UNIVERSITY OF MARYLAND EASTERN SHORE
Office of the President

October 14, 2022

James D. Fielder, Jr., Ph.D.
Secretary of Higher Education
Maryland Higher Education Commission
6 N. Liberty Street, 10th Floor
Baltimore, Maryland 21201

RE: New Academic Program Proposal – Bachelor of Science in Biomedical Engineering

Dear Dr. Fielder:

The University of Maryland Eastern Shore hereby submits a new academic program proposal as indicated below:

Program: BS in Biomedical Engineering

The Department of Engineering and Aviation Sciences is proposing to offer a BS degree in Biomedical Engineering (BME). The proposed program will play a crucial role in preparing professionals to work in various positions related to the medical industry and help address the shortage of biomedical engineers and healthcare technical talents in rural areas.

The proposed biomedical engineering program will significantly strengthen and expand the capability of UMES, one of the four HBCUs in the state, to provide high-quality and unique educational experiences to students to support the rural healthcare system. With expertise spanning physiology, biology, healthcare, health informatics, mechanics, and engineering, biomedical engineers can combine their diverse skills to create solutions to continuing worldwide health issues, helping to change how patients are treated and lowering the cost of care, which becomes increasingly important and urgent for rural area healthcare system, like the eastern shore of Maryland. Moreover, the COVID-19 pandemic has stimulated an unprecedented engineering response across all domains of healthcare infrastructure, logistics, personal protective equipment, medical and digital technology, diagnostics, testing, monitoring, infrastructure, logistics,

prevention, vaccine bioprocessing, and therapeutics. Within this arena biomedical engineers who work as the interface of physiology, pathology, and treatment have come to the fore. They have devised new technologies, established fast routes for translation, and have demonstrably had a significant clinical impact.

The attached proposal has undergone the established UMES curriculum approval process and I fully support the proposed program.

I greatly appreciate your considering this request.

Sincerely,

Heidi M. Anderson, Ph.D., FAPhA
President

Copy: Dr. Rondall Allen, Provost and Vice President for Academic Affairs
Dr. Derrek Dunn, Dean, School of Business and Technology
Dr. Yuanwei Jin, Professor and Chair, Department of Engineering and Aviation Sciences

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Cover Sheet for In-State Institutions
New Program or Substantial Modification to Existing Program

Institution Submitting Proposal	University of Maryland Eastern Shore

Each action below requires a separate proposal and cover sheet.

- (●) New Academic Program
- ( ) New Area of Concentration
- ( ) New Degree Level Approval
- ( ) New Stand-Alone Certificate
- ( ) Off Campus Program
- ( ) Substantial Change to a Degree Program
- ( ) Substantial Change to an Area of Concentration
- ( ) Substantial Change to a Certificate Program
- ( ) Cooperative Degree Program
- ( ) Offer Program at Regional Higher Education Center

Payment Submitted: ( ) Yes ( ) No Payment Type: ( ) R*STARS # ( ) Check # Payment Amount: Date Submitted:

Department Proposing Program	Engineering and Aviation Sciences	
Degree Level and Degree Type	Bachelor of Science	
Title of Proposed Program	Biomedical Engineering	
Total Number of Credits	125	
Suggested Codes	HEGIS: 90500.00	CIP: 140501.0000
Program Modality	(●) On-campus	( ) Distance Education (*fully online*)
Program Resources	( ) Using Existing Resources	(●) Requiring New Resources
Projected Implementation Date	(●) Fall ( ) Spring ( ) Summer	Year: 2023
Provide Link to Most Recent Academic Catalog	URL: http://catalog.umes.edu/index.php	
Preferred Contact for this Proposal	Name: Yuanwei Jin, PhD	
	Title: Chairperson, Department of Engineering and Aviation Sciences	
	Phone: (410) 621-3410	
	Email: yjin@umes.edu	
President/Chief Executive	Type Name: Heidi M. Anderson	
	Signature:  Date: 10/14/2022	
	Date of Approval/Endorsement by Governing Board:	

Revised 1/2021

Proposal for New Undergraduate Degree Program

Bachelor of Science in Biomedical Engineering (BME)

A. Centrality to Institutional Mission Statement and Planning Priorities

1. Provide a description of the program, including each area of concentration (if applicable), and how it relates to the institution's approved mission.

The Department of Engineering and Aviation Sciences proposes to establish a Bachelor of Science degree in Biomedical Engineering within the School of Business and Technology (SBT) at UMES. Biomedical engineers play a critical role in the design of artificial organs, prostheses, instrumentation, medical information systems, health management and care delivery systems, medical devices used in various medical procedures, and imaging systems. As an emerging issue, COVID-19 is one of the most severe global health crises that humanity has ever faced. Researchers have restlessly focused on developing solutions for monitoring and tracing the viral culprit, SARS-CoV-2, as vital steps to break the chain of infection. Biomedical engineering (BME) has demonstrated its pivotal role in nurturing the maturation of COVID-19 diagnostic technologies. The proposed BME program aims to offer perspective students the educational opportunity to pursue a bachelor of science degree in biomedical engineering and take the inside track to a career that combines engineering and medical technology to find ways to improve the quality of human life.

The curriculum of the program consists of core engineering courses, supportive science and math courses, and major electives, in addition to the general education courses. The program consists of two tracks: (1) Biomechanics and Tissue Engineering track and (2) Bioelectric and Bio-computational Engineering track. This curriculum is designed to offer both a core understanding of traditional engineering disciplines, and an in-depth knowledge of the body. Our courses emphasize experimental and analytical coursework to gain a strong understanding of medical technology and complex living systems.

The institution's mission of UMES, as an 1890 HBCU land-grant institution, is to promote distinctive learning, discovery and engagement opportunities in the arts and sciences, education, technology, engineering, agriculture, business and health professions. Central to this purpose is the guided interest in providing individuals, including first generation college students, access to a holistic learning environment that fosters multicultural diversity, academic success, and intellectual and social growth. The proposed program imbibes itself in this mission and it is guided by the opportunity to increase graduation rate of the underrepresented minorities in the fields of biomedical engineering.

2. Explain how the proposed program supports the institution's strategic goals and provide evidence that affirms it is an institutional priority.

The proposed graduate program supports the institution's strategic goals. According to the UMES Strategic Plan 2018-2020, (see the link
https://wwwcp.umes.edu/president/wp-content/uploads/sites/16/2021/05/Strategic-Plan-2020.pdf

we identified the following two goals:

- "Goal IV: Meet the educational needs of the state of Maryland with high-quality and innovative academic programming" in order to align academic programs with the educational needs of the state of Maryland; and
- "Goal VI: Achieve and Maintain National Eminence and Global Impact" by creating signature academic programs to prepare students for careers nationally and internationally.

The proposed degree program will help the institution achieve its strategic goals listed above and position UMES to the forefront of educational innovation in health care related academic programs. The proposed biomedical engineering program, similar to the existing programs at UMES, including Kinesiology, Pharmacy, Physical Therapy, Physician Assistant and Rehabilitation Services is expected to improve the health and well-being of the community through health education and promotion. According to Bureau of Labor statistics, nationwide, employment of bioengineers and biomedical engineers is projected to grow 6 percent from 2020 to 2030, about as fast as the average for all occupations. About 1,400 openings for bioengineers and biomedical engineers are projected each year, on average, over the decade. Biomedical engineers work with a broad range of professionals ranging from other engineering specialties, to basic laboratory scientists, to physicians and nurses, which are in short supply in the rural area of Eastern Shore.

