UNIVERSITY OF MARYLAND
OFFICE OF THE PRESIDENT

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December 22, 2020

James D. Fielder, Jr.
Secretary of Higher Education
Maryland Higher Education Commission
6 N. Liberty Street
Baltimore, MD 21201

Dear Secretary Fielder:

I am writing to request approval for a new Bachelor of Science program in Mechatronics. This program will be offered exclusively at the Universities at Shady Grove; accordingly, we request a waiver for the on-campus requirement as outlined in COMAR 13B.02.03.20. The proposal for the new program is attached. I am also submitting this proposal to the University System of Maryland for approval.

The proposal was endorsed by the appropriate faculty and administrative committees and was recommended for approval by the University Senate at its meeting on December 8, 2020. I also endorse this proposal and am pleased to submit it for your approval.

Sincerely,

Darryll J. Pines

Darryll J. Pines
President
Glenn L. Martin Professor of Aerospace Engineering

DJP/mdc

cc: Antoinette Coleman, Associate Vice Chancellor for Academic Affairs
Mary Ann Rankin, Senior Vice President and Provost
Robert Briber, Dean, A. James Clark School of Engineering

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

Institution Submitting Proposal	University of Maryland, College Park

Each action below requires a separate proposal and cover sheet.

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

Payment Submitted: ( ) Yes (●) No	Payment Type: (●) R*STARS ( ) Check	Payment Amount: 850	Date Submitted:

Department Proposing Program	Aerospace Engineering
Degree Level and Degree Type	Bachelor: Bachelor of Science
Title of Proposed Program	Mechatronics
Total Number of Credits	121
Suggested Codes	HEGIS: 092100 — CIP: 14.4201
Program Modality	(●) On-campus ( ) Distance Education (*fully online*)
Program Resources	(●) Using Existing Resources ( ) Requiring New Resources
Projected Implementation Date	(●) Fall ( ) Spring ( ) Summer Year: 2022
Provide Link to Most Recent Academic Catalog	URL: https://academiccatalog.umd.edu/
Preferred Contact for this Proposal	Name: Michael Colson
	Title: Senior Coordinator for Academic Programs
	Phone: (301) 405-5626
	Email: mcolson@umd.edu
President/Chief Executive	Type Name: Darryll J. Pines
	Signature: Darryll J. Pines Date: 12/02/2020
	Date of Approval/Endorsement by Governing Board:

Revised 4/2020

A. Centrality to the University's Mission and Planning Priorities

Description. Mechatronics can be concisely described as the combination of mechanical, electrical, and information systems engineering. Mechatronics engineers design, develop, and test automated production systems, transportation and vehicle systems, robotics, computer-machine controls, and many other integrated systems. Mechatronics engineers also develop new technologies for use in the automotive and aviation industry, advanced manufacturing operations, and often specialize in areas such as robotics, autonomous vehicles, and manufacturing systems. The Bachelor of Science in Mechatronics will provide students with a fundamental understanding of mechatronic systems analysis, the knowledge of how these systems are developed and deployed, and the practical experience required to implement mechatronic systems in real-world applications. Graduates of the program are expected to be highly sought after in fields such as aerospace & defense, energy, infrastructure, manufacturing & automation, robotics, and biomedical engineering.

The proposed Bachelor of Science in Mechatronics, to be offered at the Universities at Shady Grove, seeks to address the growing need for cross-disciplinary engineers skilled in the areas of robotics, automation, and advanced manufacturing technologies, collectively known as Industry 4.0. As society moves into the 4th industrial revolution, the regional economy is redoubling its focus on high-tech industries like biotechnology and aerospace/defense, fields which rely heavily on the broad expertise offered by engineers trained in Mechatronics.

Relation to Strategic Goals. The proposed major in Mechatronics relates to UMD's strategic goals by adding to its STEM program offerings, most specifically at the Universities at Shady Grove (USG). The Mechatronics major aligns with the University Mission Statement, to "advance knowledge in areas of importance to the State", as well as the undergraduate learning objectives 4.1.3 and 4.1.9, to "increase the number of graduates in fields that support the workforce needs of the state and the nation by creating new programs and pathways", and to "continue to improve pathways for transfer students in our undergraduate programs on the College Park campus and at regional centers such as the Universities at Shady Grove," respectively.

The Mechatronics program is the third of three UMD engineering programs planned for delivery specifically at the Universities at Shady Grove to contribute to workforce development in the state and most specifically in the Montgomery County region, taking advantage of the robust partnership with Montgomery College. USG's mission is *"to support and expand pathways to affordable, high-quality public higher education that meet the distinctive needs of the region and are designed to support workforce and economic development in the state; to achieve these goals through partnerships and collaborations with academic, business, public sector and community organizations that promote student success, high academic achievement and professional advancement."* This program contributes directly to the goals of access and affordability, to high quality programming, and to regional and state capacity building, as articulated in USG mission statement.

Funding. Resources for the new program will be drawn from the University System of Maryland's Workforce Development Initiative that was approved by the State Legislature beginning in FY19. Funds were specifically directed to increasing the number of undergraduate degree offerings in STEM areas at the Universities at Shady Grove.

Institutional Commitment. The program will be administered by the Department of Aerospace Engineering within the A. James Clark School of Engineering. Each of UMD's USG programs has an on-site program director. In addition, two staff members are currently in residence at USG to support the program directors in admissions decisions and to provide academic operational support such as recruiting, outreach to community colleges, access to training, and to act as a liaison to academic services on the College Park campus. The University of Maryland (UMD) is also the managing institution for USG, and in that role supports many administrative services for the operation of USG.

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

Need. This program will be offered exclusively at the Universities at Shady Grove; accordingly, we request a waiver for the on-campus requirement as outlined in COMAR 13B.02.03.20. The Maryland State Plan for Postsecondary Education highlights the need to ensure equitable access to higher education for the diverse population of the state, and offering a Mechatronics baccalaureate program at USG expands opportunities for students along the I-270 tech corridor region who may otherwise be geographically prohibited from participation at other USM institutions. The program will offer students who have completed their first two years of STEM-focused postsecondary education at a Maryland public community college (MPCC) or institutions a pathway to continue their studies in a growing field and earn a terminal four year degree. Providing for these students' success through this lower cost option - 2 years at an MPCC followed by 2 years in a UMD program delivered at USG - helps to reduce the financial burden potential students may face otherwise. The innovative curriculum will combine a solid theoretical foundation with practical implementation skills that prepare graduates for a productive and impactful career in regional industries like defense, aerospace, and advanced manufacturing.

State Plan. The proposed program aligns with the *Maryland State Plan for Postsecondary Education* in several ways. First, the program aligns with the state's emphasis on career training and research. Strategy 7 of the *Maryland State Plan* is "Enhance career advising and planning services and integrate them explicitly into academic advising and planning."[1] Career advising will not only be integrated with student advising, it will also be incorporated in the program coursework. All of the core courses for the program will help students achieve this outcome

[1] Maryland Higher Education Commission. (2017). *Maryland State Plan for Postsecondary Education.* (p. 60). Retrieved October 29, 2018 from: http://www.mhec.state.md.us/About/Documents/2017.2021%20Maryland%20State%20Plan%20for%20Higher%20Education.pdf.

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

The US Department of Labor, Education and Training Agency (DOL ETA) recently added a classification for Mechatronics Engineer (17-2199.05) distinct from other occupations.[2] Combined with the related occupations of Robotics Engineers (17-2199.08) and others, the U.S. Department of Labor's Bureau of Labor Statistics, Occupational Employment Statistics Program (BOL OESP) projects 4%-6% average growth in this occupation from 2018-2028 nationwide, accounting for nearly 12,000 new jobs.[3]The State of Maryland in particular is projected to see higher than average opportunities for Mechatronics Engineers[4], both in terms of job placement and median wages, which according to the BOL OESP are 45% higher than the national average ($140,840 in Maryland vs. $96,980 nationwide). This corresponds to over 7,000 jobs in Mechatronics and related industries specifically, and an even greater number considering the broad based skill set that Mechatronics engineering students offer to employers.[5]

D. Reasonableness of Program Duplication

During the time that this program has been under development, there were no Bachelor's degree programs for Mechatronics in the State of Maryland. Anne Arundel Community College offers an Associate of Applied Science (AAS) degree in Mechatronics Technology. Additionally, Johns Hopkins University offers a Master's degree program in Mechatronics, Robotics, and Automation Engineering. The proposed Mechatronics program at USG will help fill an important gap, particularly in the central and northwest geographic areas of the state in which there is significant market demand. The program is expected to draw students who have already acquired the fundamentals in Maryland's community college system and who are not interested in pursuing one of the more standard 4-year engineering degrees available within the University of System of Maryland or other campuses in the state.

In November 2020, Morgan State University announced plans to launch a Mechatronics program on approximately the same time scale as the program proposed here[6]. It is our belief that the market demand is sufficiently high, the geographic draw of students is sufficiently distinct, that both programs will provide valuable contributions to the Maryland workforce.

