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 – Doctor of Philosophy in Applied Computing and Engineering

Dear Dr. Fielder:

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

Program: Ph.D. in Applied Computing and Engineering

The School of Business and Technology is proposing to offer a Ph.D. degree in Applied Computing and Engineering (ACE). The proposed program UMES would like to offer will play a crucial role in preparing professionals to work in various positions related to applied computing and engineering.

The proposed Ph.D. in Applied Computing and Engineering program aims to produce the next generation leaders in computing and engineering and offer prospective students a graduate program with strong foundations in a versatile and dynamic field that blends knowledge across multiple disciplines in applied computing and engineering. The curriculum of the program is devised to harness faculty expertise and experience in various technical fields in the School of Business and Technology at UMES. The program, if established, will facilitate and promote students to develop innovative technologies in emerging fields such as cybersecurity, data and computational science, software engineering, control systems, mechatronics, networking, and communication systems, for a wide range of applications including business, finance, agriculture, healthcare, automobile, aerospace, and clean energy systems, etc. that are critical to the economic development of the region and the state.

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. Payam Matin, Professor and Acting Chair, Department of Computer Science and Engineering 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	○ Substantial Change to a Degree Program
○ New Area of Concentration	○ Substantial Change to an Area of Concentration
○ New Degree Level Approval	○ Substantial Change to a Certificate Program
○ New Stand-Alone Certificate	○ Cooperative Degree Program
○ Off Campus Program	○ Offer Program at Regional Higher Education Center

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

Department Proposing Program	School of Business and Technology (CSET and EAVS)	
Degree Level and Degree Type	Ph.D. with En Passant M.S.	
Title of Proposed Program	Applied Computing and Engineering	
Total Number of Credits	60	
Suggested Codes	HEGIS: 90100.00	CIP: 140101.0000
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: Derrek B. Dunn, Ph.D.
	Title: Dean, School of Business and Technology
	Phone: (410) 651-6348
	Email: ddunn@umes.edu

President/Chief Executive	Type Name: Heidi M. Anderson
	Signature: Heidi M. Anderson Date: 10/15/2022
	Date of Approval/Endorsement by Governing Board:

Revised 1/2021

Proposal for New Graduate Degree Program

Doctor of Philosophy in Applied Computing and Engineering (PHACE) with En Passant M.S.

The Department of Computer Science and Engineering Technology, jointly with the Department of Engineering and Aviation Sciences, proposes to establish an Interdisciplinary program of Ph.D. in Applied Computing and Engineering (PHACE) within the School of Business and Technology (SBT) at UMES. The PHACE aims to offer prospective students a graduate program with strong foundations in theory and practice to meet the needs of technical professionals including but not limited to those in the Eastern Shore of Maryland with more advanced learning in a specialized discipline of cybersecurity, electrical, and mechatronics engineering and applied computer science. The program, if established, will help students develop new technologies in the emerging fields such as cybersecurity, data, and computational sciences, software engineering, robotics and automation, drone design, unmanned systems and control, mechatronics, computer networks, wireless communications, and Internet of Things (IoT) for a wide range of applications including business, finance, agriculture, health care, automobile, aerospace, and clean energy systems, etc. It will also prepare them, especially those with disadvantaged backgrounds, with the knowledge and tools necessary to take on computing and engineering leadership roles to shape the future of technology advancement.

The proposed PHACE program will have the following concentrations:

1. Concentration #1: Cybersecurity
2. Concentration #2: Data and Computational Science
3. Concentration #3: Software Engineering
4. Concentration #4: Mechatronics and Control
5. Concentration #5: Communications and Networks

These areas of concentration align with the expertise and research focus of existing faculty in both departments and emerging research areas in related fields. The PHACE requires a minimum of sixty (60) credit hours of graduate-level coursework.

Bachelor degree holders who are directly admitted into the proposed doctoral program will have the option to obtain a Master’s degree once he/she passes the qualifying exam and completes the coursework equivalent to the curriculum in the Master’s Degree under the following situations.

Prospective bachelor degree holders with direct admission into the proposed doctoral program who choose either the Communication and Networks concentration or the Mechatronics and Control concentration will receive a Master’s degree in Electrical and Mechatronics Engineering. Since the Department of Engineering and Aviation Sciences does not have a graduate program at the current time, a separate proposal will be submitted from the department to establish an M.S. in Electrical and Mechatronics Engineering.

Also, prospective bachelor degree holders with direct admission into the proposed doctoral program who choose the Software Engineering or Data and Computational Science Concentrations will have the option to obtain a Master’s in Applied Computer Science. Lastly, prospective bachelor holders who are admitted directly into the proposed doctoral program and choose the

Cybersecurity concentration will have the option to obtain a Master of Science in Cybersecurity Engineering Technology.

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 proposed Ph.D. in Applied Computing and Engineering program consists of five concentrations: (1) Cybersecurity, (2) Data and Computational Science, (3) Software Engineering, (4) Mechatronics and Control, and (5) Communications and Networks. The mission of the PHACE program is to provide a unique opportunity for graduate education to individuals who are motivated to advance to become higher-level experts in widely related areas of Applied Computing and Engineering. The program is targeted to those who have a BS degree in mathematics, sciences, engineering, and technology, or related areas as well as those who already have an MS degree in these or related areas. The potential graduates of this program will have advanced growth opportunities in government agencies, higher education, computational engineering in various industries, such as data science, software engineering, electrical and computing engineering, network related areas, and a variety of technical specializations. Their research work is intended to promote innovation and technology development in the emerging field of robotics, automation, drones, and autonomous systems, cybersecurity, as well as related computing fields that will drive the UMES research enterprise; and contribute to the economic development in the State of Maryland, especially in the Eastern Shore region where learning opportunities in applied computing and engineering disciplines is severely lacking.

   This proposed program is grounded in the Institution's mission as an 1890 HBCU land-grant institution whose stated purpose 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 the graduation rate of the underrepresented minorities in the fields of science and 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://www.umes.edu/uploadedFiles/_DEPARTMENTS/President/Content/Strategic%20Plan%202020_Full.pdf), in particular with the following two goals:

   - "Goal II: Become Eminent in Research, Innovation, and Economic Competitiveness" to foster and facilitate interdisciplinary collaboration for research on local, regional, and global challenges to include workforce needs, and

- "Goal V: Achieve and Maintain National Eminence and Global Impact" to enhance research activity and doctoral programs to retain and sustain Carnegie Doctoral University (DU- High Research Activity) Classification, and of building partnerships with other research universities to strengthen research and development enterprise.

The proposed degree program will substantially help the institution achieve its strategic goals listed above, and position UMES at the forefront of emerging research in critical areas such as cybersecurity, data, and computational sciences, software engineering, robotics and automation, drone design, unmanned systems, and control, mechatronics, computer networks, wireless communications, and Internet of Things (IoT) for a wide range of applications including business, finance, agriculture, health care, automobile, aerospace, and clean energy systems, etc. While there currently exists some collaborations across disciplines on campus, the proposed PHACE program is expected to enable stronger and multi-disciplinary research collaborations across the campus community, thus fueling research in many other different disciplines more than in the applied science and engineering disciplines and creating a 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 cleanroom, and Microwave Anechoic Chamber Lab, etc. The collaborating departments on this proposal are housed in this facility with adequate lab space for both programs. Additionally, the provision of funding for additional faculty lines and other resources required to implement this program will be derived from the $577 million settlement funds reached by the state and the HBCUs as a result of providing inequitable resources to its four historically black colleges and universities. UMES is expected to receive about 9 million dollars each year over the next ten years and funding for this initiative has already been assigned. By the beginning of the 2022 – 2023 academic year, it is expected that two faculty positions will be funded. This process will continue for the next five years.

4. **Describe the institution's commitment to:**

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

As indicated in the preceding section, the leadership of UMES is committed to adequately funding 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 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 leveraging, in part, the existing faculty and staff in the Departments of Computer Science and Engineering Technology and 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. The current computer science and engineering faculty (tenured and tenure-track) and dedicated support staff will collectively assist in the proposed Ph.D. degree program. The university is fully committed to continuing the proposed Ph.D. program for a sufficient period 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

According to the International Society for Applied Computing: “Applied computing refers to the practical application of computer principles, concepts, and technologies to address real-world problems. Applied computing uses aspects of computer science to solve problems in various disciplines, including politics, business, education, environment, engineering, biology, chemistry, physics, nano-sciences and nano-technology, statistics, economics, finances, and social sciences. Working in this field, you'll likely use a range of programming, software engineering, graphic applications, networking, and operating systems management skills to collect, analyze, store and distribute information that will help resolve issues for individuals, groups, and companies.”

Interdisciplinary engineering has a broader scope than traditional engineering, which incorporates the knowledge and skills associated with other disciplines, which requires students to take courses from different non-traditional disciplines. Interdisciplinary Engineering is a much better fit for some jobs which need knowledge outside any traditional engineering scope. This degree program enables a synergistic integration of applied computing, electrical, mechanical systems with electronics, and intelligent computer control in the design and manufacturing of products and processes. The blending of electrical, mechanical, electronic, software, and control theory engineering topics into a unified framework that enhances the design process. Electrical Engineering with a mechatronics background applies mechanical, electrical, and computer engineering theories and techniques to create automated, intelligent products, smart devices, and industrial control systems - systems that can then be “taught” to improve their performance. This is where many future engineering jobs are headed. For example, in the automotive industry, mechatronics engineering is a fast-growing discipline, one that today’s electric vehicle (EV) manufacturers hope to leverage in gaining a leg up with tomorrow's vehicles. In other areas, mechatronics engineers will be engaged in the automation of process industries. They will design insulin pumps for diabetics, robotic systems for law enforcement, and autonomous flying machines to support military troops on the ground (such as unmanned aerial vehicles or UAVs). They may even create automated systems for tomorrow’s vast farming industry called precision agriculture, and robots that will learn to efficiently explore the surface of Mars. The newly proposed Ph.D. combines the advantages of Applied Computing and Engineering, allowing students to go well beyond any traditional program, which fits well for the current market since interdisciplinary principles and multi-disciplinary knowledge and skills are in large demand and getting more desirable by industrial and governmental organizations.

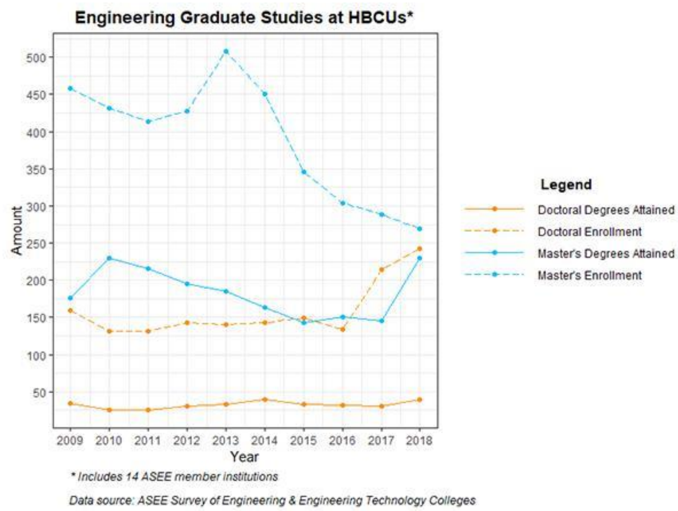
b. **Societal needs, including expanding educational opportunities and choices for minority and educationally disadvantaged students at institutions of higher education**

UMES is located in Maryland’s Somerset County, which is among the poorest counties in the state according to the US Census Bureau. UMES currently offers the only engineering Bachelor’s degree program on the Eastern Shore of Maryland. The Department of Computer Science and Engineering Technology currently offers a Bachelor’s degree in Computer Science and a Masters’ degree in Applied Computer Science and a Master of Science in Cybersecurity Engineering Technology. Offering the proposed Ph.D. program will open opportunities for all races and ethnic groups. However, since UMES is one of the four HBCUs in Maryland, it is well positioned to attract more African American and educationally disadvantaged students, thus expanding the educational opportunities and choices for minorities as well as addressing critical needs of the state and the local economy.

