UNIVERSITY SENATE | **LEGISLATION APPROVAL | #18-19-19**

Approved by the Senate on December 4, 2018

PCC Proposal to Establish a Bachelor of Science in Embedded Systems and the Internet of Things (Senate Document #18-19-19)

TO **Wallace D. Loh | President**

FROM **Christopher Walsh | Chair, University Senate**

I am pleased to forward the accompanying legislation for your consideration and approval. Janna Bianchini, Chair of the Programs, Curricula, & Courses (PCC) Committee, presented the PCC Proposal to Establish a Bachelor of Science in Embedded Systems and the Internet of Things (Senate Document #18-19-19), which the University Senate approved at its meeting on December 4, 2018. Please inform the Senate of your decision and any administrative action related to your conclusion.

Approved: _____ **Date:** **12-11-2018**

Wallace D. Loh
President

Copies of this approval and the accompanying legislation will be forwarded to:

Mary Ann Rankin, Senior Vice President and Provost
Reka Montfort, Executive Secretary and Director, University Senate
Michael Poterala, Vice President and General Counsel
Cynthia Hale, Associate Vice President for Finance and Personnel
John Bertot, Associate Provost for Faculty Affairs
Elizabeth Beise, Associate Provost for Academic Planning & Programs
Sylvia B. Andrews, Academic Affairs
Darryll Pines, Dean, A. James Clark School of Engineering
Mel Gomez, Associate Chair for Undergraduate Education, Department of Electrical and Computer Engineering
Neruh Ramirez, Director, Department of Electrical and Computer Engineering
Janna Bianchini, Chair, Programs, Curricula, & Courses Committee
Ken Kiger, Professor, Department of Electrical and Computer Engineering

Establish a Bachelor of Science in Embedded Systems and Internet of Things (PCC 18037)

PRESENTED BY	**Janna Bianchini, Chair, Senate Programs, Curricula, and Courses Committee**
REVIEW DATES	**SEC – November 16, 2018 | SENATE – December 4, 2018**
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 Electrical Engineering within the A. James Clark School of Engineering (Clark School) proposes to establish a Bachelor of Science degree program in Embedded Systems and Internet of Things. The concept of "embedded systems" is commonly associated with the hardware and software used in devices that operate as part of a larger computing system. These systems are becoming more prevalent in household, healthcare, and transportation systems, as well as industrial applications such as power and manufacturing. The proposed program goes beyond the scope of embedded systems into the realm of what is known as the "Internet of Things" (IoT), which includes smart devices, communication systems and protocols, system architecture, data collection and analysis using so-called edge and cloud computing platforms, and applications. At the foundation of the IoT infrastructure are the microelectronic circuits that perform data acquisition, signal processing, and communications within a device, along with the software codes that determine their functions. These circuits, collectively called smart devices, are interconnected with the network from which applications are implemented. The proposed program will provide students with a solid foundation in the key emerging technologies of the IoT.

This program will be offered at the Universities of Shady Grove and is mainly 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.

Students applying to the program will need to have completed 60 degree credits, all major courses with a minimum grade of C-, and all lower-level General Education requirements. Students must also meet the Clark School requirements for admission to a Limited Enrollment Program.

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. Students will be able to focus these major electives into one of the following specializations: Hardware, Computational, or Security. The department expects that graduates will

be in high demand in such occupational areas as computer developers, computer systems analysts, network architects and administrators, information security analysts, information systems analysts and computer programmers.

This proposal was approved by the Senate Programs, Curricula, and Courses committee on November 2, 2018.

RECOMMENDATION(S)

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

COMMITTEE WORK

The committee considered this proposal at its meeting on November 2, 2018. Mel Gomez and Neruh Ramirez, of the Department of Electrical Engineering, and Ken Kiger of the A. James Clark School of Engineering, presented the proposal. The proposal was unanimously approved by the committee. The proposal was initially submitted as “Embedded Systems,” but was later revised to “Embedded Systems and Internet of Things.” This revised title was accepted by the committee.

ALTERNATIVES

The Senate could decline to approve this new 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.

X

University of Maryland PCC
Program/Curriculum/Unit Proposal

PCC Log No: 18037

Program: Embedded Systems

Department/Unit: Electrical & Computer Engineering

College/School: A. James Clark School of Engineering

Proposal Contact Person (with email): Romel Gomez (rdgomez@ece.umd.edu); Neruh Ramirez (nram@ece.umd.edu)

Type of Action (check one):

- ☐ Curriculum change (includes modifying minors, concentrations/specializations and creating informal specializations)
  - ☐ Curriculum change is for an LEP Program
- ☐ *Rename a program or formal Area of Concentration*
- ☐ *Establish/Discontinue a formal Area of Concentration*
- ☐ Other:
- ☒ *Establish a new academic degree/certificate program*
- ☐ Create an online version of an existing program
- ☐ Establish a new minor
- ☐ *Suspend/Discontinue a degree/certificate program*
- ☐ Establish a new Master or Certificate of Professional Studies program
  - ☐ New Professional Studies program will be administered by Office of Extended Studies

Italics indicate that the proposal must be presented to the full University Senate for consideration.

Approval Signatures - *Please print name, sign, and date. For proposals requiring multiple unit approvals, please use additional cover sheet(s).*

1. Department Committee Chair for Gang Qu 9/21/18
2. Department Chair 9/21/18
3. College/School PCC Chair 10/24/18
4. Dean Kenneth T. Kuju 10/24/18
5. Dean of the Graduate School (if required) _____
6. Chair, Senate PCC Janna Bianchini 11-2-18
7. University Senate Chair (if required) _____
8. Senior Vice President and Provost _____

Instructions:
When approved by the dean of the college or school, please send the proposal and signed form to the Office of the Associate Provost for Academic Planning and Programs, 1119 Main Administration Building, Campus-5031, **and** email the proposal document as an MSWord attachment to pcc-submissions@umd.edu.

