Michigan Tech

Office Memo

Office of the Provost and
Senior Vice President for Academic Affairs

Phone: (906) 487-2440
Fax: (906) 487-2935

TO: Richard Koubek, President

FROM: Jacqueline E. Huntoon, Provost & Senior Vice President for Academic Affairs

Jacqueline E Huntoon

DATE: November 18, 2020

SUBJECT: Senate Proposal 20-21

Attached is Senate proposal 20-21, “Establishment of a New Graduate Certificate in Dynamic Systems,” and a memo stating the Senate passed this proposal at their November 11, 2020 meeting. I have reviewed this memo and recommend approving this proposal.

I concur__X__ do not concur_______ with this recommendation.

______________________________ 11/19/20

Richard Koubek, President Date

Michigan Tech

University Senate

DATE:	November 12, 2020
TO:	Richard Koubek, President
FROM:	Sam Sweitz University Senate President
SUBJECT:	Proposal 20-21
COPIES:	Jacqueline E. Huntoon, Provost & Senior VP for Academic Affairs

At its meeting on November 11, 2020, the University Senate approved Proposal 20-21, "Establishment of a New Graduate Certificate in Dynamic Systems". Feel free to contact me if you have any questions.

The University Senate of Michigan Technological University
Proposal 20-21

Establishment of a New Graduate Certificate in Dynamic Systems

Submitted by:
Department of Mechanical Engineering – Engineering Mechanics

1. **Proposal Date:** May 22, 2020
2. **Proposing Contacts and Departments:** Gordon Parker, John and Cathi Drake Chair of Mechanical Engineering, ggparker@mtu.edu
3. **Sponsor Department Approvals:** May 26, 2020
4. **General Description and Characteristics**

4.1. General Description: The objectives of the nine credit Graduate Certificate in Dynamic Systems are:

a) Attract engineering students to Michigan Tech who are interested in modeling, analyzing and designing multiphysics dynamic systems.

b) Provide a compact sequence for engineers seeking to refresh their dynamics background and move into advanced concepts and applications.

c) Mentor engineers to develop best-practice skills in dynamic system modeling and design using state-of-the-art analysis tools, methods, and workflows.

4.2. Catalog Description: The Certificate in Dynamic Systems develops a foundation of analytical mechanics and multiphysics modeling from which students explore applications suited to their interests. The curriculum combines individual and team exercises to build skills in dynamic system analysis, modeling, simulation and design using state-of-the-art analysis tools, methods, and workflows.

5. **Rationale for the Certificate**

Dynamic system simulation is ubiquitous in engineering and is critical to designing complex, multiphysics systems prior to costly prototyping and testing [1]. Model-based data generation for training machine learning algorithms is a rapidly emerging area [2]. Being able to evaluate the quality of a model's output requires an engineer to have not only a foundation in mathematical modeling but also simulation development, verification and validation. Completing this sequence equips students with the necessary skills to be successful in model-based engineering that can be used across engineering disciplines.

The Dynamic Systems Certificate will serve: (1) certificate-seeking students who wish to develop dynamic system modeling and simulation skills as part of their professional development and (2) degree-seeking students who require multiphysics modeling and simulation skills for their research or students with a passion for the topic.

6. Related Programs

Several similar certificates can be pursued online with a few examples shown below. Our proposed certificate is unique in its requirement of a simulation course where students not only learn how a numerical simulation engine works but also have project-based opportunities to develop hands-on experience with existing simulation tools.

1. ***Michigan State University*** – Computational Modeling. 12 Semester Credits. Three courses are required where two must come from a list of 6 courses with a numerical methods theme and the remaining course from a list of 33. This provides great flexibility without tying the certificate to a particular discipline.

2. ***Portland State University*** – Computer Modeling and Simulation. 16 Quarter Credits (12 Semester Credits). Completion of four courses emphasizing supply chain applications, simulation architecture with optional courses in linear and nonlinear system theory.

3. ***Villanova University*** – Modeling and Simulation. 15 Semester Credits. Completion of five courses where all students obtain background in numerical methods and finite element analysis. Students can then select a multiphysics modeling, vibrations, or control systems emphasis.