The proposed BME program is expected to enable a stronger and multi-disciplinary research collaboration across campus community, thus fueling research forward in many other different disciplines more than in applied science and engineering disciplines and creating much broader impact on the entire campus as well as the Eastern Shore community.

3. Provide a brief narrative of how the proposed program will be adequately funded for at least the first five years of program implementation. (Additional related information is required in section L.

With the commission of the Engineering and Aviation Science Complex, a $103 million investment from the state, the proposed program will be supported by about two dozen state-of-the-art engineering laboratories such as Robotics and Automation Lab, MEMS Lab with a class ISO 5 clean room, and Microwave Anechoic Chamber Lab, etc. Four (4) new faculty lines will be allocated to support this proposed BME program to develop courses and deliver instructions and labs. The new faculty lines will be funded by the HBCU settlement fund that UMES receives for the first five years of program implementation. Beginning of 2022 – 2023 academic year, it is expected that one tenure track faculty position will be funded. This process will continue for the next four years.

Two additional new teaching labs for the BME program will be developed: The Bioinstrumentation Lab and the Biomedical Engineering Lab. These two labs will enable the program to conduct measurements on living systems. The department has started acquiring measurement kits, for example, the BSL BME Teaching Package to start the development process.

4. Provide a description of the institution's a commitment to:

a. ongoing administrative, financial, and technical support of the proposed program

The University Administration is committed to adequately fund this program and it has made this program one of the priority areas of extending the footprint of the institution. With the HBCU

Lawsuit Settlement fund, UMES and the School of Business and Technology, and Department of Engineering and Aviation Sciences are equipped with the needed resources, and are committed to supporting the program in every way, including ongoing administrative support, financial support, and technical support of the program.

b) continuation of the program for a period of time sufficient to allow enrolled students to complete the program.

This degree program is created by levering, in part, the existing faculty and staff in the Departments of Engineering and Aviation Sciences at UMES, as well as the state-of-the-art engineering laboratories in the Engineering and Aviation Science Complex on UMES campus. Four additional new full-time tenure track faculty members with terminal degrees in the field of biomedical engineering or a closely related field will be recruited to develop and deliver courses and labs for the program. The university is fully committed to continue the proposed BME program for a sufficient period of time to allow enrolled students to complete the program.

B. Critical and Compelling Regional or Statewide Need as Identified in the State Plan

1. Demonstrate demand and need for the program in terms of meeting present and future needs of the region and the State in general based on one or more of the following:

a. The need for the advancement and evolution of knowledge

Bioengineers and biomedical engineers combine engineering principles with sciences to design and create equipment, devices, computer systems, and software. Bioengineers and biomedical engineers work in manufacturing, in research facilities, and for a variety of other employers.

The current pandemic has stimulated an unprecedented engineering response across all domains of healthcare infrastructure, logistics, personal protective equipment, medical and digital technology, diagnostics, testing, monitoring, infrastructure, logistics, prevention, vaccine bio-processing, and therapeutics. Within this, engineers who work as the interface of physiology, pathology and treatment have come to the fore. They have devised new technologies, established fast routes for translation, and have demonstrably had significant clinical impact. The COVID-19 pandemic has shone a light on the critical role medical technology plays in patient care. As demand for ventilators and patient monitoring equipment has surged, biomedical engineers are working around the clock to keep patients safe.

The need for the advancement and evolution of medical and healthcare technology demands academic programs such as the proposed BME program to educate and produce next generation medical researchers and engineers to handle challenges in future global infectious diseases.

b. Societal needs, including expanding educational opportunities and choices for minority and educationally disadvantaged students at institutions of higher education

UMES is located in Maryland's Somerset County, which is among the poorest counties in the state according to the U. S. Census Bureau. Lack of educational opportunities and choices for minority and educationally disadvantaged students calls for development of high-quality and innovative academic programming in order to align academic programs with the educational needs of the region and the state of Maryland.

With expertise spanning physiology, biology, healthcare and health informatics, mechanics, and engineering, biomedical engineers can combine their diverse skills to create solutions to continuing worldwide health issues, helping to change how patients are treated and lowering the cost of care, which becomes increasingly important and urgent for rural area healthcare system, like the eastern shore of Maryland.

UMES currently offers the only general engineering bachelor of science degree program in the Eastern Shore of Maryland. In the past 15 years since inception of the engineering program, there has been more than 130 graduates. Among those graduates, more than a dozen former graduates are working in the Wallops Island area for NASA and its contractors. About 20 of them went on to pursue graduate degrees (master's and doctorate) in mechanical engineering, electrical engineering, and engineering science in other engineering schools, including Dartmouth College and Rensselaer Institute of Technology. The graduation and job placement data have demonstrated the success of the engineering program. The proposed biomedical engineering program is expected to further enhance UMES's position as a top choice of higher education institution for STEM education for minority and educationally disadvantaged students in the state and the surrounding regions with the ultimate goal of developing a pipeline of engineering and STEM workforce for the state.

c. The need to strengthen and expand the capacity of historically black institutions to provide high quality and unique educational programs

The proposed BME program will significantly strengthen and expand the capability of UMES, one of the four HBIs in the state, to provide high quality and unique educational experiences to students. No HBIs in the state offers any biomedical engineering or bioengineering program. In fact, only two HBCUs in the nation offers biomedical engineering and bioengineering programs, that is University of the District of Columbia (UDC)'s biomedical engineering program (since 2019) and the North Carolina Agricultural and Technical State University (NCA&T)'s bioengineering program (since 2013). The proposed BME program at UMES will advance the increase of minorities BME degree grantees in the fields of heath care, biomedical research and engineering. It will also strengthen and expand the research capacity of UMES to provide high quality and unique educational programs to a high level.

2. Provide evidence that the perceived need is consistent with the Maryland State Plan for Postsecondary Education**.**

The proposed BME degree program is well aligned with the 2017-2021 Maryland State Plan for Postsecondary Education in all three areas: Access, Success, and Innovation.

Access – Ensure equitable access to affordable and quality postsecondary education for all Maryland residents.

The BME degree program is intended to prepare highly trained scientists and engineers at the undergraduate level in biomaterials, tissue engineering, cardiovascular engineering, biomedical imaging, bioinformatics, bioinstrumentation, machine learning in biomedical engineering, which are becoming increasingly important and relevant to our society, and public health. However, the field of health care and biomedical technology is a specialized field with many barriers for students to access. The proposed BME degree program will provide equitable access and quality education to all Maryland residents, including those with disadvantaged background, in order to develop a strong biomedical engineering workforce for the state.

Success – Promote and implement practices and policies that will ensure student success.

The practices and policies concerning the proposed BME degree program align with the all existing policies at the University, which will ensure student success. By providing a carefully developed curriculum, sufficient engineering laboratory facilities, equipment, and adequate faculty members for advising and teaching, the proposed degree program will help ensure student graduation and successful job placement.

Innovation – Foster innovation in all aspects of Maryland higher education to improve access and student success

Specifically, the proposed BME degree program aligns with the goal of "Innovation" of the State Plan, which aims to "foster innovation in all aspects of Maryland higher education to improve access and student success". The proposed program will help achieve the goal of "Economic Growth and Vitality", which is centered on supporting a knowledge-based economy through increased education and training, and is to ensure that Historically Black Institutions are "competitive, both in terms of program and infrastructure", with Maryland's other state institutions. Ultimately, the proposed degree program will prepare highly qualified scientists and engineers to contribute to the economic growth and vitality of Maryland by providing them new knowledge and skillsets in emerging technologies so they can maintain the skills they need to succeed in the workforce.

