Fluid Mechanics and Heat Transfer
(Energy-Thermo-Fluids 2)
MEEM 3201, Section R02, Fall 2019
Mechanical Engineering - Engineering Mechanics
Michigan Technological University

Lecture MWThF 2:00 - 3:00 pm MEEM 403

Instructor Dr. Kishan S. Bellur
MEEM 129
906-487-2513
ksbellur@mtu.edu

Office Hours Mondays 3:00 - 4:00 pm, MEEM 129
Tuesdays Noon - 1:00 pm, MEEM 129
Thursdays 3:00 - 4:55 pm, MEEM 129
or by appointment

Email Correspondence

Messages about the class will be sent by email using a class list. I will not use the messaging system in Canvas. Any email correspondence to me concerning the class should have the subject line begin with "MEEM3201" so that I can find the message and respond in a timely manner.

Course Objectives

This course focuses on fundamentals and applications of fluid mechanics and heat transfer to fluid flow in ducts and pipes (internal flow). Topics covered include (i) application of conservation of mass, energy and momentum via control volume theory, (ii) application of dimensional analysis and similitude, (iii) one-dimensional steady and (iv) unsteady heat conduction, (v) pipe flow and pipe networks, (vi) principles of fan and pump performance with system effects, (vii) convective heat transfer with an emphasis on internal flows, and (viii) simple heat exchanger analysis. By the end of the course, you are expected to demonstrate:

1. Conceptual understanding of fluid flow and convective heat transfer :
    - definitions, concepts & terminology
    - thermodynamic and transport properties of fluids
    - rationale for distinctions and classifications of fluid flow; internal vs external flows
    - relationship between pressure, velocity, friction, and heat transfer
    - modes of heat transfer

2. The ability to setup, simplify, and solve a variety of internal flow problems:
    - Control Volume Analysis – determine force and work exerted by or extracted from fluids in motion
    - Dimensional Analysis & Similitude – identify important forces and effects, reduction of experimental data, and scaling laboratory experiments to physical world
    - Elementary analytical methods for steady-state and transient heat conduction
    - Design of pipe and duct networks with and without heat transfer
    - Design of heat exchangers

Textbooks
Two complete textbooks are required:
- Munson, Young and Okiishi's *Fundamentals of Fluid Mechanics*, 8th edition, Wiley 2016
- Bergman & Lavine's *Fundamentals of Heat and Mass Transfer*, 8th edition, Wiley 2017

Option 1: Print versions of latest edition textbooks purchased either through the campus bookstore or online.
Option 2: Electronic versions of latest edition textbooks. Links posted on canvas.
Option 3: Previous (or International) versions of textbooks. You can usually purchase old editions at a lower cost. These may be electronic or printed. This is perfectly fine for reading material. However, homework exercises may be assigned from the latest edition. You are responsible for obtaining access to the homework exercises as some numbers may have changed. Ask a friend/classmate or use the book on reserve at the library to verify each homework set. Please note that the previous edition of the heat transfer book was authored by Incropera, Dewitt, Bergman and Lavine.

Both textbooks are REQUIRED, but If you are planning to take *MEEM 4202 - Intermediate Fluid Mechanics / Heat Transfer* then I highly recommended that you purchase non-expiring e-books or print versions. These are very useful reference books.

Please contact me with questions.

Reading Assignments
Reading assignments and supplemental instructional materials will be posted in Canvas. You are responsible for keeping up with the reading assignments. Completing the readings prior to class will improve comprehension of the lecture material and enable participation in discussions.

Class Attendance & Participation
You are responsible for the material covered during lecture, which supplements the assigned readings and homework. Class time is intended to be interactive. Participation in class discussions is expected and will be used as part of your overall grade. Use of any recording or communicating devices of any kind is not permitted in class without prior approval from the instructor. Announcements concerning changes to homework assignments, exam dates, etc. will be given in class or via email. You are responsible for keeping up-to-date with the course. Please turn off or silence your cell phones during the class period.

Professional travel to workshops and conferences is required of all faculty. I anticipate being on travel for at least four instructional days during the semester; course material will be covered via alternative means during these periods.

Disability Accommodations
Michigan Tech complies with all federal and state laws and regulations regarding discrimination, including the Americans with Disabilities Act of 1990 (ADA). If you have a disability and need a reasonable accommodation for equal access to education or services at MTU, please call the Dean of Student Affairs at 487-2212.

