The University Senate of Michigan Technological University

Proposal 03-26

Proposal for a Graduate Certificate in Internal Combustion Engine Systems

Basic Program Information

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Program/Degree type: Graduate Certificate

Program Title: Internal Combustion Engine Systems

Planned Implementation Date: Spring 2026

Program Location/modality: Online and In-person

Target student population: Working professionals; MTU graduate students wanting to earn an extra credential in internal combustion (IC) engines.

General description and characteristics of the program

We propose a 9-credit graduate certificate in Internal Combustion Engine (ICE) Systems. The certificate is aimed at both online and in-person MS students.

The certificate can be completed online in two to three semesters, including offerings in the summer if a student can take two courses in one of the semesters and/or one or more of the lab sections in the summer.

Rationale

MTU has a longstanding history and a robust curriculum and professional development program in propulsion, with internal combustion (IC) engines being a key component. There is a continued strong demand for individuals with advanced knowledge in IC engines due to their critical importance in all types of ground mobility, including on-road and off-road commercial vehicles, and military power generation and vehicles. IC engines remain the key power conversion for power generation and in numerous industrial applications. For many industries that recruit at MTU, this is a core need. This includes companies such as Cummins, Caterpillar, Deere, Waukesha, Detroit Diesel, Briggs and Stratton, Mercury Marine, Harley-Davidson, Generac, General Dynamics, Mahle, AVL, Marathon Petroleum Corp., as well as all light-duty vehicle manufacturers and their suppliers. This certificate is closely aligned with Global Campus initiatives and partners.

The continued advancement of internal combustion (IC) engine technologies is critical to the success of industry leaders, creating both a strong demand for Michigan Tech graduates and a need for upskilling current employees. At the same time, the number of universities offering specialized IC engine courses has declined, presenting an opportunity to attract students seeking this expertise. IC engines must address evolving technological, environmental, and economic challenges, and this graduate certificate program is designed to equip the next generation of engineers with the knowledge and skills necessary to tackle these complex issues.

Related programs: within MTU and at other institutions

MTU offers undergraduate electives in IC engines in the MAE and MET programs. The MAE offers two graduate courses and four laboratory courses in IC engines. There are related courses in the existing curriculum that are proposed to be in the certificate.

University of Wisconsin-Madison had a previous online program, Engine Systems, through their Interdisciplinary Professional Programs in the College of Engineering. This program was terminated, and we are looking to attract students from their program. Clemson University has PhD, MS, and a 12-credit graduate certificate in Automotive Systems. University of Michigan-Dearborn has a 12-credit graduate certificate in Internal Combustion Engines.

Projected Enrollment

Enrollment in our IC engine undergraduate and graduate courses was high through the 1990s to the late 2010’s with peak enrollments in the 60’s and 40’s, respectively. There was a downturn in enrollment from 2018 to 2022, but enrollment is now increasing. There have been requests from several industry partners to offer this certificate as a result of UW-Madison's termination. Expected enrollment is 25-30 students per year, split between on-campus and distance learning.

Specialized Accreditation Requirements

There is no discipline-specific accreditation.

Professional Licensure Requirements

No licensure is required.

Curriculum Details

A total of nine credits is required for the certificate. There are two - three credit required courses, for a total of 6 credits as given below. These two can be taken in either order. Three credits from the elective courses must be taken and are listed below the required courses.

Required Courses (6 credits)

ME-5250* Internal Combustion Engines II (Taught every spring with both on-campus and distance learning sections as a 3-credit hour course).

Pre-reqs not included: ME4220 - Introduction to Internal Combustion Engines & ME4201 - Applied Thermodynamics. It is expected that students in this graduate certificate have an ME undergraduate degree that provides the necessary foundation in introductory internal combustion engines and applied thermodynamics

ME-5990*⧫✦ Thermodynamics of Internal Combustion Engines (taught as 5990 in Fall 2024 as a 3-credit-hour course)

An additional 3 credits are required from the following elective courses.

