UNIVERSITY SENATE | TRANSMITTAL | #20-21-18

Senate Programs, Curricula, and Courses (PCC) Committee

Establish a Bachelor of Science in Mechatronics (PCC 20044)

PRESENTED BY	**Valerie Orlando, Chair, Senate Programs, Curricula, and Courses Committee**
REVIEW DATES	**SEC – November 18, 2020 | SENATE – December 8, 2020**
VOTING METHOD	**In a single vote**
RELEVANT POLICY/DOCUMENT	**N/A**
NECESSARY APPROVALS	**Senate, President, University System of Maryland Board of Regents, and Maryland Higher Education Commission**

ISSUE

The Department of Aerospace Engineering, within the A. James Clark School of Engineering, proposes to establish a Bachelor of Science in Mechatronics. Mechatronics is the combination of mechanical, electrical, and information systems engineering. The program addresses the growing need for cross-disciplinary engineers skilled in the areas of robotics, automation, and advanced manufacturing technologies, collectively known as Industry 4.0. 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.

This program will be offered at the Universities at Shady Grove and is primarily intended for students who have completed an associate's degree from a Maryland public community college. The program will be supported through a targeted enhancement-funding request to the State of Maryland, and through tuition revenue. Reallocated funds assume support from the state's Workforce Development Initiative targeted towards programs to be delivered at the Universities at Shady Grove. 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. The other two programs are the Bachelor of Science in Embedded Systems and Internet of Things, which was approved in 2019, and the Bachelor of Science in Biocomputational Engineering, which was approved in May of 2020.

The program will offer courses at the 300 and 400-level, which constitute the junior and senior year of the program. The curriculum will require 43 credits of core courses and 18 credits of program-specific electives. The curriculum was developed by faculty in the Aerospace Engineering department in collaboration with faculty in Electrical and Computer Engineering and in Mechanical Engineering. Students graduating from the Mechatronics program will be uniquely positioned for the job market because of the curriculum's focus on both a solid foundation in the relevant theoretical and analytical backgrounds, as well as the practical competencies required to enter the workforce.

The regional economic pillars of the aerospace and defense industries and related governmental partners will directly benefit from this local source of highly skilled graduates.

This proposal was approved by the Senate Programs, Curricula, and Courses committee on November 6, 2020.

RECOMMENDATION(S)

The Senate Committee on Programs, Curricula, and Courses recommends that the Senate approve this bachelor's degree program.

COMMITTEE WORK

The committee considered this proposal at its meeting on November 6, 2020. Andrew Becnel, from the Department of Aerospace Engineering, and Ken Kiger, from the A. James Clark School of Engineering, presented the proposal and answered questions from the committee. The proposal was approved by the committee.

ALTERNATIVES

The Senate could decline to approve this new bachelor's degree program.

RISKS

If the Senate declines to approve this degree program, the university will lose an opportunity to take advantage of additional state funding to provide University of Maryland students at Shady Grove with a new program option in a growing technological industry.

FINANCIAL IMPLICATIONS

The program will be supported through a targeted enhancement funding request to the State of Maryland, and through tuition revenue. Reallocated funds assume support from the state's Workforce Development Initiative targeted towards programs to be delivered at the Universities at Shady Grove.

686: MECHATRONICS

In Workflow

1. D-ENAE PCC Chair (rmsanner@umd.edu)
2. D-ENAE Chair (wereley@umd.edu)
3. ENGR PCC Chair (mcbell@umd.edu; nroop@umd.edu; sash1@umd.edu)
4. ENGR Dean (kkiger@umd.edu; mcbell@umd.edu; nroop@umd.edu; sash1@umd.edu)
5. Academic Affairs Curriculum Manager (mcolson@umd.edu)
6. Senate PCC Chair (mcolson@umd.edu; vorlando@umd.edu)
7. University Senate Chair (mcolson@umd.edu)
8. President (mcolson@umd.edu)
9. Board of Regents (mcolson@umd.edu)
10. MHEC (mcolson@umd.edu)
11. Provost Office (mcolson@umd.edu)
12. Undergraduate Catalog Manager (lyokoi@umd.edu; wbryan@umd.edu)

Approval Path

1. Mon, 24 Feb 2020 19:18:15 GMT
   Michael Colson (mcolson): Rollback to Initiator
2. Thu, 21 May 2020 14:03:54 GMT
   Robert Sanner (rmsanner): Approved for D-ENAE PCC Chair
3. Mon, 22 Jun 2020 17:57:00 GMT
   Norman Wereley (wereley): Approved for D-ENAE Chair
4. Mon, 19 Oct 2020 18:41:47 GMT
   Mary Bell (mcbell): Approved for ENGR PCC Chair
5. Mon, 19 Oct 2020 19:18:49 GMT
   Kenneth Kiger (kkiger): Approved for ENGR Dean
6. Mon, 02 Nov 2020 14:36:21 GMT
   Michael Colson (mcolson): Approved for Academic Affairs Curriculum Manager
7. Fri, 06 Nov 2020 15:25:10 GMT
   Valerie Orlando (vorlando): Approved for Senate PCC Chair
8. Fri, 06 Nov 2020 15:40:21 GMT
   Michael Colson (mcolson): Rollback to Senate PCC Chair for University Senate Chair
9. Tue, 10 Nov 2020 06:11:00 GMT
   Valerie Orlando (vorlando): Approved for Senate PCC Chair

New Program Proposal

Date Submitted: Fri, 06 Mar 2020 19:57:09 GMT

Viewing: 686 : Mechatronics

Last edit: Tue, 10 Nov 2020 14:07:06 GMT

Changes proposed by: Andrew Becnel (abecnel)

Program Name

Mechatronics

Program Status

Proposed

Effective Term

Fall 2022

Catalog Year

2022-2023

Program Level

Undergraduate Program

Program Type

Undergraduate Major

Delivery Method

Off Campus

Does an approved version of this program already exist?

