engineering program combines the department’s established chemical engineering fundamentals with a specialized curriculum to equip graduates with the skills needed to excel in multiple, new career fields, such as biomaterials, drug development and biomedical*

*device design. In addition, this program will prepare students to solve the unique problems of managing research and production in the rapidly growing healthcare industry.”*

Dr. Jorge A. Ochoa, Managing Partner, Principal Engineer, Biomedical Dynamics LLC, states that *“The proposed program prospectus I reviewed meets the present and future needs of the healthcare industry in the United States and internationally. The demand for biomedical engineers is anticipated to increase substantially in the coming years, as the aging population, chronic diseases, and technological advancements continue to drive the expansion of the healthcare industry. By establishing this program, Missouri S&T can help meet this demand and prepare future generations of biomedical engineers to positively impact society.”*

In addition to the external letters of support, there are two internal letters of support that are from: Dr. Colin Potts, Provost and Executive Vice Chancellor for Academic Affairs, and Dr. David Borrok, Vice Provost and Dean of College of Engineering and Computing.

The program's proposed curriculum is designed to align with the key competencies that employers are looking for in graduates, ensuring that students are well-equipped for success in the workforce. In particular, key competencies employers may seek include:

- **Strong foundation in engineering principles:** Graduates should have a solid understanding of engineering concepts and the ability to apply them to biomedical applications.
- **Expertise in biomanufacturing processes:** Employers may expect graduates to be knowledgeable about bioprocessing techniques, equipment, and the production of biological products, such as pharmaceuticals and medical devices.
- **Materials science knowledge:** Graduates should be familiar with biomaterials, their properties, and applications in medical devices and other healthcare products.
- **Problem-solving and critical thinking skills:** The ability to analyze complex problems, develop innovative solutions, and make data-driven decisions is essential in the biomedical engineering field.
- **Interdisciplinary collaboration:** Graduates should be comfortable working in multidisciplinary teams, incorporating perspectives from engineering and life science disciplines.
- **Effective communication:** Employers may expect graduates to effectively communicate complex technical concepts to diverse audiences, both in writing and verbally.

### *3.A.2. Student Demand for the Program*

Our Lightcast™ report reveals a growing demand for biomedical engineering and bioengineering bachelor's degrees, with a nationwide increase in the number of degrees conferred. In 2021, a total of 8,478 bachelor's degrees in biomedical engineering and bioengineering were awarded by 175 public and private institutions, representing a 21%

increase compared to 2017. During the 2017-2021 period, 33 more institutions began to award BME and bioengineering degrees. Among those degrees, 71.0% were awarded by public institutions, 28.6% by private not-for-profit institutions, and only 0.4% by private for-profit institutions. Each institution produced an average of 48.4 BS degrees annually during this time. Furthermore, 86.9% more degrees were awarded in 2021 than in 2012. Job growth of 15.35% is anticipated for biomedical engineers and bioengineers for the next decade (2022-2032). As market and student demand continue to rise, there is still room for growth in available degree programs and capacity in the US.

A good predictor of student demand for our proposed degree program is the enrollment in similar programs within our region. The University of Missouri-Columbia transitioned from a bioengineering program to a BME program in 2018. By 2020, its enrollment increased to 191 students, and 14 BS BME degrees were awarded. In 2021, 24 BME degrees were awarded. This program has demonstrated a strong positive enrollment trajectory, indicating a similar potential for our new degree program.

There are also additional BME programs offered by private institutions in Missouri, including Washington University in St. Louis and Saint Louis University. Although these programs graduate a substantial number of students annually (120 completions in total in 2021), we feel there is still ample room for an additional program within the UM System. The geography and demographics of the pool of students we recruit to S&T also tend to be different than those of private institutions, and S&T’s national reputation for outstanding “return-on-investment” for our undergraduate engineering degrees. Recently, S&T was ranked one of the nation’s top 10 “high-value institutions,” according to a March 27 Times article by Frank Bruni titled “*There’s Only One College Rankings List That Matters.*” Such national reputation will attract students who might be otherwise challenged by the costs of those other programs.

At Missouri S&T, there is substantial interest in a BME BS program. Our department has a history of offering chemical engineering BS degrees with a biochemical engineering emphasis, and there is an existing BME minor administered within the Materials Science and Engineering Department. The table below shows sustained interest in BME education on our campus, with an average of 21 individuals annually graduating with either a BME minor or biochemical engineering emphasis or both between 2017 and 2021.

<b>Degree Awarded</b>	<b>AY17-18</b>	<b>AY18-19</b>	<b>AY19-20</b>	<b>AY20-21</b>	<b>AY21-22</b>
Biomedical Engineering Minor	13	11	13	19	11
Biochemical Engineering Emphasis	13	6	10	15	12
Dual Minor & Emphasis	1	2	4	6	4
<b>Total Individuals</b>	<b>25</b>	<b>15</b>	<b>19</b>	<b>28</b>	<b>19</b>

Many students pursuing the emphasis area or minor would likely have chosen a BME BS program had one been available. Many other students probably opted not to attend

Missouri S&T due to the lack of a formal BME degree. Given our data, it would be reasonable to anticipate an initial enrollment of 19 students in the new BME BS program, with an annual growth of approximately 25% for the first five years of the program, consistent with national averages. This growth will allow us to reach our goal of enrolling around 124 students in the program within five years.

**Table 1a. Student Enrollment Projections** (anticipated total number of students enrolled in the program during the first five fall semesters following implementation.)

<b>Year:</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>
<b>Full-time</b>	19	42	70	96	124
<b>Part-time</b>	0	0	0	0	0
<b>Total</b>	19	42	70	96	124

**Table 1b. New Student Enrollment Projections** (anticipated number of students enrolled in the program during the first five fall semesters following implementation that are new to the University.)

<b>Fiscal Year:</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>
<b>Full-time</b>	9	32	60	86	114
<b>Part-time</b>	0	0	0	0	0
<b>Total</b>	9	32	60	86	114

We anticipate to accept internal transfer students to this new program and estimate 10 transfer students per year in years 1-5.