AE 4530★ Compressible Flow (3cr)

ME 5201■ Fundamentals of Spark-Ignition Engines – Lab (1cr)

ME 5202■ Fundamentals of Diesel Engines – Lab (1cr)

ME 5203■ Spark-Ignition Engine Control Systems – Lab (1cr)

ME 5204■ Diesel Engine Control Systems – Lab (1cr)

ME 5255*✦ Advanced Powertrain Instrumentation (3cr)

ME 5990*✦ Independent Study (1-3cr)

ME 5990*✦ Exhaust Aftertreatment (2cr)

ME 5990*✦ Engine Design (3cr)

ME 5990*✦ Perspectives on Engine Modeling (2cr)

ME 5990*✦ Analysis and Trends in Engines – Seminar (1cr)

* *Courses that have been taught online and will be available online. None of the courses has been reviewed per Senate procedure 116.1.1. Online courses will be submitted for review by February 28, 2026.*

⧫ *Courses in MEA are not normally assigned a formal number until the course has been taught at a minimum of two times, and then it goes through the formal binder process.*

■ *Courses are available remotely via the Mobile Laboratory on demand with sufficient enrollment. These are offered in the summer in Track A / Track B with only three (3) days of attendance at MTU required. Several online students have selected to come to MTU for this lab.*

✦*Courses available only online.*

★ *The inclusion of this 4000-level undergraduate course is essential because it covers compressible flow, choked flow, and turbomachinery. These topics are critical for advanced study in internal combustion engines that are not addressed in the required undergraduate Mechanical Engineering fluid mechanics*

curriculum.

Sufficient courses will be available for both online and distance-learning students to obtain the certificate within the targeted time.

Learning Goals

1) Apply engineering principles of energy conversion, thermodynamics, and fluid mechanics to include thermochemistry and thermodynamics of reacting mixtures for the assessment of internal engine systems.
2) Analyze, evaluate, and specify engine subsystems to include turbocharged air-handling and fuel injection components by application of theory and established engineering correlations.
3) Demonstrate technical competencies in at least two of the following areas:
    i. Design and plan testing in dynamometer-based engine testing and interpret performance and emissions data.
    ii. Utilize cylinder pressure data and computed combustion metrics to quantify combustion characteristics, including heat release rates and mass fraction burned, for engine calibration and optimization.
    iii. Calibrate engine controls for performance and emissions with constraints such as abnormal combustion and component limits.
    iv. Create, simulate, and validate one-dimensional engine performance models for system design and evaluation.
    v. Assess engine and aftertreatment requirements and designs in relation to current and future US emissions regulations.

Assessment Plan

Attached at the end of this proposal.

Curriculum Design

The MTU courses have been offered for many years in person and online, and only minor changes will be required to integrate into the curriculum. The new courses for MTU have been offered online in other venues. The two required courses, ME 5990 Thermodynamics of Internal Combustion Engines and ME 5250 Internal Combustion Engines II, will be offered Fall and Spring respectively for both on-campus and distance learning students. Other courses are spread across the Fall, Spring, and Summer semesters to ensure students can take at least two courses per semester and complete in the targeted time.

New Course Descriptions

The new MTU courses have been previously developed and taught as part of University of Wisconsin – Madison's terminated program and are ready to be delivered here at MTU with no extra preparation required.

Course #'s	Title	Description
ME	Thermodynamics for Engine	Examination of engine systems through

5990	Systems (3cr)	thermodynamic principles. Application of 1st & 2nd laws of thermodynamics to analyze ICE's. Ideal gas mixtures, thermodynamics, and combustion principles are used to determine adiabatic flame temperature and chemical equilibrium.
ME 5990	Engine Design (3cr)	Provides an understanding of engine applications, stakeholder needs assessment, setting requirements, and engineering product planning.
ME 5990	Perspectives on Engine Modeling (2cr)	Problem definition and planning, tool selection, model construction, calibration, and application for selection of appropriate modeling tools for engine design and development project. *Discusses the types of modeling used for engine design including 0D, 1D and CFD. 1D GT-Power modeling will be utilized to examine SI and diesel engine operation*
ME 5990	Analysis & Trends in Engines – Seminar (1cr)	Scientifically based look at trends in energy availability, emission control, regulations, and technological advances in the assessment of the future of engines and powertrain systems with an emphasis on vehicles.
ME 5990	Exhaust Aftertreatment (2cr)	Fundamental development of the science and engineering underlying the design and operation of ICE exhaust aftertreatment systems. Emphasis on spark-ignited gasoline and compression ignition diesel combustion engines.

Model Schedule

The schedule is shown in the table below. Students may begin in any semester. Both required courses, **Thermodynamics for Engine Systems** (offered each Fall) and **Internal Combustion Engines** (offered each Spring) are available online every year. The courses are independent of one another and may be taken in either order. The other three credits can also be taken independently of these two required courses, including in the same semester.