No

Departments

Department
Aerospace Engineering

Colleges

College
The A. James Clark School of Engineering

Degree(s) Awarded

Degree Awarded
Bachelor of Science

Proposal Contact

Andrew Becnel

Proposal Summary

Proposal to establish a new academic degree program : Bachelor of Science in Mechatronics

(PCC Log Number 20044)

Program and Catalog Information

Provide the catalog description of the proposed program. As part of the description, please indicate any areas of concentration or specializations that will be offered.

Mechatronics can be concisely described as the combination of mechanical, electrical, and information systems engineering. 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. In their senior year, students can focus their electives in one of two tracks: Robotics or Autonomous Air Vehicles.

Mechatronics engineers design, develop, and test automated production systems, transportation and vehicle systems, robotics, computer-machine controls, and many other integrated systems. Mechatronics engineers 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.

Catalog Program Requirements:

Course	Title	Credits
Required Foundation Courses		**43**
ENMT301	Course ENMT301 Not Found (Dynamics)	3
ENMT305	Course ENMT305 Not Found (Electro-Mechanical Circuits and Systems)	3
ENMT313	Course ENMT313 Not Found (Real Time Software Systems and Microprocessors)	3
ENMT324	Course ENMT324 Not Found (Structures)	3
ENMT364	Course ENMT364 Not Found (Aerospace Sciences Laboratory)	4
ENMT380	Course ENMT380 Not Found (Flight Software Systems)	3
ENMT387	Course ENMT387 Not Found (Manufacturing Processes)	3
ENGL393	Technical Writing	3
ENMT432	Course ENMT432 Not Found (Classical Control Theory)	3
ENMT461	Course ENMT461 Not Found (Mechatronics and Controls Lab I)	3
ENMT462	Course ENMT462 Not Found (Mechatronics and Controls Lab II)	3

ENMT483	Course ENMT483 Not Found (Mechatronic Systems I)	3
ENMT484	Course ENMT484 Not Found (Mechatronic Systems II)	3
TECHNICAL ELECTIVE	Course TECHNICAL ELECTIVE Not Found (Any approved 300 or 400 level course outside of ENMT)	3
Elective Courses (Select 6 courses based on track of study) [1]		**18**
ENMT471	Course ENMT471 Not Found (Advanced Manufacturing and Automation)	3
ENMT472	Course ENMT472 Not Found (UAV Flight Testing)	3
ENMT473	Course ENMT473 Not Found (Motion Planning for Autonomous Systems)	3
ENMT474	Course ENMT474 Not Found (Hands On Autonomous Aerial Vehicles)	3
ENMT475	Course ENMT475 Not Found (Introduction to Robotics)	3
ENMT476	Course ENMT476 Not Found (Bio-Inspired Robotics)	3
ENMT477	Course ENMT477 Not Found (Machine Learning in Mechatronics Engineering)	3
Transfer Credits^ (Consult with academic advisor) **^May vary depending on previous coursework**		**60-90***
Total Credits		**121**

[1] Students may use a relevant course outside of ENMT with permission of advisor.

Sample plan. Provide a term by term sample plan that shows how a hypothetical student would progress through the program to completion. It should be clear the length of time it will take for a typical student to graduate. For undergraduate programs, this should be the four-year plan.

FIRST & SECOND YEAR

Prior to being admitted to the Mechatronics major, students should have completed the Engineering LEP gateway courses, basic math/science courses, lower-level General Education requirements, and at least 60 applicable degree credits.

Course	Title	Credits
First & Second Year		
ENGL101	Academic Writing	3
MATH140	Calculus I	4
MATH141	Calculus II	4
MATH241	Calculus III	4
MATH246	Differential Equations for Scientists and Engineers	3
MATH240	Introduction to Linear Algebra	4
CHEM135	General Chemistry for Engineers (General Chemistry for Engineers)	3
PHYS161	General Physics: Mechanics and Particle Dynamics	3
PHYS260	General Physics: Vibration, Waves, Heat, Electricity and Magnetism	3
PHYS261	General Physics: Vibrations, Waves, Heat, Electricity and Magnetism (Laboratory)	1
PHYS270	General Physics: Electrodynamics, Light, Relativity and Modern Physics	3
PHYS271	General Physics: Electrodynamics, Light, Relativity and Modern Physics (Laboratory)	1
ENES100	Introduction to Engineering Design	3
ENES102	Mechanics I	3
ENES220	Mechanics II	3
ENES232	Thermodynamics	3
Lower-Level general education requirements or A.A./A.S. degree from a Maryland public institution		Varies
Total		60

JUNIOR & SENIOR YEAR AT SHADY GROVE

Fall of Junior Year

Course	Title	Credits
ENMT364	Course ENMT364 Not Found (Aerospace Sciences Laboratory)	4
ENMT301	Course ENMT301 Not Found (Dynamics)	3
ENMT305	Course ENMT305 Not Found (Electro-Mechanical Circuits and Systems)	3
ENMT380	Course ENMT380 Not Found (Flight Software Systems)	3
ENMT387	Course ENMT387 Not Found (Manufacturing Processes)	3
Total Credits		16

