

Mechanical Engineering 708: Two-Phase Flow and Heat Transfer
McMaster University, Faculty of Engineering, Fall 2023

INSTRUCTORS

Dr. J.S. Cotton, JHE-212a, ext. 24899, cottonjs@mcmaster.ca

Dr C.Y. Ching, JHE-103, ext. 24998, chingcy@mcmaster.ca

OBJECTIVES

To teach the fundamental concepts in two-phase flow and heat transfer and the application of these principles in engineering.

CALENDER DESCRIPTION

Mech Eng 708: Two-Phase Flow and Heat Transfer

Development of conservation laws for two-phase flow systems, two-phase flow modelling, pressure drop and void fraction in piping systems, pool and convective boiling transfer, critical heat flux in pool and flow boiling and condensation, post-dryout heat transfer, critical two-phase flow and flow instabilities.;

SUGGESTED TEXT BOOK REFERENCES

- Brennen C.E., 2005, **Fundamentals of Multiphase Flows**, *Cambridge University Press*.
- Collier, J.G. and Thome, J.R., 1996, **Convective Boiling and Condensation**, Oxford Science Publications
- Carey, V.P., 1992, **Liquid Vapour Phase-Change Phenomena**, Taylor and Francis.
- Whalley, P.B., 1987, **Boiling Condensation and Gas-Liquid Flow**, Oxford Science Publications
- Faghri, A. and Zhang, Y., 2006, **Transport in Multiphase Systems**, Elsevier Academic Press

LECTURES

Thursdays – 9:00 to 12:00 hours in JHE 323 (Sept 7 – Nov 30) Oct 5 lecture cancelled

Students are expected to stay abreast of announcements and schedule changes made in lectures.

ASSIGNMENTS

2 Critical Paper Evaluation and Presentation each 15%

6 Assignments - Problem sets are planned for roughly every other week. ~ 5% Each

TESTS

Final examination: 4 hours in duration. The final exam will cover all lecture material. Open book

Thursday December 7 2023 8:00 – 1:00 JHE 323

ASSESSMENT

The following distribution of marks will be used unless there is a valid and compelling reason to use an alternative weighting. Missed assignments and tests will have a grade of zero entered without legitimate and documented reason. The course of action for missed mid-terms with Associate Dean's approval is the weight of the mid-term will be re-distributed to the final exam.

Assignments	30%
Critical review #1	15%
Critical review #2	15%
Final Exam:	40%

DETAILED COURSE DESCRIPTION

Introduction:

- Definitions and Base
- The nature of Two-Phase Flow
- Flow Regimes and Maps

Pressure Drop and Void Fraction

Phase Change Heat Transfer

- Single and Multi Component Systems
- Condensation Heat Transfer
- Boiling
- Convective Flow Boiling, Evaporation, Film
- Two-Phase Heat Transfer Augmentation

Basic Flow Equations

- Two-Phase Conservation Equations
- Closure Laws
- Overview of Mixture and Separate Flow Models
- Homogenous Models
- Mixture Models
- Drift Flux Model

Counter-Current Flow Limitations

- CCFL Limitations, Flooding Correlations and Models

Two-Phase Instabilities

Two-Phase Flow and Heat Transfer in Nuclear Reactor Applications

ASSIGNMENT SOLUTIONS FORMAT AND EVALUATION

Format: All homework submissions should adhere to the following format. Adherence to format will help us grade faster and more efficiently. So, help us give you a better grade.

- Use a clean, white, lined or grid 8-1/2" x 11" (letter size) paper.
- Follow the approach to problem solving described below:
 - Problem Statement
 - Schematic and Given Data
 - Assumptions
 - Physical Laws
 - Know Data & Properties
 - Analysis/Calc's – with Units
- Numerical substitutions should be made after an algebraic solution has been formulated. You may get a good grade even if your numerical answer is wrong but your algebraic approach is reasonable. Try restraining yourself from numerical substitutions as long as you can.
- **Highlight** your final answer and be sure to not forget the **UNITS**.

If a computer program is used to attain a solution, attach a copy of the program and the data sheet.

ASSIGNMENT SUBMISSIONS

All homework should be submitted in class on the due date or via Avenue to Learn\Assessments\Assignment\ by 11:59pm on the due date if we have to move online.

ME708 – Two Phase Flow and Heat Transfer

Critical Reviews

Prepare a 5 page Critical Review of the journal paper provided.

Important note: do not confuse a literature review with an annotated bibliography. An annotated bibliography deals with each text in turn, describing and evaluating the text, using one paragraph for each text.

In contrast, a literature review synthesises many texts in one paragraph. Each paragraph (or section if it is a long thesis) of the literature review should classify and evaluate the themes of the texts that are relevant to your paper; each paragraph or section of your review should deal with a different aspect of the literature.

Like all academic writing, a literature review must have an introduction, body, and conclusion.

The introduction should include:

- the nature of the topic under discussion (the topic of your thesis)
- the parameters of the topic (what does it include and exclude)?
- the basis for your selection of the literature

The conclusion should include:

- A summary of major agreements and disagreements in the literature
- A summary of general conclusions that are being drawn.

The body paragraphs could include relevant paragraphs on:

- historical background, including classic texts;
- current mainstream versus alternative theoretical or ideological viewpoints, including differing theoretical assumptions, differing outlooks, and other conflicts;
- possible approaches to the subject (empirical, mechanistic, theoretical, etc);
- definitions in use;
- current research studies;
- current discoveries about the topic;
- principal questions that are being asked;
- general conclusions that are being drawn;
- methodologies and methods in use;

Critical Review #1

Critical Review: 10% Due October 5, 2023 – Submit through Avenue

15 min Presentation: 5% October 12, 2023

Critical Review #2

Critical Review: 10% Due November 23, 2023 – Submit through Avenue

15 min Presentation: 5% November 30, 2023

For more information on Accreditation, please visit: <https://www.engineerscanada.ca>

EQUITY, DIVERSITY, AND INCLUSION

Every registered student belongs in this course. Diversity of backgrounds and experiences is expected and welcome. You can expect your Instructor to be respectful of this diversity in all aspects of the course, and the same is expected of you.