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

The proposed Ph.D. 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. It is a terminal degree, which will advance the increase of minority Ph.D. grantees in the fields of applied science and engineering. It will also strengthen and expand the research capacity of historically black institutions to provide high quality and unique educational programs to a high level.

The chart below from the American Society for Engineering Education (ASEE) clearly shows how the establishment of a doctoral program in engineering has had a positive impact on the graduate enrollments at HBCUs.



Also, the above figure supports why UMES has chosen to pursue a Doctor of Philosophy in Applied Computing and Engineering with En Passant Master's as the increase in graduate engineering enrollment at HBCUs is occurring at the doctoral level.

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

The proposed Ph.D. 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 Ph.D. Degree Program is intended to prepare highly trained scientists and engineers at the graduate level in an emerging area of cybersecurity, data, and computational science, software engineering, mechatronics and control, communications and networks, etc. that is becoming increasingly important and relevant to our society. However, applied science and engineering are specialized fields with many barriers to student access. The proposed graduate degree program will provide equitable access and quality education to all Maryland residents, including those with disadvantaged backgrounds, to develop a strong applied science and engineering workforce for the state.

Success – Promote and implement practices and policies that will ensure student success.
The practices and policies concerning the proposed Ph.D. degree program align with all existing policies at the University, which will ensure student success. By providing a carefully developed curriculum, sufficient computer science and 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 Ph.D. 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 with new knowledge and skill sets 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.**

The current engineering program at the Bachelor’s Degree level has produced over 100 graduates. Many of them have been employed as engineers by major engineering companies such as Lockheed Martin, Boeing, Northrop Grumman Corporation, as well as government sectors such as NASA, US Navy, US Army, etc. By leveraging its success, it is expected that graduates of the proposed Master’s degree program will lead to mid-level technical and management jobs in the industry and the government sectors where the engineering workforce is highly sought. Our current graduates with a Bachelor’s degree in Computer Science or Engineering Technology, or MS in Applied Computer Science or Cybersecurity Engineering Technology are working for various companies from small to large, including Microsoft, General Electric, and Amazon, to name a few. Some are working for government sectors such as NASA, and the Department of Defense. Graduates with BS degrees normally start with entry level positions, while graduates with MS degrees normally start with mid-level positions.

Those who will graduate with a degree in the Ph.D. in Applied Computing and Engineering program will be proficient in their concentrations and related areas, and this knowledge will propel them to land jobs in both the private and public sectors. Graduates can work in a wide array of positions from middle level to top level, including but not limited to: Senior Data and Computational Scientist, Senior Information Security Analyst, or Senior Software Architecture. For the type of positions in Computer and Information Research Scientists, the U.S. Bureau of Labor projected the job increase of 22% from 33000 (in 2020) to 402000 (in 2030), and the Maryland Department of Labor projected the job increase of 13.3% from 2794 in 2018 to 3168 in 2028 in the state of Maryland. For the type of jobs in Computer Science

Teacher (Postsecondary), the Maryland Department of Labor projected a job increase of 17.52% from 959 in 2018 to 1127 in 2028 in the state of Maryland alone. The graduates from our proposed Ph.D. in Applied Computing and Engineering are a nice fit for most of these positions in both Computer Science Teacher (Postsecondary) and Computer and Information Research Scientists.

Letters of support from industry or governmental organizations which describe potential industry employment opportunities or needs can be found at the following link.

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 indicates that employment in computer and information technology occupations is projected to grow 13 percent from 2020 to 2030, faster than the average for all occupations. These occupations are projected to add about 667,600 new jobs. Demand for these workers will stem from greater emphasis on cloud computing, the collection and storage of big data, and information security. The Bureau of Labor Statistics further indicated that the overall employment of electrical and electronics engineers is projected to grow 7 percent from 2020 to 2030, about as fast as the average for all occupations. About 22,700 openings for electrical and electronics 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.

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. The proposed degree program will produce engineers working in an interdisciplinary area that requires skill sets in electrical engineering and mechanical engineering. In particular, Electrical Engineers will conduct research, design, develop, test, or supervise the manufacturing and installation of electrical equipment, components, or systems for commercial, industrial, military, or scientific use. According to the BLS data in 2018, there were 330,300 jobs in the Electrical and Electronics Engineering field. For engineers with a broader skill in electro-mechanical systems, it is predicted a 5% increase in employment in the next decade. The broad skill sets in electrical, electronics, and mechatronics engineering will help sustain demand for their service. All the jobs in the emerging industry and market sectors such as unmanned systems, self-driving automobiles, next generation communications systems and networks, and renewable energy industry require a workforce with a background in electrical engineering fields.

The Maryland Department of Labor Licensing and Regulation (DLLR) website does not have a specific job category for applied computing, however, there is an umbrella category of Computer and Information Research scientists which is representative of the field of applied computing. Therefore, according to the Maryland Department of Labor Licensing and

Regulation (DLLR) website, there is a current need of over 2,700 positions in the State of Maryland for a person with the educational background or graduate degree, to fill positions related to Computer and Information Research Scientist.

Table #1 Employment outlook of computer and information research scientist occupations

Job Title	# of Maryland Positions (2018)	# of Maryland Position (2028)	Percentage Growth
Computer and Information Research Scientists	2,794	3,168	13.3%

Source: http://www.dllr.state.md.us/lmi/iandoproj/maryland.shtml (accessed February 17, 2022).

While the United States Bureau of Labor Statistics (USBLS) website does not have a specific job category for applied computing, however, there is an umbrella category of Computer and Information Research scientists which is representative of the field of applied computing. Therefore, according to the United States Bureau of Labor Statistics (USBLS) website located there is a current need for 33,000 positions nationally for a person with an education background or graduate degree, to fill positions related to Computer and Information Research Scientist. The median salary for an individual who is properly credentialed in the field is estimated to be $126,830, according to the USBLS.

Table #2 Employment outlook of computer and information research scientist occupations

Job Title	# of Positions (2020)	# of Positions (2030)	Percentage Growth
Computer and Information Research Scientists	33,000	40,200	22%

Source: https://www.bls.gov/ooh/computer-and-information-technology/computer-and-information-research-scientists.htm (accessed February 17, 2022).

Table #3 Employment outlook of electrical and mechatronics engineering occupations

Employment projections data for electrical and electronics engineers, 2020-30			
Occupation Title	**Employment 2020**	**Projected Employment 2030**	**Change 2020-2030**
Electrical and Electronics Engineers	313,200	333,600	7%
Electrical Engineers	188,000	200,700	6%
Electronics Engineers, Except Computer	125,200	132,900	6%

Table #4 Computer Occupations, Projected employment 2019-2029

Computer occupations projected employment 2019-2029

Occupation Title	Employment 2019	Projected Employment 2029	Change 2019-2029
Total, all occupations	162,795.6	168,834.7	3.7%
Computer occupations	4,633.4	5,164.6	11.5%
Information security analysts	131	171.9	31.2%
Software developers and software quality assurance analysts and testers	1,469.2	1,785.2	21.5%
Computer and information research scientists	32.7	37.7	15.4%
Database administrators and architects	132.5	145.3	9.7%
Web developers and digital interface designers	174.3	188.3	8%
Computer user support specialists	687.2	741.9	8%
Computer systems analysts	632.4	679	7.4%
Computer network support specialists	195.1	207.7	6.4%
Computer network architects	160.1	168.1	5%
Network and computer systems administrators	373.9	389.9	4.3%
Computer programmers	213.9	193.8	-9.4%

The data from the Maryland Department of Labor job projections as shown below supplement the current trend projected by the U.S. Bureau of Labor Statistics

Table #5 Maryland Occupational Projects

Maryland Occupational Projections 2018 - 2028			
Occupation Title	**Employment 2018**	**Employment 2028**	**Change 2018-2028**
Computer and information systems manager	13,644	15,444	13.2%
Computer and mathematical occupations	113,209	130.011	14.8%
Computer Occupations	104,469	118,979	13.9%
Computer and Information Research Scientists	2,794	3,168	13.4%
Computer Systems Analysts	15,927	18,014	13.1%
Information Security Analysts	4,116	5,727	39.1%
Software developers, applications	9,311	11,773	26.4%
Software developers, systems software developers	13,025	14,762	13.3%
Database Administrators	2,993	3,420	14.3%
Network and computer systems administrators	2,913	3,312	13.7%
Computer Network Architects	12,868	14,561	13.2%
Computer Users Support Specialists	4,629	5,281	14.1%

Computer Network Support Specialists	10,101	11,569	14.5%
Computer Occupations, all other	6,717	7,594	13.1%
Computer science teacher postsecondary	14,550	15,457	6.2%

4. **Provide data showing the current and projected supply of prospective graduates.**
The number of graduates from the current Bachelor Science in Computer Science (BSCS), Bachelor Science in Engineering (BSE) Master of Science in Applied Computer Science (MSACS), and Master of Science in Cybersecurity Engineering Technology (MSCSET) at UMES is summarized as follows:

Program	2014-2015	2015-2016	2016-2017	2017-2018	2018-2019	2019-2020*
BSCS	17	15	11	18	23	22
BSE	14	11	11	7	22	19
MSACS	3	10	8	4	4	5
MSCSET	-	-	-	3	6	6
Total	**34**	**36**	**30**	**32**	**55**	**52**

Based on the above number of graduates who will be eligible to enroll in the proposed Doctoral program with a pass-through Master's, the projected supply of prospective graduates from the program is estimated to be 10 in the first year with a projection of five new students per year for the initial five years of the programs' operation.

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 builds upon the existing faculty expertise in the general engineering program at UMES. There are no other Ph.D. degree programs in the Eastern Shore of Maryland. Although other institutions in Maryland, such as the University of Maryland College Park, University of Maryland Baltimore County, and Morgan State University offer Ph.D. degrees, these institutions are located about 140 miles away from the Eastern Shore. Moreover, the proposed program offers a unique curriculum with a focus in cybersecurity, data and computational science, software engineering, mechatronics and control, and communications and networks, aiming to offer a non-conventional pathway towards a degree that prepares students for emerging technologies in unmanned system design, automation and control, communications and networks for internet of things (IoT), precision agriculture, and aerial imaging for crop monitoring, etc.

The proposed UMES program does not duplicate similar programs offered by other Maryland institutions. We serve a different geographical area and academic program degree-level.

2. **Provide justification for the proposed program**

By leveraging the existing computer science and engineering faculty expertise from the two Departments as well as the new positions to be filled for this program starting from the 2022 – 2023 academic year, we are positioned, uniquely, to address challenges in an emerging industry and job sectors in automation, unmanned systems, IoTs, intelligent systems, cyber operations, software engineering, computer animation, etc. There is a huge market demand for skills in automation, artificial intelligence, and unmanned system technology. The leading companies in the US – Google, GM, Tesla, etc., have research and development groups that actively recruit educated professionals in this area. There are many startups and opportunities to attract venture capital given the growing number of possible applications of unmanned system technology. Other leading drone manufacturers in the US include Boeing Co., Lockheed Martin Corp., AeroVironment Inc. produce drones largely as defense contractors, and AeroVironment manufactures unmanned aircraft as its principal line of business. Companies such as Microsoft and Apple are developing new technologies to defend, mitigate, and prevent cyber-attacks. Companies such as Amazon and IBM are leading the research in new methods to make software systems more efficient.

However, in all these areas and others, the United States is not producing enough STEM majors with graduate degrees in general, and particularly, in computer science and engineering, to satisfy the demand US companies and the federal government have in terms of their workforce needs.

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.**

There is no comparable degree program offered at the Ph.D. level at any of the Historically Black Institutions in Maryland. It is stated in the mission that "UMES prepares graduates to address challenges in a global knowledge-based economy while maintaining its commitment to meeting the workforce and economic development needs of the Eastern Shore, the state, the nation, and the world." It is the University's strategic plan to "Meet the educational needs of the state of Maryland with high-quality and innovative academic programming." Since the area of Applied Computing and Engineering is in high demand both locally and globally, and such a program is fully offered in UMES, an HBI, the PHACE is not only consistent with UMES established mission, and strategic plan, but also will extend our existing doctoral programs in a new area in computing and engineering. While the new PHACE program is for all people of any race or ethnic group, it will attract and provide opportunities for more African Americans and it will have a positive impact on HBIs overall. This program is consistent with UMES's established mission, identity, and uniqueness, as well as being consistent with Maryland State Plan for Postsecondary Education towards access, success, and innovation for African Americans and all people, both locally and globally. The PHACE will promote UMES and state education to a wide perspective nationally and internationally.