Spring of Junior Year

Course	Title	Credits
ENMT313	Course ENMT313 Not Found (Realt Time Software Systems and Microprocessors)	3
ENMT432	Course ENMT432 Not Found (Classical Control Theory)	3
ENGL393	Technical Writing	3
ENMT324	Course ENMT324 Not Found (Structures)	3
ENMT3XX	Course ENMT3XX Not Found (Technical Elective (based on track))	3
Total Credits		15

Fall of Senior Year

Course	Title	Credits
ENMT483	Course ENMT483 Not Found (Mechatronic Systems I) a. Autonomous Systems -or- b. Robotics Systems	3
ENMT461	Course ENMT461 Not Found (Mechatronics and Controls Lab I)	3
PROGRAM ELECTIVE	Course PROGRAM ELECTIVE Not Found (Program-Specific Elective)	3
PROGRAM ELECTIVE	Course PROGRAM ELECTIVE Not Found (Program-Specific Elective)	3
PROGRAM ELECTIVE	Course PROGRAM ELECTIVE Not Found (Program-Specific Elective)	3
Total Credits		15

Spring of Senior Year

Course	Title	Credits
ENMT484	Course ENMT484 Not Found (Mechatronic Systems II) a. Autonomous Systems -or- b. Robotics Systems	3
ENMT462	Course ENMT462 Not Found (Mechatronics and Controls Lab II)	3
PROGRAM ELECTIVE	Course PROGRAM ELECTIVE Not Found (Program-Specific Elective)	3
PROGRAM ELECTIVE	Course PROGRAM ELECTIVE Not Found (Program-Specific Elective)	3
PROGRAM ELECTIVE	Course PROGRAM ELECTIVE Not Found (Program-Specific Elective)	3
Total Credits		15

Course	Title	Credits
Suggested Autonomous Air Vehicles Elective Courses		
ENMT471	Course ENMT471 Not Found (Advanced Manufacturing and Automation)	3
ENMT472	Course ENMT472 Not Found (UAV Flight Testing)	3
ENMT473	Course ENMT473 Not Found (Motion Planning for Autonomous Systems)	3
ENMT474	Course ENMT474 Not Found (Hands On Autonomous Aerial Vehicles)	3
ENMT477	Course ENMT477 Not Found (Machine Learning in Mechatronics Engineering)	3
ADDITIONAL COURSE	Course ADDITIONAL COURSE Not Found	3

Course	Title	Credits
Suggested Robotic Systems Elective Courses		
ENMT471	Course ENMT471 Not Found (Advanced Manufacturing and Automation)	3
ENMT473	Course ENMT473 Not Found (Motion Planning for Autonomous Systems)	3
ENMT475	Course ENMT475 Not Found (Introduction to Robotics)	3
ENMT476	Course ENMT476 Not Found (Bio-Inspired Robotics)	3
ENMT477	Course ENMT477 Not Found (Machine Learning in Mechatronics Engineering)	3
ADDITIONAL COURSE	Course ADDITIONAL COURSE Not Found	3

List the intended student learning outcomes. In an attachment, provide the plan for assessing these outcomes.

Learning Outcomes
An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
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
An ability to communicate effectively with a range of audiences
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
An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives

An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions

An ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

New Program Information

Mission and Purpose

Describe the program and explain how it fits the institutional mission statement and planning priorities.

Mechatronics can be concisely described as the combination of mechanical, electrical, and information systems 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. The creation of 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 proposed Mechatronics program seeks to train students in a design process that integrates mechanical, electrical, and information systems engineering to develop systems that can operate, perhaps autonomously, in the physical world. These systems could be robotic systems, flight systems including unmanned aircraft systems, or biomedical devices. Students graduating with a Bachelor’s Degree in Mechatronics will be uniquely skilled in the synergistic application of modern technologies that work together in systems that are more productive, more efficient, and less wasteful. The goal of this program is to enroll students who have completed the first two years of lower level engineering gateway courses, basic math/science courses, lower-level General Education courses & at least 60 applicable degree credits.
https://svp.umd.edu/sites/default/files/2019-09/Mission-Vision.pdf

Program Characteristics

What are the educational objectives of the program?

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:

Apply their training in combining mechanical, electrical, and aerospace problem solving skills to contribute professionally in industrial or research settings;

Demonstrate leadership, teamwork, and professional ethical responsibility;

Demonstrate an appreciation for their professional activities on society as a whole.

Describe any selective admissions policy or special criteria for students interested in this program.

As an undergraduate program within the A. James Clark School of Engineering, the Mechatronics major will be designated as a Limited Enrollment Program (LEP) Admission so the program will follow the School of Engineering’s admission criteria found on the LEP website: http://www.lep.umd.edu
Students will need to fulfill the following gateway courses to gain admission to the Mechatronics major:
Completion of MATH 141 (Calculus II) with a minimum grade of B-.
Completion of PHYS 161 (Physics I) with a minimum grade of B-.
Completion of either CHEM 135 or CHEM 271 or CHEM 134 with a minimum grade of C-. (Students who take CHEM 134 must also have completed CHEM 131 with a minimum grade of C-.)
Additionally, students will need to fulfill the following requirements to gain admission to the Mechatronics program major:
Completion of all first and second year required major courses with a minimum grade of C-.
Completion of all lower-level University General Education requirements.
Completion of 60 applicable degree credits.

A minimum grade point average of 3.0 in all courses taken at the University of Maryland and all other institutions is required for internal and external transfer students.

Due to the similarity in curriculum content and the physical location of course offerings, students in the Aerospace Engineering and Mechanical Engineering programs at UMD will not be eligible to add Mechatronics as a second major or degree (and vice versa).