Summary of Proposed Action (use additional sheet if necessary):

Unit Code(s) (to be entered by the Office of Academic Planning and Programs):

In order to complete this form, you will need to copy this template to your own document, then complete, print, and submit this proposal with the PCC Cover Sheet

Program: Bachelor of Science in Embedded Systems

Date of Proposal: September 2018

Start Term for New Program: Fall 2020

A new degree program proposal will need to be approved not just by campus but also by the University System of Maryland (USM) Board of Regents and the Maryland Higher Education Commission (MHEC). New certificate programs need to be approved by the USM Chancellor and MHEC. The following prompts are based on academic policies for programs and reflect campus requirements and MHEC requirements. The prompts also include questions frequently asked by review committees. See http://mhec.maryland.gov/institutions_training/Pages/acadaff/AcadProgInstitApprovals/NewAcademicProgramProposals.aspx for more information about MHEC requirements. Please feel free to add additional information at the end of this document or in a separate appendix.

Mission and Purpose

1. Describe the program and explain how it fits the institutional mission statement and planning priorities. The University Mission Statement and Strategic Plan can be found on this site: https://www.umd.edu/history-and-mission.

With the rapid pace of growth in new products and applications, there is a pressing need in industry and government for engineers with special skills in hardware and software design and who are well-versed with both analog and digital electronics and information systems. This proposed Bachelor of Science in Embedded Systems, to be offered at the Universities at Shady Grove, will address this demand. The establishment of the Embedded Systems major follows the spirit of the University's Strategic plan of creating knowledge to address the most important issues of our time. The program will train future engineers who are cognizant of the latest trends in circuits and hardware-oriented software that are capable of immediate contribution to the private and public sector institutions in which they will work. It is intended to be the first of its kind in the U.S. from a top tier university. This program will draw students from Maryland public community colleges and will admit students who have completed their first two years of coursework as outlined by the program and who satisfy admission requirements to the A. James Clark School of Engineering.

As a society, we are currently within an era of the "Internet of People": Facebook, YouTube, Instagram, and Twitter; along with a myriad other social networking sites being ubiquitous and omnipresent. These social media platforms have revolutionized how people communicate and interact with each other, and their impact is felt in nearly all facets of human enterprise, including commerce, entertainment, health, and politics. Yet despite its current importance, the Internet of People will soon give way to the "Internet of Things" (IoT). In a few years, our human senses to "see, hear, touch, smell and taste" and our ability to rearrange our environment will be supplemented with inanimate sensors and actuators that collect information, and communicate with one another. These devices will be rigidly managed by a control algorithm that will analyze voluminous data and perform appropriate actions to achieve a mission.

At the foundation of an Internet of Things infrastructure are the microelectronic circuits that perform data acquisition, signal processing, and communications within the device. These are performed by integrated circuits and microcontrollers that are incorporated within the device, commonly referred to as "embedded systems." These systems are becoming more ubiquitous in household, healthcare and transportation systems as well as industrial applications such as power and manufacturing. These are the key elements in popular home automation products such as Google Home and Amazon Alexa, as well self-driving vehicle systems such as Alphabet Waymo and Tesla. At the other end are the data analytics and control systems that process the information and implement applications. In between lies the computing platforms, protocols and gateways that seamlessly connect these devices, and process the data into actionable information while providing security that all is trustworthy and safe.

Program Characteristics

2. 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.

The Bachelor of Science in Embedded Systems will provide students with a solid foundation in key emerging technologies of the Internet of Things (IoT), the ability to integrate devices into complete IoT systems, and an understanding of how IoT fits within the wider context of information and communications technology, including data analytics and cloud computing. At the senior level, students will be able to specialize in one of the following tracks: Hardware, Computational, or Security track. It is expected that graduates will be in high demand in such occupational areas as computer developers, computer systems analysts, network architects and administrators, information security analysts, information systems analysts and computer programmers.

3. What are the educational objectives of the program?

The program education objective of this program is to produce well-trained workforce in the emerging technologies of internet of things. The Bachelor of Science in Embedded Systems and Internet of Things will produce engineering graduates who

- Use their hardware and software engineering design training and problem-solving skills to contribute professionally in an industrial, research and applications environment;
- Demonstrate initiative, leadership, teamwork, and continued professional development;
- Demonstrate understanding of the impact of their professional activities on society.

4. 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 Embedded Systems major will be designated as a Limited Enrollment Program (LEP). Admission to this program will follow School of Engineering's admissions criteria found on the LEP website: http://www.lep.umd.edu.

Students beyond their first semester and those off campus wishing to transfer are required to meet the following gateway criteria:

- 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 CHEM134 with a minimum grade of C-. (Students who take CHEM134 must also have completed CHEM131 with a minimum grade of C-.)

Additionally, students will need to fulfill the following requirements to gain admissions to the Embedded Systems major:

- Completion of all first and second year required major courses (as outlined in section #7) with a minimum grade of a "C-."
- Completion of all lower-level University General Education requirements.
- Completion of 60 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 Electrical Engineering, Computer Engineering, and Computer Science programs at UMD, will not be eligible to add Embedded Systems 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 year 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 admissions into the School of Engineering and the Embedded Systems 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 credits.

5. Indicate the course requirements with course numbers, titles and credits. If applicable, indicate if any course will also count for a general education requirement. In an appendix, provide the course catalog information (credits, description, prerequisites, etc.) for all of the courses. Note that suffixed "selected" or "special" topics courses should be avoided. If suffixed-selected or special topics courses are offered regularly in the new program, you should make the courses permanent. Also, please review the basic requirements of degree programs or certificate programs to ensure that they meet the minimum policy requirements.