C. Quantifiable and Reliable Evidence and Documentation of Market Supply and Demand in the Region and State

1. Describe potential industry or industries, employment opportunities, and expected level of entry (*ex: mid-level management*) for graduates of the proposed program.

Biomedical engineering is a fascinating discipline, blending traditional engineering with issues of health care. As outlined by an article from the American Society of Mechanical Engineers, biomedical engineers work to help improve the lives of patients living with various conditions in a variety of ways, including through the design of new digital tools, software platforms, instruments and other devices. In essence, the practice of biomedical engineering refers to the design and creation of technologies that aid the health care process

in some way. For example, commonplace medical devices that can be credited to the bioengineering field include MRI machines and dialysis machines. Innovation in this area of engineering will no doubt continue in accordance with the development of technology - improving health care and patient outcomes in the process. The proposed BME program will produce graduates in all these technical fields, expected as entry level engineers or engineering managers.

2. Present data and analysis projecting market demand and the availability of openings in a job market to be served by the new program.

The Bureau of Labor Statistics (BLS) indicates that the number of jobs in bioengineering and biomedical engineering in 2020 is 19,300. In terms of the job outlook, it is expected to grow at the rate of 6% annual in the next ten years (2020-2030). The median pay for biomedical engineer is $92,620 per year. Data by BLS (https://www.bls.gov/ooh/architecture-and-engineering/biomedical-engineers.htm) shows that about 1,400 openings for bioengineers and biomedical engineers are projected each year, on average, over the decade. Many of those openings are expected to result from the need to replace workers who transfer to different occupations or exit the labor force, such as to retire.

Industry analysis also shows that biomedical engineers will likely see greater demand for their services because of the broadness of both their profession and their training. A recent study on the job market for biomedical engineers in the US (https://www.careerexplorer.com/careers/biomedical-engineer/job-market/) shows that Maryland currently employs 710 biomedical engineers in the industry, ranked No. 8 among 50 states in the nation. This shows that Maryland has the potential to further increases the number of employment opportunities in biomedical engineering field.

Moreover, according to Occupational Information Network, i.e., O-Net Online, (https://www.onetonline.org/link/summary/17-2031.00), job titles suitable for graduates of the BME program vary, such as Biomedical Electronics Technician, Biomedical Engineer, Biomedical Engineering Technician, Biomedical Equipment Technician (BMET), Biomedical Technician, Engineer, Process Engineer, Research Engineer, Research Scientist. Among those position titles, industries with the highest levels of employment in Bioengineers and Biomedical Engineers are listed in the table below:
(https://www.bls.gov/oes/current/oes172031.htm)

Industry	Employment	Annual Mean Wage
Medical Equipment and Supplies Manufacturing	3090	$97,800
Scientific Research and Development Services	3090	$104,00
Pharmaceutical and Medicine Manufacturing	2560	$98,610
Navigational, Measuring, Electromedical, and Control Instruments Manufacturing	1570	$109,220
General Medical and Surgical Hospitals	1570	$81,910

3. Discuss and provide evidence of market surveys that clearly provide quantifiable and reliable data on the educational and training needs and the anticipated number of vacancies expected over the next 5 years.

The employment data from the Bureau of Labor Statistics (BLS) is typically used to determine market demand. Data by BLS (https://www.bls.gov/ooh/architecture-and-engineering/biomedical-engineers.htm) shows that about 1,400 openings for bioengineers and biomedical engineers are projected each year, on average, over the decade. These openings are to be filled by those with educational and training background in the field of biomedical engineering.

The career outlook for biomedical engineers is strong. Industry data shows (www.recruiter.com) demand for Bioengineers and Biomedical Engineers is expected to go up, with an expected 3,550 new jobs filled by 2029. This represents an annual increase of 2.11 percent over the next seven years (2022-2029).

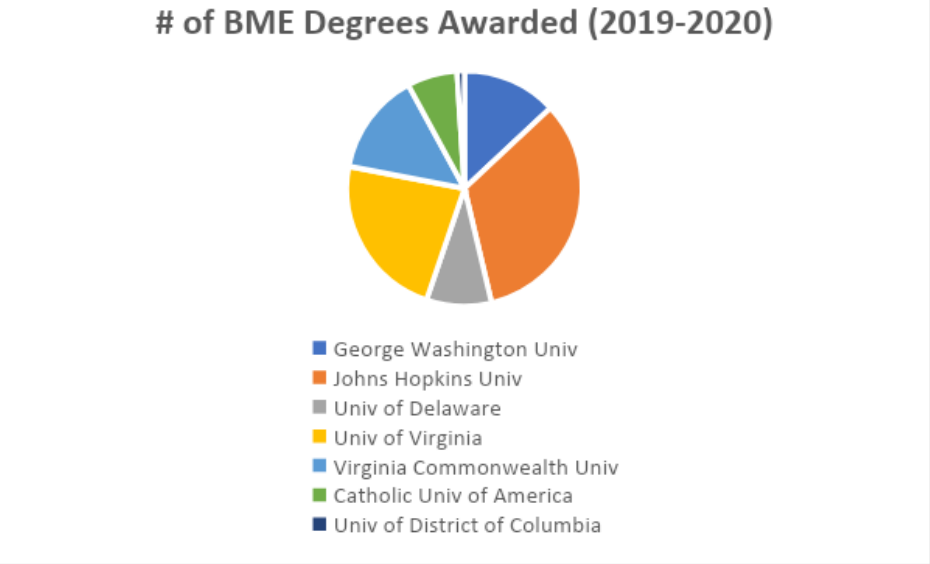
4. Provide data showing the current and projected supply of prospective graduates.

According to the ABET database of accredited programs (https://amspub.abet.org/aps/name-search?searchType=program&keyword=biomedical%20engineering), similar biomedical engineering BS programs in the DC/MD/VA/DE regions include: George Washington University, The Catholic University of America, The Johns Hopkins University, University of Delaware, University of District of Columbia (UDC), Virginia Commonwealth University, University of Virginia. Similar bioengineering BS programs include George Mason University and University of Maryland College Park. Among HBCUs in the four states, only UDC offers a BS biomedical engineering program. In fact, UDC became the first of its kind among HBCUs nationwide to receive accreditation by ABET in 2019. Based upon the data provided by www.collegefactural.com, the number of BME BS degree awarded by the seven BME programs in the DC/MD/VA/DE region is summarized below:

Institutions	**# of BME BS Degree Awarded in 2019 – 2020**
George Washington University	51
Johns Hopkins University	130
University of Delaware	35
University of Virginia	89
Catholic University of America	27
Virginia Commonwealth Univ	55
University of District of Columbia	4
Total	**391**

It is clear that UDC has the lowest number of BME BS degrees awarded, which amounts to 1% of the 391 degrees awarded in 2019-2020. This implies that the number of awarded BS

degrees in biomedical engineering from a HBCU that is comparable to UMES in the surrounding states is very low. UMES is in a good position to address the shortage of HBCU graduates of a BME program.



It is our belief that the market demand is sufficiently high, the geographic draw of students is sufficiently distinct, the proposed BME program to be offered in the Eastern Shore of the state, along with other similar programs in the state (e.g., JHU's BME and UMD's Bioengineering) will provide valuable contributions to the Maryland workforce.