The proposed curriculum will offer courses at the 300 and 400-level, which constitute the junior and senior years of the program. The program is mainly 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 in the School of Engineering and the Mechatronics major until they have completed the Engineering LEP gateway courses, required first and second year major courses, lower-level General Education requirements, and have earned at least 60 applicable degree credits.

Summarize the factors that were considered in developing the proposed curriculum (such as recommendations of advisory or other groups, articulated workforce needs, standards set by disciplinary associations or specialized-accrediting groups, etc.).

Robotics, automation, and advanced manufacturing technologies, collectively known as Industry 4.0, is the emerging "4th industrial revolution" that motivates the establishment of the proposed Bachelor of Mechatronics Degree program at USG. According to a 2018 Deloitte industry report, top executives from more than 350 global companies point to finding, training, and retaining the right talent as their top organizational and cultural challenge in this context. Educating students in a 4-year Mechatronics degree program will provide the appropriate combination of mechanical, electronics, and information systems engineering skills that define this cross-disciplinary environment. Existing programs within the University System of Maryland do not currently span the scope of the Mechatronics discipline, so the proposed program curriculum has been developed by the Aerospace Engineering Department at UMD in consultation with the Mechanical Engineering Department. Students graduating from the Mechatronics program will be uniquely positioned among all USM graduates through the curriculum's focus on both a solid foundation in the relevant theoretical and analytical backgrounds, as well as the practical competencies required to enter the workforce. The regional economic pillars of the aerospace and defense industries and related governmental partners will directly benefit from this local source of highly skilled graduates.

Identify specific actions and strategies that will be utilized to recruit and retain a diverse student body.

The proposed Mechatronics Bachelor degree 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. 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. Providing for these students' success through this lower cost option - 2 years at an MPCC followed by 2 years in a UMCP program delivered at USG - helps to reduce the financial burden potential students may face otherwise. Finally, the innovative curriculum of the program 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.

Off Campus

Indicate the location for this off-campus program.

Universities at Shady Grove

Describe the suitability of the site for the off-campus programs.

The program will be delivered in the new Biomedical Sciences and Engineering Education Building (Building IV) at the Universities at Shady Grove. Dedicated and shared laboratory and classroom facilities, as well as office space, has been identified for the program.

Describe the method of instructional delivery, including online delivery, on-site faculty, and the mix of full-time and part-time instructors (according to MHEC 13B.02.03.20.D(2), "At least # of the classes offered in an off-campus program shall be taught by full-time faculty of the parent institution").

The program will be offered exclusively at the Universities at Shady Grove. All undergraduate programs at USG are junior and senior years only. Expectations for lower-level coursework will be established through articulation agreements with the Maryland community colleges or taken at College Park prior to admissions to the School of Engineering and Mechatronics major. 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 support for commuting to/from USG is included in the proposed budget.

Discuss the resources available for supporting faculty at the location. In an attachment, please indicate the faculty involved in the program. Include their titles, credentials, and courses they may teach for the program.

The curriculum would be strongly 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. The program will be supported through a targeted enhancement funding request to the State of Maryland, and as with all undergraduate programs within the A. James Clark School of Engineering, students will be required to pay differential tuition at the approved rate. See Appendix B for a list of tenure/tenure-track and professional track faculty supporting the program.

Discuss how students will have reasonable and adequate access to the range of student support services (library materials, teacher interaction, advising, counseling, accessibility, disability support, and financial aid) needed to support their learning activities.

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.

Discuss how the off-campus program will be comparable to the existing program in terms of academic rigor. What are the learning outcomes for the online offering? Do they differ from the existing on-site program?

All courses, except for Technical Writing, will be delivered by the AE and ME departments. The Provost's Office will coordinate with the Technical Writing program in the English Department to offer a section of ENGL 393 for the Mechatronics majors.

Describe the quality control and evaluation of the off-campus program's effectiveness. How will the program be evaluated?

Assessment of the Mechatronics major 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.

Relationship to Other Units or Institutions

If a required or recommended course is o#ered by another department, discuss how the additional students will not unduly burden that department's faculty and resources. Discuss any other potential impacts on another department, such as academic content that may significantly overlap with existing programs. Use space below for any comments. Otherwise, attach supporting correspondence.

N/A

Accreditation and Licensure. Will the program need to be accredited? If so, indicate the accrediting agency. Also, indicate if students will expect to be licensed or certified in order to engage in or be successful in the program's target occupation.

It is expected that the School will seek to include this program within ABET accreditation, once established.

Describe any cooperative arrangements with other institutions or organizations that will be important for the success of this program.

N/A

Faculty and Organization

Who will provide academic direction and oversight for the program? In an attachment, please indicate the faculty involved in the program. Include their titles, credentials, and courses they may teach for the program.

The departments participating in this program would be:
AE-Aerospace Engineering (Norman M. Wereley wereley@umd.edu)
ME-Mechanical Engineering (Balakumar Balachandran balab@umd.edu)
Aerospace Engineering will lead the Mechatronics Bachelor degree program and will be supported by the Mechanical Engineering Department. The faculty within these departments will provide academic direction and oversight for the program. Appendix B contains a list of the AE tenured, tenure-track, and professional faculty.

Indicate who will provide the administrative coordination for the program

Aerospace Engineering will lead administrative coordination for the Mechatronics Bachelor degree program.

Resource Needs and Sources

Each new program is required to have a library assessment prepared by the University Libraries in order to determine any new library resources that may be required. This assessment must be done by the University Libraries. Add as an attachment.

Attached

Discuss the adequacy of physical facilities, infrastructure and instructional equipment.