Summer 2026	**Title**
ME 5202	Fundamentals of Diesel Engines – Lab (1cr)
ME 5204	Diesel Engine Control Systems – Lab (1cr)
Fall 2026	**Title**
ME 5990 (Req)	Thermodynamics for Engine Systems (3cr)

ME 5990	Perspectives on Engine Modeling (2cr)
Spring 2027	**Repeats from above**
ME 5250 (Req)	Internal Combustion Engines II (3cr)
ME 5255	Advanced Powertrain Instrumentation (3cr)
ME 5990	Analysis and Trends in Engines – Seminar (1cr)
Summer 2027	**Title**
ME 5201	Fundamentals of Spark-Ignition Engines (1cr)
ME 5203	Spark-Ignition Engine Control Systems (1cr)
Fall 2027	**Title**
ME 5990 (Req)	Thermodynamics for Engine Systems (3cr)
ME 5990	Perspectives on Engine Modeling (2cr)
ME 5990	Engine Design (3cr)

Additional elective courses are offered based on department scheduling, typically once per year, spring or fall semester.

- AE 4230 – Compressible Flow/Gas Dynamics (3cr)
- ME 5990 – Independent Study (1-3cr)

Enrollment and credit for the independent study must follow MAE Department policies. Students must identify a Mechanical Engineering faculty advisor with expertise in the chosen topic and submit a detailed study proposal that includes objectives, a timeline, and evaluation criteria. Approval is required from both the ME Graduate Program Director and the Graduate Director of the Internal Combustion Engine Systems Certificate. Upon completion, a final report and presentation must be submitted to the advising faculty member, the ME Graduate Program Director, and the Certificate Graduate Director.

Faculty Qualifications

Faculty teaching in the certificate courses have been teaching these same courses in-person for many years and are experienced in online delivery and education. Professors Naber and Miers have already been recognized as meeting Michigan Tech's qualification standards for online/remote instruction; Prof. Strzelec will submit qualifications per Senate Policy 116.1 in the Spring 2026 semester.

> Jeffrey D. Naber, Dr. Naber has extensive experience in online and hybrid teaching, having taught more than 15 online course sections since 2009. He helped launch Michigan Tech's hybrid retraining program for displaced engineers in 2009, which enrolled 62 online

students. Dr. Naber co-developed both the Hybrid Electric Vehicle (HEV) and Automotive Engineering graduate certificates, each designed for online delivery. His contributions to engineering education have been recognized by SAE International through the Ralph R. Teetor Educational Award.

Scott Miers, Associate Professor, MAE, Dr. Miers has been recognized in 2017 Distinguished Teaching Award in the professor/associate professor category and has extensive experience in the technical content of this certificate. His contributions to engineering education have also been recognized by SAE International through the Ralph R. Teetor Educational Award.

Andrea Strzelec, Adjunct Assistant Professor, MAE, has more than 10 years of experience in hybrid and online teaching. She has taught nearly 20 online courses since 2015, at 3 universities. Dr. Strzelec was previously the Program Director for the UW-Madison Masters of Engineering in Engine Systems, Engine Design Certificate, and Powertrain Electrification Certificate, all online programs.

Program-specific policies, regulations, and rules

There are no program-specific policies or rules.

Resources Needed

Library and other learning resources needed

GT-Power simulation tool is used in MEEM 4220 and MEEM 5250. It will also be used in the new course “Perspectives in Engine Modeling”.

Support of Global Campus for marketing the certificate.

No other additional resources are needed.

Suitability of existing space, facilities, and equipment

Existing space, facilities, and equipment are sufficient.

Online courses will be offered through Michigan Tech’s learning portal Canvas with asynchronous and synchronous instruction using Zoom and Huskycast. Campus courses will utilize classrooms on campus, scheduled as normal by the ME department. Laboratory courses will utilize the Mobile lab located in the APSRC Building located at 23199 Airpark Blvd, Calumet, MI 49913. There are already several laboratory courses taught from this location in the ME undergraduate and graduate program.

Program Costs

All courses have been taught at MTU or developed and delivered elsewhere. For those from other venues, materials are ready for use at MTU through collaboration with USCAR, requiring no additional preparation or cost. Laboratory courses with lab fees are already established with resources.

These courses will be on a standard 14-week semester, except the lab courses, which are offered either in Summer track A or track B.