**Table 1c. Projected Number of Degrees Awarded**

<b>Year:</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>	<b>7</b>	<b>8</b>	<b>9</b>	<b>10</b>
<b># of Degrees Awarded</b>	0	0	0	10	17	30	34	44	51	62

We anticipate students to finish their degrees in 4 or 5 years and expect some transfer students to graduate sooner.

### **3.B. Financial Projections**

A completed Pro Forma for the financial projections was prepared, reviewed and endorsed by S&T's fiscal officer.

#### *3.B.1. Additional Resources Needed*

Resources will be required for supplies in teaching labs; these are projected to increase year-by-year as the program and the expenses increase. As enrollments (and tuition revenue) grow we also plan to add additional faculty members. We have tentatively budgeted for one tenure track faculty member and one non-tenure track teaching faculty member in year three of the program. Budgeting includes the cost of the estimated startup package for the tenure track faculty member. These plans could be staggered,

delayed, or even accelerated based on measured enrollment growth, and on staffing priorities in the College of Engineering and Computing.

No new laboratory space or equipment will be required to support the initial cohorts of BME students. Current labs and equipment in Bertelsmeyer Hall, McNutt Hall, and Schrenk Hall will be utilized. With increasing enrollments, some basic equipment, including incubators, microscopes, cell readers, etc., dedicated to the BME program will need to be purchased.

We have also allocated a portion of our budget to Other/Miscellaneous expenses. These costs, starting at \$17,000 in Year 1 and incrementally increasing in subsequent years, are pivotal for the seamless functioning and sustainability of our program. Items of need include specialized software and software subscriptions, minor maintenance and upgrades to equipment, marketing materials, and conducting workshops.

It is anticipated that by year 5, at least one teaching laboratory in Bertlesmeyer Hall will need to be repurposed and dedicated to the growing BME program, and a second T/TT professor will need to be hired.

### 3.B.2. Revenue

Revenue will be generated solely through tuition and fees from students new to the campus. Additional revenue for undergraduate education programs will be secured through education grants from the National Science Foundation (NSF) and other funding agencies and foundations to enhance the quality and reach of our educational offerings, enabling greater opportunities for students in their academic pursuits.

### 3.B.3. Net Revenue

Starting from the first year, annual revenue is projected to exceed annual expenses.

**Table 2. Financial Projections for Proposed Program for Years 1 Through 5.**

	Year 1	Year 2	Year 3	Year 4	Year 5
<b>1. Expenses per year</b>					
<b>A. One-time</b>					
<i>New/Renovated Space</i>	0	0	0	0	\$200,000
<i>Equipment</i>	0	\$10,000	\$20,000	\$25,000	\$50,000
<i>Library</i>	0	0	0	0	0
<i>Consultants</i>	0	0	0	0	0
<i>Other (startup package)</i>	0	0	\$400,000	0	\$400,000
<b>Total one-time</b>	0	\$10,000	\$420,000	\$25,000	\$650,000

<b>B. Recurring</b>					
<i>Faculty</i>	0	0	\$175,000	\$182,000	\$295,000
<i>Staff</i>	0	0	0	0	0
<i>Benefits</i>	0	0	\$62,335	\$64,828	\$105,079
<i>Equipment</i>	0	0	0	0	0
<i>Library</i>	0	0	0	0	0
<i>Other (miscellaneous expenses)</i>	\$17,000	\$18,700	\$20,570	\$22,627	\$24,890
<b>Total recurring</b>	\$17,000	\$18,700	\$257,905	\$269,455	\$424,969
<b>Total expenses (A+B)</b>	\$17,000	\$28,700	\$677,905	\$294,455	\$1,074,969
<b>2. Revenue per year</b>					
<i>Tuition/Fees</i>	\$273,888	\$617,545	\$1,049,826	\$1,468,557	\$1,934,824
<i>Institutional Resources</i>	0	0	0	0	0
<i>State Aid -- CBHE</i>	0	0	0	0	0
<i>State Aid -- Other</i>	0	0	0	0	0
<b>Total revenue</b>	\$273,888	\$617,545	\$1,049,826	\$1,468,557	\$1,934,824
<b>3. Net revenue (loss) per year</b>					
	\$256,888	\$588,845	\$371,921	\$1,174,102	\$859,855
<b>4. Cumulative revenue (loss)</b>					
	\$256,888	\$845,733	\$1,217,654	\$2,391,756	\$3,251,610

Financial projections for a 50% enrollment scenario have also been considered. In this situation, the program would continue to be financially viable, achieving a positive net revenue from Year 1. In this scenario the hiring of the non-tenure track faculty member is eliminated.

#### *3.B.4. Academic and Financial Viability*

We anticipate a minimum enrollment of 50 students by Year 5 to ensure academic viability. In this scenario, we would admit approximately 10 students annually and offer one section for each class to accommodate all enrolled students. This approach aligns with the definition of an academically viable program, which is characterized by having adequate talent, resources, and student enrollment to foster a dynamic and engaging learning environment.



We estimate a minimum of 37 students by Year 5 (representing a 30% enrollment scenario) to guarantee financial viability while maintaining academic health. Under this scenario, we will not hire the additional faculty member nor renovate the teaching lab, as planned in the initial “full growth” budget. Therefore, we project an overall enrollment of 50 students to ensure both academic and financial viability are sustained.

**Table 3. Enrollment for Academic and Financial Viability**

<b>Viability</b>	<b>Minimum Enrollment</b>
<b>Academic</b>	<b>50</b>
<b>Financial</b>	<b>37</b>
<b>Overall</b>	<b>50</b>

### **3.C. Business Plan: Marketing, Student Success, Transition & Exit Strategies**

#### *3.C.1. Marketing Plan*

The marketing plan for our new BME BS degree program will involve a multi-faceted approach to reach our target audience, promote the program's unique offerings, and attract prospective students. Our marketing efforts will be primarily managed by the University's Marketing and Communications Department, with shared responsibility by the Department Chair of Chemical and Biochemical Engineering and our Vice Provost for Enrollment Management.

Key components of our marketing plan include:

**Rebranding:** Once the program is approved, the department will pursue authorization to rebrand as the Doshi Department of Chemical and Biomedical Engineering. This new name will underscore the coexistence of two distinct programs within the department. By effectively conveying its updated identity and vision, the department aims to cultivate robust relationships across academia, industry, and the wider community, and to become an obvious destination for high school students interested in BME careers.

