

# **The University Senate of Michigan Technological University**

## **Proposal 5-21**

### **Establishment of a New Graduate Certificate in Vehicle Dynamics**

**Submitted by:**

**Department of Mechanical Engineering – Engineering Mechanics**

1. **Proposal Date:** May 22, 2020
2. **Proposing Contacts and Departments:** Darrell Robinette, Assistant Professor,  
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3. **Sponsor Department Approvals:** May 26, 2020

#### **4. General Description and Characteristics of Certificate**

##### **4.1. General Description:**

The objectives of the nine credit Graduate Certificate in Vehicle Dynamics are to prepare students with the fundamental knowledge of lateral and longitudinal vehicle dynamics coupled with the ability to adequately construct a model, perform simulations, and assess performance relative to targets and specifications. Vehicle propulsion system design and integration is mixed into the curriculum, methods to move the vehicle with basic controls, and calibration strategies for dynamics and energy consumption.

##### **4.2. Catalog Description:**

The Certificate in Vehicle Dynamics covers fundamental courses in lateral and longitudinal vehicle dynamics and the application of vehicle propulsion system engineering. Topics include modeling, analysis and simulation of lateral and longitudinal vehicle characteristics relative to basic vehicle motion and includes details relative to suspension, tires, propulsion system designs, chassis system integration and principles of control systems for traction, propulsion, braking and automated driving.

#### **5. Rationale for the Certificate:**

Vehicle dynamics is an integral component of vehicle and propulsion system engineering and is critical to the development of new vehicle platforms and automated driving control systems for future autonomous and connected vehicles.

The Vehicle Dynamics Certificate will serve 1) certificate-seeking students who wish to learn fundamental vehicle dynamics and develop modeling and simulation skills necessary to assess design tradeoffs for meeting performance requirements and 2) degree-seeking students who require knowledge and skills in modeling, simulated and assessing vehicle dynamics for their research or students with a passion for the topic.

## 6. Related Programs:

There are several other on-campus and online certificate programs in vehicle dynamics or more broadly, automotive engineering. Within Michigan, the University of Detroit Mercy offers a certificate in Smart and Autonomous Vehicle Graduate Certificate that is a 15 credit, 5 course program. The University of Michigan Dearborn also offers 12 credit graduate certificates in Automotive Powertrains, Automotive Noise, Vibration & Harshness and Vehicle Electronics & Controls.

Other similar programs are offered at:

- **Clemson University** (12 credits/4 courses)  
<https://www.clemson.edu/cecas/departments/automotive-engineering/academic-programs/ae-certificate/ae-certificate-grad.html>
- **University of Detroit Mercy** (15 credit/5 courses)  
<https://eng-sci.udmercy.edu/academics/engineering/sav>
- **Indiana University Purdue University Indiana** (29 credit)  
<https://et.iupui.edu/departments/ent/programs/met/undergrad/certificates/>
- **The Ohio State University** (1 & 2 professional certificates, customized topics)  
<https://englearn.osu.edu/curriculum/certificate>

## 7. Projected Enrollments:

Initially, the program will have most of the enrollment from currently enrolled Michigan Tech graduate students. An online offering will expand the number of students enrolled. Given the current level of interest, we expect the program to grow before stabilizing enrollment. If interest exceeds this projected enrollment, in particular through online enrollment, additional resources will be required. The enrollment cap depends on the number of sections that can be allocated to each course.

Academic Year	Estimated Enrollment	
	On Campus	Online
2020-21	4-5	3
2021-22	5	5
2022-23	5	7
2023-24	6	10
2024-25	7	12

8. **Scheduling Plans:** On-campus sections will not require changes to class scheduling while online sections can be implemented asynchronously.

## **9. Curriculum Design:**

This 9-credit certificate consists of two 3-credit required courses and one 3-credit elective. Only three credits may be at the 4000 level. The required and elective course list with the course descriptions are given below. It is expected that students will work with the program advisor to select courses that fit their interests and prerequisite skills.