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.**

   More than 85% of the students at UMES are students of color, and 73% of students in the Engineering program identify themselves as people of color. The mission of UMES and the proposed PHACE program is to provide opportunities for minorities and first-generation college students, allows many individuals who might not otherwise have a chance to earn a graduate degree in areas of cybersecurity, data and computational science, software engineering, mechatronics and control and communications and networks to do so. The establishment of the proposed Ph.D. degree program is critical to the mission of UMES as a Historically Black 1890 land-grant institution, and to its unique identity as a higher learning institution to facilitate social mobility for those from a disadvantaged background, especially for those from the Lower Shore region where learning opportunities in advanced sciences and engineering are severely lacking. Additionally, the program will enhance UMES' Carnegie Classification as a High Research Activity Doctoral University. Furthermore, it will open doors for non-traditional students to advance themselves as they can combine work and school for a greater relevance at their places of employment.

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.**

   The proposed program was established through a rigorous review of unmet needs by the institution. It started from the faculty of the computer science and engineering programs, with approval from the Departmental Curriculum Committee, School Curriculum Committee, Graduate Faculty Council, Senate Curriculum Committee, etc.

   The courses of the curriculum in the proposed Ph.D. degree program with a Master's option will be taught by faculty in the Departments of Computer Science and Engineering Technology and Engineering and Aviation Sciences, with an additional 6 engineering faculty members to be hired to balance the teaching load, and a Lab Specialist for supporting the operation of the specialized engineering laboratories in the Department.

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

Graduates with a Ph.D. in Applied Computing and Engineering will be able to:

- Demonstrate in-depth knowledge of the fundamental principles, concepts, terminologies, and methodologies used for design and analysis of broader concentration areas namely cybersecurity, data and computational science, software engineering, mechatronics and control, and communications and networks.
- Demonstrate the ability to solve real-world problems in the aforementioned areas.
- Demonstrate the ability to be gainfully employed in research-based industries and academia upon graduation from the program.
- Demonstrate the ability to be in leadership positions in cybersecurity, data and computational science, software engineering, mechatronics and control, and communications and networks, and related disciplines.

Students will learn interdisciplinary and cross-disciplinary methods that are broadly applicable in the emerging field of unmanned systems design, mechatronics and control cybersecurity, data and computational science, software engineering, communications and networks, etc.

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.
- Passing the comprehensive examination for becoming a candidate for the degree.
- Assessing comprehensive dissertation/thesis or research project report in cybersecurity, data and computational science, software engineering, mechatronics and control, and communications and networks concentrations. Tracking performance in regional and national competitions and publication records of the students before graduation.

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, as well as its computer science undergraduate and Applied Computing degree programs.

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

a. **Courses and General Requirements for the Ph.D. Degree with an option for a Master's Degree**

All students in the Masters of Science Degree will take thirty (30) credit hours with the Thesis option or thirty-three (33) credit hours with the Non-thesis option of graduate-level courses to graduate from the program, not including any provisional admission course requirements, over four semesters. All courses that are to count towards graduation must be passed with a minimum grade of B, and students must also pass at least five of these courses with a grade of A. Students can enroll in concentration area courses only if they have been admitted to the program or given permission by the course instructor.

The time limit for completing the M.S. degree is five (5) years from the first enrollment in the graduate program. This includes any Provisional Admission course requirements to be met. Any exception to the time limit must be approved by the UMES Graduate School.

Thesis option: the student is required to take three core (9 credits) and a minimum of five free elective (15 credits) graduate level courses and six credits of Thesis. The thesis must be supervised by a member of the faculty as a thesis advisor and the initial thesis proposal must be defended with an oral presentation (see below) and approved by the student's thesis committee (three members including the advisor). The thesis must be submitted to the department in a bound form after the oral defense which will take place after the thesis research is completed. A student is required to submit at least one journal/conference paper from his/her thesis work before the defense.

Non-thesis option: the student is required to take three core (9 credits) and a minimum of seven free elective (21 credits) graduate level courses and a 3-credit hour research project that must be approved by the project advisor. A copy of the resulting scholarly paper (if any) must be submitted to the department. A Student is advised to do a scholarly activity out of his/her project work.

All M.S. students must choose either the thesis or non-thesis option. There is no course-only option.

MS General Requirements

1. A maximum of two graduate-level course units may be transferred from another institution to apply toward the MS degree. Transferred courses must logically fit into the student's graduate program. The student's graduate advisor decides which courses are acceptable.

UMES approval of transfer credit may also be required. These two courses should not have been used in fulfillment of any other degree(s).

2. Any coursework more than six years old at the time of the final examination will not be used to fulfill any of the MS degree requirements.
3. All graduate credits must have letter grades of A, B, or C, or pass/fail grades of S (Satisfactory). No More than two graduate courses with letter grade C will be accepted.
4. A minimum grade point average (GPA) of 3.0 is required to remain in good standing and to graduate.
5. Elective courses should be primarily from one of the five concentrations specified in this document. Students in each concentration can take 2 courses (6 credits) from the other concentrations to satisfy graduation requirements upon approval of both student's advisor and Director of the graduate program.
6. Up to a maximum 2 courses (6 credits) from other UMES departments of the physical, mathematical, biological, agricultural, or similar sciences may be included to round out a student's overall program of study. All courses from outside of the Engineering Master's Program must be graduate 500-600 level graduate courses. Prior approval of both student's advisor and the Director of the graduate program is required for all external courses.
7. Up to a maximum of 3 credits of Independent Study are allowed upon the student's advisor and Director of the graduate program's approval. Independent Study needs to be structured by the faculty member with a clearly defined syllabus for prior approval.

Ph.D. General Requirements

The Ph.D. program will consist of a minimum of 60 credit hours broken down as follows:

(A)	Core courses	12 hrs.
(B)	Free Electives	12 hrs.
(C)	Concentration courses	24 hrs.
(D)	Dissertation hours	12 hrs.

The general requirements as outlined for the Master's option apply following the breakdown of courses as shown above. The courses applicable to the Ph.D. program will be numbered 600 – 700 level courses. A residency requirement of a year full-time on campus is required.

PHACE Degree Curriculum

The PHACE Degree curriculum combines the courses for the Ph.D. Degree along with the courses that will result in granting a student the Master's Degree should the student choose that option.

<u>CYBERSECURITY COURSES</u>

ETCS 600 Statistical Applications for Technology – 3 Credits (Current)
This course presents a broad treatment of statistics, concentrating on specific statistical techniques used in science and industry. Prerequisite(s): Graduate Standing

ETCS 606 Applied Research for Technology – 3 Credits (Current)

This course studies the research methods and processes applicable to engineering and technology. Emphasis will be placed on defining research problems, collecting, analyzing, recording, and interpreting data. Students will be required to conduct a research project. Prerequisite(s): Graduate Standing

ETCS 620 Project Management for Technology – 3 Credits (Current)
This is the introductory project management course, which is a core course in the Master's degree programs. Prerequisite(s): Graduate Standing

ETCS 678 Mobile Wireless Networking and Security – 3 Credits (Current)
This course is a comprehensive examination of wireless local area networks, with an emphasis on the IEEE P802.11 family of WLAN standards. Prerequisite(s): Graduate Status or Permission of Instructor

ETCS 680 Networking Technology for Industry – 3 Credits (Current)
An advanced study of network technology fundamentals. The course stresses the state-of-the-art developments that support the World Wide Web and a wide array of specific applications. Prerequisite(s): Graduate Standing

ETCS 681 System Integrity for Cyber security – 3 Credits (Current)
This course identifies elements of system integrity for Cyber security including firewall design, types of security threats, and responses to security attacks. This course also studies the use of best practices to design, implement, and monitor a network security plan. This course also examines security incident postmortem reporting, and ongoing network security activities. Prerequisite(s): Graduate Status or Permission of Instructor.

ETCS 682 Cyber security Administration – 3 Credits (Current)
This course explores the concepts of governance and how it applies to information systems. Discussion includes the importance of compliance with laws, regulations, policies, and procedures as a means of minimizing risk through mandated security and control measures. Through this course, students also gain an understanding of Cyber security Auditing processes and principles. Prerequisite(s): Graduate Standing

ETCS 683 Network Intrusion, Detection and Incident Response – 3 Credits (Current)
This course presents an exploration of the theory and implementation of intrusion detection and intrusion prevention. Prerequisite(s): ETCS 685 or Permission of Instructor

ETCS 685 Fundamentals of Network Security – 3 Credits (Current)
This course presents topics that include cryptography, cipher systems, practical security schemes, confidentiality, authentication, integrity, access control, nonrepudiation, and their integration across telecommunications (i.e., computer) networks. Prerequisite(s): Graduate Status or Permission of Instructor

ETCS 686 Advance Network Security – 3 Credits (Current)
This course covers advanced information from topics presented in ETCS 685. Topics include cryptography, cipher systems, practical security schemes, confidentiality, authentication, integrity,

access control, nonrepudiation, and their integration across telecommunications (i.e., computer) networks. Prerequisite(s): ETCS 685 or Permission of Instructor

ETCS 687 Legal and Ethical Issues in Cybersecurity – 3 Credits (Current)

This course focuses on the ways that law, ethics, and Cyber security overlap and intersect. Besides laws related to Cyber security, the course examines laws related to intellectual property, civil litigation, criminal prosecutions, and privacy. Prerequisite(s): Graduate Standing

ETCS 690 Master's Seminar – 3 Credits (Current)

This course serves a dual role. First and foremost, this is a graduate seminar course with the major objective of preparing students for research in practical applications. It will challenge students with a critical and philosophical exploration of the ideas of Cyber security and will consist of lectures, readings, and class discussions in which every student is expected to be an active participant. Since students come to this course with diverse interests in graduate work in Cyber security, the scope of readings and discussions on research and practical applications will be broad. The second role of this course is a capstone graduation requirement for all master's students. For that purpose, the goal is to learn the practical skills of giving a presentation and writing a research paper. Prerequisite(s): Permission of Instructor

DOCTORAL LEVEL CYBERSECURITY CONCENTRATION COURSES

ETCS 700 Applied Cryptography – 3 Credits (New)

This course presents a study of cryptographic topics such as classical cryptographic algorithms, symmetric-key cryptography, public-key cryptosystems, authentication, stream ciphers, block ciphers, public-key cryptography, RSA cryptosystem, hash functions, and digital signatures. The course will also discuss advanced cryptographic tasks, privacy mechanisms, and other forms of encryption. Prerequisite: Graduate Standing

ETCS 710 Advanced Study in Cybersecurity I – 3 Credits (New)

This course presents an advanced study of cybersecurity topics including cybersecurity administration, social engineering, legal and ethical Issues, cyber-operations project management. Prerequisite: Graduate Standing

ETCS 720 Advanced Study in Cybersecurity II – 3 Credits (New)

This course presents an advanced study of cybersecurity topics including wireless security, applied cryptography, cellular mobile, and network instruction, detection, and incidence response. Prerequisite: Graduate Standing

ETCS 730 Cybersecurity and Intelligent Systems – 3 Credits (New)

This course presents an advanced study of cybersecurity issues for intelligent systems focusing on such areas as agriculture (precision farming), transportation (smart cars), medical devices (intelligent sensors), and government initiatives (smart cities). Prerequisite: Graduate Standing

ETCS 740 Cybersecurity for Critical Infrastructure – 3 Credits (New)

This course presents an advanced study of critical infrastructure, including physical and cyber systems and assets vital to the modern world's operation. Prerequisite: Graduate Standing

ETCS 750 Cybersecurity for Navigation Systems – 3 Credits (New)
This course presents an advanced study of cyber risk associated with navigation systems such as the Global Navigation Satellite Systems (GNSS) and the impact of spoofing and jamming attacks. Prerequisite: Graduate Standing

DOCTORAL LEVEL DISSERTATION COURSES

ACIE 795 Research/Ph.D. Dissertation Writing I – 3 Credits (New)
Research under faculty supervision in an area of specialization leads to the preparation and submission of a Dissertation in partial fulfillment of the graduation requirements.