**Digital Marketing:** We will leverage our university's website, social media platforms, and digital media to highlight the program's strengths, share news about research breakthroughs, showcase faculty expertise, and present student success stories. Digital marketing efforts will also include search engine optimization, targeted Google Ads, and social media advertising campaigns.

**Recruitment Events and Campus Visits:** Our admissions team will attend regional and national college fairs, high school visits, and other targeted recruitment events to raise awareness about the program. We will also host open house events, virtual information sessions, webinars, and develop summer camps to provide prospective students and their families with an opportunity to learn more about our program and campus.

### **Collaboration with High Schools, Community Colleges, and External**

**Partnerships:** We will establish partnerships with local high schools, community colleges, national organizations, foundations, and community organizations to facilitate dual enrollment, transfer pathways, and joint events to increase program awareness and encourage enrollment. We will also join the campus efforts with the National Consortium of Specialized Secondary Schools of Math, Science and Technology (NCSSSMST) and the Technology Student Association.

**Alumni Engagement and Industry Partnerships:** We will engage our alumni network and industry partners to serve as ambassadors for the program, share their experiences, and help us connect with prospective students and create opportunities for internships, co-op experiences, and job placements for our graduates.

**Press Releases and Announcements:** When the program launches, we will prepare a press release and send out announcements to appropriate professional societies, such as the American Institute of Chemical Engineers, Biomedical Engineering Society, International Society of Pharmaceutical Engineers, American Society for Engineering Education (ASEE), and target corporations through a listserv or other forms of communication.

We will monitor enrollment trends, marketing analytics, and collect feedback from enrolled students to better understand their decision-making process, which will help us refine our marketing efforts. We will evaluate the program annually to track costs and revenue, and make adjustments to marketing and recruiting strategies as needed.

### *3.C.2. Student Success Plan*

To support and retain students in the BME BS program, we will implement a comprehensive student success plan that includes:

**ABET Accreditation:** We will put into place a plan to have the new BME program accredited by the ABET Engineering Accreditation Commission within the first two years of the start of the program; see Section 5.A. ABET accreditation is recognized by employers and academic peers as a measure of program quality and will ensure that the graduates of our program have access to the greatest numbers of employment and academic opportunities

**Academic Advising:** Each student will be assigned a dedicated professional academic advisor to provide guidance on course selection, program requirements, and academic progress. Advisors will also help connect students with campus resources and support services.

**Faculty Mentorship:** Students will be paired with faculty mentors who can offer guidance on undergraduate research projects, internships, and career planning, as well as provide networking opportunities within the industry.

**Tutoring and Supplemental Instruction:** We will work with our office of student success to offer tutoring services and supplemental instruction sessions for challenging courses, giving students additional support to ensure their academic success.

**Peer Mentorship:** Upper-class students will serve as peer mentors to incoming students, providing guidance and support throughout their academic journey. This peer-to-peer connection will foster a sense of community and belonging within the program.

**Workshops and Seminars:** We will organize workshops and seminars focused on topics such as time management, study strategies, and career development to equip students with the necessary skills to succeed academically and professionally.

**Student Organizations:** Students will have the opportunity to join program-related student organizations, which will help them build professional networks and develop leadership skills.

### *3.C.3. Transition Plan*

If the department chair who is primarily responsible for the program leaves the institution or assumes other responsibilities, a transition plan will be in place to ensure program continuity and quality. The plan includes the appointment of an interim department chair by the vice-provost and dean of the College of Engineering and Computing. This will be followed by a national search to identify and hire a new department chair. If the BME degree program coordinator leaves or assumes other responsibilities, the department chair will appoint a new member of the faculty as the program coordinator.

### *3.C.4. Exit Strategy*

If the program underperforms expectations or fails to meet minimum enrollment criteria for financial viability, the following exit strategy will be implemented:

1. A thorough program evaluation will be conducted by the Office of the Provost to identify any areas in need of improvement or adjustment.
2. Marketing and recruitment efforts will be re-assessed and adjusted as needed to attract more students.
3. If the program continues to underperform after implementing these changes, the university will place the program on hiatus to re-evaluate its offerings and strategies.
4. In the event that the program must be discontinued, the department will develop a teach-out plan to ensure that currently enrolled students can complete their degree requirements in a timely manner. This may include offering necessary

courses until all enrolled students graduate, or assisting students in transferring to comparable programs at other institutions.

## **4. Institutional Capacity**

Missouri S&T has a strong foundation and the necessary resources to support the implementation of the new BME BS program.

The Doshi Department of Chemical and Biochemical Engineering (ChBE) currently has 12 tenure track (TT)/non-tenure track (NTT) faculty members, 1 lecturer, adjunct faculty, and affiliated faculty. These faculty members will serve as the foundation for the new degree program. If we see enrollment growth as planned over the next three years, we will hire additional faculty members (NTT and T/TT) with specialized expertise in the field to support the expansion of the program.

ChBE is housed in Bertelsmeyer Hall, a recently constructed (2017) 68,500-square-foot, three-story building. The department manages state-of-art equipment and laboratories dedicated to chemical and biochemical engineering research and teaching activities. There is enough existing space in Bertelsmeyer Hall to accommodate the faculty, staff, and class requirements anticipated for the new program. The University also has a Bio-Imaging Facility, a Bioanalytical Laboratory, a Histology Laboratory, and a small animal vivarium, which we will leverage to support the proposed BME program. The BME curriculum will continue to have access to the laboratory space and equipment in McNutt Hall, which is currently utilized for teaching biomaterials courses included in the program.

Missouri S&T offers a wide range of support services, including academic advising, career counseling, and tutoring, which will be available to students enrolled in the new degree program. The university has dedicated academic advisors for engineering students, and the Career Opportunities and Employer Relations (COER) office provides specialized support for engineering students seeking internships, co-ops, and full-time positions.

Tuition revenue from the increased enrollment in these programs, which is projected to reach 124 students in the BS program within five years, will contribute to the financial sustainability of the program. With this strong institutional capacity, Missouri S&T is well-positioned to successfully develop and implement the new BME BS degree program, ensuring that students have access to high-quality education and the necessary resources to excel in their chosen fields.