### **Required Courses – 6 Credits**

MEEM 4450 – Vehicle Dynamics (3 cr., spring)

EE/MEEM 5812 – Automotive Control Systems (3 cr., spring)

### **Elective Courses – 3 credits (select 1)**

MEEM 5730 – Dynamic System Simulation (3 cr., spring)

MEEM 5701 – Intermediate Dynamics (3 cr., fall)

## **10. Course Descriptions:**

### **MEEM 4450 - Vehicle Dynamics – 3 credits**

This course will develop the models and techniques needed to predict the performance of a road vehicle during drive off, braking, ride, and steering maneuvers. Topics to be covered include: acceleration and braking performance, power train architecture, vehicle handling, suspension modeling, tire models, and steering control. Matlab, Adams Car, and Amesim, will be used as computational tools.

### **EE/MEEM 5812 - Automotive Control Systems – 3 credits**

Introduction to automotive control systems. Modeling and control methods are presented for: air-fuel ratio, transient fuel, spark timing, idle speed, transmission, cruise speed, anti-lock brakes, traction, active suspension systems, and hybrid electric vehicles. Advanced control methodologies are introduced for appropriate applications.

### **MEEM 5730 - Dynamic System Simulation – 3 credits**

Methods for simulating dynamic systems described by ordinary differential equations using numerical integration are developed. Quantifying simulation errors for both batch and real-time, control system applications is covered along with numerical optimization strategies for model validation. MATLAB and Simulink are used to illustrate key concepts.

### **MEEM 5701 - Intermediate Dynamics – 3 credits**

Intermediate study of several topics in engineering dynamics, including three-dimensional kinematics and kinetics, generalized coordinates, Lagrange's equation, and Hamilton's principle. Uses computer-aided dynamic simulation tools for analyzing dynamic systems.

**11. Model Schedule Demonstrating Completion Time:**

The typical completion time is two semesters. A typical schedule is shown below:

Fall Semester	Spring Semester
MEEM 5701	MEEM 4450
	MEEM 5812

**12. Library and other Learning Resources:**

None

**13. Faculty Resumes:**

The associated faculty, and the certificate courses they have taught, are given below.

Steven Ma, MEEM 4450

<https://www.mtu.edu/mechanical/people/lecturers/ma/>

Gordon Parker, MEEM 5730, MEEM 5701

<https://www.mtu.edu/mechanical/people/faculty/parker/>

Bo Chen, MEEM 5812

<https://www.mtu.edu/mechanical/people/faculty/chen/>

**14. Equipment:**

None

**15. Program Costs:**

There are no new costs to offer the certificate to on-campus students. Costs will be incurred for the on-line version to (1) develop initial online content for MEEM 4450 and 5701 and (2) adjust online content for new software versions and examples. These costs can be met assuming the tuition return to departments are not decreased. We anticipate that the initial enrollment load can be covered with our current faculty.

**16. Space:**

None

**17. Policies, Regulations, and Rules:**

None

**18. Accreditation Requirements:**

Michigan Tech is accredited by the Higher Learning Commission (HLC),

<https://www.mtu.edu/provost/accreditation/hlcommission/>. The proposed certificate will not require additional accreditation and will meet HLC criteria 3 and 4.

**19. Planned Implementation Date:**

Spring 2021

**20. Assessment:**

The Graduate Learning Objectives (GLO) of the Certificate are:

1. Demonstrate core proficiency in vehicle dynamics through project-based assignments dealing with open ended design and synthesis of multi-degree and multi-body simulation of vehicle chassis, suspension and tire systems under various road and surface conditions.
2. Demonstrate understanding of the applications of vehicle dynamics, propulsion and control techniques to engineering problems through use of design problem solving using digital tools to model and analysis vehicle system and subsystems under dynamic loading scenarios.
3. Demonstrate professional skills of vehicle dynamics (simulation, modeling, written, and oral communication) through design project(s) in the certificate courses that require the student to follow the engineering “V” diagram and meet performance objectives by satisfying specified design requirements.

**Department approval:** May 26,2020

**College of Engineering approval:** May 28, 2020