One might also anticipate some overlap between a Mechatronics degree program and a Mechanical Engineering program, such as that to be offered by the University of Maryland Baltimore County at the Universities at Shady Grove. Experts from the two universities have met to discuss the similarities and differences between the two programs and have determined

[2] 2018 ASEE Southeastern Section Conference American Society for Engineering Education, 2018 Growth of 2-Year programs for Mechatronics Marilyn Barger, Richard Gilbert

[3] National Center for O*NET Development. 17-2199.05 - Mechatronics Engineers. O*NET Online. Retrieved January 28, 2020, from https:// www.onetonline.org/link/summary/17-2199.05

[4]National Center for O*NET Development. State Map for Mechatronics Engineers. My Next Move. Retrieved January 28, 2020, from https:// www.mynextmove.org/profile/state/17-2199.05?from=profile

[5] https://www.dllr.state.md.us/lmi/iandoproj/maryland.shtml

[6] https://news.morgan.edu/stem-program-offerings/

that the curricula are distinct and complementary, although discussion is already underway about the possibility of sharing both equipment and program electives.

E . Relevance to Historically Black Institutions (HBIs)

As noted above, development of the UMD Mechatronics program began in 2018, responding to a call for engineering pathway programs at the Universities at Shady Grove and with the support of Governor Hogan's Workforce Development Initiative. At that time, we had determined that no historically black institutions in Maryland offered a bachelor's program in Mechatronics. With the proposed new program at Morgan State University now in view, our position remains that the two programs, while leading to the same credential, differ substantially in the target student audience. It is important to note that there are no residential facilities at the Universities at Shady Grove so all students in the program proposed here would have to be within commuting distance from the Rockville campus. A significant majority of students will be drawn from Montgomery College.

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

See above.

G. Adequacy of Curriculum Design, Program Modality, and Related Learning Outcomes

Curricular Development. The curriculum was developed by faculty of the Aerospace Engineering department in collaboration with faculty in Electrical and Computer Engineering and in Mechanical Engineering. All of the undergraduate programs within the A. James Clark School of Engineering are "limited enrollment programs", due to high demand and finite capacity.

The program will be offered exclusively at the Universities at Shady Grove. All undergraduate programs at USG are years 3 and 4 only. Expectations for lower-level coursework will be established through articulation agreements with the Maryland community colleges or taken at College Park prior to admission to the School of Engineering and the major. The proposed curriculum will offer courses at the 300- and 400-level, which constitute the junior and senior year of the program. The program is primarily intended for students transferring from a Maryland public community college. While students at the College Park campus can pursue the program, they will not be able to seek admission into the School of Engineering and Mechatronics major until they have completed the Engineering Limited Enrollment Program (LEP) gateway courses, required prior study major courses, lower-level General Education requirements (or an Associate's Degree), and have earned at least 60 credits.

Faculty Oversight. The faculty within the department of Aerospace Engineering will provide academic direction and oversight for the program. Appendix A contains a list of the relevant faculty.

Educational Objectives and Learning Outcomes. The educational objectives of this program are established to produce top-notch graduates to fill the growing need for workers experienced with integrated mechanical and electrical systems. The Bachelor of Science in Mechatronics will produce engineering graduates who:

1. Apply their training in combining mechanical, electrical, and aerospace problem solving skills to contribute professionally in industrial or research settings;
2. Demonstrate leadership, teamwork, and professional ethical responsibility;
3. Demonstrate an appreciation for their professional activities on society as a whole.

The program will additionally use the following ABET learning outcomes:

1. An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics;
2. An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economics factors;
3. An ability to communicate effectively with a range of audiences;
4. An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts;
5. An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goads, plan tasks, and meet objectives;
6. An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions;
7. An ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

Institutional assessment and documentation of learning outcomes. Assessment of the program will follow the same plan that the Department of Aerospace Engineering (ENAE) uses for assessing its major for ABET accreditation purposes. Aerospace Engineering and Mechanical Engineering faculty members establish and assess the Mechatronics Program Educational Objectives (PEOs). The faculty members evaluate achievement of the PEOs based on indicators informed by reviewing relevant data from program constituencies (students, faculty, and corporate partners). The departments' Undergraduate Affairs Committees will evaluate recommendations from these constituencies before modification of PEOs. A proposal of these modifications will be presented to the Chairs, the Department Councils, and Department Advisory Boards for feedback prior to a vote for adoption by faculty.

Student Learning Outcomes are evaluated through course-specific performance indicators. The Department will establish rubrics for each performance indicator and develop a course-related assessment as part of this evaluation. Faculty members will then be asked to evaluate the students through these course assessments. Assessment of learning outcomes will take place each year.

Course requirements.

FIRST & SECOND YEAR

Prior to being admitted to the Mechatronics major, students should have completed the Engineering LEP gateway courses, basic math/science courses, and lower-level General Education requirements. Below is the representative set of requirements; specific articulation agreements will be established with each of the local community colleges.

Course	Title	Cr
ENGL 101	Academic Writing	3
MATH 140	Calculus I	4
MATH 141	Calculus II	4
MATH 241	Calculus III	4
MATH 240	Introduction to Linear Algebra	4
MATH 246	Differential Equations for Scientists and Engineers	3
CHEM 135	General Chemistry for Engineers	3
PHYS 161	General Physics: Mechanics and Particle Dynamics	3
PHYS 260/261	General Physics: Vibration, Waves, Heat, Electricity and Magnetism (plus Laboratory)	4
PHYS 270/271	General Physics: Electrodynamics, Light Relativity and Modern Physics (plus Laboratory)	4
ENES 100	Introduction to Engineering Design	3
ENES 102	Mechanics I	3
ENES 220	Mechanics II	3
ENES 232	Thermodynamics	3
GenEd Courses	General Education Requirements (for A.A.S.)	12
	Total Credits	**60**

JUNIOR & SENIOR YEARS AT SHADY GROVE

Junior Year 1st Semester

Course	Title	Cr
ENMT 301	Dynamics	3
ENMT 305	Electro-mechanical Circuits and Systems	3
ENMT 364	Aerospace Sciences Laboratory	4

ENMT 380	Flight Software Systems	3
ENMT 387	Manufacturing Processes	3
	Total Semester Credits	**16**

Junior Year 2nd Semester

Course	**Title**	**Cr**
ENMT 313	Real Time Software Systems and Microprocessors	3
ENMT 432	Classical Control Theory	3
ENMT 324	Structures	3
ENMT 3XX	Technical Elective (based on track within program)	3
ENGL 393	Professional Writing	3
	Total Semester Credits	**15**

Senior Year 1st Semester

Course	**Title**	**Cr**
ENMT 483	Mechatronics Systems I	3
ENMT 461	Mechatronics and Controls Lab I	3
ENMT XXX	Three program electives (see below)	9
	Total Semester Credits	**15**

Senior Year 2nd Semester

Course	**Title**	**Cr**
ENMT 484	Mechatronics Systems II	3
ENMT 462	Mechatronics and Controls Lab II	3
ENMT XXX	Three program electives (see below)	9
	Total Semester Credits	**15**

TOTAL DEGREE CREDITS	**121**

The program will offer electives; at the same time, opportunities for electives outside the program may become available as the program matures, including USG programs offered by other universities.

Autonomous Air Vehicles Track – Program Elective Courses

Course	**Title**	**Cr**
ENMT 471	Advanced Manufacturing and Automation	3
ENMT 472	UAV Flight Testing	3
ENMT 473	Motion Planning for Autonomous Systems	3
ENMT 474	Hands-on Autonomous Aerial Vehicles	3
ENMT 477	Machine Learning in Mechatronics Engineering	3
	Additional electives by permission of advisor	

Robotics Systems Track – Program Elective Courses

Course	Title	Cr
ENMT 471	Advanced Manufacturing and Automation	3
ENMT 473	Motion Planning for Autonomous Systems	3
ENMT 475	Introduction to Robotics	3
ENMT 476	Bio-inspired Robotics	3
ENMT 477	Machine Learning in Mechatronics Engineering	3
	Additional electives by permission of advisor	

See Appendix B for course descriptions.

General Education. Students will complete their science and mathematics general education requirements by way of fulfilling major requirements. Students who transfer to UMD with an Associate's degree from a Maryland community college are deemed to have completed their General Education requirements with the exception of Professional Writing, which is typically taken in their third year of study.

Accreditation or Certification Requirements. As with other undergraduate Engineering degree programs at UMD, the Clark School of Engineering will seek to have this program accredited by the Accreditation Board of Engineering and Technology (ABET).

121 Credit Total. Because of ABET accreditation requirements for engineering undergraduate programs, this program, as with other engineering programs, requires more than 120 credits. At 121 credits, the total is still lower than many engineering programs and is, by design, lower in credits than either the Mechanical Engineering or Aerospace Engineering majors offered on the College Park campus, which have minimum requirements of 124 credits.

Other Institutions or Organizations. The department does not currently intend to contract with another institution or non-collegiate organization for this program.

Student Support. Shady Grove students will receive academic advising and support from a full-time academic advisor at Shady Grove who will report to the Director, Office of Undergraduate Studies in Aerospace Engineering at UMD. This advising includes the usual scheduling of classes, evaluation of progress towards the degrees, and identification of resources. The Mechatronics major will have a mandatory advising process, where students will be required to meet with their advisor, once each semester prior to registration, to check up on the academic progress.

