The University Senate of Michigan Technological University

Proposal 27-10

(Voting Units: Academic)

"GRADUATE CERTIFICATE IN HYBRID ELECTRIC DRIVE VEHICLE ENGINEERING"

1. General Description

This proposal recommends establishing a "Graduate Certificate in Hybrid Electric Drive Vehicle Engineering" through the College of Engineering of Michigan Technological University. Students completing this Certificate will develop competencies in advanced hybrid electric drive vehicle (HEDV) engineering. Students enrolling in this certificate will have a Bachelor's degree in Chemical, Electrical, Materials, or Mechanical Engineering, or a degree in a closely related field. The Certificate Advisor will be appointed by the Dean of the College of Engineering.

Catalog Description **-** The Graduate Certificate in Electric Drive Vehicle Engineering program provides the student with advanced knowledge of the design, calibration, and operating characteristics of electric drive and hybrid electric vehicles. It is expected that students beginning this Certificate have a working understanding of: i) thermodynamics equivalent to that gained in MEEM2220, or MY3100, or CM3230, ii) electric circuits equivalent to EE2110, or EE3010, and iii) programming, or simulation tools (e.g. MATLAB).

2. Rationale

The light vehicle industry is facing a shortage of engineering talent needed to retool for the use of electric drives as the primary source of motive power. In recognition of this, the State of Michigan and the US Department of Energy put in place programs to encourage universities to offer programs that help address these education needs.

Michigan Tech has received support from both the DOE and Michigan for this curricular development and is creating several new courses in this area. Michigan Tech should offer certificates to students who complete a set of new and existing courses in this area in order to give them a credential indicating their knowledge in this emerging field.

3. Related Programs

The Graduate Certificate in Electric Drive Vehicle Engineering is related to the proposed Certificate in Hybrid Electric Drive Vehicle Engineering at the undergraduate level. The Graduate Certificate uses twenty five existing courses in the Chemical, Electrical, Materials and Mechanical Engineering degree programs, several of which are being modified to include HEDV content. Seven new courses (some are dual listed between departments) are being developed under a DOE Transportation Electrification grant.

There are similar certificate programs being developed at Wayne State University, Purdue (leading a consortium of Indiana universities), Colorado State University, and Missouri University of Science and Technology.

There are similar courses offered from the University of Michigan, University of Detroit – Mercy, NC State University, and West Virginia University.

4. Projected Enrollment

It is expected that we will have a steady state enrollment of 20-25 students. The graduate enrollments in the first three offerings of MEEM 5990DL, Advanced Propulsion Systems for Hybrid Vehicles, have been 96 in the Spring of 2009 (includes 30 on-campus students), 104 in the Fall of 2009, and 92 students in the Spring of 2010. It is not believed that these enrollments are sustainable for the certificate program, but they do reflect a strong demand for the technology.

5. Scheduling

No change in the regular scheduling of the existing courses is anticipated. The Departments delivering the new courses have agreed to fit them into their regular scheduling plans.

6. Curriculum Design

Required Courses (9 credits): NEW courses in Boldface

EE/MEEM 5295 Adv. Propulsion Systems for Electric Drive Vehicles (3)

Any **two** of the following:

EE/MEEM 4295	**Intro. to Propulsion Systems for Electric Drive Vehicles (3)**
EE 4227	Power Electronics (3)
MY/CM 5760	**Vehicle Battery Cells and Systems (3)**
EE 5221	Advanced Electrical Machines (3)
MEEM 5450	**Vehicle Dynamics (3)**

Electives Courses (6 credits):

EE/MEEM 4295	Intro. to Propulsion Systems for Electric Drive Vehicles (3)
EE 4227	Power Electronics (3)
MY/CM 5760	Vehicle Battery Cells and Systems (3)
EE 5221	Advanced Electrical Machines (3)
MEEM 5450	Vehicle Dynamics (3)
EE/MEEM 4296	**Intro. to Propulsion Systems for Electric Drive Vehicles Laboratory (1)**
EE/MEEM 5296	**Adv. Propulsion Systems for Electric Drive Vehicles Laboratory (1)**
EE/MEEM 4750/5750	**Distributed Embedded Control Systems (3)**
EE 5200	Advanced Methods in Power Systems (3)
EE 3120	Electric Energy Systems, *not EE and not CPE*, (3)
EE 4221	Power System Analysis 1 (3)
EE 4222	Power System Analysis 2 (3)
EE 5223	Power System Protection (3)
EE 5230	Power System Operations (3)
EE 5290	Selected Topics in Power Systems (3)
MEEM 4220	IC Engines 1 (3)
MEEM 5250	IC Engines 2 (3)
MEEM 5670	Experimental Design in Engineering (3)
MEEM 5680	Optimization (3)
MEEM 5700	Dynamic Measurement and Signal Analysis (3)
MEEM 5715	Linear Systems (3)
MEEM 4260/5220	Fuel Cell Technology (3)
MY 4165	Corrosion and Environmental Effects (3)
MY 5100	Thermodynamics and Kinetics I (3)
MY 5110	Thermodynamics and Kinetics II (3)
MY 5410	Materials for Energy Applications (3)
CM/Ent 3974	Fuel Cell Fundamentals (1)
CM/Ent 3977	Fundamentals of Hydrogen as an Energy Carrier (1)
CM/Ent 3978	Hydrogen Measurements Laboratory (1)

Total of 15 credits are required for the certificate. Up to 6 credits of 3000 and 4000 level courses are allowed.