ACIE 796 Research/Ph.D. Dissertation Writing II – 3 Credits (New)
Research under faculty supervision in an area of specialization leads to the preparation and submission of a Dissertation in partial fulfillment of the graduation requirements.

ACIE 797 Research/Ph.D. Dissertation Writing II – 3 Credits (New)
Research under faculty supervision in an area of specialization leads to the preparation and submission of a Dissertation in partial fulfillment of the graduation requirements.

ACIE 798 Research/Ph.D. Dissertation Writing II – 3 Credits (New)
Research under faculty supervision in an area of specialization leads to the preparation and submission of a Dissertation in partial fulfillment of the graduation requirements.

The table below is a mapping for students who enter the Ph.D. program with an M.S. in Cybersecurity Engineering Technology.

CYBERSECURITY CONCENTRATION

Courses	Master's			Ph.D.			
	Core	Free Ele	Project	Core	Concen	Free Ele	Diss
ETCS 600	X					X	
ETCS 606	X					X	
ETCS 620	X					X	
ETCS 678		X			X		
ETCS 680		X			X		
ETCS 681		X			X		
ETCS 682		X			X		
ETCS 683		X			X		
ETCS 685		X			X		
ETCS 686		X			X		
ETCS 687		X				X	
ETCS 690			X			X	
ETCS 700				X			
ETCS 710				X			
ETCS 720				X			
ECTS 730				X			
ETCS 740					X		
ETCS 750					X		

ACIE 795							X
ACIE 796							X
ACIE 797							X
ACIE 798							X

COMPUTER SCIENCE COURSES

CSDP 600 Advanced Programming Languages – 3 Credits (Current)
Topics include (not limited to): Advanced topics in programming language theory, design and implementation, in depth understanding of data types, binding, scope and extent abstraction, extensibility and control mechanisms, formal semantics and program verification, and alternative programming language paradigms.

CSDP 601 Analysis and Design of Algorithms – 3 Credits (Current)
Topics include (not limited to); NP completeness and approximation algorithms, design techniques for efficient algorithms such as amortized analysis, dynamic programming, and greedy algorithms. Computational geometry, graph algorithms, primality and other number-theoretic algorithms, specialized data structure techniques such as augmenting data structures, combinational graph reduction, and functional repetition.

CSDP 602 Database Management System – 3 Credits (Current)
Topics include (not limited to); A study of the theoretical foundations of database management systems. Design and implementation of alternatives for various database models, including, but not limited to, hierarchical network and relational models, comparison of the reliability, security, and integrity of various database systems. Implementation of a simple database system.

CSDP 603 Advanced Operating System – 3 Credits (Current)
Topics include (not limited to); Structure and functions of operating system, inter-process communication techniques, high-level concurrent programming, virtual memory system, basic queuing theory, security, distributed system, design and implementation of operating systems.

CSDP 604 Computer Methods in Statistics – 3 Credits (Current)
This course is an introduction to the principles and applications of probability and statistics needed in graduate studies in various academic areas and to the computer realization of these methods. The course begins with a brief intensive review of basic statistical principles.
Prerequisite(s): One semester of calculus. NOTE: The department is committed to offering CSDP 604 (Computer Methods in Statistics) as an elective course on-demand.

CSDP 605 Software Engineering – 3 Credits (Current)
Topics include (not limited to); A formal study of the software development process, lifecycle models, requirements definition specifications, design, implementation, validation, verification, maintenance and reuse, team work on a project.

CSDP 638 Computer Applications in Science and Mathematics – 3 Credits (Current)
Current areas include numerical methods, exact solutions of algebraic problems, and special computer methods in number theory.

CSDP 648 Computer Applications in Industry – 3 Credits (Current)

Current areas include artificial neural networks and their algorithms, parallel operating environments, and the use of parallel languages under parallel environments.

CSDP 668 Advance Data Management – 3 Credits (Current)
Topics include (but are not limited to): Parallel and Distributed database system architectures, distributed database design, client/server database systems, selected topics from new development in extended relational databases, multimedia databases, information retrieval systems, object-oriented databases, temporal databases.

CSDP 697 CSDP Special Topics – 3 Credits (Current)
A special topic course is introduced by the faculty in his/her research area or the current topic related to the master's curriculum which is approved by the graduate committee. This course may be repeated (with different topics) for a maximum of 9 credits.

CSDP 698 Master's Project I – 4 Credits (Current)
The student is required to take a minimum of ten graduate level courses (30 credits) and a 4-credit hour research project (CSDP 698) that must be approved by the project advisor. A copy of the resulting scholarly paper (if any) must be submitted to the department. A student is advised to do a scholarly activity out of his/her project work.

CSDP 699 Master's Project in Computer Science I – 4 Credits (Current)
During this semester/session, the student will carry out the analysis and design of a state-of-the-art system of programs in his/her area of expertise and interest and begin the actual programming and documentation. Students desiring to change their project topic after it has been approved MUST sign up for CSDP 699 for a second time. Prerequisite: Certification by the advisor that the student is prepared to begin research work in computer science.

CSDP 798 Master's Project II – 4 Credits (Current)
During this semester, the student will complete the project begun in CSDP 699, including all documentation, and give a public demonstration of its effectiveness, originality, and appropriateness to the field of application. In addition, the student will prepare a written version of the material in a form consistent with departmental and Graduate School standards. Successful completion of this course requires either: (a) the acceptance for publication of this project description by a national journal in the appropriate field or by a national conference that publishes its proceedings in full [the actual publication may occur after the course ends]; or (b) the approval of this project and its documentation by a departmental graduate committee set up for this purpose. CSDP 798 is four (4) credits in the first semester/session it is taken; and then one credit for each semester/session thereafter as required. A student must be enrolled in CSDP 798 for any semester/session in which he/she needs to consult with his/her project advisor. Prerequisite: CSDP 699.

<u>DOCTORAL LEVEL COMPUTER SCIENCE COURSES</u>
The following are new CS courses for the PHACE program.

CSDP 705 Programming Language Semantics – 3 Credits (New)

The theory of design, description, and implementation of programming languages, and comparative study of major programming languages. Topics can be selected from the following types of languages: Procedural-Oriented, Object-Oriented, Functional, Algorithmic, Artificial Intelligence, Computational, Data-Oriented, or others.

CSDP 710 Machine Learning – 3 Credits (New)
Introduction to fundamental concepts in machine learning, including various learning algorithms, and applications to real-world problems. The choice of topics includes but is not limited to supervised learning, unsupervised learning, computational learning theory, deep learning, reinforcement learning, and applications.

CSDP 715 Object-Oriented Design – 3 Credits (New)
This course addresses the concepts, skills, methods, techniques, and tools in object-oriented programming and design. It is focused on both object-oriented design and efficient implementation of the design. Topics include principles of software engineering, management issues, and the prototyping, development, testing, debugging, reuse, and maintenance of software systems.

CSDP 720 Data Science and Analytics – 3 Credits (New)
Introduction to fundamental concepts, theories, and technologies of data and data science, including data acquisition, wrangling, visualization, exploration, modeling, transformation, and classification. Topics can be selected from parameter estimation, hypothesis testing, regression analysis, dimensionality reduction, model selection, and feature selection.

CSDP 725 Big Data Analytics – 3 Credits (New)
Introduction to fundamental concepts, techniques, algorithms to big data, including various topics in big data from data generation, storage, management, transfer, analytics, data mining, and knowledge discovery. Applications in different areas are introduced to illustrate the development, deployment, and execution of a wide range of emerging big-data solutions.

CSDP 730 Computational Science – 3 Credits (New)
Introduction to the numerical algorithms that form the foundations of computations, and that apply advanced computing capabilities to understand and solve complex problems. Algorithms include mathematical models, computational models, and computer simulations. Applications can be selected from a wide range of areas in Computational X.

CSDP 740 Advanced Software Engineering – 3 Credits (New)
This course covers advanced software engineering principles and techniques. Topics can be selected from specification, design patterns, reverse engineering, design recovery, refactoring, software analysis, software comprehension, software evolution, domain specific techniques, advanced design, formal methods, software life-cycle, etc.

CSDP 750 Special Topics in Software Engineering – 3 Credits (New)
A special topic course is introduced by the faculty in his/her research area in software engineering related to the curriculum which is approved by the graduate committee. This course may be repeated (with different topics) for a maximum of 9 credits.

CSDP 760 Special Topics in Data Science – 3 Credits (New)
A special topic course is introduced by the faculty in his/her research area in data science related to the curriculum which is approved by the graduate committee. This course may be repeated (with different topics) for a maximum of 9 credits.

CSDP 770 Special Topics in Computational Science – 3 Credits (New)
A special topic course is introduced by the faculty in his/her research area in computational science related to the curriculum which is approved by the graduate committee. This course may be repeated (with different topics) for a maximum of 9 credits.

CSDP 780 Special Topics – 3 Credits (New)
A special topic course is introduced by the faculty in his/her research area or the current topic related to the curriculum which is approved by the graduate committee. This course may be repeated (with different topics) for a maximum of 9 credits.

The tables below are mappings for students who enter the Ph.D. program with an M.S. in Applied Computer Science.

DATA AND COMPUTATIONAL SCIENCE CONCENTRATION

Courses	**Master's**			**Ph.D.**			
	Core	**Free Ele**	**Project**	**Core**	**Concen**	**Free Ele**	**Diss**
CSDP 600							
CSDP 601	X			X			
CSDP 602	X			X			
CSDP 603	X			X			
CSDP 604		X		X			
CSDP 605		X				X	
CSDP 606		X			X		
CSDP 610		X			X		
CSDP 613		X				X	
CSDP 615		X				X	
CSDP 619		X				X	
CSDP 628		X				X	

CSDP 638		X			X	X	
CSDP 648		X				X	
CSDP 658		X				X	
CSDP 697		X				X	
CSDP 698			X				
CSDP 705		X			X		
CSDP 710					X		
CSDP 715		X				X	
CSDP 720	X				X		
CSDP 725	X				X		
CSDP 730	X				X		
CSDP 740		X				X	
CSDP 750		X				X	
CSDP 760						X	
CSDP 770						X	
CSDP 780						X	
ACIE 795							X
ACIE 796							X
ACIE 797							X
ACIE 798							X

SOFTWARE ENGINEERING CONCENTRATION

Courses	**Master's**			**Ph.D.**			
	Core	**Free Ele**	**Project**	**Core**	**Concen**	**Free Ele**	**Diss**
CSDP 600							
CSDP 601	X			X			
CSDP 602	X			X			
CSDP 603	X				X		
CSDP 604		X			X		
CSDP 605	X				X		
CSDP 606		X				X	
CSDP 610		X				X	
CSDP 613		X				X	
CSDP 615		X				X	
CSDP 619		X				X	

CSDP 628		X				X	
CSDP 638		X				X	
CSDP 648		X				X	
CSDP 658		X				X	
CSDP 697		X				X	
CSDP 698			X				
CSDP 705		X			X		
CSDP 710		X				X	
CSDP 715	X				X		
CSDP 720		X				X	
CSDP 725		X				X	
CSDP 730		X				X	
CSDP 740	X				X		
CSDP 750		X			X		
CSDP 760		X				X	
CSDP 770						X	
CSDP 780						X	
ACIE 795							X
ACIE 796							X
ACIE 797							X
ACIE 798							X

The following are new ENEM courses for the PHACE program.

<u>ELECTRICAL AND MECHATRONICS ENGINEERING COURSES</u>

ENEM 601 Linear Systems Theory – 3 Credits (New)
Methods of linear system analysis, in both time and frequency domains for continuous and discrete systems, as well as the analysis and design of systems control. This course will introduce time-domain systems dynamic control fundamentals and their design issues for electrical engineering applications. Emphasis will be on linear, time-invariant, multi-input multi-output continuous-time systems. Topics include open and closed-loop state-space representations, analytical solutions, computer simulations, stability, controllability, observability, and controller/observer design.