In addition, the AE department will maintain offices at Shady Grove. We will designate an AE faculty member as the Faculty Program Director. The Faculty Program Director will spend one to two days per week at the Shady Grove facility to address the concerns of students, faculty, and instructors. In addition, we will hire an on-site lab technician to maintain the instructional and fabrication laboratory facilities at Shady Grove and a part-time IT specialist serving dual roles at USG and UMD. These personnel will report to the corresponding group leaders in the AE department at UMD. Students evaluate courses and faculty through the courses evaluation system for UMD.

Additional services are provided for all programs at the Universities at Shady Grove through USG's Center for Academic Success.

Marketing and Admissions Information. The AE office of external relations in collaboration with the undergraduate office will produce marketing materials and will conduct recruitment events throughout the year. Following procedures previously established at the Universities at Shady Grove, the Clark School's Assistant Director of Transfer Student Advising and Admissions will review the accepted Mechatronics cohort to ensure all students meet the Clark School's LEP admission criteria.

H. Adequacy of Articulation

Montgomery College is expected to be the largest feeder, although students who have completed two years in any engineering program in a Maryland Community College will be eligible for admission provided they meet the program's eligibility requirements. The Clark School's requirements for transfer students are articulated with the Montgomery College Associate of Science in Engineering. Montgomery College students can enter the program upon completing the Mechanical Engineering focus at Montgomery College with ENES240 – Scientific and Engineering Computation (or equivalent).

I. Adequacy of Faculty Resources

Program faculty. Appendix A contains a full list of Aerospace Engineering department faculty. Instruction will also be supported by UMD's Mechanical Engineering department. Four tenured or tenure-track (TTK) faculty and five professional track (PTK) faculty will be engaged in delivery of the program on-site. Two to three graduate students will be employed as teaching assistants on-site, and stipends/fringe benefits as well as support for commuting to/from USG is included in the proposed budget. The curriculum will also be supported by various existing centers and laboratories in the Clark School of Engineering including Space Systems Laboratory (ENAE), Smart Structures Laboratory (ENAE), the Maryland Robotics Center (ENGR) and the UMD Unmanned Air Systems (UAS) Test Site.

Faculty training. All faculty will receive guidance from the Aerospace Engineering and Mechanical Engineering departments, both of which considers teaching to be critical to the success of its program. For the learning management system, faculty teaching in this program will have access to instructional development opportunities available across the College Park campus, including those offered as part of the Teaching and Learning Transformation Center.

For online elements of the coursework, instructors will work with the learning design specialists on campus to incorporate best practices when teaching in the online environment.

J. Adequacy of Library Resources

The University of Maryland Libraries has conducted an assessment of library resources required for this program. The assessment concluded that the University Libraries are able to meet, with its current resources, the curricular and research needs of the program. Resources are available locally at USG's Priddy Library as well as on the College Park campus.

K. Adequacy of Physical Facilities, Infrastructure, and Instructional Resources

The program will be delivered in the new Biomedical Sciences and Engineering Education (BSE) building (also called Building IV) at the Universities at Shady Grove. This state-of-the-art educational facility has a suite of shared active-learning classrooms, computing resources, wet labs, a dental clinic, product design laboratory and maker space, as well as offices for faculty and staff delivering the curricula and student support services. Dedicated and shared laboratory and classroom facilities, as well as office space, have been identified for the program.

L. Adequacy of Financial Resources

Resources for the program will come from tuition revenue and from the Governor's Workforce Development Initiative funds that were specifically directed towards implementation of STEM degree programs at the Universities at Shady Grove. Students in this program will represent new enrollment at UMD the tuition revenue associated with this enrollment will be directed towards program needs. Tuition revenue alone is not adequate to support the program; UMD, USG and USM have articulated a memorandum of understanding to maintain funding for the program, beyond revenue expected from tuition. See Tables 1 and 2 for anticipated resources and expenditures.

M. Adequacy of Program Evaluation

Formal program review is carried out according to the University of Maryland's policy for Periodic Review of Academic Units, which includes a review of the academic programs offered by, and the research and administration of, the academic unit (http://www.president.umd.edu/policies/2014-i-600a.html). Program Review is also monitored following the guidelines of the campus-wide cycle of Learning Outcomes Assessment (https://www.irpa.umd.edu/Assessment/LOA.html). Faculty within the department are reviewed according to the University's Policy on Periodic Evaluation of Faculty Performance (http://www.president.umd.edu/policies/2014-ii-120a.html). Since 2005, the University has used an online course evaluation instrument that standardizes course evaluations across campus. The course evaluation has standard, university-wide questions and also allows for supplemental, specialized questions from the academic unit offering the course.

N. Consistency with Minority Student Achievement goals

An important aspect of this program is to draw upon students in the community colleges, which have traditionally larger numbers of African and Latin Americans than does UMD, and thereby improving the numbers of underrepresented minorities in STEM education. This will be a factor in student recruitment.

O. Relationship to Low Productivity Programs Identified by the Commission

N/A

P. Adequacy of Distance Education Programs

N/A

Tables 1 and 2: Resources and Expenditures

TABLE 1: RESOURCES

Resources Categories	Year 1	Year 2	Year 3	Year 4	Year 5
1.Reallocated Funds	$0	$0	$0	$0	$0
2. Tuition/Fee Revenue (c+g below)	$116,800	$360,912	$495,652	$638,153	$788,757
a. #FT Students	10	30	40	50	60
b. Annual Tuition/Fee Rate	$11,680	$12,030	$12,391	$12,763	$13,146
c. Annual FT Revenue (a x b)	$116,800	$360,912	$495,652	$638,153	$788,757
d. # PT Students	0	0	0	0	0
e. Credit Hour Rate	$485.00	$499.55	$514.54	$529.97	$545.87
f. Annual Credit Hours	16	16	16	16	16
g. Total Part Time Revenue (d x e x f)	$0	$0	$0	$0	$0
3. Grants, Contracts, & Other External Sources	$0	$0	$0	$0	$0
4. Other Sources	$900,000	$900,000	$900,000	$900,000	$900,000
TOTAL (Add 1 - 4)	**$1,016,800**	**$1,260,912**	**$1,395,652**	**$1,538,153**	**$1,688,757**

Tuition revenue is based on AY2020-21 rates for the A. James Clark School of Engineering. It does not include mandatory fees or laboratory fees. Reallocated funds assume support from the States Workforce Development Initiative targeted towards programs to be delivered at the Universities at Shady Grove.

TABLE 2: EXPENDITURES

Expenditure Categories	Year 1	Year 2	Year 3	Year 4	Year 5
1. Full time Faculty (b+c below)	$478,800	$657,552	$677,279	$871,996	$898,156
a. #FTE	3.0	4.0	4.0	5.0	5.0
b. Total Salary	$360,000	$494,400	$509,232	$655,636	$675,305
c. Total Benefits	$118,800	$163,152	$168,047	$216,360	$222,851
2. Part time Faculty (b+c below)	$14,000	$28,000	$70,000	$70,000	$70,000
a. #FTE	0.2	0.4	1.0	1.0	1.0
b. Total Salary	$14,000	$28,000	$70,000	$70,000	$70,000
c. Total Benefits	$0	$0	$0	$0	$0
3. Admin. Staff (b+c below)	$186,200	$191,786	$246,924	$254,332	$261,962
a. #FTE	2.0	2.0	2.5	2.5	2.5
b. Total Salary	$140,000	$144,200	$185,658	$191,227	$196,964
c. Total Benefits	$46,200	$47,586	$61,267	$63,105	$64,998
4. Technical Support staff (b+c below)	$53,200	$54,796	$56,440	$58,133	$59,877
a. #FTE	0.5	0.5	0.5	0.5	0.5
b. Total Salary	$40,000	$41,200	$42,436	$43,709	$45,020
c. Total Benefits	$13,200	$13,596	$14,004	$14,424	$14,857
5. Graduate Assistants (b+c below)	$44,144	$89,341	$90,425	$91,542	$92,692
a. #FTE	1.0	2.0	2.0	2.0	2.0
b. Stipend	$20,000	$40,000	$40,000	$40,000	$40,000
c. Tuition Remission	$17,544	$36,141	$37,225	$38,342	$39,492
d. benefits	$6,600	$13,200	$13,200	$13,200	$13,200
6. Equipment	$50,000	$25,000	$25,000	$25,000	$25,000
7. Library	$5,000	$5,000	$5,000	$5,000	$5,000
8. New or Renovated Space	$0	$0	$0	$0	$0
9. Marketing/Advertising	$10,000	$10,000	$10,000	$10,000	$10,000
10. Other Expenses: Operational Expenses	$50,000	$50,000	$50,000	$50,000	$50,000
11. Office Space Rental	$10,500	$10,815	$11,139	$11,474	$11,818
12. Classroom Rental	$0	$9,000	$9,270	$9,548	$9,835
13. university administrative fee	$11,680	$36,091	$49,565	$63,815	$78,876
TOTAL (Add 1 - 13)	**$913,524**	**$1,167,381**	**$1,301,042**	**$1,520,840**	**$1,573,215**

Notes: Graduate assistants are included in the budget to support instruction. Other expenses include lab equipment and software maintenance, materials and supplies, program outreach, and travel related to the program.