D. Reasonableness of Program Duplication

1. Identify similar programs in the State and/or same geographical area. Discuss similarities and differences between the proposed program and others in the same degree to be awarded.

The proposed program is unique and building upon the existing faculty expertise in the general engineering program at UMES. There is no other biomedical engineering degree program in the Eastern Shore of Maryland. Although other institutions in Maryland, such as University of Maryland College Park offers bioengineering degree and the Johns Hopkins University offers a BME degree program, these institutions are located about 140 miles away from the Eastern Shore. UMES serves a different geographical area compared with other parts or regions of the state. Moreover, the proposed program offers unique curriculum with a focus in biomaterials, bioinstrumentation, tissue engineering, cardiovascular engineering, biomechanics of rehabilitation in which technical talents and workforce is lacking, especially in the rural eastern shore of the state. The proposed UMES program does not duplicate similar programs offered by other Maryland institutions.

2. Provide justification for the proposed program

Healthcare workforce shortages impact healthcare access in rural communities. One measure of healthcare access is having a regular source of care, which is dependent on having an

adequate healthcare workforce. A shortage of healthcare professionals in rural areas of the U.S. can restrict access to healthcare by limiting the supply of available services. Equally importantly, equipment malfunctions are a major challenge for rural, resource-poor healthcare centers, limiting the ability of medical staff to diagnose and treat patients.

The BME program we propose will enables biomedical engineering students to obtain both practical experience with medical devices and de novo design training to develop improved devices that are safe and reliable. As we can imagine, BME graduates will diagnose and repair medical equipment at local healthcare facilities, thus helping to address the barriers of healthcare access in the rural area, such as the Eastern Shore of Maryland.

E. Relevance to High-demand Programs at Historically Black Institutions (HBIs)

1. **Discuss the program's potential impact on the implementation or maintenance of high-demand programs at HBI's.**

Engineering program with various sub-disciplinary has always been in high demands on the employment spectrum. Among of the four HBIs in the state of Maryland, no biomedical engineering or bioengineering program is offered. Only a handful of HBCUs in the nation offers biomedical engineering BS degree programs or bioengineering BS degree programs. The proposed BME program at UMES, if established, will position UMES as a center for medical technology education and research in the rural area of Eastern Shore. The program will enable UMES to produce a pipeline of high caliber workforce in biomedical engineering to support health care facilities and other industry fields in health care and human factors.

F. Relevance to the identity of Historically Black Institutions (HBIs)

1. **Discuss the program's potential impact on the uniqueness and institutional identities and missions of HBIs.**

UMES has established a series of strong programs in pharmacy and health professions, such as Kinesiology, Pharmacy, Physical Therapy, Physician Assistant and Rehabilitation Services. The proposed BME program at UMES, if established, will strengthen the position of UMES as a center for medical technology education and research in the rural area of Eastern Shore. The program will enable UMES to produce a pipeline of high caliber workforce in biomedical engineering to support health care facilities and other industry fields in health care and human factors.

G. Adequacy of Curriculum Design, Program Modality, and Related Learning Outcomes (as outlined in COMAR 13B.02.03.10):

1. **Describe how the proposed program was established, and also describe the faculty who will oversee the program.**

Curriculum Design: The proposed program was established through a rigorous review of unmet needs by the institution. It started from the faculty in the engineering program, with approval from the Departmental Curriculum Committee, School Curriculum Committee, Graduate Faculty Council, Senate Curriculum Committee, etc. The curriculum was developed by the faculty in the

Department of Engineering and Aviation Sciences, with consultation with School of Pharmacy and Health Professions, and School of Agriculture and Natural Sciences.

Faculty Oversight: The courses of the curriculum in the proposed BME bachelor of science degree program will be taught by faculty in the Department of Engineering and Aviation Sciences, with 4 new full-time tenure-track faculty members with Ph.D. degrees in the biomedical engineering fields to be hired. The four new faculty will develop courses and labs and deliver teaching and research in the biomedical engineering field. In addition, the existing faculty in the department will also help with the BME program because 10 courses in the core and elective of the BME curriculum are the same as the courses in the existing Engineering Program curriculum. This arrangement ensures the new BME program is fully supported in terms of faculty resources. Please the detailed list of faculty background in the current engineering program below.

Program Modality: The program will be offered at the main campus of UMES.

2. Describe educational objectives and learning outcomes appropriate to the rigor, breadth, and (modality) of the program.

The educational objectives of the curriculum of the proposed BME program are to enable graduates of the program to develop ability of

- Applying principles of engineering, biology, human physiology, chemistry, calculus-based physics, mathematics (through differential equations), and statistics;
- Solving bio/biomedical engineering problems, including those associated with the interaction between living and non-living systems;
- Analyzing, modeling, designing and realizing bio/biomedical engineering devices, systems, components, or processes; and
- Making measurements on and interpreting data from living systems

The learning outcomes of the program align with the learning outcomes of the ABET (1)-(7) specified by the Engineering Accreditation Commission (EAC).

- [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 economics 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 goads, 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.

Students will learn analytical and experimental methods that are broadly applicable in the field of biomedical engineering. They will also be given specific instruction and hands-on laboratory experimental leaning experiences on how to apply these methods to a large range of problems in biomedical engineering.

3. Explain how the institution will:

a. provide for assessment of student achievement of learning outcomes in the program

Assessment Methods based on established departmental standards will include the following:

- Assessing written and oral student presentations, written assignments and research projects.
- Evaluating student performance in exams, quizzes and assignments in required major courses.
- Assessing comprehensive senior design project report in the two tracks of the program.

b. document student achievement of learning outcomes in the program

The department will document student achievement of the learning outcomes in the program in the same fashion as its current accredited engineering undergraduate program periodically. Assessment of learning outcomes will be conducted every six years per ABET accreditation requirements.

4. Provide a list of courses with title, semester credit hours and course descriptions, along with a description of program requirements

The Biomedical Engineering program consists of **125** total credit hours. The curricula include 28 credit hours of general education courses in English, arts and humanities, social and behavioral sciences, and emerging issues. An additional 12 credits in mathematics and physical sciences are required under the General Education program, which are included as a part of the requirements for the Engineering major. This makes the total credits for General Education to be 40 credit hours. The Biomedical Engineering curriculum also requires 27 credits of supportive math, physics and biology courses. Students take 43 credit hours of core biomedical engineering courses. Students choose 15 credit hours of elective courses from the two elective tracks of 1) biomechanics and tissue engineering, or 2) bioelectrics and biocomputational engineering. The program is on semester base. The total number of credits and their distribution is given as follows:

Category	***Distribution***
I. General Education Courses	40 credit hours
II. Supportive Math & Science Courses	27 credit hours
III. Engineering Core Courses	43 credit hours
IV. Elective Courses	15 credit hours

Biomedical Engineering Core Requirement		**43 credits needed**
Course Code	**Course Title**	**Credit Hours**
BMEN 150	Freshmen Biomedical Engineering Design	3 hrs
ENGE 260	Statics	3 hrs
BMEN 265	Biomaterials	3 hrs
ENGE 320	Statistics and Probability for Engineers	3 hrs
BMEN 242	Fluid Mechanics for Biosystems	3 hrs
BMEN 245	Bio-theromodynamics	3 hrs
BMEN 346	Transport Phenomena for Bio-systems	3 hrs
BMEN 362	Biomechanics	3 hrs
BMEN 364	Human Physiology for Engineers	3 hrs
BMEN 365	Cell Biology for Engineers	3 hrs
ENGE 370	Computational Methods in Engineering	3 hrs
BMEN 380	Bioinstrumentation	3 hrs
BMEN 383	Bioinstrumentation Lab	1 hrs
BMEN 384	Biomedical Engineering Lab	1 hrs
BMEN 475	Biomedical engineering Seminar	1 hrs
BMEN 476	Senior Design Project I	2 hrs
BMEN 477	Senior Design Project II	2 hrs