ENEM 602 Computational Methods in Engineering – 3 Credits (New)
Fundamentals of linear algebra and basic operations of vectors and matrices; error analysis; solution of a system of linear equations; iterative solution of nonlinear equations; numerical integration; numerical solution of differential equations; introduction to Matlab software; programming and applications relating to the computational functions in Matlab.

ENEM 603 Random Signals Analysis – 3 Credits (New)
Foundations for the engineering analysis of random signals and stochastic processes: Review of probability theory, Introduction to stochastic processes, Continuous time and discrete time processes, Mean functions, correlation functions, covariance functions, noise, Strict- and wide-sense stationarity, ergodicity, Gaussian processes, power spectral densities, mean square estimation, Markov processes, estimation of random variables, and model parameters.

ENEM 611 Mechatronics – 3 Credits (New)
Physical and mathematical modeling of mechanical, electrical, electromechanical, thermal, fluid, and multidisciplinary physical systems; sensors and electronics for measurements of the system; embedded/external feedback control using conventional and intelligent control algorithms; computer aided engineering tools for mechatronic system design and analysis; practical applications using mechatronic devices.

ENEM 612 Microelectronic Devices and Circuits – 3 Credits (New)
Introduces Modeling of microelectronic devices, and basic microelectronic circuit analysis and design. The topics covered include modeling of microelectronic devices, basic microelectronic circuit analysis and design, physical electronics of semiconductor junction and MOS devices, the relation of electrical behavior to internal physical processes, development of circuit models, and understanding the uses and limitations of various models.

ENEM 613 Digital Control Systems – 3 Credits (New)
The course addresses the theoretical foundation needed to implement the microprocessor in control applications. Effects of sampling, data conversion, quantization, finite word length, and time delays on system response and stability are examined. Pole-placement and observer/estimator techniques. The actual construction of a microcomputer-based controller culminates the course.

ENEM 614 Robotics – 3 Credits (New)
Introduction to industrial manipulator systems; Kinematic and dynamic models of robotic arms; homogeneous transformations; forward and inverse kinematics; motion control through coordinate transformations; robotic vision and sensors.

ENEM 615 Nonlinear Systems Analysis and Control – 3 Credits (New)
Introduction to Nonlinear Phenomena: Multiple Equilibria, Limit Cycles, Complex Dynamics, Bifurcations Second Order Nonlinear Systems: Phase Plane Techniques, Limit Cycles - Poincare-Bendixson Theorem, Index Theory, Input-output Analysis, and stability: Small Gain Theorem, Passivity, Describing Functions Lyapunov Stability Theory: Basic stability and instability theorems, LaSalle's theorem, Indirect method of Lyapunov Linearization by State Feedback: Input-Output and Full State Linearization, Zero Dynamics, Inversion, Tracking, and Stabilization.

ENEM 616 Embedded Systems Design – 3 Credits (New)
Topics covered include automotive embedded system requirements, verification during design, sneak circuit analysis, worst-case circuit analysis, design considering component tolerances and non-ideal behavior, thermal analysis, EMC analysis, FMEA analysis, grounding rules for circuits,

six sigma, fault tolerance, risk analysis, reliability issues, trade-offs in design, delays in automotive networks, and software-in-the-loop and hardware-in-the-loop tests.

ENEM 617 Autonomous Systems – 3 Credits (New)
Present applications and future roles of autonomous manned and unmanned systems. The course introduces theoretical and practical backgrounds for components and integration of autonomous vehicle systems. Topics include mobility dynamics and control, sensors and perception, cognition and decision, action and commands, computer communications, and integration. Case studies include lane following, obstacle avoidance, leader following, waypoint navigation, and guidance.

ENEM 618 Mechatronic System Design, Integration, and Test – 3 Credits (New)
This course addresses in detail the systems engineer's responsibilities and activities during the conceptual, design, integration, and test and Evaluation phases of a system development program. Systems engineering tools commonly employed at these stages of a program are presented along with selected problems that illustrate both the applicability and limitations of commonly employed tools and procedures. The course steps through conceptual design beginning with an analysis of needs and objectives, and proceeding to the exploration of alternative concepts and the selection of a concept that best meets goals of performance, timeliness, and affordability. Topics include a definition of operational scenarios, functional analysis, risk assessment, system tradeoffs, measures of effectiveness, and requirements formulation.

ENEM 619 Micro-Electro-Mechanical Systems – 3 Credits (New)
A comprehensive overview of MEMS technique and MEMS control. Topics include MEMS fabrication processes, MEMS sensors and actuators, Dynamic modeling of MEMS, control, signal processing, and electronics for MEMS, and case studies of MEMS devices.

ENEM 620 Mechanical Vibrations – 3 Credits (New)
Linear free and forced response of one and multiple degrees of freedom systems. Equations of motion of discrete systems. Free vibration eigenvalues and eigenvectors. Applications to engineering systems include vibration isolation, rotating imbalance, vibration absorbers and balancing of rotating machinery, and energy harvesting.

ENEM 621 Structural Design – 3 Credits (New)
Introduction to elasticity, stress, strain, material properties, stress function, failure criteria, fracture, fatigue, elasticity solution to bending, advanced torsion, buckling of columns, energy methods, plates and shells, and plastic deformation.

ENEM 622 Advanced Dynamics – 3 Credits (New)
The course deals with the study of mechanical systems undergoing a change of state described by the motions of their part under the influence of surrounding factors. The primary objective of this course is to equip students with the analytical tools needed to conduct accurate and realistic dynamic analysis, and it is recommended for students pursuing an interest in system dynamics, mechanics, robotics, controls, and other relevant areas of mechanical and aerospace systems. The fundamental concepts of Newtonian mechanics and Hamilton's principle from the viewpoint of the Variational approach will be taught in this class. Students will also learn the analytical

applications of Euler's and Lagrange's equations of motion to model rigid body system dynamical properties.

ENEM 623 Finite Element Method and Applications – 3 Credits (New)
This course covers the introduction to finite element methods and applications such as unmanned and mechatronics systems; relations between stresses, strains, displacements, temperature, and material properties; discretization and meshing; force vector, displacement vector, stiffness matrix, assembly process, solution techniques; truss elements, beam elements; triangular and quadrilateral elements; iso-parametric formulation; plane stress and plane strain applications; penalty and Lagrangian methods; software applications and simulations.

ENEM 624 Aerodynamics for Unmanned Aerial Systems – 3 Credits (New)
This course covers the introduction to aerodynamics fundamental concepts such as lift, drag, moment, pressure distribution, boundary layers for design and testing of unmanned aerial systems (UAS) with fixed or rotary wings; potential theory of bodies; airfoil theory and applications; finite wing theory and applications; introduction to Navier-Stokes equations; laminar boundary layers; turbulent boundary layers; instability and turbulence/separation; introduction to airfoil design; computational fluid dynamics (CFD) technique.

ENEM 641 Estimation and Detection Theory – 3 Credits (New)
Decision theory: Binary hypothesis testing, M-ary testing, Bayes, Neyman-Pearson, Min-Max. Performance. Probability of error, ROC. Estimation theory: linear and nonlinear estimation, and parameter estimation. Bayes, MAP, maximum likelihood, Cramér-Rao bounds. Bias, efficiency, consistency. Asymptotic properties of estimators. Orthogonal decomposition of random processes and harmonic representation. Waveform detection and estimation. Wiener filtering and Kalman-Bucy filtering. Elements of identification. Recursive algorithms. Spectral estimation. The level of this course is suitable for research students in communications and control, signal processing, and related areas.

ENEM 642 Digital Signal Processing – 3 Credits (New)
Introduction to digital signal processing; discrete-time description of signals; z-transform; digital filter structures; infinite and finite impulse response filter design techniques. Advanced topics include the design of quadrature mirror filter banks and discrete wavelet transforms.

ENEM 643 Principles of Digital Communications – 3 Credits (New)
This course focuses on the fundamental principles behind reliable digital data transmission over noisy and band-limited channels. Signaling schemes, channel models, and receiver structures widely used in practical systems are developed and analyzed. The communication techniques covered in the course are applications of digital signal processing, detection, estimation, and information theories. The covered topics include modern communications; probabilistic viewpoint; vector representation of signal; signal spaces; vector channels; additive white Gaussian noise; optimum receivers; maximum-likelihood detection; error probabilities; memoryless modulation methods; intersymbol interference (ISI); Nyquist signaling; equalization; complex baseband models; noncoherent detection; source coding; error control coding.

ENEM 644 Wireless Communications – 3 Credits (New)

Introduction to wireless communication principles and systems. Wireless channel models, TDMA, FDMA, spread spectrum, CDMA, equalization, detection, estimation, coding, security, quality assessment of service, and personal communications. Modern generation wireless standards are also discussed.

ENEM 645 Principles of Communications Networks – 3 Credits (New)
This course covers advanced subjects in computer networks. Topics will include Internet architecture and core protocols for congestion control, forwarding, naming, and routing; approaches to achieve reliability, scalability, and security; and design of hyper-scale cloud networks, data centers, wireless networks, content delivery, enterprise networks, quality of service, and network security. The material will range from the classics to the latest results, and from analytical foundations to systems design, and real-world deployment.

ENEM 646 Wireless Networks – 3 Credits (New)
Fundamental concepts of wireless networks: network architecture for personal communications systems, wireless LANs, radio, tactical, and other wireless networks, design, and analysis of protocols, and wireless network programming.

ENEM 647 Advanced Computer Networks – 3 Credits (New)
Introduces security principles and practices of computer and network systems. Topics include basic computer security concepts, common attacking techniques, common security policies, basic cryptographic tools, authentication, access control, network intrusion detection, software security, operating system security, network security, firewalls, network management, email, and web security, legal and ethical issues in computer security.

ENEM 648 Coding Theory and Applications – 3 Credits (New)
The theory and practice of error control coding with emphasis on linear, cyclic, convolutional, and parallel concatenated codes (Hamming codes, Repetition codes, polynomial codes, Reed Solomon Codes). Turbo codes, Viterbi decoding, and applications.

ENEM 649 Design and Optimization of Networks – 3 Credits (New)
A comprehensive introduction to network flows with an integrative view of theory, algorithms, and applications. It covers shortest path, maximum flow, and minimum cost flow problems, including a description of new and novel polynomial-time algorithms. It also covers topics from basic network design to protection and restoration design, to multi-layer network design while taking into account routing and flow requirements as applicable in different network architecture, protocols, and technologies.

ENEM 650 Digital Integrated Circuit Design – 3 Credits (New)
Studies the design process of VLSI CMOS circuits. Also covers all the major steps of the design process, including logic, circuit, and layout design. A variety of computer-aided tools are discussed and used to provide VLSI design experience that includes design of basic VLSI CMOS functional blocks, and verification of the design, testing, and debugging procedures.

ENEM 651 RF Integrated Circuit Design – 3 Credits (New)

Studies the design and analysis of radio frequency integrated circuits (RFICs) for communications. Topics include an overview of RF and wireless technology, fundamental concepts in RF design such as nonlinearity, sensitivity, and dynamic range. Matching and impedance transformation networks, and S-parameters. Transceiver architectures (Heterodyne, Direct Conversion, etc.), modulation, and up-conversion concepts. A detailed examination of each of the blocks in the transceiver architectures discussed: Low Noise Amplifiers, Mixers, Oscillators, Frequency Synthesizers, and Power Amplifiers.

ENEM 652 Introduction to Machine Learning – 3 Credits (New)
Introduces theoretical foundations, algorithms, methodologies, and applications for machine learning and provides a foundation for advanced study in topics shared by machine learning, statistical inference, and signal processing. Topics may include supervised methods for regression and classification (linear models, trees, neural networks, ensemble methods, instance-based methods); generative and discriminative probabilistic models; Bayesian parametric learning; density estimation and clustering; Bayesian networks; time series.

ENEM 653 Computer Vision and Image Processing – 3 Credits (New)
An introduction to computer vision, including fundamentals of image formation, camera imaging geometry, feature detection, and matching, stereo, motion estimation, and tracking, image classification, scene understanding, and deep learning with neural networks. We will develop basic methods for applications that include finding known models in images, depth recovery from the stereo, camera calibration, image stabilization, automated alignment, tracking, boundary detection, and recognition.