## **5. Program Characteristics**

### **5.A. Program Outcomes**

As defined by ABET (incorporated as the Accreditation Board for Engineering and Technology, Inc.), graduates of the BME program are expected to have:

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.

Upon completion of the BME BS degree program with a focus on biomanufacturing and biomaterials tracks, students will have acquired a comprehensive set of knowledge, skills, and abilities specific to these areas of the field. Graduates will have a strong foundation in engineering principles, proficiency in biomanufacturing processes, and a deep understanding of biomaterials and their applications in BME.

In the biomanufacturing track, students will learn about the design, development, and optimization of biological products. They will gain hands-on experience with state-of-the-art techniques and current and new equipment used in the production and testing of these products.

In the biomaterials track, students will acquire knowledge about the properties, design, and applications of various materials used in BME, such as polymers, ceramics, metals, and composites. They will learn how to select and customize these materials for specific biomedical applications, taking into consideration biocompatibility, mechanical properties, functionality, and other factors.

By focusing on these specialized tracks, graduates will be well-prepared for careers in various sectors of the biomedical engineering field, including biomanufacturing, biomaterials research and development, medical device design, and tissue engineering, and they will be well-prepared to pursue advanced degrees related to the medical sciences and engineering. Additionally, their interdisciplinary knowledge and problem-solving skills will enable them to contribute effectively to multidisciplinary teams and projects, enhancing their value in the job market.

## **5.B. Program Design & Content**

To design the curriculum for the BME BS program, we reviewed the curricula of successful BME programs at peer institutions to identify best practices and key components that contribute to a well-rounded education. Such reviews will be done periodically to ensure that our program remains competitive and up-to-date with the latest developments in the field. Moreover, the courses were chosen to align with the program outcomes, including those required for ABET accreditation, ensuring that students gain the necessary knowledge and skills to excel in their chosen career paths. We also focused on a comprehensive curriculum that encompasses a balance of theoretical knowledge, practical skills, and hands-on experiences, and that reflects the interdisciplinary strengths of the S&T faculty who will participate in the program. The curriculum includes core courses in BME and electives that allow students to explore specialized areas.

In alignment with ABET criteria, the following Program Educational Objectives (**PEOs**) for our BME BS program have been adopted:

- Program graduates will make a meaningful impact as individual contributors or leaders in their chosen industry, business, and community, by utilizing their biomedical engineering knowledge and skills to improve human health and well-being.
- Program graduates will work collaboratively in multidisciplinary teams to enhance the economic and societal environment of their industry sector and community, while addressing diverse needs and advancing the field of biomedical engineering.
- Program graduates will continuously expand their career skills and adapt to the evolving needs of the profession through lifelong learning, staying current with emerging technologies, and methodologies in biomedical engineering.

The proposed BS program in BME will leverage mathematics, engineering, and science courses already available across our campus, including components from chemical engineering, biological sciences, chemistry, computer science, electrical engineering, materials science and engineering, mathematics and statistics, and mechanical engineering. The curriculum also requires the development of three new core courses, (1) Intro to Transport for Biologicals (BME3xxx), (2) Biomedical Engineering Capstone Design I (BME4xxx) & (3) Biomedical Engineering Capstone Design II (BME4xxx).

Recently two courses have been added to our biochemical engineering emphasis and will be used for the biomanufacturing track: (1) Drug and Gene Delivery, (2) Vaccine Manufacturing. In addition, the department is working to add two new courses (1) Biomedical Polymers and Metals, (2) Hard Tissue Medical Devices, both of which will be taught by our newly hired professor. These two courses will be used for the biomaterials track. These courses have been carefully designed to enhance the

curriculum and provide students with specialized knowledge and skills relevant to the rapidly evolving field of biomedical engineering.

By incorporating these new required courses into the curriculum, the BME BS program at Missouri S&T will ensure that graduates are well-equipped to tackle complex challenges and contribute to the advancement of biomedical engineering in various industries and research settings. Additional courses may be added or substituted for others in the future in response to changes in market demand for key skills.

Our curriculum includes two tracks: (1) biomanufacturing, and (2) biomaterials. In addition, we have specifically designed each track such that students can also complete the pre-med minor currently offered by our Biological Sciences Department. We have identified pathways where students can get the BME BS degree with the pre-med minor, which is offered by Department of Biological Sciences at Missouri S&T, without taking additional course hours. The pre-med minor focuses on adding additional biological sciences skills and is geared towards students who have an aspiration to attend medical school. To get the minor, students would simply need to choose the proper electives for the BME degree program, which already has a pre-medicine approved curriculum. Students from Missouri S&T have achieved impressive success in gaining admission to medical schools nationwide. Notably, these students have shown remarkable success in securing placements at MU and UMKC medical schools. Over the past two decades, out of 56 students admitted to medical schools, 30 were accepted into MU and UMKC.

Students in the biomanufacturing track will learn skills associated with the production of biopharmaceuticals, downstream processing, and pharmaceutical engineering, whereas, the biomaterials track focuses on coursework for students to develop an understanding of how engineered materials are utilized in biomedical applications and how they interact with biological systems. In the future, we may consider adding additional tracks, such as bioinstrumentation, biomechanics, and bioinformatics, to meet student demand and market need. The suggested four-year plans of study for each track, including the pre-med minor, are shown below. The prerequisites for the BME program are also outlined.

