PURDUE UNIVERSITY | College of Engineering

Engineering Faculty Document No. EFD 01-23
March 30, 2022

Memorandum

To: The College of Engineering Faculty

From: Autonomous and Connected Systems Initiative (ACSI)

Re: new Engineering Major in Autonomy

The faculty council of the Autonomous and Connected Systems Initiative (ACSI) has approved the following **Residential Interdisciplinary Professional Master of Science in the Engineering Major in Autonomy** under the Interdisciplinary Engineering (IDE) Degree program at the College of Engineering. This action is now submitted to the Engineering Faculty with a recommendation for approval.

Description: The new Engineering Major in Autonomy focuses on the area of analysis, control and design of autonomous systems spanning a variety of application domains. The courses in this new major will establish fundamental theories and tools for modeling, analyzing and developing algorithms to achieve autonomy of both individual systems and a network of interconnected systems. It spans core topics such as control theories, machine learning, artificial intelligence, networks, as well as advanced courses in emerging topics.

Reasons: Autonomous systems are playing a significant role in modern society including self-driving cars, unmanned aerial/ground/underwater vehicles, and so on. Current and future engineers will be faced with significant challenges in designing, analyzing and controlling autonomous systems in many engineering applications including exploration of unknown areas (such as Mars), search and rescue, package delivery, and so on. As such, there is a significant demand for students that have the core skills and knowledge in both classical theories in control, optimization and networks and recent advanced in learning and AI.

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Residential Interdisciplinary Professional Master of Science in the new Engineering Major in Autonomy

A few paragraphs on what the goal of the new major is:

1. What is the topic focus of the major?

The new Engineering Major in Autonomy focuses on the area of analysis, control and design of autonomous systems spanning a variety of application domains. The courses in this new major will establish fundamental theories and tools for modeling, analyzing and developing algorithms to achieve autonomy of both individual systems and a network of interconnected systems. It spans core topics such as control theories, machine learning, artificial intelligence, networks, as well as advanced courses in emerging topics.

2. Why might students want to take/benefit from this major?

Autonomous systems are playing a significant role in modern society including self-driving cars, unmanned aerial/ground/underwater vehicles, and so on. Current and future engineers will be faced with significant challenges in designing, analyzing and controlling autonomous systems in many engineering applications including exploration of unknown areas (such as Mars), search and rescue, package delivery, and so on. As such, there is a significant demand for students that have the core skills and knowledge in both classical theories in control, optimization and networks and recent advanced in learning and AI.

3. What might the demand be from students?

The demand for this new major was determined through discussions with employers, alumni, potential applicants, and research interests of the graduate application pools across the College of Engineering. The target audience is composed of students who intend to learn specialized skills in autonomy along with core training in area of autonomous and connected systems. It is expected that students attracted to these majors are interested in pursuing advanced graduate degrees in these specific areas or interested in attaining industrial positions in these specific areas. Specifically, the target audiences will be: *Current Purdue B.S. students* wishing to undertake graduate studies, improve their autonomy skills, increase their employability in the promising emerging autonomous and connected systems industry, or prospects for admission into a PhD program in related areas. The B.S. degree should have been awarded before being formally admitted to the master's degree, unless the student has been admitted to an approved Combined BS/MS program in the College of Engineering; *Domestic and international students* BS wishing to undertake graduate studies, improve their autonomy skills, increase their employability in the promising emerging autonomous and connected systems industry, or prospects for admission into a PhD program in related areas. *Practicing professional engineers* wishing to return to school for specialized autonomy expertise, in order to improve their career pathways, increase their employability in the promising emerging autonomous and connected systems industry, or prospects for admission into a PhD program in related areas.

Proposing University Unit

Purdue College of Engineering is proposing this new major.

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Required Courses

For the Residential Interdisciplinary Professional Master of Science in the new Engineering Major in Autonomy, 30 credits are required.

