December 18, 2014

MEMORANDUM

TO: Darryll Pines  
   Dean, A. James Clark School of Engineering

FROM: Elizabeth Beise  
       Associate Provost for Academic Planning and Programs

SUBJECT: Proposal to Establish a Software Engineering Option for the Master of Engineering (PCC log no. 14001)

At its meeting on October 3, 2014, the Senate Committee on Programs, Curricula, and Courses approved your proposal to establish a Software Engineering Option for the Master of Engineering. A copy of the approved proposal is attached.

The change is effective Spring 2015. Please ensure that the change is fully described in the Graduate Catalog and in all relevant descriptive materials, and that all advisors are informed.

MDC/

Enclosure

cc: Gregory Miller, Chair, Senate PCC Committee  
    Barbara Gill, Office of Student Financial Aid  
    Reka Montfort, University Senate  
    Erin Taylor, Division of Information Technology  
    Pam Phillips, Institutional Research, Planning & Assessment  
    Anne Turkos, University Archives  
    Linda Yokoi, Office of the Registrar  
    Alex Chen, Graduate School  
    William Fournier, A. James Clark School of Engineering  
    George Syrmos, Office of Advanced Engineering Education
THE UNIVERSITY OF MARYLAND, COLLEGE PARK
PROGRAM/CURRICULUM/UNIT PROPOSAL

- Please email the rest of the proposal as an MSWord attachment to pcc-submissions@umd.edu.
- Please submit the signed form to the Office of the Associate Provost for Academic Planning and Programs, 1119 Main Administration Building, Campus.

College/School: ENGR
Please also add College/School Unit Code-First 8 digits: 01320101

Department/Program: Office of Advanced Engineering Education
Please also add Department/Program Unit Code-Last 7 digits: 1322302

Type of Action (choose one):

☐ Curriculum change (including informal specializations) ☐ New academic degree/award program
☐ Renaming of program or formal Area of Concentration ☐ New Professional Studies award iteration
☐ Addition/deletion of formal Area of Concentration ☐ New Minor
☐ Suspend/delete program ☑ Other

Italics indicate that the proposed program action must be presented to the full University Senate for consideration.

Summary of Proposed Action:

Creation of an academic option in Software Engineering to the existing Professional Master of Engineering program through the Office of Advanced Engineering Education.

APPROVAL SIGNATURES - Please print name, sign, and date. Use additional lines for multi-unit programs.

1. Department Committee Chair: Samir Khuller April 4, 2014 (Samir Khuller, Department Chair, Computer Science)

2. Department Chair

3. College/School PCC Chair

4. Dean

5. Dean of the Graduate School (if required)

6. Chair, Senate PCC

7. University Senate Chair (if required)

8. Senior Vice President and Provost
Proposal for a New Specialization in Software Engineering in the Professional Master of Engineering Program

Revised 09/26/14 to address comments from Academic Planning and Programs.

I. Overview and Rationale

Established in 1994, the Office of Advanced Engineering Education (OAEE) in the Clark School of Engineering is responsible for lifelong learning programs designed for working engineers and technical professionals. OAEE offers both credit and non-credit programs, but our primary offering is the Master of Engineering degree and the Post-Baccalaureate Certificate. We refer to these programs as the Professional Master of Engineering (ENPM) program and the Graduate Certificate in Engineering (GCEN) program. The Master of Engineering degree is awarded with completion of ten courses (30 credits) and no thesis/research project, scholarly paper, or comprehensive exam are required. Each academic option has its own set of course requirements. The GCEN was developed to serve as a more highly focused area of study. It requires the completion of four specific courses (12 credits) by academic option. There are currently over 600 students in our programs with over 2000 graduates. Students take classes on campus, at regional education centers throughout Maryland, and seven programs are offered online. Enrollments have been averaging 50% on campus and 50% distance/online for the past few years.

OAEE currently offers nineteen academic options under these two program (http://advancedengineering.umd.edu/degrees-certificates). Academic options were originally versions of the Master of Science programs in each academic department (i.e. Aerospace, Mechanical, Electrical, etc.). However, as the need grew for more interdisciplinary programs, we began working with research institutes and centers in the Clark School to develop and offer programs to meet the needs of the engineering/technology community. We have developed niche academic options in Sustainable Energy Engineering, Project Management, Robotics, Energetics, Software Engineering, and Cybersecurity. In 2003, we began offering our programs online to give national and worldwide access to the outstanding programs available at Maryland.

We propose the creation of a Master of Engineering in Software Engineering academic option that will be a complement to the existing Graduate Certificate in Engineering in Software Engineering and the research work being done in the Department of Computer Science, Department of Electrical & Computer Engineering, and the Fraunhofer Center for Experimental Software Engineering at Maryland (www.fc-md.umd.edu)

The need for highly educated software engineers equipped with the latest skills and techniques is critical to every facet of modern society. Part of the leadership in research of software engineering is to develop the educational curriculum for a program that will allow the dissemination of these advances to the engineering/technology community. With the Fraunhofer Center, we have developed five fundamental courses in software engineering, system and software requirements, software design and implementation, software testing and maintenance, and reverse software engineering. Additional core and elective courses are to be developed. Students expected to participate in the program are engineers, computer scientists, and technical professionals interested in software engineering.