Biomechanics and Tissue Engineering Elective Track		**15 credits needed**
Course Code	**Course Title**	**Credit Hours**
BMEN 450	Bio-Solid Mechanics	3 hrs
BMEN 386	Design and Modeling in Bio-Solid Mechanics	3 hrs

BMEN 448	Cardiovascular Engineering	3 hrs
BMEN 388	Tissue Engineering	3 hrs
BMEN 390	Bio-reaction Engineering	3 hrs
BMEN 410	Nanotechnology	3 hrs
BMEN 415	Cellular Biotechnology	3 hrs
ENGE 261	Dynamics	3 hrs
ENGE 382	Control System	3 hrs
BMEN 448	Biomechanics of Human Movement	3 hrs
BMEN 449	Biomechanics of Rehabilitation	3 hrs
ENME 442	Micro-Electro-Mechanical Systems	1 hrs
BMEN 472	Selected Topics in Biomedical Engineering	1 hrs

Bioelectric and Bio-computational Engineering Elective Track		**15 credits needed**
Course Code	**Course Title**	**Credit Hours**
ENGE 240	Basic Circuit Theory	3 hrs
BMEN 340	Bioelectronics	3 hrs
BMEN 349	Neural Engineering	3 hrs
ENEE 330	Signals and Systems	3 hrs
ENEE 460	Digital Signal Processing	3 hrs
BMEN 445	Biomedical Imaging	3 hrs
BMEN 446	Bioimage Processing	3 hrs
BMEN 422	Machine Learning in Biomedical Engineering	3 hrs
BMEN 452	Artificial Intelligence in Biomedical Engineering	3 hrs
BMEN 450	Electrical Biophysics	3 hrs
BMEN 461	Bioinformatics	3 hrs

ENGE 382	Control Systems	3 hrs
ENME 442	Micro-Electro-Mechanical Systems	3 hrs
BMEN 472	Selected Topics in Biomedical Engineering	3 hrs

Supportive Science & Math Requirement		**27 credits needed**
Course Code	**Course Title**	**Credit Hours**
MATH 211	Calculus II	4 hrs
MATH 212	Calculus III	4 hrs
MATH 241	Differential Equation for Engineers	3 hrs
PHYS 262	General Physics II	3 hrs
PHYS 263	Genera Physics II Lab	1 hrs
CHEM 112	Principles of Chemistry II	3 hrs
CHEM 114	Principles of Chemistry II Lab	1 hrs
BIOL 111	Principal of Biology I	3 hrs
BIOL 113	Principal of Biology I Lab	1 hrs
BIOL 222	Genetics	3 hrs
BIOL 223	Genetics Lab	1 hrs

Note: the following nine (9) courses are cross-listed in the existing engineering program curriculum: ENGE 260, ENGE 320, ENGE 370, ENGE 261, ENGE 382, ENGE 240, ENEE 330, ENEE 460, ENME 442. This arrangement enables the existing engineering faculty to contribute to course offering to the proposed BME program.

BIOMEDICAL ENGINEERING CORE AND ELECTIVE COURSE DESCRIPTIONS

BMEN 150 Freshman Biomedical Engineering Design: 3 credits. An introduction to modern biomedical engineering design with emphasis on various aspects of developing a biomedical product via hands-on design approach, communication skills, and teamwork; use of product visualization and computer software such as word processing, power point, and spreadsheet; students work as teams to develop and design a working prototype.

BMEN 265 Biomaterials: 3 credits. Introduction to bioengineering material such as metals, ceramics, polymers, carbons, and composites as well as their applications in biomedical devices

and implants. The biomedical applications of the biomaterials in several areas including tissue engineering, drug delivery, orthopedic implants, ophthalmologic devices, and cardiovascular devices.

BMEN 242 Fluid Mechanics of Bio-systems: 3 credits. Introduction to fundamentals of fluid mechanics as applied to biomedical systems. Topics include fluid properties, fluid statics, conservation of mass, momentum and energy as it applies to biomedical systems. Integral and differential analysis of biological flows applicable in human physiology and biotechnology.

BMEN 245 Bio-Thermodynamics: 3 credits. Principles of thermodynamics as applied to biomedical systems. First law and second law of thermodynamics, statistical thermodynamics, and reaction kinetics as relate to biological systems, and biomedical technologies.

BMEN 346 Transport Phenomena for Bio-systems: 3 credits. Fundamentals of chemical and mass transport as it relates to biomedical systems. Conservation of momentum, mass and energy as applied to cellular and organ level transport. Understanding transport phenomena applicable to design and development of modern biomedical devices and bio-artificial organs.

BMEN 362 Biomechanics: 3 credits. Fundamental of engineering mechanics such as dynamics and deformable body mechanics as applied to biological tissues and systems. Topics include linear and angular kinematics as well as kinetics as they apply to biomechanical systems; Apply methods of statics to biomechanical systems for deformation analysis; Principle of mechanics of materials including stress, strain, material properties, materials models of biological tissues, multi-axial deformation, torsion, bending and Mohr's circle.

BMEN 364 Human Physiology for Engineers: 3 credits. This course has two distinct components. The first component is to introduce the major organ systems of the body with an emphasis on regulatory processes and interactions with other systems. The second component is to implement physical and mathematical models along with engineering approaches to analyze different physiological systems quantitatively. Systems examined in these two components include cellular, musculoskeletal, cardiovascular, respiratory, endocrine, gastrointestinal, and renal.

BMEN 365 Cell Biology for Engineers: 3 credits. The course has two distinct components. The first component provides general contents of cell biology including cell structure and functioning. The second component implements physical and engineering models to provide quantitative and/or semiquantitative analyses to address several problems in cell biology.

BMEN 380 Bio-instrumentation: 3 credits. Introduction to sensing, measurement, instrumentation and data acquisition as applied to biological and biomedical systems. Topics include bioelectric signals, biomedical electronics, biomedical electrodes and sensors, instrumentation in diagnostic cardiology, extracorporeal devices, instrumentation in blood circulation, and new technologies and advances in medical instrumentation.

BMEN 383 Bio-instrumentation Lab: 1 credit. The lab aims to demonstrate the principles covered in Bio-instrumentation course. Experiments cover bio-signal recording (finger pulse, ECG, EEG, and EMG), muscle stimulation and fatigue, Wheatstone bridge circuit, and Op-Amp and filter circuits; Data collection, data analysis and written lab reports are expected.

BMEN 384 Biomedical Engineering Lab: 1 credit. The lab aims to expose students to formulating and solving problems in biomedical systems using experimental design, experimentations and subsequent data collection and data analysis. In particular, the experiments cover biomaterials, biomechanics, bio-thermal and bio-fluid mechanics topics. Written lab reports are expected.

BMEN 450 Bio-Solid Mechanics: 3 credits. Fundamentals of continuum mechanics and constitutive modeling relevant for biological tissues. Constitutive models including linear elasticity, nonlinear elasticity, viscoelasticity and poroelasticity. Structure-function relationships, which link tissue morphology and physiology to tissue constitutive models, are covered for skeletal, cardiovascular, pulmonary, abdominal, skin, eye and nervous tissues.