Please note: new courses or modifications to courses need to be submitted through the Testudo Curriculum Management system and will need to follow the normal VPAC course proposal review process. You may submit individual course changes to VPAC concurrently with the PCC proposal; however, the course changes may be held depending on the outcome of the PCC proposal.

Required Foundation Courses (43 required credits)

Course	Title	Cr
ENEB 302	Analog Circuits	4
ENEB 304	Microelectronics and Sensors	3
ENEB 340	Intermediate Programming Concepts and Applications for Embedded Systems (C/C++)	2
ENEB 341	Introduction to Internet of Things	3
ENEB 344	Introduction to Digital Circuits	4
ENEB 352	Introduction to Networks and Protocols	3
ENEB 353	Computer Organization for Embedded Systems	3
ENEB 354	Discrete Mathematics for Information Technology	3
ENEB 355	Algorithms in Python	3
ENEB 408x	Capstone Design Lab I	3
ENEB 408x	Capstone Design Lab II	3
ENEB 443	Hardware/Software Security for Embedded Systems	3
ENEB 454	Embedded Systems	3
ENGL 393	Technical Writing	3

Elective Courses (18 required elective credits)

Course	Title	Cr
ENEB 453	Web Based Application Development	3
ENEB 455	Advanced FPGA System Design using Verilog	3
ENEB 444	Operating Systems for Embedded Systems	3
ENEB 451	Network Security	3
ENEB 345	Probability and Statistical Inference	3
ENEB 452	Advanced Software for Embedded Systems-Connected Systems	3
ENEB 456	Machine Learning Tools	3
ENEB 457	Database	3

See Appendix A for course descriptions

6. 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.).

The field of IoT is projected by some experts (Forbes, Dec. 2017) to have a global market value of $457B by 2020 with a Compound Annual Growth Rate of 28%, and the need for a trained workforce to fuel this growth is essential. The proposed curriculum is a synthesis of some of the core concepts in electrical engineering, computer engineering, computer science, information technology and telecommunications. The curriculum was developed by faculty from the Department of Electrical & Computer Engineering (ECE), with consultations with industrial partners in the hardware (Texas Instruments) and software/data analytics (Microsoft) spaces. The contents are outside the scope of any of these traditional disciplines, making it unique and customized for the anticipated needs of this emerging technology.

7. 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 Embedded System major, students should have completed the Engineering LEP gateway courses, basic math/science courses, lower-level General Education requirements, and at least 60 credits.

Course	Title	Cr
MATH 140	Calculus I	4
MATH 141	Calculus II	4
ENGL 101	Academic Writing	3
CHEM 135	General Chemistry for Engineers	3
PHYS 161	General Physics: Mechanics and Particle Dynamics	3
PHYS 260	General Physics: Vibration, Waves, Heat, Electricity and Magnetism	3
PHYS 261	General Physics: Vibrations, Waves, Heat, Electricity and Magnetism (Laboratory)	1
Prog Req*	Programming Requirement (see below for details)	2-4
ENES 100	Introduction to Engineering Design	3
MATH 2xx	MATH246 (Diff. Eq.), MATH241 (Calc III), **OR** MATH240 (Linear Algebra)	3-4
GenEd Courses	General Education Requirements/Additional Electives	28-31
	Total Credits	**60**

*Programming Requirement:
Embedded Systems major will accept any of the following programming courses or their equivalents:

- ENEE140
- CMSC131
- CMSC106
- Any introductory course in C, C++, Java, or Python (students must submit the course to ECE Department for evaluation)

JUNIOR & SENIOR YEAR AT SHADY GROVE

Junior Year 1st Semester

Course	Title	Cr
ENEB 302	Analog Circuits	4
ENEB 344	Introduction to Digital Circuits	4
ENEB 354	Discrete Mathematics for Information Technology	3
ENEB 340	Intermediate Programming Concepts and Applications for Embedded Systems (C/C++)	2

ENEB 341	Introduction to Internet of Things	3
	Total Semester Credits	**16**

Junior Year 2nd Semester

Course	Title	Cr
ENEB 304	Microelectronics and Sensors	3
ENEB 352	Introduction to Networks and Protocols	3
ENEB 353	Computer Organization for Embedded Systems	3
ENEB 355	Algorithms in Python	3
ENGL 393	Technical Writing	3
	Total Semester Credits	**15**

Senior Year 1st Semester

Course	Title	Cr
ENEB 408x	Capstone Design Lab I	3
ENEB 454	Embedded Systems	3
ENEB 4xx	Senior Level Electives (based on track)	9
	Total Semester Credits	**15**

Senior Year 2nd Semester

Course	Title	Cr
ENEB 408x	Capstone Design Lab II	3
ENEB 443	Hardware/Software Security for Embedded Systems	3
ENEB 4xx	Senior Level Electives (based on track)	9
	Total Semester Credits	**15**

TOTAL DEGREE CREDITS	**121**

PROGRAM TRACKS

Students in the Embedded Systems major will be required to choose one of three program tracks available in the major. Each track will have its specific senior level course required course(s) and electives.

- The **Hardware Track** is focused primarily on the physical layer and concentrating on operations performed at the device level.
- The **Computational Track** is focused on the modeling and software level, and concentrating on data analytical methods and applications.
- The **Security Track** is focused on security issues on cyber-physical systems and concentrating on hardware and software aspects of data integrity, corruption and threats.