II. Program Audience

Based on our internal review, which included discussions with faculty, research sponsors, experts in industry and government as well as evaluation of competing higher education institutions and a search
of software related technical jobs currently available, we believe there is a high-demand for engineers and technical professionals with a graduate level expertise in software engineering and a lack of adequate academic programs to fill this need. The target audience is adults who have completed at least a Bachelor’s degree in engineering, computer science, applied mathematics, mathematics, or physics. This program will be of interest to working engineers and technical professionals as an opportunity to gain knowledge in a new area and advance their careers as well as recent graduates who desire a career in software development and implementation. We expect that due to high demand for employment, the strength and reputation of the Clark School of Engineering, Department of Computer Science and the Fraunhofer Center for Experimental Software Engineering, and our highly effective distance learning experience we will provide an outstanding educational option for engineers and technical professionals through Maryland and the DC Metro area.

Full admission as a degree seeking student requires the following prerequisites:

- A bachelor's degree, GPA of 3.0 or better, in engineering; Computer, Electrical, or Computer Science, Mathematics, or Applied Mathematics from an accredited institution
- Courses in mathematics (Calculus I, II) and at least one (1) programming language course are required to be considered for admission.
- Three letters of recommendation

III. Program Administration

OAEE provides administrative oversight to all Master of Engineering and Graduate Certificate in Engineering academic options, including student services, faculty support, admissions, and academic outreach. In addition, OAEE works with faculty to develop new courses and programs that meet the needs of the engineering/technology communities. OAEE researches industry needs, meets with private and public sector leaders, attends various professional society and technology conferences to learn about possible program development areas. For each academic option there is an identified academic advisor/content matter expert who advises OAEE and our students on curriculum matters. For the traditional academic options (i.e. aerospace, bioengineering, mechanical, etc.) and advisor is assigned by that department chair. For our interdisciplinary programs, the primary department/research center/institute assigns an academic advisor. These interdisciplinary areas also have curriculum committees that review student and faculty performance, course content, and curriculum development. OAEE has administered the Graduate Certificate in Engineering – Software Engineering option since 2000. As with all programs in OAEE, curriculum and academic oversight for the core and elective courses in the series will be through a faculty advisory committee that will collaborate with the OAEE Executive Director, making sure that both commitment to support this new specialization and academic excellence are in place. Evaluation and assessment of this option will be performed by the faculty of Computer Science and Electrical & Computer Engineering, more specifically a faculty member in the Software Engineering group in the Computer Science Department will be the first academic advisor. Professor Atif Memon will be the first academic advisor and he will work with the OAEE Executive Director to be sure that academic integrity is met (see the attached Assessment Plan approved for all OAEE academic options). The new specialization will comply with all UMCP policies and requirements for graduate admission, time of study, and graduation requirements.

IV. Curriculum

The curriculum presented represents the beginning of what will be an evolving program that will continue to offer the latest developments in this rapidly changing and critically important field of study.
Students in the Master of Engineering – Software Engineering program (10 courses or 30 credits) will complete six core courses (see below) along with four elective courses from the recommended elective sets in Computer Engineering, Cybersecurity, Systems Engineering, or an individual plan that meets their specific career goals and makes sense pedagogically to complete a program of study in Software Engineering. OAEE along with faculty and researchers from our Computer Science, Electrical and Computer Engineering, and Fraunhofer will continue to develop courses that will add to the depth of the curriculum. All electives will require prior approval by the academic advisor assigned. As stated above, Professor Atif Memon will be the initial academic advisor for the Software Engineering academic option. The attached list of technical electives highlights areas of specialization available to the students. Other areas of specialization will be considered on a case-by-case basis with the approval of the academic advisor. Students must also meet the prerequisites for any technical elective course they wish to take. If appropriate, the prerequisite course may be included as an elective.

V. Budget Resources
The Office of Advanced Engineering Education is a self-support program and the Master of Engineering programs are administered through its resources.

VI. Courses
Core Courses (additional courses to be developed)

**ENPM 611 Software Engineering**
Prerequisite: Competency in a programming language. This course covers software engineering, concepts, methods, and practices important to both the theorist and the practitioner. The entire range of responsibilities expected of a software engineer is presented. The fundamental areas of requirements development, software design, programming languages, and testing are covered extensively. Sessions on supporting areas such as systems engineering, project management, and software estimation are also included.

*Instructor: Dr. Christopher Ackerman, Ph.D., Computer Science, University of Maryland*
*Lead Applications Engineer, CACI*

**ENPM 612 System & Software Requirements**
Prerequisite: Competency in a programming language. This course focuses on the theoretical and practical aspects of requirements development. Students will recognize the place of requirements, how to work with users, requirements methods and techniques, the various requirements types, how to set requirements development schedules, requirements evolution, how to model and prototype requirements, how to evaluate and manage risk in requirements, techniques to test requirements, how to manage the requirements process, and how to write an effective requirements document.