Appendix A: Faculty in the Fischell Department of Bioengineering

All faculty hold doctoral degrees in a field relevant to the discipline. Faculty biographies and research interests can be found in the department's web site (https://bioe.umd.edu/clark/facultydir?drfilter=1). All faculty listed are full-time. Specific course assignments have not yet been made, but will be made in time to schedule the courses for the target start term of Fall 2021. Some additional hires are anticipated to support the program at Shady Grove.

Faculty Name	**Highest Degree Earned - Field and Insitution**	**Rank**
Akin, David	Ph.D., Aeronautics & Astronautics, Massachusetts Institute of Technology	Associate Professor
Baeder, James	Ph.D., Aeronautics & Astronautics, Stanford University	Professor
Bauchau, Olivier	Ph.D., Structural Dynamics, Massachusetts Institute of Technology	Professor
Cadou, Christopher	Ph.D., Mechanical Engineering, UCLA	Professor
Chopra, Inderjit	Sc.D., Aeronautics & Astronautics, Massachusetts Institute of Technology	Distinguished Univ Professor
Datta, Anubhav	Ph.D., Aerospace Engineering, University of Maryland	Associate Professor
Flatau, Alison	Ph.D., Mechanical Engineering, University of Utah	Prof & Assoc Chair
Jones, Anya	Ph.D., Aerodynamics, University of Cambridge	Associate Professor
Laurence, Stuart	Ph.D., Aeronautics, California Institute of Technology	Associate Professor
Lee, Sung	Ph.D., Aeronautics & Astronautics, Massachusetts Institute of Technology	Professor
Martin Aguirre, Maria		Associate Professor
Paley, Derek	Ph.D., Mechanical & Aerospace Engineering, Princeton University	Professor
Sanner, Robert	Ph.D., Aeronautics & Astronautics, Massachusetts Institute of Technology	Assoc Prof & Assoc Chair
Sedwick, Raymond	Ph.D., Aeronautics & Astronautics, Massachusetts Institute of Technology	Professor
Wereley, Norman	Ph.D., Aeronautics & Astronautics, Massachusetts Institute of Technology	Prof & Chair
Winkelmann, Allen	Ph.D., Aerospace Engineering, University of Maryland	Associate Professor
Yu, Kenneth	Ph.D., Aerospace Engineering, UC Berkeley	Professor

Akin, David	Ph.D., Aeronautics & Astronautics, Massachusetts Institute of Technology	Associate Professor
Baeder, James	Ph.D., Aeronautics & Astronautics, Stanford University	Professor
Bauchau, Olivier	Ph.D., Structural Dynamics, Massachusetts Institute of Technology	Professor
Cadou, Christopher	Ph.D., Mechanical Engineering, UCLA	Professor
Hartzell, Christine	Ph.D. Aerospace Engineering Sciences, University of Colorado at Boulder	Assistant Professor
Otte, Michael	Ph.D., Computer Science, Univeristy of Colorado at Boulder	Assistant Professor
Xu, Huan	Ph.D., Mechanical Engineering, California Institute of Technology	Assistant Professor
Hartzell, Christine	Ph.D. Aerospace Engineering Sciences, University of Colorado at Boulder	Assistant Professor
Becnel, Andrew	Ph.D., Aerospace Engineering, University of Maryland	Senior Lecturer
Bowden, Mary	Sc.D., Aeronautics & Astronautics, Massachusetts Institute of Technology	Visiting Asst Professor
Carignan, Craig	Sc.D. Aeronautics & Astronautics, Massachusetts Institute of Technology	Lecturer

Appendix B: Course Descriptions

ENMT301 - Dynamics
Kinematics and dynamics of three dimensional motion of point masses and rigid bodies with introduction to more general systems. Primary emphasis on Newtonian methods. Practice in numerical solutions and computer animation of equations of motion using MATLAB.

ENMT305 - Electro-mechanical Circuits and Systems
Analysis techniques for simulating resonances and impedances in systems that couple physical interactions electrical, mechanical, magnetic and piezoelectric domains. Analysis applied to modeling the electro-magneto-mechano-acoustic domain interactions in traditional loudspeaker designs, and can be extended to the design of sensors, energy harvesters and actuators.

ENMT313 - Real Time Software Systems and Microprocessors
Timing, synchronization and data flow; parallel, serial, and analog interfaces with sensors and actuators; microprocessor system architecture; buses; direct memory access (DMA); interfacing considerations.

ENMT324 - Structures
Analysis of torsion, beam bending, plate bending, buckling and their application to aerospace and robotic systems.

ENMT364 - Aerospace Sciences Laboratory
Application of fundamental measuring techniques to measurements in aerospace engineering. Includes experiments in aerodynamics, structures, propulsion, flight dynamics and astrodynamics. Correlation of theory with experimental results.

ENMT380 - Flight Software Systems
Avionics using advanced sensor and computing technologies are at the heart of every modern Aerospace vehicle. Advanced software systems to improve safety and enable unmanned and deep-space missions. Object-oriented programming and software engineering concepts required to design and build complex flight software systems. Software validation, verification and real-time performance analysis to assess flight software system reliability and robustness. Human-machine interface design for piloted systems. Automatic onboard data acquisition and decision-making for unmanned air and space vehicles.

ENMT387 - Manufacturing Processes
An introduction to common manufacturing processes and the mindset of "design-for-manufacture" in a mechatronics context. Establishing datums, geometric dimensioning and tolerancing (GD&T), and planning for the manufacturing methods that will successfully produce the desired parts. Overview of common small- and large-volume production methods, such as milling, turning, stamping and bending of sheet metal, and injection molding.

ENMT432 - Classical Control Theory
An introduction to the feedback control of dynamic systems. Laplace transforms and transfer function techniques; frequency response and Bode diagrams. Stability analysis via root locus and Nyquist techniques. Performance specifications in time and frequency domains, and design of compensation strategies to meet performance goals.

ENMT461 - Mechatronics and Controls Lab I
Basic instrumentation electronics including DC electronics, AC electronics, semiconductors, electro-optics and digital electronics. Sensing devices used to carry out experiments including metrology, machine tool measurements, bridge circuits, optical devices, and introduction to computer based data acquisition.

ENMT462 - Mechatronics and Controls Lab II
Design of mechanical motion transmission systems: gearing, couplings, belts and lead-screws; Sensing and measurement of mechanical motion, sensor selection; Electromechanical actuator selection and specification; PLCs and sequential controller design, digital I/O; Case studies.

ENMT471 - Advanced Manufacturing and Automation
Develop a comprehensive understanding of additive and subtractive manufacturing, including extrusion-based deposition, stereolithography, powder bed-based melting, inkjet-based deposition, and computer numerical controlled (CNC) machining operations, including milling and laser cutting. Cultivate a "design-for-advanced manufacturing" skill set for combining computer-aided design (CAD) and computer-aided manufacturing (CAM) methodologies to produce desired parts. Fabricate 3D mechanical objects using a variety of manufacturing technologies on campus. Execute a design project that demonstrates how advanced manufacturing technologies can overcome limitations of traditional manufacturing processes and the challenges of applying these processes at scale.

ENMT472 - UAV Flight Testing
Provides basic instruction to unmanned aircraft flight testing and demonstrates need for systematic, well-proven technique to allow for accurate performance measurements. Concepts of aerodynamics, airplane performance, and stability and control. Emphasis on small, general use quadrotor type aircraft.

ENMT473 - Motion Planning for Autonomous Systems
Autonomous systems (e.g., aircraft, vehicles, manipulators, and robots) must plan long-term movement that respects environmental constraints such as obstacles, other actors, and wind; system constraints such as kinematics, dynamics, and fuel; as well as factors such as time and safety. Robust autonomy also requires dealing with environmental changes, new information, and uncertainty. This course provides an overview of such problems and the methods used to solve them.

ENMT474 - Hands on Autonomous Aerial Vehicles
Exposes the students to mathematical foundations of computer vision, planning and control for

aerial robots. The goal is to train the students to develop real-time algorithms for the realization of autonomous aerial systems. The course is designed to balance theory with an application on hardware. The assignments will require a significant investment of time and energy. All projects will be carried using quadrotors in a group of students.

ENMT475 - Introduction to Robotics
Introduction to the kinematics, dynamics, and control of robot manipulators. DH parameters, serial and parallel manipulators, kinematic redundancy, sensors, actuators, and mechanism design. Control concepts introduced ranging from independent joint control to impedance control. Examples drawn from space robotics, wearable robotics, and other areas.

ENMT476 - Bio-Inspired Robotics
Successful realization of a flapping wing micro air vehicle (MAV) requires development of a light weight drive mechanism converting the rotary motion of the motor into flapping motion of the wings. Students will have an opportunity to develop and understand the physics and associated control algorithms enabling wings to change their position and speed instantaneously in order to perform maneuvers autonomously, such as controlled dives and loitering. Kinematics and dynamics principles essential to modeling the forces that control the flight maneuvers.