## **1) Biomanufacturing Track**

## Biomufacturing Track

				<b>Freshman</b>		<b>Total credits</b>
FE 1100	Intro to Engineering	1	CompSci 1500	Intro to Computing	3	
Chem 1100	Lab Safety	1	Math 1215	Calculus II	4	
Chem 1310	General Chem I	4	Chem 1320	General Chem II	3	
Chem 1319	General Chem I Lab	1	Phys 1135	Physics I	4	
Math 1214	Calculus I	4	Track Elec	Choice	3	
Hist/PoISci	Choice	3				
Engl 1120	Exposition And Argumentation	3				
		<b>17</b>			<b>17</b>	<b>34</b>
				<b>Sophomore</b>		
Econ 11/1200	Micro or Macro Economics	3	Math 3304	Differential Equations	3	
Math 2222	Calculus III	4	Phys 2135	Physics II	4	
BioSci 2213/19	Cell Biology/Lab	4	ChemEng 2110	Thermodynamics I	3	
ChemEng 2100	Mass & Energy Balances	4	ChemEng 3210	Intro to Biomedical Engineering	3	
			Chem 2210/19	Organic Chemistry I/Lab	4	
		<b>15</b>			<b>17</b>	<b>32</b>
				<b>Junior</b>		
BME 3xxx	Intro to Transport for Biologicals	4	Engl 3560	Technical Writing	3	
ChemEng 3120	Thermodynamics II	3	SP&MS 1185	Principles of Speech	3	
Stat 3425	Intro to Biostatistics	3	H/SS elect	Elective	3	
BioSci 3333/59	Anatomy and Physiology I/Lab	4	ChemEng 5250	Bioseparations	3	
Phil 3223	Bioethics	3	ChemEng 3150	Reactor Design	3	
		<b>17</b>			<b>15</b>	<b>32</b>
				<b>Senior</b>		
BME 4xxx	BioMed Eng Design I	3	BME 4xxx	BioMed Eng Design II	3	
ChemEng 4201	Bioseparations Lab	3	ChemEng 4220	Bioreactor Lab	3	
ChemEng 4241	Safety	3	UL H/SS	Upper-level elective	3	
MS&E 5210	Tissue Engineering	3	ChemEng 5xxx	Vaccine Manufacturing	3	
ChemEng 4210	Bioreactors	3	Track Elect	Choice	3	
		<b>15</b>			<b>15</b>	<b>30</b>
						<b>128</b>

### Track Electives

BioSci 1113/1219	General Biology/Lab	4
Chem 2220/2229	Organic Chemistry II/Lab	4
ChemEng3131	Separations	3
ChemEng 3141	Process Operations	3
ChemEng 4110	Process Control	3
BME 5xxx	Drug and Gene Delivery	3
BME 5xxx	Hard Tissue Med Devices	3
BioSci 2223	General Genetics	3
BioSci 4353	Cancer Cell Biology	3
BioSci 4373	Stem Cell Biology	3



**Hist/PolSci Requirement:** Hist 1200, Hist 1300, Hist 1310, or PolSci 1200

Notwithstanding any prerequisite requirements, track electives may be taken in any semester. Students enrolled in the biomanufacturing track who wish to pursue a pre-med minor should consider selecting BioSci 1113/1219 (4 credits) as their track elective in year 1. In addition, they must take Chem 2220/2229 (4 credits) for a later track elective. Both courses are necessary requirements for a pre-med minor in the Biological Sciences Department. Students less interested in the pre-med minor may decide to take other electives instead. Our professional advisor will guide students in selecting courses that enable them to make progress towards earning their degree within a four-year time frame.

**2) Biomaterials Track**

<b>Biomaterials Track</b>					
<b>Freshman</b>					<b>Total credits</b>
FE 1100	Intro to Engineering	1	CompSci 1500	Intro to Computing	3
Chem 1100	Lab Safety	1	Math 1215	Calculus II	4
Chem 1310	General Chem I	4	Chem 1320	Gen Chem II	3
Chem 1319	General Chem I Lab	1	Phys 1135	Physics I	4
Math 1214	Calculus I	4	Track Elec	Choice	3
Hist/PolSci	Choice	3			
Engl 1120	Exposition And Argumentation	3			
		<b>17</b>			<b>17</b>
					<b>34</b>
<b>Sophomore</b>					
Phys 2135	Physics II	4	Math 3304	Differential Equations	3
Math 2222	Calculus III	4	Stat 3425	Intro to Biostatistics	3
Chem 2210	Organic Chemistry I	3	Chem2220	Organic Chemistry II	3
BioSci 2213/19	Cell Biology/Lab	4	ChemEng 3210	Intro to Biomedical Engineering	3
Cer Eng 2210	Ceramics in the Modern World	2	Civ Eng 2200	Statics	3
		<b>17</b>			<b>15</b>
					<b>32</b>
<b>Junior</b>					
BME 3xxx	Intro to Transport for Biological Systems	4	Engl 3560	Technical Writing	3
Cer Eng 3230	Thermodynamics of Materials	3	Track elective	Choice	3
Cer Eng 3220	Phase Equilibria	3	Sp&MS 1185	Principles of Speech	3
BioSci 3333/59	Anatomy and Physiology I/Lat	4	Econ 11/1200	Micro or Macro Economics	3
BME 4xxx	Biomed Polymers & Metals	3	MS&E 5310	Biomaterials I	3
		<b>17</b>			<b>15</b>
					<b>32</b>
<b>Senior</b>					
BME 4xxx	BioMed Eng Design I	3	BME 4xxx	BioMed Eng Design II	3
MS&E 5210	Tissue Engineering	3	BioSci 3783	Biological Design & Innovation	3
Phil 3223	Bioethics	3	BME 5xxx	Hard Tissue Med Devices	3
Track elective	Choice	3	BME 5xxx	Drug and Gene Delivery	3
UL H/SS	Upper-level elective	3			
		<b>15</b>			<b>12</b>
					<b>27</b>
					<b>125</b>

**Track Engineering Electives: At least one engineering course needed**

ChemEng 5250	Bioseparations	3
MS&E 4810	Chemistry & Inherent Properties of Polymers	3
MS&E 5810	Introduction to Polymeric Materials	3
MS&E 5460	Molecular Engineering of Materials	3
ElecEng 2100/01	Circuits/Lab	4
ElecEng 2200/01	Electronic Devices/Lab	4

**Track Non-Engineering Electives**

Chem 2219	Organic Chemistry I Lab	1
Chem 2229	Organic Chemistry II Lab	1
BioSci 1113/1219	General Biology/Lab	4
BioSci 4666	Nanobiotechnology	3
BioSci 4383	Toxicology	3
BioSci 5533	Pharmacology	3

**Hist/PolSci Requirement:** Hist 1200, Hist 1300, Hist 1310, or PolSci 1200

A minimum of one engineering track elective must be taken. Notwithstanding any prerequisite requirements, track electives may be taken in any semester. Students enrolled in the biomaterials track who wish to pursue a pre-med minor should consider selecting BioSci 1113/1219 (4 credits) as their track elective in year 1. In addition, they must take Chem 2220/2229 (4 credits) for a later track elective. Both courses are necessary requirements for a pre-med minor in the Biological Sciences Department. Students less interested in the pre-med minor may decide to take other electives instead. Our professional advisor will guide students in selecting courses that enable them to make progress towards earning their degree within a four-year time frame.