Hardware Track (18 credits) – *Students must take two required courses and 4 out of the 5 elective courses.*

Status	Course	Title	Cr
Required	ENEB 444	Operating Systems for Embedded Systems	3
Required	ENEB 455	Advanced FPGA System Design Using Verilog	3
Elective	ENEB 453	Web Based Application Development	3
Elective	ENEB 451	Network Security	3
Elective	ENEB 345	Probability and Statistical Inference	3
Elective	ENEB 456	Machine Learning Tools	3
Elective	ENEB 457	Database	3

Computational Track (18 credits) - *Students must take five required courses and 1 out of 3 elective courses.*

Status	Course	Title	Cr
Required	ENEB 444	Operating Systems for Embedded Systems	3
Required	ENEB 453	Web Based Application Development	3
Required	ENEB 345	Probability and Statistical Inference	3
Required	ENEB 456	Machine Learning Tools	3
Required	ENEB 452	Advanced Software for Embedded Systems-Connected Systems	3
Elective	ENEB 455	Advanced FPGA System Design Using Verilog	3
Elective	ENEB 451	Network Security	3
Elective	ENEB 457	Database	3

Security Track (18 credits) - *Students must take five required courses and 1 out of 2 elective courses.*

Status	Course	Title	Cr
Required	ENEB 453	Web Based Application Development	3
Required	ENEB 345	Probability and Statistical Inference	3
Required	ENEB 451	Network Security	3
Required	ENEB 452	Advanced Software for Embedded Systems-Connected Systems	3
Required	ENEB 444	Operating Systems for Embedded Systems	3
Elective	ENEB 455	Advanced FPGA System Design Using Verilog	3
Elective	ENEB 456	Machine Learning Tools	3

See Appendix A for Course Descriptions

8. Indicate whether the program will be offered either online or off-campus. Please note that MHEC requires a separate proposal for off-campus delivery. If the program will be offered exclusively online or will have both a face-to-face and online version of the program, please complete this additional form and add as an appendix:

https://docs.google.com/document/d/1ojpUBt4mAWINPCjQNzZ48UH68zGPYj31TPgEOfW3q1E/

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 Embedded Systems major.

9. If the program will be offered in a non-semester format, identify the term structure that will be used for the program:

- **Approved Campus 12-Week Term (see Academic Calendars)**
- ***Non-Standard Term**

***If you are using a non-standard term structure, indicate whether relevant offices, such as the Registrar's Office and International Scholar & Student Services, have been notified and support the program. Non-standard terms need to fit within the university's scheduling system calendar, and non-standard terms need to work with international student visa requirements.**

Not applicable to this program.

10. For Master's degree programs, describe the thesis requirement and/or the non-thesis requirement.

Not applicable to this program.

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

Program Educational Objectives (PEO)

Within 3 to 5 years from graduation, a graduate of BS in Embedded Systems and Internet of Things will have engaged in life-long learning and will have attained any of the following program educational objectives:

PEO #1. Gainful employment and advancement to a leadership position in a reputable industry or government institution.
PEO #2. Successful innovator and/or entrepreneur in embedded systems, information technology or related space.

Student Learning Outcomes (SLO)

The program must enable students to attain, by the time of graduation:

(a) An ability to apply knowledge of computing and mathematics appropriate to the program's student outcomes and to the discipline;

(b) An ability to analyze a problem, and identify and define the computing requirements appropriate to its solution;

(c) An ability to design, implement, and evaluate a computer-based system, process, component, or program to meet desired needs;

(d) An ability to function effectively on teams to accomplish a common goal;

(e) An understanding of professional, ethical, legal, security and social issues and responsibilities;

(f) An ability to communicate effectively with a range of audiences;

(g) An ability to analyze the local and global impact of computing on individuals, organizations, and society;

(h) Recognition of the need for and an ability to engage in continuing professional development;

(i) An ability to use current techniques, skills, and tools necessary for computing practice.

See appendix C for assessment plan.

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

Recruitment for the Embedded Systems major will target students attending Montgomery College (MC), which has a very diverse student population. Per the Office of Institutional Research & Analysis, 52% of students at MC are from an underrepresented minority group; from this population 27.4% are Hispanic and 24.6% are African American (Source: MC at Glance https://cms.montgomerycollege.edu/research/). The program will also recruit in other Maryland community colleges through transfer fairs, Universities at Shady Grove recruiment programs, and individual institution visits.

To insure the success of a diverse student body, the ECE system will implement a mandatory advising system, where students will be required to meet with an academic advisor each semester to track their academic progress. Furthermore, the Department will identify any major courses with a high DWF rate, and will provide academic support to students in those course. Finally, the ECE Department, will work with the existing academic support units at Shady Grove, such as the Center for Academic Success, to provide academic coaching and support services to our students (https://shadygrove.umd.edu/student-services/center-for-academic-success).

Relationship to Other Units or Institutions

13. If a required or recommended course is offered 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, add supporting correspondence as an appendix.

All courses, except for Professional Writing, will be delivered by the ECE department. The Provost's Office will coordinate with the Professional Writing program in the English Department to offer a section of ENGL393 for the Embedded Systems majors.

14. 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.

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

Not applicable to this program.

Faculty and Organization

16. Faculty and organization. Who will provide academic direction and oversight for the program? As an appendix, please indicate the faculty involved in the program. Include their titles, credentials, and courses they may teach for the program.

The faculty within the department of Electrical and Computer Engineering will provide academic direction and oversight for the program. Appendix B contains a list of the ECE tenured, tenured-track, and professional track faculty.

Resource Needs and Sources

17. 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. Please contact your departmental/programmatic library liaison or Daniel Mack at dmack@umd.edu, Associate Dean of Collections, to request a library assessment that will be added as an appendix.

See attached letter.

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

Required classroom facilities are spaces for four lecture classes/semester of 50-75 students each, and space for hosting a microelectronics lab, an FPGA lab/embedded microcontroller lab, and a software lab. In year two, we will additionally need a general-purpose lab for the capstone projects. We estimate each lab will need a

room of about 400 sq. ft. in area. These spaces are expected to be available (for rent) within the new Biomedical Sciences and Engineering (BSE) Building at the Universities at Shady Grove. The BSE building is scheduled to open in spring 2019.

19. 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.

