Graduate Certificate in Hybrid Electric Vehicle Technology

Development of the next generation of fuel-efficient and environmentally-responsible advanced electric drive vehicles is one of the nation's top priorities. The State of Indiana plays a major role in the design, development, and manufacturing of these types of vehicles, such as electric vehicle (EV), hybrid electric vehicle (HEV) or plugin hybrid electric vehicle (PHEV), or their components. This is a very technically intensive and competitive field that requires multidisciplinary approaches. Expertise in the HEV technology will be greatly needed to meet the demands in the hybrid vehicle sector of the automotive industry.

This certificate program is designed to address industry's increased needs for engineers having expertise in EV/HEV/PHEV. It will prepare today's engineers to be competitive in taking on the new challenges facing the industry so that the companies in automotive sector can compete globally.

The certificate is a Purdue University certificate that would appear on a student's transcript upon completion.

Who should join the program?

Practicing engineers who joined the workforce after bachelor's degree and graduate students would be interested in obtaining training on these new technologies in order for them to be current in solving complex hybrid drive related problems. The proposed certificate program will provide them with the necessary technical skills.

What are the requirements to complete the graduate certificate program?

1. Total requirement: 12 credit hours

2. GPA requirements

   a. Minimum overall GPA
   Successful completion of the certificate requires at least a B average over all courses counting towards the certificate.

   b. Minimum grade:
   Courses with a grade of C- or less must be taken again to count towards the certificate. The minimum grade that will be accepted in any single course is C. For transfer credits, only the courses taken that result in a grade of B or better may be transferred for this certificate program.

3. Curriculum

There are a number of courses in both the primary and related areas. The certificate requires selection of at least two courses in the primary area and the remaining two courses in the related area.

The primary area courses consist of:

- ME 50105 Hybrid and Electric Transportation
- ECE 59500 Advanced Hybrid and Electric Vehicle Systems and Control

- ME 59700 Dynamics and Simulation of Hybrid-electric vehicles
- ME 59700 Energy Storage Devices and Systems
- ME 50104 Powertrain Integration
- ECE 61000 Energy Conversion (required for students in ECE)

The related courses include:

- ME 50400 Automotive Control
- ME 59700 Renewable Energy and Fuel Cells
- ECE 59500 Automotive Control (dual listed with ME 50400, cannot be taken with ME 50400)
- ECE 59500 Introduction to Smart Grid Theory and Implementation
- ECE 58000 Optimization Methods for Systems and Control

Are there on-line options for these courses?
Yes. The majority of the graduate courses are offered in late afternoon hours to accommodate the needs of part-time students. In addition, a number of course lectures may be available in both live lecture and online via video streaming modes.

Will any of these four courses count toward a graduate degree?
Yes! All four courses may be used toward the requirements for a graduate degree in mechanical engineering, if one wishes to pursue a formal degree program.

What are the requirements for admission to the certificate program?
In order to be eligible for this certificate program, the students must have a bachelor's degree from an accredited institution in an area which provides the necessary mathematical preparation for an engineering degree with a minimum undergraduate GPA of 3.0 out of 4.0. A conditional admission may be offered for applicants not meeting this criterion who have superior overall credentials. Applicants with non-engineering degrees, including mathematics, physical sciences, and engineering technology, may be required to take undergraduate mechanical engineering courses before admission to the program. Appropriate work experience also will be taken into account in making decisions about admission. Students will be required to submit a statement of interest and three letters of recommendation. A minimum TOEFL score of 550 (paper based) / 77 (internet based) or higher is required for international applicants whose native language is not English. Applicants taking IELTS must score at least 6.5 on the academic module.

Students admitted directly to the Purdue University graduate program can be considered for this certificate program, provided the student formally applies for the certificate program and receives admission. Courses completed under certificate program are not automatically transferred to a graduate degree program, unless the student makes a petition to the graduate committee in respective departments. A student already enrolled in a graduate degree program may complete the certificate irrespective of his / her major so long as the requirements of the certificate are fulfilled.

I have completed a few graduate courses in the past. Can I use the credits toward the certificate program?
If you have already earned credits for one or more of the equivalent courses from another institution or another certificate program, you may request to transfer up to a maximum of three credits of these courses toward this certificate. A maximum of 6 equivalent credit hours taken prior to admission to the certificate program, including 3 credit hours taken from another

institution, may be counted towards the certificate. The rest of the courses must be completed at IUPUI within a three-year period from the time of admission. Any waivers or substitutions require approval. No undergraduate courses can be applied to this certificate program.

How do I apply for admission to the certificate program?
To apply for admission, contact Valerie Lim Diemer, Coordinator for Graduate Engineering Programs by telephone at (317) 278-4961 or by email: wvlim@iupui.edu .