7. Projected Enrollments

One of the certificate's core courses, Dynamic System Simulation, MEEM 5730, was offered online in Spring 2020 as MEEM 5990. Though the course was not marketed, there were 6 enrolled online students from a variety of companies (Ford, John Deere, etc.). Table 1 shows estimated minimum targets assuming a more aggressive marketing approach is deployed. The enrollment cap depends on the number of sections that can be allocated to each course.

Table 1. Estimated minimum enrollment targets by year.

Academic Year	**Estimated Minimum Enrollment Targets**	
	On-Campus	On-Line
2020-2021	5	6
2021-2022	5	10
2022-2023	5	15
2023-2024	5	15
2024-2025	5	15

8. Scheduling Plans

On-campus sections will not require changes to class scheduling while online sections can be implemented asynchronously.

9. Curriculum

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 5701 Intermediate Dynamics (3cr, Fall)
MEEM 5730 Dynamic System Simulation (3cr, Spring, offered as MEEM 5990 in Spring 2020)

Elective Courses - 3 credits (select 1 course)

MEEM 4450 Vehicle Dynamics (3cr, Spring)
MEEM 4775 Analysis and Design of Feedback Control Systems (4cr, Fall)
MEEM 5702 Analytical Vibroacoustics (3cr, Fall)
EE/MEEM 5715 Linear System Theory and Analysis (3cr, Fall)

10. Course Descriptions

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.

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 are covered along with numerical optimization strategies for model validation. Advanced topics in analytical mechanics are introduced in addition to theoretical aspects of simulation error analysis. MATLAB and Simulink are used to illustrate key concepts.

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.

MEEM 4775 Analysis and Design of Feedback Control Systems – 3 credits

This course covers topics of control systems design. Course includes a review for modeling of dynamical systems, stability, and root locus design. Also covers control systems design in the frequency domain, fundamentals of digital control and nonlinear systems.

MEEM 5702 – Analytical Vibroacoustics – 3 credits
First in a series of two courses on vibro-acoustics to provide a unified approach to study noise and vibration. Emphasizes interaction between sound waves and structures. Presents advanced vibration concepts with computational tools. Discusses wave-modal duality.

EE/MEEM 5715 – Linear Systems Theory and Design – 3 credits
Overview of linear algebra, modern control; state-based design of linear systems, observability, controllability, pole placement, observer design, stability theory of linear time-varying systems, Lyapunov stability, optimal control, linear quadratic regulator, Kalman filter,

11. Model Schedule Demonstrating Completion Time
The minimum completion time is two semesters. A typical schedule is shown below.

Fall Semester	***Spring Semester***
MEEM 5701	MEEM 5730
MEEM 4775	

12. Library and Other Learning Resources
None

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

Andrew Barnard, MEEM 5702
https://www.mtu.edu/mechanical/people/faculty/barnard/

Jason Blough, MEEM 5702
https://www.mtu.edu/mechanical/people/faculty/blough/

Steven Ma, MEEM 4450
https://www.mtu.edu/mechanical/people/lecturers/ma/

Gordon Parker, MEEM 4775, MEEM 5701, MEEM 5730, MEEM 5715
https://www.mtu.edu/mechanical/people/faculty/parker/

Wayne Weaver, MEEM 4775, MEEM 5715
https://www.mtu.edu/mechanical/people/faculty/weaver/

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 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.

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. Implementation Date
Spring 2021

20. Assessment
The Graduate Learning Objectives (GLO) of the certificate are listed below.

1. Given a physical description of a dynamic system be able to:
    a) Using rigid body kinematics concepts, create a suitable set of generalized coordinates
    b) Develop the system's holonomic and nonholonomic constraint equations
    b) Create its differential equation model, and any energy-like conservation equations, using Lagrange's Equation.
    c) Create verifiable, component-based and signal-based numerical models

2. Communicate the dynamic system analysis process, through written project reports, including: statement of assumptions, equation of motion derivation, listing of conserved quantities, numerical model architecture justification and steps taken to verify numerical results.

21. References

1. Inside HPC Staff. "Aerospace Moving Forward with Modeling and Simulation." Inside HPC., 14 May 2019. Web. 24 April 2020. https://insidehpc.com/2019/05/aerospace-moving-forward-with-modeling-and-simulation/.
2. A., L. Fumagalli, and I. Roda, "Role of Simulation in Industrial Engineering: Focus on Manufacturing Systems," IFAC-Papers OnLine. (2018): 496:501.

Department approval: May 26, 2020
College of Engineering approval: May 28, 2020