Resources required to deliver the program include additional faculty (both tenure track and professional track), academic advisors, and graduate assistants for the teaching laboratories, shared administrative and technical support, some initial ope ating equipment, ongoing materials and supplies, and some modest scholarship support. The program will be supported through a targeted enhancement funding request to the State of Maryland, and through tuition revenue. As with all other undergraduate programs within the Clark School, students will be expected to pay differential tuition at the approved rate.

20. 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 Electrical and Computer Engineering at UMCP. This advising includes the usual scheduling of classes, evaluation of progress towards the degree, and identification of resources. The Embedded Systems 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 academic progress.

In addition, the ECE department will maintain offices at Shady Grove. We will designate an ECE faculty member as the Faculty F rogram 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 a lab technician to maintain the labs at Shady Grove and part-time IT specialist. These personnel will report to the corresponding group leaders in the ECE department at UMCP. Students evaluate courses and faculty through the online course evaluation system for UM courses. The ECE office of external relations in collaboration with the undergraduate office will produce marketing materials and will conduct recruitment events at various times in the year.

21. Use the Maryland Higher Education Commission (MHEC) commission financial tables to describe the program's financial plan for the next five years: https://docs.google.com/spreadsheets/d/1V6iSZG05edMitWP6CAOXjCoGO58Gf6VXxPaacKfrhZ4/edit#gid=0. Add these tables as attachments. Use the space below for any additional comments on program funding.

See attached document.

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

If the proposed program is for a Post-Baccalaureate Certificate that is derived entirely from existing courses within an existing Master s degree program, then you **only** need to respond to prompts 22 (on market demand) and 25 (curriculum of current master's degree program).

22. 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.

A report by McKinsey[1], Inc. in 2017 has projected that the number of connected "things" will grow from 10 billion today to 30 billion devices by 2020, or about 3 billion new devices per year. It further cites an estimate that the global impact of IoT can be as high as $6.2 trillion by 2025, or roughly 23% of the US Gross Domestic Product (GDP) projected by the Congressional Budget Office. Graduates of this program will be suitable for the high demand occupational areas as computer developers, computer systems analysts, network architects and administrators, information security analysts, information systems analyst and computer programmers. Students graduating from the program can successfully compete for jobs in the information technology, cyber-security, software engineers and analysts, in addition to the specialized jobs in Internet of Things.

23. 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, or Maryland state Occupational and Industry Projections 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 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.

From the US Bureau of Labor Occupational Outlook Handbook (https://www.bls.gov/ooh/computer-and-information-technology/home.htm), computer and information technology occupations is projected to grow 13 percent from 2016 to 2026 in the US, faster than the average for all occupations. These occupations are projected to add about 557,100 new jobs. Demand for these workers will stem from greater emphasis on cloud computing, the collection and storage of big data, and information security. For the State of Maryland (http://www.dllr.state.md.us/lmi/iandoproj/maryland.shtml), the combined job demand for software systems and applications developers is expected to be around 40,000 in 2024, up by more than 31% from 2014. Similarly, the job search site www.indeed.com, show that there are 570 job listings under the category of internet of things in the zip code 20850 (Universities at Shady Grove.)

[1] https://www.mckinsey.com/industries/semiconductors/our-insights/the-internet-of-things-sizing-up-the-opportunity) Disruptive technologies: Advances that will transform life, business, and the global economy

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

To our knowledge, there are no institutions in the state that offer a program that is focused on embedded systems – developing deep expertise in both analog and digital circuits along with the required software skills, would be unique to the region.

25. 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?

Two of the four historically black institutions in Maryland, offer bachelor's programs in electrical engineering, they are the University of Maryland, Eastern Shore (UMES) and Morgan State University. Given the specialization of the Embedded Systems program, we do not expect to draw from students who intend to study electrical engineering at these historically black institutions.

26. For new Post-Baccalaureate Certificates derived from existing master's programs only, include the complete curriculum of the existing master's program.

Not applicable to this program.

Appendix A: Course Descriptions

ENEB 302 Analog Circuits
Foundations of circuits, focusing on applications including signal amplification, power amplification, instrumentation, and filters. Prerequisite: completion of approved MATH2xx course and PHYS260/261 with a grade of "C-" or better.

ENEB 304 Microelectronics and Sensors
The course covers the basics of analog amplifier design starting from single-stage to multiple stage units. The four basic single stage configurations (common-source/common-emitter, follower, cascade and differential pair) are stressed, as are the bias networks that go along with them. Mid-band gains and impedances are derived and the concepts of frequency and time domain analysis are presented. Topics on introductory power electronics will be included. Prerequisite: ENEB302 with a grade of "C-" or better.

ENEB 340 Intermediate Programming Concepts and Applications for Embedded Systems (C/C++)
Description: Principles of software development, high-level languages, input/output, data types and variables, operators and expressions, program selection, repetition, functions, arrays, strings, introduction to algorithms, software projects, debugging, documentation. Target hardware: ARM-based evaluation or development kit, e.g., Atmel AVR. Prerequisite: Completion of required programming course (see first/second year course requirements for details) with a grade of "C-" or better.

ENEB 341 Introduction to Internet of Things
Description: The course begins by covering the fundamentals of IoT, including devices, applications, and business models. The course will include basic tools for networking, protocols, and gateways. Introduction to data analytics and cloud computing platform.

ENEB 344 Introduction to Digital Circuits
Hands-on approach to learning foundations of digital circuits, including input/output, logic gates, Karnaugh maps, latches, flip-flops, and state-machines. Ref: Learn Digital Design with PSoC, a bit at a time, Van Ess. The adoption of PSoC is suggested. Appropriate tutorial on C programming will be supplemented if needed. Co-requisite: ENEB340.