BMEN 386 Design and Modeling in Bio-Solid Mechanics: 3 credits. Introduce concepts, tools and methodologies to model, design and analyze a biomedical system or product. Fundamental of solid modeling and computer aided design (CAD), as well as computer aided engineering (CAE) including applied finite element analysis (FEA) are covered for the purpose of modeling, designing, analyzing, and examining the performance of a biomedical system or product.

BMEN 447 Cardiovascular Engineering: 3 credits. Introduction to modeling and measurement methods for the cardiovascular system, analysis of blood flow dynamics, function of the heart, and noninvasive approaches. Applications to cardiovascular instrumentation, basic cardiovascular system research, assistive and repair devices, and disease processes.

BMEN 388 Tissue Engineering: 3 credits. The course applies the principles of biomedical engineering to design and fabricate a wide range of functional tissues and organs. The topics include tissue components, biomaterials for tissue engineering, cell-matrix interactions, regenerative processes, engineering of specific tissues, and recent advances in tissue engineering.

BMEN 390 Bio-reaction Engineering: 3 credits. The course introduces engineering aspects of biological reactions as applied to biomedical systems. Topics to be covered includes enzyme kinetics, enzyme inhibition, biochemical pathway engineering, mass and energy balance, cell growth and differentiation, cell engineering, bioreactor design, and analysis of the human body, organs, tissues, and cells as bioreactors. The application of bioreaction/bioreactor principles to tissue engineering is also covered.

BMEN 410 Nanotechnology: 3 credits. The course covers emerging topics in nanotechnology relating to biomedical systems. Topics includes scaling laws, nanodevices, nanotools, nanoparticles, nanoscale phenomena applicable to biomedical systems. Computational models and tools as they apply to nano-biosystems are covered.

BMEN 415 Cellular Biotechnology: 3 credits. This course covers the engineering principles behind rapidly growing field of biotechnology. The emerging topics such as protein engineering, synthetic biology, nanomedicine, biosimilars, microtechnologies, organ-on-chip platforms, drug delivery, immunotherapies, gene editing, stemcells, tissue engineering, regenerative medicine, personalized medicine may be covered.

BMEN 448 Biomechanics of Human Movement: 3 credits. The course introduces musculoskeletal biomechanics and the quantitative analysis of human movement. Topics covered include rigid-body kinematics, dynamics, motion capture, external force measurement,

electromyography, and mechanical properties of muscles and tendons; muscles are presented as mechanical actuators that produce movements; experimental and computational methods are implemented to evaluate the functions of muscles, bones, and joints together as a mechanical system.

BMEN 449 Biomechanics of Rehabilitation: 3 credits. This course covers biomechanical topics related to design and application of rehabilitation engineering and assistive technologies in a wide range of areas including wheeled mobility, seating and positioning, environmental control, computer access, augmentative communication, sensory aids, as well as emerging technologies.

BMEN 472 Selected Topics in Biomedical Engineering: 3 credits. Selected topics on special or current topics and issues relating to biomedical engineering structured for students in biomedical engineering and other areas.

BMEN 340 Bio-Electronics: 3 credits. The course covers fundamental concepts of electronics, assembly of electronic components into functional circuits, and integration of functional electronic devices and circuits into a biomedical system. Development and design of sensors, stimulators, and their medical devices for bio-integrated electronics. Materials design and fabrication of passive and active components for sensitive, multimodal, and robust wearable and implantable devices.

BMEN 349 Neural Engineering: 3 credits. The course introduces principles and techniques for understanding and interacting with the nervous system. Topics include quantitative models of neurons, recording and stimulation models, as well as machine learning techniques to extract information from large neural datasets.

BMEN 445 Biomedical Imaging: 3 credits. The course covers biomedical imaging system with an emphasis on fundamental principles and applications of each modern imaging modality including X-ray radiography, computed tomography (CT), nuclear medicine (SPECT and PET), magnetic resonance imaging (MRI), and ultrasound.

BMEN 446 Bio-image Processing: 3 credits. The course covers principles of signal and image processing including machine learning techniques as applicable to biomedical systems. The course covers how biomedical signals and images are analyzed and converted into helpful information for detection and diagnostic purposes.

BMEN 422 Machine Learning in Biomedical Engineering: 3 credits. This course introduces fundamental concepts, methods and applications of machine learning as applied to biomedical problems. Topics to be covered include parametric and non-parametric learning algorithms, support vector machines, neural networks, clustering, clustering and principal components analysis applicable to biomedical systems.

BMEN 452 Artificial Intelligence in Biomedical Engineering: 3 credits. The course covers Artificial Intelligence (AI) tools to problems in Biomedical Engineering. AI algorithms can learn patterns from biomedical data sets to provide actionable insights on disease diagnosis or treatment. This course will provide an overview of a wide range of AI and machine-learning tools (e.g. clustering, regression, decision trees, random forests and neural networks), biomedical data sets (imaging, omics, health records) and diseases (cancer, cardiovascular-, infectious- and brain diseases)

BMEN 450 Electrical Biophysics: 3 credits. Electrical biophysics of nerve and muscle; electrical conduction in excitable tissue; quantitative models for nerve and muscle including the Hodgkin Huxley equations; biopotential mapping, cardiac electrophysiology and functional electrical stimulation

BMEN 461 Bioinformatics: 3 credits. This course introduces theoretical background and a working knowledge of the techniques employed in bioinformatics. Emphasis is placed on biological sequence (DNA, RNA, protein) analysis and its applications.

5. Discuss how general education requirements will be met, if applicable.

Students in the biomedical engineering majors will take a total of 40 credits of General Education courses. This includes 28 credit hours of general education courses in English, arts and humanities, social and behavioral sciences, and emerging issues. An additional 12 credits in mathematics and physical sciences are required under the General Education program, which are included as a part of the requirements for the Engineering major. The total number of GenEd credits (40) and the composition of the GenEd courses are the same as the requirement for the current Engineering majors at UMES.

6. Identify any specialized accreditation or graduate certification requirements for this program and its students.

The accreditation body of the biomedical engineering program is Engineering Accreditation Commission of ABET. Since the current general engineering program is ABET accredited, we will leverage the faculty expertise and resources to pursue ABET accreditation for the proposed BME program.

7. If contracting with another institution or non-collegiate organization, provide a copy of the written contract.

No other institution or non-collegiate organization is required to offer this degree program.

8. Provide assurance and any appropriate evidence that the proposed program will provide students with clear, complete, and timely information on the curriculum, course and degree requirements, nature of faculty/student interaction, assumptions about technology competence and skills, technical equipment requirements, learning management system, availability of academic support services and financial aid resources, and costs and payment policies.

The entire curriculum and course specific information of the proposed degree program will be posted on the Department of Engineering and Aviation Science website:www.umes.edu/engavi. Information pertaining to the availability of academic/student support services, financial aid resources and tuition payment policies can be found on the webpages of the UMES Office of Admissions and the Office of Financial Aid.

9. Provide assurance and any appropriate evidence that advertising, recruiting, and admissions materials will clearly and accurately represent the proposed program and the services available.