ENEM 670 Selected Topics in Engineering – 3 Credits (New)
This course covers selected topics on special or current topics and issues relating to electrical engineering, mechatronics control, communications, networks, etc. for master's students in engineering and other areas.

ENEM 688 Independent Study – [1-3 credits] Credits (New)
An independent study is conducted with a faculty member on a relevant topic. The course must be structured by the faculty member with a clearly defined syllabus for the Master's student. The course requires the prior approval of the student's advisor and graduate program director.

ENEM 696 Master Project – 3 Credits (New)
The student will conduct advanced research of interest to the student and the instructor. A written proposal, which outlines the nature of the project, must be submitted for approval. This course is only available to project option students. Prerequisite: Masters standing and Consent of advisor.

ENEM 697 Master Thesis - credits var. (3-6). (New)
Master of Science thesis research will be conducted under the supervision of the thesis committee chairperson leading to the completion of the Master's thesis. This course is only available to thesis option students. Prerequisite: Master standing and Consent of advisor.

DOCTORAL LEVEL ELECTRICAL AND MECHATRONICS ENGINEERING COURSES

ENEM 711 Continuum Mechanics – 3 Credits (New)
The general theory of continuous medium governs both solid and fluid mechanics. Kinematics of large deformation, stress, and strain tensors, conservation laws including conservation of mass, energy, linear and angular momentum, constitutive equations, and material models for elasticity, viscoelasticity, and plasticity.

ENEM 712 Elasticity – 3 Credits (New)
Fundamentals of solid mechanics and deformation, stress-strain and equilibrium and compatibility equations, generalized Hooke's law, boundary conditions. Plane strain, generalized plane stress, and planar elasticity. Airy stress function, torsion and bending, St. Venant principle, introduction to thermoelasticity, and numerical methods.

ENEM 713 Mechanics of Composite Structures – 3 Credits (New)
Current and potential applications of composite materials, fibers, matrices, manufacturing methods for composites, anisotropic elasticity, micromechanics for determining mechanical properties of composite materials, classical lamination theory, failure and strength analysis of composite materials, mathematical modeling, and other advanced topics related to mechanics of composite materials.

ENEM 714 Design of Autonomous Aerial Systems – 3 Credits (New)
Introduction to unmanned aerial vehicles, unmanned aircraft design; conceptual unmanned aerial vehicles design based on concepts drawn from weight estimation, aerodynamics, aircraft structure, stability and control, propulsion, navigation, guidance, communication, and design of control system; design for efficiency, design for performance, design for stability; flight dynamics equations are emphasized for design purposes; introduction to ground, wind tunnel, and flight testing.

ENEM 715 Nano-mechanics – 3 Credits (New)
Topics in computational nanomechanics, which involve the study of materials properties and structures down to a nanometer; classical molecular dynamics, lattice mechanics, Methods of thermodynamics and statistical mechanics, multiple-scale modeling, bridging scale and numerical applications, the material design.

ENEM 716 Advanced Fluid Mechanics – 3 Credits (New)
Advanced topics in fluid mechanics include Navier-Stokes equations and their exact solutions for classic cases, approximate solutions of Navier-Stokes equations, inviscid flow, irrotational flow, potential flow, and applications; boundary layer theory, introduction to compressible flow, and introduction to turbulent flow.

ENEM 717 Computational Fluid Dynamics – 3 Credits (New)
Physical and mathematical foundations of computational fluid mechanics with emphasis on applications. Classification of partial differential equations and solution techniques, Finite Difference Formulations, Solution methods for model equations, the Euler and the Navier-Stokes equations. The finite volume formulation of the equations, Truncation errors, stability, conservation, monotonicity, mesh generation. Computer coding and commercial software projects are included.

ENEM 718 Advanced Vibrations – 3 Credits (New)
Free and forced vibrations of multi-degree-of-freedom systems, modal analysis, Hamilton Principle and Energy Method to analyze free and forced vibrations of continuous systems such as axial bars, beams, shafts, etc. with different boundary conditions; different numerical methods and in particular finite difference methods to analyze discretized multi-degree-of-freedom systems.

ENEM 719 Optimal Control – 3 Credits (New)
Principles of optimal control theory for dynamics systems, constrained and unconstrained optimization problems, vibrational calculus, dynamic programming, Pontryagin's maximum principle, Hamilton-Jacobi-Bellman equation. Interactive numerical techniques for finding optimal trajectories.

ENEM 720 Adaptive Control – 3 Credits (New)
Introduction to control of systems with undetermined or time-varying parameters. Theory and application of self-tuning and model reference adaptive control for continuous and discrete-time deterministic systems. Model-based methods for estimation and control, stability of nonlinear systems, adaptation laws, and design and application of adaptive control systems.

ENEM 741 Probability and Random Process – 3 Credits (New)
Discrete-time and continuous-time cases. Basic concepts of random variables, random vectors, stochastic processes, and random fields. Common random processes include the white noise, Gaussian processes, Markov processes, Poisson processes, and Markov random fields. Moment analysis (including Karhunen- Loeve transform), the frequency-domain description, and linear systems applied to stochastic processes. Elements of estimation theory and optimal filtering include Wiener and Kalman filtering. Advanced topics in modern statistical signal processing such as linear prediction, linear models, and spectrum estimation are discussed.

ENEE 742 Stochastic Process – 3 Credits (New)
Correlations and spectra. Quadratic mean calculus, including stochastic integrals and representations, wide-sense stationary processes (filtering, white noise, sampling, time averages, moving averages, autoregression). Renewal and regenerative processes, Markov chains, random walk and run, branching processes, Markov jump processes, uniformization, reversibility and queuing applications.

ENEM 743 Information Theory – 3 Credits (New)
Introduction to information theory. Information measures: entropy, mutual information, relative entropy, and differential entropy. These topics are connected to practical problems in communications, compression, and inference, including lossless data compression, Huffman coding, asymptotic equipartition property, channel capacity, Gaussian channels, rate distortion theory, and Fisher information.

ENEM 744 Adaptive Signal Processing – 3 Credits (New)
Theory and application of adaptive algorithms like LMS and RLS in addition to non-linear extensions like generalized linear models, and Fokker-Planck theory for discrete time measurements of a continuous time state.

ENEM 745 Channel Coding Theory and Applications – 3 Credits (New)
The theory and application of channel coding for reliable communication. Basic results from information and coding theory (e.g., error exponents). Study of families of good codes, collectively referred to as turbo-like codes. Space-time code for multi-antenna wireless fading channels. Channel coding with transmitter side information, coding in the presence of feedback, connections between communications and control, coding for multi-user channels, recent capacity achieving codes such as polar codes, etc.

ENEM 746 Stochastic Control – 3 Credits (New)
Analysis and optimization of controlled stochastic systems. Models: linear and nonlinear stochastic controlled systems, controlled Markov chains. Optimization of systems described by Markov processes; dynamic programming under perfect and imperfect information, finite and infinite horizons. System identification: off-line, recursive. Stochastic adaptive control: Markov chains, self-tuning regulators, and bandit problems.

ENEM 747 Optimization Methods in Signal Processing and Machine Learning – 3 Credits (New) Optimization methods that are suitable for large-scale problems arising in data science and machine learning applications. Optimization algorithms are explored for solving convex/nonconvex, and smooth/nonsmooth problems appearing in signal processing and machine learning. The efficacy of these methods, which include (sub)gradient methods, proximal methods, Nesterov's accelerated methods, ADMM, quasi-Newton, trust-region, cubic regularization methods, and (some of) their Stochastic variants are studied. Constraint optimization over Riemannian manifold is also included.

ENEM 748 Introduction to Microwave Circuit – 3 Credits (New)
Transmission-line theory, microstrip and coplanar lines, S-parameters, signal-flow graphs, matching networks, directional couplers, low-pass and band-pass filters, diode detectors. Design, fabrication and measurements (1-10GHz) of microwave-integrated circuits using CAD tools and network analyzers.

ENEM 749 Introduction to Numerical Electromagnetics – 3 Credits (New)
Introduction to numerical methods in electromagnetics including finite difference, finite element and integral equation methods for static, harmonic and time dependent fields; use of commercial software for analysis and design purposes; applications to open and shielded transmission lines, antennas, cavity resonances and scattering.

ENEM 770 Special Topics – 3 Credits (New)
Topics of current interest selected by the faculty.

ENEM 797 Dissertations – 3 ~ 12 Credits (New)
This is the Ph.D. Dissertation for engineering graduate students.

The tables below are mappings for students who enter the Ph.D. program with the proposed M.S. in Electrical and Mechatronics Engineering.

ELECTRICAL AND MECHATRONICS ENGINEERING

Courses	Master's			Ph.D.			
	Core	Elective	Project/Thesis	Core	Concen	Elective	Diss
ENEM 601	X					X	
ENEM 602	X					X	
ENEM 603	X					X	
ENEM 611		X				X	
ENEM 612		X				X	
ENEM 613		X				X	
ENEM 614		X				X	
ENEM 615		X				X	
ENEM 616		X				X	
ENEM 617		X				X	
ENEM 618		X				X	
ENEM 619		X				X	
ENEM 620		X				X	
ENEM 621		X				X	
ENEM 622		X				X	
ENEM 623		X				X	
ENEM 624		X				X	
ENEM 641		X				X	
ENEM 642		X				X	
ENEM 643		X				X	
ENEM 644		X				X	
ENEM 645		X				X	
ENEM 646		X				X	
ENEM 647		X				X	
ENEM 648		X				X	
ENEM 649		X				X	
ENEM 650		X				X	
ENEM 651		X				X	
ENEM 652		X				X	
ENEM 653		X				X	
ENEM 670		X					
ENEM 688		X					
ENEM 696		X	X				
ENEM 697		X	X				
ENEM 711		X			X		
ENEM 712		X			X		
ENEM 713		X			X		
ENEM 714		X			X		
ENEM 715		X			X		
ENEM 716		X			X		
ENEM 717		X			X		
ENEM 718		X			X		
ENEM 719		X			X		
ENEM 720		X			X		
ENEM 741		X			X		
ENEM 742		X			X		
ENEM 743		X			X		
ENEM 744		X			X		
ENEM 745		X			X		
ENEM 746		X			X		
ENEM 747		X			X		
ENEM 748		X			X		
ENEM 749		X			X		
ENEM 770		X			X		
ENEM 797							X

Note:

1. **ENEM 797 Dissertation 3 - 12 credits for Ph.D. Dissertation**

2. **Students who hold an MS degree in Engineering can take 600-level courses as electives approved by the advisor towards the Ph.D. degree**
3. **Students who started with a BS in Engineering are expected to work towards MS in Electrical and Mechatronics Engineering first, then move on towards the Ph.D. program**

b. **Admission Standards**

To be considered for admission into the Ph.D./M.S. Degree Program in PHACE, a student (US and international) must satisfy the university-wide requirements for admission to graduate programs as established by the Graduate School of the university. However, the graduate committees for the various concentrations may require higher academic standards for admitting students to the departments' graduate programs. In general, the applicant must have completed a Bachelor's degree in electrical engineering, computer engineering, mechatronics engineering, general engineering, or a closely related technical field from an accredited undergraduate program. The applicant must have an acceptable GRE score. The applicant must submit all documents required by the graduate school to the admission office of the graduate school. In addition, each applicant should also submit:

i. Graduate Record Examination (GRE) basic test scores;
ii. A letter of intent describing his/her graduate studies goals and objectives.
iii. Three letters of reference from faculty, engineers, or supervisors that can certify his/her ability to pursue studies at the Ph.D./Master of Science level.

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

The section is not applicable as the proposed program is at the graduate level and does not contain any general education requirements.

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

The section is not applicable as the proposed program is at the graduate level and therefore, is not required to meet any specialized accreditation of graduate certification requirements.

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

The section is not applicable as the proposed program will not have a contract with another institution or non-collegiate organization.