ENEB 345 Probability and Statistical Inference
Simplest tests of statistical hypotheses; applications to before-and-after and matched pair studies. Events, probability, combinations, independence. Binomial probabilities, confidence limits. Random variables, expected values, median, variance, standard distributions, moments, law of large numbers, tests based on ranks, normal approximation, central limit theorem. Sampling methods, estimation of parameters, testing of hypotheses.

ENEB352 Introduction to Networks and Protocols
Description: An overview of design issues and the important industry standards for digital communications networks. This includes protocols, data communications technologies, error correction and detection, congestion control, traffic routing, Local Area Network (LAN) protocols, TCP/IP, and some security issues. It covers layered architectures for the construction of networks, following a simplified OSI reference model. This includes error detection, protocols for retransmission, data link control protocols, medium access control protocols, and both intradomain and interdomain routing. In addition to detailed study of TCP/IP networks,

SONET, ATM, and WDM are also considered. Both wired and wireless local area networks are studied. Prerequisite: completion of ENEB341 with a grade of "C-" or better.

ENEB353 Computer Organization for Embedded Systems
Description: This course covers the basics of computer organization and design. The topics include assembly and machine instructions, datapath and controller design, pipelining and memory hierarchy. Prerequisite: completion of ENEB344 and ENEB354 with a grade of "C-" or better.

ENEB 354 Discrete Mathematics for Information Technology
Foundations of discrete math for information technology. Topics include sets, relations, functions and algorithms, proof techniques and induction, Number theory, Counting and combinatorics and Graph theory.

ENEB355 Algorithms in Python
Description: A study of Python programming language and its use in some algorithms related to sorting, graphs, and trees, combinatorics. Suggested text: Python Algorithms: Mastering Basic Algorithms, Magnus Lie Hetland. Prerequisite: completion of ENEB354 and ENEB340 with a grade of "C-" or better.

ENGL393 Technical Writing
The writing of technical papers and reports. This course teaches students how to make the technologies they work with understandable to many different types of readers. (Offered by the English department)

ENEB 408x Capstone Design (Two Semester Capstone Design Course)
This focuses on a culminating design experience with specific attention to real-world requirements in terms of constraints and component selection, optimization, security and integration into systems. Prerequisite: Senior level standing in program.

ENEB 443 Hardware/Software Security for Embedded Systems
Description: The objective is to gain a solid understanding of the critical systems level software and hardware issues to be considered when designing industry standard secured embedded systems. Prerequisite: completion of ENEB454 with a grade of "C-" or better.

ENEB 444 Operating System for Embedded Systems
The course will present the theory, design, implementation, and analysis of computer operating systems. Through classroom lectures, homework, and projects, students learn the fundamentals of concurrency, process management, interprocess communication and synchronization, job scheduling algorithms, memory management, input-output devices, file systems, and protection and security in operating systems. Optional topics may include communications protocols, computer security, and real-time operating systems. Prerequisite: completion of ENEB340 and ENEB344 with a grade of "C-" or better.

ENEB 451 Network Security
This course covers the foundations of modern cryptography and the current efforts from both academia and industry in building trustworthy computing. We will focus on the technology advances, industrial standards, and law enforcement that have been or have to be made to establish trust in four key areas to establish the trust in computing: security, privacy, reliability, and business integrity. Prerequisite: completion of ENEB352 with a grade of "C-" or better.

ENEB 452 Advanced Software for Embedded Connected Systems
Description: This course focuses on the hardware and software foundations, evaluation and validation, application mapping, optimization and testing of cyber-physical systems connected via the web. Emphasis is

placed on the two basic technologies of ICT systems, namely, embedded systems and communication technologies. Prerequisite: Senior level standing in program.

ENEB 453 Web-based Applications Development
Description: Introduction to computer programming in the context of developing full featured dynamic websites. Uses a problem-solving approach to teach basics of program design and implementation using JavaScript; relates these skills to the creation of dynamic websites; then explores both the potential and limits of web-based information sources for use in research. Prerequisite: completion of ENEB355 and ENEB341 with a grade of "C-" or better.

ENEB 454 Embedded Systems
Description: This course will provide students with the essential knowledge base that will enable them to tackle complex problems encountered in embedded systems design. In addition to the overview of associated hardware components and software methodologies and tools used in the development of modern embedded systems, and theory behind them, the course will include a carefully selected collection of hands-on Lab exercises that would help students get a sense of how the presented theoretical concepts connect with the real-world embedded systems applications. Prerequisite: completion of ENEB353 with a grade of "C-" or better.

ENEB 455 Advanced FPGA System Design using Verilog
Description: This is a project-oriented course to on digital system design using Verilog hardware description language (HDL) in an industry-standard design environment. Students will implement real-world designs in field programmable gate arrays (FPGAs) as well as test and optimize the FPGA-implemented systems. Prerequisite: completion of ENEB344 and ENEB340 with a grade of "C-" or better.

ENEB 456 Machine Learning Tools
A broad introduction to machine learning and statistical pattern recognition. Topics include: Supervised learning (Bayesian learning and classifier, parametric/non-parametric learning, discriminant functions, support vector machines, neural networks, deep learning networks); Unsupervised learning (clustering, dimensionality reduction, auto-encoders). The course will also discuss recent applications of machine learning, such as computer vision, data mining, autonomous navigation, and speech recognition. Prerequisite: completion of ENEB345 and ENEB341 with a grade of "C-" or better.

ENEB 457 Database
Students are introduced to database systems and motivates the database approach as a mechanism for modeling the real world. An in-depth coverage of the relational model, logical database design, query languages, and other database concepts including query optimization, concurrency control; transaction management, and log-based crash recovery. Distributed and Web database architectures are also discussed. Prerequisite: completion of ENEB345, ENEB352, and ENEB355 with a grade of "C-" or better.