The program will be advertised alongside other academic graduate programs within the School of Business and Technology of UMES. Proper venues include Public Radio WESM 91.3, and social media such as UMES Facebook page, the University Key, as well as UMES alumni association, and other professional societies. The Department has a tradition of strong outreach program. For example, the Department has hosted in the past three years the "National Engineer's Week" (in the month of February each year) celebration for high schools from the local counties, such as Wicomico County, Somerset County, etc. Faculty with different disciplines in engineering developed hands-on activities to enable high schools for have first hand exposure to different engineering disciplines. We will continue this engagement as an effort of advertising, recruiting and promoting engineering education.

H. **Adequacy of Articulation**

1. If applicable, discuss how the program supports articulation with programs at partner institutions. Provide all relevant articulation agreements.

This is a new program to be established at UMES home campus. UMES has existing articulation agreements with community colleges in the state, such as Wor-Wic Community College, and high schools. We will leverage the existing partnerships to develop, when appropriate, new articulation agreements with high schools in the local counties and community colleges for the proposed BME program.

I. **Adequacy of Faculty Resources** (as outlined in COMAR 13B.02.03.11).

1. Provide a brief narrative demonstrating the quality of program faculty. Include a summary list of **faculty with appointment type, terminal degree title and field, academic title/rank, status (full-time, part-time, adjunct) and the course(s) each faulty member will teach in the proposed program.**

Four (4) new faculty lines have been allocated to support the proposed BME degree program by the HBCU settlement fund. Furthermore, the existing faculty in the engineering program will also be able to provide needed expertise to support partially the teaching of courses when necessary. In addition, there are seven (7) full-time engineering faculty qualified to teach the ten (10) courses cross-listed in the proposed BME curriculum and the existing general engineering curriculum.

Existing seven (7) faculty are listed below:

Dr. Yuanwei Jin, Professor and Chair. He received Ph.D. degree in Electrical Engineering from the University of California at Davis. He was with Carnegie Mellon University before joining UMES. His research interests are in the general area of signal processing and sensor array processing, with applications in medical imaging, communications, radar/sonar, and networks.

Dr. Ibibia K. Dabipi, **Professor**. He received his Ph.D. and M.S. in Electrical Engineering from Louisiana State University. His experiences include working at Bell Communications

Research and AT&T Bell Labs as a member of technical staff with primary research focus in communications and networks.

Dr. Payam Matin, **Professor**. He received his Ph.D. in Mechanical Engineering from Oakland University, Rochester, Michigan. His research has been in the areas of computational mechanics and experimental mechanics with applications in solid mechanics, structural design, plasticity, and sheet metal forming, drone design, etc.

Abhijit Nagchaudhuri, **Professor**. He received Ph.D. degree in Mechanical Engineering from Duke University. His teaching and research area is in the fields of robotics and mechatronics, remote sensing and precision agriculture, and, biofuels and renewable energy.

Dr. Alvernon Walker, Associate Professor. He received his Ph.D. in Electrical Engineering from North Carolina State University. His primary research area is electronics, digital system design and mixed-signal system design.

Dr. Lei Zhang, Associate Professor. He received his Ph.D. in Electrical Engineering from the University of Nevada, Las Vegas. His primary research area is in computer networks, microprocessor and microcomputers, embedded system design, etc.

Dr. Lanju Mei, **Assistant Professor**. She received her Ph.D. degree in Aerospace and Mechanical Engineering from Old Dominion University. Her primary research interests include MEMS sensor, additive manufacturing, computational fluid dynamics.

2. Demonstrate how the institution will provide ongoing pedagogy training for faculty in evidenced-based best practices, including training in:

a) Pedagogy that meets the needs of the students

b) The learning management system

(a) and (b): Faculty support for the development and instruction of courses is provided by the Faculty Development Center of UMES. The department also supports faculty professional development for attending conferences such as ASEE (American Society of Engineering Education) for pedagogy training in engineering education, as well as ABET Symposium for continuous improvement.

d. Evidenced-based best practices for distance education, if distance education is offered.

Not applicable.

J. **Adequacy of Library Resources** (as outlined in COMAR 13B.02.03.12)**.**

1. Describe the library resources available and/or the measures to be taken to ensure resources are adequate to support the proposed program.

The University assures that institutional library resources meet the new program needs. For the proposed degree program, typically library resources include textbooks, reference books and technical papers. Although UMES does not have the IEEE Digital Library IEEE Explore, the technical papers could be accessed through the Inter-Library Loan (ILL) services.

K. Adequacy of Physical Facilities, Infrastructure and Instructional Equipment (as outlined **in COMAR 13B.02.03.13)**

1. **Provide an assurance that physical facilities, infrastructure and instruction equipment are adequate to initiate the program, particularly as related to spaces for classrooms, staff and faculty offices, and laboratories for studies in the technologies and sciences.**

The UMES department of Engineering and Aviation Sciences is housed in the Engineering and Aviation Science Complex, a 166,000 square feet facility that houses more than 20 engineering laboratories. They include Robotics Lab, Fluid/Thermal lab, Materials lab, Aerospace lab, Electronics Lab, Circuits Lab, Micro-Electro-Mechanical Systems (MEMS) Lab with a Clean Room (ISO Class 5, 6 and 7), Control System Lab, and Embedded System Lab, Communications Lab, Microwave Chamber, CAD/VLSI Lab, High Bay Area, and Multiple Computer Labs, etc. These labs can support majority of the activities in the new courses and research activities. A complete list of engineering labs with brief descriptions is shown by the link:

https://www.umes.edu/Engineering/DynContent/Laboratories/

All engineering faculty and staff have individual offices that will facilitate student advising, office hours, etc. Sufficient classrooms are available also in the same building, which make it very convenient for students to take classes and conduct laboratory experiments. To support the proposed BME program, two new engineering teaching labs on UMES campus are to be developed, including acquiring educational packet, data acquisition systems for data measurement on cells and living systems, and data analysis software. The two labs are (1) Bioinstrumentation Lab, and (2) Biomedical Engineering Lab. Both labs are BSL (biosafety level) Level 1 labs. They follow basic safety procedures, called Standard Microbiological Practices and require no special equipment or design features. BSL-1 are common to biomedical engineering programs in the country. A good example of a typical biomedical engineering teaching lab is shown in the picture (for example, BME Teaching Lab at U. Vermont).

To develop the two teaching labs for the BME program, there are two options. The first option is retrofit the existing lab space, for example, Room 2051 in the Engineering and Aviation Complex to become a Biomedical Engineering teaching lab. The second option is to share with other academic units BSL-1 level labs in other buildings on campus in the beginning of the program.

2. Provide assurance and any appropriate evidence that the institution will ensure students enrolled in and faculty teaching in distance education will have adequate access to:

a. An institutional electronic mailing system, and

b. A learning management system that provides the necessary technological support for distance education

(a) and (b): Faculty support for the development and instruction is provided by the Information Technology Department and also Academic Computing Unit professionals. Consultation is available for issues such as instructional design, software development, educational research, Blackboard learning management system, etc. These technologies and opportunities ensure students enrolled in and faculty teaching have adequate access to leaning resources.

L. **Adequacy of Financial Resources with Documentation** (as outlined in COMAR 13B.02.03.14)

1. Complete Table 1: Resources and Narrative Rationale. Provide finance data for the first five years of program implementation. Enter figures into each cell and provide a total for each year. Also provide a narrative rationale for each resource category. If resources have been or will be reallocated to support the proposed program, briefly discuss the sources of those funds.