Program Course Listing and Descriptions

ME 50105 - Hybrid and electric transportation (3) Class: 3 Lab: 0 Rec: 0 This course will cover fundamentals of hybrid electric and battery electric transportation systems with particular emphasis on automotive vehicles. It will cover basic powertrain configurations of Hybrid Electric Vehicle (HEV), Plug-in Hybrid Electric Vehicle (PHEV), and Battery Electric Vehicle (BEV). The principal elements of these powertrain will be discussed: Battery, Electric Motor, Engine, and Transmission.

ME 59700 Dynamics and Simulation of Hybrid-electric vehicles (3) Class: 3 Lab: 0 The aim of this course is to teach students advanced multi-body dynamics and finite element computational techniques that can be used to predict the dynamic response of passenger cars with emphasis on hybrid electric vehicles. The vehicle geometry will be created using advanced solid modeling CAD software. The geometry will then be imported into high fidelity multi-body dynamics/finite element software to create computational models of the various vehicle components, including: chassis, tires, suspension system, steering system, drive-train, transmission system, electric drive (including motor and batteries), gas engine, regenerative braking system and electric generator system. The computational models consist of rigid bodies and flexible bodies that are connected using various types of joints. Flexible bodies can be modeled using solid, shell or beam elements. Joints include spherical, revolute, cylindrical and prismatic joints. In addition, the rigid/flexible bodies can come into frictional contact.

ME 50400 Automotive Control (3) Class: 3 Lab: 0 Rec: 0 Concepts of automotive control. Electro-mechanical systems that are controlled by electronic control modules via an appropriate algorithm (such as fuel injection timing control, emission control, transmission clutch control, anti-lock brake control, traction control, stability control, etc.), In-depth coverage on modeling and control of these automotive systems, MATLAB/SIMULINK modeling and simulation.

ME 59700 Renewable Energy and Fuel Cells (3) Class: 3 Lab: 0 Rec: 0 This course intends to provide engineers and students with a comprehensive yet practical guide to the characteristics, principles of operation, and power potential of the most dominant renewable energy systems, including solar energy, wind turbines, battery and fuel cells, biomass, geothermal energy and hydropower. The course focuses on the engineering and design of alternative energy systems. Students will learn details of renewable energy storage devices, with special emphasis on batteries and fuel cells, through hands-on project assignments.

ME 50104 Powertrain Integration (3) Class: 3 Lab: 0 Rec: 0 The holistic view of powertrain development that includes engine, transmission, and driveline is now well accepted. Current trends indicate an increasing range of engines and transmissions in the future with, consequently, a greater diversity of combinations. Coupled with the increasing introduction of hybrid vehicles, the scope for research, novel developments and new products is clear. This course discusses engines, transmissions, and drivelines in relation to their interfaces with chassis systems. This course also explores the concept to market evolution as well as powertrain and chassis integration.

Energy Storage Devices and Systems (3) Class: 3 Lab: 0 Rec: 0 Fundamental principles of battery science and engineering (battery reactions, charge and mass transport in batteries, battery safety, battery management, and materials development in the batteries, battery system designs and integrations), current state-of-the-art battery technology and the current technical challenges on the development of batteries, codes and standards for safe handling of batteries.

ECE 59500 Hybrid Electric Propulsion Systems and Control (3) Class: 3 Lab: 0 Rec: 0 This course provides students with theoretical and design foundation to understand various aspects of operations and control of hybrid and electric vehicle (HEV) systems. The course covers dynamics of internal combustion engine, electric motor and generator, energy storage devices and systems, batteries, and vehicle. Various design methods for HEV energy management systems and battery management modules are presented. Advanced control techniques for electric motor/generator, battery system, regenerative braking and other subsystems are discussed.

ECE 59500 Automotive Control (3) Class: 3 Lab: 0 Rec: 0 This course is dual listed with ME 50400.

ECE 59500 Introduction to Smart Grid Theory and Implementation (3) Class: 3 Lab: 0 Rec: 0 Electrical power system infrastructure and American national electricity policy; electrical transmission system operations; power system reliability; electricity market design and operation; Smart grid technologies – distributed generation, demand response, advanced meter infrastructure; Smart grid standards development – interconnection, interoperability and cyber security; Smart grid impact on power system reliability and electricity market.

ECE 61000 Energy Conversion (3) Class: 3 Lab: 0 Basic principles of static and electromechanical energy conversion. Control of static power converters. Reference frame theory applied to the analysis of rotating devices. Analysis and dynamic characteristics of induction and synchronous machines. State variable analysis of electromechanical devices and converter supplied electromechanical drive systems.