7. New Course descriptions

EE/MEEM 4295 Introduction to Propulsion Systems for Hybrid Electric Drive Vehicles - Hybrid electric drive vehicle analysis will be developed and applied to examine the operation, integration, and design of powertrain components. Model based simulation and design is applied to determine vehicle performance measures in comparison to vehicle technical specifications. Power flows, losses, energy usage, and drive quality are examined over drive-cycles via application of these tools.

EE/MEEM 4296 Introduction to Propulsion Systems for Hybrid Electric Drive Vehicles Laboratory - Hybrid electric drive vehicles and their powertrain components will be examined from the aspects of safety, testing and analysis, energy conversion, losses, and energy storage, and vehicle technical specifications and vehicle development process. The lab will culminate with vehicle testing to perform power flow and energy analysis during a drive-cycle.

EE/MEEM 5295 Advanced Propulsion Systems for Hybrid Electric Drive Vehicles - Hybrid electric drive vehicles (HEDV) will be studied and simulated using advanced powertrain component analysis and

modeling. An in-depth analysis and study of power flows, losses and energy usage are examined for isolated powertrain components and HEDV configurations. Simulation tools will be developed and applied to specify powertrain and vehicle components and to develop control and calibration for a constrained optimization to vehicle technical specifications.

EE/MEEM 5296 Advanced Propulsion Systems for Hybrid Electric Drive Vehicles Laboratory - Hybrid electric drive vehicles (HEDV) and their components will be examined in a series of laboratories. This includes quantification of power flows and losses in components, calibration of component models based upon experimental data, measurement and quantification of drive quality, failure Mode & Effects Analysis, calibration practices and trade-offs. A HEDV model will be tuned and validated through analysis and fitting to vehicle test data.

MEEM 4450/5450 Vehicle Dynamics - This course will develop the necessary models to predict performance and handling and compare analytical results to selected measured data from hybrid vehicle test data. Topics to be covered include: acceleration and braking performance, hybrid electric powertrain architecture, drivetrain performance, vehicle handling, suspension modeling, tire models, steering and steering control, 2DOF dynamics model, and multi-body dynamics. This will culminate in a design project which will require the design of a hybrid vehicle to meet a given vehicle technical specification. Credit may not be received for both MEEM4450 and MEEM5450.

MY/CM 5760 Vehicle Battery Cells and Systems - The behavior and application of batteries will be examined by introducing concepts from thermodynamics, materials science, transport processes and equivalent circuits. The non-ideal power source behavior of rechargeable batteries in applications will be treated using electrolyte: electrode transport and electrode materials chemistry.

EE/MEEM 4750/5750 Distributed Embedded Control Systems - This course will develop an understanding for the design and application of embedded control systems. Topics to be covered include: embedded system architecture, model-based embedded system design, real-time control, communication protocols, signal processing, and human machine interface. Embedded applications in advanced hybrid electric vehicles will also be introduced.

8. Library and other Learning Resources

Students in this program will need only the Library resources presently available to all enrolled students.

9. Computing Access Fee

On campus Students will be charged the appropriate department computer access fees. Online students will not be charged computer access fees. Online students will be charged online learning fees.

10. Faculty Resumes

Jeff Naber	http://www.me.mtu.edu/meem/facultybio/naber.html
Jeff Allen	http://www.me.mtu.edu/meem/facultybio/allen.html
Bo Chen	http://www.me.mtu.edu/meem/facultybio/b_chen.html
Wayne Weaver	http://www.ece.mtu.edu/pages/faculty/Weaver.html
Leonard Bohmann	http://www.ece.mtu.edu/pages/faculty/Bohmann.html
John Beard	http://www.me.mtu.edu/meem/facultybio/beard.html
Bruce Mork	http://www.ece.mtu.edu/faculty/bamork.html
Jason Keith	http://www.chem.mtu.edu/chem_eng/faculty/jmkeith.htm
Steve Hackney	http://www.mse.mtu.edu/faculty/hackney.html

11 . Equipment

A **mobile laboratory** needed for the introductory and advanced propulsion systems courses is being fabricated using funds from a United States Department of Energy (DOE) grant. An existing portable chassis dynamometer will also be used. Some upgrades to the chassis dynamometer will be required, with the funding from those upgrades coming from the same DOE grant as the mobile laboratory. AVL, a partner in the DOE grant will be providing an additional $750,000 in support for the mobile laboratory.

12. Program Costs

The new courses developed or modified for this certificate are funded from a DOE grant. The remaining courses are presently being taught on a regular basis.

Funding for Michigan Tech's Educational Technology Services to support the development of the new online courses is available from a DOE grant.

13. Space

The mobile laboratory including the portable chassis dynamometer, and the hybrid electric vehicles will be housed at KRC.

14. Policies, Regulations, and Rules.

Credits earned for this certificate may also be applied toward a single graduate degree at Michigan Technological University.

15. Accreditation Requirements

None

XVI. Internal Status of the proposal.

Approved by the College of Engineering

XVII. Planned Implementation Date

Fall 2010

Senate Introduction: 31 March 2010
Adopted by Senate: 14 April 2010
Approved by administration: 21 April 2010