Michigan Tech

Office Memo

Office of the Provost and
Senior Vice President for Academic Affairs

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TO: Richard Koubek, President

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

DATE: November 18, 2020

SUBJECT: Senate Proposal 19-21

Attached is Senate proposal 19-21, "Establishment of a New Graduate Certificate in Computational Fluid Dynamics," 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 19-21
COPIES:	Jacqueline E. Huntoon, Provost & Senior VP for Academic Affairs

At its meeting on November 11, 2020, the University Senate approved Proposal 19-21, "Establishment of a New Graduate Certificate in Computational Fluid Dynamics". Feel free to contact me if you have any questions.

The University Senate of Michigan Technological University
Proposal 19-21

Establishment of a New Graduate Certificate in Computational Fluid Dynamics

Submitted by:
Department of Mechanical Engineering – Engineering Mechanics

1. **Proposal Date:** Sept. 20, 2020
2. **Proposing Contacts and Departments:** Chunpei Cai, ccai@mtu.edu
3. **Sponsor Department Approvals:** May 26, 2020
4. **General Description and Characteristics**

4.1. General Description: The objectives of the 9-credit Graduate Certificate in Computational Fluid Dynamics (CFD) are:

a) Attract engineering students to Michigan Tech who are interested in modeling and analyzing fluid dynamics & heat transfer problems, and numerical simulations;

b) Provide a compact sequence for engineers seeking to refresh their fluid dynamics and heat transfer backgrounds and move into advanced concepts and applications;

c) Mentor engineers to develop best-practice skills in CFD simulations using state-of-the-art commercial simulation packages, scheme analysis methods, and new scheme development;

4.2. Catalog Description: The certificate in Computational Fluid Dynamics (CFD) will provide students a foundation that will allow them to 1) solve practical fluid flow & heat transfer problems by using commercial software packages; 2) perform stability and accuracy analysis on classical CFD schemes; and/or, 3) implement classical CFD schemes with computer programs. Based on these skills, students can explore applications suited to their interests. The curriculum combines individual and team exercises to solve practical CFD problems, including but not limited to: 1) problem modelling; 2) Mesh generation; 3) Setup boundary conditions; 4) Simulation parameter selections; 5) Simulation result analysis; 6) Post processing; 7) Development of reports and presentations.

5. **The Rationale for the Certificate**

Fluid dynamic and heat transfer problem simulations are ubiquitous in engineering and are critical to study various gas, liquid, or plasma flows. Numerical simulations can offer insights into those problems. Incorporation of reliable CFD simulations adds efficiency and reliability in the investigation of complex problems, where theoretical analysis and experimental measurements alone are inadequate. CFD can reduce investigation cost significantly and can achieve working conditions which cannot be studied with other methods. Fluid flow & heat transfer simulations have been extremely helpful and successful in studying engineering problems. Mastering computational fluid dynamics and heat transfer (CFD/CHT) requires an engineer to have foundations in fluid mechanics and heat transfer, mathematical modeling, proper selections of numerical schemes, qualitative and quantitative analyses of results, typical scheme analyses, and associated programming. Completing this sequence will equip students with the necessary skills to be successful in multiple disciplines, including but not limited to engineering, mathematics, and physics.

The CFD Certificate will be helpful to: (1) the professional development of certificate-seeking students, who wish to develop modeling and simulation skills for problems involving fluid flows and heat transfer; and (2) degree-seeking students who require fluid dynamic and heat transfer modeling and simulation skills for their research or students with a passion for these topics.

6. Related Programs

Our proposed certificate is unique in its requirement and incorporation of simulation and schemes analysis topics where students not only have project-based opportunities to develop hands-on experience with existing CFD tools but, also, learn how to analyze and implement current or new CFD schemes. Several computations intensive certificates can be pursued online, a few examples are outlined below.

1. ***Michigan State University*** – Computational Modeling. 12 Semester Credits. Two courses are required, focusing on commercial software package applications and computational scheme analysis and implementations. Another two must come from a list of 5 courses focusing on fluid dynamics, thermodynamics, and heat transfer. This provides great flexibility.
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. ***Georgia Tech.*** **-**Computational Science and Engineering. A total of 12-semester credits. Completion of 4 courses. Combining the knowledge, skills, and practices associated with the study of computer-based models of natural phenomena and engineered systems with integrated principles from mathematics, computer science, and engineering, to be able to create significant computational artifacts.

7. Projected Enrollments

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 by year.

Academic Year	**Estimated Minimum Enrollment**	
	On-Campus	On-Line
2020-2021	5	5
2021-2022	7	5
2022-2023	10	10
2023-2024	10	10
2024-2025	10	10

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 5215*/4210* Computational Fluids Engineering (3 cr., Fall)
MEEM 5240 Computational Fluid Dynamics for Engineering (3 cr., Spring)

* MEEM 5215/4210 are dual-listed courses, credit cannot be given for both. If 4210 is applied toward certificate, it is the only 4000-level credits allowed.