In addition to four lecture classrooms per semester of 40 students each, the following specialized teaching laboratories are available to provide a lab space for students to work on engineering lab work and to provide tools for basic and intermediate fabrication and assembly activities with a focus on mechatronics:
Mechatronics and Controls Laboratory (ENMT 461 and ENMT 462)
Instrumentation Systems Laboratory (ENMT 30X and ENMT 31X)
Vehicle Simulator Laboratory (ENMT 380)
Mechatronics Design Suite (a design lab with 8 collaboration stations, 72" tables attached to the wall with desktop computers with CAD software, large screen monitor, comfy chairs, projectors, and glass boards throughout).

Attached to the Mechatronics Design Suite would be a Mechatronics Fabrication Laboratory with various fabrication capabilities for electronics, additive manufacturing, machining (mill, lathe, drill press etc.) A list of proposed fab lab supplies and equipment is available upon request.

Discuss the instructional resources (faculty, staff, and teaching assistants) that will be needed to cover new courses or needed additional sections of existing courses to be taught. Indicate the source of resources for covering these costs.

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 would be strongly 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. The program will be supported through the Governor's Workforce Development Funding Initiative, and as with all undergraduate programs within the A. James Clark School of Engineering, students will be required to pay differential tuition at the approved rate.

Discuss the administrative and advising resources that will be needed for the program. Indicate the source of resources for covering these costs.

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 courses. The AE office of external relations in collaboration with the undergraduate office will produce marketing materials and will conduct recruitment events throughout the year. The source of the resources for covering these costs is targeted enhancement funding from the State of Maryland and student tuition.

Use the Maryland Higher Education Commission (MHEC) commission financial tables to describe the program's financial plan for the next five years. See help bubble for financial table template. Use space below for any additional comments on program funding.

See attached budget tables.

Implications for the State (Additional Information Required by MHEC and the Board of Regents)

Explain how there is a compelling regional or statewide need for the program. Argument for need may be based on the need for the advancement of knowledge and/or societal needs, including the need for "expanding educational opportunities and choices for minority and educationally disadvantaged students at institutions of higher education." Also, explain how need is consistent with the Maryland State Plan for Postsecondary Education **(**https://mhec.state.md.us/About/Documents/2017.2021%20Maryland%20State%20Plan%20for%20Higher%20Education.pdf**).**

The proposed Mechatronics Bachelor degree 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. 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. 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. Finally, the innovative curriculum of the program 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.

Present data and analysis projecting market demand and the availability of openings in a job market to be served by the new program. Possible sources of information include industry or disciplinary studies on job market, the USBLS Occupational Outlook Handbook **(**https://www.bls.gov/ooh/**), or Maryland state** Occupational and Industry Projections **(**http://www.dllr.state.md.us/lmi/iandoproj/**) over the next five years. Also, provide information on the existing supply of graduates in similar programs in the state (use MHEC's Office of Research and Policy Analysis** webpage (http://mhec.maryland.gov/publications/Pages/research/**) for Annual Reports on Enrollment by Program) and discuss how future demand for graduates will exceed the existing supply. As part of this analysis, indicate the anticipated number of students your program will graduate per year at steady 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(1). 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(2). The State of Maryland in particular is projected to see higher than average opportunities(3) for Mechatronics Engineers 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.(4)

(1) 2018 ASEE Southeastern Section Conference American Society for Engineering Education, 2018 Growth of 2-Year programs for Mechatronics Marilyn Barger, Richard Gilbert

(2) 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
(3) 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
(4) https://www.dllr.state.md.us/lmi/iandoproj/maryland.shtml

Identify similar programs in the state. Discuss any di#erences between the proposed program and existing programs. Explain how your program will not result in an unreasonable duplica on of an existing program (you can base this argument on program di#erences or market demand for graduates). The MHEC website can be used to find academic programs operatinng in the state: http://mhec.maryland.gov/institutions_training/pages/HEPrograms.aspx

There are currently no Bachelors 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. Therefore, the proposed Mechatronics Bachelor's Degree program at USG would bridge the gap in training students towards the only 4-year degree of its kind in the state. Additionally, because of the unique combined expertise in both mechanical, electrical, and information systems engineering that the proposed program offers, it 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 standard 4-year engineering degrees available within the UM system.

Discuss the possible impact on Historically Black Institutions (HBIs) in the state. Will the program affect any existing programs at Maryland HBIs? Will the program impact the uniqueness or identity of a Maryland HBI?

No historically black institutions in Maryland offer bachelor's programs in mechatronics engineering, so given the specialization of the Mechatronics program we do not expect to draw from students who intend to study related engineering disciplines at these historically black institutions.

Supporting Documents

Attachments

Course Descriptions.pdf
AEFaculty List USG PCC.pdf
Collection_Assessment_Mechatronics.pdf
BS Mechatronics - MHEC-Budget-2019_FY21Update Final.xlsx
Mechatronics_Assessment_Plan.pdf

Reviewer Comments

Michael Colson (mcolson) (Mon, 24 Feb 2020 19:18:15 GMT): Rollback: Rolling back to initiator for edits.

Norman Wereley (wereley) (Mon, 01 Jun 2020 14:48:23 GMT): I APPROVE THIS PROPOSAL

Michael Colson (mcolson) (Fri, 06 Nov 2020 15:40:21 GMT): Rollback: Rolling back to Senate PCC chair

Key: 686

Appendix A : 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.

ENMT388 - 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.

ENGL393 - Technical Writing
The writing of technical papers and reports for modern communication media.

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.

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.

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.

ENMT478 - 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.

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.

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.

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.