**5.C. Program Structure**

### 5.C.1. Program Structure Form

The program includes two tracks, 1) Biomanufacturing, and 2) Biomaterials, with each having a set of courses that are specifically designed for the track's focus. Each track is designed to meet the ABET criteria for biomedical engineering.

#### 1) Biomanufacturing Track

- **Total Credits Required for Graduation:** 128
- **Residence requirements, if any:** None
- **General education**
  - a. Total general education credits: 24

Courses (specific course or distribution area and credit hours):

Course	Hrs	Course	Hrs	Course	Hrs
Hist/PolSci: Choice	3	Engl 1120: Exposition and Argumentation	3	Econ 11/1200: Micro or Macro Economics	3
Phil 3223: Bioethics	3	Engl 3560: Technical Writing	3	SP&MS 1185: Principles of Speech	3
H/SS elect: Elective	3	UL H/SS: Upper-level elective	3		

- **Major Requirements**
  - a. Total credits specific to degree: 104 (including math, basic sciences and engineering topics)

Courses (specific course or distribution area and credit hours):

Course	Hrs	Course	Hrs	Course	Hrs
FE 1100: Intro to Engineering	1	Chem 1310: General Chem I	4	Chem 1319: General Chem I Lab	1
Chem 1100: Lab Safety	1	CompSci 1500: Intro to Computing	3	Math 1215: Calculus II	4
Math 1214: Calculus I	4	Phys 1135: Physics I	4	Math 2222: Calculus III: 4	4
Chem 1320: General Chem II	3	ChemEng 2100: Mass & Energy Balances	4	Math 3304: Differential Equations	3
BioSci 2213/19: Cell Biology/Lab	4	ChemEng 2110: Thermodynamics I	3	ChemEng 3210: Intro to Biomedical Engineering	3
Phys 2135: Physics II	4	BME 3xxx: Intro to Transport for Biologicals	4	ChemEng 3120: Thermodynamics II	3

Chem 2210/19: Organic Chemistry I/Lab	4	BioSci 3333/59: Anatomy and Physiology I/Lab	4	ChemEng 5250: Bioseparations	3
Stat 3425: Intro to Biostatistics	3	ChemEng 3150: Reactor Design	3	BME 4xxx: BioMed Eng Design I	3
ChemEng 4201: Bioseparations Lab	3	ChemEng 4241: Safety	3	MS&E 5210: Tissue Engineering	3
ChemEng 4210: Bioreactors	3	BME 4xxx: BioMed Eng Design II	3	ChemEng 4220: Bioreactor Lab	3
ChemEng 5xxx: Vaccine Manufacturing	3	Track Elec: Choice	3	Track Elec: Choice	3

- **Free elective credits**
  - a. Total free elective credits: 0  
Although there are no completely unrestricted electives, students are able to choose from a list of 9 courses to fulfill 6 credit hours of track electives.
- **Requirement for thesis, internship, or other capstone experience:**  
All the seniors are required to take capstone design I&II, and to meet S&T requirements for experiential learning activities.
- **Any unique features such as interdepartmental cooperation:**  
Courses that are mandatory for the program will be instructed by faculty members from different departments, such as Chemical and Biochemical Engineering, and Computer Science. For the track elective courses, students may choose from a range of degree programs, such as those offered by Chemical and Biochemical Engineering, Biological Sciences, and Chemistry.

## 2) Biomaterials Track

1. **Total Credits Required for Graduation:** 125
2. **Residence requirements, if any:** None
3. **General education**
  - a. Total general education credits: 21

Courses (specific course or distribution area and credit hours):

Course	Hrs	Course	Hrs	Course	Hrs
Hist/PolSci: Choice	3	Engl 1120: Exposition and Argumentation	3	Econ 11/1200: Micro or Macro Economics	3
Phil 3223: Bioethics	3	Engl 3560: Technical Writing	3	SP&MS 1185: Principles of Speech	3
UL H/SS: Upper-level elective	3				

#### 4. Major Requirements

- a. Total credits specific to degree: 104 (including math, basic sciences and engineering topics)

Courses (specific course or distribution area and credit hours):

Course	Hrs	Course	Hrs	Course	Hrs
FE 1100: Intro to Engineering	1	Chem 1310: General Chem I	4	Chem 1319: General Chem I Lab	1
Chem 1100: Lab Safety	1	Math 1214: Calculus I	4	CompSci 1500: Intro to Computing	3
Math 1215: Calculus II	4	Chem 1320: Gen Chem II	3	Phys 1135: Physics I	4
Phys 2135: Physics II	4	Math 2222: Calculus III: 4	4	Chem 2210: Organic Chemistry I	3
BioSci 2213/19: Cell Biology/Lab	4	Cer Eng 2210: Ceramics in the Modern World	2	Math 3304: Differential Equations	3
Stat 3425: Intro to Biostatistics	3	Chem2220: Organic Chemistry II	3	ChemEng 3210: Intro to Biomedical Engineering	3
Civ Eng 2200 : Statics	3	BME 3xxx: Intro to Transport for Biologicals	4	Cer Eng 3230: Thermodynamics of Materials	3
Cer Eng 3220: Phase Equilibria	3	BioSci 3333/59: Anatomy and Physiology I/Lab	4	BME 4xxx: Biomed Polymers & Metals	3
MS&E 5310: Biomaterials I	3	BME 4xxx: BioMed Eng Design I	3	MS&E 5210: Tissue Engineering	3
BME 4xxx: BioMed Eng Design II	3	BioSci 3783: Biological Design & Innovation	3	BME 5xxx: Hard Tissue Med Devices	3
BME 5xxx: Drug and Gene Delivery	3	Track elective: Choice	3	Track elective: Choice	3
Track elective: Choice	3				

#### 5. Free elective credits

- a. Total free elective credits: 0

Although there are no completely unrestricted electives, students are able to choose from a list of 6 engineering courses to fulfill 3 credit hours of engineering track electives and a list of 12 combined engineering and non-engineering courses to fulfill the remaining 6 credit hours of track electives.