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, 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 websites of the Departments of Computer Science and Engineering Technology and Engineering and Aviation Science. Information about the availability of academic/student support services, financial aid resources, and tuition payment policies can be found on the UMES Office of Graduate Studies website, as well as in the Financial Aid Office of UMES.

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.**

As with all other academic programs offered by the University of Maryland Eastern Shore, the proposed program will ensure that advertising, recruiting, and admissions materials will clearly and accurately represent the proposed program and the services available. In addition, the program will be advertised alongside other academic graduate programs within the School of Business and Technology at UMES. Proper venues include Public Radio WESM 91.3, and social media such as UMES Facebook page, the University Key, as well as through UMES alumni association, and other professional societies.

H. **Adequacy of Articulation**

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

The proposed program does not have articulation partners currently at the Ph.D./Master's degree level. However, the proposed program will support establishing an articulation with other system institutions at the bachelor's degree level, for example, a B.S./Ph.D. articulation between the B.S. in Physics program at Salisbury University and the proposed doctoral program at UMES. The goal of UMES is to work with partner institutions to provide a pathway for students interested in engineering or closely related fields to obtain a Ph.D. degree in engineering.

I. **Adequacy of Faculty Resources**

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 faculty member will teach in the proposed program.**

   There are six (6) full-time faculty qualified and (3) part-time faculty to teach in the Cybersecurity, Data and Computational Science, and Software Engineering concentrations. In addition to the current faculty resources, three (3) new faculty members will be added via the hiring process to support the Cybersecurity, Data and Computational Science, and Software Engineering concentrations over the next five years. Therefore, at the end of the five-year period, there will be nine (9) full-time faculty and (3) part-time faculty dedicated to the Cybersecurity, Data and Computational Science, and Software Engineering concentrations.

   The existing nine (9) faculty are listed below.

   Dr. Joe Ashby is a part-time faculty member in the Department of Computer Science and Engineering Technology. He received his Ph.D. in Computing Technology in Education from Nova Southeastern, M.S and B.S. degrees in Electronics & Computer Engineering Technology from Indiana State University. Dr. Ashby has extensive experience in Automation Engineering and Project Management, experience as a department chair, and face-to-face as well as online course development and delivery practice.

   Dr. DeWayne Brown is a part-time faculty member in the Department of Computer Science and Engineering Technology. Dr. Dewayne R. Brown holds the rank of Professor in Electronics Technology. He received his Ph.D. in Electrical Engineering from Virginia Polytechnic Institute and State University (Virginia Tech), his M.S. in Electrical Engineering from North Carolina Agricultural & Technical State University. He received his B.S. in Electrical Engineering from the University of South Carolina. His experiences include working at Naval Surface Warfare Center (NSWC), SPAWAR Joint-Base, Charleston, SC, and Penn State Applied Research Laboratory as a summer faculty researcher with a primary research focus in the area of global positioning systems.

   Dr. Celeste Chamberlain, CISSP, is a part-time faculty member in the Department of Computer Science and Engineering Technology. She received her D.Sc. in Emergency Management from Jacksonville State University, M.S. in Informatics from Northeastern University, and B.Sc in Computer Science from Hampton University. Her experiences include working with the U.S. Senate Homeland Security and Governance Affairs Committee as a cybersecurity legislative advisor, and 20 years creating cybersecurity governance under the Department of Homeland Security.

   Dr. Derrek B. Dunn is a tenured Professor in Computer Science and Engineering Technology. He received his Ph.D. and M.S. in Electrical Engineering from Virginia Polytechnic Institute and State University (Virginia Tech). His experiences include working at Hewlett-Packard Laboratory and Oak Ridge National Laboratory as a summer faculty researcher with a primary research focus in communications and networks. Dr.

Dunn teaches and conducts research in the areas of Cybersecurity, Global Positioning Systems, and Wireless Communication Systems.

Dr. Kenny Fotouhi is a Professor of Electrical Engineering Technology in the Department of Computer Science and Engineering Technology. He received his MS in Electrical Engineering from Oklahoma State University in 1979, and his Ph.D. in Electrical Engineering from the University of Missouri-Rolla in 1983. He was an Interim Chair of the Department of Technology from 2018-to 2021. Dr. Fotouhi has been active in area research and published numerous papers in Electrical Engineering and Solid- State Physics Fields. He has been involved in joint research in the growth and development of new semiconductors and Maryland offShore Wind Energy Research and Smart Agriculture- Smart farming. He was the recipient of the 1990 University of Maryland Eastern Presidential Distinguished Research Award and he is a member of ASEE and IEEE and the Eta Kappa Nu Honor Society.

Dr. Gurdeep S. Hura is a faculty in the Department of Computer Science and Engineering Technology. Dr. Gurdeep S. Hura received his B. E. from Jabalpur University (India) in 1972, M. E. from University of Roorkee (India) in 1975, and Ph.D. from University of Roorkee (India) in 1984, respectively. He was on the faculty of REC, Kurukshetra (India) 1975-1984, a Post Doctoral Fellow in the Department of Computer Science, Concordia University, Montreal, Canada 1984-1985, faculty in the Department of Computer Science and Engineering of Wright State University, Dayton, Ohio (USA), 1984-1993, faculty and visiting research fellow in the School of Applied Science, Nanyang Technological University, Singapore 1993-1998, Director and coordinator of Department of Computer Science, University of Idaho, Idaho Falls 1998-2005. Dr. Hura served as Professor and Chair in the Department of Electrical and Computer Engineering, West Virginia University Institute of Technology, Montgomery, West Virginia Jan 2005-July, 2006, Professor and Chair of Department of Mathematics and Computer Science, University of Maryland Eastern Shore July 2006-Sept 2011, and a Professor in the same department since Oct 2011. He was awarded an excellent teaching award in 1991 and 2001 and excellence in advising in 2003. He is an author/co-author of over a hundred technical papers, which were published, in International IEEE journals and refereed conferences. He guest edited three special issues on "Petri nets and related graph models: Past, Present and Future", 1991, “The Practice of Performance modeling and reliability analysis,” 1996, and “Internet: The state of the art,” Computer Communication (Elsevier, UK), 1998. He is a senior member of IEEE and was elevated to Fellow of the Society for Design and Process Science in 2002. He received a Post-Tenure Review award of Excellence in recognition of the outstanding achievement of exemplary Research/Scholarship and Service, May 2018 and Distinguished Scholar Award, School of Graduate Studies, UMES, 2015. He has organized tutorials on Computer Networks, Modeling and analysis, Software engineering, Cyberinfrastructure, Cyber security, and Accreditation Boards of Engineering and Technology (ABET) accreditation, and has presented invited talks on these at various International Conferences.

Dr. Rakesh Sharma is a Lecturer in the Department of Computer Science and Engineering. He has been teaching Computer Science and Math classes in the Department of Computer Science and Engineering Technology at the University of Maryland Eastern Shore for more than 18 years. He completed his B.S. degree in Engineering from the University of North Carolina at Charlotte, and MIS Degree from the North Carolina Central University-Durham. He has completed 18 graduate credit hours in Computer Science and 18 credit hours in Cyber Security. He completed his Ph.D. in Computer Science from Gyan Vihar University, Jaipur. Before joining the University of Maryland he worked for EDS (as an IT contractor for the Department of Defense, American Airlines, US Postal Service), IBM, and Micron Computers. Dr. Sharma has done considerable research in the following areas: machine learning, cybersecurity, decision support systems for critical infrastructure, data analysis, and project and resource management. He has published over fifteen research papers in peer-reviewed journals and given several conference presentations.

Dr. Weiwei Stone is an Associate Professor in the Department of Computer Science and Engineering. With a multi-background in computer science, applied mathematics, and electronic engineering, she has taught over 20 courses in multi-disciplines and advised students' research and graduate projects at both the undergraduate and graduate levels. Her research interests include Blockchain, big data analysis, game-based learning, tsunami prediction, wavelet analysis, and non-uniform B-spline analysis. Dr. Stone has been active in serving in professional areas as well as in the local community. She also directs the graduate program of the department.

Dr. Jun Zhang is a tenured Associate Professor in the Department of Computer Science and Engineering Technology. He is the first Interim Chair of the new Department of Computer Science and Engineering Technology, established in January 2021. He joined UMES as an Assistant Professor in August 2014. At UMES, he has taught over 10 classes at both the undergraduate and graduate levels, including Programming Languages, Algorithms and Data Structures, Operating Systems, Software Engineering, Computational Science, among other courses. Dr. Zhang has been actively conducting research works; his research interests include algorithms and theory, data and computational science, and computer science education. Dr. Zhang is well educated in both China and the USA. He has four degrees, including a Ph.D. from the University of Rhode Island in Computer Science. Dr. Zhang has ample work experience in both academia and industry, as he previously worked as an advanced software engineer at Siemen and has taught in China, Vietnam, and the USA.

There are seven (7) full-time faculty qualified to teach Electrical and Mechatronics Engineering courses in the two concentrations, i.e., Mechatronics and Control, and Communications and Networks. Three (3) new faculty members will be hired over the next five years to support the Mechatronics and Control, and Communications and Network concentrations. Therefore, at the end of the five-year period, there will be ten (10) full-time faculty dedicated to the Mechatronics and Control, and Communications and Network concentrations.

The existing seven (7) faculty are listed below.

Dr. Ibibia K. Dabipi, **Professor of Electrical Engineering**. 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 a primary research focus in communications and networks.

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

Dr. Payam Matin, **Professor of Mechanical Engineering**. 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, sheet metal forming, drone design, etc.

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

Abhijit Nagchaudhuri, **Professor of Mechanical Engineering**. He received a 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 of Electrical Engineering. 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 of Electrical Engineering. He received his Ph.D. in Electrical Engineering from the University of Nevada, Las Vegas. His primary research area is in computer networks, microprocessors and microcomputers, embedded system design, etc.

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

The Center for Teaching Excellence (CTE) provides ongoing pedagogy training for faculty in evidence-based best practices to support high-impact practices pedagogy to meet the needs of UMES students. To accomplish its mission of ensuring expanding and enhancing faculty pedagogy training, CTE has developed three broad program areas to support faculty teaching success which includes evaluation of teaching techniques, professional development of faculty as it relates to pedagogy, and recognition of faculty who have demonstrated outstanding pedagogy methodology.

The evaluation of teaching techniques program includes the use of student experience of learning surveys, peer observation of teaching, and open classroom week. The professional development of the faculty program includes funding to attend pedagogy conferences, faculty workshops, FACTE working group, seminar series for new faculty, and innovation in teaching & learning conferences. Lastly, CTE's faculty recognition program includes student choice for teaching excellence e-badge, CTE website – faculty spotlights, and SOTL publication opportunities.

b) The learning management system

The Center for Instructional Technology and Online Learning (CITOL) at UMES supports the development, design, and delivery of online and hybrid programs, classes, and workshops with a focus on flexibility, resiliency, equity, accessibility, privacy, and safety (FREAPS). CITOL assists faculty, staff, and students in all aspects of digital teaching and learning concerning pedagogy and technology. This includes the use of the Canvas Learning Management System, Echo360, Google Workspace, Respondus 4.0, and Respondus LockDown Browser.

c) Evidence-based best practices for distance education, if distance education is offered.

The Center for Instructional Technology and Online Learning (CITOL) at UMES supports the development, design, and delivery of online and hybrid programs, classes, and workshops with a focus on flexibility, resiliency, equity, accessibility, privacy, and safety (FREAPS). CITOL assists faculty, staff, and students in all aspects of digital teaching and learning concerning pedagogy and technology. This includes the use of the Canvas Learning Management System, Echo360, Google Workspace, Respondus 4.0, and Respondus LockDown Browser. Other Services offered by the Center for Instructional Technology and Online Learning include: supporting Canvas Learning Management System (LMS) and other instructional software which can be found on the CITOL website: new resources; providing ongoing professional development through virtual workshops; conducting UMES Online Teaching Certification & Course Quality Review; developing interactive and assessment materials for classes; and helping troubleshoot student problems on LMS.

