

Request for a New Graduate Certificate Program

Purdue School of Engineering and Technology, IUPUI

Hybrid Electric Vehicle Technology Certificate

To be offered as a Purdue Certificate at IUPUI

October 21, 2011

Rev: Dec.12, 2011

Rev Jan 11, 2012

Purpose of the program

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. Today there are numerous Indiana companies that participate in various aspects of vehicle electrification. This is a very technically intensive and competitive field that requires multidisciplinary approaches. It is imperative that Indiana has adequately trained workforce that can take up on this challenge and provide leadership in this growing technological field.

The Departments of Mechanical Engineering and Electrical and Computer Engineering, Purdue School of Engineering and Technology, IUPUI have been developing and developed a number of courses that cover the fundamentals of advanced electric and hybrid electric drives as well as the key components. These graduate level courses aim at providing EV/HEV discipline specific training to existing engineers to make a smooth and effective transition to the new area. In this document, a curriculum for a Hybrid Electric Vehicle Technology Certificate (HEVTC) program is presented.

This certificate program is designed to address industry's increased needs for engineers who have 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 our Indiana companies can compete globally.

The purpose of this new graduate-certificate program in mechanical engineering is to enable engineers to become certified in EV/HEV/PHEV technology without formally pursuing a graduate degree. The certificate will provide a core set of courses on HEV transportation, hybrid electric propulsion systems, energy storage devices and system, and powertrain integration. Also, the students are allowed to select two courses in related engineering disciplines. Students completing this certificate will be able to understand the foundations of the EV/HEV/PHEV and to use the knowledge combined with previous engineering training to serve the respective companies effectively.

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

Relation to existing certificate programs

Currently, there is no certificate program in “Hybrid Electric Vehicle Technology” area available on the IUPUI campus. It is not anticipated that similar certificate programs would be developed by other disciplines in engineering and sciences.

The target audience

Indiana is a manufacturing state, which has significant amount of automotive/transportation related manufacturing companies such as Delphi, General Motor, Allison Transmission, Think City, Cummins, Chrysler, Remy International, EnerDel, Rolls-Royce Corporation, and their suppliers. The trend to have more fuel efficient powertrains has pushed these companies to consider hybrid drivetrain systems. It is anticipated that practicing engineers who joined the workforce after bachelor’s degree 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 required technical skills.

After completing the certificate program, Students may choose the option of applying to the M.S. program in Mechanical Engineering (MSME) or M.S. program in Electrical and Computer Engineering (MSECE) with the courses taken during the certificate program transferred.

Plan for sustaining steady-state enrollment

In the first year starting Fall 2012, five to ten students will likely participate in the program. It is anticipated that this number will rise rapidly to 15 to 20 students per year in the next two to three years, as the awareness of the program increases. The potential exists for much greater growth beyond this in subsequent years.

New resources

The required infrastructure (computers and software) needed to support the certificate program is already in place in the Departments of Mechanical Engineering and Electrical and Computer Engineering. The graduate level courses will continue to be taught by the faculties in both Departments and can be used for the degree programs. Therefore, the certificate program can be offered with no additional demands for faculty or facilities.

Proposed date of the initiation of the certificate program

Proposed date of implementation is Fall 2012, assuming all necessary approvals have been obtained.

Persons designated as the certificate program head

Dr. Sohel Anwar, Associate Professor, Department of Mechanical Engineering will serve as the program director.

Dr. Jie Chen, Professor and Chair of Mechanical Engineering, Dr. Yaobin Chen, Professor and Chair of Electrical and Computer Engineering will provide the administrative oversight of the program.

Faculty initially involved in the program and their credentials

Dr. Jie Chen
Professor and Chair
Department of Mechanical Engineering
Research and Teaching Interests: System design and simulation, engineering design, energy storage, and solid mechanics.

Dr. Sohel Anwar
Associate Professor of Mechanical Engineering
Research and Teaching Interests: Hybrid and Electric Vehicle Design / Control, Mechatronics / Robotics, Vehicle active safety system design, Fault tolerant control, Drive-By-Wire, Autonomous vehicles

Dr. Yaobin Chen
Professor and Chair
Department of Electrical and Computer Engineering
Research and Teaching Interests: Modeling, simulation, optimization and control of advanced automotive systems, intelligent transportation and vehicle systems, computational intelligence applications.