#### 6. Requirement for thesis, internship or other capstone experience:

All the seniors are required to take capstone design I & II, and to meet S&T requirements for experiential learning activities.

#### 7. Any unique features such as interdepartmental cooperation:

Courses that are mandatory for the program will be instructed by faculty members from different departments, including chemical and biochemical engineering, computer science, civil engineering, materials science and engineering. For the track elective courses, students may choose from a range of degree programs, such as those offered by Chemical and Biochemical Engineering, Electrical Engineering, Materials Science and Engineering, Biological Sciences, and Chemistry.

## **5.D. Program Goals and Assessment**

This program is designed to prepare students for careers at the intersection of engineering, medicine, and biology. Admission to this program follows the general campus admission process.

### **Assessing Learning Outcomes:**

The BME program will employ a variety of assessment methods to ensure students are meeting learning outcomes. These may include:

1. Coursework and lab assessments
2. Student performance on national and local assessments
3. Senior capstone projects and presentations
4. Internship evaluations
5. Surveys of graduates and employers

The assessment process for the BME BS program at Missouri S&T is rigorous and comprehensive, designed to ensure continuous improvement and alignment with the program's educational objectives. The process is centered around performance indicators (PIs) for each student outcome (SO) and a graduating student exit survey.

*Performance Indicators:* Performance indicators are measurable quantitative assessments of students progressing through the BME Curriculum. These indicators link specific courses, curricula, and extracurricular activities directly to student outcomes and indirectly to program educational objectives. Performance indicators are the foundation for rigorous assessment of student outcomes by defining diagnostic problems, special assignments, projects, and reports through the designated courses and student activities. They provide essential information for assessing student learning and the attainment of outcomes related to critical knowledge, skills, and behaviors necessary for future careers.

To prepare for ABET accreditation, faculty collect data every semester on a three-year cycle, and the department faculty and the department's Industrial Advisory Council evaluate this data at the end of each cycle. The Industrial Advisory Council has recently been reconstituted to include members with backgrounds in chemical engineering and biomedical engineering. For each performance indicator, multiple assessments are defined and conducted to increase the reliability of the assessment.

Graduating Student Exit Survey: The exit survey, given to all graduating seniors, provides an overall evaluation of the student outcomes. The survey consists of questions that assess the accomplishment and importance of the student outcomes. In general, the results of the rigorous assessment through performance indicators reflect the effectiveness of the program courses in meeting individual criteria, while the exit survey results reflect the effectiveness of the entire undergraduate program. The university requires all students to complete an experiential learning activity, for which students must write a reflection essay. This essay is also used for the assessment process.

Feedback from the Industrial Advisory Council, based on their interactions with undergraduate students, is considered a supplemental assessment for the student outcomes. The exit survey response rate has improved to nearly 100% every semester, enabling the program to gather valuable feedback from students.

The Department chair and coordinator for the BME program at Missouri S&T will use this assessment process to continuously improve the curriculum, ensuring that students gain the necessary skills and knowledge for success in their future careers. By regularly evaluating student outcomes and adjusting the program accordingly, the university demonstrates its commitment to providing a high-quality education in the field of biomedical engineering.

### **Performance Projections:**

Based on the rigorous curriculum and the support provided by the university, we project the following performance metrics for students in the BME program:

1. 90% retention rate for first-year students.
2. 80% six-year graduation rate.
3. 90% placement rate in related fields within six months of graduation.

### **Additional Measures of Success:**

The BME program will use additional measures of success to evaluate the program's effectiveness, including:

1. Number of students participating in undergraduate research projects
2. Number of students receiving scholarships or awards in the field of biomedical engineering
3. Student satisfaction with the program, as measured through exit surveys
4. Survey on whether or not program education objectives are achieved from alumni two to five years post-graduation
5. Employer satisfaction with program graduates, as assessed through surveys and feedback

## **5.E. Student Preparation**

To ensure success in the BME BS program at Missouri S&T, prospective students should focus on building a strong foundation in science, mathematics, and problem-solving skills before entering the program. The following preparation guidelines are recommended for students considering the BME program:

1. Strong background in mathematics: Students should have completed high school courses in algebra, geometry, trigonometry, and pre-calculus. AP or college-level calculus courses are highly recommended.
2. Science coursework: Prospective students should have a solid background in high school biology, chemistry, and physics. Advanced courses, such as AP or college-level courses in these subjects, are strongly encouraged.
3. Problem-solving and critical thinking skills: Students should develop their problem-solving and critical thinking abilities through participation in extracurricular activities, such as science clubs, engineering competitions, or research projects.
4. Communication skills: Biomedical engineers often work in interdisciplinary teams, so strong written and oral communication skills are essential. Students should practice these skills through writing assignments, presentations, and group projects.

### **Target Population:**

The BME program is designed for students who have a strong interest in engineering, medicine, and biology, and are motivated to pursue careers in this interdisciplinary field. The target population includes:

1. High school students with strong backgrounds in mathematics and science who are seeking a challenging and rewarding undergraduate engineering program with employment opportunities in the medical and health-related fields.
2. Transfer students from community colleges or other institutions who have completed the necessary foundational coursework and meet the program's GPA requirements.

## **5.F. Faculty and Administration**

The program will draw on the expertise of over twenty existing faculty members from the different departments who are slated to offer courses listed on the curriculum. A list of Chemical and Biochemical Engineering faculty members with qualifications is included as **Appendix 2**.

Approximately 95% of the credit hours in the program will be assigned to full-time faculty members. It is also planned that the required courses will always be taught by full-time faculty members. Dr. Hu Yang, department chair, will be the primary point person for the program, and Dr. Christi Luks, associate chair for academic affairs, will help keep track of activities, students, and advising for the proposed BME BS Degree.