Tenured Faculty		
	Akin, David	Associate Professor
	Baeder, James	Professor
	Bauchau, Olivier	Professor
	Cadou, Christopher	Professor
	Chopra, Inderjit	Distinguished Univ Professor
	Datta, Anubhav	Associate Professor
	Flatau, Alison	Prof & Assoc Chair
	Jones, Anya	Associate Professor
	Laurence, Stuart	Associate Professor
	Lee, Sung	Professor
	Martin Aguirre, Maria	Associate Professor
	Paley, Derek	Professor
	Sanner, Robert	Assoc Prof & Assoc Chair
	Sedwick, Raymond	Professor
	Wereley, Norman	Prof & Chair
	Winkelmann, Allen	Associate Professor
	Yu, Kenneth	Professor

Tenure Track Faculty		
	Hartzell, Christine	Assistant Professor
	Otte, Michael	Assistant Professor
	Xu, Huan	Assistant Professor

Professional Track Faculty		
	Becnel, Andrew	Senior Lecturer
	Bowden, Mary	Visiting Asst Professor
	Carignan, Craig	Lecturer
	Castano, Lina	Asst Research Scientist
	Wolek, Artur	Post-Doctoral Associate
	Yeo, Derrick	Asst Research Scientist

DATE: February 19, 2020

TO: Norman Wereley

Department Chair, Aerospace Engineering

FROM: On behalf of the University of Maryland Libraries:

Sarah Over, Engineering Librarian

Maggie Saponaro, Director of Collection Development Strategies

Daniel Mack, Associate Dean, Collection Strategies & Services

RE: Library Collection Assessment

We are providing this assessment in response to a proposal by the Aerospace Engineering department within the Clark School of Engineering to create a Bachelor of Science in Mechatronics program. The Aerospace Department asked that we at the University of Maryland Libraries assess our collection resources to determine how well the Libraries support the curriculum of this proposed program.

Serial Publications

The University of Maryland Libraries currently subscribe to a large number of scholarly journals, with almost all in online format that focus on various areas in robotics, aerospace, and bioengineering, including those relevant to this proposed program in mechatronics such as autonomous systems. Those serials not available online can be requested via the article/chapter request form within Interlibrary Loan (ILL, https://www.lib.umd.edu/access/ill) so that faculty and students at Shady Grove can utilize these publications without traveling to College Park.

The Libraries subscribe to many of the top ranked journals that are listed in the categories of: Engineering – Aerospace, Engineering – Biomedical, Engineering – Mechanical, Mechanics, and Robotics in *Journal Citation Reports.** These journals include the following, most of which are available online:

- Advances in Applied Mechanics (print only)
- AIAA Journal
- Autonomous Robots
- Annual Review of Biomedical Engineering
- Biotechnology Advances
- IEEE-ASME Transactions on Mechatronics
- Journal of Air Transportation
- Journal of Biomechanics
- Journal of Guidance, Control, and Dynamics
- Journal of the American Helicopter Society

- Nature Biotechnology
- Science Robotics
- Soft Robotics
- IEEE Publications^ (including serials on robotics and autonomous systems)

Due to the interdisciplinary nature of this program, with applications in medical fields, there are highly-ranked journals such as Nature Biomedical Engineering to which the Libraries in College Park do not currently subscribe. However, articles in journals that we do not own will be available through Interlibrary Loan (more details given later in this document).

^There are a number of IEEE serials that are relevant to this proposed program, and can be accessed through the relevant database, as discussed below.

*Note: *Journal Citation Reports* is a tool for evaluating scholarly journals. It computes these evaluations from the relative number of citations compiled in the *Science Citation Index* and *Social Sciences Citation Index* database tools.

Databases

The Libraries' *Database Finder* (http://www.lib.umd.edu/dbfinder) resource offers online access to databases that provide indexing and access to scholarly journal articles and other information sources. Many of these databases cover subject areas that would be relevant to this proposed program, especially due to the variety of applications for mechatronics. Databases that would most be useful for this program include: *ACM Digital Library, AIAA Aerospace Research Central, ASME Digital Collection, ASTM Compass, IEEE Xplore, IEEE/Wiley eBooks*, and *Techstreet*. Some of the more interdisciplinary databases that would be relevant to this curriculum include: *Knovel, ScienceDirect, SIAM eBooks, SPIE eBook Collection, Springer eBooks*, and *Web of Science*. The Libraries also indexes free/open databases such as *PubMed* that this program can take advantage of for instruction and research.

In many and likely in most cases, these indexes offer full text copies of the relevant journal articles. In those instances that the journal articles are available only in print format, the Libraries can make copies available through Libraries' Interlibrary Loan service (https://www.lib.umd.edu/access/ill-article-request).

Monographs

The Libraries regularly acquire scholarly monographs in a variety of topics relevant to mechatronics. Monographs not already part of the collection can usually be added directly to the collection at Shady Grove upon request.

A search of the University of Maryland Libraries' WorldCat UMD catalog was conducted for monographs, using a variety of relevant subject terms. UMD owns thousands of titles relevant to this proposed program, including:

- Mechatronics – 811 items

- Robotics – 4865 items
- (Bio-inspired or "biologically inspired") and (robotics or robots) – 174 items
- Autonomous aerial vehicles – 54 items
- Unmanned aerial vehicles – 197 items
- Machine learning – 2681 items

In addition, we own hundreds of monographs published within the last five years, insuring the program has access to relevant and recent holdings.

A further search revealed that the Libraries' membership in the Big Ten Academic Alliance (BTAA) dramatically increases these holdings with an increase to 1526 results for "mechatronics" and 7803 results for "machine learning." As with our own materials, students can request that chapters from these BTAA books if the books are not available electronically. Finally, monographs can be sent to Priddy Library for pickup, avoiding the need to travel to College Park, which may be inconvenient for students and faculty in this program.