Appendix B: ECE Tenured and Tenure-Track Faculty

All ECE faculty hold doctoral degrees in a field relevant to the discipline. Faculty biographies and research interests can be found in the ECE department website faculty listings. The list below includes tenured/tenured-track and professional track (PTK) faculty.

Faculty Name	Degree Field and Year	Rank
Abed, E.H.	Electrical Engineering, 1982	Prof
Abshire, P.	Electrical Engineering, 2002	Prof
Antonsen, T.	Electrical Engineering, 1977	Prof
Babadi, B.	Engineering Sciences, 2011	Asst Prof
Baras, J.	Applied Mathematics, 1973	Prof
Barg, A.	Electrical Engineering, 1987	Prof
Barua, R.	Electrical & Computer Engineering, 2000	Prof
Beaudoin, B.	Electrical Engineering, 2011	PTK
Bhattacharyya, S.	Electrical & Computer Science,1994	Prof
Blankenship, G.	Electrical Engineering, 1971	Prof
Chellappa, R.	Electrical Engineering, 1981	Prof
Dachman- Soled,D.	Computer Science, 2011	Asst Prof
Dagenais, M.	Physics, 1978	Prof
Daniels, K.	Electrical Engineering, 2014	Asst Prof
Davis, C.	Physics, 1970	Prof
Dumitras, T.	Electrical Engineering, 2010	Asst Prof
Ephremides, A.	Electrical Engineering, 1971	Prof
Espy-Wilson, C.	Electrical Engineering, 1987	Prof

Franklin, M.	Computer Science, 1993	Assoc Prof
Ghodssi, R.	Electrical Engineering, 1996	Prof
Goldhar, J.	Physics, 1976	Prof
Goldsman, N.	Electrical Engineering, 1989	Prof
Gomez, R.	Physics, 1990	Prof
Hafezi, M.	Theoretical Physics, 2009	Assoc Prof
Horiuchi, T.	Computation and Neural Systems Program, 1997	Assoc Prof
Iliadis, A.	Electrical Engineering, 1980	Prof
Jacob, B.	Computer Science & Engineering, 1997	Prof
JaJa, J.	Applied Mathematics, 1977	Prof
Khaligh, A.	Electrical Engineering, 2006	Assoc Prof
Krishnaprasad, P.	Engineering 1977	Prof
La, R.	Electrical Engineering, 2000	Prof
Lawson, W.	Electrical Engineering, 1985	Prof
Liu, K. J.	Electrical Engineering, 1990	Prof
Makowski, A.	Mathematics, 1981	Prof
Manocha, D.	Computer Science, 1992	Prof
Marcus, S.	Electrical Engineering, 1975	Prof
Martins, N.	Electrical Engineering and Computer	Assoc Prof
Mayergoyz, I.	Electrical Engineering, 1968	Prof
Milchberg, H.	Astrophysical Sciences, 1985	Prof
Mogul, N.	Science and Technology Studies, 2002	PTK
Munday, J.	Physics, 2008	Assoc Prof

Murphy, T.	Electrical Engineering, 2001	Prof
Narayan, P.	Electrical Engineering, 1981	Prof
Newcomb, R.	Electrical Engineering, 1960	Prof
Oruc, A.	Electrical Engineering, 1983	Prof
Ott, E.	Electrophysics, 1967	Prof
Papamanthou, C.	Computer Science, 2011	Asst Prof
Papamarcou, A.	Electrical Engineering, 1987	Assoc Prof
Qu, G.	Computer Science, 2000	Prof
Romero, D.	Physics, 1999	PTK
Rotkowitz, M.	Aeronautics & Astronautics, 2005	Asst Prof
Shamma, S.	Electrical Engineering, 1980	Prof
Shayman, M.	Applied Mathematics, 1981	Prof
Shoukry, Y.	Electrical Engineering, 2015	Asst Prof
Simon, J.	Physics, 1990	Prof
Sprangle, P.	Physics, 1973	Prof
Srivastava, A.	Computer Science, 2002	Prof
Tits, A.	Electrical Engineering, 1980	Prof
Ulukus, S.	Electrical and Computer Engineering, 1998	Prof
Vishkin, U.	Computer Science, 1981	Prof
Waks, E.	Electrical Engineering, 2003	Prof
Wu, M.	Electrical Engineering, 2001	Prof
Yeung, D.	Electrical Engineering, 1998	Prof

Appendix C: Assessment Plan

Assessment of the Embedded Systems major will be follow the same plan that the Department of Electrical & Computer Engineering (ECE) uses for assessing its two other academic majors for ABET accreditation purposes.

Program Educational Objectives (PEO)

ECE faculty members are responsible for establishing and assessing the Program Educational Objectives (PEO) for the Embedded Systems major. The faculty set the indicator levels for successful achievement of the PEOs and review relevant data collected from all the program's constituencies to inform their decisions on this matter. The Department's Undergraduate Affairs Committee evaluates all recommendations for changes to the PEOs and makes appropriate medications. A fully developed proposal is presented to the Chair, the Department Council, and Department Advisory Board for feedback prior to a vote for adoption by the faculty.

Assessment of PEO's will be done through surveys of the different program constituents (students, faculty, and corporate partners).

Student Learning Outcomes (SLO)

The program's Student Learning Outcomes, support the attainment of the Program Educational Objectives. The Embedded Systems major will have the following SLOs, based on the ABET learning outcomes model:

(a) An ability to apply knowledge of computing and mathematics appropriate to the program's student outcomes and to the discipline;

(b) An ability to analyze a problem, and identify and define the computing requirements appropriate to its solution;

(c) An ability to design, implement, and evaluate a computer-based system, process, component, or program to meet desired needs;

(d) An ability to function effectively on teams to accomplish a common goal;

(e) An understanding of professional, ethical, legal, security and social issues and responsibilities;

(f) An ability to communicate effectively with a range of audiences;

(g) An ability to analyze the local and global impact of computing on individuals, organizations, and society;

(h) Recognition of the need for and an ability to engage in continuing professional development;

(i) An ability to use current techniques, skills, and tools necessary for computing practice.