Dr. Jian Xie
Assistant Professor of Mechanical Engineering
Research and Teaching interests: Polymer Electrolyte Fuel Cells, Advanced Batteries, Hydrogen Generation and Storage, Energy, Composite and Nano Materials, Electric Propulsion Systems for EV and HEV, Electrochemical Engineering, Renewable Energy

Dr. Maher Rizkalla
Professor and Associate Chair
Department of Electrical and Computer Engineering
Research and Teaching Interests: Applied superconductivity, solid state electronics, VLSI signal processing and electronics manufacturing.

Dr. Likun Zhu
Assistant Professor of Mechanical Engineering
Research and Teaching interests: MEMS and Nanotechnology, Micro and nano fabrication, Polymer Electrolyte Fuel Cells, Hydrogen Generation and Storage, Renewable Energy.

Dr. Tamer Wasfy
Associate Professor of Mechanical Engineering
Research and Teaching interests: Computational mechanics, Flexible multi-body dynamics, Computational fluid dynamics, Fluid-structure interaction, Virtual-reality for scientific visualization, Kinematics, Dynamics and Vibrations.

Admissions requirements and procedures

- | In order to be eligible ~~to for~~ this certificate program, the students must have a bachelor's degree in an area which provides the necessary mathematical preparation for an engineering degree with a recommended minimum GPA of 3.0 out of 4.0. 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.

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.

Completion requirements and audit and certification procedures

a. Requirements for the certificate program

Total requirement: 12 credit hours.

~~It is not necessary to be admitted to the Graduate School to earn the certificate. However, at most twelve hours of course work taken prior to admission to Graduate School can be counted towards a graduate degree provided that the admission requirements are met. Thus, decision to apply to Graduate School by qualified students should be made at an earlier time in order not to lose credits. Credits earned in the certificate program with a grade of B or better may be applied towards the Master's degree subject to approval by the Graduate Committee in the respective departments. After completion of the certificate, students are encouraged to apply to the Masters program of their respective disciplines and are encouraged to request the transfer of credits earned in the certificate to this Masters program.~~

To earn a certificate, the students admitted to this certificate program are required to complete twelve credit hours of graduate courses. There are courses in the primary and related areas. The certificate requires selection of at least two courses in the primary area and the rest in related area.

The primary area courses consist of:

- ME 59700 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 59700 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

Substitutions to the above courses are possible with approval of the Graduate Committee of the Department.

Minimum overall GPA

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

Maximum number of credits that can be transferred from another institution

Applicants who have already earned credit for one or more of the equivalent courses from other institutions and other certificate programs may request to apply up to a maximum of three credits of these courses toward this certificate. Any waivers or substitutions have to be approved by the graduate committee that oversees the program.

Maximum number of undergraduate courses that can be applied

No undergraduate courses can be applied to this certificate program.

Maximum time for completion

All requirements for the certificate must be completed within three years. Most students enrolled in this program will be part-time students, employed full time. Thus two years may be needed for the completion of all courses if the participating student takes one course per semester.

Number of credit hours taken prior to admission to the certificate program that may be counted to completion of the degree

Up to 6 equivalent credit hours taken prior to admission to the certificate program including 3 hours taken from another institution may be counted towards the certificate. The rest of the courses must be completed at IUPUI within three-year period from the time of admission.

b. Transfer credits to a degree program

Although it is not necessary to be admitted to a graduate degree program to earn the certificate, at most twelve credit hours of course work taken in the certificate program can be counted towards a graduate degree provided that the admission requirements are met. Credits earned in the certificate program with a grade of B or better may be applied towards the Master's degree subject to approval by the Graduate Committee in the respective departments. After completion of the certificate, students are encouraged to apply to the Masters program of their respective disciplines and are encouraged to request the transfer of credits earned in the certificate to this Masters program.

Course lists for the program including course descriptions

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 online via video streaming. The following list contains the catalog description of the courses.

ME 59700 - 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, 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 59700 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.

Procedures for governing the program including construction of committees that will provide oversight

A committee comprised of Dr. Jie Chen, Dr. Sohel Anwar, and Dr. Yaobin Chen will jointly oversee the program. All advising will be done by participating faculty members listed in this document. The Department of Mechanical Engineering will take responsibility for all record keeping and tracking of students.

Procedures for program evaluation including the criteria for success

Upon completion of the program, exit interviews will be conducted for all students to determine the effectiveness of the program in meeting their needs and to identify how they are using the skills and tools learned in the program in their professions. Follow-up interviews will be conducted after three and five years. Given the projected enrollment of this program, and the fact that many of the graduates will remain employed locally, it is anticipated that most students will be tracked this way.

Success of the program will be defined in terms of demand (enrollment) and the responses of the students surveyed upon completion of their degree and in the follow-up interviews.