ENMT477 - Machine Learning in Mechatronics Engineering
Learn how to apply techniques from Artificial Intelligence and Machine Learning to solve engineering problems and design new products or systems. Design and build a personal or research project that demonstrates how computational learning algorithms can solve difficult tasks in areas you are interested in. Master how to interpret and transfer state-of-the-art techniques from computer science to practical engineering situations and make smart implementation decisions.

ENMT483 - Mechatronic Systems I
Principles of mechatronic systems analysis and design. Performance analysis and optimization. Design of systems including avionics, power, propulsion, human factors, structures, actuators and mechanisms, and thermal control. Design processes and design synthesis. Individual student projects in mechatronic systems design.

ENMT484 - Mechatronic Systems II
Senior capstone design course in Mechatronics. Group preliminary design of a mechatronic system, including system and subsystem design, configuration control, costing, risk analysis, and programmatic development. Course also emphasizes written and oral engineering communications. Groups of students will complete, brief and report on a major design study to specific requirements.

ENGL393: Technical Writing
The writing of technical papers and reports. Technical track of Professional Writing that is required of all UMD undergraduates.

A. Centrality to the University's Mission and Planning Priorities

Description. Mechatronics can be concisely described as the combination of mechanical, electrical, and information systems engineering. Mechatronics engineers design, develop, and test automated production systems, transportation and vehicle systems, robotics, computer-machine controls, and many other integrated systems. Mechatronics engineers also develop new technologies for use in the automotive and aviation industry, advanced manufacturing operations, and often specialize in areas such as robotics, autonomous vehicles, and manufacturing systems. The Bachelor of Science in Mechatronics will provide students with a fundamental understanding of mechatronic systems analysis, the knowledge of how these systems are developed and deployed, and the practical experience required to implement mechatronic systems in real-world applications. Graduates of the program are expected to be highly sought after in fields such as aerospace & defense, energy, infrastructure, manufacturing & automation, robotics, and biomedical engineering.

The proposed Bachelor of Science in Mechatronics, to be offered at the Universities at Shady Grove, seeks to address the growing need for cross-disciplinary engineers skilled in the areas of robotics, automation, and advanced manufacturing technologies, collectively known as Industry 4.0. As society moves into the 4th industrial revolution, the regional economy is redoubling its focus on high-tech industries like biotechnology and aerospace/defense, fields which rely heavily on the broad expertise offered by engineers trained in Mechatronics.

Relation to Strategic Goals. The proposed major in Mechatronics relates to UMD's strategic goals by adding to its STEM program offerings, most specifically at the Universities at Shady Grove (USG). The Mechatronics major aligns with the University Mission Statement, to "advance knowledge in areas of importance to the State", as well as the undergraduate learning objectives 4.1.3 and 4.1.9, to "increase the number of graduates in fields that support the workforce needs of the state and the nation by creating new programs and pathways", and to "continue to improve pathways for transfer students in our undergraduate programs on the College Park campus and at regional centers such as the Universities at Shady Grove," respectively.

The Mechatronics program is the third of three UMD engineering programs planned for delivery specifically at the Universities at Shady Grove to contribute to workforce development in the state and most specifically in the Montgomery County region, taking advantage of the robust partnership with Montgomery College. USG's mission is *"to support and expand pathways to affordable, high-quality public higher education that meet the distinctive needs of the region and are designed to support workforce and economic development in the state; to achieve these goals through partnerships and collaborations with academic, business, public sector and community organizations that promote student success, high academic achievement and professional advancement."* This program contributes directly to the goals of access and affordability, to high quality programming, and to regional and state capacity building, as articulated in USG mission statement.

Funding. Resources for the new program will be drawn from the University System of Maryland's Workforce Development Initiative that was approved by the State Legislature beginning in FY19. Funds were specifically directed to increasing the number of undergraduate degree offerings in STEM areas at the Universities at Shady Grove.

Institutional Commitment. The program will be administered by the Department of Aerospace Engineering within the A. James Clark School of Engineering. Each of UMD's USG programs has an on-site program director. In addition, two staff members are currently in residence at USG to support the program directors in admissions decisions and to provide academic operational support such as recruiting, outreach to community colleges, access to training, and to act as a liaison to academic services on the College Park campus. The University of Maryland (UMD) is also the managing institution for USG, and in that role supports many administrative services for the operation of USG.

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

Need. The Maryland State Plan for Postsecondary Education highlights the need to ensure equitable access to higher education for the diverse population of the state, and offering a Mechatronics baccalaureate program at USG expands opportunities for students along the I-270 tech corridor region who may otherwise be geographically prohibited from participation at other USM institutions. The program will offer students who have completed their first two years of STEM-focused postsecondary education at a Maryland public community college (MPCC) or institutions a pathway to continue their studies in a growing field and earn a terminal four year degree. Providing for these students' success through this lower cost option - 2 years at an MPCC followed by 2 years in a UMD program delivered at USG - helps to reduce the financial burden potential students may face otherwise. The innovative curriculum will combine a solid theoretical foundation with practical implementation skills that prepare graduates for a productive and impactful career in regional industries like defense, aerospace, and advanced manufacturing.

State Plan. The proposed program aligns with the *Maryland State Plan for Postsecondary Education* in several ways. First, the program aligns with the state's emphasis on career training and research. Strategy 7 of the *Maryland State Plan* is "Enhance career advising and planning services and integrate them explicitly into academic advising and planning."[1] Career advising will not only be integrated with student advising, it will also be incorporated in the program coursework. All of the core courses for the program will help students achieve this outcome

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

[1] Maryland Higher Education Commission. (2017). *Maryland State Plan for Postsecondary Education.* (p. 60). Retrieved October 29, 2018 from: http://www.mhec.state.md.us/About/Documents/2017.2021%20Maryland%20State%20Plan%20for%20Higher%20Education.pdf.

The US Department of Labor, Education and Training Agency (DOL ETA) recently added a classification for Mechatronics Engineer (17-2199.05) distinct from other occupations.[2] Combined with the related occupations of Robotics Engineers (17-2199.08) and others, the U.S. Department of Labor's Bureau of Labor Statistics, Occupational Employment Statistics Program (BOL OESP) projects 4%-6% average growth in this occupation from 2018-2028 nationwide, accounting for nearly 12,000 new jobs.[3]The State of Maryland in particular is projected to see higher than average opportunities for Mechatronics Engineers[4], both in terms of job placement and median wages, which according to the BOL OESP are 45% higher than the national average ($140,840 in Maryland vs. $96,980 nationwide). This corresponds to over 7,000 jobs in Mechatronics and related industries specifically, and an even greater number considering the broad based skill set that Mechatronics engineering students offer to employers.[5]

D. Reasonableness of Program Duplication

During the time that this program has been under development, there were no Bachelor's degree programs for Mechatronics in the State of Maryland. Anne Arundel Community College offers an Associate of Applied Science (AAS) degree in Mechatronics Technology. Additionally, Johns Hopkins University offers a Master's degree program in Mechatronics, Robotics, and Automation Engineering. The proposed Mechatronics program at USG will help fill an important gap, particularly in the central and northwest geographic areas of the state in which there is significant market demand. The program is expected to draw students who have already acquired the fundamentals in Maryland's community college system and who are not interested in pursuing one of the more standard 4-year engineering degrees available within the University of System of Maryland or other campuses in the state.

In November 2020, Morgan State University announced plans to launch a Mechatronics program on approximately the same time scale as the program proposed here[6]. It is our belief that the market demand is sufficiently high, the geographic draw of students is sufficiently distinct, that both programs will provide valuable contributions to the Maryland workforce.

One might also anticipate some overlap between a Mechatronics degree program and a Mechanical Engineering program, such as that to be offered by the University of Maryland Baltimore County at the Universities at Shady Grove. Experts from the two universities have met to discuss the similarities and differences between the two programs and have determined that the curricula are distinct and complementary, although discussion is already underway about the possibility of sharing both equipment and program electives.

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[2] 2018 ASEE Southeastern Section Conference American Society for Engineering Education, 2018 Growth of 2-Year programs for Mechatronics Marilyn Barger, Richard Gilbert

[3] National Center for O*NET Development. 17-2199.05 - Mechatronics Engineers. O*NET Online. Retrieved January 28, 2020, from https:// www.onetonline.org/link/summary/17-2199.05

[4]National Center for O*NET Development. State Map for Mechatronics Engineers. My Next Move. Retrieved January 28, 2020, from https:// www.mynextmove.org/profile/state/17-2199.05?from=profile

[5] https://www.dllr.state.md.us/lmi/iandoproj/maryland.shtml

[6] https://news.morgan.edu/stem-program-offerings/

E . Relevance to Historically Black Institutions (HBIs)

As noted above, development of the UMD Mechatronics program began in 2018, responding to a call for engineering pathway programs at the Universities at Shady Grove and with the support of Governor Hogan's Workforce Development Initiative. At that time, we had determined that no historically black institutions in Maryland offered a bachelor's program in Mechatronics. With the proposed new program at Morgan State University now in view, our position remains that the two programs, while leading to the same credential, differ substantially in the target student audience. It is important to note that there are no residential facilities at the Universities at Shady Grove so all students in the program proposed here would have to be within commuting distance from the Rockville campus. A significant majority of students will be drawn from Montgomery College.