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 complete evaluate the student's through these course assessments. The assessment of learning outcomes will likely take place every year.

RESOURCES AND EXPENDITURES
Department of Electrical & Computer Engineering
Embedded Systems Proposal

TABLE 1: RESOURCES

Resources Categories	Year 1	Year 2	Year 3	Year 4	Year 5
1.Reallocated Funds	$900,000	$900,000	$900,000	$900,000	$900,000
2. Tuition/Fee Revenue (c+g below)	$251,275	$517,627	$1,066,311	$1,372,875	$1,696,873
a. #FT Students	25	50	100	125	150
b. Annual Tuition/Fee Rate	$10,051	$10,353	$10,663	$10,983	$11,312
c. Annual FT Revenue (a x b)	$251,275	$517,627	$1,066,311	$1,372,875	$1,696,873
d. # PT Students	0	0	0	0	0
e. Credit Hour Rate	$ 360.00	$ 370.80	$ 381.92	$ 393.38	$ 405.18
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	$ -	$ -	$ -	$ -	$ -
TOTAL (Add 1 - 4)	**$1,151,275**	**$1,417,627**	**$1,966,311**	**$2,272,875**	**$2,596,873**

Tuition revenue is based on AY2018-19 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. Faculty (b+c below)	$465,500	$616,455	$846,598	$871,996	$898,156
a. #FTE	3.5	4.5	6.0	6.0	6.0
b. Total Salary	$350,000	$463,500	$636,540	$655,636	$675,305
c. Total Benefits	$115,500	$152,955	$210,058	$216,360	$222,851
2. Admin. Staff (b+c below)	$325,850	$335,626	$493,849	$813,863	$1,047,849
a. #FTE	3.5	3.5	5.0	8.0	10.0
b. Total Salary	$245,000	$252,350	$371,315	$611,927	$787,856
c. Total Benefits	$80,850	$83,276	$122,534	$201,936	$259,993
3. Total Support Staff (b+c below)	$166,250	$171,238	$176,375	$181,666	$187,116
a. #FTE	2.5	2.5	2.5	2.5	2.5
b. Total Salary	$125,000	$128,750	$132,613	$136,591	$140,689
c. Total Benefits	$41,250	$42,488	$43,762	$45,075	$46,427
4. Equipment	$50,000	$25,000	$25,000	$25,000	$25,000
5. Library	$5,000	$5,000	$5,000	$5,000	$5,000
6. New or Renovated Space	$0	$0	$0	$0	$0
7. Other Expenses: Operational Expenses	$450,000	$450,000	$500,000	$500,000	$500,000
TOTAL (Add 1 - 7)	**$1,462,600**	**$1,603,318**	**$2,046,822**	**$2,397,525**	**$2,663,121**

Notes: The "admin staff" category includes graduate assistants to support laboratory instruction. Other expenses include tuition remission for graduate assistants, lab equipment and maintenance ($200K), materials and supplies, program outreach, and $75K per year in scholarships.

UNIVERSITY OF MARYLAND

Ramirez, Neruh <nram@ece.umd.edu>

Library Assessment for Program Proposal

Goldhar, Julius <jgoldhar@umd.edu> Wed, Sep 19, 2018 at 2:11 PM
To: "Ramirez, Neruh" <nram@ece.umd.edu>
Cc: "R. D. Gomez" <rdgomez@ece.umd.edu>

Dear Neruh,
The students and faculty at the Shady Grove Campus should have online access to the University of Maryland Libraries. I think that they will not require any additional library resources.
Sincerely,
Julius Goldhar
ECE Department Library Liaison

On Mon, Sep 17, 2018 at 4:13 PM, Ramirez, Neruh <nram@ece.umd.edu> wrote:

> Hello Dr. Goldhar,
>
> As you may know, we are in the process of getting our new Embedded Systems program approved. This is the new program that will be based in Shady Grove. As part of the proposal, we are required to have a library assessment in order to determine if any new library resources that may be required for the new program. The instructions from the University is to contact our Departmental library liaison to request the library assessment. As the ECE library liaison, would you be able to assist us with this? Thank you.
>
> - Neruh
>
> Mr. Neruh Ramirez
> Director of Undergraduate Studies
> Department of Electrical & Computer Engineering
> A. James Clark School of Engineering
> University of Maryland
>
> PH: (301) 405-3685 | FAX: (301) 314-6082
> E-mail: nram@umd.edu
>
> Visit us online at: www.ece.umd.edu

Addendum: Revised Program Title

The program proposal was submitted with the name “Embedded Systems,” but the program title should be “Embedded Systems and Internet of Things.”

This request is made for the following reasons:

1. "Embedded Systems" is commonly associated only with the hardware and software for the devices that operate as part of a larger computing system. The proposed program is broader in scope than narrowly focused on embedded systems. It includes the smart devices, the communication system and protocols, the system architecture, data collection and analysis using so-called edge and cloud computing platforms and of course, the applications. All of the aforementioned inclusions are in the realm of what we currently call "Internet of Things".

2. “Internet of things” may sound transitory at the moment, however we submit that it will eventually become a permanent field of concentration that merges electrical engineering, computer engineering, computer science and information technology. This is similar to the situation several decades ago when computer engineering was argued to be a special application of electrical engineering.

3. Lastly, we submit that a degree that explicitly mentions “Internet of Things” is easier to appreciate than “Embedded Systems” alone from the standpoint of students and employers. With the proposed name, it will be clear that the degree will encompass subject areas not limited to smart devices but also machine learning, system architecture, data analytics and cyber security in both hardware and software areas.