Interlibrary Loan Services

Interlibrary Loan services (https://www.lib.umd.edu/access/ill) provide online delivery of bibliographic materials that otherwise would not be available online. As a result, these services are especially helpful for users at Shady Grove (or online courses). All Interlibrary Loan services are available free of charge for users.

The article/chapter request service scans and delivers journal articles and book chapters within three business days of the request–provided that the items are available in print on the UM Libraries' shelves or in microform. In the event that the requested article or chapter is not available on campus, the request will be automatically forwarded to the Interlibrary Loan service (ILL). Interlibrary Loan is a service that enables borrowers to obtain online articles and book chapters from materials not held in the University System of Maryland.

Additional Materials and Resources

In addition to serials, monographs and databases available through the University Libraries, students in the proposed program will have access to a wide range of media, datasets, software, and technology. Media in a variety of formats that can be utilized both on-site and via ELMS course media is available. GIS Datasets are available through the GIS Data Repository (https://www.lib.umd.edu/gis/data-and-resources) while statistical consulting and additional research support is available through the Research Commons (http://www.lib.umd.edu/rc) and technology support and services are available through the Terrapin Learning Commons (http://www.lib.umd.edu/tlc). Finally, this program can also use the patent and trademark consultation services, which are provided by our Patents & Trademarks librarian, James Miller (jmiller2@umd.edu).

Students can also access print textbooks required for their classes through Priddy Library's Course Reserves program. This is a critical service due to the rising cost of textbooks.

The engineering subject specialist at Shady Grove, Amy Trost (atrost1@umd.edu, 301-738-6122), and the subject specialist librarian for engineering in College Park, Sarah Over (sover@umd.edu, 301-405-9142) will both serve as important resources to programs such as the one proposed. Through departmental partnerships, subject specialists actively develop innovative services and materials that support the University's evolving academic programs and changing research interests. Subject specialists provide one-on-one research assistance online, in-person, or via the phone. They also provide information literacy instruction and can provide answers to questions regarding publishing, copyright and preserving digital works.

Other Research Collections

Because of the University's unique physical location near Washington D.C., Baltimore and Annapolis, students and faculty have access to some of the finest libraries, archives and research centers in the country vitally important for researchers in this discipline. These include the Library of Congress, the National Archives, the Smithsonian, and more.

Conclusion

With our substantial journals holdings and databases, as well as additional support services and resources, the University of Maryland Libraries have the resources to support teaching and learning in mechatronics. These materials are supplemented by a strong monograph collection and additional holdings through the Big Ten Academic Alliance. Additionally, the Libraries' Interlibrary Loan services make materials that otherwise would not be available online, accessible to remote users not physically located in College Park. As a result, our assessment is that the University of Maryland Libraries are able to meet the curricular and research needs of the proposed Bachelor of Science in Mechatronics program to be offered at the Universities at Shady Grove.

Mechatronics Assessment Plan

The Mechatronics program at Universities at Shady Grove will follow the assessment strategy detailed herein to ensure that the articulated student learning outcomes are met and ABET accreditation can be pursued. The student learning outcomes (SLO) are aligned with the assessments in accordance with ABET requirements. The distinct SLOs are:

1. Ability to apply knowledge of mathematics
2. Ability to apply knowledge of basic science (chemistry, physics)
3. Ability to apply knowledge of engineering principles
4. Ability to use computers to solve engineering problems
5. Ability to identify, formulate, and solve engineering problems
6. Ability to design and conduct experiments
7. Ability to analyze and interpret data
8. Ability to design a component, system, or process to meet desired needs under realistic constraints
9. Ability to use the techniques, skills, and tools of modern engineering practice
10. Ability to write effectively
11. Ability to speak effectively
12. Ability to function effectively as part of a multidisciplinary team
13. Understanding of professional and ethical responsibility
14. Knowledge of contemporary issues in engineering
15. Understanding of the impact of engineering solutions in a global, economic, societal, and environmental context
16. Awareness of the need to continually upgrade my technical knowledge base and skills

Assessment of these SLOs will be performed each year by the course instructor and submitted to the Aerospace Engineering Undergraduate Affairs Committee. The committee will provide recommendations for modifications to the instructors every three years, twice per ABET cycle. A template to track assessments, based on the same process currently utilized by the Aerospace Engineering program at UMCP, is shown below.

**********Begin Student Learning Outcome Template**********

Aerospace ABET Direct Assessment Form

1. **Course Title:**

2. **In the first column, please rate the relevance of each learning outcome in your course using the 0-4 rating scale described below (following the table, at the top of the next page).**
3. **For each outcome rated 3 or 4 in the first column, give a numerical quantification of the *demonstrated ability* of your students during the semester. This quantification should be based on a representative subset of the assessments which covered the outcome during the semester. Please normalize your rating to the same 0-4 scale used in the first column. If you curve the individual or final grades in your course, please reflect such adjustments in the ratings you give.**

4. **Finally, please provide on the second page a list of the specific assessments (e.g. Q4 on PS2, etc) from your class that you used as the basis for each rating you give in the second column.**