Homework Assignments
Homework is one of the most important parts of the course. This component of the class develops your problem-solving skills and comprehension of fluid flow and heat transfer phenomena. Problem solving examples are given in the textbook and supplementary notes. Solutions for the homework assignments will either discussed in class or posted to Canvas. All homework must be prepared in a straightforward and professional manner; include all pertinent information such as coordinate axis, free body diagrams, control volumes, and units. Points will be deducted for convoluted or unprofessional work. The solution to each problem should begin on a new page. Multiple page assignments must be stapled together. Loose, folded, or paper-clipped papers will not be accepted. A random subset of problems in each homework assignment will be graded. Late homework will not be accepted without prior approval from the instructor. Bonus problems for extra credit will be available with some homework assignments.

Exams & Quizzes
There will be two exams and a final. Exams and quizzes will be closed book. All exams are comprehensive. Formula sheets and property data will be supplied with each examination. There will be several in-class quizzes during lectures throughout the term. No makeup exams or quizzes will be given. If an absence during an is unavoidable, arrangements must be made with the instructor for an oral exam prior to the date of the absence. Missing an exam due to documented illness or emergency will be handled on a case-by-case basis; also with oral examinations.

Archiving of Student Work
A subset of student’s work on each homework, quiz, exam and project will be archived for the purposes of degree accreditation and instructional review. All names will be redacted from the work prior to archival.

Academic Integrity
I have a zero tolerance policy with regard to cheating. “Intentional, unauthorized use of any study aids, equipment, or another’s work on an academic exercise” is cheating. “Knowingly allowing or helping another individual to plagiarize, cheat or fabricate information” also falls under academic dishonesty and will be treated the same as cheating. Using the internet (email, www, listservs, usenet, blogs, wiki’s, etc.) or social media to gather information on topics related to homework and projects is permissible. However, do not solicit solutions to homework problems, exams, or projects from the internet. Academic dishonesty is a serious violation of University Policy and will be dealt with accordingly. Cheating on a quiz or exam will result in a grade of zero on that quiz or exam and the material will be turned over to the Dean of Student Affairs. Any questions regarding permissible collaborations or information sources should be brought to the instructor for clarification.

Grading

Grading is absolute:
A: ≥ 93%,
AB: 88% – 92%,
B: 83% – 87%,
BC: 78% – 82%,
C: 73% – 77%,
CD: 68% – 72%,
D: 63% – 67%, and
F: ≤ 63%.

Grade weighting:
30% homework,
15% exam 1,
15% exam 2,
25% final exam,
10% quizzes, and
5% participation & initiative.

Tentative Schedule

Week	Topic	Deliverable
1-2	**Introduction to fluids, fluid flow and Heat Transfer** Unit systems, thermodynamic and transport properties of momentum and heat transfer. Fluid Statics, Manometry and Pressure	HW 1
2-3	**Control Volume Analysis** Conservation laws Reynolds Transport Theorem Examples on Mass Conservation No class on 02/01/2019 (Instructor at Gordon Conference)	HW 2, HW 3
4	No class on 02/06/2019 (Instructor at Gordon Conference)	Exam 1 02/04/2019
5	**Control Volume Analysis** Examples on Momentum and Energy Conservation Bernoulli equation & Applications	HW 4
6-7	**Steady State Conduction Heat Transfer** Boundary and Initial Conditions Thermal Resistance Networks Adding dimensions and changing coordinate systems	HW 5, HW 6
8	**Dimensional Analysis** Buckingham Pi Theorem Scaling experimental data	HW 7
9	**Transient Heat Transfer** Lumped Mass Analysis & Biot number	HW 8

10-12	**Internal flow** laminar vs turbulent flow entrance length, fully-developed flow pressure and shear stress laminar pipe flow from dimensional analysis and conservation of energy turbulent pipe flow – major losses & Moody diagram – minor losses & loss coefficients parallel pipe flow project assignment; determining system losses fan & pump performance, dimensional analysis, fan/pump laws balancing fan/pump performance with systems losses	HW 9, HW 10, Exam 2 TBD
12-13	**Internal flow with convective heat transfer** Thermal and inertial entrance lengths, Re, Nu, Pr Heat conduction in a stationary fluid Newtons law of cooling Constant heat flux condition Constant wall temperature condition, log-mean-temperature	HW 11
14	**Advanced Topics - TBD**	HW 12
15		Final Exam