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

See above.

G. Adequacy of Curriculum Design, Program Modality, and Related Learning Outcomes

Curricular Development. The curriculum was developed by faculty of the Aerospace Engineering department in collaboration with faculty in Electrical and Computer Engineering and in Mechanical Engineering. All of the undergraduate programs within the A. James Clark School of Engineering are "limited enrollment programs", due to high demand and finite capacity.

The program will be offered exclusively at the Universities at Shady Grove. All undergraduate programs at USG are years 3 and 4 only. Expectations for lower-level coursework will be established through articulation agreements with the Maryland community colleges or taken at College Park prior to admission to the School of Engineering and the major. The proposed curriculum will offer courses at the 300- and 400-level, which constitute the junior and senior year of the program. The program is primarily intended for students transferring from a Maryland public community college. While students at the College Park campus can pursue the program, they will not be able to seek admission into the School of Engineering and Mechatronics major until they have completed the Engineering Limited Enrollment Program (LEP) gateway courses, required prior study major courses, lower-level General Education requirements (or an Associate's Degree), and have earned at least 60 credits.

Faculty Oversight. The faculty within the department of Aerospace Engineering will provide academic direction and oversight for the program. Appendix A contains a list of the relevant faculty.

Educational Objectives and Learning Outcomes. The educational objectives of this program are established to produce top-notch graduates to fill the growing need for workers experienced with integrated mechanical and electrical systems. The Bachelor of Science in Mechatronics will produce engineering graduates who:

1. Apply their training in combining mechanical, electrical, and aerospace problem solving skills to contribute professionally in industrial or research settings;
2. Demonstrate leadership, teamwork, and professional ethical responsibility;
3. Demonstrate an appreciation for their professional activities on society as a whole.

The program will additionally use the following ABET learning outcomes:

1. An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics;
2. An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economics factors;
3. An ability to communicate effectively with a range of audiences;
4. An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts;
5. An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goads, plan tasks, and meet objectives;
6. An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions;
7. An ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

Institutional assessment and documentation of learning outcomes. Assessment of the program will follow the same plan that the Department of Aerospace Engineering (ENAE) uses for assessing its major for ABET accreditation purposes. Aerospace Engineering and Mechanical Engineering faculty members establish and assess the Mechatronics Program Educational Objectives (PEOs). The faculty members evaluate achievement of the PEOs based on indicators informed by reviewing relevant data from program constituencies (students, faculty, and corporate partners). The departments' Undergraduate Affairs Committees will evaluate recommendations from these constituencies before modification of PEOs. A proposal of these modifications will be presented to the Chairs, the Department Councils, and Department Advisory Boards for feedback prior to a vote for adoption by faculty.

Student Learning Outcomes are evaluated through course-specific performance indicators. The Department will establish rubrics for each performance indicator and develop a course-related assessment as part of this evaluation. Faculty members will then be asked to evaluate the students through these course assessments. Assessment of learning outcomes will take place each year.

Course requirements.

FIRST & SECOND YEAR

Prior to being admitted to the Mechatronics major, students should have completed the Engineering LEP gateway courses, basic math/science courses, and lower-level General Education requirements. Below is the representative set of requirements; specific articulation agreements will be established with each of the local community colleges.

Course	**Title**	**Cr**
ENGL 101	Academic Writing	3
MATH 140	Calculus I	4
MATH 141	Calculus II	4
MATH 241	Calculus III	4
MATH 240	Introduction to Linear Algebra	4
MATH 246	Differential Equations for Scientists and Engineers	3
CHEM 135	General Chemistry for Engineers	3
PHYS 161	General Physics: Mechanics and Particle Dynamics	3
PHYS 260/261	General Physics: Vibration, Waves, Heat, Electricity and Magnetism (plus Laboratory)	4
PHYS 270/271	General Physics: Electrodynamics, Light Relativity and Modern Physics (plus Laboratory)	4
ENES 100	Introduction to Engineering Design	3
ENES 102	Mechanics I	3
ENES 220	Mechanics II	3
ENES 232	Thermodynamics	3
GenEd Courses	General Education Requirements (for A.A.S.)	12
	Total Credits	**60**

JUNIOR & SENIOR YEARS AT SHADY GROVE

Junior Year 1st Semester

Course	**Title**	**Cr**
ENMT 301	Dynamics	3
ENMT 305	Electro-mechanical Circuits and Systems	3
ENMT 364	Aerospace Sciences Laboratory	4
ENMT 380	Flight Software Systems	3
ENMT 387	Manufacturing Processes	3
	Total Semester Credits	**16**

Junior Year 2nd Semester

Course	Title	Cr
ENMT 313	Real Time Software Systems and Microprocessors	3
ENMT 432	Classical Control Theory	3
ENMT 324	Structures	3
ENMT 3XX	Technical Elective (based on track within program)	3
ENGL 393	Professional Writing	3
	Total Semester Credits	**15**

Senior Year 1st Semester

Course	Title	Cr
ENMT 483	Mechatronics Systems I	3
ENMT 461	Mechatronics and Controls Lab I	3
ENMT XXX	Three program electives (see below)	9
	Total Semester Credits	**15**

Senior Year 2nd Semester

Course	Title	Cr
ENMT 484	Mechatronics Systems II	3
ENMT 462	Mechatronics and Controls Lab II	3
ENMT XXX	Three program electives (see below)	9
	Total Semester Credits	**15**

TOTAL DEGREE CREDITS	**121**

The program will offer electives; at the same time, opportunities for electives outside the program may become available as the program matures, including USG programs offered by other universities.

Autonomous Air Vehicles Track – Program Elective Courses

Course	Title	Cr
ENMT 471	Advanced Manufacturing and Automation	3
ENMT 472	UAV Flight Testing	3
ENMT 473	Motion Planning for Autonomous Systems	3
ENMT 474	Hands-on Autonomous Aerial Vehicles	3
ENMT 477	Machine Learning in Mechatronics Engineering	3
	Additional electives by permission of advisor	

Robotics Systems Track – Program Elective Courses

Course	Title	Cr
ENMT 471	Advanced Manufacturing and Automation	3
ENMT 473	Motion Planning for Autonomous Systems	3
ENMT 475	Introduction to Robotics	3
ENMT 476	Bio-inspired Robotics	3
ENMT 477	Machine Learning in Mechatronics Engineering	3
	Additional electives by permission of advisor	

See Appendix B for course descriptions.

General Education. Students will complete their science and mathematics general education requirements by way of fulfilling major requirements. Students who transfer to UMD with an Associate's degree from a Maryland community college are deemed to have completed their General Education requirements with the exception of Professional Writing, which is typically taken in their third year of study.

Accreditation or Certification Requirements. As with other undergraduate Engineering degree programs at UMD, the Clark School of Engineering will seek to have this program accredited by the Accreditation Board of Engineering and Technology (ABET).

121 Credit Total. Because of ABET accreditation requirements for engineering undergraduate programs, this program, as with other engineering programs, requires more than 120 credits. At 121 credits, the total is still lower than many engineering programs and is, by design, lower in credits than either the Mechanical Engineering or Aerospace Engineering majors offered on the College Park campus, which have minimum requirements of 124 credits.

Other Institutions or Organizations. The department does not currently intend to contract with another institution or non-collegiate organization for this program.

Student Support. Shady Grove students will receive academic advising and support from a full-time academic advisor at Shady Grove who will report to the Director, Office of Undergraduate Studies in Aerospace Engineering at UMD. This advising includes the usual scheduling of classes, evaluation of progress towards the degrees, and identification of resources. The Mechatronics major will have a mandatory advising process, where students will be required to meet with their advisor, once each semester prior to registration, to check up on the academic progress.

In addition, the AE department will maintain offices at Shady Grove. We will designate an AE faculty member as the Faculty Program Director. The Faculty Program Director will spend one to two days per week at the Shady Grove facility to address the concerns of students, faculty, and instructors. In addition, we will hire an on-site lab technician to maintain the instructional and fabrication laboratory facilities at Shady Grove and a part-time IT specialist serving dual roles at USG and UMD. These personnel will report to the corresponding group leaders in the

AE department at UMD. Students evaluate courses and faculty through the courses evaluation system for UMD.

Additional services are provided for all programs at the Universities at Shady Grove through USG's Center for Academic Success.

Marketing and Admissions Information. The AE office of external relations in collaboration with the undergraduate office will produce marketing materials and will conduct recruitment events throughout the year. Following procedures previously established at the Universities at Shady Grove, the Clark School's Assistant Director of Transfer Student Advising and Admissions will review the accepted Mechatronics cohort to ensure all students meet the Clark School's LEP admission criteria.