The Department of Mechanical Engineering is committed to creating an environment in which students of all genders, cultures, ethnicities, races, sexual orientations, abilities, and socioeconomic backgrounds have equal access to education and are welcomed and treated fairly. If you have any concerns regarding inclusion in our Department, in particular if you or one of your peers is experiencing harassment or discrimination, you are encouraged to contact the Chair, Associate Graduate Chair, Academic Advisor or to contact the [Equity and Inclusion Office](#).

PHYSICAL AND MENTAL HEALTH

For a list of McMaster University's resources, please refer to the [Student Wellness Centre](#).

ACADEMIC INTEGRITY

You are expected to exhibit honesty and use ethical behaviour in all aspects of the learning process. Academic credentials you earn are rooted in principles of honesty and academic integrity. **It is your responsibility to understand what constitutes academic dishonesty.**

Academic dishonesty is to knowingly act or fail to act in a way that results or could result in unearned academic credit or advantage. This behaviour can result in serious consequences, e.g. the grade of zero on an assignment, loss of credit with a notation on the transcript (notation reads: "Grade of F assigned for academic dishonesty"), and/or suspension or expulsion from the university. For information on the various types of academic dishonesty please refer to the [Academic Integrity Policy](https://secretariat.mcmaster.ca/university-policies-procedures-guidelines/), located at <https://secretariat.mcmaster.ca/university-policies-procedures-guidelines/>

The following illustrates only three forms of academic dishonesty:

1. plagiarism, e.g. the submission of work that is not one's own or for which other credit has been obtained.
2. improper collaboration in group work.
3. copying or using unauthorized aids in tests and examinations.

AUTHENTICITY / PLAGIARISM DETECTION

Some courses may use a web-based service (Turnitin.com) to reveal authenticity and ownership of student submitted work. For courses using such software, students will be expected to submit their work electronically either directly to Turnitin.com or via an online learning platform (e.g. A2L, etc.) using plagiarism detection (a service supported by Turnitin.com) so it can be checked for academic dishonesty.

Students who do not wish their work to be submitted through the plagiarism detection software must inform the Instructor before the assignment is due. No penalty will be assigned to a student who does not submit work to the plagiarism detection software. **All submitted work is subject to normal verification that standards of academic integrity have been upheld** (e.g., on-line search, other software, etc.). For more details about McMaster's use of Turnitin.com please go to www.mcmaster.ca/academicintegrity.

COURSES WITH AN ON-LINE ELEMENT

McMaster is committed to an inclusive and respectful community. These principles and expectations extend to online activities including electronic chat groups, video calls and other learning platforms.

Some courses may use on-line elements (e.g. e-mail, Avenue to Learn (A2L), LearnLink, web pages, capa, Moodle, ThinkingCap, etc.). Students should be aware that, when they access the electronic components of a course using these elements, private information such as first and last names, user names for the McMaster e-mail accounts, and program affiliation may become apparent to all other students in the same course. The available information is dependent on the technology used. Continuation in a course that uses on-line elements will be deemed consent to this disclosure. If you have any questions or concerns about such disclosure, please discuss this with the course instructor.

CONDUCT EXPECTATIONS

As a McMaster student, you have the right to experience, and the responsibility to demonstrate, respectful and dignified interactions within all of our living, learning and working communities. These expectations are described in the [Code of Student Rights & Responsibilities](#) (the "Code"). All students share the responsibility of maintaining a positive environment for the academic and personal growth of all McMaster community members, **whether in person or online.**

It is essential that students be mindful of their interactions online, as the Code remains in effect in virtual learning environments. The Code applies to any interactions that adversely affect, disrupt, or interfere with reasonable participation in University activities. Student disruptions or behaviours that interfere with university functions on online platforms (e.g. use of Avenue 2 Learn, WebEx or Zoom for delivery), will be taken very seriously and will be investigated. Outcomes may include restriction or removal of the involved students' access to these platforms.

ACADEMIC ACCOMMODATION OF STUDENTS WITH DISABILITIES

Students with disabilities who require academic accommodation must contact [Student Accessibility Services \(SAS\)](#) at 905-525-9140 ext. 28652 or sas@mcmaster.ca to make arrangements with a Program Coordinator. For further information, consult McMaster University's [Academic Accommodation of Students with Disabilities](#) policy.

COURSE POLICY ON MISSED WORK, EXTENSIONS, AND LATE PENALTIES

1. It is the students' responsibility to regularly check the course webpage (ex. Avenue to Learn) for updates and announcements.

COPYRIGHT AND RECORDING

Students are advised that lectures, demonstrations, performances, and any other course material provided by an instructor include copyright protected works. The Copyright Act and copyright law protect every original literary, dramatic, musical and artistic work, **including lectures** by University instructors

The recording of lectures, tutorials, or other methods of instruction may occur during a course. Recording may be done by either the instructor for the purpose of authorized distribution, or by a student for the purpose of personal study. Students should be aware that their voice and/or image may be recorded by others during the class. Please speak with the instructor if this is a concern for you.

EXTREME CIRCUMSTANCES

The University reserves the right to change the dates and deadlines for any or all courses in extreme circumstances (e.g., severe weather, labour disruptions, etc.). Changes will be communicated through regular McMaster communication channels, such as McMaster Daily News, A2L and/or McMaster email.