No new faculty hires will be needed to start the degree program. However, new faculty hires in year three and year five of the program are anticipated if warranted by program enrollment growth. These new hires will include NTT and T/TT faculty.

Because the BME degree is interdisciplinary in nature, participating departments and faculty members will have a stake in the program's curriculum, assessment and related features. Moreover, the contributions by faculty members outside the Chemical and Biochemical Engineering department will be recognized and appropriately credited to their home departments. To this end, a program steering committee will be formed that includes at least one faculty member from each participating department. The chair of the committee will be the department chair of the program's home department (initially Chemical and Biochemical Engineering). At the end of each academic year, the committee will be tasked with generating a program evaluation report that includes (but need not be limited to) the following:

- 1) Undergraduate enrollment numbers for the BME program and programs/departments that are affiliated with it.
- 2) Student credit hours taught by each faculty member and department in support of the BME degree.
- 3) A summary of recruiting and retention efforts for the BME degree program with appropriate attribution to faculty members and departments.
- 4) A summary of ABET data collection activities associated the BME degree program with appropriate attribution to faculty members and departments.

This report will be completed annually by August 1 and sent out to the chairs of participating departments, the deans for colleges that host these departments, and the provost. Enrollment numbers in BME and the level of participation in supporting the degree will be considered in the allocation of future resources for the departments and colleges involved.

### **5.G. Alumni and Employer Survey**

We are committed to continuously gathering feedback from both alumni and employers to evaluate and improve the quality of this new program. Surveys and communication channels are utilized to collect relevant information, ensuring that the program meets the expectations and requirements of both alumni and employers. The following methods and schedules are used for collecting feedback from these key stakeholders:

#### **Alumni Survey:**

Method: Online questionnaires and mailed surveys are sent to alumni who graduated three to five years prior. The survey focuses on evaluating their satisfaction with the program and the extent to which it prepared them for their careers.

Schedule: Alumni surveys are conducted biennially, allowing for a comprehensive and up-to-date understanding of alumni perspectives.

Expected/desired satisfaction rates: The department aims to achieve a satisfaction rate of at least 80% among respondents, with the goal of continuously improving the program based on alumni feedback.

### **Employer Survey:**

Method: Online questionnaires and surveys are distributed to employers of the program's graduates. The surveys seek to evaluate the preparedness and performance of alumni in their respective workplaces, as well as solicit suggestions for program improvements.

Schedule: Employer surveys are conducted every three years, allowing sufficient time to gather meaningful feedback while keeping the information current.

Expected/desired satisfaction rates: The department aims to achieve a satisfaction rate of at least 85% among employer respondents, using their input to adapt the program to better meet industry needs and expectations.

In addition to the scheduled surveys, the department encourages ongoing communication with alumni and employers through various channels, including departmental events, Industrial Advisory Council meetings, and direct communication with alumni and employers at on-campus career fairs. This continuous feedback loop helps to ensure that the program stays relevant and aligned with the needs of both alumni and employers.

## **5.H. Program Accreditation**

We are committed to maintaining the highest standards of quality in our educational programs. To this end, the department will seek accreditation from ABET, a recognized accrediting body for engineering programs. ABET accreditation assures that the program meets established criteria for preparing students to excel in their chosen fields.

It is important to note that accreditation through the Engineering Accreditation Commission (EAC) of ABET cannot be sought until the first students have graduated from the program. The curriculum for the new BS degree in BME has been designed to achieve ABET accreditation. We will request an initial ABET accreditation review in year 4 when degrees are awarded and a full ABET accreditation review in year 6 for the new BME BS degree.

### **Process and Timeline for Achieving Accreditation:**

- Self-Study Report: The department will prepare a comprehensive self-study report, providing detailed information about the program, its objectives,

outcomes, curriculum, resources, faculty, and assessment processes. This report will be submitted to ABET approximately one year before the scheduled accreditation visit.

- On-site Evaluation: ABET will conduct an on-site evaluation, during which a team of program evaluators (PEVs) will visit the campus to assess the program's compliance with ABET criteria. The evaluation typically occurs in the fall semester, with the specific dates agreed upon by the department and ABET.
- Evaluation Report and Institutional Response: Following the on-site visit, the department will receive a draft evaluation report from ABET. The department will have the opportunity to respond to any findings or concerns raised in the report, providing additional information or clarification as needed.
- Final Accreditation Decision: The ABET Engineering Accreditation Commission (EAC) will review the self-study report, evaluation report, and institutional response before making a final accreditation decision. This decision is usually communicated to the department within a few months after the EAC's review.
- Continuous Improvement: Upon receiving accreditation, the department will continue to monitor and improve the program, ensuring that it remains aligned with ABET criteria and the needs of its constituencies. ABET accreditation is typically valid for a period of six years, after which the department will need to undergo the reaccreditation process.

By pursuing and maintaining ABET accreditation, the Chemical and Biochemical Engineering Department demonstrates its commitment to providing a high-quality educational experience for its students and preparing them for success in their careers.

## 6. Appendices

### Appendix 1: Letters of Support

- Dr. Colin Potts, Provost and Executive Vice Chancellor for Academic Affairs, Missouri S&T
- Dr. David Borrok, Vice Provost and Dean of College of Engineering and Computing, Missouri S&T
- Bipin Doshi, Trustee Missouri S&T, Board Member KI Foundation, Past Chair Beacon Health System Board, South Bend, Indiana
- Jason Shenefield, President and CEO, Phelps Health
- Justin Sperry, Vice President – Transformational Technology and Chesterfield Site Head, Pfizer
- Mart Berutti, VP Sales Life Sciences, Emerson
- Charles W. Lyon, Senior Vice President and Chief Commercial Officer, FutureFuel Chemical Company
- Sarah Bock, Director Capital Engineering, Curium
- Ralph Grant, Director of Business Development-Associate, Clark, Richardson and Biskup Consulting Engineers, Inc.
- Fred Kielhorn, CEO, DeNovix Inc.
- Brian Donley, Founder, bd Solutions LLC
- Dr. Jorge A. Ochoa, Managing Partner, Principal Engineer, Biomedical Dynamics LLC

### Appendix 2: ChBE Faculty Qualifications ABET Style Summary