TABLE 1: RESOURCES					
Resources Categories	(Year 1)	(Year 2)	(Year 3)	(Year 4)	(Year 5)
1. Reallocated Funds[1]	$0.00	$0.00	$0.00	$0.00	$0.00
2. Tuition/Fee Revenue[2] (c+g below)	$139,068.00	$275,400.00	$411,730.00	$548,064.00	$694,396.00
a. # FT Students	15	30	45	60	75
b. # Annual Tuition/Fee Rate	$8,724.00	$8,724.00	$8,724.00	$8,724.00	$8,724.00
c. Annual / Full Time Revenue (a x b)	$130,860.00	$261,720.00	$392,580.00	$523,440.00	$654,300.00
d. # PT Students	3	5	7	9	11
e. Credit Hour Rate	$228.00	$228.00	$228.00	$228.00	$228.00
f. Annual Credit Hours	12	12	12	12	12
g. Total Part Time Revenue (d x e x f)	$8,208.00	$13,680.00	$19,150.00	$24,624.00	$30,096.00

3. Grants, Contracts & Other External Sources[3]	$0.00	$0.00	$0.00	$0.00	$0.00
4. Other Sources	$0.00	$0.00	$0.00	$0.00	$0.00
TOTAL (Add 1 - 4)	$139,068.00	$275,400.00	$411,730.00	$548,064.00	$694,396.00

2. Complete Table 2: Program Expenditures and Narrative Rationale. Provide finance data for the first five years of program implementation. Enter figures into each cell and provide a total for each year. Also provide a narrative rationale for each expenditure category.

TABLE 2: EXPENDITURES					
Expenditure Categories	(Year 1)	(Year 2)	(Year 3)	(Year 4)	(Year 5)
1. Total Faculty Expenses (b + c below)	105,600	211,200	316,800	422,400	422,400
a. # FTE	1	2	3	4	4
b. Total Salary	80,000	160,000	240,000	320,000	320,000
c. Total Benefits	25,600	51,200	76,800	102,400	102,400
2. Total Administrative Staff Expenses (b + c) below	0	0	0	0	0
a. # FTE	0	0	0	0	0
b. Total Salary	0	0	0	0	0
c. Total Benefits	0	0	0	0	0
3. Total Support Staff Expenses (b + c below)	0	0	0	0	0
a. # FTE	0	0	0	0	0
b. Total Salary	0	0	0	0	0
c. Total Benefits	0	0	0	0	0

4. Equipment	50,000	0	0	0	0
5. Library	0	0	0	0	0
6. New or Renovated Space	0	0	0	0	0
7. Other Expenses	10,000	10,000	10,000	10,000	0
TOTAL (Add 1 - 7)	165,600	221,200	326,800	432,400	422,400

Narrative Rationale for Table 1: Resources

1. Reallocated Funds
   No funds will be reallocated from existing programs.

2. Tuition and Fee Revenue
   We assumed that tuition and fees will remain unchanged for the next five years. The annual in-state tuition rate is $8724 for full time students. For part-time students, the credit hour rate is $228/credit. The two values were used in calculating the revenue for full time students and 6 credits per semester (i.e., 12 credit per year) for part-time students.

3. Grants and Contracts
   No additional sources of funding are expected at this time.

4. Other Sources
   No additional sources of funding are expected at this time.

5. Total Year: 5 year estimate is provided.

Narrative Rationale for Table 2: Expenditures

1. Faculty (# FTE, Salary and Benefits)

   Four (4) new full-time tenure-track faculty members with terminal degree in biomedical engineering or a closely related field are required to support the proposed Bachelor of Science in Biomedical Engineering Program. Each year, one new faculty will be hired to deliver instruction and develop labs. This process will continue for four years to recruit four new faculty members. The rate of fringe benefits is 32% per year for full time faculty.

2. Support Staff (# FTE, Salary and Benefits)

There will be no need for additional administrative staff. The existing department and school administrative staff will be sufficient to run the program.

3. Equipment
   $50,000 is requested for acquiring educational packet, equipment, and supplies for developing two labs (1) Biomedical Engineering Lab and (2) Bioinstrumentation Lab for the purpose of enabling data measurement on living systems.
4. Library
   Minimal funds are needed to purchase additional engineering textbook.

5. New and/or Renovated Space
   Not needed

6. Other Expenses
   $10,000 Startup Package for each new hire at the rate of $10,000 per person. A total of $40,000 is requested. The startup package is to support new faculty, especially at the assistant professor level, for professional development, including developing proposals for grant and contracts, travel and supplies for specialized engineering labs.

M. Adequacy of Provisions for Evaluation of Program (as outlined in COMAR 13B.02.03.15).

1. **Discuss procedures for evaluating courses, faculty and student learning outcomes.**
2. **Explain how the institution will evaluate the proposed program's educational effectiveness, including assessments of student learning outcomes, student retention, student and faculty satisfaction, and cost-effectiveness.**

1 and 2:

UMES has a comprehensive course and program evaluation process. Each course syllabus has a set of written student learning outcomes. The course learning outcomes are assessed through embedded questions on tests, assignments and portfolio that address specific course outcomes. Data is collected and analyzed and results are used to improve course curriculum and pedagogy.

Once the program is launched, its courses will enter the course evaluation system. Teaching evaluations ask students to reflect on the course structure, the course content, and the instructor's performance. Summary data will be reviewed by faculty members, the program chair, and the school administration to determine whether revision or improvement actions are necessary.

In addition, every faculty is evaluated each year. The evaluation process includes an assessment of faculty teaching, faculty research record and productivity, school wide and department service. In order to receive high evaluation, a faculty member must demonstrate effective teaching, active scholarly activities and publication, etc. There is also a provision for

administration to set out an improvement plan for faculty members who have not done well in the area of teaching. Tenured faculty will undergo five-year post-tenure review.

Periodic academic program review takes place in a cycle of every five years. Data regarding program enrollment, retention and graduation rates are collected by the Institutional, Advancement, Marketing, and Research Division in conjunction with the program coordinator. The data are analyzed against program outcomes and results are used to improve the program.

Program accreditation comprehensive review takes place very six years per ABET criteria. The assessment, evaluation, and continuous improvement are integral part of faculty teaching and performance evaluation.

N. Consistency with the State's Minority Student Achievement Goals (as outlined in COMAR 13B.02.03.05).

1. **Discuss how the proposed program addresses minority student access & success, and the institution's cultural diversity goals and initiatives.**

UMES mission is compatible with the State of Maryland's minority achievement goals. UMES is an 1890 land grant HBCU. Our programs attract a diverse set of students with the majority of student population is African-American and those who are multiethnic and multicultural. The University actively recruits minority populations for all undergraduate and graduate level degrees. Special attention is also provided to recruit females into the STEM and multidisciplinary programs at all degree levels – undergraduate, Master's, and doctoral. The same attention will be given to the proposed B.S. degree program in biomedical engineering.

O. Relationship to Low Productivity Programs Identified by the Commission:

1. **If the proposed program is directly related to an identified low productivity program, discuss how the fiscal resources (including faculty, administration, library resources and general operating expenses) may be redistributed to this program.**

The proposed program has no relationship to low productivity programs.

P. Adequacy of Distance Education Programs (as outlined in COMAR 13B.02.03.22)

1. **Provide affirmation and any appropriate evidence that the institution is eligible to provide Distance Education.**
2. **Provide assurance and any appropriate evidence that the institution complies with the C-RAC guidelines, particularly as it relates to the proposed program.**

Not applicable. The proposed program is not a distance education program.