Outcome	**Relevance**	**Evaluation**
1. Ability to apply knowledge of mathematics		
2. Ability to apply knowledge of basic science (chemistry, physics)		
3. Ability to apply knowledge of engineering principles		
4. Ability to use computers to solve engineering problems		
5. Ability to identify, formulate, and solve engineering problems		
6. Ability to design and conduct experiments		
7. Ability to analyze and interpret data		
8. Ability to design a component, system, or process to meet desired needs under realistic constraints		
9. Ability to use the techniques, skills, and tools of modern engineering practice		
10. Ability to write effectively		
11. Ability to speak effectively		
12. Ability to function effectively as part of a multidisciplinary team		
13. Understanding of professional and ethical responsibility		
14. Knowledge of contemporary issues in engineering		
15. Understanding of the impact of engineering solutions in a global, economic, societal, and environmental context		
16. Awareness of the need to continually upgrade my technical knowledge base and skills		

Rating scale for first column:

0 = no coverage of this outcome in the course
1 = material related to the outcome is mentioned briefly in the course, but is not assessed
2 = material related to the outcome is discussed in the course, but not significantly assessed.
3 = important supporting skills, reinforced during the course
4 = course content is designed to directly address this outcome

Every course should have at least one, and possibly several, outcomes rated at level 4 in the first column.

Student skill in outcomes rated 3 or 4 in the first column should be frequently assessed by the course homework, examinations, laboratories, and final projects. These assessments should be used as the basis for the ratings given in column 2.

Basis for column 2 ratings (give a list of assessments used for each rating given; use additional pages as needed):

**********End Student Learning Outcome Template**********

In addition to yearly course assessments provided instructors, students will complete a senior exit survey prior to graduate each year. The results from these exit surveys will be reviewed by the Undergraduate Studies Committee and suggested improvements to the curriculum will be collected to the Mechatronics program Faculty Director.

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)	$ -	$ -	$ -	$ -	$ -
3. Grants, Contracts, & Other External Sources	$ -	$ -	$ -	$ -	$ -
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**

Undergraduate	**Full time**	**Part Time**		**Full time**	**Part time**
AY20-21	**annual**	**per credit hour**	**inflation**	**% in-state**	
resident tuition	$ 8,824.00	$ 367.00	1.03	1.00	1.00
non-resident tuition	$34,936.00	$ 1,456.00		0.00	0.00
diff'l addition (BMGT, ENGR, CS)	$ 2,856.00	$ 118.00			
				standard FT/PT/in/out	
				0.80	0.90
Graduate				0.20	0.10
FY20	**annual**	**per credit hour**			
resident	$17,544.00	$ 731.00			
non-resident	$39,000.00	$ 1,625.00			

Change rows 2 and 12, depending on whether this is a graduate or undergraduate program.

TABLE 2: EXPENDITURES

Expenditure Categories	Year 1	Year 2	Year 3	Year 4	Year 5	Year 0
1. Full time Faculty (b+c below)	$478,800	$657,552	$677,279	$871,996	$898,156	$145,586
a. #FTE	3.0	4.0	4.0	5.0	5.0	1.0
b. Total Salary	$360,000	$494,400	$509,232	$655,636	$675,305	$112,596
c. Total Benefits	$118,800	$163,152	$168,047	$216,360	$222,851	$32,990
2. Part time Faculty (b+c below)	$14,000	$28,000	$70,000	$70,000	$70,000	$132,289
a. #FTE	0.2	0.4	1.0	1.0	1.0	0.9
b. Total Salary	$14,000	$28,000	$70,000	$70,000	$70,000	$102,312
c. Total Benefits	$0	$0	$0	$0	$0	$29,977
3. Admin. Staff (b+c below)	$186,200	$191,786	$246,924	$254,332	$261,962	$136,794
a. #FTE	2.0	2.0	2.5	2.5	2.5	1.0
b. Total Salary	$140,000	$144,200	$185,658	$191,227	$196,964	$101,030
c. Total Benefits	$46,200	$47,586	$61,267	$63,105	$64,998	$35,764
4. Technical Support staff (b+c below)	$53,200	$54,796	$56,440	$58,133	$59,877	$69,671
a. #FTE	0.5	0.5	0.5	0.5	0.5	0.3
b. Total Salary	$40,000	$41,200	$42,436	$43,709	$45,020	$53,883
c. Total Benefits	$13,200	$13,596	$14,004	$14,424	$14,857	$15,788
5. Graduate Assistants (b+c+d below)	$44,144	$89,341	$90,425	$91,542	$92,692	$115,660
a. #FTE	1.0	2.0	2.0	2.0	2.0	2.0
b. Stipend	$20,000	$40,000	$40,000	$40,000	$40,000	$69,525
c. Tuition Remission	$17,544	$36,141	$37,225	$38,342	$39,492	$36,141
d. benefits	$6,600	$13,200	$13,200	$13,200	$13,200	$46,135
6. Equipment	$50,000	$25,000	$25,000	$25,000	$25,000	$300,000
7. Library	$5,000	$5,000	$5,000	$5,000	$5,000	$0
8. New or Renovated Space	$0	$0	$0	$0	$0	$0
9. Marketing/Advertising	$10,000	$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	$0
11. Office Space Rental	$10,500	$10,815	$11,139	$11,474	$11,818	$0
12. Classroom Rental	$0	$9,000	$9,270	$9,548	$9,835	$0
13. Student Services Support (OES)	$11,680	$36,091	$49,565	$63,815	$78,876	$0
TOTAL (Add 1 - 13)	**$913,524**	**$1,167,381**	**$1,301,042**	**$1,520,840**	**$1,573,215**	**$910,000**
resources - expenditures	$103,276	$93,531	$94,610	$17,313	$115,541	($910,000)

These budget estimates are resources and expenditures to the University overall, and not to the program or unit. Do not include revenue-sharing agreements between units, between unit and college, or with the university (e.g., for entrepreneurial programs) as an expenditure.

benefits	0.33
inflation	1.03