H. Adequacy of Articulation

Montgomery College is expected to be the largest feeder, although students who have completed two years in any engineering program in a Maryland Community College will be eligible for admission provided they meet the program's eligibility requirements. The Clark School's requirements for transfer students are articulated with the Montgomery College Associate of Science in Engineering. Montgomery College students can enter the program upon completing the Mechanical Engineering focus at Montgomery College with ENES240 – Scientific and Engineering Computation (or equivalent).

I. Adequacy of Faculty Resources

Program faculty. Appendix A contains a full list of Aerospace Engineering department faculty. Instruction will also be supported by UMD's Mechanical Engineering department. Four tenured or tenure-track (TTK) faculty and five professional track (PTK) faculty will be engaged in delivery of the program on-site. Two to three graduate students will be employed as teaching assistants on-site, and stipends/fringe benefits as well as support for commuting to/from USG is included in the proposed budget. The curriculum will also be supported by various existing centers and laboratories in the Clark School of Engineering including Space Systems Laboratory (ENAE), Smart Structures Laboratory (ENAE), the Maryland Robotics Center (ENGR) and the UMD Unmanned Air Systems (UAS) Test Site.

Faculty training. All faculty will receive guidance from the Aerospace Engineering and Mechanical Engineering departments, both of which considers teaching to be critical to the success of its program. For the learning management system, faculty teaching in this program will have access to instructional development opportunities available across the College Park campus, including those offered as part of the Teaching and Learning Transformation Center. For online elements of the coursework, instructors will work with the learning design specialists on campus to incorporate best practices when teaching in the online environment.

J. Adequacy of Library Resources

The University of Maryland Libraries has conducted an assessment of library resources required for this program. The assessment concluded that the University Libraries are able to meet, with its current resources, the curricular and research needs of the program. Resources are available locally at USG's Priddy Library as well as on the College Park campus.

K. Adequacy of Physical Facilities, Infrastructure, and Instructional Resources

The program will be delivered in the new Biomedical Sciences and Engineering Education (BSE) building (also called Building IV) at the Universities at Shady Grove. This state-of-the-art educational facility has a suite of shared active-learning classrooms, computing resources, wet labs, a dental clinic, product design laboratory and maker space, as well as offices for faculty and staff delivering the curricula and student support services. Dedicated and shared laboratory and classroom facilities, as well as office space, have been identified for the program.

L. Adequacy of Financial Resources

Resources for the program will come from tuition revenue and from the Governor's Workforce Development Initiative funds that were specifically directed towards implementation of STEM degree programs at the Universities at Shady Grove. Students in this program will represent new enrollment at UMD the tuition revenue associated with this enrollment will be directed towards program needs. Tuition revenue alone is not adequate to support the program; UMD, USG and USM have articulated a memorandum of understanding to maintain funding for the program, beyond revenue expected from tuition. See Tables 1 and 2 for anticipated resources and expenditures.

M. Adequacy of Program Evaluation

Formal program review is carried out according to the University of Maryland's policy for Periodic Review of Academic Units, which includes a review of the academic programs offered by, and the research and administration of, the academic unit (http://www.president.umd.edu/policies/2014-i-600a.html). Program Review is also monitored following the guidelines of the campus-wide cycle of Learning Outcomes Assessment (https://www.irpa.umd.edu/Assessment/LOA.html). Faculty within the department are reviewed according to the University's Policy on Periodic Evaluation of Faculty Performance (http://www.president.umd.edu/policies/2014-ii-120a.html). Since 2005, the University has used an online course evaluation instrument that standardizes course evaluations across campus. The course evaluation has standard, university-wide questions and also allows for supplemental, specialized questions from the academic unit offering the course.

N. Consistency with Minority Student Achievement goals

An important aspect of this program is to draw upon students in the community colleges, which have traditionally larger numbers of African and Latin Americans than does UMD, and thereby improving the numbers of underrepresented minorities in STEM education. This will be a factor in student recruitment.

O. Relationship to Low Productivity Programs Identified by the Commission

N/A

P. Adequacy of Distance Education Programs

N/A

Tables 1 and 2: Resources and Expenditures

TABLE 1: RESOURCES

Resources Categories	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**
1.Reallocated Funds	$0	$0	$0	$0	$0
2. Tuition/Fee Revenue (c+g below)	$116,800	$360,912	$495,652	$638,153	$788,757
a. #FT Students	10	30	40	50	60
b. Annual Tuition/Fee Rate	$11,680	$12,030	$12,391	$12,763	$13,146
c. Annual FT Revenue (a x b)	$116,800	$360,912	$495,652	$638,153	$788,757
d. # PT Students	0	0	0	0	0
e. Credit Hour Rate	$485.00	$499.55	$514.54	$529.97	$545.87
f. Annual Credit Hours	16	16	16	16	16
g. Total Part Time Revenue (d x e x f)	$0	$0	$0	$0	$0
3. Grants, Contracts, & Other External Sources	$0	$0	$0	$0	$0
4. Other Sources	$900,000	$900,000	$900,000	$900,000	$900,000
TOTAL (Add 1 - 4)	**$1,016,800**	**$1,260,912**	**$1,395,652**	**$1,538,153**	**$1,688,757**

Tuition revenue is based on AY2020-21 rates for the A. James Clark School of Engineering. It does not include mandatory fees or laboratory fees. Reallocated funds assume support from the States Workforce Development Initiative targeted towards programs to be delivered at the Universities at Shady Grove.

TABLE 2: EXPENDITURES

Expenditure Categories	Year 1	Year 2	Year 3	Year 4	Year 5
1. Full time Faculty (b+c below)	$478,800	$657,552	$677,279	$871,996	$898,156
a. #FTE	3.0	4.0	4.0	5.0	5.0
b. Total Salary	$360,000	$494,400	$509,232	$655,636	$675,305
c. Total Benefits	$118,800	$163,152	$168,047	$216,360	$222,851
2. Part time Faculty (b+c below)	$14,000	$28,000	$70,000	$70,000	$70,000
a. #FTE	0.2	0.4	1.0	1.0	1.0
b. Total Salary	$14,000	$28,000	$70,000	$70,000	$70,000
c. Total Benefits	$0	$0	$0	$0	$0
3. Admin. Staff (b+c below)	$186,200	$191,786	$246,924	$254,332	$261,962
a. #FTE	2.0	2.0	2.5	2.5	2.5
b. Total Salary	$140,000	$144,200	$185,658	$191,227	$196,964
c. Total Benefits	$46,200	$47,586	$61,267	$63,105	$64,998
4. Technical Support staff (b+c below)	$53,200	$54,796	$56,440	$58,133	$59,877
a. #FTE	0.5	0.5	0.5	0.5	0.5
b. Total Salary	$40,000	$41,200	$42,436	$43,709	$45,020
c. Total Benefits	$13,200	$13,596	$14,004	$14,424	$14,857
5. Graduate Assistants (b+c below)	$44,144	$89,341	$90,425	$91,542	$92,692
a. #FTE	1.0	2.0	2.0	2.0	2.0
b. Stipend	$20,000	$40,000	$40,000	$40,000	$40,000
c. Tuition Remission	$17,544	$36,141	$37,225	$38,342	$39,492
d. benefits	$6,600	$13,200	$13,200	$13,200	$13,200
6. Equipment	$50,000	$25,000	$25,000	$25,000	$25,000
7. Library	$5,000	$5,000	$5,000	$5,000	$5,000
8. New or Renovated Space	$0	$0	$0	$0	$0
9. Marketing/Advertising	$10,000	$10,000	$10,000	$10,000	$10,000
10. Other Expenses: Operational Expenses	$50,000	$50,000	$50,000	$50,000	$50,000
11. Office Space Rental	$10,500	$10,815	$11,139	$11,474	$11,818
12. Classroom Rental	$0	$9,000	$9,270	$9,548	$9,835
13. university administrative fee	$11,680	$36,091	$49,565	$63,815	$78,876
TOTAL (Add 1 - 13)	**$913,524**	**$1,167,381**	**$1,301,042**	**$1,520,840**	**$1,573,215**

Notes: Graduate assistants are included in the budget to support instruction. Other expenses include lab equipment and software maintenance, materials and supplies, program outreach, and travel related to the program.

Appendix A: Faculty in the Fischell Department of Bioengineering

All faculty hold doctoral degrees in a field relevant to the discipline. Faculty biographies and research interests can be found in the department's web site (https://bioe.umd.edu/clark/facultydir?drfilter=1). All faculty listed are full-time. Specific course assignments have not yet been made, but will be made in time to schedule the courses for the target start term of Fall 2021. Some additional hires are anticipated to support the program at Shady Grove.