J. **Adequacy of Library Resources**

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

The Frederick Douglass Library is the only library on the University of Maryland Eastern Shore (UMES) campus. As a member of the University of System of Maryland and Affiliated Institutions (USMAI) consortium, the Frederick Douglass Library is affiliated with 17 public universities and colleges in the state of Maryland. The integrated library system ALEPH makes it possible for patrons to have 24/7 access to USMAI library collections and electronic resources. In-person visits to the library are available 91.5 hours per week including weekends.

The Frederick Douglass Library has the following resources available and/or the measures to be taken to ensure resources are adequate to support the proposed programs:

Books, periodicals, and other reference materials may be located and obtained for patron usage at any time online via the library catalog, online databases, interlibrary loan, inter-campus loan, or by visiting the library.

ILLIAD (Interlibrary Loan) service allows students, faculty, and staff to take advantage of the millions of items from other universities that are not available at the Frederick Douglass Library.

Interlibrary Loan allows the borrower to request items (books, and articles from non-university of Maryland System libraries. The average time to receive an article is 2 weeks. The average time to receive a book is 3 weeks. There is also Rapid Interlibrary Loan (Rapid ILL) where most articles may be received within 24 hours.

Borrowers are notified by email from the FDL staff to pick up items from the Inter-Library Loan service desk. Many articles requested will be received electronically and available to be accessed within ILLIAD.

Inter-campus loans may be requested from another University of Maryland System Library and delivered to the FDL for patron pick up. The average time to receive a book is 3-5 days.

Resources that are available electronically via the Frederick Douglass webpage are databases, e-books and e-journals. Open Education Resource Textbooks is a search interface that allows faculty to retrieve OER resources to be used as course materials at no cost to students.

There are over 140 databases pertaining to research in 17 subject areas.

Databases by Subject

Agriculture	Health & Medicine
Business Management & Accounting	History
Computer Science & Engineering Technology	Hospitality & Tourism Management
Criminal Justice & Government	Human Ecology
Education	Life Sciences
Engineering & Aviation Science & Built Environment	Pharmacy
English & Modern Languages	Physical Sciences
Fine Arts	Physician Assistant
	Social Sciences

Library Holdings as of 2022 for Proposed Degree Programs

New Program(s)	eJournal Titles	eBooks

Applied Computing and Engineering	125	500
Construction Engineering Program	150	750
Biomedical & Bioengineering Program	20	400
Simulation & Game Development Program	40	150
Aviation Science	25	100

Print books and periodicals are located on the three floors of the Frederick Douglass Library. Periodicals are housed on the Lower Level. Reference books are on the first floor. Circulating and Special Collections books are located on the second floor of the library.

To ensure that resources are adequate to support the proposed programs, the library director and library liaisons will network and collaborate with program faculty with the selection of resources to be housed in the library. There is a one-credit Library Information Literacy class that is taught each semester, winter and summer sessions. Individual classroom library sessions are also taught upon request by the instructor. This instruction can range from basic research and knowledge of the library to the highest level of research for those seeking graduate degrees.

The University assures that institutional library resources meet the new program's 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 Xplore, the technical papers could be accessed through the Interlibrary Loan (ILL) services.

K. **Adequacy of Physical Facilities, Infrastructure, and Instructional Equipment**

1. **Assure 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: an Embedded System Lab, Communications Lab, Microwave Chamber, CAD/VLSI Lab, High Bay Area, multiple computer labs, etc. The before-mentioned labs can support the proposed new courses and research activities. A complete list of engineering labs with brief descriptions can be viewed at the following link:
   https://www.umes.edu/Engineering/DynContent/Laboratories/

   The Department of Computer Science and Engineering Technology is located in the Engineering and Aviation Science Complex, a state-of-the-art building with 166,000 square feet facility that houses classrooms, laboratories, tutorial rooms, an auditorium, student lounges, study areas, and a fast-food restaurant. All faculty and staff have individual offices where they can conduct various works, including student advising, office hours, research, and services.

The Department of Computer Science and Engineering Technology has six dedicated computer laboratories (where students learn programming and coding using C++, COBOL, Assembly, Java, Python, Networking, SAS, etc.) at their disposal, including:

- EASC 2112 - Supercomputer Lab (contains the mainframe)
- EASC 2108 - Graduate Lab (22 computer stations with private desks and overhead storage that graduate students may use for conducting research and completing projects)
- EASC 2122 - CS Computer Lab Computer Programming (classroom/lab with 31 computer stations loaded with software, applications, and programs)
- EASC 2121 - CS Computer Lab Computer Programming (classroom/lab with 35 computer stations loaded with software, applications, and programs)
- EASC 2090 - Software Engineering Lab (classroom/lab with 28 computer stations loaded with a variety of software, applications, and programs)
- EASC 2091 - Database Lab (classroom/lab with 35 computer stations loaded with software, applications, and programs)
- The Department has five dedicated laboratories for engineering technology:
- ATC 1046 – Electronics Lab: The Electronics Lab contains circuit analysis and test equipment utilized by the Electrical/Electronic Engineering Technology program. The equipment includes function generators, oscilloscopes, digital multimeters, a PCB milling machine, high power generation, and transmission trainer, soldering equipment, and other various test equipment. The lab is fitted with 14 computers with double screen monitors that host several types of software related to electronics.
- ATC 1050 – Communications Lab: The Communications Lab contains specialized equipment for analyzing and testing Radio Frequency (RF) and Microwave communication signals and systems. The equipment includes two network analyzers, two spectrum analyzers, two Lab-Volt analog communications, trainers, two Lab-Volt digital communication trainers, LCR meters, frequency counters, oscilloscopes, and an antenna design and testing trainer.
- ATC 1045 – Global Positioning Systems (GPS) Laboratory: The GPS Lab is a dedicated lab space for developing and testing communication systems related to GPS. This lab includes a grant funded $250,000 CAST Navigation system for simulating and modeling advanced navigation technology related to military, federal, and commercial sectors of industry.
- EASC 1028 – Communications Laboratory: The Communications Laboratory is a shared laboratory space with the Department of Engineering. This Lab includes 32 computers with various engineering, programming, and simulation software. This computer lab is fitted with five wall mounted LCD screens for multiple viewing angles and small work groups.
- EASC 1028 – Embedded Systems Laboratory: The Embedded Systems Laboratory is a shared laboratory with the Department of Engineering. This laboratory contains equipment for designing, testing, and simulating embedded devices and systems.

The equipment in this lab includes benchtop multimeters, oscilloscopes, function generators, 3D printers, Bolt Sphero robots, digital logic analyzers, digital electronics trainers, soldering stations, and 10 computers.

These labs can support the instruction in the new courses and research activities as part of the proposed degree program. A complete list of computer science and engineering technology labs with brief descriptions can be found using the link: https://wwwcp.umes.edu/cset/cset-laboratories/

All engineering faculty and staff have individual offices that will facilitate student advising, office hours, etc. Sufficient classrooms are also available in the same building, which makes it very convenient for students to take classes and conduct laboratory experiments.

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 learning resources.

L. **Adequacy of Financial Resources with Documentation**

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)	$95,208	$135,056	$236,812	$281,025	$326,912
a. # FT Students	5	10	15	20	25
b. # Annual Tuition/Fee Rate	$9,300	$9,486	$9,676	$9,869	$10,067
c. Annual / Full Time Revenue (a x b)	$37,200	$75,888	$116,109	$157,908	$201,332
d. # PT Students	5	5	10	10	10
e. Credit Hour Rate	$413	$422	$430	$439	$447
f. Annual Credit Hours	18	18	18	18	18
g. Total Part Time Revenue (d x e x f)	$58,008	$59,168	$120,703	$123,117	$125,579
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)	$95,208	$135,056	$236,812	$281,025	$326,912

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)	$189,000	$283,500	$378,000	$472,500	$567,000
a. # FTE	2	3	4	5	6

b. Total Salary	$140,000	$240,000	$280,000	$350,000	$420,000
c. Total Benefits [35%]	$49,000	$73,500	$98,000	$122,500	$147,000
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	$50,000	$50,000	$50,000	$50,000
5. Library	0	0	0	0	0
6. New or Renovated Space	0	0	0	0	0
7. Other Expenses	$17,500	$16,000	$16,000	$16,000	$16,000
TOTAL (Add 1 - 7)	$256,500	$349,500	$444,000	$538,500	$633,000

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 increase for the next five years ($9,300, $9,486, $9,676, $9,869, and $10,067). The in-state part-time tuition rate per credit hour is currently $413 per credit. This value was used in calculating the revenue assuming 9 credits per semester for full-time students and 18 credits per academic 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)

   Over the next five years, six (6) new full-time tenure-track faculty members (with backgrounds in the proposed concentrations) will be hired. The new faculty hires, in addition to the current faculty, will support the proposed doctoral programs including the pass-thru master's program(s).

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

2. Support Staff (# FTE, Salary and Benefits)
   None

3. Equipment
   Funds in this budget line will be used to purchase major equipment to support the research efforts of the proposed granted program.

4. Library
   Minimal funds are needed to purchase additional engineering textbooks.

5. New and/or Renovated Space
   Not needed

6. Other Expenses
   Funds allocated in this line will be used for the start-up package to support the new faculty. The funds will be used for professional development, including developing proposals for grants and contracts, travel, and supplies for specialized engineering labs.

M. **Adequacy of Provisions for Evaluation of Programs**

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 portfolios 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, and school-wide and department service. To receive a high evaluation, a faculty member must demonstrate effective teaching, active scholarly activities, publication, etc. There is also a provision for the administration to set out an improvement plan for faculty members who have not done well in the area of teaching. Tenured faculty will undergo a five-year post-tenure review.

Program assessment takes place in a six-year cycle. 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.

N. Consistency with the Commission’s Minority Student Achievement Goals

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

   UMES's 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 the student population being 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 M.S. in Electrical and Mechatronics Engineering program.

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.
Appendix A: Funding Letter from Microsoft Corporation

Microsoft Corporation
One Microsoft Way
Redmond, WA 98052-6399

Tel 425 882 8080
Fax 425 706 7329
www.microsoft.com

Microsoft

March 2, 2022

Dr. Derrek B. Dunn
University of Maryland Eastern Shore
30665 Student Services Center
EASC Complex, Suite 3087
Princess Anne, MD 21853

Dear Dr. Dunn,

Microsoft is pleased to provide the University of Maryland Eastern Shore with an unrestricted gift of $75,000 to support the School of Business and Technology in funding the Computing and Interdisciplinary Engineering Degree Programs Branding Project, the Student Club Combined Organization Project, the Micro-credential/Badge Initiative Project and the Aviation and Cybersecurity Project.

Microsoft is committed to compliance with any and all applicable laws, regulations and ethics rules concerning the receipt of contributions, including university policies. Microsoft engaged with the University of Maryland Eastern Shore without seeking promises or favoritism for Microsoft or any of its affiliates in any bidding arrangements. Further, no exclusivity will be expected from you, your institution, or its affiliates in consideration for this engagement.

Dr. Brissa Quiroz will be your main contact regarding Microsoft's financial support. If you have any questions regarding this contribution, please feel free to contact her by e-mail at brissaq@microsoft.com or by phone at (559) 290-9079.

Sincerely,

Kathryn Neal

Dr. Kathryn Neal
Senior Director, University Relations

Microsoft Corporation is an equal opportunity employer.

Appendix B: Support Letters from Corporations, Government, and Educational Entities

Dr. Derrek B. Dunn, Professor and Dean
School of Business and Technology
30665 Student Services Center
EASC Complex, Suite 3087
Princess Anne MD 21853

Re: Ph.D. in Applied Computing and Engineering

February 23, 2022

Dear Dr. Dunn,

Please accept this letter in support of the proposed Ph.D. in Applied Computing and Engineering academic program at the University of Maryland Eastern Shore (UMES).

Our leading economic sectors include agriculture, aeronautics, wireless component manufacturing, life sciences (animal and human) and health care. All of these areas can greatly benefit from the proposed program by encouraging advanced degrees among existing employees and in offering job opportunities at advanced levels to program graduates. This would strengthen these important sectors, help in attracting additional jobs and investments from prospective companies and further stabilize and offer growth opportunities for the Lower Eastern Shore's economy.

Thank you for your leadership and please let me know how I or my office may further assist.

Very Truly Yours,

David Ryan
Executive Director