*Instructor: Dr. Mikael Lindvall, Ph.D., Computer Science, Linkopings University, Sweden*
*Technology Director, Fraunhofer Center for Experimental Software Engineering, University of Maryland*

**ENPM 613 Software Design and Implementation**
Prerequisite: Competency in a programming language and ENPM 611 or ENPM 612. This course covers software design concepts and practices within the field important to both the practitioner and the theorist. Architectural and detailed designs are included for batch, client/server, and real-time systems. Design considerations for structured, object-oriented, and Web-based systems are covered. Design of databases, user interfaces, forms, and reports are also included. Implementation issues that affect the design, including error handling, performance, and inter-process communication, are presented.

*Instructor: Dr. Arnab Ray, Ph.D., Computer Science, SUNY-Stonybrook*
Senior Research Scientist, Fraunhofer Center for Experimental Software Engineering, University of Maryland

ENPM 614 Software Testing and Maintenance
Prerequisite: ENPM 612 or ENPM 613. This course covers aspects of software development after coding is completed. Students will understand the various levels of testing, techniques for creating test data, how to manage test cases and scenarios, testing strategies and methods, testing batch, client/server, real-time, and Internet systems, and the development of an effective test plan. Software maintenance will include the creation of easily maintained software; preventive maintenance, corrective maintenance, and enhancements; configuration management practices; and assuring quality in software maintenance.

Instructor: Dr. Mikael Lindvall, Ph.D., Computer Science, Linkopings University, Sweden
Technology Director, Fraunhofer Center for Experimental Software Engineering, University of Maryland

ENPM 808F Reverse Software Engineering
Prerequisite: ENPM691 Secure Programming in C, CMSC 106 Introduction to C Programming, or permission of the instructor. This course provides in-depth, hands-on training for reverse engineering tools, including the IDA Pro disassembler, the Wireshark network protocol analyzer, debuggers, and binary tools. Students will become familiar with the x86 instruction set through both assembly programming and disassembly. Class exercises include revealing back doors and exploiting buffer overflows. Each student will develop a network-based application and in turn reverse engineer and exploit one of their peer's completed applications.

Instructor: Dr. Charles Song, Ph.D., Computer Science, University of Maryland
Software Development Leader, Fraunhofer Center for Experimental Software Engineering, University of Maryland

ENPM 808 Software Engineering Core Course TBD

Electives
Specialized Elective Tracks (completing a focus area will allow student to also earn GCEN in that area)

Computer Engineering (four courses)
http://advancedengineering.umd.edu/programs/electrical-computer/masters/courses
ENPM 607 Computer System Design and Architecture
ENPM 609 Microprocessor-Based Design
ENPM 610 Digital VLSI Design
(one of the following courses)
ENPM 675 Operating System Design
ENPM 676 VLSI Testing and Design for Testability
ENPM 808 Embedded Systems

Cybersecurity (four courses)
http://advancedengineering.umd.edu/programs/cybersecurity/certificate/courses
ENPM 808E Information Assurance
ENPM 691 Secure Programming in C
ENPM 693 Network Security
ENPM 808A Networks and Protocols
ENPM 808B Secure Operating Systems

Systems Engineering (four courses)
http://advancedengineering.umd.edu/programs/systems-engineering/masters/courses
ENPM 641 Systems Concepts, Issues, and Processes
ENPM 642 Systems Requirements, Design and Trade-Off Analysis
ENPM 643, Systems Projects, Validation and Verification
   (one of the following courses)
ENPM 644 Human Factors in Systems Engineering
ENPM 646 System Life Cycle Cost Analysis and Risk Management
ENPM 647 Systems Quality and Robustness Analysis
### Student Learning Outcomes for assessments that will occur during the academic year

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<th>Student Learning Outcomes</th>
<th>Assessment Methods &amp; Criteria</th>
<th>Assessment Results</th>
<th>Impact of Results</th>
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| 1. Demonstrate knowledge of advanced principles in engineering. | **Criterion:** All ENPM courses offered during any given semester. The final exam in all these courses will include a question specifically tailored to demonstrate understanding of a fundamental principle in engineering.  
**Measure:** At least 70% of the students in every ENPM course offered during any given semester would be expected to successfully answer this question posed on the final exam. | | |
| 2. Demonstrate knowledge of advanced principles in engineering. | **Criterion:** 90% of the Master of Engineering students should have a GPA equal or greater than 3.0  
**Measure:** GPA | | |
| 3. Demonstrate continued retention of students and progress towards degree completion. | **Criterion:** 80% enrollment by existing students each semester.  
**Measure:** Registrar’s Enrollment Records. | | |
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<th>Demonstrate completion of degree program.</th>
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| 4. | Criterion: 80% graduation rate of students within the five year limit for Master of Engineering students.  
     Measure: Registrar's Graduation Records. |
|   | Point-of-graduation survey. The survey is web based. Graduating students, prior to the end of the semester, are sent the website in which to fill in the appropriate information and submit the survey electronically. The survey seeks to ascertain a student’s experiences in the ENPM Program regarding the quality of courses, the general program, faculty, and staff. The survey also collects information on employment (position, salary, etc.) at graduation. |
| 5. | Criterion: 50% response rate by graduating students.  
     Measure: Graduation Survey. |