Faculty Name	**Highest Degree Earned - Field and Insitution**	**Rank**
Akin, David	Ph.D., Aeronautics & Astronautics, Massachusetts Institute of Technology	Associate Professor
Baeder, James	Ph.D., Aeronautics & Astronautics, Stanford University	Professor
Bauchau, Olivier	Ph.D., Structural Dynamics, Massachusetts Institute of Technology	Professor
Cadou, Christopher	Ph.D., Mechanical Engineering, UCLA	Professor
Chopra, Inderjit	Sc.D., Aeronautics & Astronautics, Massachusetts Institute of Technology	Distinguished Univ Professor
Datta, Anubhav	Ph.D., Aerospace Engineering, University of Maryland	Associate Professor
Flatau, Alison	Ph.D., Mechanical Engineering, University of Utah	Prof & Assoc Chair
Jones, Anya	Ph.D., Aerodynamics, University of Cambridge	Associate Professor
Laurence, Stuart	Ph.D., Aeronautics, California Institute of Technology	Associate Professor
Lee, Sung	Ph.D., Aeronautics & Astronautics, Massachusetts Institute of Technology	Professor
Martin Aguirre, Maria		Associate Professor
Paley, Derek	Ph.D., Mechanical & Aerospace Engineering, Princeton University	Professor
Sanner, Robert	Ph.D., Aeronautics & Astronautics, Massachusetts Institute of Technology	Assoc Prof & Assoc Chair
Sedwick, Raymond	Ph.D., Aeronautics & Astronautics, Massachusetts Institute of Technology	Professor
Wereley, Norman	Ph.D., Aeronautics & Astronautics, Massachusetts Institute of Technology	Prof & Chair
Winkelmann, Allen	Ph.D., Aerospace Engineering, University of Maryland	Associate Professor
Yu, Kenneth	Ph.D., Aerospace Engineering, UC Berkeley	Professor

Akin, David	Ph.D., Aeronautics & Astronautics, Massachusetts Institute of Technology	Associate Professor
Baeder, James	Ph.D., Aeronautics & Astronautics, Stanford University	Professor
Bauchau, Olivier	Ph.D., Structural Dynamics, Massachusetts Institute of Technology	Professor
Cadou, Christopher	Ph.D., Mechanical Engineering, UCLA	Professor
Hartzell, Christine	Ph.D. Aerospace Engineering Sciences, University of Colorado at Boulder	Assistant Professor
Otte, Michael	Ph.D., Computer Science, Univeristy of Colorado at Boulder	Assistant Professor
Xu, Huan	Ph.D., Mechanical Engineering, California Institute of Technology	Assistant Professor
Hartzell, Christine	Ph.D. Aerospace Engineering Sciences, University of Colorado at Boulder	Assistant Professor
Becnel, Andrew	Ph.D., Aerospace Engineering, University of Maryland	Senior Lecturer
Bowden, Mary	Sc.D., Aeronautics & Astronautics, Massachusetts Institute of Technology	Visiting Asst Professor
Carignan, Craig	Sc.D. Aeronautics & Astronautics, Massachusetts Institute of Technology	Lecturer

Appendix B: Course Descriptions

ENMT301 - Dynamics
Kinematics and dynamics of three dimensional motion of point masses and rigid bodies with introduction to more general systems. Primary emphasis on Newtonian methods. Practice in numerical solutions and computer animation of equations of motion using MATLAB.

ENMT305 - Electro-mechanical Circuits and Systems
Analysis techniques for simulating resonances and impedances in systems that couple physical interactions electrical, mechanical, magnetic and piezoelectric domains. Analysis applied to modeling the electro-magneto-mechano-acoustic domain interactions in traditional loudspeaker designs, and can be extended to the design of sensors, energy harvesters and actuators.

ENMT313 - Real Time Software Systems and Microprocessors
Timing, synchronization and data flow; parallel, serial, and analog interfaces with sensors and actuators; microprocessor system architecture; buses; direct memory access (DMA); interfacing considerations.

ENMT324 - Structures
Analysis of torsion, beam bending, plate bending, buckling and their application to aerospace and robotic systems.

ENMT364 - Aerospace Sciences Laboratory
Application of fundamental measuring techniques to measurements in aerospace engineering. Includes experiments in aerodynamics, structures, propulsion, flight dynamics and astrodynamics. Correlation of theory with experimental results.

ENMT380 - Flight Software Systems
Avionics using advanced sensor and computing technologies are at the heart of every modern Aerospace vehicle. Advanced software systems to improve safety and enable unmanned and deep-space missions. Object-oriented programming and software engineering concepts required to design and build complex flight software systems. Software validation, verification and real-time performance analysis to assess flight software system reliability and robustness. Human-machine interface design for piloted systems. Automatic onboard data acquisition and decision-making for unmanned air and space vehicles.

ENMT387 - Manufacturing Processes
An introduction to common manufacturing processes and the mindset of "design-for-manufacture" in a mechatronics context. Establishing datums, geometric dimensioning and tolerancing (GD&T), and planning for the manufacturing methods that will successfully produce the desired parts. Overview of common small- and large-volume production methods, such as milling, turning, stamping and bending of sheet metal, and injection molding.

ENMT432 - Classical Control Theory
An introduction to the feedback control of dynamic systems. Laplace transforms and transfer function techniques; frequency response and Bode diagrams. Stability analysis via root locus and Nyquist techniques. Performance specifications in time and frequency domains, and design of compensation strategies to meet performance goals.

ENMT461 - Mechatronics and Controls Lab I
Basic instrumentation electronics including DC electronics, AC electronics, semiconductors, electro-optics and digital electronics. Sensing devices used to carry out experiments including metrology, machine tool measurements, bridge circuits, optical devices, and introduction to computer based data acquisition.

ENMT462 - Mechatronics and Controls Lab II
Design of mechanical motion transmission systems: gearing, couplings, belts and lead-screws; Sensing and measurement of mechanical motion, sensor selection; Electromechanical actuator selection and specification; PLCs and sequential controller design, digital I/O; Case studies.

ENMT471 - Advanced Manufacturing and Automation
Develop a comprehensive understanding of additive and subtractive manufacturing, including extrusion-based deposition, stereolithography, powder bed-based melting, inkjet-based deposition, and computer numerical controlled (CNC) machining operations, including milling and laser cutting. Cultivate a "design-for-advanced manufacturing" skill set for combining computer-aided design (CAD) and computer-aided manufacturing (CAM) methodologies to produce desired parts. Fabricate 3D mechanical objects using a variety of manufacturing technologies on campus. Execute a design project that demonstrates how advanced manufacturing technologies can overcome limitations of traditional manufacturing processes and the challenges of applying these processes at scale.

ENMT472 - UAV Flight Testing
Provides basic instruction to unmanned aircraft flight testing and demonstrates need for systematic, well-proven technique to allow for accurate performance measurements. Concepts of aerodynamics, airplane performance, and stability and control. Emphasis on small, general use quadrotor type aircraft.

ENMT473 - Motion Planning for Autonomous Systems
Autonomous systems (e.g., aircraft, vehicles, manipulators, and robots) must plan long-term movement that respects environmental constraints such as obstacles, other actors, and wind; system constraints such as kinematics, dynamics, and fuel; as well as factors such as time and safety. Robust autonomy also requires dealing with environmental changes, new information, and uncertainty. This course provides an overview of such problems and the methods used to solve them.

ENMT474 - Hands on Autonomous Aerial Vehicles
Exposes the students to mathematical foundations of computer vision, planning and control for

aerial robots. The goal is to train the students to develop real-time algorithms for the realization of autonomous aerial systems. The course is designed to balance theory with an application on hardware. The assignments will require a significant investment of time and energy. All projects will be carried using quadrotors in a group of students.

ENMT475 - Introduction to Robotics
Introduction to the kinematics, dynamics, and control of robot manipulators. DH parameters, serial and parallel manipulators, kinematic redundancy, sensors, actuators, and mechanism design. Control concepts introduced ranging from independent joint control to impedance control. Examples drawn from space robotics, wearable robotics, and other areas.

ENMT476 - Bio-Inspired Robotics
Successful realization of a flapping wing micro air vehicle (MAV) requires development of a light weight drive mechanism converting the rotary motion of the motor into flapping motion of the wings. Students will have an opportunity to develop and understand the physics and associated control algorithms enabling wings to change their position and speed instantaneously in order to perform maneuvers autonomously, such as controlled dives and loitering. Kinematics and dynamics principles essential to modeling the forces that control the flight maneuvers.

ENMT477 - Machine Learning in Mechatronics Engineering
Learn how to apply techniques from Artificial Intelligence and Machine Learning to solve engineering problems and design new products or systems. Design and build a personal or research project that demonstrates how computational learning algorithms can solve difficult tasks in areas you are interested in. Master how to interpret and transfer state-of-the-art techniques from computer science to practical engineering situations and make smart implementation decisions.

ENMT483 - Mechatronic Systems I
Principles of mechatronic systems analysis and design. Performance analysis and optimization. Design of systems including avionics, power, propulsion, human factors, structures, actuators and mechanisms, and thermal control. Design processes and design synthesis. Individual student projects in mechatronic systems design.

ENMT484 - Mechatronic Systems II
Senior capstone design course in Mechatronics. Group preliminary design of a mechatronic system, including system and subsystem design, configuration control, costing, risk analysis, and programmatic development. Course also emphasizes written and oral engineering communications. Groups of students will complete, brief and report on a major design study to specific requirements.

ENGL393: Technical Writing
The writing of technical papers and reports. Technical track of Professional Writing that is required of all UMD undergraduates.