The 30 credits consist of the following:

- Core Courses (9 credits)
- Autonomy Major Courses (9 credits)
- Professional Skills Courses (9 credits) – up to 6 of the professional skills course credits may be project course with a participating faculty member in the major area
- ACS Elective Courses (3 credits)

Up to 7 credits of courses are allowed to be taken online. Project courses are NOT allowed to be taken online. Course lists are provided in the next section.

Core Courses:
All students must take 9 credits of ACS Core Courses consisting of the following:

- 1 Applied Math course (3 credits) + 1 IoT course (3 credits) + 1 Robotics course (3 credits)

Major Courses:
All students must take 9 credits of courses in the Autonomy Major Course List.

Professional Skill Courses:
All students must take 9 credits of Professional Skill Courses.
In the course lists, there are courses denoted with an asterisk (*) to indicate that it qualifies as a Professional Skills course. Up to 6 of the professional skills course credits may be project course with a participating faculty member in the major area. The research topic and semester deliverables will be mutually agreed upon by the student and faculty by the end of the second week of the semester. The participating faculty member must be affiliated with both Purdue College of Engineering and also Purdue Engineering Initiative in Autonomous and Connected Systems https://engineering.purdue.edu/Initiatives/AutoSystems/Faculty

Elective courses:
Elective course can be any additional course on the either the Robotics, Autonomy, or IoT course list.

Note: the same course cannot be counted in more than once to fulfil the major requirements. Students must choose one designate for the course in their study plan.

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Course Lists

These course lists will be reviewed and updated regularly by the participating faculty

Autonomy Major Course List:

- CE 59700: Machine Learning and Artificial Intelligence for Autonomous Vehicle Operations*
- CS 57800: Statistical Machine Learning
- CS 59000: Reinforcement Learning
- ECE 57000 Artificial Intelligence*
- ECE 59500: Introduction to Deep Learning
- AAE 59000: Multi-Agent Systems and Control*
- ME 59700: Autonomous Systems*
- ECE 50024 Machine Learning*

Robotics Course List

- ME 57200: Analysis and Design of Robotic Manipulators*
- ME 57500: Theory and Design of Control Systems
- ME 57800: Digital Control
- ME 58600: Microprocessors in Electromechanical Systems*
- ME 58800: Mechatronics – Integrated Design of Electro-Mechanical Systems*
- ME 59700: Autonomous Systems*
- AAE 59000: Multi-Agent Systems and Control*
- ECE 56900: Introduction to Robotic Systems
- AAE 66800/ECE 69500: Hybrid Systems: Theory and Applications
- ECE 58000: Optimization Methods for Systems and Control
- ECE 60200: Lumped System Theory
- ECE 67500: Introduction to Analysis of Non-Linear Systems
- ECE 68000: Modern Automatic Control
- ME 67700: Nonlinear Feedback Controller Design
- ME 68900: Adaptive Control
- IE 57400: Industrial Robotics and Flexible Assembly

IoT Course List:

- ME 58600: Microprocessors in Electromechanical Systems*
- ME 58800: Mechatronics – Integrated Design of Electro-Mechanical Systems
- ME 59700: Industrial IoT Implementation for Smart Manufacturing (under review) *
- ECE 69500 System-on-Chip Design
- ECE 55900 MOS VLSI Design
- ECE 56800 Embedded Systems*
- ECE 43700 Computer Design and Prototyping
- ECE 69500 Mobile Computing Systems*

- ECE 59500 Introduction to Operating Systems
- ECE 59500 Computer Network Systems

Applied Math Course List:

- MA 51100: Linear Algebra
- MA 52700: Advanced Mathematics for Engineers and Physicists I
- MA 52800: Advanced Mathematics for Engineers and Physicists II
- ME 58100: Numerical Methods in Mechanical Engineering
- ME 59700: Uncertainty Analysis
- STAT 51100: Statistical Methods
- STAT 51200: Applied Regression Analysis
- STAT 51400: Design of Experiments