Elective Courses - 3 credits (select 1)

MEEM 4230 Compressible Flow and Gas Dynamics (3 cr., Spring)
MEEM 5210 Advanced Fluid Mechanics (3 cr., Fall)
MEEM 6245 Advanced Computational Fluid Dynamics (3 cr., Spring)

10. Course Descriptions

A. MEEM 5215/4210 (*) - Computational Fluids Engineering (required, 3 credit hours)

This course introduces students to computational methods used to solve fluid mechanics and thermal transport problems. Computer-based tools are used to solve engineering problems involving fluid mechanics and thermal transport.

(*MEEM 5215/4210 are dual-listed courses, credit cannot be given for both. If 4210 is applied toward certificate, it is the only 4000-level credits allowed.)

B. MEEM 5240 - Comp Fluid Dynamics for Engineering (required, 3 credit hours)

Introduces finite-difference and finite-volume methods used in solving fluid dynamics and heat transfer problems. Covers numerical grid generation, turbulence modeling, and application to some selected problems.

C. MEEM 4230 - Compressible Flow/Gas Dynamics (3 credit hours)

Fundamentals of one-dimensional gas dynamics, including flow in nozzles and diffusers, normal shocks, frictional flows, and flows with heat transfer or energy release; introduction to oblique shocks.

D. MEEM 5210 - Advanced Fluid Mechanics (3 credit hours)

Develops control volume forms of balance laws governing fluid motion and applies to problems involving rockets, pumps, sprinklers, etc. Derives and studies differential forms of governing equations for incompressible viscous flows. Some analytical solutions are obtained and students are exposed to the rationale behind computational solutions in conjunction with CFD software demonstration. It also covers qualitative aspects of lift and drag, loss of stability of laminar flows, turbulence, and vortex shedding.

E. MEEM 6245 - Advanced Computational Fluid Dynamics (3 credit hours)

An advanced graduate CDF course based on finite difference/ volume methods. Topics are selected from the following list: numerical grid generation, turbulence modeling, multi-phase flows, chemically reacting flows, lattice Boltzmann method, gas kinetic scheme, molecular dynamics method, Monte Carlo Method, particle-in-cell method, etc.

11. Model Schedule Demonstrating Completion Time

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

Fall Semester	***Spring Semester***
MEEM 5215	MEEM 5240
MEEM 5210 or MEEM 5230	

12. Library and Other Learning Resources

None

13. Faculty Resumes

The associated faculty who taught or can teach related courses, are given below.

Dr. Song-Lin Yang (MEEM 4230, MEEM 5240)
https://www.mtu.edu/mechanical/people/faculty/yang/

Dr. Fenando Ponta (MEEM 5210, MEEM 5215, MEEM 5240)
https://www.mtu.edu/mechanical/people/faculty/ponta/

Dr. Amitbah Narian (MEEM 5210, MEEM 5230, MEEM 5280)
https://www.mtu.edu/mechanical/people/faculty/narain/

Dr. Jeffrey S. Allen (MEEM 4230)
https://www.mtu.edu/mechanical/people/faculty/allen/

Dr. Lyon B. King (MEEM 5210)
https://www.mtu.edu/mechanical/people/faculty/king/

Dr. Youngchul Ra
https://www.mtu.edu/mechanical/people/faculty/ra/

Dr. Chunpei Cai (MEEM 5210, MEEM 5240)
https://www.mtu.edu/mechanical/people/faculty/cai/

Dr. Hassan Masoud (MEEM 5230)
https://www.mtu.edu/mechanical/people/faculty/masoud/

Dr. Sajjad Bigham (MEEM 5280)
https://www.mtu.edu/mechanical/people/faculty/bigham/

Dr. Aneet Narendranath (MEEM 4405, MEEM 5210)
https://www.mtu.edu/mechanical/people/lecturers/narendranath/

14. Equipment
None

15. Program Costs
There are no new costs in offering this certificate to on-campus students. Costs will be incurred for the on-line version to cover (1) initial online content and (2) adjust online content for new software versions and examples. These costs can be met assuming the tuition return to departments is 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. The proposed certificate will meet HLC criteria 3 and 4.

19. Implementation Date
Spring 2021

20. Assessment
The Graduate Student Learning Objectives (GLO) of the Certificate are:
1. Can successfully solve engineering problems by using proper commercial CFD packages.
2. Can write and debug CFD programs to solver specific engineering problems,
3. Can independently build a CFD project, perform algorithm analysis and programing, write report, and give a presentation to judge the results and propose further improvement.

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/.

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